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GE 115

General Electric Company

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SUMMARY REPORT: GE-115

.01 INTRODUCTION

The GE-115, announced in March, 1965, is designed primarily as a replacement for conventional punched-card tabulating equipment and as a remote terminal for GE's larger computer systems (the GE-400 Series and the GE-600 Series). The GE-115 represents the first joint development effort by General Electric (USA), Bull-GE (France) and Olivetti-GE (Italy). All of its components have been developed by one of these three organizations. The design is based principally upon the Olivetti 4035 computer. The contributions to the system by GE (USA) are the CR-10 Card Reader, the DS-12 Removable Disc Storage Unit, and portions of the software. Initially, all GE-115 systems will be manufactured in Italy; future plans call for GE-115 systems to be manufactured in France and the USA as well. Because of the problems involved in maintaining a widespread service force for a system with such a small margin of profit, the initial marketing effort in the USA will be directed toward current users of other GE computer equipment.

A GE-115 system with a card reader, printer, and communications adapter (a typical remote terminal configuration) can be rented for as little as $1,240 per month. Typical card system rentals will be in the $1,340 to $2,300 range. First system delivery is scheduled for early 1966, and the current delivery schedule is 11 to 14 months for most components.

Significant features of the GE-115, and the paragraphs where they are described in this Summary Report, include:

- Up to 8,192 eight-bit character positions of 8-microsecond core storage (Paragraph .041).
- Over one million characters of on-line random-access storage using the DS-12 Disc Storage Unit (Paragraph .042).
- Card reading speeds of 300 or 600 cards per minute, and three program-selectable stackers (Paragraphs .071 and .072).
- Economical 300-card per-minute photoelectric card reader (Paragraph .073).
- Card punching speeds of up to 300 cards per minute (Paragraphs .074 and .075).
- Punched paper tape reading at 400 characters per second and punching at 100 characters per second (Paragraphs .076 and .077).
- Printing at speeds of 300 or 600 lines per minute (Paragraphs .081 and .082).
- Adaptors that permit communication with a remote computer system (Paragraph .101).
- Ability to perform two I/O data transfer operations simultaneously (Paragraph .11).
- Software that includes a basic assembler, service routines, a program for simulating tabulating equipment, and a remote terminal program (Paragraph .15).

.02 DATA STRUCTURE

The basic unit of data storage is a "character" consisting of eight data bits plus a parity bit. Each character position can contain one alphanumeric character, two decimal digits (packed), a one-decimal-digit arithmetic operand, or an 8-bit binary operand.

.02 DATA STRUCTURE (contd.)

Decimal arithmetic is performed on unsigned 4-bit BCD digits (one digit per character position); the remaining four bits of each character are ignored.

Most GE-115 instructions can process operands from 1 to 16 characters long; the code translation and editing instructions can operate on fields of up to 256 characters. GE-115 instructions are two, four, or six characters in length and specify zero, one, or two core storage addresses, respectively.

Note that there is no direct compatibility between the GE-115 and the IBM System/360, although both systems use 8-bit character codes.

.03 SYSTEM CONFIGURATION

Every GE-115 computer system has a GE-115 Central Processor with a built-in console and 4,096 or 8,192 locations of core storage.

One printer and one card reader can be connected directly to a GE-115 Central Processor. Two other peripheral devices can be connected through the GE-100 Standard Interface. Alternatively, one (but not both) of the peripheral devices connected through the Standard Interface can be replaced either by a directly-connected communications terminal or by up to 64 peripheral devices operating through synchronizers connected to the Standard Interface.

Peripheral devices available include line printers, card readers, card punches, a paper tape reader, a paper tape punch, and a removable disc storage unit. The peripheral devices are described in subsequent paragraphs.

A typical configuration that could be used to replace a unit record accounting machine is presented in Paragraph .031. Paragraph .032 illustrates a GE-115 configuration suitable for use as a remote terminal for a GE-400 or GE-600 Series computer system.

.031 Typical Card System; Standard Configuration I

Equipment	Rental
1 - GE-115 Central Processor with 8,192 characters of core storage	$ 700
1 - PR-11 Printer; 600 lpm	650
1 - CR-12 Card Reader; 600 lpm	250
1 - CP-21 Card Punch; 300 cpm	575
Total Rental	$2,175

.032 Typical Remote Terminal System

Equipment	Rental
1 - GE-115 Central Processor with 4,096 characters of core storage	$ 500
1 - PR-10 Printer; 300 lpm	415
1 - CR-10 Card Reader; 300 cpm	125
1 - DATANET-10 or DATANET-11 Communications Terminal*	200
Total Rental	$1,240

* Does not include cost of the necessary digital subset.

NOTE: A DS-12 Removable Disc Storage Unit can be added to provide 1,179,645 characters of on-line random-access storage. Total rental of the above system with one DS-12 unit (two disc handlers and controller) would be $1,890.

.04 INTERNAL STORAGE

.041 Core Storage

A GE-115 Central Processor can contain 4,096 or 8,192 locations of core storage. Each location holds one character of 8 information bits plus a parity bit. Cycle time per one-character access is eight microseconds. The maximum effective internal transfer rate is 62,000 characters per second (124,000 digits per second when transferring packed decimal data).

(Contd.)

.042 DS-12 Removable Disc Storage Unit

This unit, developed by the General Electric Computer Department in Phoenix, Arizona, provides an economical, low-capacity, random-access storage device for GE-115 systems. Two disc handlers and the controller are housed in a single cabinet. Additional disc handlers are available in pairs. The controller can control a total of six disc handlers.

Each disc handler contains one access mechanism capable of accessing all positions of one side of the single-disc cartridge. The disc cartridge must be physically removed, turned over, and replaced to gain access to the information recorded on the other side. Storage capacity is 589,824 characters per surface. Thus, each DS-12 subsystem provides up to 3.5 million characters of on-line storage. The average random access to any sector of data is 445 milliseconds, including rotational delay. The peak data transfer rate is 95,040 characters per second.

.05 CENTRAL PROCESSOR

The GE-115 Central Processor is basically a character-oriented, variable-word-length, two-address, sequential processor. All addressing is in the binary mode and is direct; i.e., no indexing or other automatic address modification facilities are provided.

The basic instruction format is:

Part:	F	C	IA	IB
Size in bits:	8	8	16	16

Reduced formats of two or four 8-bit characters are used for some instructions which require no reference, or only one reference, to memory. The operation code is represented by F; the high-order two bits of this word specify the format of the instruction. The C character can represent an operand length for logical instructions (up to 256 characters), the length of two operands for arithmetic instructions (up to 16 digits each), an 8-bit literal, an I/O device specification, or the complement of the operation code, depending upon the particular instruction. The 16-bit fields IA and IB, when present, represent the addresses of the operands.

A total of 25 instructions provide facilities for decimal addition and subtraction, binary addition and subtraction, decimal and binary comparison, editing, branching based upon the status of indicators set by compare operations, and the Boolean operations Inclusive OR, AND, and Exclusive OR. Literal operands can be used only in a one-character store and a one-character compare operation.

Several interesting and potentially valuable instructions are included in the GE-115 repertoire. Among these are the Transcode instruction for translating between any two 8-bit codes; the Pack and Unpack instructions for converting decimal data between the two-digits-per-location packed format and the one-digit-per-location format required for arithmetic instructions; and search instructions for locating a specified character within a field. Note that all decimal arithmetic instructions operate on unsigned fields. A subroutine is required to obtain the conventional algebraic type of arithmetic operations. The only interrupt facility is the capability for recognizing a request from a DATANET-10 or DATANET-11 terminal.

Probable execution times for decimal arithmetic are as follows, where B represents the operand length in 8-bit characters and D represents the operand length in decimal digits. Note that these times are for unsigned fields; additional time must be allowed if signed, algebraic-type operations are desired.

	Time, Microseconds
For random addresses —	
$c = a + b$:	96 + 40D.
$b = a + b$:	48 + 20D.
Sum N items:	(48 + 20D)N.
$c = ab$:	? *
$c = a/b$:	? *
For arrays of data —	
$c_i = a_i + b_j$:	372 + 40D.
$b_j = a_i + b_j$:	234 + 20D.
Sum N items:	(216 + 20D)N.
$c = c + a_ib_j$:	? *
Moving data:	48 + 16B.

* subroutines are required for multiplication and division; execution times are not available to date.

.051 Compatibility

There is no direct program compatibility between the GE-115 and any of GE's other computer systems (the 200 Series, 400 Series and the 600 Series). Neither is there any direct compatibility with the IBM System/360. However, through use of the Transcode instruction, data files on punched cards and paper tape from almost any other system can be utilized.

.06 CONSOLE

A control panel built into the central processor cabinet provides the switches, keys, and lights required for manual control of the system. No provision for keyboard input or console typewriter output has been announced to date.

.07 PUNCHED CARD AND PAPER TAPE INPUT-OUTPUT

.071 CR-12 Card Reader

This unit, developed by Olivetti-GE, reads standard 80-column punched cards at a peak speed of 600 cards per minute. The effective speed will normally be very close to the peak speed because this unit has an infinite clutch, so a complete cycle is not lost when the processing time exceeds the time available between cards.

A 1200-card hopper and three 500-card stackers are provided. Cards can be directed to any of the three stackers under program control. The CR-12 card reader can be equipped to read and translate the IBM, ISO, or Bull card code. Alternatively, cards can be read in a column binary mode without translation.

The card reader can operate concurrently with any other peripheral device connected to the other data channel. However, only the time between cards is available for internal processing. This time depends on the number of characters read from the card and is a minimum of 20 milliseconds per card when all 80 columns are being read at the peak, 600 cpm speed.

.072 CR-11 Card Reader

This unit is virtually the same as the CR-12 except that its peak speed is 300 cards per minute.

.073 CR-10 Card Reader

The CR-10, developed by GE (USA), is a low-cost model similar to the CR-11 but without multiple stackers. A 500-card hopper and one 500-card stacker are provided.

.074 CP-11 Card Punch

This unit, developed by Bull-GE, punches standard 80 column cards serially by column at 100 columns per second. The peak punching speed varies from 60 cards per minute when punching 80 columns per card to a maximum of 200 cards per minute. The CP-11 is equipped with one 1500-card hopper and one 1500-card stacker.

.075 CP-21 Card Punch

This unit is a version of the CP-20 Card Punch developed by GE for the GE-400 and GE-600 Series computer systems. The CP-21 Card Punch punches standard 80-column cards at a peak rate of 300 cards per minute. This unit has a 1200-card hopper, one 1200-card output stacker, and one 100-card reject stacker. The characteristics of the CP-21 are similar to those of the CP-20 Card Punch described in Section 330:072 of the GE-400 Series report.

.076 TR-10 Punched Tape Reader

The TR-10 was developed by Olivetti-GE and operates entirely under program control. It can read punched paper tape at a peak speed of 400 characters per second. Either square-hole (Olivetti) or conventional round-hole 5-, 6-, 7-, and 8-level tapes can be read. Reading can be done in either direction, and the device can stop on a single character. Even or odd parity checking is used with conventional round-hole tapes. When reading square-hole tapes, checking is accomplished by a second reading station and a comparison of the characters read by the first and second heads.

(Contd.)

.077 TP-10 Punched Paper Tape Punch

The TP-10 was also developed by Olivetti-GE and is capable of punching standard 5-, 6-, 7, and 8-level tapes at a peak speed of 100 characters per second. Another version of this unit is available to punch square-hole (Olivetti) tape.

.08 PRINTERS

.081 PR-11 Line Printer

The PR-11 Printer is an asynchronous line printer developed by Olivetti-GE. Skipping is initiated immediately following the last printed character of a line. Some of the more important characteristics of this printer are:

- 104, 120, or 136 printing positions.
- 10 characters per inch horizontal spacing.
- 6 lines per inch vertical spacing.
- 64 printable characters (GE standard character set).
- 12 inches per second continuous skipping speed.

The PR-11 will accept continuous forms from 3 to 22 inches in width. An optional feature allows form skipping at 64 inches per second.

The maximum printing rate utilizing the full 64-character set is 600 single-spaced lines per minute.

.082 PR-10 Line Printer

The PR-10 Printer is a slowed-down version of the PR-11 Printer described in the previous paragraph. The maximum printing rate of the PR-11 is 300 single-spaced lines per minute when using the full 64-character set. Other characteristics of the PR-11 Printer are similar to those of the PR-10, except that the high-speed skip option is not available for the PR-11.

.09 MAGNETIC TAPE

No provisions for magnetic tape input-output have been announced to date for the GE-115.

.10 OTHER INPUT-OUTPUT EQUIPMENT

.101 DATANET-10 and DATANET-11

These two devices enable a GE-115 system to be connected to a remote GE-400 Series or GE-600 Series computer system via a second DATANET (any model) at the remote site and a dial-up or private-line communication circuit.

The DATANET-10 allows the GE-115 to be connected to the Bell System DSS201A, a 2,000-baud circuit. The DATANET-11 allows connection to the Bell System DSS201B, a 2,400-baud private-line circuit.

Typical transmission rates between a GE-400 or GE-600 Series computer system and the GE-115 are shown in Table I. These rates are based on record lengths of 80 characters per card or 120 characters per print line. Reduced record lengths can increase the transmission rates up to the peak rates of the individual peripheral devices.

TABEL I: TYPICAL GE-115 REMOTE TERMINAL PERFORMANCE

Peripheral Device	Rate
Card Reader (any model)	125 cards/min
CP-21 Card Punch	85 cards/min
Printer (any model)	95 lines/min

.11 SIMULTANEOUS OPERATIONS

The GE-115 Central Processor has two data channels and four outlets for connecting peripheral devices. Under program control, the data channels can be switched to service different outlets. Data Channel 1 can service outlets 1 and 2. Data Channel 2 can service outlets 2, 3, and 4. Only a printer can be connected to outlet 1; only a card reader can be connected to outlet 2. One peripheral device with controller can be connected to outlet 3 and one to outlet 4 through the GE-100 Standard Interface. Alternatively, a communications device can be connected directly to outlet 4, and a total of up to 64 peripheral devices with controllers can be attached to outlet 3 via Synchronizers.

Data transfers on both channels can take place concurrently through time-sharing of the core storage accesses required by each peripheral device. The processor, however, is locked out during every peripheral operation from the initiation of the data transfer until all data for that operation has been transferred. Thus, the time between card columns is not available for internal processing, but the time between successive cards is. In general, the processor delay is dependent upon the number of characters transferred in a peripheral operation (see Table II).

The Sychronizer (or "Channel Expander") enables four peripheral controllers to be connected to one outlet. Each outlet of the sychronizer can be similarly expanded, and up to three levels of Synchronizers can be cascaded in this manner. Thus, up to 64 peripheral controllers can be connected to outlet 3. Each controller is addressed individually. Two peripheral devices connected to the same outlet via Sychronizers cannot transfer data simultaneously.

Table II summarizes the delays imposed upon central processor operations by most of the GE-115 input-output devices.

TABLE II: PROCESSOR DELAYS DURING I/O OPERATIONS

Function	Device	Peak Speed	Cycle Time, msec	Maximum Processor Delay, msec
Card Reading	CR-10 CR-11 CR-12	300 cpm 300 cpm 600 cpm	200 200 100	108 108 80
Card Punching	CP-10 CP-21	100 col/sec 300 cpm	300 min.* 200	? ?
Printing	PR-10 PR-11	300 lpm 600 lpm	200 100	160 80
Paper Tape Reading and Punching	TR-10 TP-10	400 cps 100 cps	* *	? ?
Disc Storage Reading or Writing	DS-12	95, 040 cps	*	?

* Varies with number of characters read, punched, or written.

.15 SOFTWARE

GE has announced a limited amount of software to be available for the GE-115 by June, 1965. The software will include a basic one-for-one assembler; a macro assembler for disc systems; a library of subroutines, debugging aids, and utility routines; a group of routines to aid in conversion from unit record tabulating equipment; and a remote terminal program. Detailed specifications for these routines are not available to date.

PRICE DATA

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
CENTRAL PROCESSOR		GE-115 Central Processor			
	115-04	4,096 characters	500	?	24,000
	115-08	8,192 characters	700	?	33,600
INTERNAL STORAGE		Core storage is included in the GE-115 Central Processor above.			
RANDOM ACCESS STORAGE	RDC115	DS-12 Removable Disc Storage and Controller (2 disc handlers); 1 million words	650	?	31,200
	ASU115	Additional 2 Disc Handlers	400	?	19,200
	ADS115	Additional Disc Cartridge	—	?	260
INPUT-OUTPUT	CRZ100	CR-10 Card Reader; 300 cpm	125	?	6,000
	CRZ110	CR-11 Card Reader; 300 cpm	160	?	7,680
	CRZ120	CR-12 Card Reader; 600 cpm	250	?	12,000
	CPZ101	CP-11 Card Punch; 60 to 200 cpm	300	?	14,400
	CPZ103	CP-21 Card Punch; 300 cpm	575	?	27,600
		PR-10 Printer; 300 lpm:			
	PRT100	With 104 print positions	415	?	21,600
	OPT075	With 120 print positions	450	?	23,280
	OPT076	With 136 print positions	485	?	29,040
		PR-11 Printer; 600 lpm:			
	PRT110	With 104 print positions	605	?	29,040
	OPT077	With 120 print positions	650	?	31,200
	OPT078	With 136 print positions	695	?	33,360
	OPT079	Fast Skip Option (for PR-11)	70	?	3,360
	PTR100	Paper Tape Reader; 400 cps	110	?	5,280
	PTP100	Paper Tape Punch; 100 cps	120	?	5,760
	CLI100	DATANET-10; 2,000 baud	200	?	9,600
	CLI110	DATANET-11; 2,400 baud	200	?	9,600
	SYN115	Synchronizer (four outlets)	70	?	3,360

GE 215

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CONTENTS

* Refer to indicated section of GE 225 report; all GE 225 software is directly usable on the GE 215.

CONTENTS (Contd.)

* Refer to indicated section of GE 225 report; all GE 225 software is directly usable on the GE 215.

INTRODUCTION

§ 011.

The GE 215 is a small scale, solid-state data processing system that is adaptable to a wide range of business and scientific applications. System rentals can range from approximately $2,600 to over $18,000 per month, but most installations will probably fall within the $4,000 to $12,000 range. The GE 215 was announced in February, 1963, and initial customer deliveries are scheduled for the fourth quarter of 1963.

Compatibility

The GE 215 is the smallest member of General Electric Computer Department's recently expanded line of general purpose digital computers. The more powerful GE 225 and GE 235 systems (Computer System Reports 321 and 323) are fully program-compatible with the GE 215 and offer essentially the same line of peripheral equipment. Internal processing speeds of the GE 225 and 235 systems are approximately twice as fast and six times as fast, respectively, as those of the GE 215, offering the potential for upward expansion without reprogramming as the user's computer needs grow. (The GE 215 central processor is, in fact, a slowed-down GE 225 central processor.)

The principal differences between the GE 215 system and the earlier GE 225 can be summarized as follows:

- Core storage cycle time is 36 microseconds in the GE 215, versus 18 microseconds in the GE 225.
- Maximum GE 215 core storage size is 8,192 words, versus 16,384 words in the GE 225.
- Maximum magnetic tape speed is 15,000 characters per second in the GE 215; a 41,667 character per second handler is available for the GE 225.
- The high speed printer has a rated speed of 450 alphameric lines per minute in GE 215 systems, versus 900 lines per minute in GE 225 systems.
- The total number of controllers for magnetic tape, disc storage, high speed printers, magnetic ink document handlers, data communication terminals, and the Auxiliary Arithmetic Unit is limited to three in the GE 215, versus up to eight in the GE 225.
- Only one magnetic tape controller can be used in a GE 215 system, versus up to eight in a GE 225.
- Only one disc storage controller can be used in a GE 215 system, versus up to eight in a GE 225.

Hardware

Core storage in the GE 215 can consist of 4,096 or 8,192 word locations. Each 20-bit location can hold a one-address instruction, a binary data word of 19 bits plus sign, or 3 alphameric characters in 6-bit BCD representation. Core storage cycle time is 36 microseconds. A parity check is performed upon all internal transfer operations.

The central processor provides complete arithmetic facilities for single word-length binary operands. Loading, storing, addition, and subtraction of double-length binary data items can also be performed. An optional feature permits addition and subtraction (but not multiplication or division) of single- or double-length data items in BCD form. This feature

INTRODUCTION (Contd.)

§ 011.

Hardware (Contd.)

can significantly reduce the number of time-consuming radix conversions required in business data processing, but will seldom eliminate the problem completely.

Three index registers and a fourth location that serves as a convenient counter register are standard. An optional feature makes 31 additional 4-word groups in core storage available as index registers or counters. Only one group, selected by a special instruction, can be active at a time. Other optional features for the central processor are a Move Command (which expedites internal block transfer operations), Three-Way Compare, Automatic Priority Interrupt, and a Real-Time Clock. Instructions are executed at the rate of about 10,000 per second in typical GE 215 routines.

The Auxiliary Arithmetic Unit can perform double-length arithmetic in either fixed or floating point mode under control of the central processor. This optional unit greatly increases the 215's internal processing speeds on scientific problems.

Standard 80-column punched cards can be read at 400 or 1,000 cards per minute and punched at 100 or 300 cards per minute. Paper tape can be read at 250 or 1,000 characters per second and punched at 110 characters per second. A console typewriter provides typed output at 10 characters per second. Input via the console typewriter is an optional feature.

All peripheral devices except those mentioned above are connected to the central processor through a three-way multiplexing device called the Controller Selector, which gives the GE 215 capabilities for simultaneous operations that rival more costly systems. Up to three controllers for magnetic tape units, disc storage units, printers, magnetic document handlers, data communication equipment, and the Auxiliary Arithmetic Unit can be connected to the Controller Selector. One peripheral unit on each controller can operate simultaneously with internal processing and card reading and punching. Accesses to core storage are automatically allocated among the operating units by a straightforward priority system. Maximum gross data transfer rate for the system is 27,800 words per second.

The printer has a peak speed of 450 alphameric lines per minute and a skipping speed of 25 inches per second. The printer controller provides automatic editing and format control.

The magnetic tape handler has a peak data transfer rate of 15,000 characters per second at a recording density of 200 rows per inch. The tape format is compatible with the IBM 727, 729, and 7330 Magnetic Tape Units at low density. Two tape handlers are mounted in a single cabinet, one above the other. Up to eight tape handlers can be connected to the tape controller, but only one tape read or write operation can occur at a time.

Each Mass Random Access Data Storage (MRADS) unit provides disc storage for approximately 18.87 million alphameric characters in 98,304 fixed record locations of 64 words (or 192 characters) each. The average total waiting time for access to a randomly-placed record is 225 milliseconds. Up to 294,912 characters per MRADS unit can be transferred without repositioning any of the 16 access arms. A maximum of four MRADS file units can be connected to the MRADS controller. Only one MRADS read or write operation can occur at a time.

Magnetically encoded paper documents can be read and sorted at a peak speed of 1,200 documents per minute. Two document handlers can be connected to each controller.

The DATANET-15 controls the transmission and reception of digital data over telephone and telegraph lines and two-wire cables at speeds ranging from 60 to 2,400 bits per second. Up to 15 data transmission lines and a paper tape reader and punch can be connected to a DATANET-15, but it can control only one data transfer operation at a time.

INTRODUCTION (Contd.)

§ 011.

Hardware (Contd.)

GE's line of data communications equipment also includes:

- The DATANET-30 programmed data communication system.
- The DATANET-600 paper tape terminal.
- The DATANET-90 magnetic-tape-to-computer terminal.
- The DATANET-91 off-line magnetic-tape-to-magnetic-tape terminal.
- A variety of special digital input-output devices.

GE's MOSE (Modification of Standard Equipment) group offers a variety of special-purpose hardware for use with the 215 system, such as peripheral device switching controllers, printer plotting option, plotter interface units, etc.

Software

All of the programs and programming systems that have been developed for the GE 225 are directly usable on similarly equipped GE 215 systems. The available software is summarized below and described in detail in the GE 225 report, Sections 321:151 through 321:191.

The General Assembly Program (GAP) is the basic symbolic assembly system for the GE 215. It permits full utilization of the hardware facilities, is relatively easy to learn and use, but provides few refinements. GAP-coded programs can be assembled on GE 215 systems with punched card, paper tape, or magnetic tape input-output equipment.

ZOOM is a "macro assembly system" designed to facilitate machine oriented programming by reducing the amount of detailed coding required while retaining high object program efficiencies. The ZOOM programmer uses a combination of pseudo-English statements, algebraic expressions, and GAP symbolic statements. These are translated into an all-GAP program which is then assembled in the normal manner. Magnetic tape is not required, but can be utilized to facilitate the translation process.

GECOM is offered as an all-purpose process oriented language. The basic language structure is similar to that of COBOL-61 but is not compatible with it. (A COBOL-61 to GECOM translator will be provided.) GECOM also handles algebraic expressions and mathematical functions, and includes a report writer and TABSOL, a system that permits decision logic to be expressed in a concise tabular format. At least four magnetic tape handlers and 8,192 core storage locations are required for GECOM compilations.

WIZ is a one-pass algebraic compiler for use on punched card or paper tape systems with at least 8,192 core storage locations. WIZ is less powerful than the FORTRAN or ALGOL language, but it is easy to learn and provides high compilation speeds.

FORTRAN II is available for GE 215 systems with at least 8,192 core storage locations and 4 magnetic tape units. Arrays are limited to two dimensions, and Boolean, complex, and double precision statements are not permitted. On the other hand, several useful extensions of the FORTRAN II language have been incorporated.

BRIDGE II is a tape file maintenance and run sequencing program whose functions are directed by control cards. FORWARD is a generalized sort/merge generator. Simulation programs are available for simulating the operations of IBM 650 and General Precision LGP-30 computers on the GE 215. The Card Program Generator simplifies the programming of existing punched card tabulator and calculator runs for the GE 215. An adequate library of generalized input-output, diagnostic, and mathematical routines are available, as are special-purpose packages for the banking and electric utility industries, numerical tool control, inventory management, assembly line balancing, critical path scheduling, and information retrieval.

DATA STRUCTURE

§ 021.

.1 STORAGE LOCATIONS

Name of Location	Size	Purpose or Use
Word:	20 bits + parity	basic addressable location.
Sector:	64 words	Mass Random Access Data Storage record location.
Band:	8 or 16 sectors	Mass Random Access Data Storage.
Disc:	512 bands	Mass Random Access Data Storage.

.2 INFORMATION FORMATS

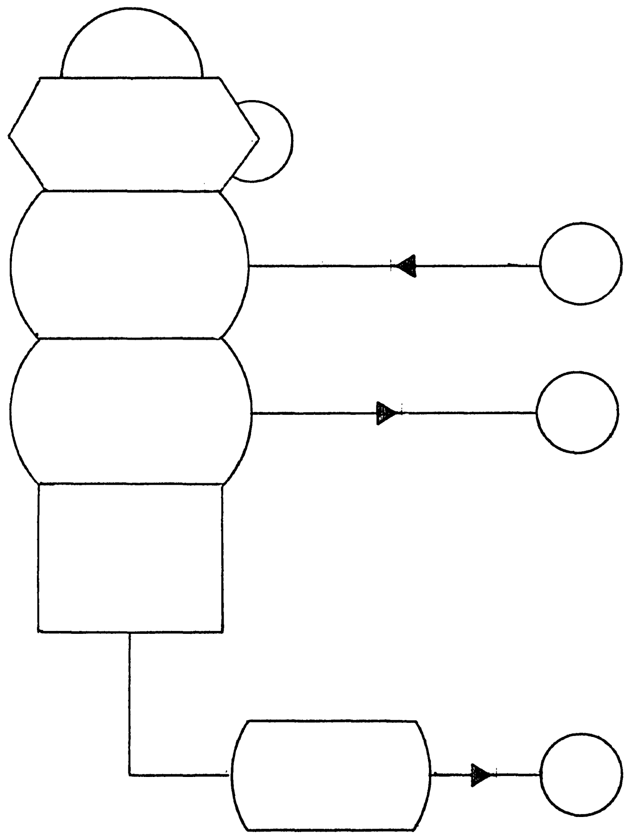
Type of Information	Representation
Numeral (BCD):	three 6-bit characters per word.
Letter (BCD):	three 6-bit characters per word.
Number (BCD):	one or two 3-character words.
Number (binary): . . .	one or two 20-bit words.
Number (floating point):	two words (30 bits + sign for mantissa; 8 bits + sign for exponent).
Instruction:	one word (two words for certain input-output instructions.

SYSTEM CONFIGURATION

§ 031.

.1 TYPICAL CARD SYSTEM (CONFIGURATION I)

Deviations from Standard Configuration: . . . . core storage is 75% larger.
card punch is 50% faster.
printer is 55% slower.
2 more simultaneous data transfer operations are possible.
2 more index registers.



Equipment	Rental
Core Storage: 4,096 words Central Processor, Console, & Typewriter	$2,200
Card Reader & Controller: 1,000 cards/min.	810
Card Punch & Controller: 300 cards/min.	825
Controller Selector	-
Printer & Controller: 450 lines/min.	775

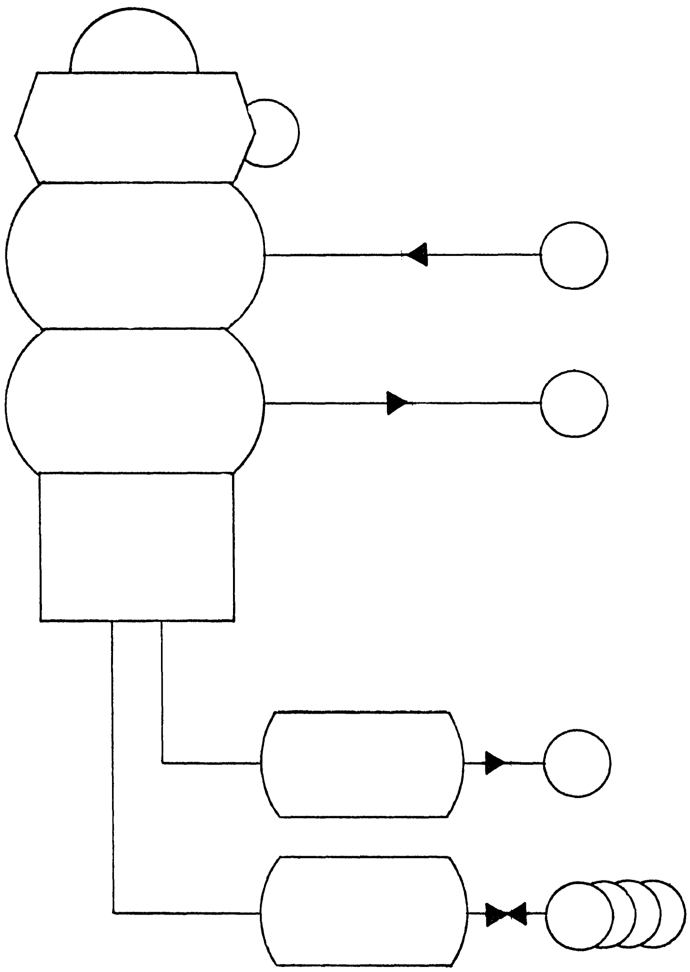
Optional Features Included: . . . .

Move command.	75
Three-way compare. Decimal addition & subtraction. Additional address modification groups.	200
TOTAL	$4,885

§ 031.

.2 4-TAPE BUSINESS SYSTEM (CONFIGURATION II)

Deviations from Standard Configuration: . . . . core storage is 75% larger.
card reader is 20% slower.
3 more simultaneous non-tape data transfer operations are possible.
3 index registers, console typewriter, and multiply-divide are standard.



Equipment	Rental
Core Storage: 4,096 words Central Processor, Console, & Typewriter	$2,200
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	-
Printer & Controller: 450 lines/min.	775
Magnetic Tape Units (4) & Controller: 15,000 char/sec.	2,500

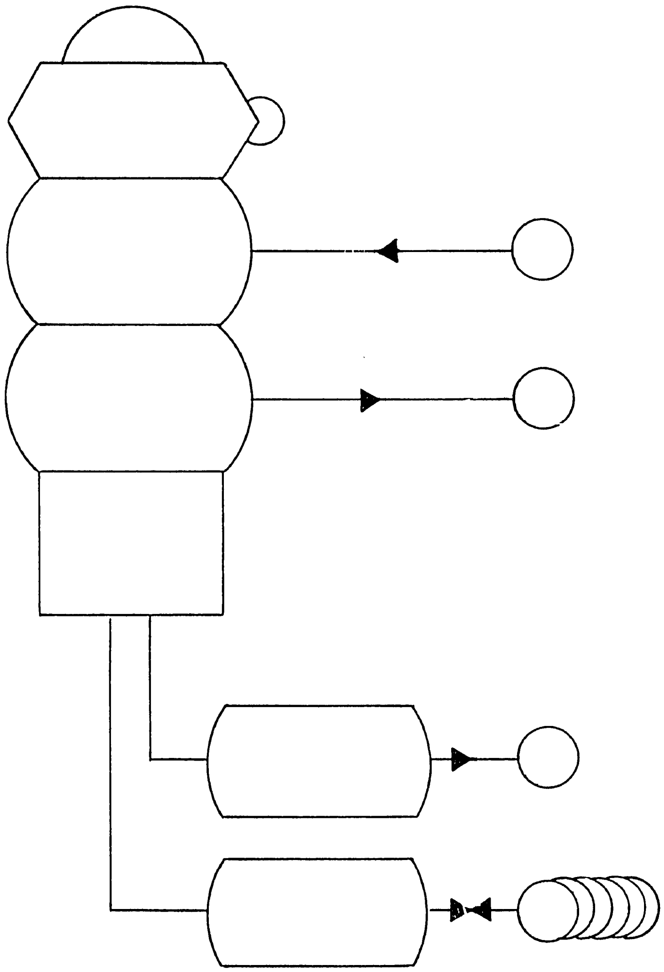
Optional Features Included: . . . . none. -

TOTAL $6,250

§ 031.

.3 6-TAPE BUSINESS SYSTEM (CONFIGURATION III)

Deviations from Standard Configuration: . . . . card reader is 20% slower.
magnetic tape is 50% slower.
2 more simultaneous non-tape data transfer operations are possible.



Equipment	Rental
Core Storage: 4,096 words; Central Processor, Console, & Typewriter	$2,200
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	
Printer & Controller: 450 lines/min.	775
Magnetic Tape Units (6) & Controller: 15,000 char/sec.	3,350

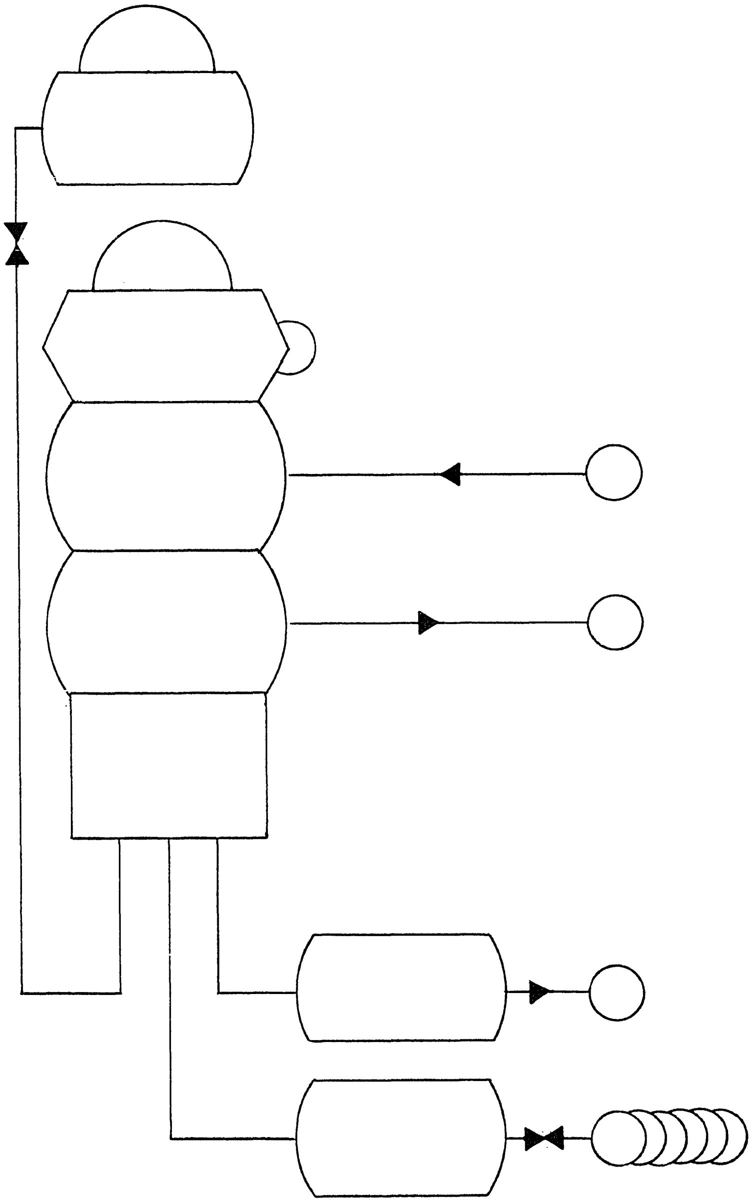
Optional Features Included: . . . . Move Command. 75
Three-way compare.
Decimal addition & subtraction.
Additional address modification groups. 200

TOTAL $7,375

§ 031.

.5 6-TAPE AUXILIARY STORAGE SYSTEM (CONFIGURATION V)

Deviations from Standard Configuration: . . . . card reader is 20% slower.
magnetic tape is 50% slower.
2 more simultaneous non-tape data transfer operations are possible.



Equipment	Rental
Mass Random Access (Disc) Storage & Controller: 18,874,368 characters	$2,625
Core Storage: 4,096 words; Central Processor, Console, & Typewriter	2,200
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	-
Printer & Controller: 900 lines/min.	775
Magnetic Tape Units (6) & Controller: 15,000 char/sec.	3,350

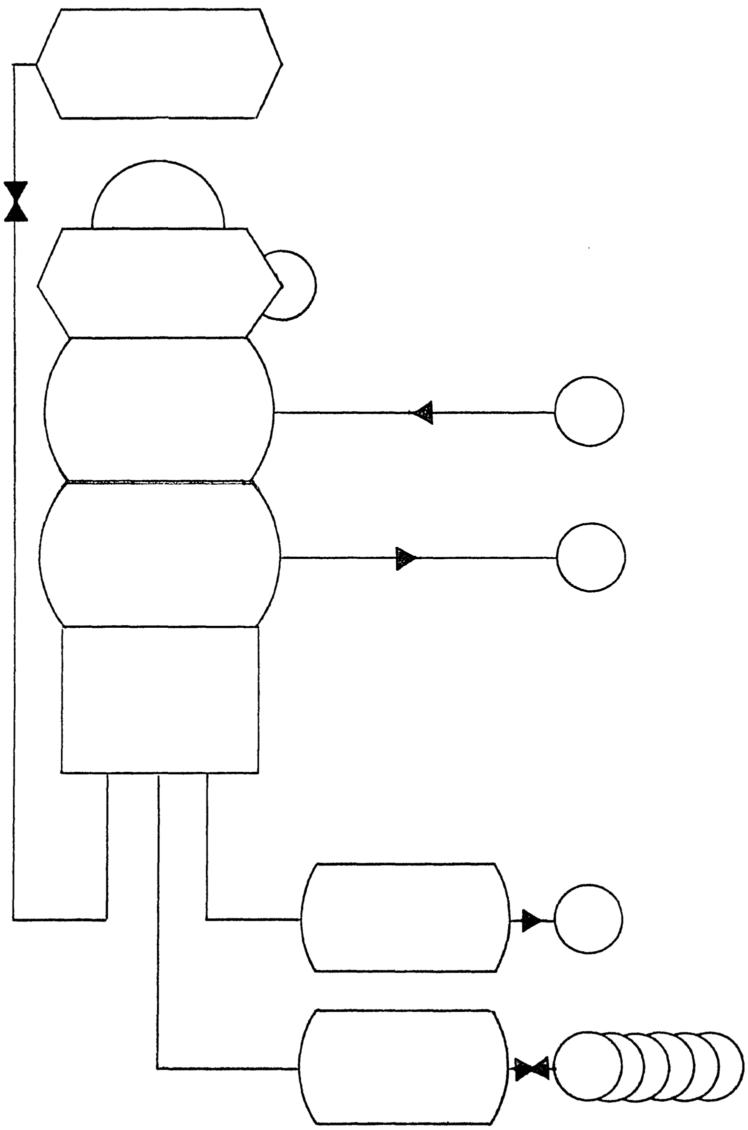
Optional Features Included: . . . .

Feature	Rental
Move Command.	75
Three-Way Compare; Decimal Addition & Subtraction.; Additional Address Modification Groups.	200
Automatic Interrupt.	75
TOTAL	$10,075

§ 031.

.6 6-TAPE BUSINESS/SCIENTIFIC SYSTEM (CONFIGURATION VI)

Deviations from Standard Configuration: . . . . core storage is 56% smaller.
card reader is 20% slower.
magnetic tape is 50% slower.
2 more simultaneous non-tape transfer operations are possible.



Equipment	Rental
Auxiliary Arithmetic Unit	$ 650
Core Storage: 8,192 words; Central Processor, Console, & Typewriter	2,500
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	-
Printer & Controller: 450 lines/min.	775
Magnetic Tape Units (6) & Controller: 15,000 char/sec.	3,350

Optional Features Included: . . . .

Move Command.	75
Three-Way Compare.; Decimal Addition & Subtraction.; Additional Address Modification Groups.	200
TOTAL	$8,325

INTERNAL STORAGE: CORE STORAGE

§ 041.

.1 GENERAL

.11 Identity: . . . . Core Storage.
CA215A (4,096 locations).
CB215A (8,192 locations).

.12 Basic Use: . . . . working storage.

.13 Description

Core Storage is housed in the Central Processor cabinet and may consist of 4,096 or 8,192 locations. The corresponding processor model numbers are listed above. Each storage location consists of twenty data bits and one parity bit and can hold a single-address instruction, a binary data word of nineteen bits plus sign, or three BCD characters. Single or double word-length load and store operations are possible in the basic processor; and internal block transfers of any length are possible with the optional Move Command, at a maximum effective rate of 13,900 words per second.

.14 Availability: . . . . . . 8 months as of March, 1963.

.15 First Delivery: . . . . late 1963.

.16 Reserved Storage

Purpose	No. of Locations	Locks
Index registers and counters:	4 (128 optional)	none.
Arith registers:	none.	
Logic registers:	none.	
I/O control:	none.	

.2 PHYSICAL FORM

.21 Storage Medium: . . . . magnetic core.

.22 Physical Dimensions: . not available.

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by program: . . . . yes.
.242 Data regenerated constantly: . . . . . . no.
.243 Data volatile: . . . . . yes (usually retained).
.244 Data permanent: . . . . no.
.245 Storage changeable: . . no.

.28 Access Techniques

.281 Recording method: . . . coincident current.
.283 Type of access: . . . . uniform.

.29 Potential Transfer Rates

.292 Peak data rates
Unit of data: . . . . . 1 word.
Conversion factor: . . 20 bits per word.
Cycling rate: . . . . . 27,800 cycles/second.
Data rate: . . . . . . 27,800 words/second.

.3 DATA CAPACITY

.31 Module and System Sizes

	Minimum Storage	Maximum Storage
Identity:	CA215A	CB215A.
Words:	4,096	8,192.
Characters:	12,288	24,576.
Instructions:	4,096	8,192.
Modules:	1	1.

.32 Rules for Combining Modules: . . . . all configurations are shown above.

.4 CONTROLLER: . . . . none.

.5 ACCESS TIMING

.51 Arrangement of Heads: one access device per system.

.52 Simultaneous Operations: . . . . . . none.

.53 Access Time Parameters and Variations

.531 For uniform access
Access time: . . . . . 18 μsec.
Cycle time: . . . . . . 36 μsec.
For data unit of: . . . 1 word.

.6 CHANGEABLE STORAGE: . . . . . . no.

.7 PERFORMANCE

.71 Data Transfer

Pairs of storage units possibilities

With self: . . . . yes.
With Mass Random Access File: . . . . . yes (see Section 320:042).

.72 Transfer Load Size

With self: . . . . 1 or 2 words; or, with optional Move Command, 1 to N words, where N is limited by storage capacity.

§ 041.

.73 Effective Transfer Rate

With self, using indexed loop: . . . . . 4,000 words/second.
With self, using optional Move Command: . . . . . . 13,900 words/second.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	none.	
Receipt of data:	parity check	indicator & alarm; optional stop.
Dispatch of data:	send parity bit.	
Conflicting commands:	not possible.	
Recovery of data:	parity check	indicator & alarm; optional stop.
Recording of data:	record parity bit.	

INTERNAL STORAGE: MASS RANDOM ACCESS DATA STORAGE

§ 042.

.1 GENERAL

.11 Identity: . . . . Mass Random Access Data Storage.
M640A.
MRADS.

.13 Description

Each Mass Random Access file unit consists of sixteen data discs and two checking discs on a common vertical axis. Up to four files can be connected to one MRADS Controller, which occupies one of the three "hubs" on the Controller Selector.

Each disc surface is divided into 256 bands. The outer 128 bands contain sixteen sectors each and the inner 128 bands contain eight sectors each. One 64-word block of data (192 alphameric characters) can be stored in each sector, and from one to sixteen sectors can be transferred between disc storage and core storage in a single MRADS read or write operation. Total capacity of each MRADS unit is 98,304 sectors, 6.29 million words, 18.87 million characters, or about 34.6 million decimal digits.

Each disc is served by an individual positioning arm containing eight read-write heads. Four heads serve the top disc surface and the other four serve the bottom surface, so only sixty-four arm positions are required to cover all the bands on a disc. Arm positioning time ranges from 70 to 305 milliseconds, and the average total waiting time for random accessing is 225 milliseconds. Up to 98,304 words per file unit can be transferred without moving any of the positioning arms. Peak transfer rate is 23,700 words per second for data recorded on the outer bands and 11,850 words per second for the inner bands. An effective bulk transfer rate of 20,000 words per second can be obtained with optimum data placement.

A parity bit is recorded and checked for each word. In addition, the sixty-fifth word recorded in each sector is composed of one longitudinal parity check bit for each of the twenty bit positions of the sixty-four data words. This two-way parity check makes it possible to locate and correct, by means of a subroutine, a single-bit error occurring anywhere in a sector. The address of each sector is permanently recorded in a "header" word and used for sector identification and band address confirmation.

Three instructions words are required for each disc seek, read, or write operation. The first word selects the proper controller and transfers to it the next two words, which specify the exact operation and the addresses involved. Simultaneous read or write operations are limited to one per Mass Random

.13 Description (Contd.)

Access Controller. Only one head positioning operation at a time may occur in each MRADS unit, or up to four at a time per controller.

.14 Availability: . . . . . . 1 month as of March, 1963.

.15 First Delivery: . . . . 1963.

.16 Reserved Storage: . . . no addressable locations reserved.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . multiple discs.

.22 Physical Dimensions

.222 Disc
Diameter: . . . . . . 31 inches.
Thickness or length: . thin.
Number on shaft: . . . 18 discs (16 for data).

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by program: . . . . yes.
.242 Data regenerated constantly: . . . . . . no.
.243 Data volatile: . . . . . no.
.244 Data permanent: . . . . no.
.245 Storage changeable: . . no.

.25 Data Volume per Band of 1 Track

Words: . . . . 1,024 (outer) or 512 (inner).
Characters: . . . . . . 3,072 (outer) or 1,536 (inner).
Digits: . . . . 5,632 (outer) or 2,816 (inner).
Instructions: . . . . . . 1,024 (outer) or 512 (inner).
Sectors: . . . . 16 (outer) or 8 (inner).

.26 Bands per Physical Unit: 512 (256 per disc surface).

.27 Interleaving Levels: . . 1.

.28 Access Techniques

.281 Recording method: . . . moving heads.
.283 Types of access

Description of stage	Possible starting stage
Move head to selected band:	if new band is selected.
Wait for start of selected sector: . . .	if head movement is unnecessary.
Transfer data:	no.

§ 042.

.29 Potential Transfer Rates

.291 Peak bit rates
- Cycling rates: . . . . 1,200 rpm.
- Bits/inch/track: . . . 400 maximum.
- Bit rate per track: . . 500,000 or 250,000 bits/sec/track.

.292 Peak data rates
- Unit of data: . . . . . word.
- Conversion factor: . . 20 data bits/word.
- Gain factor: . . . . . 1.
- Data rate: . . . . . . 23,700 (outer) or 11,850 (inner) words/sec.

.3 DATA CAPACITY

.31 Module and System Sizes

	Minimum Storage	Single MRADS Unit	Maximum Storage per Controller and per System
Identity:		M640A	M640A (4 units)
Discs:	0	16	64
Words:	0	6.29×10^6	25.2×10^6
Characters:	0	18.87×10^6	75.5×10^6
Instructions:	0	6.29×10^6	25.2×10^6
Digits:	0	34.60×10^6	138.4×10^6
Sectors:	0	98,304	393,216
Modules:	0	1	4

.32 Rules for Combining Modules: . . . . up to 4 MRADS units per controller; 1 controller per system.

.4 CONTROLLER

.41 Identity: . . . . MRADS Controller. M225B.

.42 Connection to System

.421 On-line: . . . . 1 per system; requires 1 of the 3 Controller Selector hubs.

.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 4.

.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of Load: . . . . . . 1 to 16 sectors of 64 words each.

.442 Input-output area: . . . core storage.

.443 Input-output area access: . . . . each word.

.444 Input-output area lockout: . . . . none.

.445 Synchronization: . . . . automatic during a read or write operation

.447 Table control: . . . . . none.

.448 Testable conditions: . . MRADS ready, controller ready.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of stacks
- Stacks per system: . . 128 to 512 per controller.
- Stacks per module: . . 128.
- Stacks per yoke: . . . 8.
- Yokes per module: . . 16 (one for each disc).

.512 Stack movement: . . . . in horizontal plane only.

.513 Stacks that can access any particular location: . . . . 1.

.514 Accessible locations
- By single stack
  - With no movement: . 16 or 8 sectors.
  - With all movement: . 1,024 or 512 sectors.
- By all stacks
  - With no movement: . 1,536 per module. 6,144 per controller. 49,152 per system.

.515 Relationship between stacks and locations: . least significant 7 bits of MRADS address specify stack and sector.

.52 Simultaneous Operations

- A: . . . . waiting for access to specified location.
- C: . . . . reading.
- D: . . . . recording.

a + c + d = at most 1 per MRADS unit.
c + d = at most 1 per system.

.53 Access Time Parameters and Variations

.532 Variation in access time

Stage	Variation, msec	Example, msec
Move head to selected band: . . .	0 or 70 to 305	199 (avg.)
Wait for start of selected sector: . .	0 to 52	26 (avg.)
Transfer 1 sector of data:	3.1 or 6.2	3.1.
Total:	3.1 to 363.2	328.1

.6 CHANGEABLE STORAGE: . . . . . . no.

.7 AUXILIARY STORAGE PERFORMANCE

.71 Data Transfer

Pair of storage units possibilities

- With self: . . . . no.
- With core storage: . . yes.

§ 042.

.72 Transfer Load Size

With core storage: . . . 1 to 16 sectors of 64 words each.

.73 Effective Transfer Rate

With core storage: . . . 20,000 words/sec or 60,000 char/sec.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	indicator.
Receipt of data:	parity	indicator.
Dispatch of data:	send parity bit.	
Conflicting commands:	check	indicator.
Recovery of data:	word & sector parity	indicator.
Wrong record selected:	address comparison	indicator.
Recording of data:	generate parity word.	

CENTRAL PROCESSOR

§ 051.

.1 GENERAL

.11 Identity: . . . . Central Processor.
CA215, CB215.

Auxiliary Arithmetic Unit.
X225A.
AAU.

.12 Description

The GE 215 is completely program-compatible with the larger GE 225 and GE 235 systems. Its effective core storage cycle time is 36 microseconds (or twice as long as that of the GE 225), and it is more restricted in the number of peripheral devices that can be connected.

The 215 is a single-address, fixed word-length, sequential processor. The main arithmetic and control circuitry, core storage, and console controls are housed in the processor cabinet. The two models differ only in the amount of core storage they contain. Word length of core memory locations and control registers is twenty bits. One location may contain an instruction, a binary data word consisting of a sign bit and nineteen data bits, or an alphameric data word consisting of three six-bit BCD-coded characters. Complete arithmetic facilities for single word-length binary data are built in.

Because the twenty-bit word is too short for many data processing and scientific applications, standard instructions are provided for double word-length addition, subtraction, and data transfers. In these cases, the combined A and Q Registers serve as a double-length accumulator. In the standard processor, subroutines must be used for double-length binary multiplication and division and for all decimal and floating point arithmetic operations. Optional hardware which can provide many of these arithmetic facilities is described below.

Three index registers and a fourth location that serves as a convenient counter register are standard, and special instructions facilitate incrementing and testing them. A variety of instructions is provided for inter-register transfers, shifting, normalizing, and complementing. These instructions do not require an operand address, so bits 7 through 19, which would normally contain the address, are used to define the exact operation to be performed. Through various combinations of these thirteen bits, the advanced programmer can create many special instructions in addition to those in the standard GE-defined repertoire. This technique is termed "micro-programming".

There are no table look-up facilities, and multiword internal transfers require the optional Move Command. Editing is accomplished by format control

.12 Description (Contd.)

circuitry in the printer controller; this reduces time demands upon the Central Processor while permitting a high degree of flexibility in the printed output. Conditional branch instructions result in execution of the next sequential instruction (which will normally be an unconditional branch) if the tested condition is true; otherwise, the next sequential instruction is skipped.

Optional Features

Auxiliary Arithmetic Unit (AAU): This independent unit provides complete hardware facilities for double word-length binary arithmetic in either fixed or floating point mode. Data can be transferred directly between the forty-bit AAU accumulator register and core storage, and Central Processor operations can continue while an arithmetic operation is in progress in the AAU. The AAU is connected to the Processor through the Controller Selector. Like the other peripheral devices, it can be tested for "ready" or "not ready" status and for various error conditions; unlike the others, only one instruction word is required for any AAU operation. A floating point data item is represented by thirty bits plus sign for the mantissa and eight bits plus sign for the exponent. This is the equivalent of 9 decimal digits of precision and an exponent range of 10^{-76} to 10^{+76}.

Decimal Addition and Subtraction: This feature enables the Central Processor to perform single and double-length addition and subtraction on decimal data stored in the six-bit BCD form. A carry indicator facilitates the coding of additions or subtractions of fields more than six characters long, but negative BCD numbers must be stored in the inconvenient ten's complement form. Instructions are provided to shift between the decimal and binary arithmetic modes.

Additional Address Modification Word Groups: This makes a total of thirty-two four-word groups (core storage locations 0000-0127) available as index registers or counters. Only one group, selected by a special instruction, may be active at a time, and only three of the four words are usable for address modification.

Three-Way Compare: Permits branching to the first, second, or third sequential instruction depending upon whether the contents of a specified single or double-length core storage location are greater than, equal to, or less than the contents of the accumulator.

Move Command: Provides a single instruction to transfer any number of successive words from one core storage area to another. The A and Q registers must contain, respectively, the new initial address and the number of words to be moved.

§ 051.

.12 Description (Contd.)

Automatic Priority Interrupt: Provides automatic storing of the sequence counter contents and a transfer of control to core storage location 0132 whenever any selected peripheral controller switches from "not ready" to "ready" status. Interruption from the console is not possible. The interrupt feature is especially useful for overlapping data transcription operations with independent processing routines.

Real Time Clock: Provides a nineteen-bit binary clock counter that measures time in sixths of seconds from zero to 24 hours. The clock can be set by the stored program or the operator and can be interrogated by the program through a special instruction.

.13 Availability: . . . . . . 8 months as of March, 1963.

.14 First Delivery: . . . . late 1963.

.2 PROCESSING FACILITIES

.21 Operations and Operands

Operation and Variation	Provision	Radix	Size
.211 Fixed point			
Add-Subtract:	automatic	binary (decimal with option)	1 or 2 words.
Multiply			
Short:	none.		
Long:	automatic	binary	1 word (2 with AAU).
Divide			
No remainder:	none.		
Remainder:	automatic	binary	1 word (2 with AAU).
.212 Floating point			
Add-Subtract:	subroutine or AAU	binary	30 & 8 bits (2 words).
Multiply:	subroutine or AAU	binary	30 & 8 bits (2 words).
Divide:	subroutine or AAU	binary	30 & 8 bits (2 words).
.213 Boolean			
AND:	none.	binary	1 word.
Inclusive OR:	automatic	binary	1 word.
Extract:	automatic	binary	1 word.
.214 Comparison			
Numbers:	subtract & test		1 word.
Absolute:	none.		
Letters:	subtract & test		1 word.
Mixed:	subtract & test		1 word.

Collating sequence: 0 - 9, A - Z; special characters interspersed among letters; see 321:144.100.

Comment: Direct high-low-equal comparisons on 1 or 2 words of numeric or alpha data are possible with optional Three-Way Compare.

.215 Code translation

Provision	From	To
subroutine	paper tape	internal.
subroutine	internal	paper tape.

.216 Radix conversion

Provision	From	To
subroutine	BCD	binary.
subroutine	binary	BCD.

.217 Edit format

	Provision	Size
Alter size:	automatic	up to 120 char.
Suppress zero:	automatic	up to 120 char.
Round off:	automatic	up to 120 char.
Insert point:	automatic	up to 120 char.
Insert spaces:	automatic	up to 120 char.
Insert any char:	automatic	up to 120 char.
Float $:	none.	up to 120 char.
Protection:	none.	up to 120 char.

.218 Table lookup: . . . . . no provision.

.219 Others

	Provision	Comment	Size
Normalize:	automatic	binary	1 or 2 words.
Decimal mode shift:	automatic	with optional Decimal Add-Subtract only.	
1's complement:	automatic	binary	1 word.
2's complement:	automatic	binary	1 word.
Select index group:	automatic	optional	1 of 32 groups.

.22 Special Cases of Operands

.221 Negative numbers: . . . 2's complement (10's complement with Decimal Add-Subtract.

.222 Zero: . . . . one form; 0 in all bit positions.

.223 Operand size determination: . . . . fixed.

.23 Instruction Formats

.231 Instruction structure: . 1 word (3 words for certain input-output operations).

.232 Instruction layout:

Part	Op	X	Addr or Op'
Size (bits)	5	2	13

.233 Instruction parts

Name	Purpose
Op:	operation code.
X:	index register specification.
Addr:	operand address.
Op':	extension of operation code in instructions with no operand address.

.234 Basic address structure: 1 + 0.

.235 Literals

Arithmetic: . . . . . . none.

Comparisons and tests: . . . . up to 8,192 on index registers only.

Incrementing modifiers: . . . . . up to 8,192.

.236 Directly address operands

.2361 Internal storage type	Minimum size	Maximum size	Volume Accessible
Core:	1 word	2 words *	8,192 words.
Disc:	64 words	1,024 words	total capacity.

* or total capacity with Move Command.

.2362 Increased address capacity: . . . . . . none.

§ 051.

.237 Address indexing
.2371 Number of methods: . . 1.
.2372 Names: . . . . indexing.
.2373 Indexing rule: . . . . . addition, modulo 32,768.
.2374 Index specification: . . bits 5 & 6 of instruction to be modified.
.2375 Number of potential indexers: . . . . . . 3 (96 optional).
.2376 Addresses which can be indexed: . . . . . operand addresses in arithmetic, load, store, and unconditional branch instructions.
.2377 Cumulative indexing: . none.
.2378 Combined index and step: . . . . . . none.
.238 Indirect addressing: . . none.
.239 Stepping: . . . . index registers.
.2391 Specification of increment: . . . . . in stepping instruction.
.2392 Increment sign: . . . . always positive.
.2393 Size of increment: . . 1 to 8,192.
.2394 End value: . . . . . . specified in test instruction.
.2395 Combined step and test: . . . . no.

.24 Special Processor Storage

.241 Category of storage

Category	Number of locations	Size in bits	Program usage
Central Processor:	1	20	upper accumulator, A.
Central Processor:	1	20	lower accumulator, Q.
Central Processor:	1	20	instruction register, I.
Central Processor:	1	15	sequence counter, P.
Central Processor:	1	6	single char, buffer, N.
Central Processor:	1	20	memory buffer, M.
Central Processor:	1	20	arithmetic buffer, B.
Aux. Arith. Unit:	1	40	upper accumulator, AX.
Aux. Arith. Unit:	1	40	lower accumulator, QX.
Core Storage:	3 (96 with option)	20	index registers.

.242 Category of storage

Category	Total Number locations	Physical form	Access time, μsec	Cycle time, μsec
Central Processor:	7	register	?	36.
Aux. Arith. Unit:	2	register	?	36.
Core Storage:	3 (96 with option)	core	18.0	36.

.3 SEQUENCE CONTROL FEATURES

.31 Instruction Sequencing

.311 Number of sequence control facilities: . . 1.
.314 Special sub-sequence counters: . . . . none.
.315 Sequence control step size: . . . . 1 word.
.316 Accessibility to program: . . . . can be stored in an index register.
.317 Permanent or optional modifier: . . . . no.

.32 Look-Ahead: . . . . . . none.

.33 Interruption: . . . . . . with optional Automatic Priority Interrupt only.

.331 Possible causes
In-out units: . . . . . indirectly, through controller status.
In-out controllers: . . change in status of peripheral controller from "not ready" to "ready".
Storage access: . . . indirectly, through controller status.
Processor errors: . . no.
Other: . . . . none.
.332 Program control
Individual control: . . peripheral controllers.
Method: . . . . "Priority Set" instruction permits selected controller(s) to interrupt.
.333 Operator control: . . . physical switch for each controller permits or locks out interruption by that controller.
.334 Interruption conditions: 1) in "Priority Set" mode. 2) not in priority routine. 3) change in status of any selected controller.
.335 Interruption process
Disabling interruption: automatic.
Registers saved: . . . sequence counter automatic; others by own coding.
Destination: . . . . . fixed jump to location 0132.
.336 Control methods
Determine cause: . . own coding; must test selected controllers.
Enable interruption: . own coding; "Priority Set" instruction.

.34 Multi-running: . . . . . limited capability with Automatic Priority Interrupt feature.

.341 Method of control: . . . own coding.
.342 Maximum number of programs: . . . . . 2 is practical limit.
.343 Precedence rules: . . . own coding.
.344 Program protection
Storage: . . . . none.
In-out units: . . . . . none.

.35 Multi-sequencing: . . . none.

.4 PROCESSOR SPEEDS

.41 Instruction Times in μsec

.411 Fixed point

	Single Precision	Double Precision	Double Precision, with AAU
Add:	72	108	148.
Subtract:	90	126	148.
Multiply:	216 to 468	4,550 (SR)	341 to 778.
Divide:	504 to 558	5,250 (SR)	1,071 to 1,217.

.412 Floating point

	Single Precision	Double Precision	Double Precision, with AAU
Add-subtract:	none	10,620 (SR)	162 to 709.
Multiply:	none	11,304 (SR)	297 to 1,062.
Divide:	none	28,267 (SR)	837 to 1,231.

.413 Additional allowance for

	Single Precision	Double Precision	Double Precision, with AAU
Indexing:	36	36	36.
Re-complementing:	none	none	none.

§ 051.

.414 Control

Compare (with Three-Way Compare:	90 to 108	90 to 144.
Branch:	36.	
Test & branch:	90.	

.415 Counter control

Step:	108.
Step & test:	198.
Test:	90.

.416 Edit: . . . . 0 (done in Printer Controller).

.417 Convert

BCD to binary: . . . . 220 + 525D (SR).

Binary to BCD: . . . . 698 to 9,415 (SR, for D = 6, with Decimal Add-Subtract).
1,750 + 1,400D (SR, without Decimal Add-Subtract).

.418 Shift: . . . . 60 + 12B (approximate, for shift of B bits).

Note: SR indicates that a programmed subroutine is used.
D is field length in decimal digits.

.42 Processor Performance in μsec

.421 For random addresses

	Fixed point, single precision	Floating point, with AAU (average)
c = a + b:	216	724.
b = a + b:	216	724.
Sum N items:	72N	436N.
c = ab:	594	1,068.
c = a/b:	675	1,322.

.422 For arrays of data

$c_i = a_i + b_j$:	684	1,192
$b_j = a_i + b_j$:	684	1,192.
Sum N items:	504N	1,012N.
$c = c + a_ib_j$:	1,098	1,936.

.423 Branch based on comparison

	Without Three-Way Compare	With Three-Way Compare
Numeric data (19-bit precision): .	720	666.
Alphabetic data (3-char precision): .	720	666.

.424 Switching

Unchecked:	288.
Checked:	720.
List search:	108 + 540N.

.425 Format control per character

Unpack

Without radix conversion: . . . . 40.

Including BCD-to-binary conversion: 595 (approx.).

Compose

Without radix conversion: . . . . 36.

Including binary-to-BCD conversion: . 1,225 (approx., without Decimal Add-Subtract).
700 (approx., with Decimal Add-Subtract).

.426 Table look up per comparison (single precision)

	Without Three-Way Compare	With Three-Way Compare
For a match:	540	504.
For least or greatest:	568	532.
For interpolation point:	540	504.

.427 Bit indicators

Set bit in separate location:	144.
Set bit in pattern: . .	180.
Test bit in separate location:	288.
Test bit in pattern: . .	288.
Test AND for B bits: .	648 ($B \leq 19$).
Test OR for B bits: . .	720 ($B \leq 19$).

.428 Moving data

Single word:	144.
Double-length word: .	216.
N words, using programmed loop: .	72 + 252N.
N words, using optional MC:	252 + 72N.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Overflow:	check	indicator & alarm.
Underflow:	check (AAU only)	indicator & alarm.
Zero divisor:	overflow check	indicator & alarm.
Invalid data:	none.	
Invalid operation:	all codes used.	
Arithmetic error:	none.	
Invalid address:	none.	
Receipt of data:	parity check	indicator & alarm. optional stop.
Dispatch of data:	parity check	indicator & alarm. optional stop.

CONSOLE

§ 061.

.1 GENERAL

.11 Identity: . . . . contained in 215 Central Processor cabinet.

.12 Associated Units: . . . . Console Typewriter and 400 card per minute Card Reader (if used) stand upon the console desk. (A free-standing 400 cpm card reader is also available.)

.13 Description:

The console control panel is mounted vertically at desk-top level on the narrower face of the Central Processor cabinet. A wide, L-shaped desk is placed directly in front of the control panel and provides ample working space. The unusual shape of the combined processor cabinet and console desk may make it difficult to arrange the system components for operating convenience in a small room, particularly since the printer and magnetic tape controllers and the Arithmetic Auxiliary Unit all contain alarm and condition lights which are clearly visible only at close range. The control panel contains a fairly typical complement of register displays, alarm lights, and control buttons; these are fully described below.

The Console Typewriter is a modified IBM electric model that stands on the right-hand wing of the console desk. Data cannot be entered into the system from the typewriter keyboard; the unit is used for output only, at 10 characters per second. Data to be typed, in BCD form, is sent to the unit via the 6-bit N Register, one character at a time. The typewriter character set includes only the 26 letters, 10 numerals, and the special symbols / . , $ - and space. Other BCD codes cause the unit to "hang up".

Optional Feature:

Console Typewriter Input: Permits using the Console Typewriter as an input device. In the input mode, one BCD character is transmitted to the N register when a typewriter key is activated. The character then may be shifted to the A register and used in any manner desired.

.2 CONTROLS

.21 Power

Name	Form
Power on:	button.
Power off:	button.

.22 Connections: . . . . . . none.

.23 Stops and Restarts

Name	Form	Comment
Start:	button	initiates automatic operation if Auto-Manual switch is in AUTO position.
Auto-Manual:	2-position switch	halts automatic operation when switched to MANUAL.
Stop on Parity Alarm:	2-position switch	when ON, system halts on all parity errors.

.24 Stepping

Name	Form	Comment
Start:	button	initiates a single step if Auto-Manual switch is in MANUAL position.
Word-Instruction:	2-position switch	selects steps of one machine cycle or one full instruction.
Save P:	switch	inhibits normal advance of the sequence counter (P Register), so same instruction is repeated.

.25 Resets

Name	Form	Comment
Reset Alarm:	button	resets all alarms and error indicators.
Reset P:	button	clears sequence counter to location 0000.
Reset A:	button	clears accumulator (A Register).

.26 Loading

Name	Form	Comment
Load Card:	button	reads one binary card into Core Storage starting at location 0000.

.27 Sense Switches

Name	Form	Comment
Bit Switches:	20 3-position center-off toggle switches	used to place 1 bits into any desired positions in the A register (when raised); and to set patterns that can be read into the A register under program control (when lowered) to control program branching.

.28 Special

Name	Form	Comment
A $\longrightarrow$ I	button	transfers contents of the A (accumulator) Register into the I (instruction) Register.
XAQ	button	interchanges contents of the A and Q Registers.

§ 061.

.3 DISPLAY

.31 Alarms

Name	Form	Condition Indicated
Parity:	light	parity error.
Overflow:	light	arithmetic overflow.
Card Reader:	light	error involving Card Reader.
Card Punch:	light	error involving Card Punch.
Echo:	light	peripheral controller unable to respond when addressed.

.32 Conditions

Name	Form	Condition Indicated
Priority:	light	loss of priority by Central Processor to a peripheral controller, alarm condition, or auto-manual switch in manual mode.
Card Reader Ready:	light	reader available for input.
Card Punch Ready:	light	punch available for output.
N Register Ready:	light	N Register available for paper tape or typewriter operation.
AIM:	light	processor in priority interrupt routine.
IX Group:	5 lights	index register group in use.
Decimal Mode:	light	Central Processor operating in decimal mode.

.33 Control Registers

Name	Form	Comment
P Register:	15 lights	binary display of sequence counter contents.
I Register:	20 lights	binary display of next instruction to be executed.
A Register:	20 lights	binary display of accumulator contents; pressing XAQ will display Q Register contents.

.34 Storage: . . . . no direct display available.

.4 ENTRY OF DATA

.41 Into Control Registers: 20 Bit Switches permit direct data entry into A Register only; A ⟶ I and XAQ buttons permit loading of I and Q Registers from A Register.

.42 Into Storage

1. Set Auto-Manual switch to MANUAL.
2. Set "Store A Register" instruction, with desired Core Storage location as operand address, in Bit Switches.
3. Depress A ⟶ I button to load the instruction.
4. Set Bit Switches to desired data value.
5. Depress Start button.

.5 CONVENIENCES

.51 Communication: . . . . none.

.52 Clock: . . . . none.

.53 Desk Space: . . . . . . ample free work space is provided on the console desk.

.54 View: . . . . Central Processor cabinet, 32 inches wide by 76 inches high, is directly in front of seated operator; view in other directions is unobstructed.

INPUT-OUTPUT: CARD READER (400CPM)

§ 071.

.1 GENERAL

.11 Identity: . . . . Card Reader. D225B

.12 Description:

This is the English-built Elliott reader for standard eighty-column punched cards, extensively modified and improved by GE. The rated 400 card per minute speed is achieved when reading continuously into alternating input areas in core storage. When feeding one card at a time upon demand, the maximum speed is 360 cards per minute. The unit is extremely compact and usually stands upon the console desk; an optional base converts it into a free-standing unit. It provides none of the usual checks upon card reading accuracy such as dual reading stations or hole count checks. Programmed tests can be made to insure only that proper read synchronization was achieved; i.e., that each column was read once and only once. After every card is read, the photocells are checked to ensure that they are working.

Cards are read serially by column, and the input instruction selects one of three data formats:

Column decimal; data in each card column is translated automatically into one internal BCD character, and three characters are stored in each core storage location.

Ten-row binary; data in two successive card columns fills one twenty bit core storage location.

Twelve-row binary; data in each card column fills the twelve least significant bit positions of one core storage location. (Continuous feeding is not possible in this mode.)

The automatic reading of data from successive cards into alternating core storage areas in the column decimal and ten-row binary modes can save Central Processor time through the elimination of internal transfers before the input data is processed.

.13 Availability: . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . March, 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs: . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . none.
.222 Sensing system: . . . photoelectric.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . 12.
Methods of use: . . . . 80 columns per card, one at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column cards.
.312 Phenomenon: . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . 80 columns at standard spacing.
.322 Parallel by: . . . . . . 12 rows at standard spacing.
.324 Track use
Data: . . . . 80.
Total: . . . . 80.
.325 Row use
Data: . . . . 12 (10 for 10-row binary data).

.33 Coding: . . . . Decimal: column code as in Data Code Table No. 3.
10-Row Binary: 2 card columns per 20-bit core storage word.
12-Row Binary: 1 card column per core storage word, into the 12 least significant bit positions.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 80-column cards: . . .	not required.

.35 Physical Dimensions: . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Reader Controller. (housed in Central Processor).

§ 071.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . cannot be used in same system with 1,000-card-per-minute reader.

.44 Data Transfer Control

.441 Size of load: . . . . . 1 to N cards of 80 columns per card.
.442 Input-output areas: . . core storage; address of first location filled must be a multiple of 128 and less than 2048.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic within a card; by program for successive cards.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation Input: . . . . fixed.

.52 Input-Output Operations

.521 Input: . . . . 1 to N cards forward; cards are read continuously until "halt card reader" command is given.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by processor: column decimal to internal BCD; or 10- or 12-row binary to internal binary.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with automatic Priority Interrupt.
Offset card: . . . . . . no.
Select stacker: . . . . no.
Select format: . . . . no.
Select code: . . . . . yes, in "read" command.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: . no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 400 cards/minute.
.623 Overhead: . . . . asynchronous; reading rate is controlled by program.
.624 Effective speeds: . . . 400 cards/min. when feeding continuously.
360 cards/min. maximum if "halt card reader" instruction is given after each card (demand feeding).

.63 Demands on System

Component	m.sec per card,	or	Percentage
Core Storage:	3.0		2.0

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls: . . . . none.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	600 cards.
Stacker:	600 cards.

.732 Replenishment time: . . 0.25 to 0.50 mins. reader does not need to be stopped.
.733 Adjustment time: . . . none.
.734 Optimum reloading period: . . . . 1.5 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	none.	
Input area overflow:	none.	
Invalid code:	check.	
Exhausted medium:	check	stop reader; alarm.
Imperfect medium:	none.	
Timing conflicts:	none.	
Misfeed:	check	stop reader; alarm.
Stacker full:	check	stop reader; alarm.
Synchronization:	check	set bit indieator in core storage.

INPUT-OUTPUT: CARD READER (1,000 CPM)

§ 072.

.1 GENERAL

.11 Identity: . . . . Card Reader.
D225C, D225D.

.12 Description

This unit has been developed by GE to provide high speed punched card input to the 215 system. Currently rated at 1,500 cards per minute when feeding continuously, it is said to be capable of higher speeds. When cards are fed singly on demand, the rated maximum speed drops to 890 cards per minute. A character validity check (on decimal coded data only) and a read error check provide checks on reading accuracy. The unit reads standard eighty-column cards only, and the hopper and single stacker have capacities of 2,000 cards each. Cards are fed singly by a vacuum pick-off and transported by a moving belt past the photoelectric read heads. Input instructions, card data formats, and code translation facilities are identical to those for the slower reader, so there is a high degree of upward compatibility between the two units.

.13 Availability: . . . . . . 9 months as of March, 1963.

.14 First Delivery: . . . . March, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . moving belt friction.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system:. . . none.
.222 Sensing system: . . . . photoelectric (solarcells).

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . reading.
Stacks: . . . . 1.
Heads/stack:. . . . . . 12.
Method of use: . . . . . 80 columns per card, one at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column cards.
.312 Phenomenon: . . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . 80 columns at standard spacing.
.322 Parallel by: . . . . . . 12 rows at standard spacing.
.324 Track use
Data: . . . . 80.
Total:. . . . . 80.
.325 Row use
Data: . . . . 12 (10 for 10-row binary data).

.33 Coding:. . . . . Decimal: column code as in Data Code Table No. 3.
10-Row Binary: 2 card columns per 20-bit core storage word.
12-Row Binary: 1 card column per core storage word, into the 12 least significant bit positions.
Read Card Intermixed option permits reading cards in decimal and binary modes intermixed (on Model D225D only).

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 80-column cards:.	not required.

.35 Physical Dimensions: . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Reader Controller (housed in Central Processor).

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions:. . . . . . cannot be used in same system with 400-card-per-minute reader.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N cards of 80 columns per card.
.442 Input-output areas: . . core storage; address of first location filled must be a multiple of 128 and less than 2048.

§ 072.

.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic within a card; by program for successive cards.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation Input: . . . . fixed.

.52 Input-Output Operations

.521 Input: . . . . 1 to N cards forward; cards are read continuously until "halt card reader" command is given.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by processor: column decimal to internal BCD; or 10- or 12-row binary to internal binary.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Offset card: . . . . . . no.
Select stacker: . . . . . no.
Select format: . . . . . no.
Select code: . . . . . . yes, in "read" command.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.
End of file: . . . . yes.
Invalid character (Hollerith): . . . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 1,000 cards/minute nominal.
.623 Overhead: . . . . asynchronous; reading rate is controlled by program.
.624 Effective speeds: . . . 1,500 cards/min. when feeding continuously.
890 cards/min. maximum if "halt card reader" instruction is given after each card (demand feeding).

.63 Demands on System

Component	msec per card	or	Percentage
Core Storage:	3.0		7.5 max.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls

Function	Form	Comment
Clear-read error:	button	resets error alarms.
End of file:	button	sets bit indicator when last card is read.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	2,000 cards.
Stacker:	2,000 cards.

.732 Replenishment time: . . 0.25 to 0.50 minutes. reader does not need to be stopped.
.733 Adjustment time: . . . none.
.734 Optimum reloading period: . . . . 1.3 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	read check	set bit 18.
Input area overflow:	none.	
Invalid code:	check (BCD data only)	set bit 17.
Exhausted medium:	check	set bit 19.
Imperfect medium:	none.	
Timing conflicts:	none.	
Misfeed:	check	stop reader.
Stacker full:	check	set bit 16.
End of file:	check	set bit 1.
Synchronization:	check	set bit pattern.

Note: "Set bit" denotes that the indicated bit in the "synchronization word" (first, second, or fourth core location after the last word read from the card) is set to 0 if the associated error occurs and to 1 if it does not. The bit configuration of this word must be tested by the program.

INPUT-OUTPUT: CARD PUNCH

§ 073.

.1 GENERAL

.11 Identity: . . . . Card Punch.
E225K (100 cards/min.).
E225M (300 cards/min.).

.12 Description:

Designed and built by General Electric, these units punch standard 80-column cards at peak speeds of 100 and 300 cards per minute. They are compatible with the IBM Model 523 and 544 punches that were used in early GE 225 systems. Cards can be punched in column decimal code from alphameric data stored in the BCD form, or in ten-row or twelve-row binary modes. The output instruction specifies the mode to be used. The starting core storage address of the data to be punched must be a multiple of 128 and less than 2,048.

The only available check on punched output of the 100 card per minute model is a plugboard-wired check for double punches and blank columns; it can check up to 30 columns and is effective only on decimal-coded numeric data. Check sums are usually punched into binary cards to make possible a programmed check on punching and reading accuracy when the data is re-entered. The 300 card per minute model checks the complete card by the read-after-punch technique, by counting the holes in each card row.

.13 Availability: . . . . . Model E225K: 3 months as of March, 1963.
Model E225M: 12 months as of March, 1963.

.14 First Delivery

E225K. . . . . April, 1962.
E225M . . . . September, 1963.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . die punch.
.222 Sensing system: . . . . brush.
.223 Common system: . . . no.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . punching.
Stacks: . . . . 1.
Heads/stack: . . . . . 80.
Method of use: . . . . . one row at a time.

Use of station: . . . . . checking.
Stacks: . . . . 1.
Heads/stack: . . . . . . 80.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column punch cards.
.312 Phenomenon: . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . 12 rows at standard spacing.
.322 Parallel by: . . . . . . 80 columns at standard spacing.
.324 Track use: . . . . all for data.
.325 Row use: . . . . all for data.

.33 Coding

Decimal: . . . . column code as in Data Code Table No. 3.
10-Row Binary: . . . . 2 card columns per 20-bit core storage word.
12-Row Binary: . . . . 1 card column per core storage word, from the 12 least significant bit positions.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 80-column cards:	not required.

.35 Physical Dimensions: . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Punch Controller. (housed in Central Processor).

§ 073.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . usable for independent gang-punching.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 card of 80 columns.
.442 Input-output areas: . . core storage; address of first word punched must be a multiple of 128 and less than 2,048.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation: . . fixed size.

.52 Input-Output Operations

.521 Input: . . . . none.
.522 Output: . . . . 1 card forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic; internal BCD to column decimal or internal binary to 10- or 12-row binary.

.54 Format Control

Control: . . . . plugboard; seldom used.
Format alternatives: . undefined.
Rearrangement: . . . . yes.
Suppress zeros: . . . . no.
Insert point: . . . . . . yes.
Insert spaces: . . . . . yes.
Section sizes: . . . . . no.
Select columns to be checked: . . . . yes (on 100 card per minute model only).

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Program Interrupt.
Offset card: . . . . no.
Select stacker: . . . . no.
Select format: . . . . . no.
Select code: . . . . . yes, in "punch" command.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.

.6 PERFORMANCE

.61 Conditions

I : . . . . Model E225K Card Punch.
II: . . . . Model E225M Card Punch.

.62 Speeds

.621 Nominal or peak speed
I : . . . . 100 cards/minute.
II: . . . . 300 cards/minute.
.622 Important parameters
Clutch cycle
I : . . . . 600 msec.
II: . . . . 200 msec.
.623 Overhead
Clutch points per cycle
I : . . . . 14.
II: . . . . 1.
.624 Effective speeds: . . . peak speeds are maintained if "punch" instruction occurs within 10 m. sec after punching of previous card is completed.

.63 Demands on System

Component	Condition	m. sec per card,	or	Percentage
Core Storage:	I	34.6		5.8.
	II	34.6		17.3.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . none.

.72 Other Controls

Function	Form	Comment
Reset:	button	resets error alarms.

.73 Loading and Unloading

.731 Volumes handled

Storage	Condition I	Condition II
Hopper:	800 cards.	3,500 cards.
Stacker:	800 cards.	3,500 cards.

.732 Replenishment time: . . 0.25 to 0.50 mins. punch does not need to be stopped.
.733 Adjustment time: . . . none.
.734 Optimum reloading period
I : . . . . 8.0 mins.
II: . . . . 11.3 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording (Model E225K):	double punch, blank column *	stop punch; alarm.
Recording (Model E225M):	read after punch	stop punch; alarm.
Output block size:	fixed.	
Invalid code:	all codes valid.	
Exhausted medium:	check	stop punch; alarm.
Imperfect medium:	none.	
Timing conflicts:	check	stop punch; alarm.
Misfeed:	check	stop punch; alarm.
Stacker full:	check	stop punch; alarm.

* For decimal-coded numeric data only; checks up to 30 columns on E225K.

INPUT-OUTPUT: PAPER TAPE READER

§ 074.

.1 GENERAL

.11 Identity: . . . . Paper Tape System (Reader only).

.12 Description

The Paper Tape System is a free-standing unit housing a reader, punch, and control circuitry for perforated tape input-output. Individual reader and punch units also are available. The reader and punch are mechanically independent of one another and are covered in separate sections of this report.

The reader offers a choice of speeds of 250 or 1,000 characters per second on five-, six-, seven-, or eight-track tape. At 250 characters per second, it can stop on a single character and handle spooled tape. At the higher speed, only unspooled strips can be handled, and one additional character is read after a "halt reader" instruction is given. Data from five or six tracks is read continuously into the six-bit N Register, one character at a time. Synchronization and code translation must be provided by the stored program. Input parity checks are made on seven- and eight-track codes, but the parity bit is not transmitted to the processor. The Paper Tape Reader may not be turned on at the same time as either the Paper Tape Punch or the Console Typewriter, since they all use the same input-output instructions. A delay of 200 milliseconds must be programmed between the "reader on" instruction and the first paper tape input instruction.

Optional Feature

Eight-Bit N Register provides two additional bits in the N Register, enabling data from as many as eight tracks to be read into the Central Processor.

.13 Availability: . . . . 3 months as of March 1963.

.14 First Delivery: . . . . October, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs
Number: . . . . 2.
Form: . . . . swinging arm.
Capacity: . . . . 12 inches.
.213 Feed drive: . . . . . . motor.
.214 Take-up drive: . . . . . motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . none.
.222 Sensing system: . . . . . photoelectric.

.23 Multiple Copies: . . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . . 8.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . . punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 10 per inch.
.322 Parallel by: . . . . 5, 6, 7, or 8 tracks at standard spacing.
.324 Track use
Data: . . . . 5 or 6 (up to 8 with Eight-Bit N Register option).
Redundancy check: . . . 1 (7- & 8-track tape only).
Timing: . . . . 1 (sprocket holes).
Control signals: . . . . . 1 (8-track tape only).
Total: . . . . 5 to 8 plus sprocket track.
.325 Row use: . . . . all for data (1-row inter-block gaps required for reading at 1,000 char/sec).

.33 Coding: . . . . any 5, 6, 7 or 8-track code with up to 6 data tracks (up to 8 with Eight-Bit N Register option) can be read.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 5-, 6-, 7-, or 8-track paper tape:	programmed.

.35 Physical Dimensions

.351 Overall width: . . . . . . 11/16, 7/8, or 1 inch.
.352 Length: . . . . up to 1,000 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . built into Paper Tape System.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

§ 074.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N characters.
.442 Input-output areas: . . . N register, a single-character I/O buffer.
.443 Input-output area access: . . . . contents can be shifted into A register only.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . . none.
.446 Synchronization: . . . . by program.
.447 Synchronizing aids: . . . test for "N Register ready"

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . . 1 to N characters.
.512 Block demarcation
Input: . . . . any selected character, or programmed counter.

.52 Input-Output Operations

.521 Input: . . . . read forward continuously until halted by program command.
.522 Output: . . . . see Paper Tape Punch section, 320:075.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . programmed.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . no.
Select format: . . . . . no.
Select code: . . . . no.
Rewind: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . no.
Nearly exhausted: . . . . no.
Busy controller: . . . . . no.
End of medium marks: no.
Busy I/O register: . . . yes.
Exhausted: . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 250 or 1,000 char/sec. (higher speed usable on tape strips only.)

.622 Important parameters
Tape speed: . . . . . . 25 or 100 inches/sec.
Maximum stop distance
At 25 inches/sec.: . . 0.025 inch.
At 100 inches/sec.: . 0.150 inch.
Start time (to first char.)
At 25 inches/sec.: . . 1.5 m.sec.
At 100 inches/sec.: . 0.5 m.sec.

.624 Effective Speeds
At 25 inches/sec.: . . $\frac{250N}{(N+1)}$ char/sec.
At 100 inches/sec.: . . $\frac{1,000N}{(N+2)}$ char/sec.
where N = number of characters per block.

.63 Demands on System

Component	m.sec per char	or Percentage
Central Processor:	0.216	5.4 or 21.6

Comment: This is the time required to test "N Register ready" and shift the six data bits from N to A Register; code translation time is not included.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Number of tracks:	rotary switch	5, 6, 7, or 8 tracks.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Reel:	1,000 feet, or up to 120,000 char.

.732 Replenishment time: . . 1.0 to 1.5 mins; reader needs to be stopped
.733 Adjustment time: . . . . 1.5 to 2.0 mins.
.734 Optimum reloading period: . . . . 8.0 minutes

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	parity (7- or 8-track tape)	indicator & alarm.
Input area overflow:	none.	
Invalid code:	none.	
Exhausted medium:	check	will remain "busy".
Imperfect medium:	none.	
Timing conflicts:	none.	

INPUT-OUTPUT: PAPER TAPE PUNCH

§ 075.

.1 GENERAL

.11 Identity: . . . . Paper Tape System (Punch only).

.12 Description:

This is the Teletype 110-character-per-second punch, housed in the Paper Tape System cabinet along with the reader and control circuitry. Individual reader and punch units also are available. Paper tape with five, six, seven, or eight tracks can be punched. One punch model is available for punching 5 track tape only; another model permits punching 6, 7, or 8 track tape codes only. Tape codes to be punched are set up by the program in the Central Processor's six-bit N Register, and odd parity bits are generated automatically for seven or eight-track codes. Each paper tape output instruction causes a single character to be punched. The punch cannot be turned on at the same time as either the Paper Tape Reader or the Console Typewriter, and a delay of five hundred milliseconds must be programmed between the "punch on" instruction and the first paper tape output instruction.

Optional Feature

Eight-bit N Register provides two additional bits in the N Register, enabling data to be punched in up to eight tracks.

.13 Availability: . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . October, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive.
.212 Reservoirs: . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . die punches.
.222 Sensing system: . . . . none.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . punching.
Stacks: . . . . 1.
Heads/stack: . . . . . 8.
Method of use: . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 row at 10 per inch.
.322 Parallel by: . . . . . . 5, 6, 7, or 8 tracks at standard spacing.
.324 Track use
Data: . . . . 5 or 6 (up to 8 with Eight-Bit N Register option).
Redundancy check: . . 1 (7 & 8 track tape only).
Timing: . . . . 1 (sprocket holes).
Control signals: . . . 1 (8 track tape only).
Total: . . . . 5 to 8 plus sprocket track.
.325 Row use: . . . . all for data (1-row inter-block gaps required if tape is to be read at 1,000 char/sec).

.33 Coding: . . . . any 5, 6, 7, or 8-track code with up to 6 data tracks.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 5, 6, 7, or 8-track paper tape:	programmed.

.35 Physical Dimensions

.351 Overall width: . . . . . 11/16, 7/8, or 1 inch.
.352 Length: . . . . up to 1,000 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . built into Paper Tape System.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: . 1.
.432 Restrictions: . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 character.
.442 Input-output areas: . . . N register, a single-character I/O buffer.

§ 075.

.443 Input-output area access: . . . . loaded by shift from A register only.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . . none.
.446 Synchronization: . . . . by program.
.447 Synchronizing aids: . . . test for "N Register ready".

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . . 1 to N characters.
.512 Block demarcation
Output: . . . . as programmed.

.52 Input-Output Operations

.521 Input: . . . . see Paper Tape Reader section, 320:074.
.522 Output: . . . . punch 1 row forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . programmed.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . no.
Select format: . . . . . . no.
Select code: . . . . no.
Rewind: . . . . no.

.56 Testable Conditions

Disabled: . . . . no.
Busy device: . . . . . . no.
Nearly exhausted: . . . no.
Busy controller: . . . . . no.
End of medium marks: . no.
Busy I/O register: . . . yes.
Exhausted: . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . . . none.

.62 Speeds

.621 Nominal or peak speed: 110 char/sec.
.622 Important parameters
Tape speed: . . . . . . 11 inches/sec.
.624 Effective speeds: . . . 110 char/sec. if not more than 9 m.secs. elapse between successive "punch" instructions.

.63 Demands on System

Component	m.sec per char.	or	Percentage
Central Processor:	0.216		2.4

Comment: This is the Processor time required to test "N Register ready", shift the six data bits from A to N Register, and punch a row; code translation is not included.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Number of tracks:	rotary switch	for 6, 7, or 8 tracks only.

.72 Other Controls

Function	Form	Comment
Simulator switches:	6 switches	set up bit pattern for manual punching.

.73 Loading and Unloading

.731 Volumes handled
Storage Capacity
Reel: . . . . 1,000 feet, or up to 120,000 characters.
.732 Replenishment time: . . . 2.0 to 3.0 mins. punch needs to be stopped.
.733 Adjustment time: . . . . 3.0 to 4.0 mins.
.734 Optimum reloading period: . . . . 18.1 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	none.	
Invalid code:	all codes punched.	
Exhausted medium:	check.	will remain "busy".
Imperfect medium:	none.	
Timing conflicts:	none.	

INPUT-OUTPUT: PRINTER

§ 081.

.1 GENERAL

.11 Identity: . . . . High Speed Printer. P215E.

.12 Description

The High Speed Printer utilizes the well-known Anelex Series 4 drum printing mechanism, with a rated peak speed of 450 alphameric lines per minute at single spacing. There are 120 printing positions and 50 printable characters. Skipping speed is 25 inches per second, and the print instruction may include a skip to any of 8 channels in the paper tape control loop or a step of zero to 63 lines.

One printer and its controller can be attached to any of the three hubs on the Controller Selector. The controller includes automatic format control circuitry which uses a block of format words in Core Storage to control zero suppression, insertion of any desired format characters, and deletion of data characters in any desired positions. Dollar field editing is automatic, but no automatic provision is made for check protection or for floating dollar, plus, or minus signs. Each printer output operation requires three instruction words. The first word selects the approximate Controller Selector hub and causes the next two words to be transferred to the Printer Controller, which then assumes control of the operation. It causes from one to forty BCD-coded data words and the corresponding format words to be transferred from Core Storage, performs the specified editing functions, and causes the line to be printed. This system minimizes time demands upon the Central Processor during printing.

The Printer Controller includes a manual control button that initiates an octal dump of the entire contents of Core Storage. A parity check is made on data received by the controller for printing, and a print cycle check detects synchronization errors.

.13 Availability: . . . . . 6 months as of March, 1963.

.14 First Delivery: . . . . March, 1963.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive - paper punched both sides.

.212 Reservoirs: . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . on-the-fly hammer stroke against engraved drum.

.222 Sensing system: . . . . none

.23 Multiple Copies

.231 Maximum number
Interleaved carbon: . . 5.

.233 Types of master
Multilith: . . . . . . yes.
Xerox: . . . . yes.
Spirit: . . . . yes.

.24 Arrangement of Heads

Use of station: . . . . printing.
Stacks: . . . . 1.
Head/stack: . . . . 120.
Method of use: . . . . prints 1 full line at a time.

.25 Range of Symbols

Numerals:	10	0 - 9
Letters:	26	A - Z
Special:	14	+ . - $ * % _ / = , [ ] # @
Alternatives:		any character set can be requested as a standard modification.
FORTRAN set:		optional.
Req. COBOL set: . . .		by request.
Total:	50 and blank.	

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . continuous fan-fold sprocket-punched stationery.

.312 Phenomenon: . . . . . printing.

.32 Positional Arrangement

.321 Serial by: . . . . . . 1 line at 6 per inch (6 or 8 lines/inch available as an option).

.322 Parallel by: . . . . . . 120 columns at 10 per inch.

.324 Track use
Data: 120
Total: . . . . 120.

.325 Row use: . . . . all for data.

.33 Coding: . . . . engraved character font. (Internal coding as in Data Code Table No. 1).

.34 Format Compatibility: none.

§ 081.

.35 Physical Dimensions

.351 Overall width: . . . . . 3.5 to 19.5 inches by vernier.
.352 Length: . . . . up to 22.0 inches per sheet, by 1/6-inch increments.
.353 Maximum margins:
Left: . . . . 3,875 inches.
Right: . . . . 3,875 inches.

.4 CONTROLLER

.41 Identity: . . . . Printer Controller.

.42 Connection to System

.421 On-line: . . . . up to 3; each requires 1 of the 3 Controller Selector hubs.
.422 Off-line: . . . . none (Off/On-Line Printer and Controller are available).

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 line of 3 to 120 characters.
.442 Input-output areas: . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lookout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 line of 3 to 120 characters.
.512 Block demarcation
Output: . . . . . . 1-bit in sign position of last word to be printed. (not required when full 40-word line is printed).

.52 Input-Output Operations

.521 Input: . . . . none.
.522 Output: . . . . 1 line forward, with automatic format control optional.
.523 Stepping: . . . . step 0 to 63 lines; may be combined in "print then step".
.524 Skipping: . . . . skip to 1 of 8 channels in paper tape loop; may be combined in "print then skip".
.525 Marking: . . . . none.
.526 Searching: . . . . . . none.

.53 Code Translation: . . . automatic, by controller (from internal BCD code only).

.54 Format Control

Control: . . . . program or automatic, using format words.
Format alternatives: . unlimited.
Rearrangement: . . . . by program only.
Suppress zeros: . . . . yes.
Insert point: . . . . . . yes.
Insert spaces: . . . . . yes.
Section sizes: . . . . . yes.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with optional Automatic Priority Interrupt.
Select format: . . . . . yes.
Select code: . . . . . . no.
Select controller: . . . yes.

.56 Testable Conditions

Disabled: . . . . yes
Busy device: . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . yes.
End of medium marks: . no.
Exhausted medium: . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . . . none.

.62 Speeds

.621 Nominal or peak speed: 450 lines/min.
.622 Important parameters
Skipping speed: . . . 25 inches/sec.
.623 Overhead: . . . . 6.7 msec per single line step.
.624 Effective speeds

Average spacing, inches	Effective speed, lines/min.
1/6	450
2/6	429
3/6	410
1	360
2	290
3	243
4	209
5	184

.63 Demands on System

Basis: Printing full lines with automatic format control, at single spacing.

Component	msec per line,	or	Percentage
Core Storage:	3.0		2.25

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method
Forms width:	sliding forms tractors.
Vertical forms positioning:	knob.
Forms tension: . . .	knob.
Penetration control: .	knob.

§ 081.

.72 Other Controls

Function	Form	Comment
On or off-line:	button.	
Skip to top of page:	button.	
Memory dump:	button	prints entire Core Storage contents in octal form.
Manual clear:	button	halts printer operation.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	30-inch stack.
Stacker:	30-inch stack.

.732 Replenishment time: . . . 1 to 2 minutes. Printer needs to be stopped.

.733 Adjustment time: . . . 3 to 5 minutes.

.734 Optimum reloading period: . . . . 124 minutes.
Basis: . . . . 2-part forms, 17 inches long, at 1-inch line spacing.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	automatic cut-off.	
Invalid code:	none	print space.
Exhausted medium:	check	indicator and alarm.
Imperfect medium:	none	
Timing conflicts:	check	stop printer.
Receipt of data:	parity	indicator and alarm.
Hammer fuses:	check	indicator and alarm.
Synchronization:	print cycle check	stop printer.

INPUT-OUTPUT: MAGNETIC TAPE HANDLERS

§ 091.

.1 GENERAL

.11 Identity: . . . . Magnetic Tape Handler. MTH680 (dual 15,000 char/sec unit).

.12 Description

Each dual Magnetic Tape Handler consists of two modified Ampex digital tape transports mounted one above the other in a single cabinet. Tape speed is 75 inches per second and recording density is 200 rows per inch, providing a peak data transfer rate of 15,000 characters per second. There is full tape format compatibility with GE 225 and 235 systems and with IBM 727, 729, and 7330 Magnetic Tape Units - all at low density only. Block lengths are variable, and tape can be read backward as well as forward.

Only one Magnetic Tape Controller can be used in a GE 215 system. It is connected to one of the three Controller Selector hubs, and can control up to eight tape transports (i.e., four dual tape handlers). Only one magnetic tape input or output operation can occur at a time, but tape operations are fully overlapped with internal processing and other input-output operations. Checking features include lateral and longitudinal parity checks on both reading and recording (i.e., "read-after-write" checking), and checks for loss of data due to timing errors.

Data can be recorded in any of three modes:

1. BCD - three tape rows per GE 215 word (sign and "1" bit are ignored, and some internal codes are converted to achieve IBM compatibility).

2. Binary - four tape rows per word (zeros are inserted into four excess bit positions in the fourth row). This mode must be used when a record contains both BCD and binary data.

3. Special binary - three tape rows per word (sign and "1" bit are ignored).

.13 Availability: . . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . March, 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs
Number: . . . . . . 2 per transport.
Form: . . . . vacuum pocket.
Capacity: . . . . . . about 8 inches each.
.213 Feed drive: . . . . . . motor.
.214 Take-up drive: . . . . motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . magnetic head.
.222 Sensing system: . . . . magnetic head.
.223 Common system: . . . two-gap head provides read-after-write checking.

.23 Multiple copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . recording.
Stacks: . . . . 1.
Heads/stack: . . . . . 7.
Method of use: . . . . one row at a time.

Use of station: . . . . . sensing.
Stacks: . . . . 1.
Heads/stack: . . . . . 7.
Method of use: . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . plastic tape with magnetizable surface.
.312 Phenomenon: . . . . . magnetization.

.32 Positional Arrangement

.321 Serial by: . . . . 3 to N rows at 200 rows/inch; N limited by available core storage.

.322 Parallel by: . . . . . . 7 tracks.
.324 Track use
Data: . . . . 6.
Redundancy check: . . 1.
Timing: . . . . 0 (self-clocking).
Control signals: . . . 0.
Unused: . . . . 0.
Total: . . . . 7.
.325 Row use
Data: . . . . 3 to N.
Redundancy check: . . 1 per block.
Timing: . . . . 0.
Control signals: . . . 0.
Unused: . . . . 0.
Gap: . . . . 0.75 inch inter-block; 3.75 inch end of file.

.33 Coding: . . . . BCD Mode: one tape row per character, as in Data Code Table No. 2.
Binary mode: 4 tape rows per 20-bit word.
Special Binary mode: 3 tape rows per word; sign bit and highest-order data bit are ignored.

§ 091.

.34 Format Compatibility

Other device or system	Code translation
IBM 727, 729, 7330 tape units at 200 rows/inch:	generally not required.
GE 225/235 systems:	not required.

.35 Physical Dimensions

.351 Overall width: . . . . . 0.50 inch.
.352 Length: . . . . 2,400 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . Magnetic Tape Controller. MTC680.

.42 Connection to System

.421 On-line: . . . . 1 controller; requires 1 of the 3 Controller Selector hubs.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 4 dual handlers (8 tape transports).
.432 Restrictions: . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . 1 to N words, limited by available core storage.
.442 Input-output areas: . . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 to N words; 3 or 4 tape rows per word.
.512 Block demarcation
Input: . . . . gap on tape; maximum N specified in "read" instruction.
Output: . . . . N specified in "write" instruction.

.52 Input-Output Operations

.521 Input: . . . . 1 block forward or backward.
.522 Output: . . . . 1 block forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . 1 block backward (backspace).
.525 Marking: . . . . inter-block gap, 0.75 inch long.
end-of-file character and 3.75-inch gap.
.526 Searching: . . . . . . none.

.53 Code Translation: . . . automatic, by controller.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . yes, with optional Automatic Priority Interrupt.
Select format: . . . . . . no.
Select code: . . . . yes, in I/O instruction.
Rewind: . . . . yes.
Unload: . . . . no.
Select density: . . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . yes.
Output lock: . . . . no.
Nearly exhausted: . . . no.
Busy controller: . . . . yes.
End of medium marks: . yes.
End of file mark: . . . yes.
Any tape rewinding: . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . . . none.

.62 Speeds

.621 Nominal or peak speed: . 15,000 char/sec.
.622 Important parameters
Tape speed: . . . . . 75 inches/sec.
Start + stop time: . . . 12.0 m.sec.
Full rewind time: . . . 2.5 minutes.
Inter-block gap: . . . 0.75 inch.
End-of-file gap: . . . 3.75 inches.
.623 Overhead: . . . . 12.0 m.sec/block.
.624 Effective speed: . . . . . 15,000N/(N+180) char/sec.
where N = char/block.
(See also Graph 320:091.801.)

.63 Demands on System

Component	m.sec per block, or	Percentage of data transfer time
Core Storage:	0.108 + 0.012N	18.0
Tape Controller:	12.0 + 0.067N	100.0

where N is number of characters per block.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . none.

.72 Other Controls

Function	Form	Comment
Address selection:	rotary switch	addresses 0 - 7.
File protection:	ring on reel	ring permits writing.
Rewind:	button.	
Manual transport control:	3 buttons	forward/reverse/stop.

§ 091.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Reel:	2,400 feet; 5,000,000 characters for 1,000-char blocks.

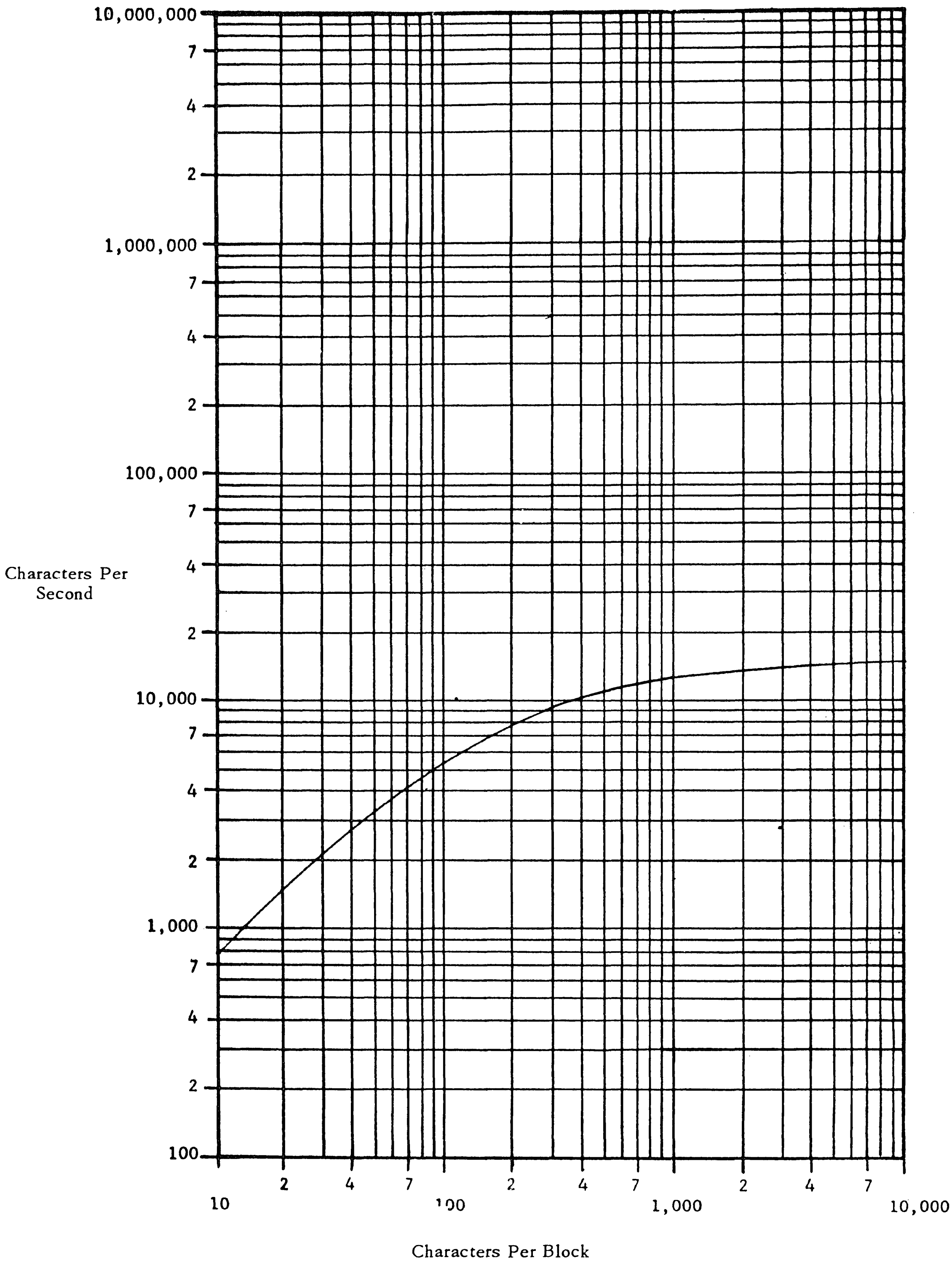
.732 Replenishment time: . . 0.5 to 1.0 minute. tape unit needs to be stopped.

.734 Optimum reloading period: . . . . 6.4 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	lateral & longitudinal parity	indicator & alarm.
Reading:	lateral & longitudinal parity	indicator & alarm.
Input area overflow:	check	stop transfer; set bit.
Output block size:	preset	
Invalid code:	all codes valid.	
Exhausted medium:	reflective spot on tape	indicator & alarm.
Imperfect medium:	none	
Timing conflicts:	I/O register exhaust or overflow check	indicator & alarm.
Incorrect number of characters per word:	modulo 3 or 4 check	indicator & alarm.

EFFECTIVE SPEED: MTH 680



INPUT-OUTPUT: DOCUMENT HANDLER

§ 101.

.1 GENERAL

.11 Identity: . . . . Magnetic Ink Document Handler.
S12B, S12C.

.12 Description

The Document Handler reads and sorts magnetically encoded paper documents at a peak rate of 1,200 documents per minute. It can operate on-line with the GE 215 system or off-line as a sorter only. One Document Handler can be connected to a single Controller Selector hub through a Document Handler Adapter.

The unit will feed, transport, and stack documents of intermixed sizes within the following ranges:

Length:	5.75 to 8.75 inches
Width:	2.50 to 3.75 inches
Thickness:	0.0027 to 0.0070 inches

It reads a single line of magnetic ink characters printed in Font E-13B (adopted as standard by the American Bankers' Association). Recognizable characters are limited to the ten numerals and four cue characters.

In on-line operation, data read from the document is stored as one BCD character per core storage location, in the six low-order bit positions. Invalid or unrecognizable characters cause an indicator to be set and an asterisk to be transmitted to storage. One of the twelve stacker pockets must be selected by the stored program. To achieve the peak rate, documents must be fed continuously and synchronization controlled by the program. When documents are fed singly upon demand, the maximum rate drops to six hundred documents per minute. Three instruction words are required to initiate each Document Handler input or control operation.

When operating off-line, the Document Handler is controlled by the manual control panel and a wired plugboard. The plugboard can define the format of up to twelve sort fields, each containing up to ten digits. The desired field and digit position for sorting are selected by push buttons. A "Zero Suppression" feature eliminates repeated handling of documents which are already properly sorted by routing them to the Special pocket. The alternative "Multiple Digit Selection" feature causes documents which contain a field of up to ten characters whose value is equal to a corresponding field defined by plugboard wiring to be sent to the Special pocket.

.13 Availability: . . . . . . 10 months as of March, 1963.

.14 First Delivery: . . . . March, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . moving belt friction; document feeding and pocket selection by "vacuum pickup."

.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.222 Sensing system: . . . . magnetic heads.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station:	reading.
Stacks:	1.
Heads/stack:	?
Method of use:	?

.25 Range of Symbols

Numerals:	10	0 - 9.
Letters:	none.	
Special:	4	amount, dash, transit, on-us.
Alternatives:	none.	
Total:	14.	

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper documents.
.312 Phenomenon: . . . . . . magnetic ink imprinting.

.32 Positional Arrangement

.321 Serial by: . . . . character; up to 64 characters per document.
.322 Parallel by: . . . . . . ? tracks.
.323 Bands: . . . . one, consisting of visually readable imprinted characters.
.324 Track use: . . . . all for data.
.325 Row use: . . . . all for data.

.33 Coding: . . . . Font E-13B magnetic ink characters.

.34 Format Compatibility

Other device or system	Code translation
All equipment using Font E-13B characters in standard A.B.A. format:	none required.

§ 101.

.35 Physical Dimensions

.351 Overall width: . . . . . 2.50 to 3.75 inches.
.352 Length: . . . . 5.75 to 8.75 inches.
.353 Maximum margins
Distance of leading edge of first symbol from edge of document: . . . . . . 0.3125 ± 0.0625 inches.

.4 CONTROLLER

.41 Identity: . . . . Document Handler Adapter. SA225.

.42 Connection to System

.421 On-line: . . . . 1; requires 1 of the 3 Controller Selector hubs.
.422 Off-line

Use	Associated equipment
Document sorting:	none.

.43 Connection to Device

.431 Devices per controller: 1 per SA225 Adapter.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 document.
.442 Input-output areas: . . core storage; base address, M, must be a multiple of 64; one character is read into the least significant 6 bits of each location, starting at M + 63 and continuing downward.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic within a document; by program for successive documents.
.447 Synchronizing aids: . . tests for sorter ready, sorter feeding, late pocket decision.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . up to 64 characters per document.
.512 Block demarcation
Input: . . . . plugboard wiring.

.52 Input-Output Operations

.521 Input: . . . . read 1 document and halt; or read 1 document and continue feeding next document.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic by controller.

.54 Format Control

Control: . . . . plugboard and program.
Format alternatives: . . undefined.
Rearrangement: . . . . by program.
Suppress zeros: . . . . by program.
Insert point: . . . . . . no.
Insert spaces: . . . . . no.
Section sizes: . . . . . plugboard.
Select fields for off-line sorting: . . . plugboard and control panel.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Select stacker: . . . . . yes.
Select format: . . . . . no.
Select code: . . . . . . no.
Halt continuous feeding: yes.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . yes.
Feeding documents: . . yes.
Late pocket decision: . yes.
Invalid character read: yes.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . no.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 1,200 documents/minute.
.622 Important parameters
Space between documents: . . . . . variable (synchronous feed).
Time for pocket selection: . . . . . . 47 msecs max. after completion of reading.
.624 Effective speeds: . . . 1,200 documents/minute when feeding continuously. 600 documents/minute maximum when feeding on demand ("read 1 document and halt").

.63 Demands on System

Component	msec per character
Core storage:	0.036.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none required (feeds intermixed documents of varying sizes).

.72 Other Controls

Function	Form	Comment
Sort field selection:	12 buttons	for off-line sorting only.

§ 101.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Feed hopper:	12 inch stack (approx. 2,500 documents).
Stackers (12):	10 inch stack each.

.732 Replenishment time: . . 0.5 to 1.0 minutes. reader needs to be stopped.

.734 Optimum reloading period: . . . . 2 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	see "Invalid code."	
Input area overflow:	none.	
Invalid code:	validity check	transmit * to storage & set indicator.
Exhausted medium:	check	indicator & alarm.
Imperfect medium:	none.	
Timing conflict:	none.	
Full stacker:	check	halt reader.
Misfeed:	check	halt reader.
Late pocket selection:	check	indicator & alarm.

INPUT-OUTPUT: DATANET-15

§ 102.

.1 GENERAL

.11 Identity: . . . . DATANET-15.

.12 Description

The DATANET-15 links telecommunication terminals to the GE 215 Central Processor via the Controller Selector. The Automatic Priority Interrupt feature is required on all GE 215s using the DATANET-15. This feature permits the DATANET-15 to operate concurrently with and time-share the core storage facilities with other peripheral devices and internal processing. The manufacturer estimates that less than 4 per cent of the central processor time will be used for normal communications storage accesses.

The basic DATANET-15 controller receives and sends digital data over a maximum of two teletype or telephone grade transmission facilities. Therefore, the basic model is called a "two-channel" controller, even though data can be transferred over only one of the two connected transmission facilities at a time. Optional features, described below, permit connection of up to 15 transmission units and 1 Paper Tape Unit, with the same restriction to 1 data transfer operation into core storage at a time.

Transmission speeds of 75, 110, or 1,050 bits per second are the standard options, but any transmission speed between 60 and 2,400 bits per second is available upon request. The transmission speed is controlled by a timing plug which emits a pulse to coincide with each bit. The transmission speed of a facility can be changed at any time by replacing the existing timing plug with one corresponding to the speed desired. Only one speed, for all of the channels on a DATANET-15, is possible at one time. Any serial five-, six-, seven-, or eight-bit data code using start-stop bits to indicate the beginning and end of each transmitted or received character will be accepted by the DATANET-15. The start-stop bits are stripped off and added by the DATANET-15 for each character as needed.

Data are transferred serially by character and in parallel by bit between the DATANET-15 and the GE 215 computer and between the DATANET-15 and the Paper Tape Unit. Data transfers are serial by bit, using start-stop bits, between the DATANET-15 and remote units.

Each character is represented in core storage in the five, six, or seven least significant bits of a GE 215 word, depending on the code used. There is no automatic code conversion, but a plugboard allows rearrangement of the bit structure in any way desired, thus effectively allowing conversion to any desired character code. When using the five-bit character code for receiving data, a bit is automatically generated in the sixth bit position to indicate that the character is either a letter or a numeral. In the

.12 Description (Contd.)

transmit mode, only five bits are transferred to the DATANET-15; therefore, the message must be programmed so the letter or numeric shift code is inserted into the proper position within the message.

The DATANET-15 has two modes of operation: the Receive mode and the Transmit mode. In the Receive mode, a request-for-access signal from a remote station is stored in a flip-flop indicator for that station. Once every 300 microseconds, a scanner within the DATANET-15 interrogates the status of the flip-flop indicators for each channel until either a request-for-access signal is detected, a branch select is executed, or the computer initiates a transmission. When a request-for-access signal is detected, the scanner stops on the requesting channel, causes an automatic program interrupt to service it, and locks out all other channels. After servicing the request, scanning is resumed by a start-scanning instruction. After a scan instruction has been executed, a total of 250 milliseconds elapses and the controller is interlocked before the scanning operation is resumed, unless the previous instruction was a scan instruction.

A 250 millisecond delay is encountered whenever the mode of the DATANET-15 is changed, allowing time for the communication channel to change modes. The transmit mode is entered when a transmit instruction is executed. In this mode, the scanner is positioned on the channel specified in the instruction, enabling data to be transmitted character by character from core storage to the remote station via the DATANET-15.

The instructions required to activate the DATANET-15 are identical in format for either mode and consist of three instruction words which contain the address of the remote station, the core storage address, and the character count of the message. The character count is placed in the character counter, which provides a means for controlling the length of each message transferred between core storage and the DATANET-15. The counter can count up to 2,048 characters. When the specified number of characters has been counted, the character counter automatically terminates data transfer between the DATANET-15 and core storage until a new command is executed. Messages can also be terminated by sensing an end of message or end of transmission character. It is possible to transmit messages longer than 2,048 characters by breaking the message down into blocks of fewer than 2,048 characters each. Reception of messages containing more than 2,048 characters can occur without the loss of a character by issuing another receive instruction within half the time required to receive a bit. (When transmitting at a rate of 75 bits per second, the new receive instruction must be issued within 6.7 milliseconds after the indication of the character counter overflow.)

§ 102.

.12 Description (Contd.)

Odd parity checks are automatically performed by the DATANET-15 on all input data which contains provisions for an odd parity bit. If this parity bit is in error, the DATANET-15 corrects the parity and sets a program-testable indicator.

Optional Features

Five-Channel Operation: Permits serial five-bit data codes with start and stop bits to be received or transmitted.

Six-, Seven-, or Eight-Channel Operation: Permits any single serial six-, seven-, or eight-bit data code with start and stop bits to be received or transmitted.

75-Baud Data Speed Plug: Permits transmission and reception of data at 75 bits per second.

.12 Description (Contd.)

110-Baud Data Speed Plug: Permits transmission and reception of data at 110 bits per second.

1,050-Baud Data Speed Plug: Permits transmission and reception of data at 1,050 bits per second.

Special Data Speed Plug: Permits transmission and reception of data at any other single bit rate between 60 and 2,400 bits per second.

Paper Tape Adapter: Provides the capacity to connect and control a GE free-standing Paper Tape Unit.

Four Additional Channels: Provides the capacity for accommodating up to six transmission facilities.

Thirteen Additional Channels: Provides the capacity for accommodating up to 15 transmission facilities.

Interface Adapter: Adapts the controller voltage and current levels to those needed for low-speed telegraphic operation.

SIMULTANEOUS OPERATIONS

§ 111.

.1 SPECIAL UNITS

.11 Identity: . . . . Controller Selector.
Priority Access Control.
(Both are standard in all GE 215 systems).

.12 Description

There are six input-output channels in the GE 215 system. The card reader is connected to Channel 1 and requires one access to core storage for each column read (80 accesses per card). The card punch is connected to Channel 5 through an 80-bit shift register and requires 960 accesses to core storage for each card punched. Synchronization of data transfers between the card input-output units and core storage is automatic, and card reading and punching can always be overlapped with internal processing.

The console typewriter and paper tape reader and punch are connected to the 6-bit N Register in the Central Processor, which forms the sixth input-output channel. Only one character is transferred at a time, and synchronization must be controlled by the stored program. These three units share the same power supply, and only one can be operated at a time.

All other peripheral devices must be connected to Channels 2 through 4. These three channels are called the Controller Selector.

Controller Selector: This unit, housed in the Central Processor cabinet, serves as a common control and data transfer point between the processor and the controllers for data transmission, printers, magnetic tape units, Magnetic Document Handlers, Mass Random Access Data Storage, and the Auxiliary Arithmetic Unit. The Controller Selector contains three "hubs." One peripheral controller can be plugged into each hub and assumes the address of that hub. The Controller Selector automatically controls the time-sharing of core storage accesses among all of the attached peripheral devices. One device on each peripheral controller can therefore operate simultaneously. Data is transferred through the Controller Selector at the rate of 27,800 words per second.

Requests for access to core storage are automatically served by the Priority Access Control according to the following priority order. The unit with the highest priority is listed first.

.12 Description (Contd.)

1. Card Reader (Channel 1).
2. Controller Selector (Channels 2-4).
   a. Mass Random Access File Controller.
   b. Magnetic Tape Controller.
   c. Magnetic Document Handler Adapter.
   d. Data Transmission Controller.
   e. High Speed Printer(s).
   f. Auxiliary Arithmetic Unit.
3. Card Punch (Channel 5).
4. Central Processor, with paper tape and typewriter input-output (Channel 6).

The criteria for establishing this priority order are the repetition rate of memory access demands and the consequences of not gaining access in time; the central processor can wait indefinitely without danger of error or loss of information. Priority order for the devices attached to the Controller Selector is determined by the numbers of the hubs to which they are attached and can be changed to meet changing system requirements.

This method of handling simultaneous operations is straightforward and powerful. When several high-speed peripheral units are operating simultaneously it is possible, though unlikely, that requests for memory access will occur faster than the processor can serve them, resulting in loss of data. There are error indicators in the magnetic tape and Mass Random Access Data Storage controllers to detect this condition; the other input-output units will "hang up" if they are not granted access in time.

.2 CONFIGURATION CONDITIONS: . . . . none.

.4 RULES

A total of three Controllers (or two if the Auxiliary Arithmetic Unit is installed) are permitted in a system. The types of controllers will dictate the number of simultaneous operations possible, as detailed below, since each controller is capable of only one data transfer operation at any time.

The central processor has a maximum transfer rate of 27,800 words per second, or approximately 83,400 characters per second. It is possible for various combinations of the operations listed below to exceed this capacity, resulting in a loss of data that will be signalled.

§ 111.

.4 RULES (Contd.)

Any or all of the following can be in operation simultaneously, except that the total number of operations preceded by * cannot exceed three:

Internal processing.

Read card.

Punch card.

*Print a line or advance forms on printer (one per printer controller).

Any number of magnetic tape rewind operations.

*One magnetic tape input or output operation.

*One Mass Random Access Data Storage input or output operation.

Up to four Mass Random Access Data Storage seek operations.

*One DATANET-15 input or output operation.

*One Magnetic Ink Document Handler input operation.

*Processing in Auxiliary Arithmetic Unit.

And any one of the following:

Type on console typewriter.
Read paper tape.
Punch paper tape.

SYSTEM PERFORMANCE

§201.

GENERALIZED FILE PROCESSING (320:201.1)

These problems involve updating a master file from information in a detail file and producing a printed record of each transaction. This application is one of the most typical of commercial data processing jobs and is fully described in Section 4:200.1 of the Users' Guide.

The GE 215 is basically a fixed word-length, binary processor, although an optional feature (included in Standard Configurations I and III) enables it to perform decimal addition and subtraction. To minimize time-consuming radix conversion and unpacking operations, records in the magnetic tape master file are organized in an unpacked format, with individual fields in either binary or alphameric form depending upon their usage. Each master file record, whose nominal length is 108 characters, occupies 37 GE 215 word locations or 148 magnetic tape rows. (Magnetic tape files containing mixed alphameric and binary data must be read and recorded in the binary mode, in which each computer word occupies four tape rows.)

Standard Configuration I has no magnetic tape units. Therefore, it is assumed that both the master and detail files are on punched cards, in alphameric format, and that the two files have been collated off-line so that each detail card follows its associated master record cards. Since master records with no activity (i.e., no corresponding detail cards) would, in most cases, be removed from the file before the computer run, only the times at an activity factor of 1.0 are plotted for Standard Configuration I. The relatively low speed of the card punch (300 cards per minute) in producing the updated Master File makes the over-all processing time for Configuration I much higher than for Configurations II and III, which utilize magnetic tape for the master file. It should be noted that the master record length for Standard File Problem A is 108 characters, which necessitates the use of two 80-column cards for each master file record.

In Standard Configurations II and III, the master file is on magnetic tape, the detail file is on punched cards, and the report file is produced by the on-line printer.

Standard Configuration II is a "stripped-down" magnetic tape system which includes none of the optional features that improve the GE 215's processing capabilities. Because of the lack of automatic facilities for decimal arithmetic, block transfers, and three-way comparisons, internal processing times for Configuration II are nearly twice as high as for Configuration III. Even so, throughput at the lower activity ratios is limited by the effective speed of the 15KC magnetic tape units rather than by the central processor (except in File Problem B), as indicated by the horizontal segment of each File Processing performance curve for Configuration II. At higher activity ratios, the central processor or the on-line printer becomes the limiting factor. It is significant to note that the GE 215, unlike most computers in its price class, can keep its card reader, card punch, printer, and one magnetic tape unit operating simultaneously at their maximum effective transfer rates - even in a "minimum" configuration such as this one.

Standard Configuration III includes the optional facilities for decimal arithmetic, block transfers, and three-way comparisions which are lacking in Configuration II. As a result,

SYSTEM PERFORMANCE (Contd.)

§201.

GENERALIZED FILE PROCESSING (Contd.)

central processor speeds are significantly higher and overall processing times are reduced at all except the lowest activity factors, where magnetic tape time is still the limiting factor.

SORTING (320:201.2)

The standard estimate for sorting 80-character records by straightforward merging on magnetic tape was developed from the time for Standard File Problem A by the method explained in Paragraph 4:200.213 of the Users' Guide. A two-way merge was used in Configuration II (which has only four magnetic tape units) and a three-way merge in Configuration III. The results are shown in Graph 320:201.214.

MATRIX INVERSION (320:201.3)

In matrix inversion, the object is to measure central processor speed on the straightforward inversion of a non-symmetric, non-singular matrix. No input-output operations are involved. The standard estimate is based on the time to perform cumulative multiplication ($c = c + a_i b_j$) in eight-digit precision floating point, using both standard subroutines and the Auxiliary Arithmetic Unit (see Paragraph 320:051.422). The results are shown in Graph 320:201.313. It can be seen that the inversion speeds are about ten times as high when the floating point arithmetic is performed by the Auxiliary Arithmetic Unit as when floating point subroutines are used. This is a reasonable indication of the value of the AAU for engineering and scientific applications.

GE 215
SYSTEM PERFORMANCE

GE 215 SYSTEM PERFORMANCE

WORKSHEET DATA TABLE 1

Worksheet	Item		Configuration I		Configuration II		Configuration III		Reference
1 Input-Output Times	Char/block	(File 1)	18.5 words		370 words		370 words		4:200.112
	Records/block	K (File 1)	0.5		10		10		
	msec/block	File 1 = File 2	1 = 60; 2 = 200		111		111		
		File 3	60		150		150		
		File 4	171		171		171		
	msec/switch	File 1 = File 2							
		File 3							
		File 4							
	msec/penalty	File 1 = File 2	1 = 3.0; 2 = 34.6		17.8		17.8		
		File 3	3.0		3.0		3.0		
		File 4	3.0		3.0		3.0		
2 Central Processor Times	msec/block	a1	1.368		1.368		1.368		4:200.1132
	msec/record	a2	6.156		13.968		6.156		
	msec/detail	b6	20.392		20.392		20.392		
	msec/work	b5 + b9	8.676		8.676		8.676		
	msec/report	b7 + b8	45.544		112.544		45.544		
3 Standard Problem A F = 1.0	msec/block for C.P. and dominant column.	a1	1.4		1.4		1.4		4:200.114
		a2 K	3.1		139.7		61.6		
		a3 K	37.3		1,416.1		746.1		
		File 1 Master In	3.0		17.8		17.8		
		File 2 Master Out	34.6	200.0	17.8		17.8		
		File 3 Details	1.6		30.0		30.0		
		File 4 Reports	1.6		30.0	1,710.0	30.0	1,710.0	
		Total	82.6	200.0	1,652.8	1,710.0	904.7	1,710.0	
4 Standard Problem A Space	Unit of measure	(words)							4:200.1151
		Std. routines	699		1,119		1,119		
		Fixed	4		4		4		
		3 (Blocks 1 to 23)	150		171		159		
		6 (Blocks 24 to 48)	780		840		780		
		Files	350		1,614		1,614		
		Working	50		50		50		
		Total	2,003		3,798		3,726		

SYSTEM PERFORMANCE

§ 201.

.1 GENERALIZED FILE PROCESSING

.11 Standard File Problem A

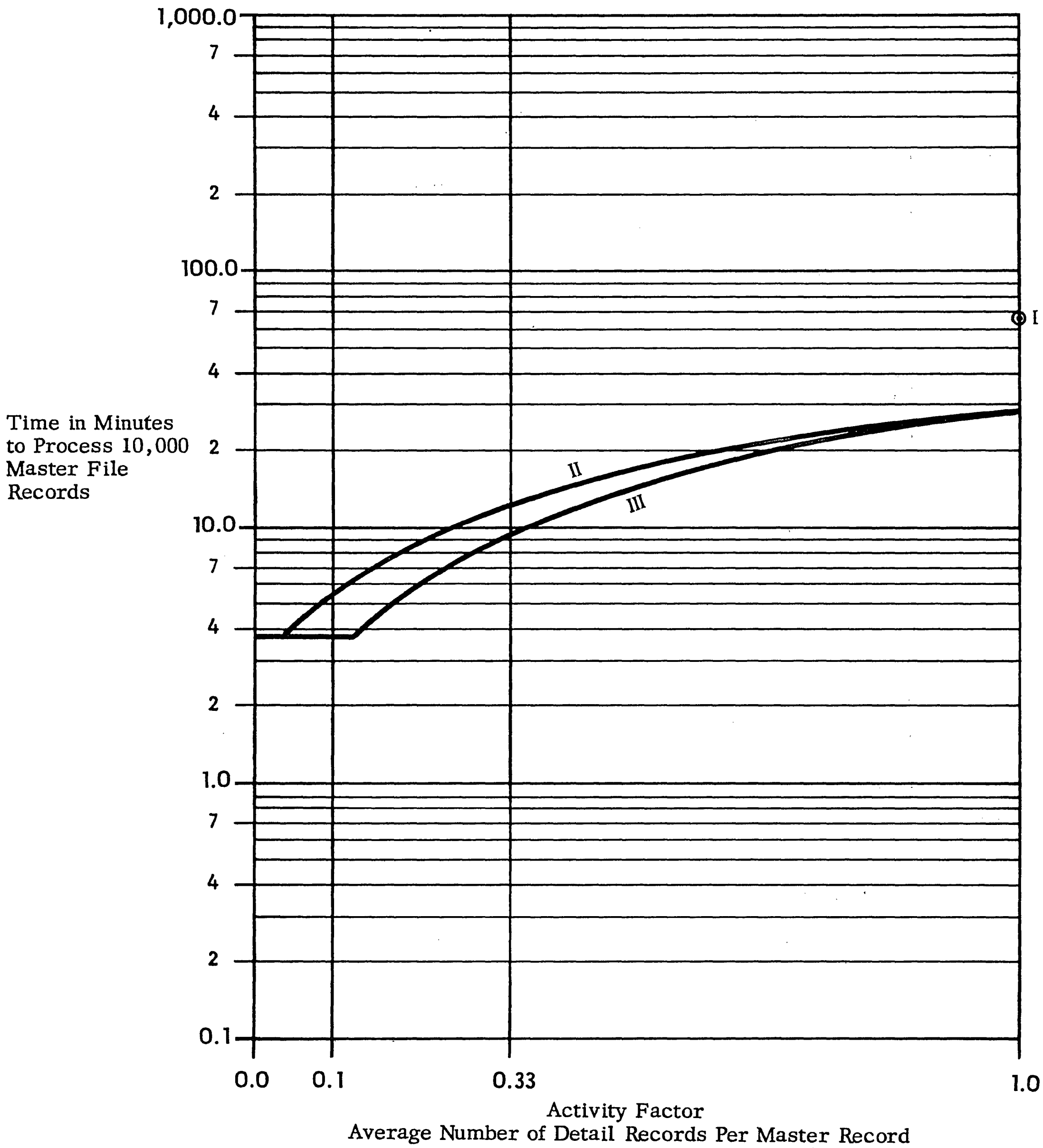
.111 Record sizes
Master file: . . . . . . 108 characters.
Detail file: . . . . . . 1 card.
Report file: . . . . . . 1 line.

.112 Computation: . . . . . standard.

.113 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.113.

.114 Graph: . . . . see graph below.

.115 Storage space required
Configuration I: . . . 2,003 words.
Configuration II: . . . 3,798 words.
Configuration III: . . . 3,726 words.



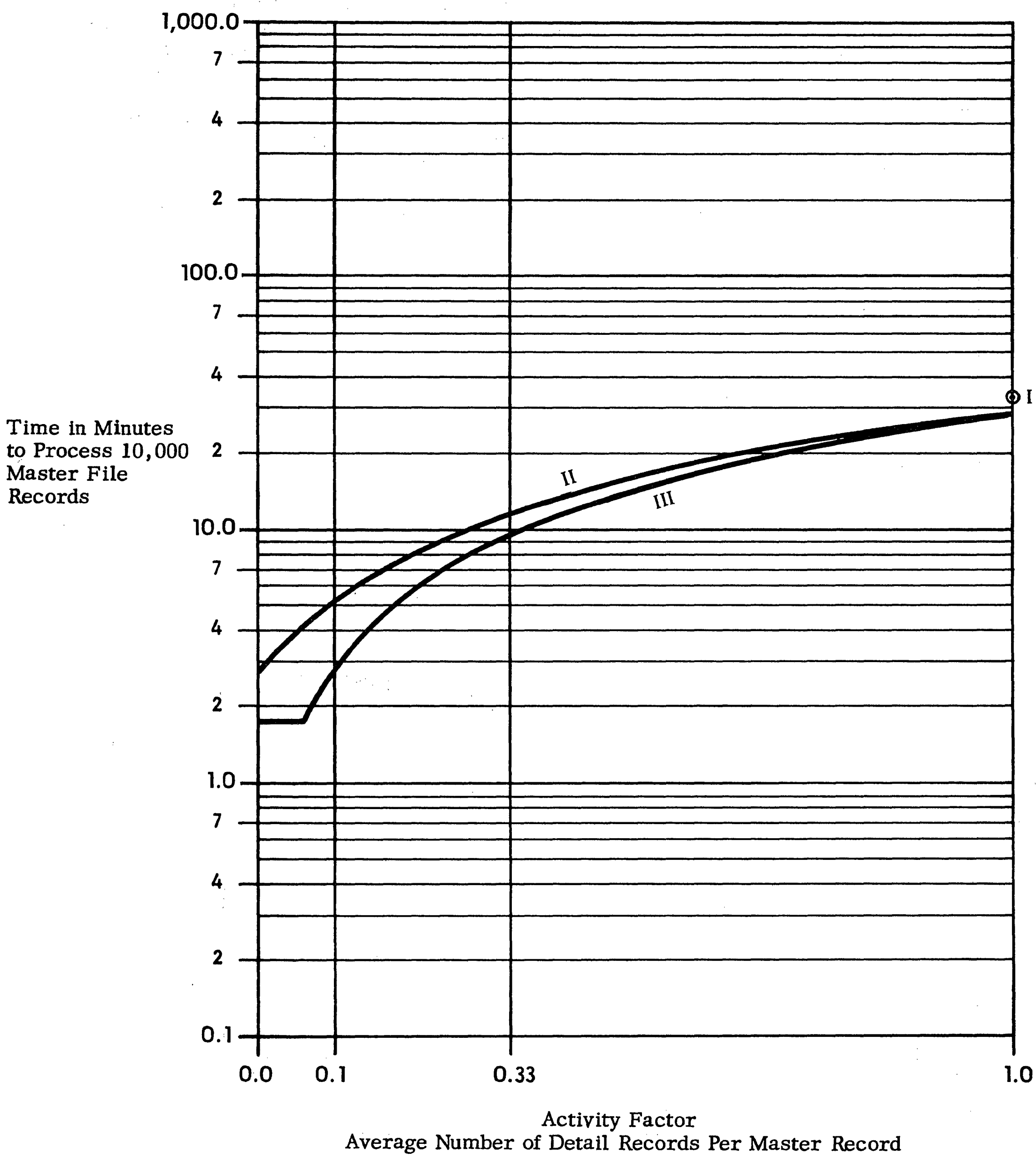
(Roman numerals denote standard System Configurations.)

§ 201.

.12 Standard File Problem B

.121 Record sizes
Master file: . . . . . 54 characters.
Detail file: . . . . . 1 card.
Report file: . . . . . 1 line.

.122 Computation: . . . . . standard.
.123 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.12.
.124 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

§ 201.

.13 Standard File Problem C

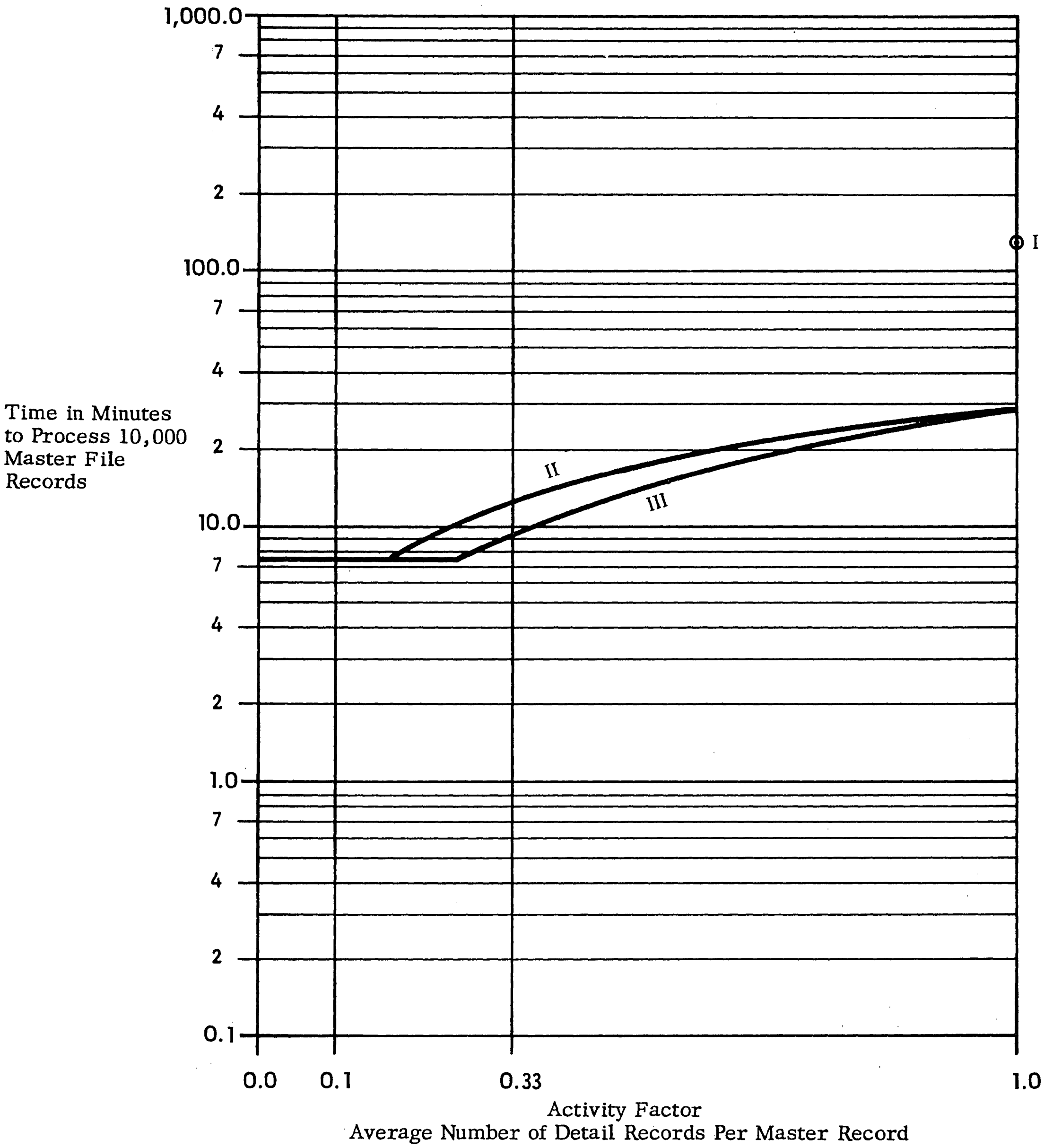
.131 Record sizes

Master file:	216 characters.
Detail file:	1 card.
Report file:	1 line.

.132 Computation: . . . . . standard.

.133 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.13.

.134 Graph: . . . . see graph below.



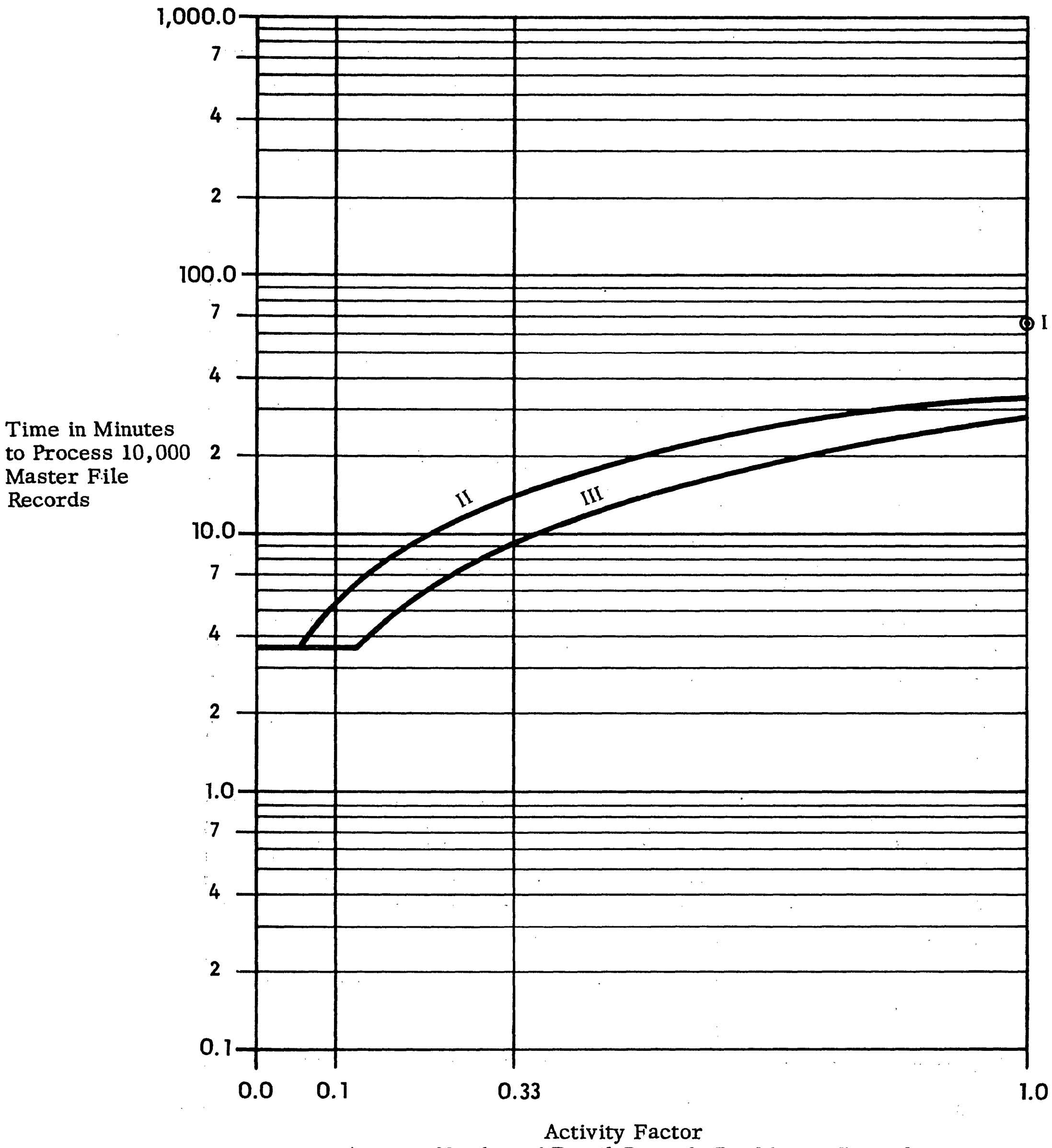
(Roman numerals denote standard System Configurations.)

§ 201.

.14 Standard File Problem D

.141 Record sizes
- Master file: . . . . . 108 characters.
- Detail file: . . . . . 1 card.
- Report file: . . . . . 1 line.

.142 Computation: . . . . . trebled.
.143 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.14.
.144 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

§ 201.

.2 SORTING

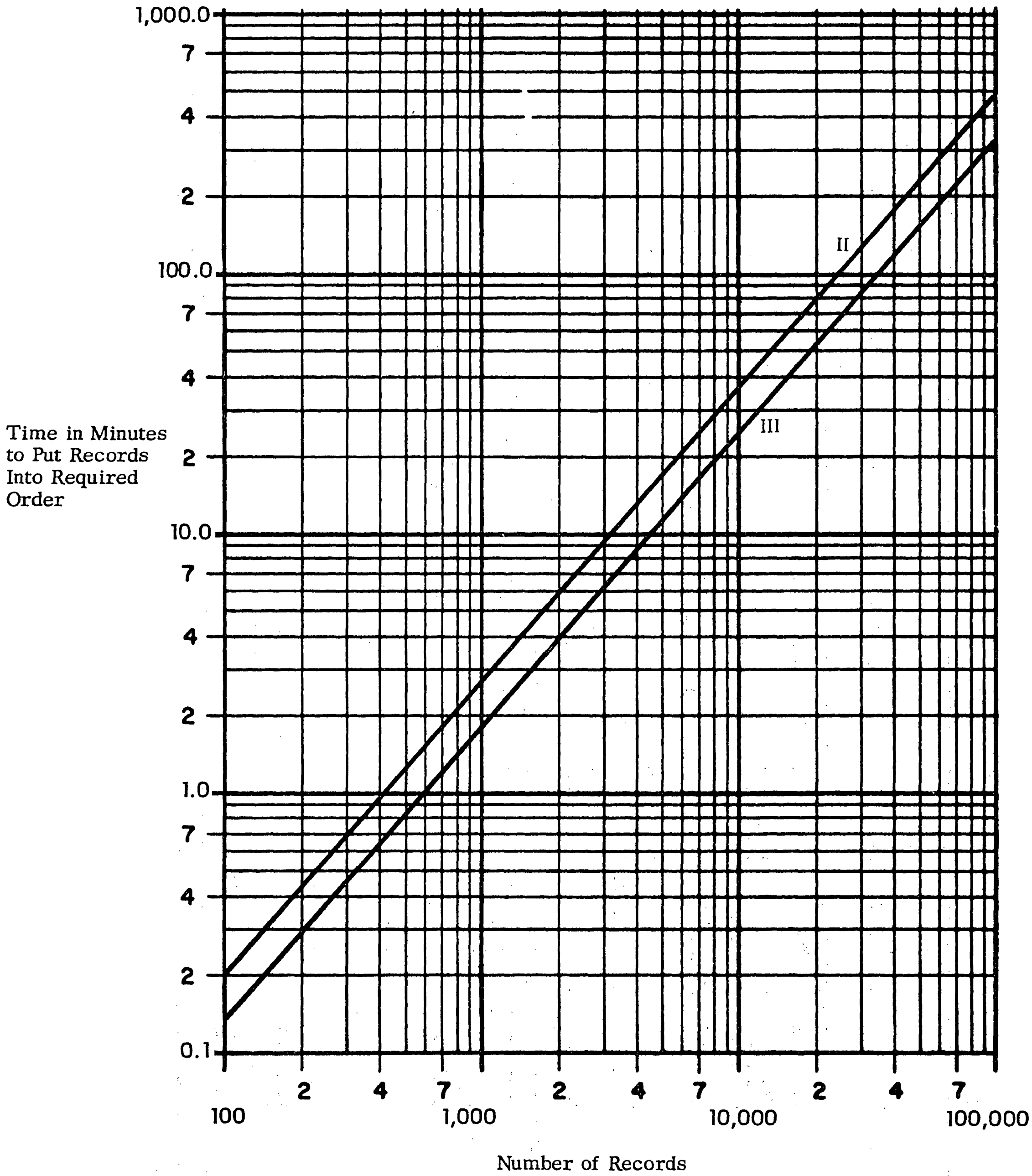
.21 Standard Problem Estimates

.211 Record size: . . . . . 80 characters.

.212 Key size: . . . . 8 characters.

.213 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.213

.214 Graph: . . . . see graph below.



§ 201.

.3 MATRIX INVERSION

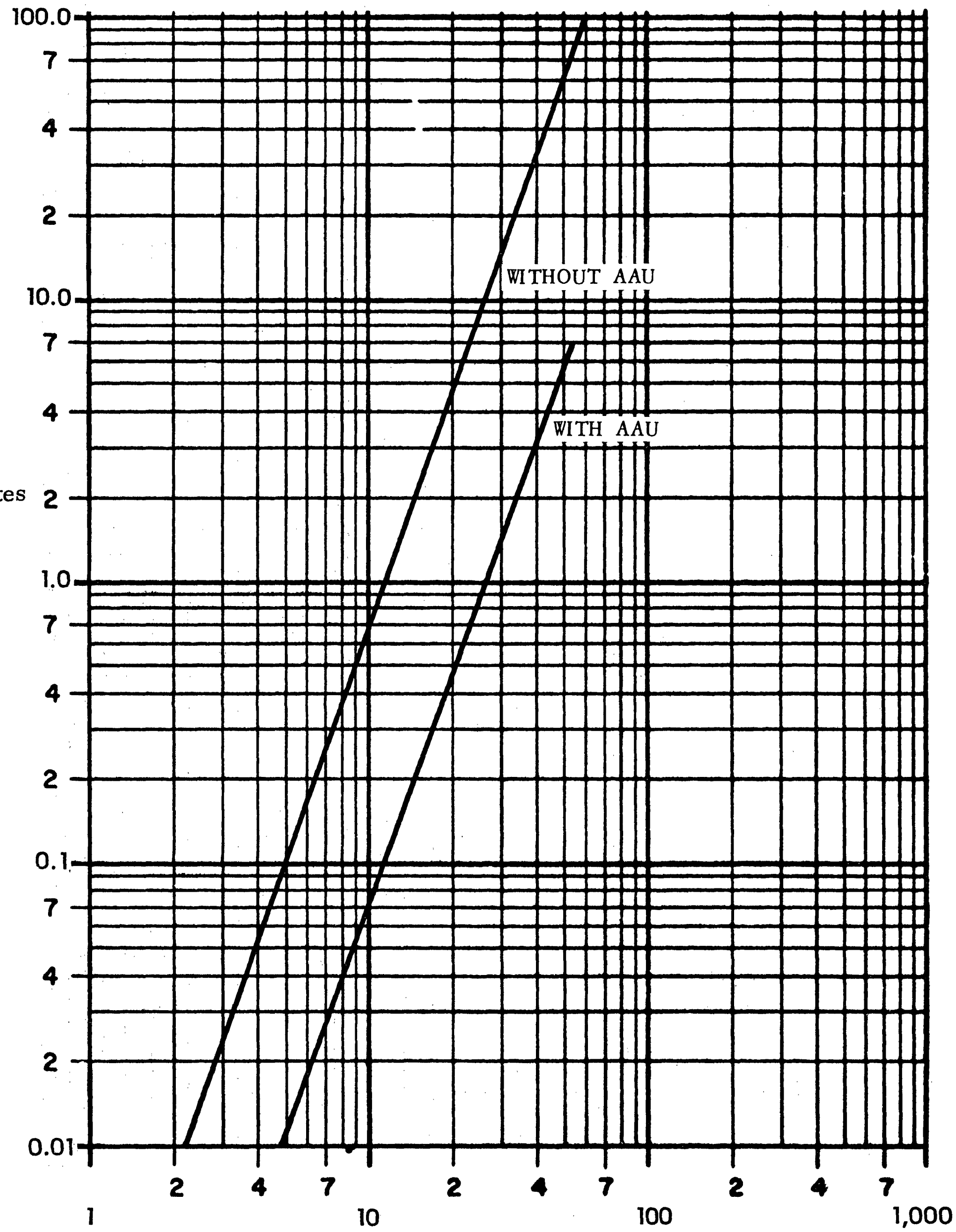
.31 Standard Problem Estimates

.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.312 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.312.

.313 Graph: . . . . see graph below.

.314 Maximum matrix sizes
4,096 core storage locations: . . . . . 40.
8,192 core storage locations: . . . . . 60.



PRICE DATA

§ 221.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
Central Processor		Central Processor, Console, and Typewriter (including 3-hub Controller Selector)			
	CA215A	With 4, 096 core storage locations	2, 200		140, 650
	CB215A	With 8, 192 core storage locations	2, 500		169, 200
		Optional Features			
		Move Command	75		3, 300
		Automatic Priority Interrupt	75		3, 800
		Three-Way Compare, Decimal Addition and Subtraction, and Additional Address Modification Groups	200		4, 410
		Real Time Clock	75		3, 600
		Console Typewriter Input	200		9, 600
	X225A	Auxiliary Arithmetic Unit	650		32, 500
Internal Storage		Core Storage: Included in Central Processor			
	M640A	Mass Random Access Data Storage Unit	1, 725		76, 000
Input-Output		Paper Tape Punch & Reader			
	GA651A	With Spooler	490		22, 000
	GA651B	Without Spooler	440		19, 800
		Card Reader & Controller			
	D225B	400 cards/minute	375		18, 350
	D225C	1, 500 cards/minute	810		32, 400
		Card Punch & Controller			
	E225K	100 cards/minute	400		21, 460
	E225M	300 cards/minute	825		41, 150
	P215E	High Speed (450 LPM) Printer and Controller	775		60, 000
	MTH680	Dual Magnetic Tape Handler (15, 000 char/sec)	850		33, 000
	S12B	Magnetic Ink Document Handler	1, 750		87, 500
	DTC901	DATANET-15	690		30, 000
Controllers	M225B	Mass Random Access Data Storage Controller	900		46, 250
	MTC680	Magnetic Tape Controller	800		37, 500
	SA225A	Magnetic Ink Document Handler Adapter (For 1 Handler)	540		21, 600

GE 225

General Electric Company

STANDARD EDP REPORTS

AUERBACH ®

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CONTENTS

CONTENTS (Contd.)

INTRODUCTION

§ 011.

The GE 225 is a small to medium scale, solid-state data processing system that is adaptable to a wide range of business and scientific applications. System rentals can range from approximately $2,400 to over $30,000 per month, but most installations fall within the $4,000 to $18,000 range. First customer deliveries of the GE 225 were made in March, 1961, and more than 100 have been installed to date.

Compatibility

The GE 225 line was expanded early in 1963 by the announcement of the GE 215 and GE 235 systems. Both the new systems are fully program-compatible with the GE 225 and offer essentially the same line of peripheral equipment. The GE 215 (described in Computer System Report 320) has internal processing speeds approximately half as high as the GE 225 and decreased capabilities for simultaneous operations. The GE 235 (described in Computer System Report 323) has internal processing speeds at least three times as high as the GE 225.

Hardware

Core storage in the GE 225 can consist of 4,096, 8,192, or 16,384 word locations. Each 20-bit location can hold a one-address instruction, a binary data word of 19 bits plus sign, or 3 alphameric characters in 6-bit BCD representation. Core storage cycle time is 18 microseconds. A parity check is performed upon all internal transfer operations.

The central processor provides complete arithmetic facilities for single word-length binary operands. Loading, storing, addition, and subtraction of double-length binary data items can also be performed. An optional feature permits addition and subtraction (but not multiplication or division) of single- or double-length data items in BCD form. This feature can significantly reduce the number of time-consuming radix conversions required in business data processing, but will seldom eliminate the problem completely.

Three index registers and a fourth location that serves as a convenient counter register are standard. An optional feature makes 31 additional 4-word groups in core storage available as index registers or counters. Only one group, selected by a special instruction, can be active at a time. Other optional features for the central processor are a Move Command (which expedites internal block transfer operations), Three-Way Compare, Automatic Priority Interrupt, and a Real-Time Clock. Instructions are executed at the rate of about 20,000 per second in typical GE 225 routines.

The Auxiliary Arithmetic Unit can perform double-length arithmetic in either fixed or floating point mode under control of the central processor. This optional unit greatly increases the 225's internal processing speeds on scientific problems.

Standard 80-column punched cards can be read at 400 or 1,000 cards per minute and punched at 100 or 300 cards per minute. Paper tape can be read at 250 or 1,000 characters per second and punched at 110 characters per second. A console typewriter provides typed output at 10 characters per second. Input via the console typewriter is an optional feature.

All peripheral devices except those mentioned above are connected to the central processor through an eight-way multiplexing device called the Controller Selector, which gives the GE 225 capabilities for simultaneous operations that rival far more costly systems. Up to eight controllers for magnetic tape units, disc storage units, printers, magnetic document handlers, data communication equipment, and the Auxiliary Arithmetic Unit can be connected to the Controller Selector. One peripheral unit on each controller can operate simultaneously with internal processing and card reading and punching. Accesses to core

INTRODUCTION (Contd.)

§ 011.

Hardware (Contd.)

storage are automatically allocated among the operating units by a straightforward priority system. Maximum gross data transfer rate for the system is 55,600 words per second.

The printer has a peak speed of 900 alphameric lines per minute and a skipping speed of 25 inches per second. The printer controller provides automatic editing and format control. Special models of the high speed printer are available for use either on-line or for independent off-line tape-to-printer data transcriptions. Another printer with a peak speed of 150 alphameric lines per minute and no automatic format control is offered for use where output volume is relatively low.

Two magnetic tape handler models are available. One has a peak data transfer rate of 15,000 characters per second at a recording density of 200 rows per inch. The other model offers a choice of 200 or 556 rows per inch, with corresponding peak speeds of 15,000 or 41,667 characters per second. The tape format is compatible with the IBM 727, 729, and 7330 Magnetic Tape Units. Two tape handlers are mounted in a single cabinet, one above the other. Up to eight tape handlers can be connected to each tape controller. No more than two 41.6KC tape read or write operations can occur at a time, but the number of simultaneous 15KC tape operations is limited only by the number of tape controllers in the system.

Each Mass Random Access Data Storage (MRADS) unit provides disc storage for approximately 18.87 million alphameric characters in 98,304 fixed record locations of 64 words (or 192 characters) each. The average total waiting time for access to a randomly-placed record is 225 milliseconds. Up to 294,912 characters per MRADS unit can be transferred without repositioning any of the 16 access arms. A maximum of four MRADS file units can be connected to each MRADS controller, and up to eight controllers can be used in a GE 225 system. Only one MRADS read or write operation can occur at a time.

Magnetically encoded paper documents can be read and sorted at a peak speed of 1,200 documents per minute. Two document handlers can be connected to each controller, providing a peak sorting speed of 2,400 documents per minute.

The DATANET-15 controls the transmission and reception of digital data over telephone and telegraph lines and two-wire cables at speeds ranging from 60 to 2,400 bits per second. Up to 15 data transmission lines and a paper tape reader and punch can be connected to a DATANET-15, but it can control only one data transfer operation at a time.

GE's line of data communications equipment also includes:

- The DATANET-30 programmed data communication system.
- The DATANET-600 paper tape terminal.
- The DATANET-90 magnetic-tape-to-computer terminal.
- The DATANET-91 off-line magnetic-tape-to-magnetic-tape terminal.
- A variety of special digital input-output devices.

GE's MOSE (Modification of Standard Equipment) group offers a variety of special-purpose hardware for use with the 225 system, such as peripheral device switching controllers, printer plotting option, plotter interface units, etc.

INTRODUCTION (Contd.)

§ 011.

Software

The General Assembly Program (GAP) is the basic symbolic assembly system for the GE 225. It permits full utilization of the hardware facilities, is relatively easy to learn and use, but provides few refinements. GAP-coded programs can be assembled on GE 225 systems with punched card, paper tape, or magnetic tape input-output equipment.

ZOOM is a "macro assembly system" designed to facilitate machine oriented programming by reducing the amount of detailed coding required while retaining high object program efficiencies. The ZOOM programmer uses a combination of pseudo-English statements, algebraic expressions, and GAP symbolic statements. These are translated into an all-GAP program which is then assembled in the normal manner. Magnetic tape is not required, but can be utilized to facilitate the translation process.

GECOM is offered as an all-purpose process oriented language. The basic language structure is similar to that of COBOL-61 but is not compatible with it. (A COBOL-61 to GECOM translator will be provided.) GECOM also handles algebraic expressions and mathematical functions, and includes a report writer and TABSOL, a system that permits decision logic to be expressed in a concise tabular format. At least four magnetic tape handlers and 8,192 core storage locations are required for GECOM compilations.

WIZ is a one-pass algebraic compiler for use on punched card or paper tape systems with at least 8,192 core storage locations. WIZ is less powerful than the FORTRAN or ALGOL language, but it is easy to learn and provides high compilation speeds.

FORTRAN II is available for GE 225 systems with at least 8,192 core storage locations and 4 magnetic tape units. Arrays are limited to two dimensions, and Boolean, complex, and double precision statements are not permitted. On the other hand, several useful extensions of the FORTRAN II language have been incorporated.

BRIDGE II is a tape file maintenance and run sequencing program whose functions are directed by control cards. FORWARD is a generalized sort/merge generator. Simulation programs are available for simulating the operations of IBM 650 and General Precision LGP-30 computers on the GE 225. The Card Program Generator simplifies the programming of existing punched card tabulator and calculator runs for the GE 225. An adequate library of generalized input-output, diagnostic, and mathematical routines are available, as are special-purpose packages for the banking and electric utility industries, numerical tool control, inventory management, assembly line balancing, critical path scheduling, and information retrieval.

DATA STRUCTURE

§ 021.

.1 STORAGE LOCATIONS

Name of Location	Size	Purpose or Use
Word:	20 bits + parity	basic addressable location.
Sector:	64 words	Mass Random Access Data Storage record location.
Band:	8 or 16 sectors	Mass Random Access Data Storage.
Disc:	512 bands	Mass Random Access Data Storage.

.2 INFORMATION FORMATS

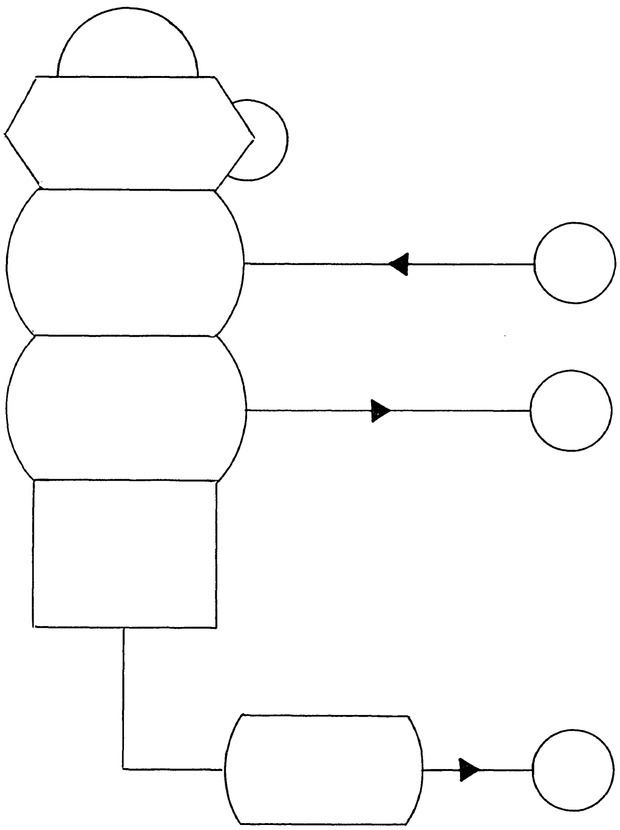
Type of Information	Representation
Numeral (BCD):	three 6-bit characters per word.
Letter (BCD):	three 6-bit characters per word.
Number (BCD):	one or two 3-character words.
Number (binary): . . .	one or two 20-bit words.
Number (floating point):	two words (30 bits + sign for mantissa; 8 bits + sign for exponent).
Instruction:	one word (two words for certain input-output instructions).

SYSTEM CONFIGURATION

§ 031.

.1 TYPICAL CARD SYSTEM (CONFIGURATION I)

Deviations from Standard Configuration: . . . . core storage is 75% larger.
card punch is 50% faster.
2 more simultaneous data transfer operations are possible.
2 more index registers.



Equipment	Rental
Core Storage: 4,096 words; Central Processor, Console & Typewriter	$1,900
Card Reader & Controller: 1,000 cards/min.	810
Card Punch & Controller: 300 cards/min.	825
Controller Selector (special 1-channel model)	30
Printer & Controller: 900 lines/min.	1,275

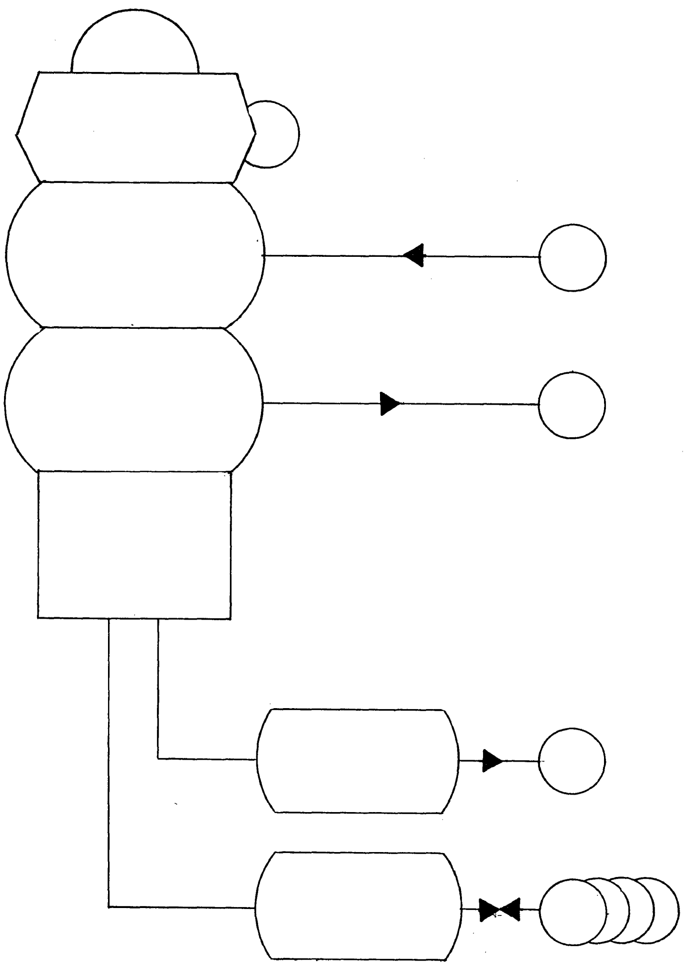
Optional Features Included: . . . .

Move command.	75
Three-way compare.; Decimal addition & subtraction.; Additional address modification groups.	200
TOTAL	$5,115

§ 031.

.2 4-TAPE BUSINESS SYSTEM (CONFIGURATION II)

Deviations from Standard Configuration: . . . . core storage is 75% larger.
card reader is 20% slower.
printer is 80% faster.
3 more simultaneous non-tape data transfer operations are possible.
3 index registers, console typewriter, and multiply-divide are standard.



Equipment	Rental
Core Storage: 4,096 words Central Processor, Console, & Typewriter	$2,900
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	-
Printer & Controller: 900 lines/min.	1,275
Magnetic Tape Units (4) & Controller: 15,000 char/sec.	2,500

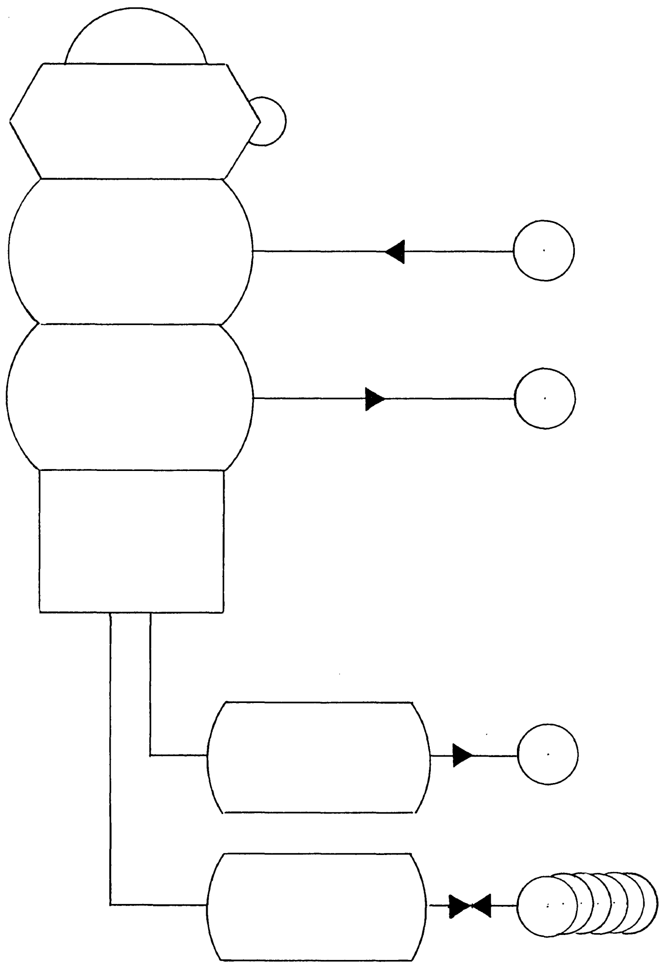
Optional Features Included: . . . . none. -

TOTAL $7,450

§ 031.

.3 6-TAPE BUSINESS SYSTEM (CONFIGURATION III)

Deviations from Standard Configuration: . . . . card reader is 20% slower.
printer is 80% faster.
magnetic tape is 39% faster.
2 more simultaneous non-tape data transfer operations are possible.



Equipment	Rental
Core Storage: 4,096 words Central Processor, Console & Typewriter	$2,900
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	-
Printer & Controller: 900 lines/min.	1,275
Magnetic Tape Units (6) & Controller: 15,000 or 41,667 char/sec.	4,930

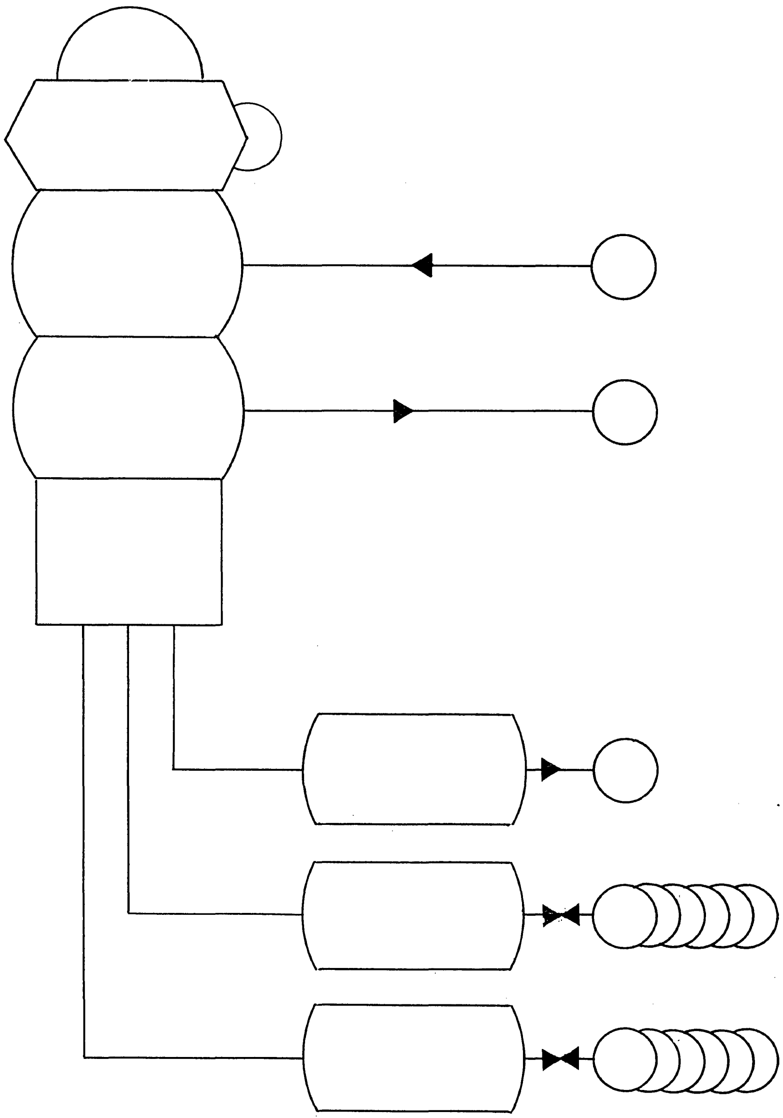
Optional Features Included: . . . .

Feature	Rental
Move Command.	75
Three-way compare. Decimal addition & subtraction. Additional address modification groups.	200
TOTAL	$10,155

§ 031.

.4 12-TAPE BUSINESS SYSTEM (CONFIGURATION IV)

Deviations from Standard Configuration: . . . . card punch is 50% faster.
magnetic tape is 30% slower.
1 more simultaneous non-tape data transfer operation is possible.



Equipment	Rental
Core Storage: 8, 192 words Central Processor, Console & Typewriter	$3, 500
Card Reader & Controller: 1, 000 cards/min.	810
Card Punch & Controller: 300 cards/min.	825
Controller Selector	-
Printer & Controller: 900 lines/min.	1, 275
Magnetic Tape Units (6) & Controller: 15, 000 or 41, 667 char/sec.	4, 930
Magnetic Tape Units (6) & Controller: 15, 000 or 41, 667 char/sec.	4, 930

Optional Features Included: . . . .

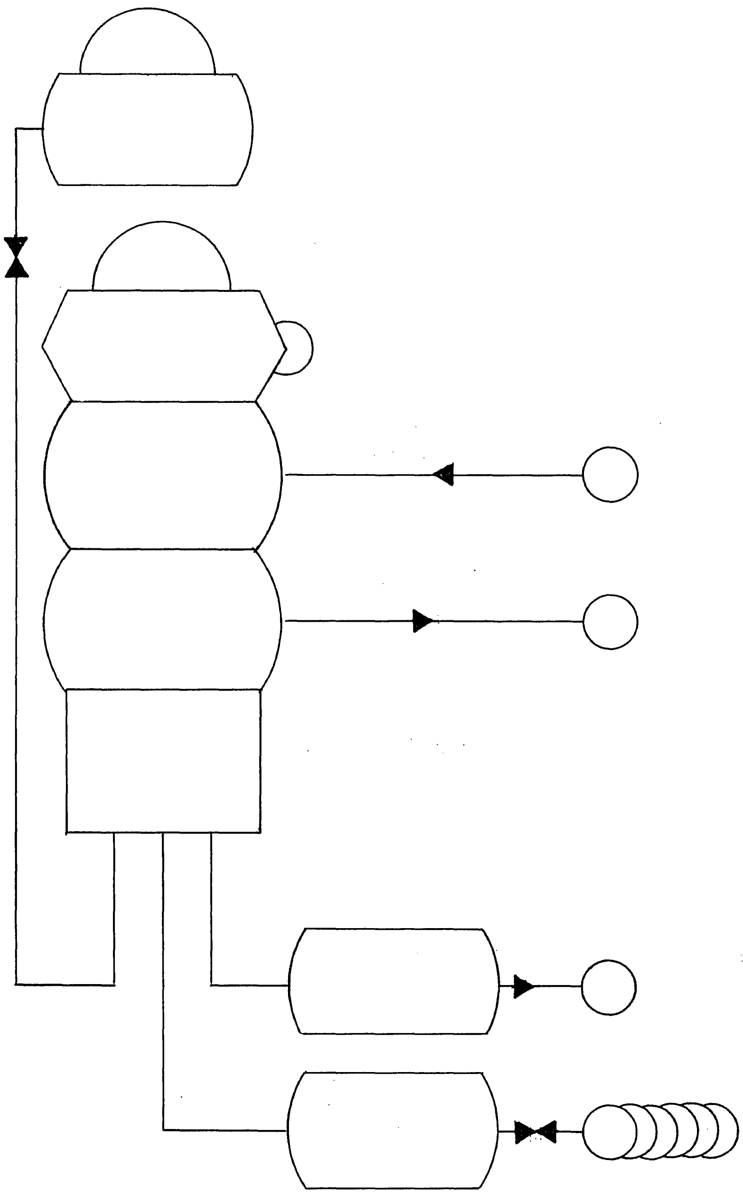
Move Command.	75
Three-Way Compare. Decimal Addition & Subtraction. Additional Address Modification Groups.	200
Automatic Interrupt.	75

TOTAL $16, 620

§ 031.

.5 6-TAPE AUXILIARY STORAGE SYSTEM (CONFIGURATION V)

Deviations from Standard Configuration: . . . . card reader is 20% slower.
printer is 80% faster.
magnetic tape is 39% faster.
2 more simultaneous non-tape data transfer operations are possible.



Equipment	Rental
Mass Random Access (Disc) Storage & Controller: 18, 874, 368 characters	$2, 625
Core Storage: 4, 096 words Central Processor, Console & Typewriter	2, 900
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	-
Printer & Controller: 900 lines/min.	1, 275
Magnetic Tape Units (6) & Controller: 15, 000 or 41, 667 char/sec.	4, 930

Optional Features Included: . . . .

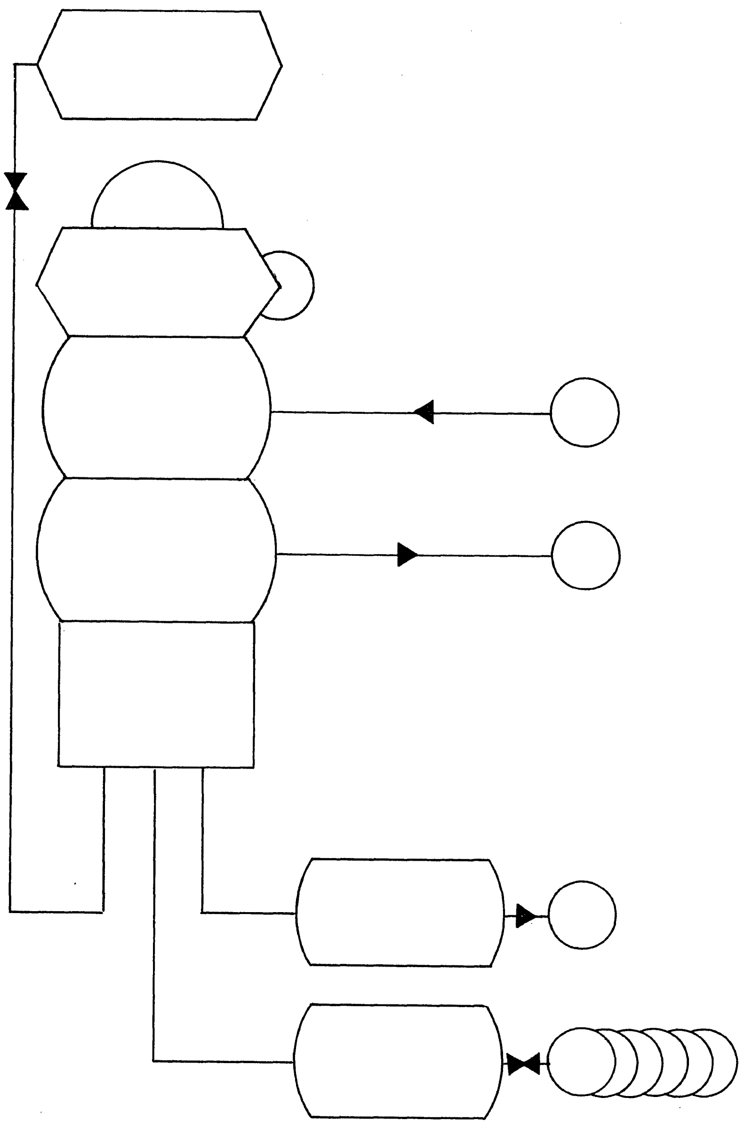
Feature	Rental
Move Command.	75
Three-Way Compare. Decimal Addition & Subtraction. Additional Address Modification Groups.	200
Automatic Interrupt.	75

TOTAL $12, 855

§ 031.

.6 6-TAPE BUSINESS/SCIENTIFIC SYSTEM (CONFIGURATION VI)

Deviations from Standard Configuration: . . . . card reader is 20% slower.
printer is 80% faster.
magnetic tape is 39% faster.
2 more simultaneous non-tape data transfer operations are possible.



Equipment	Rental
Auxiliary Arithmetic Unit	$ 650
Core Storage: 16,384 words; Central Processor, Console & Typewriter	4,900
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	-
Printer & Controller: 900 lines/min.	1,275
Magnetic Tape Units (6) & Controller: 15,000 or 41,667 char/sec.	4,930

Optional Features Included: . . . .

Feature	Rental
Move Command.	75
Three-Way Compare.; Decimal Addition & Subtraction.; Additional Address Modification Groups.	200
TOTAL:	$12,805

INTERNAL STORAGE: CORE STORAGE

§ 041.

.1 GENERAL

.11 Identity: . . . . Core Storage.
CA225B or CA225C (4,096 locations).
CB225C or CB225D (8,192 locations).
CC225A or CC225B (16,384 locations).
CS.

.12 Basic Use: . . . . working storage.

.13 Description:

Core Storage is housed in the Central Processor cabinet and may consist of 4,096, 8,192, or 16,384 locations. The corresponding processor model numbers are listed above; the first number in each pair is for the processor with the optional Controller Selector installed. Each storage location consists of twenty data bits and one parity bit and can hold a single-address instruction, a binary data word of nineteen bits plus sign, or three BCD characters. Single or double word-length load and store operations are possible in the basic processor; and internal block transfers of any length are possible with the optional Move Command at a maximum effective rate of 27,800 words per second.

.14 Availability: . . . . 3 months as of March, 1963.

.15 First Delivery: . . . . . March, 1961.

.16 Reserved Storage

Purpose	No. of Locations	Locks
Index registers and counters:	4 (128 with AAM)	none.
Arith registers:	none.	
Logic registers:	none.	
I-O control:	none.	

.2 PHYSICAL FORM

.21 Storage Medium: . . . . magnetic core.

.22 Physical Dimensions: . . not available.

.23 Storage Phenomenon: . . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by program: . . . . yes.
.242 Data regenerated constantly: . . . . no.
.243 Data volatile: . . . . . . yes (usually retained).
.244 Data permanent: . . . . . no.
.245 Storage changeable: . . . no.

.28 Access Techniques

.281 Recording method: . . . coincident current.
.283 Type of access: . . . . . uniform.

.29 Potential Transfer Rates

.292 Peak data rates
Unit of data: . . . . . . 1 word.
Conversion factor: . . . 20 bits per word.
Cycling rate: . . . . . . 55,600 cycles/second.
Data rate: . . . . 55,600 words/second.

.3 DATA CAPACITY

.31 Module and System Sizes

	Minimum Storage		Maximum Storage
Identity:	CA225B or C	CB225C or D	CC225A or B.
Words:	4,096	8,192	16,384.
Characters:	12,288	24,576	49,152.
Instructions:	4,096	8,192	16,384.
Modules:	1	1	1.

.32 Rules for Combining Modules: . . . . all configurations are shown above.

.4 CONTROLLER: . . . . . none.

.5 ACCESS TIMING

.51 Arrangement of Heads: . one access device per system.

.52 Simultaneous Operations: . . . . . . none.

.53 Access Time Parameters and Variations

.531 For uniform access
Access time: . . . . . . 9 μ sec.
Cycle time: . . . . . . 18 μ sec.
For data unit of: . . . . 1 word.

.6 CHANGEABLE STORAGE: . . . . no.

.7 PERFORMANCE

.71 Data Transfer

Pairs of storage units possibilities

With self: . . . . yes.
With Mass Random Access File: . . . . . . yes (see Mass Random Access Data Storage section).

§ 041.

.72 Transfer Load Size

With self: . . . . 1 or 2 words; or, with optional Move Command, 1 to N words, where N is limited by storage capacity.

.73 Effective Transfer Rate

With self, using indexed loop:. . . . . . 8,000 words/second.
With self, using optional MC:. . . . . . 27,800 words/second.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	none.	
Receipt of data:	parity check	indicator & alarm; optional stop.
Dispatch of data:	send parity bit.	
Conflicting commands:	not possible.	
Recovery of data:	parity check	indicator & alarm; optional stop.
Recording of data:	record parity bit.	

INTERNAL STORAGE: MASS-RANDOM ACCESS DATA STORAGE

§ 042.

.1 GENERAL

.11 Identity: . . . . Mass Random Access Data Storage.
M640A.
MRADS.
Disk Storage Unit.

.13 Description

Each Mass Random Access file unit consists of sixteen data discs and two checking discs on a common vertical axis. Up to four files can be connected to one MRADS Controller, which occupies one of the eight "hubs" on the Controller Selector. If no other peripheral units were connected into the Controller Selector, it would be possible to connect up to 32 MRADS units for a system capacity of about six hundred million characters or over one billion decimal digits.

Each disc surface is divided into 256 bands. The outer 128 bands contain sixteen sectors each and the inner 128 bands contain eight sectors each. One 64-word block of data (192 alphameric characters) can be stored in each sector, and from one to sixteen sectors can be transferred between disc storage and core storage in a single MRADS read or write operation. Total capacity of each MRADS unit is 98,304 sectors, 6.29 million words, 18.87 million characters, or about 34.6 million decimal digits.

Each disc is served by an individual positioning arm containing eight read-write heads. Four heads serve the top disc surface and the other four serve the bottom surface, so only sixty-four arm positions are required to cover all the bands on a disc. Arm positioning time ranges from 70 to 305 milliseconds, and the average total waiting time for random accessing is 225 milliseconds. Up to 98,304 words per file unit can be transferred without moving any of the positioning arms. Peak transfer rate is 23,700 words per second for data recorded on the outer bands and 11,850 words per second for the inner bands. An effective bulk transfer rate of 20,000 words per second can be obtained with optimum data placement.

A parity bit is recorded and checked for each word. In addition, the sixty-fifth word recorded in each sector is composed of one longitudinal parity check bit for each of the twenty bit positions of the sixty-four data words. This two-way parity check makes it possible to locate and correct, by means of a subroutine, a single-bit error occurring anywhere in a sector. The address of each sector is permanently recorded in a "header" word and used for sector identification and band address confirmation.

.13 Description (Contd.)

Three instruction words are required for each disc seek, read, or write operation. The first word selects the proper controller and transfers to it the next two words, which specify the exact operation and the addresses involved. Simultaneous read or write operations are limited to one per Mass Random Access Controller. Only one head positioning operation at a time may occur in each MRADS unit, or up to four at a time per controller.

.14 Availability: . . . . 1 month as of March, 1963.

.15 First Delivery: . . . . . June, 1962.

.16 Reserved Storage: . . . . no addressable locations reserved.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . multiple discs.

.22 Physical Dimensions

.222 Disc
Diameter: . . . . 31 inches.
Thickness or length: . . thin.
Number on shaft: . . . 18 discs (16 for data).

.23 Storage Phenomenon: . . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by program: . . . . yes.
.242 Data regenerated constantly: . . . . no.
.243 Data volatile: . . . . . . no.
.244 Data permanent: . . . . . no.
.245 Storage changeable: . . . no.

.25 Data volume per band of 1 track

Words: . . . . 1,024 (outer) or 512 (inner).
Characters: . . . . 3,072 (outer) or 1,536 (inner).
Digits: . . . . 5,632 (outer) or 2,816 (inner).
Instructions: . . . . 1,024 (outer) or 512 (inner).
Sectors: . . . . 16 (outer) or 8 (inner).

.26 Bands per physical unit: . 512 (256 per disc surface).

.27 Interleaving Levels: . . . 1.

§ 042.

.28 Access Techniques

.281 Recording method: . . . . moving heads.
.283 Types of access

Description of stage	Possible starting stage
Move head to selected band: . .	if new band is selected.
Wait for start of selected sector:	if head movement is unnecessary.
Transfer data:	no.

.29 Potential Transfer Rates

.291 Peak bit rates
Cycling rates: . . . . . 1,200 rpm.
Bits/inch/track: . . . . 400 maximum.
Bit rate per track: . . . 500,000 or 250,000 bits/sec/track.
.292 Peak data rates
Unit of data: . . . . . . word.
Conversion factor: . . . 20 data bits/word.
Gain factor: . . . . . . 1.
Data rate: . . . . . . 23,700 (outer) or 11,850 (inner) words/sec.

.3 DATA CAPACITY

.31 Module and System Sizes
(See table below)

.32 Rules for Combining Modules: . . . . up to 4 MRADS units per controller; up to 8 controllers per system.

.4 CONTROLLER

.41 Identity: . . . . MRADS Controller. M225B.

.42 Connection to System

.421 On-line: . . . . up to 8; each requires 1 of the 8 Controller Selector hubs.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 4.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of Load: . . . . 1 to 16 sectors of 64 words each.
.442 Input-Output area: . . . . core storage.
.443 Input-Output area access: . . . . each word.
.444 Input-Output area lockout: . . . . none.
.445 Synchronization: . . . . . automatic during a read or write operation.
.447 Table control: . . . . . . none.
.448 Testable conditions: . . . MRADS ready, controller ready.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of stacks
Stacks per system: . . 128 to 512 per controller.
Stacks per module: . . 128.
Stacks per yoke: . . . . 8.
Yokes per module: . . . 16 (one for each disc).
.512 Stack movement: . . . . in horizontal plane only.
.513 Stacks that can access any particular location: . . . . 1.
.514 Accessible locations
By single stack
With no movement: . . 16 or 8 sectors.
With all movement: . . 1,024 or 512 sectors.
By all stacks
With no movement: . . 1,536 per module.
6,144 per controller.
49,152 per system.
.515 Relationship between stacks and locations: . . least significant 7 bits of MRADS address specify stack and sector.

.52 Simultaneous Operations

A: . . . . waiting for access to specified location.
C: . . . . reading.
D: . . . . recording.

a + c + d = at most 1 per MRADS unit.
c + d = at most 1 per MRADS Control.

Note: A maximum of one MRADS controller can transfer data at a time.

	Minimum Storage	Single MRADS file	Maximum Storage per Controller	Maximum Storage per System
Identity:		M640A	M640A	M640A.
Discs:	0	16	64	512.
Words:	0	6.29×10^6	25.2×10^6	210×10^6.
Characters:	0	18.87×10^6	75.5×10^6	604×10^6.
Instructions:	0	6.29×10^6	25.2×10^6	201×10^6.
Digits:	0	34.60×10^6	138.4×10^6	$1,107 \times 10^6$.
Sectors:	0	98,304	393,216	3,145,728.
Modules:	0	1	4	32.

§ 042.

.53 Access Time Parameters and Variations

.532 Variation in access time

Stage	Variation, m.sec	Example, m.sec.
Move head to selected band:	0 or 70 to 305	199 (avg.)
Wait for start of selected sector:	0 to 52	26 (avg.)
Transfer 1 sector of data:	3.2 or 6.4	3.2.
Total:	3.2 to 363.4	328.2.

.6 CHANGEABLE STORAGE: . . . . no.

.7 AUXILIARY STORAGE PERFORMANCE

.71 Data Transfer

Pair of storage units possibilities

With self: . . . . no.
With core storage: . . . yes.

.72 Transfer Load Size

With core storage: . . . 1 to 16 sectors of 64 words each.

.73 Effective Transfer Rate

With core storage: . . . 20,000 words/sec or 60,000 char/sec.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	indicator.
Receipt of data:	parity	indicator.
Dispatch of data:	send parity bit.	
Conflicting commands:	check	indicator.
Recovery of data:	word & sector parity	indicator.
Wrong record selected:	address comparison	indicator.
Recording of data:	generate parity word.	

CENTRAL PROCESSOR

§ 051.

.1 GENERAL

.11 Identity: . . . . Central Processor.
CA225B, CB225C, CB225A, CA225C, CB225D, CC225B.

Auxiliary Arithmetic Unit.
X225A.
AAU.

.12 Description

The 225 is a single-address, fixed word-length, sequential processor. The main arithmetic and control circuitry, core storage, and console controls are housed in the processor cabinet. The six models differ only in the amount of core storage they contain and whether or not the Controller Selector is included. Word length of core memory locations and control registers is twenty bits. One location may contain an instruction, a binary data word consisting of a sign bit and nineteen data bits, or an alphameric data word consisting of three six-bit BCD-coded characters. Complete arithmetic facilities for single word-length binary data are built in.

Because the twenty-bit word is too short for many data processing and scientific applications, standard instructions are provided for double word-length addition, subtraction, and data transfers. In these cases, the combined A and Q Registers serve as a double-length accumulator. In the standard processor, subroutines must be used for double-length binary multiplication and division and for all decimal and floating point arithmetic operations. Optional hardware which can provide many of these arithmetic facilities is described below.

Three index registers and a fourth location that serves as a convenient counter register are standard, and special instructions facilitate incrementing and testing them. A variety of instructions is provided for inter-register transfers, shifting, normalizing, and complementing. These instructions do not require an operand address, so bits 7 through 19, which would normally contain the address, are used to define the exact operation to be performed. Through various combinations of these thirteen bits, the advanced programmer can create many special instructions in addition to those in the standard GE-defined repertoire. This technique is termed "micro-programming".

There are no table look-up facilities, and multiword internal transfers require the optional Move Command. Editing is accomplished by format control circuitry in the printer controller; this reduces time demands upon the Central Processor while permitting a high degree of flexibility in the printed

.12 Description (Contd.)

output. Conditional branch instructions result in execution of the next sequential instruction (which will normally be an unconditional branch) if the tested condition is true; otherwise, the next sequential instruction is skipped. Since only thirteen operand address bits are contained in an instruction, the top 8,192 words of a 16,384-word core memory can be addressed only through the use of index registers. Program instructions rather than data will normally be loaded into the upper storage bank, since the instruction address counter uses fifteen bits and can address up to 32,768.

Optional Features:

Auxiliary Arithmetic Unit (AAU): This independent unit provides complete hardware facilities for double word-length binary arithmetic in either fixed or floating point mode. Data can be transferred directly between the forty-bit AAU accumulator register and core storage, and Central Processor operations can continue while an arithmetic operation is in progress in the AAU. The AAU is connected to the Processor through the Controller Selector. Like the other peripheral devices, it can be tested for "ready" or "not ready" status and for various error conditions; unlike the others, only one instruction word is required for any AAU operation. A floating point data item is represented by thirty bits plus sign for the mantissa and eight bits plus sign for the exponent. This is the equivalent of 9 decimal digits of precision and an exponent range of 10^{-76} to 10^{+76}.

Decimal Addition and Subtraction: This feature enables the Central Processor to perform single and double-length addition and subtraction on decimal data stored in the six-bit BCD form. A carry indicator facilitates the coding of additions or subtractions of fields more than six characters long, but negative BCD numbers must be stored in the inconvenient ten's complement form. Instructions are provided to shift between the decimal and binary arithmetic modes.

Additional Address Modification Word Groups: This makes a total of thirty-two four-word groups (core storage locations 0000-0127) available as index registers or counters. Only one group, selected by a special instruction, may be active at a time, and only three of the four words are usable for address modification.

Three-Way Compare: Permits branching to the first, second, or third sequential instruction depending upon whether the contents of a specified single or double-length core storage location are greater than, equal to, or less than the contents of the accumulator.

§ 051.

.12 Description (Contd.)

Optional Features (Contd.)

Move Command: Provides a single instruction to transfer any number of successive words from one core storage area to another. The A and Q registers must contain, respectively, the new initial address and the number of words to be moved.

Automatic Priority Interrupt: Provides automatic storing of the sequence counter contents and a transfer of control to core storage location 0132 whenever any selected peripheral controller switches from "not ready" to "ready" status. Interruption from the console is not possible. The interrupt feature is especially useful for overlapping data transcription operations with independent processing routines.

Real Time Clock: Provides a nineteen-bit binary clock counter that measures time in sixths of seconds from zero to 24 hours. The clock can be set by the stored program or the operator and can be interrogated by the program through a special instruction.

.13 Availability: . . . . . . 6 months as of March, 1962.

.14 First Delivery: . . . . March, 1961.

.2 PROCESSING FACILITIES

.21 Operations and Operands

Operation and Variation	Provision	Radix	Size
.211 Fixed point			
Add-Subtract:	automatic	binary (decimal with option)	1 or 2 words.
Multiply			
Short:	none.		
Long:	automatic	binary	1 word (2 with AAU).
Divide			
No remainder:	none.		
Remainder:	automatic	binary	1 word (2 with AAU)
.212 Floating point			
Add-Subtract:	subroutine or AAU	binary	30 & 8 bits (2 words).
Multiply:	subroutine or AAU	binary	30 & 8 bits (2 words).
Divide:	subroutine or AAU	binary	30 & 8 bits (2 words).
.213 Boolean			
AND:	none.	binary	1 word.
Inclusive OR:	automatic	binary	1 word.
Extract:	automatic	binary	1 word.

.214 Comparison

Numbers:	subtract & test	1 word.
Absolute:	none.	
Letters:	subtract & test	1 word.
Mixed:	subtract & test	1 word.

Collating sequence: 0-9, A-Z; special characters interspersed among letters. See 321:144.100.

Comment: Direct high-low-equal comparisons on 1 or 2 words of numeric or alpha data are possible with optional Three-Way Compare.

.215 Code translation

Provision	From	To
subroutine	paper tape	internal.
subroutine	internal	paper tape.

.216 Radix conversion

Provision	From	To
subroutine	BCD	binary.
subroutine	binary	BCD.

.217 Edit format

	Provision	Size
Alter size:	automatic	up to 120 char.
Suppress zero:	automatic	up to 120 char.
Round off:	automatic	up to 120 char.
Insert point:	automatic	up to 120 char.
Insert spaces:	automatic	up to 120 char.
Insert any char:	automatic	up to 120 char.
Float $:	none.	up to 120 char.
Protection:	none.	up to 120 char.

.218 Table look-up: . . . . . no provision.

.219 Others

	Provision	Comment	Size
Normalize:	automatic	binary	1 or 2 words.
Decimal mode shift:	automatic	optional	
1's complement:	automatic	binary	1 word.
2's complement:	automatic	binary	1 word.
Select index group:	automatic	optional	1 of 32 groups.

.22 Special Cases of Operands

.221 Negative numbers: . . . 2's complement (10's complement with Decimal Add-Subtract).

.222 Zero: . . . . one form; 0 in all bit positions.

.223 Operand size determination: . . . . fixed.

.23 Instruction Formats

.231 Instruction structure: . 1 word (3 words for certain input-output operations).

.232 Instruction layout:

Part	Op	X	Addr or Op'
Size (bits)	5	2	13

§ 051.

.233 Instruction parts

Name	Purpose
Op:	operation code.
X:	index register specification.
Addr:	operand address.
Op':	extension of operation code in instructions with no operand address.

.234 Basic address structure: 1 + 0.

.235 Literals
Arithmetic: . . . . . . none.
Comparisons and tests: . . . . up to 8, 192, on index registers only.
Incrementing modifiers: . . . . up to 8, 192.

.236 Directly addressed operands

.2361

Internal storage type	Minimum size	Maximum size	Volume Accessible
Core:	1 word	2 words*	8, 192 words.
Disc:	64 words	1, 024 words	total capacity.

* or total capacity with Move Command.

.2362 Increased address capacity
Method — Volume accessible
Indexing: . . . . . . 16, 384 words (core).

.237 Address indexing
.2371 Number of methods: . 1.
.2372 Names: . . . . indexing.
.2373 Indexing rule: . . . . addition, modulo 32,768.
.2374 Index specification: . bits 5 & 6 of instruction to be modified.
.2375 Number of potential indexers: . . . . . . 3 (96 optional).
.2376 Addresses which can be indexed: . . . . . operand addresses in arithmetic, load, store, and unconditional branch instructions.
.2377 Cumulative indexing: . none.
.2378 Combined index and step: . . . . none.
.238 Indirect addressing: . . none.
.239 Stepping: . . . . index registers.
.2391 Specification of increment: . . . . in stepping instruction.
.2392 Increment sign: . . . always positive.
.2393 Size of increment: . . 1 to 8, 192.
.2394 End value: . . . . . . specified in test instruction.
.2395 Combined step and test: . . . . no.

.24 Special Processor Storage

.241 Category of Storage

Category	Number of locations	Size in bits	Program usage
Central Processor:	1	20	upper accumulator, A.
Central Processor:	1	20	lower accumulator, Q.
Central Processor:	1	20	instruction register, I.
Central Processor:	1	15	sequence counter, P.
Central Processor:	1	6	single char. buffer, N.

.241 Category of Storage (Contd.)

Category	Number of locations	Size in bits	Program usage
Central Processor:	1	20	memory buffer, M.
Central Processor:	1	20	arithmetic buffer, B.
Aux. Arith. Unit:	1	40	upper accumulator, AX.
Aux. Arith. Unit:	1	40	lower accumulator, QX.
Core Storage:	3 (96 with option)	20	index registers.

.242 Category of Storage

Category	Total Number locations	Physical form	Access time, µ sec	Cycle time, µ sec
Central Processor:	7	register	2.25	18.
Aux. Arith. Unit:	2	register	2.25	18.
Core Storage:	3 (96 with AAM)	core	9.00	18.

.3 SEQUENCE CONTROL FEATURES

.31 Instruction Sequencing

.311 Number of sequence control facilities: . . 1.
.314 Special sub-sequence counters: . . . . none.
.315 Sequence control step size: . . . . 1 word.
.316 Accessibility to program: . . . . can be stored in an index register.
.317 Permanent or optional modifier: . . . . no.

.32 Look-Ahead: . . . . . . none.

.33 Interruption: . . . . . . with optional Automatic Priority Interrupt only.

.331 Possible causes
In-out units: . . . . . indirectly, through controller status.
In-out controllers: . . change in status of peripheral controller from "not ready" to "ready".
Storage access: . . . indirectly, through controller status.
Processor errors: . . no.
Other: . . . . none.
.332 Program control
Individual control: . . peripheral controllers.
Method: . . . . "Priority Set" instruction permits selected controller(s) to interrupt.
.333 Operator control: . . . physical switch for each controller permits or locks out interruption by that controller.
.334 Interruption conditions: 1) in "Priority Set" mode. 2) not in priority routine. 3) change in status of any selected controller.
.335 Interruption process
Disabling interruption: automatic.
Registers saved: . . . sequence counter automatic; others by own coding.
Destination: . . . . . fixed jump to location 0132.

§ 051.

.336 Control methods
- Determine cause: . . own coding; must test selected controllers.
- Enable interruption: . own coding; "Priority Set" instruction.

.34 Multi-running: . . . . . limited capability with Automatic Priority Interrupt feature.

.341 Method of control: . . . own coding.
.342 Maximum number of programs: . . . . . . 2 is practical limit.
.343 Precedence rules: . . . own coding.
.344 Program protection
- Storage: . . . . none.
- In-out units: . . . . . none.

.35 Multi-sequencing: . . . none.

.4 PROCESSOR SPEEDS

.41 Instruction Times in μ secs

		Single Precision	Double Precision	Double Precision, with AAU
.411	Fixed point			
	Add:	36	54	94.
	Subtract:	54	90	94.
	Multiply:	162 to 414	2,600 (SR)	287 to 724.
	Divide:	468 to 522	3,000 (SR)	1,017 to 1,163.
.412	Floating point			
	Add-subtract:	none	5,310 (SR)	162 to 709.
	Multiply:	none	5,652 (SR)	297 to 1,062.
	Divide:	none	14,131 (SR)	837 to 1,231.
.413	Additional allowance for			
	Indexing:	18	18	18.
	Re-complementing:	none	none	none.
.414	Control			
	Compare (with Three-Way Compare).	54 to 72	54 to 90.	
	Branch:	18.		
	Test & branch:	54.		
.415	Counter control			
	Step:	54.		
	Step & test:	108.		
	Test:	54.		

.416 Edit: . . . . 0 (done in Printer Controller).

.417 Convert
- BCD to binary: . . . . 126 + 300 D (SR).
- Binary to BCD: . . . . 398 to 5,438 (SR, for D = 6, with Decimal Add-Subtract). 1,000 + 800D (SR, without Decimal Add-Subtract).

.418 Shift: . . . . 30 + 6B (approximate, for shift of B bits).

Note: SR indicates that a programmed subroutine is used.
D is field length in decimal-digits.

.42 Processor Performance in μ secs

		Fixed point, single precision	Floating point, with AAU (average)
.421	For random addresses		
	c = a + b:	108	580.
	b = a + b:	108	580.
	Sum N items:	36N	436N.
	c = ab	414	874.
	c = a/b	567	1,178.
.422	For arrays of data		
	$c_i = a_i + b_j$:	342	814.
	$b_j = a_i + b_j$:	342	814.
	sum N items:	252N	724N.
	$c = c + a_i b_j$:	666	1,526.

		Without Three-Way Compare	With Three-Way Compare
.423	Branch based on comparison		
	Numeric data (19-bit precision):	450	396.
	Alphabetic data (3-char precision):	450	396.

.424 Switching
- Unchecked: . . . . . . 144.
- Checked: . . . . 360.
- List search: . . . . . 54 + 270N.

.425 Format control per character
- Unpack
  - Without radix conversion: . . . . 20.
  - Including BCD-to-binary conversion: 340 (approx).
- Compose
  - Without radix conversion: . . . . 18.
  - Including binary-to-BCD conversion: . 700 (approx, without Decimal Add-Subtract). 400 (approx, with Decimal Add-Subtract).

.426 Table look up per comparison (single precision)

	Without Three-Way Compare	With Three-Way Compare
For a match:	270	252.
For least or greatest:	284	266.
For interpolation point:	270	252.

.427 Bit indicators
- Set bit in separate location: . . . . . . 72.
- Set bit in pattern: . . 90.
- Test bit in separate location: . . . . . . 144.
- Test bit in pattern: . . 144.
- Test AND for B bits: . 324 ($B \leq 19$).
- Test OR for B bits: . . 360 ($B \leq 19$).

.428 Moving data
- Single word: . . . . . 72.
- Double-length word: . 108.
- N words, using programmed loop: . . . 36 + 126N.
- N words, using optional Move Command: 126 + 36N.

§ 051.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Overflow:	check	indicator & alarm.
Underflow:	check (AAU only)	indicator & alarm.
Zero divisor:	overflow check	indicator & alarm.
Invalid data:	none.	
Invalid operation:	all codes used.	
Arithmetic error:	none.	
Invalid address:	none.	
Receipt of data:	parity check	indicator & alarm. optional stop.
Dispatch of data:	parity check	indicator & alarm. optional stop.

CONSOLE

§ 061.

.1 GENERAL

.11 Identity: . . . . contained in 225 Central Processor cabinet.

.12 Associated Units: . . . Console Typewriter and 400 card per minute Card Reader (if used) stand upon the console desk. (A free-standing 400 cpm reader is also available.)

.13 Description

The console control panel is mounted vertically at desktop level on the narrower face of the Central Processor cabinet. A wide, L-shaped desk is placed directly in front of the control panel and provides ample working space. The unusual shape of the combined processor cabinet and console desk may make it difficult to arrange the system components for operating convenience in a small room, particularly since the printer and magnetic tape controllers and the Arithmetic Auxiliary Unit all contain alarm and condition lights which are clearly visible only at close range. The control panel contains a fairly typical complement of register displays, alarm lights, and control buttons; these are fully described below.

The Console Typewriter is a modifed IBM electric model that stands on the right-hand wing of the console desk. Data cannot be entered into the system from the typewriter keyboard; the unit is used for output only, at 10 characters per second. Data to be typed, in BCD form, is sent to the unit via the 6-bit N Register, one character at a time. The typewriter character set includes only the 26 letters, 10 numerals, and the special symbols /. , $ - and space. Other BCD codes cause the unit to "hang up".

Optional Features

Console Typewriter Input: Permits using the Console Typewriter as an input device. In the input mode, one BCD character is transmitted to the N register when a typewriter key is activated. The character then may be shifted to the A register and used in any manner desired.

.2 CONTROLS

.21 Power

Name	Form
Power on:	button.
Power off:	button.

.22 Connections: . . . . . . none.

.23 Stops and Restarts

Name	Form	Comment
Start:	button	initiates automatic operation if Auto-Manual switch is in AUTO position.
Auto-Manual:	2-position switch	halts automatic operation when switched to MANUAL
Stop on Parity Alarm:	2-position switch	when ON, system halts on all parity errors.

.24 Stepping

Name	Form	Comment
Start:	button	initiates a single step if Auto-Manual switch is in MANUAL position.
Word-Instruction:	2-position switch	selects steps of one machine cycle or one full instruction.
Save P:	switch	inhibits normal advance of the sequence counter (P Register), so same instruction is repeated.

.25 Resets

Name	Form	Comment
Reset Alarm:	button	resets all alarms and error indicators.
Reset P:	button	clears sequence counter to location 0000.
Reset A:	button	clears accumulator (A Register).

.26 Loading

Name	Form	Comment
Load Card:	button	reads one binary card into Core Storage starting at location 0000.

.27 Sense Switches

Name	Form	Comment
Bit Switches:	20 3-position center-off toggle switches	used to place 1 bits into any desired positions in the A register (when raised); and to set patterns that can be read into the A register under program control (when lowered) to control program branching.

.28 Special

Name	Form	Comment
A→I	button	transfers contents of the A (accumulator) Register into the I (instruction) Register.
XAQ	button	interchanges contents of the A and Q Registers.

§ 061.

.3 DISPLAY

.31 Alarms

Name	Form	Condition Indicated
Parity:	light	parity error.
Overflow:	light	arithmetic overflow.
Card Reader:	light	error involving Card Reader.
Card Punch:	light	error involving Card Punch.
Echo:	light	peripheral controller unable to respond when addressed.

.32 Conditions

Name	Form	Condition Indicated
Priority:	light	loss of priority by Central Processor to a peripheral controller, alarm condition, or auto-manual switch in manual mode.
Card Reader Ready:	light	reader available for input.
Card Punch Ready:	light	punch available for output.
N Register Ready:	light	N Register available for paper tape or typewriter operation.
AIM:	light	processor in priority interrupt routine.
IX Group:	5 lights	index register group in use.
Decimal Mode:	light	Central Processor operating in decimal mode.
8K:	light	indicates 16K processor is operating in upper 8K.

.33 Control Registers

Name	Form	Comment
P Register:	15 lights	binary display of sequence counter contents.
I Register:	20 lights	binary display of next instruction to be executed.
A Register:	20 lights	binary display of accumulator contents; pressing XAQ will display Q Register contents.

.34 Storage: . . . . no direct display available.

.4 ENTRY OF DATA

.41 Into Control Registers: 20 Bit Switches permit direct data entry into A Register only; A ⟶ I and XAQ buttons permit loading of I and Q Registers from A Register.

.42 Into Storage

1. Set Auto-Manual switch to MANUAL.
2. Set "Store A Register" instruction, with desired Core Storage location as operand address, in Bit Switches.
3. Depress A ⟶ I button to load the instruction.
4. Set Bit Switches to desired data value.
5. Depress Start button.

.5 CONVENIENCES

.51 Communication: . . . . none.

.52 Clock: . . . . none.

.53 Desk Space: . . . . . . ample free work space is provided on the console desk.

.54 View: . . . . Central Processor cabinet, 32 inches wide by 76 inches high, is directly in front of seated operator; view in other directions is unobstructed.

INPUT-OUTPUT: CARD READER (400 CPM)

§ 071.

.1 GENERAL

.11 Identity: . . . . Card Reader.
D225 B.

.12 Description:

This is the English-built Elliott reader for standard eighty-column punched cards, extensively modified and improved by GE. The rated four hundred cards per minute speed is achieved when reading continuously into alternating input areas in core storage. When feeding one card at a time upon demand, the maximum speed is 360 cards per minute. The unit is extremely compact and usually stands upon the console desk; an optional base converts it into a free-standing unit. It provides none of the usual checks upon card reading accuracy such as dual reading stations or hole count checks. Programmed tests can be made to insure only that proper read synchronization was achieved; i.e., that each column was read once and only once. After every card read, the photocells are checked to ensure that they are working.

Cards are read serially by column, and the input instruction selects one of three data formats:

Column decimal; data in each card column is translated automatically into one internal BCD character, and three characters are stored in each core storage location.

Ten-row binary; data in two successive card columns fills one twenty bit core storage location.

Twelve-row binary; data in each card column fills the twelve least significant bit positions of one core storage location. (Continuous feeding is not possible in this mode.)

The automatic reading of data from successive cards into alternating core storage areas in the column decimal and ten-row binary modes can save Central Processor time through the elimination of internal transfers before the input data is processed.

.13 Availability: . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . March, 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs: . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . none.
.222 Sensing system: . . . . photoelectric.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . 12.
Method of use: . . . . . 80 columns per card, one at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column cards.
.312 Phenomenon: . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . . . 80 columns at standard spacing.
.322 Parallel by: . . . . . . 12 rows at standard spacing.
.324 Track use
Data: . . . . 80.
Total: . . . . 80.
.325 Row use
Data: . . . . 12 (10 for 10-row binary data).

.33 Coding: . . . . Decimal: column code as in Data Code Table No. 3.
10-Row Binary: 2 card columns per 20-bit core storage word.
12-Row Binary: 1 card column per core storage word, into the 12 least significant bit positions.

.34 Format Compatibility

Other device or system	Code translation.
All devices using standard 80-column cards: . .	not required.

.35 Physical Dimensions: . . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Reader Controller. (housed in Central Processor).

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

§ 071.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . cannot be used in same system with 1,000-card-per-minute reader.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N cards of 80 columns per card.
.442 Input-output areas: . . core storage; address of first location filled must be a multiple of 128 and less than 2048.
.443 Inter-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic within a card; by program for successive cards.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation Input: . . . . fixed.

.52 Input-Output Operations

.521 Input: . . . . 1 to N cards forward; cards are read continuously until "halt card reader" command is given.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by processor: column decimal to internal BCD; or 10- or 12-row binary to internal binary.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Offset card: . . . . no.
Select stacker: . . . . . no.
Select format: . . . . . . no.
Select code: . . . . yes, in "read" command.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . . . none.

.62 Speeds:

.621 Nominal or peak speed: 400 cards/minute.
.623 Overhead: . . . . asynchronous; reading rate is controlled by program.
.624 Effective speeds: . . . 400 cards/min. when feeding continuously.
360 cards/min. maximum if "halt card reader" instruction is given after each card (demand feeding).

.63 Demands on System

Component	m. sec per card,	or	Percentage
Core Storage:	1.5		1.0.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . none.

.72 Other Controls: . . . . none.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	600 cards.
Stacker:	600 cards.

.732 Replenishment time: . 0.25 to 0.50 mins. reader does not need to be stopped.
.733 Adjustment time: none.
.734 Optimum reloading period: . . . . 1.5 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	none.	
Input area overflow:	none.	
Invalid code:	check.	
Exhausted medium:	check	stop reader; alarm.
Imperfect medium:	none.	
Timing conflicts:	none.	
Misfeed:	check	stop reader; alarm.
Stacker full:	check	stop reader; alarm.
Synchronization:	check	set bit indicator in core storage.

INPUT-OUTPUT: CARD READER (1,000 CPM)

§ 072.

.1 GENERAL

.11 Identity: . . . . Card Reader. D225C, D225D.

.12 Description

This unit has been developed by GE to provide high speed punched card input to the 225 system. Currently rated at 1,500 cards per minute when feeding continuously, it is said to be capable of higher speeds. When cards are fed singly on demand, the rated maximum speed drops to 890 cards per minute. A character validity check (on decimal coded data only) and a read error check provide checks on reading accuracy. The unit reads standard eighty-column cards only, and the hopper and single stacker have capacities of two thousand cards each. Cards are fed singly by a vacuum pick-off and transported by a moving belt past the photoelectric read heads. Input instructions, card data formats, and code translation facilities are identical to those for the slower reader, so there is a high degree of upward compatibility between the two units.

.13 Availability: . . . . . . 9 months as of March, 1963.

.14 First Delivery: . . . . March, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . moving belt friction.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . none.
.222 Sensing system: . . . . photoelectric (solarcells).

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . . 12.
Method of use: . . . . . 80 columns per card, one at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column cards.
.312 Phenomenon: . . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . 80 columns at standard spacing.
.322 Parallel by: . . . . . . 12 rows at standard spacing.
.324 Track use
Data: . . . . 80.
Total: . . . . 80.
.325 Row use
Data: . . . . 12 (10 for 10-row binary data).

.33 Coding: . . . . Decimal: column code as in Data Code Table No. 3.
10-Row Binary: 2 card columns per 20-bit core storage word.
12-Row Binary: 1 card column per core storage word, into the 12 least significant bit positions.
Read Card Intermixed option permits reading cards in decimal and binary modes intermixed (on Model D225D only).

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 80-column cards:	not required.

.35 Physical Dimensions: . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Reader Controller (housed in Central Processor).

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . cannot be used in same system with 400-card-per-minute reader.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N cards of 80 columns per card.
.442 Input-output areas: . . core storage; address of first location filled must be a multiple of 128 and less than 2048.

§ 072.

.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic within a card; by program for successive cards.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation Input: . . . . fixed.

.52 Input-Output Operations

.521 Input: . . . . 1 to N cards forward; cards are read continuously until "halt card reader" command is given.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by processor: column decimal to internal BCD; or 10- or 12-row binary to internal binary.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Offset card: . . . . . . no.
Select stacker: . . . . . no.
Select format: . . . . . no.
Select code: . . . . . . yes, in "read" command.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.
End of file: . . . . yes.
Invalid character (Hollerith): . . . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . . . none.

.62 Speeds

.621 Nominal or peak speed: 1,000 cards/minute nominal.
.623 Overhead: . . . . asynchronous; reading rate is controlled by program.
.624 Effective speeds: . . . 1,500 cards/min. when feeding continuously.
890 cards/min. maximum if "halt card reader" instruction is given after each card (demand feeding).

.63 Demands on System

Component	msec per card, or	Percentage
Core Storage:	1.5	3.75 max.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls

Function	Form	Comment
Clear read error:	button	resets error alarms.
End of file:	button	sets bit indicator when last card is read.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	2,000 cards.
Stacker:	2,000 cards.

.732 Replenishment time: . . 0.25 to 0.50 min. reader does not need to be stopped.
.733 Adjustment time: . . . none.
.734 Optimum reloading period: . . . . 1.3 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	read check	set bit 18.
Input area overflow:	none.	
Invalid code:	check (BCD data only)	set bit 17.
Exhausted medium:	check	set bit 19.
Imperfect medium:	none.	
Timing conflicts:	none.	
Misfeed:	check	stop reader.
Stacker full:	check	set bit 16.
End of file:	check	set bit 1.
Synchronization:	check	set bit pattern.

Note: "Set bit" denotes that the indicated bit in the "synchronization word" (first, second, or fourth core location after the last word read from the card) is set to 0 if the associated error occurs and to 1 if it does not. The bit configuration of this word must be tested by the program.

INPUT-OUTPUT: CARD PUNCH

§ 073.

.1 GENERAL

.11 Identity: . . . . Card Punch.
E225K (100 cards/min.).
E225M (300 cards/min.).

.12 Description

Designed and built by General Electric, these units punch standard 80-column cards at peak speeds of 100 and 300 cards per minute. They are compatible with the IBM Model 523 and 544 punches that were used in early GE 225 systems. Cards can be punched in column decimal code from alphameric data stored in the BCD form or in ten-row or twelve-row binary modes. The output instruction specifies the mode to be used. The starting core storage address of the data to be punched must be a multiple of 128 and less than 2,048.

The only available check on punched output of the 100 card per minute model is a plugboard-wired check for double punches and blank columns; it can check up to 30 columns and is effective only on decimal-coded numeric data. Check sums are usually punched into binary cards to make possible a programmed check on punching and reading accuracy when the data is re-entered. The 300 card per minute model checks the complete card by the read-after-punch technique, by counting all holes in a card row.

.13 Availability: . . . . . . Model E225K: 3 months as of March, 1963.
Model E225M: 12 months as of March, 1963.

.14 First Delivery

E225K: . . . . April, 1962.
E225M: . . . . September, 1963.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . die punch.
.222 Sensing system: . . . . brush.
.223 Common system: . . . no.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . punching.
Stacks: . . . . 1.
Heads/stack: . . . . . . 80.
Method of use: . . . . . one row at a time.

Use of station: . . . . . checking.
Stacks: . . . . 1.
Heads/stack: . . . . . . 80.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column punch cards.
.312 Phenomenon: . . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . 12 rows at standard spacing.
.322 Parallel by: . . . . . . 80 columns at standard spacing.
.324 Track use: . . . . all for data.
.325 Row use: . . . . all for data.

.33 Coding

Decimal: . . . . column code as in Data Code Table No. 3.
10-Row Binary: . . . . 2 card columns per 20-bit core storage word.
12-Row Binary: . . . . 1 card column per core storage word, from the 12 least significant bit positions.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 80-column cards:	not required.

.35 Physical Dimensions: . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Punch Controller. (housed in Central Processor).

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . usable for independent gang-punching.

§ 073.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 card of 80 columns.
.442 Input-output areas: . . core storage; address of first word punched must be a multiple of 128 and less than 2, 048.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation: . . fixed size.

.52 Input-Output Operations

.521 Input: . . . . none.
.522 Output: . . . . 1 card forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic; internal BCD to column decimal or internal binary to 10- or 12-row binary.

.54 Format Control

Control: . . . . plugboard; seldom used.
Format alternatives: . undefined.
Rearrangement: . . . . yes.
Suppress zeros: . . . . no.
Insert point: . . . . . . yes.
Insert spaces: . . . . . yes.
Section sizes: . . . . . no.
Select columns to be checked: . . . . yes (on 100 card per minute model only).

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Offset card: . . . . . . no.
Select stacker: . . . . . no.
Select format: . . . . . no.
Select code: . . . . . . yes, in "punch" command.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.

.6 PERFORMANCE

.61 Conditions

I: . . . . Model E225K Card Punch.
II: . . . . Model E225M Card Punch.

.62 Speeds

.621 Nominal or peak speed
I: . . . . 100 cards/minute.
II: . . . . 300 cards/minute.
.622 Important parameters
Clutch cycle
I: . . . . 600 msec.
II: . . . . 200 msec.
.623 Overhead
Clutch points per cycle
I: . . . . 14.
II: . . . . 1.
.624 Effective speeds: . . . peak speeds are maintained if "punch" instruction occurs within 10 msec after punching of previous card is completed.

.63 Demands on System

Component	Condition	msec per card	or	Percentage
Core Storage:	I	17.3		2.9.
	II	17.3		8.4.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls

Function	Form	Comment
Reset:	button	resets error alarms.

.73 Loading and Unloading

.731 Volumes handled

Storage	Condition I	Condition II
Hopper:	800 cards	3,500 cards.
Stacker:	800 cards	3, 000 cards.

.732 Replenishment time: . . 0. 25 to 0. 50 min. punch does not need to be stopped.
.733 Adjustment time: . . . none.
.734 Optimum reloading period
I: . . . . 8.0 mins.
II: . . . . 11.3 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording (Model E225K):	double punch, blank column *	stop punch; alarm.
Recording (Model E225M):	read after punch	stop punch; alarm.
Output block size:	fixed.	
Invalid code:	all codes valid.	
Exhausted medium:	check	stop punch; alarm.
Imperfect medium:	none.	
Timing conflicts:	check	stop punch; alarm.
Misfeed:	check	stop punch; alarm.
Stacker full:	check	stop punch; alarm.

* For decimal-coded numeric data only; checks up to 30 columns on E225K.

INPUT-OUTPUT: PAPER TAPE READER

§ 074.

.1 GENERAL

.11 Identity: . . . . Paper Tape System (Reader only).

.12 Description

The Paper Tape System is a free-standing unit housing a reader, punch, and control circuitry for perforated tape input-output. Individual reader and punch units also are available. The reader and punch are mechanically independent of one another and are covered in separate sections of this report.

The reader offers a choice of speeds of 250 or 1,000 characters per second on five- six-, seven-, or eight-track tape. At 250 characters per second, it can stop on a single character and handle spooled tape. At the higher speed, only unspooled strips can be handled, and one additional character is read after a "halt reader" instruction is given. Data from five or six tracks is read continuously into the six-bit N Register, one character at a time. Synchronization and code translation must be provided by the stored program. Input parity checks are made on seven- and eight-track codes, but the parity bit is not transmitted to the processor. The Paper Tape Reader may not be turned on at the same time as either the Paper Tape Punch or the Console Typewriter, since they all use the same input-output instructions. A delay of 200 milliseconds must be programmed between the "reader on" instruction and the first paper tape input instruction.

Optional Feature

Eight-Bit N Register: Provides two additional bits in the N Register, enabling data from as many as eight tracks to be read into the Central Processor.

.13 Availability: . . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . October, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs
Number: . . . . 2.
Form: . . . . swinging arm
Capacity: . . . . 12 inches.
.213 Feed drive: . . . . . . motor.
.214 Take-up drive: . . . . . motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . none.
.222 Sensing system: . . . . photoelectric.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . . 8.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . . punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 10 per inch.
.322 Parallel by: . . . . . . 5, 6, 7, or 8 tracks at standard spacing.
.324 Track use
Data: . . . . 5 or 6 (up to 8 with eight-bit N Register option).
Redundancy check: . . 1 (7- & 8-track tape only).
Timing: . . . . 1 (sprocket holes).
Control signals: . . . 1 (8-track tape only).
Total: . . . . 5 to 8 plus sprocket track.
.325 Row use: . . . . all for data (1-row inter-block gaps required for reading at 1,000 char/sec).

.33 Coding: . . . . any 5, 6, 7 or 8-track code with up to 6 data tracks (up to 8 with eight-bit N Register option) can be read.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 5-, 6-, 7-, or 8-track paper tape:	programmed.

.35 Physical Dimensions

.351 Overall width: . . . . . 11/16, 7/8, or 1 inch.
.352 Length: . . . . up to 1,000 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . built into paper tape system.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

§ 074.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N characters.
.442 Input-output areas: . . N register, a single-character I/O buffer.
.443 Input-output area access: . . . . contents can be shifted into A register only.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . by program.
.447 Synchronizing aids: . . test for "N Register ready".

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 to N characters.
.512 Block demarcation
Input: . . . . any selected character, or programmed counter.

.52 Input-Output Operations

.521 Input: . . . . read forward continuously until halted by program command.
.522 Output: . . . . see Paper Tape Punch section, 321:075.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . programmed.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . no.
Select format: . . . . . no.
Select code: . . . . . . no.
Rewind: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . no.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Busy I/O register: . . . yes.
Exhausted: . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 250 or 1,000 char/sec. (higher speed usable on tape strips only.)

.622 Important parameters
Tape speed: . . . . . 25 or 100 inches/sec.
Maximum stop distance
At 25 inches/sec.: . 0.025 inch.
At 100 inches/sec.: 0.150 inch.
Start time (to first char.)
At 25 inches/sec.: . 1.5 msec.
At 100 inches/sec.: 0.5 msec.

.624 Effective Speeds
At 25 inches/sec.: . . $\frac{250N}{(N+1)}$ char/sec.
At 100 inches/sec.: . $\frac{1,000N}{(N+2)}$ char/sec.

where N = number of characters per block.

.63 Demands on System

Component	msec per char	or	Percentage
Central Processor:	0.108		2.7 or 10.8.

Comment: This is the time required to test "N Register ready" and shift the six data bits from N to A Register; code translation time is not included.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Number of tracks:	rotary switch	5, 6, 7 or 8 tracks.

.73 Loading and Unloading

.731 Volumes handled
Storage Capacity
Reel: . . . . 1,000 feet, or up to 120,000 char.
.732 Replenishment time: . . 1.0 to 1.5 mins. reader needs to be stopped.
.733 Adjustment time: . . . 1.5 to 2.0 mins.
.734 Optimum reloading period: . . . . 8.0 minutes.

.8 ERRORS, CHECKS AND ACTION

Errors	Check or Interlock	Action
Reading:	parity (7- or 8-track tape)	indicator & alarm.
Input area overflow:	none.	
Invalid code:	none.	
Exhausted medium:	check	will remain "busy".
Imperfect medium:	none.	
Timing conflicts:	none.	

INPUT-OUTPUT: PAPER TAPE PUNCH

§ 075.

.1 GENERAL

.11 Identity: . . . . Paper Tape System (Punch only).

.12 Description

This is the Teletype 110-character-per-second punch, housed in the Paper Tape System cabinet along with the reader and control circuitry. Individual reader and punch units also are available. Paper tape with five, six, seven, or eight tracks can be punched. One punch model is available for punching 5 track tape only; another model permits punching 6, 7, or 8 track tape only. Tape codes to be punched are set up by the program in the Central Processor's six-bit N Register, and odd parity bits are generated automatically for seven or eight-track codes. Each paper tape output instruction causes a single character to be punched. The punch may not be turned on at the same time as either the Paper Tape Reader or the Console Typewriter, and a delay of five hundred milliseconds must be programmed between the "punch on" instruction and the first paper tape output instruction.

Optional Feature

Eight-bit N Register: Provides two additional bits in the N Register, enabling data to be punched in up to eight tracks.

.13 Availability: . . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . October, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . die punches.
.222 Sensing system: . . . . none.

.23 Multiple Copies: . . . none.

.24 Arrangement of Heads

Use of station: . . . . . punching.
Stacks: . . . . 1.
Heads/stack: . . . . . . 8.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . . punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 row at 10 per inch.
.322 Parallel by: . . . . . . 5, 6, 7, or 8 tracks at standard spacing.
.324 Track use
Data: . . . . 5 or 6 (up to 8 with eight-bit N Register option).
Redundancy check: . . 1 (7 & 8 track tape only).
Timing: . . . . 1 (sprocket holes).
Control signals: . . . 1 (8 track tape only).
Total: . . . . 5 to 8 plus sprocket track.
.325 Row use: . . . . all for data (1-row inter-block gaps required if tape is to be read at 1,000 char/sec).

.33 Coding: . . . . any 5, 6, 7, or 8-track code with up to 6 data tracks.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 5, 6, 7 or 8-track paper tape: .	programmed.

.35 Physical Dimensions

.351 Overall width: . . . . . 11/16, 7/8, or 1 inch.
.352 Length: . . . . up to 1,000 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . built into Paper Tape System.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 character.
.442 Input-output areas: . . N register, a single-character I/O buffer.

§ 075.

.443 Input-output area access: . . . . loaded by shift from A register only.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . by program.
.447 Synchronizing aids: . . test for "N Register ready".

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 to N characters.
.512 Block demarcation
Output: . . . . as programmed.

.52 Input-Output Operations

.521 Input: . . . . see Paper Tape Reader section, 321:074.
.522 Output: . . . . punch 1 row forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . programmed.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . no.
Select format: . . . . . no.
Select code: . . . . . . no.
Rewind: . . . . no.

.56 Testable Conditions

Disabled: . . . . no.
Busy device: . . . . . . no.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Busy I/O register: . . . yes.
Exhausted: . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 110 char/sec.
.622 Important parameters
Tape speed: . . . . . 11 inches/sec.
.624 Effective speeds: . . . 110 char/sec. if not more than 9 msecs elapse between successive "punch" instructions.

.63 Demands on System

Component	msec per char, or	Percentage
Central Processor:	0.108	1.2.

Comment: This is the Processor time required to test "N Register ready", shift the six data bits from A to N Register, and punch a row; code translation is not included.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Number of tracks:	rotary switch	for 6, 7, or 8 tracks only.

.72 Other Controls

Function	Form	Comment
Simulator switches:	6 switches	set up bit pattern for manual punching.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Reel:	1,000 feet, or up to 120,000 characters.

.732 Replenishment time: . . 2.0 to 3.0 mins. punch needs to be stopped.
.733 Adjustment time: . . . 3.0 to 4.0 mins.
.734 Optimum reloading period: . . . . 18.1 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	none.	
Invalid code:	all codes punched.	
Exhausted medium:	check	will remain "busy".
Imperfect medium:	none.	
Timing conflicts:	none.	

INPUT-OUTPUT: PRINTER

§ 081.

.1 GENERAL

.11 Identity: . . . . High Speed Printer. P225A, PA690A, PA690B.

.12 Description

The High Speed Printer utilizes the well-known Anelex Series 4 drum printing mechanism, with a rated peak speed of nine hundred alphameric lines per minute at single spacing and 601 lines per minute at an average line spacing of one inch. There are 120 printing positions and fifty printable characters. Skipping speed is twenty-five inches per second, and the print instruction may include a skip to any of eight channels in the paper tape control loop or a step of zero to sixty-three lines.

One printer and its controller may be attached to any of the eight hubs on the Controller Selector. The controller includes automatic format control circuitry which uses a block of format words in Core Storage to control zero suppression, insertion of any desired format characters, and deletion of data characters in any desired positions. Dollar field editing is automatic, but no automatic provision is made for check protection or for floating dollar, plus, or minus signs. Each printer output operation requires three instruction words. The first word selects the appropriate Controller Selector hub and causes the next two words to be transferred to the Printer Controller, which then assumes control of the operation. It causes from one to forty BCD-coded data words and the corresponding format words to be transferred from Core Storage, performs the specified editing functions, and causes the line to be printed. This system minimizes time demands upon the Central Processor during printing.

The Printer Controller includes a manual control button that initiates an octal dump of the entire contents of Core Storage. A parity check is made on data received by the controller for printing, and a print cycle check detects synchronization errors.

Two 900 lines-per-minute off/on-line printer models are available. Model PA690A utilizes input from a 15KC tape unit (200 bits per inch tape density) and Model PA690B utilizes either a 15KC tape unit (200 bits per inch tape density) or a 41.6K tape unit (556 bits per inch tape density) by simply setting a hi-low density recording switch located on the tape unit. These two models permit printing up to seven different types of report formats.

The balance of the material in this section refers to the 900 lines-per-minute on-line printer, Model P225A.

.12 Description (Contd.)

Optional Features

FORTRAN Printer: This is the same printer equipped with the FORTRAN character set.

Plotter Feature: Permits use of the printer for graph plotting on rectangular coordinates in increments of 0.050 inch along both axes.

.13 Availability: . . . . . . 4 months as of March, 1963.

.14 First Delivery: . . . . March, 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive - paper punched both sides.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . on-the-fly hammer stroke against engraved drum.
.222 Sensing system: . . . . none.

.23 Multiple Copies

.231 Maximum number
Interleaved carbon: . 5.
.233 Types of master
Multilith: . . . . yes.
Xerox: . . . . yes.
Spirit: . . . . yes.

.24 Arrangement of Heads

Use of station: . . . . . printing.
Stacks: . . . . 1.
Heads/stack: . . . . . . 120.
Method of use: . . . . . prints 1 full line at a time.

.25 Range of Symbols

Numerals:	10	0 - 9.
Letters:	26	A - Z.
Special:	14	+. - $ * % _ / =, [ ] # @
Alternatives:		any character set can be requested as a standard modification.
FORTRAN set:		optional.
Req. COBOL set: . . .		by request.
Total:	50 and blank.	

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . continuous fan-fold sprocket-punched stationery.

§ 081.

.312 Phenomenon: . . . . . . printing.

.32 Positional Arrangement

.321 Serial by: . . . . 1 line at 6 per inch (6 or 8 lines/inch available as an option).
.322 Parallel by: . . . . . . 120 columns at 10 per inch.
.324 Track use
Data: . . . . 120.
Total: . . . . 120.
.325 Row use: . . . . all for data.

.33 Coding: . . . . engraved character font. (Internal coding as in Data Code Table No. 1).

.34 Format Compatibility: . none.

.35 Physical Dimensions

.351 Overall width: . . . . . 3.5 to 19.5 inches by vernier.
.352 Length: . . . . up to 22.0 inches per sheet, by 1/6-inch increments.
.353 Maximum margins
Left: . . . . 3.875 inches.
Right: . . . . 3.875 inches.

.4 CONTROLLER

.41 Identity: . . . . Printer Controller.

.42 Connection to System

.421 On-line: . . . . up to 8; each requires 1 of the 8 Controller Selector hubs.
.422 Off-line: . . . . none (Off/On-Line Printer and Controller are available).

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 line of 3 to 120 characters.
.442 Input-output areas: . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 line of 3 to 120 characters.
.512 Block demarcation
Output: . . . . 1-bit in sign position of last word to be printed. (not required when full 40-word line is printed).

.52 Input-Output Operations

.521 Input: . . . . none.
.522 Output: . . . . 1 line forward, with automatic format control optional.
.523 Stepping: . . . . stop 0 to 63 lines; may be combined in "print then step".
.524 Skipping: . . . . skip to 1 of 8 channels in paper tape loop; may be combined in "print then skip".
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by controller (from internal BCD code only).

.54 Format Control

Control: . . . . program or automatic, using format words.
Format alternatives: . unlimited.
Rearrangement: . . . . by program only.
Suppress zeros: . . . . yes.
Insert point: . . . . . . yes.
Insert spaces: . . . . . yes.
Section sizes: . . . . . yes.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with optional Automatic Priority Interrupt.
Select format: . . . . . yes.
Select code: . . . . . . no.
Select controller: . . . yes.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . yes.
End of medium marks: no.
Exhausted medium: . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 900 lines/min.
.622 Important parameters
Skipping speed: . . . . 25 inches/sec.
.623 Overhead: . . . . 6.7 msec per single line step.
.624 Effective speeds

Average spacing, inches	Effective speed, lines/min.
1/6:	900
2/6:	819
3/6:	752
1:	601
2:	430
3:	334
4:	263
5:	231

(see graph)

§081.

.63 Demands on System

Basis: Printing full lines with automatic format control, at single spacing.

Component	msec per line, or	Percentage
Core Storage:	1.50	2.25

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method
Forms width:	sliding forms tractors.
Vertical forms positioning:	knob.
Forms tension:	knob.
Penetration control:	knob.

.72 Other Controls

Function	Form	Comment
On or off-line:	button.	
Skip to top of page:	button.	
Memory dump:	button	prints entire Core Storage contents in octal form.
Manual clear:	button	halts printer operation.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	30-inch stack.
Stacker:	30-inch stack.

.732 Replenishment time: . . 1 to 2 mins.
Printer needs to be stopped.

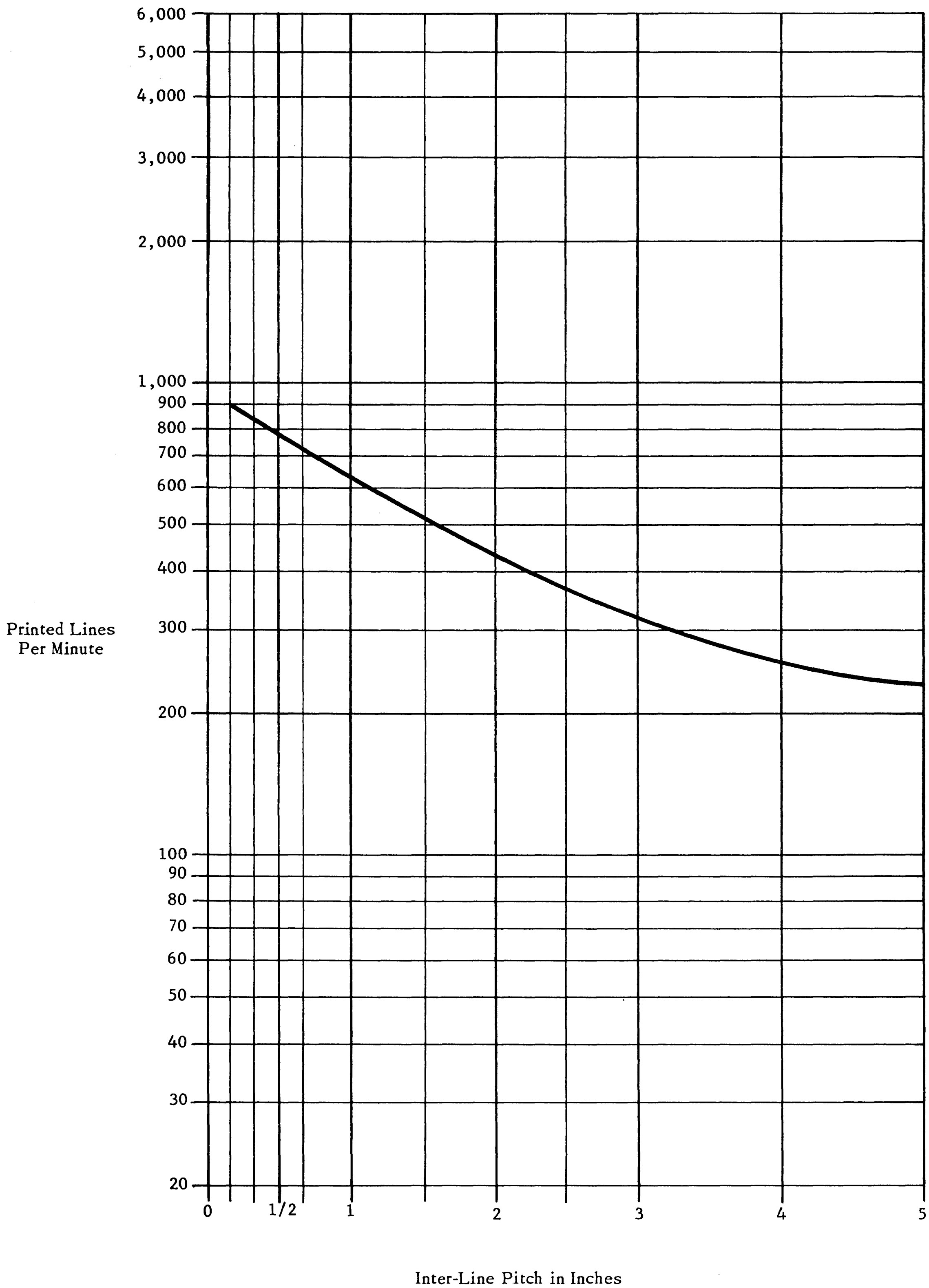
.733 Adjustment time: . . . 3 to 5 mins.

.734 Optimum reloading period: . . . . 74 minutes.
Basis: . . . . 2-part forms, 17 inches long, at 1-inch line spacing.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	automatic cut-off.	
Invalid code:	none	print space.
Exhausted medium:	check	indicator and alarm.
Imperfect medium:	none.	
Timing conflicts:	check	stop printer.
Receipt of data:	parity	indicator and alarm.
Hammer fuses:	check	indicator and alarm.
Synchronization:	print cycle check	stop printer.

EFFECTIVE SPEED: PRINTER



INPUT-OUTPUT: LOW SPEED PRINTER

§ 082.

.1 GENERAL

.11 Identity: . . . . Low Speed Printer. P225D.

.12 Description

The Low Speed Printer is designed for use where printed output at a speed intermediate between the 900 lines per minute of the High Speed Printer and the 10 characters per second of the console typewriter is desirable, as in many scientific applications. Rated peak speed is 150 lines per minute, using a 50-character set identical to that of the High Speed Printer. There are 120 print positions, spaced 10 per inch. Vertical spacing is 6 lines per inch. Skipping speed is 15 inches per second. The Low Speed Printer is connected to the N-Register of the central processor via the Peripheral Interface Unit, an optional feature. The Controller Selector is not required. Data to be printed is transferred, one character at a time, from the N-Register to a 240-character printer buffer. A separate "transfer character" instruction is required to transfer each character. The print buffer can store two full lines of data to be printed; therefore, one line can be printed while the data for the next line is being loaded into the other half of the buffer. Special character codes initiate the following control functions: print and step 1 line, print without stepping, step 1 line, skip to top of page, clear printer buffer. The automatic format control of the GE High Speed Printer is not provided in the Low Speed Printer; it must be simulated by the stored program, and a special subroutine will be made available for this purpose.

.13 Availability: . . . . . . 6 months as of May, 1963.

.14 First Delivery: . . . . late 1963.

INPUT-OUTPUT: MAGNETIC TAPE HANDLERS

§ 091.

.1 GENERAL

.11 Identity: . . . . Magnetic Tape Handler.
MTH680 (dual 15,000 char/sec unit).
MTH690 (dual 15,000 or 41,667 char/sec unit).

.12 Description

Each dual Magnetic Tape Handler consists of two modified Ampex digital tape transports mounted one above the other in a single cabinet. The two handlers differ only in number of recording densities, as shown in the following table.

Model	Tape speed, inches/sec.	Density, rows/inch	Peak transfer rate, char/sec
MTH680 (dual):	75	200	15,000
MTH690 (dual):	75	200	15,000
		556	41,667

The two models are fully compatible with each other and with the IBM 727, 729, and 7330 Magnetic Tape Units. Record lengths are variable, and tapes may be read backward as well as forward. Magnetic Tape Controllers can be connected to any or all of the eight Controller Selector hubs, and up to eight transports can be connected to each controller. One tape input or output operation on each 15KC controller can occur simultaneously with internal processing and other peripheral operations, but not more than two 41.6KC tape controllers can operate simultaneously. A variety of checking features is incorporated, including read-after-write, lateral and longitudinal parity checks on both reading and recording, and checks for loss of data due to timing errors.

Data can be recorded in any of three modes:

1. BCD - three tape rows per GE 225 word (sign and "1" bit are ignored, and some internal codes are converted to achieve IBM compatibility).
2. Binary - four tape rows per word (zeros are inserted into four excess bit positions in the fourth row). This mode must be used when a record contains both BCD and binary data.
3. Special binary - three tape rows per word (sign and "1" bit are ignored).

The T225F Magnetic Tape Handler with peak transfer rates of 24,000 and 66,700 characters per second is no longer part of the GE product line.

.13 Availability: . . . . . . 3 months as of March, 1963.

.14 First Delivery

MTH680: . . . . March, 1961.
MTH690: . . . . March, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs
Number: . . . . 2 per transport.
Form: . . . . vacuum pocket.
Capacity: . . . . about 8 inches each.
.213 Feed drive: . . . . . . motor.
.214 Take-up drive: . . . . . motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . magnetic head.
.222 Sensing system: . . . . magnetic head.
.223 Common system: . . . two-gap head provides read-after-write checking.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . recording.
Stacks: . . . . 1.
Heads/stack: . . . . . . 7.
Method of use: . . . . . one row at a time.

Use of station: . . . . . sensing.
Stacks: . . . . 1.
Heads/stack: . . . . . . 7.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . plastic tape with magnetizable surface.
.312 Phenomenon: . . . . . . magnetization.

.32 Positional Arrangement

.321 Serial by: . . . . 3 to N rows at 200 or 556 rows/inch; N limited by available core storage.
.322 Parallel by: . . . . . . 7 tracks.
.324 Track use
Data: . . . . 6.
Redundancy check: . . 1.
Timing: . . . . 0 (self-clocking).
Control signals: . . . 0.
Unused: . . . . 0.
Total: . . . . 7.
.325 Row use
Data: . . . . 3 to N.
Redundancy check: . . 1 per block.
Timing: . . . . 0.
Control signals: . . . 0.
Unused: . . . . 0.
Gap: . . . . 0.75 inch inter-block; 3.75 inch end of file.

§ 091.

.33 Coding: . . . . BCD mode: one tape row per character, as in Data Code Table No. 2.
Binary mode: 4 tape rows per 20-bit word.
Special Binary mode: 3 tape rows per word; sign and high-order data bit are ignored.

.34 Format Compatibility

Other device or system	Code translation
IBM 727, 729, 7330 tape units at 200 and 556 rows/inch:	generally not required.
GE 215/235 systems:	not required.

.35 Physical Dimensions

.351 Overall width: . . . . . 0.50 inch.
.352 Length: . . . . 2,400 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . Magnetic Tape Controller.
MTC680 (for MTH680 handlers).
MTC690 (for MTH690 handlers).

.42 Connection to System

.421 On-line: . . . . up to 8; each requires 1 of the 8 Controller Selector hubs.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 4 dual handlers (8 tape transports).
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N words, limited by available core storage.
.442 Input-output areas: . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 to N words; 3 or 4 tape rows per word.
.512 Block demarcation
Input: . . . . gap on tape; maximum N specified in "read" instruction.
Output: . . . . N specified in "write" instruction.

.52 Input-Output Operations

.521 Input: . . . . 1 block forward or backward.
.522 Output: . . . . 1 block forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . 1 block backward (backspace).
.525 Marking: . . . . inter-block gap, 0.75 inch long.
end-of-file character and 3.75-inch gap.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by controller.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . yes, with optional Automatic Priority Interrupt.
Select format: . . . . . no.
Select code: . . . . . . yes, in I/O instruction.
Rewind: . . . . yes.
Unload: . . . . no.
Select density: . . . . . yes, with dual-density transports.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Output lock: . . . . . . no.
Nearly exhausted: . . . no.
Busy controller: . . . . yes.
End of medium marks: yes.
End of file mark: . . . yes.
Any tape rewinding: . . yes.

.6 PERFORMANCE

.61 Conditions

I: . . . . MTH680 at 200 rows/inch.
II: . . . . MTH690 at 200 rows/inch.
III: . . . . MTH690 at 556 rows/inch.

.62 Speeds

.621 Nominal or peak speed
I: . . . . 15,000 char/sec.
II: . . . . 15,000 char/sec.
III: . . . . 41,667 char/sec.
.622 Important parameters
Tape speed: . . . . . 75 inches/sec.
Start + stop time: . . 12.0 msec.
Full rewind time: . . 2.5 minutes.
Inter-block gap: . . . 0.75 inch.
End-of-file gap: . . . 3.75 inches.
.623 Overhead: . . . . 12.0 msec/block.
.624 Effective speeds
I: . . . . 15,000N/(N+180) char/sec.
II: . . . . 15,000N/(N+180) char/sec.
III: . . . . 41,667N/(N+450) char/sec.

where N = char/block (see graphs).

§ 091.

.63 Demands on System

Component	Condition	m. sec per block,	or	Percentage of transfer time
Core Storage:	I	0.054 + 0.006N		9.0
	II	0.054 + 0.006N		9.0
	III	0.054 + 0.006N		25.0
Tape Controller:	I	12.0 + 0.067N		100.0
	II	12.0 + 0.067N		100.0
	III	12.0 + 0.024N		100.0

where N is number of characters per block.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Recording density:	switch	200 or 556 rows/inch (not on MTH680).

.72 Other Controls

Function	Form	Comment
Address selection:	rotary switch	addresses 0 - 7.
File protection:	ring on reel	ring permits writing.
Rewind:	button.	
Manual transport control:	3 buttons	forward/reverse/ stop.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Reel:	2,400 feet; 11,300,000 char at high density and 5,000,000 char at low density for 1,000 char blocks.

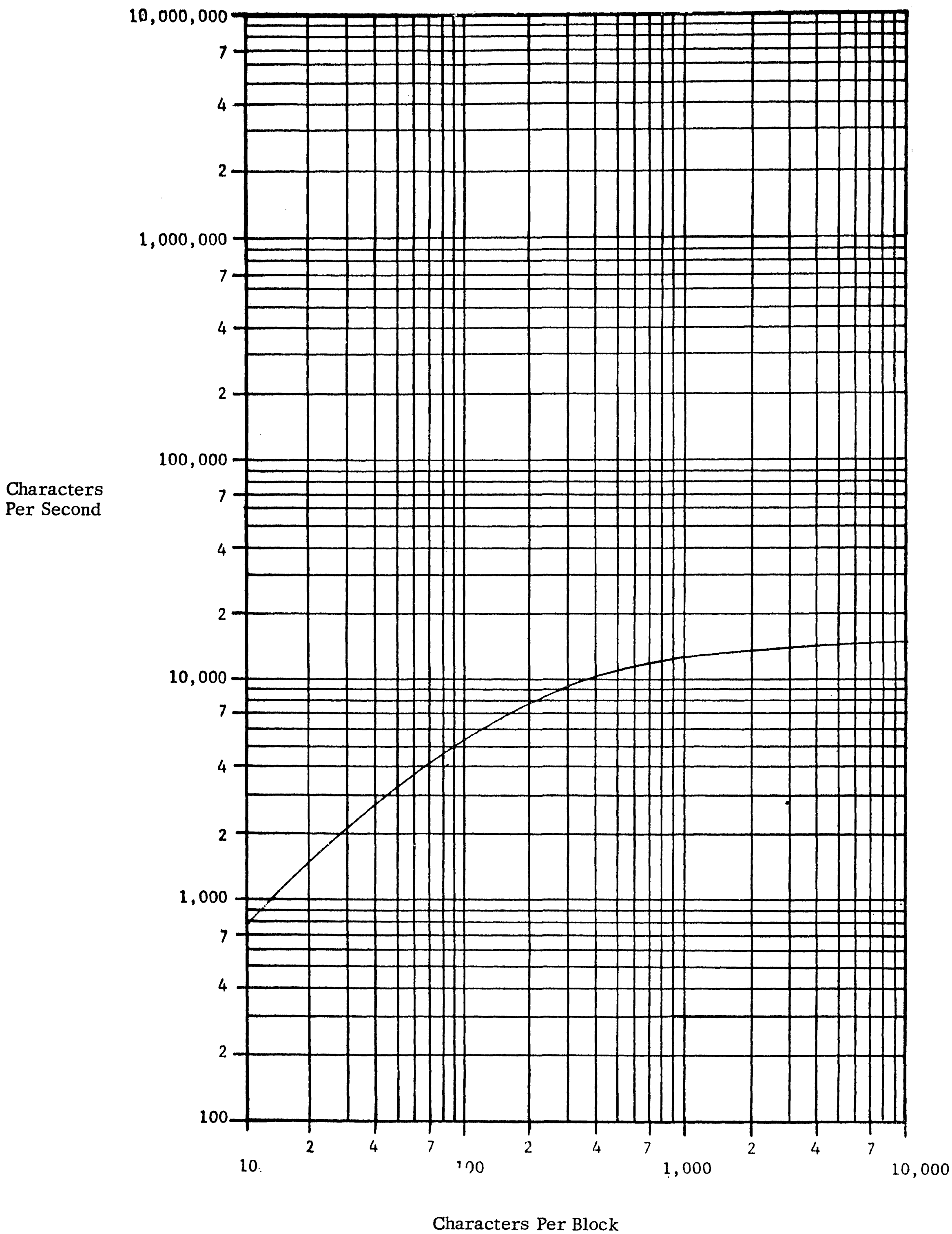
.732 Replenishment time: . . 0.5 to 1.0 minute. tape unit needs to be stopped.

.734 Optimum reloading period: . . . . 6.4 minutes.

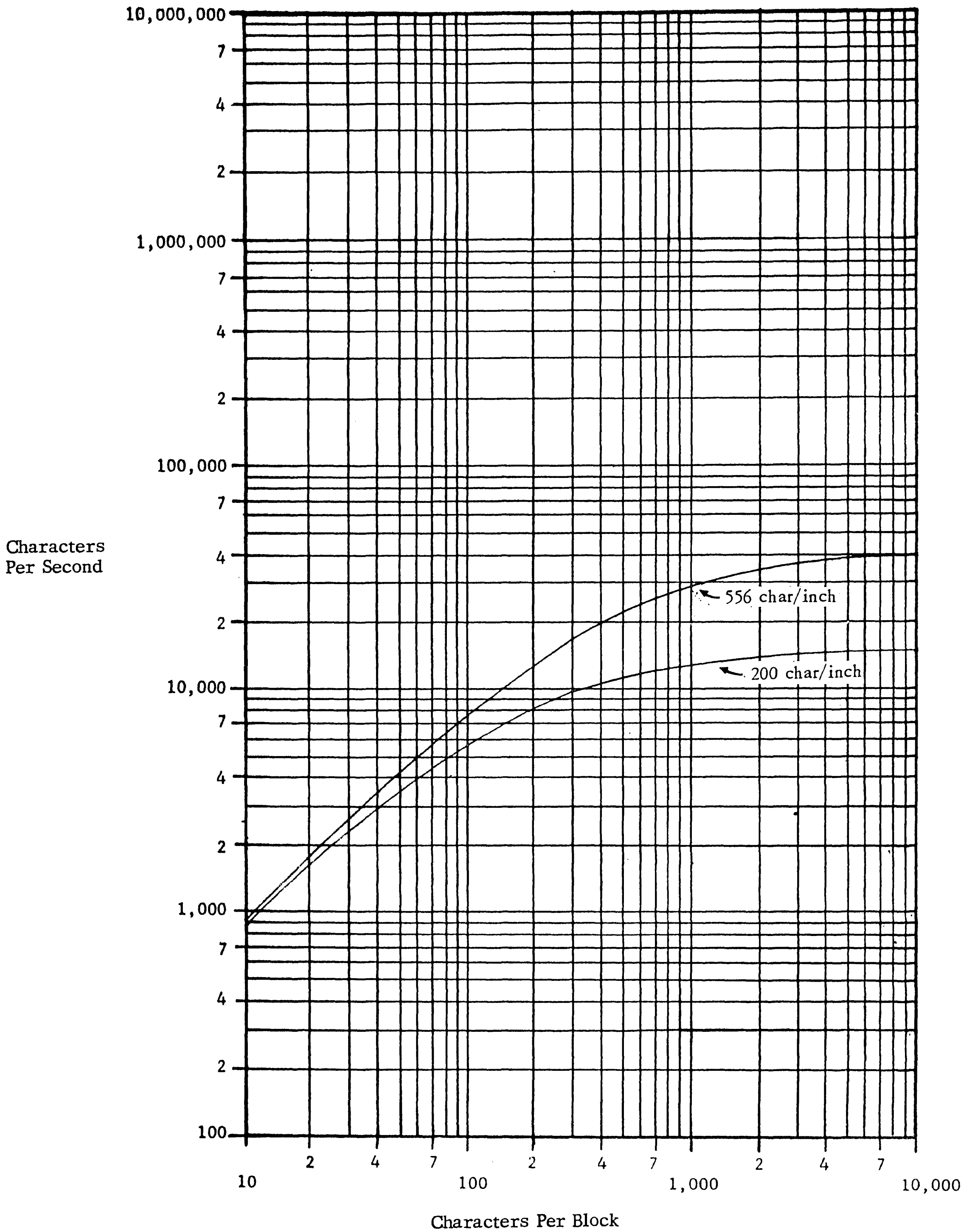
.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	lateral & longitudinal parity	indicator & alarm.
Reading:	lateral & longitudinal parity	indicator & alarm.
Input area overflow:	check	stop transfer; set bit.
Output block size:	preset.	
Invalid code:	all codes valid.	
Exhausted medium:	reflective spot on tape	indicator & alarm.
Imperfect medium:	none.	
Timing conflicts:	I/O register exhaust or overflow check	indicator & alarm.
Incorrect number of characters per word:	modulo 3 or 4 check	indicator & alarm.

EFFECTIVE SPEED: MTH 680



EFFECTIVE SPEED: MTH 690



INPUT-OUTPUT: DOCUMENT HANDLER

§ 101.

.1 GENERAL

.11 Identity: . . . . Magnetic Ink Document Handler. S12B, S12C.

.12 Description:

The Document Handler reads and sorts magnetically encoded paper documents at a peak rate of 1,200 documents per minute. It may operate on-line with the GE 225 system or off-line as a sorter only. One or two Document Handlers may be connected to a single Controller Selector hub through a Document Handler Adapter; the dual input model permits simultaneous operation of the two Document Handlers.

The unit will feed, transport, and stack documents of intermixed sizes within the following ranges:

Length: . . . . 5.75 to 8.75 inches
Width: . . . . 2.50 to 3.75 inches
Thickness: . . . . . . 0.0027 to 0.0070 inches

It reads a single line of magnetic ink characters printed in Font E-13B (adopted as standard by the American Bankers' Association). Recognizable characters are limited to the ten numerals and four cue characters.

In on-line operation, data read from the document is stored as one BCD character per core storage location, in the six low-order bit positions. Invalid or unrecognizable characters cause an indicator to be set and an asterisk to be transmitted to storage. One of the twelve stacker pockets must be selected by the stored program. To achieve the peak rate, documents must be fed continuously and synchronization controlled by the program. When documents are fed singly upon demand, the maximum rate drops to six hundred documents per minute. Three instruction words are required to initiate each Document Handler input or control operation.

When operating off-line, the Document Handler is controlled by the manual control panel and a wired plugboard. The plugboard can define the format of up to twelve sort fields, each containing up to ten digits. The desired field and digit position for sorting are selected by push buttons. A "Zero Suppression" feature eliminates repeated handling of documents which are already properly sorted by routing them to the Special pocket. The alternative "Multiple Digit Selection" feature causes documents which contain a field of up to ten characters whose value is equal to a corresponding field defined by plugboard wiring to be sent to the Special pocket.

.13 Availability: . . . . . . 10 months as of March, 1963.

.14 First Delivery: . . . . March, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . . moving belt friction; document feeding and pocket selection by "vacuum pickup".

.212 Reservoirs: . . . . none.

.22 Sensing and Recording Systems

.222 Sensing system: . . . . . magnetic heads.

.23 Multiple Copies: . . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . . ?
Method of use: . . . . . . ?

.25 Range of Symbols

Numerals:	10	0 - 9.
Letters:	none.	
Special:	4	amount, dash, transit, on-us.
Alternatives:	none.	
Total:	14.	

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper documents.
.312 Phenomenon: . . . . magnetic ink imprinting.

.32 Positional Arrangement

.321 Serial by: . . . . character; up to 64 characters per document.
.322 Parallel by: . . . . ? tracks.
.323 Bands: . . . . one, consisting of visually readable imprinted characters.
.324 Track use: . . . . all for data.
.325 Row use: . . . . all for data.

.33 Coding: . . . . Font E-13B magnetic ink characters.

.34 Format Compatibility

Other device or system	Code translation
All equipment using Font E-13B characters in standard A.B.A. format:	none required.

§ 101.

.35 Physical Dimensions

.351 Overall width: . . . . . . 2.50 to 3.75 inches.
.352 Length: . . . . 5.75 to 8.75 inches.
.353 Maximum margins
Distance of leading edge of first symbol from edge of document: . . . . 0.3125 ± 0.0625 inches.

.4 CONTROLLER

.41 Identity: . . . . Document Handler Adapter. SA225 (single input). SB225 (dual input).

.42 Connection to System

.421 On-line: . . . . up to 2; each requires 1 of the 8 Controller Selector hubs.
.422 Off-line

Use	Associated equipment
Document sorting: . .	none.

.43 Connection to Device

.431 Devices per controller: . . . . 1 per SA225A Adapter; 2 per SB225A.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . 1 document.
.442 Input-output areas: . . . core storage; base address, M, must be a multiple of 64; one character is read into the least significant 6 bits of each location, starting at M + 63 and continuing downward.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . . none.
.446 Synchronization: . . . . . automatic within a document; by program for successive documents.
.447 Synchronizing aids: . . . tests for sorter ready, sorter feeding, late pocket decision.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . . up to 64 characters per document.
.512 Block demarcation
Input: . . . . plugboard wiring.

.52 Input-Output Operations

.521 Input: . . . . read 1 document and halt; or read 1 document and continue feeding next document.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . . automatic by controller.

.54 Format Control

Control: . . . . plugboard and program.
Format alternatives: . . undefined.
Rearrangement: . . . . . by program.
Suppress zeros: . . . . . by program.
Insert point: . . . . no.
Insert spaces: . . . . . . no.
Section sizes: . . . . . . plugboard.
Select fields for off-line sorting: . . . . . . plugboard and control panel.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Select stacker: . . . . . yes.
Select format: . . . . . . no.
Select code: . . . . no.
Halt continuous feeding: . yes.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . yes.
Nearly exhausted: . . . . no.
Busy controller: . . . . . yes.
Feeding documents: . . . yes.
Late pocket decision: . . yes.
Invalid character read: . yes.
Hopper empty: . . . . . . yes.
Stacker full: . . . . no.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: . . . . 1,200 documents/minute.
.622 Important parameters
Space between documents: . . . . . . variable (synchronous feed).
Time for pocket selection: . . . . . . 47 msec max. after completion of reading.
.624 Effective speeds: . . . . 1,200 documents/minute when feeding continuously. 600 documents/minute maximum when feeding on demand ("read 1 document and halt").

63 Demands on System

Component	msec per character
Core storage:	0.018

§ 101.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none required (feeds intermixed documents of varying sizes).

.72 Other Controls

Function	Form	Comment
Sort field selection:	12 buttons	for off-line sorting only.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Feed hopper:	12 inch stack (approx. 2,500 documents).
Stackers (12):	10 inch stack each.

.732 Replenishment time: 0.5 to 1.0 mins. reader needs to be stopped.

.734 Optimum reloading period: . . . . 2 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	see "Invalid code."	
Input area overflow:	none.	
Invalid code:	validity check	transmit • to storage & set indicator.
Exhausted medium:	check	indicator & alarm.
Imperfect medium:	none.	
Timing conflict:	none.	
Full stacker:	check	halt reader.
Misfeed:	check	halt reader.
Late pocket selection:	check	indicator & alarm.

INPUT-OUTPUT: DATANET-15

§ 102.

.1 GENERAL

.11 Identity: . . . . DATANET-15.

.12 Description

The DATANET-15 links telecommunication terminals to the GE 225 Central Processor via the Controller Selector. The Automatic Priority Interrupt feature is required on all GE 225s using the DATANET-15. This feature permits the DATANET-15 to operate concurrently with and time-share the core storage facilities with other peripheral devices and internal processing. The manufacturer estimates that less than 2 per cent of the central processor time will be used for normal communications storage accesses.

The basic DATANET-15 controller receives and sends digital data over a maximum of two teletype or telephone grade transmission facilities. Therefore, the basic model is called a "two-channel" controller, even though data can be transferred over only one of the two connected transmission facilities at a time. Optional features, described below, permit connection of up to 15 transmission units and 1 Paper Tape Unit, with the same restriction to 1 data transfer operation into core storage at a time.

Transmission speeds of 75, 110, or 1,050 bits per second are the standard options, but any transmission speed between 60 and 2,400 bits per second is available upon request. The transmission speed is controlled by a timing plug which emits a pulse to coincide with each bit. The transmission speed of a facility can be changed at any time by replacing the existing timing plug with one corresponding to the speed desired. Only one speed, for all of the channels on a DATANET-15, is possible at one time. Any serial five-, six-, seven-, or eight-bit data code using start-stop bits to indicate the beginning and end of each transmitted or received character will be accepted by the DATANET-15. The start-stop bits are stripped off and added by the DATANET-15 for each character as needed.

Data are transferred serially by character and in parallel by bit between the DATANET-15 and the GE 225 computer and between the DATANET-15 and the Paper Tape Unit. Data transfers are serial by bit, using start-stop bits, between the DATANET-15 and remote units.

Each character is represented in core storage in the five, six, or seven least significant bits of a GE 225 word, depending on the code used. There is no automatic code conversion, but a plugboard allows rearrangement of the bit structure in any way desired, thus effectively allowing conversion to any desired character code. When using the five-bit character code for receiving data, a bit is automatically

.12 Description (Contd.)

generated in the sixth bit position to indicate that the character is either a letter or a numeral. In the transmit mode, only five bits are transferred to the DATANET-15; therefore, the message must be programmed so the letter or numeric shift code is inserted into the proper position within the message.

The DATANET-15 has two modes of operation: the Receive mode and the Transmit mode. In the Receive mode, a request-for-access signal from a remote station is stored in a flip-flop indicator for that station. Once every 300 microseconds, a scanner within the DATANET-15 interrogates the status of the flip-flop indicators for each channel until either a request-for-access signal is detected, a branch select is executed, or the computer initiates a transmission. When a request-for-access signal is detected, the scanner stops on the requesting channel, causes an automatic program interrupt to service it, and locks out all other channels. After servicing the request, scanning is resumed by a start-scanning instruction. After a scan instruction has been executed, a total of 250 milliseconds elapses and the controller is interlocked before the scanning operation is resumed, unless the previous instruction was a scan instruction.

A 250 millisecond delay is encountered whenever the mode of the DATANET-15 is changed, allowing time for the communication channel to change modes. The transmit mode is entered when a transmit instruction is executed. In this mode, the scanner is positioned on the channel specified in the instruction, enabling data to be transmitted character by character from core storage to the remote station via the DATANET-15.

The instructions required to activate the DATANET-15 are identical in format for either mode and consist of three instruction words which contain the address of the remote station, the core storage address, and the character count of the message. The character count is placed in the character counter, which provides a means for controlling the length of each message transferred between core storage and the DATANET-15. The counter can count up to 2,048 characters. When the specified number of characters has been counted, the character counter automatically terminates data transfer between the DATANET-15 and core storage until a new command is executed. Messages can also be terminated by sensing an end of message or end of transmission character. It is possible to transmit messages longer than 2,048 characters by breaking the message down into blocks of fewer than 2,048 characters each. Reception of messages containing more than 2,048 characters can occur without the loss of a character by issuing another receive instruction within half the time required to receive a bit. (When transmitting at a rate of 75 bits per second, the new receive

§ 102.

.12 Description (Contd.)

instruction must be issued within 6.7 milliseconds after the indication of the character counter overflow.)

Odd parity checks are automatically performed by the DATANET-15 on all input data which contains provisions for an odd parity bit. If this parity bit is in error, the DATANET-15 corrects the parity and sets a program-testable indicator.

Optional Features

Five-Channel Operation: Permits serial five-bit data codes with start and stop bits to be received or transmitted.

Six-, Seven-, or Eight-Channel Operation: Permits any single serial six-, seven-, or eight-bit data code with start and stop bits to be received or transmitted.

75-Baud Data Speed Plug: Permits transmission and reception of data at 75 bits per second.

.12 Description (Contd.)

Optional Features (Contd.)

110-Baud Data Speed Plug: Permits transmission and reception of data at 110 bits per second.

1,050-Baud Data Speed Plug: Permits transmission and reception of data at 1,050 bits per second.

Special Data Speed Plug: Permits transmission and reception of data at any other single bit rate between 60 and 2,400 bits per second.

Paper Tape Adapter: Provides the capacity to connect and control a GE free-standing Paper Tape Unit.

Four Additional Channels: Provides the capacity for accommodating up to six transmission facilities.

Thirteen Additional Channels: Provides the capacity for accommodating up to 15 transmission facilities.

Interface Adapter: Adapts the controller voltage and current levels to those needed for low-speed telegraphic operation.

SIMULTANEOUS OPERATIONS

§ 111.

.1 SPECIAL UNITS

.11 Identity: . . . . Controller Selector (optional).
Priority Access Control (standard).

.12 Description

There are eleven input-output channels in the GE 225 system. The card reader is connected to Channel 1 and requires one access to core storage for each column read (80 accesses per card). The card punch is connected to Channel 10 through an 80-bit shift register and requires 960 accesses to core storage for each card punched. Synchronization of data transfers between the card input-output units and core storage is automatic, and card reading and punching can always be overlapped with internal processing.

The console typewriter and paper tape reader and punch are connected to the 6-bit N Register in the Central Processor, which forms the eleventh input-output channel. Only one character is transferred at a time, and synchronization must be controlled by the stored program. These three units share the same power supply, and only one may be operated at a time.

All other peripheral devices must be connected to Channels 2 through 9. These eight channels are called the Controller Selector.

Controller Selector: This optional unit, housed in the Central Processor cabinet, serves as a common control and data transfer point between the processor and the controllers for data transmission, printers, magnetic tape units, Magnetic Document Handlers, Mass Random Access Data Storage, and the Auxiliary Arithmetic Unit. The Controller Selector contains eight "hubs". One peripheral controller can be plugged into each hub and assumes the address of that hub. The Controller Selector automatically controls the time-sharing of core storage accesses among all of the attached peripheral devices. One device on each peripheral controller may therefore operate simultaneously. Data is transferred through the Controller Selector at the rate of 55,600 words per second.

Requests for access to core storage are automatically served by the Priority Access Control according to the following priority order. The unit with the highest priority is listed first.

.12 Description (Contd.)

1. Card Reader (Channel 1).
2. Controller Selector (Channels 2 - 9).
   a. Mass Random Access File Controller(s).
   b. Magnetic Tape Controller(s).
   c. Magnetic Document Handler Adapter(s).
   d. Data Transmission Controller(s).
   e. High Speed Printer(s).
   f. Auxiliary Arithmetic Unit.
3. Card Punch (Channel 10).
4. Central Processor, with Paper Tape and Typewriter I/O (Channel 11).

The criteria for establishing this priority order are the repetition rate of memory access demands and the consequences of not gaining access in time; the processor can wait indefinitely without danger of error or loss of information. Priority order for the devices attached to the Controller Selector is determined by the numbers of the hubs to which they are attached and may be changed to meet changing system requirements.

This method of handling simultaneous operations is straightforward and powerful. When several high-speed peripheral units are operating simultaneously it is possible, though unlikely, that requests for memory access will occur faster than the processor can serve them, resulting in loss of data. There are error indicators in the magnetic tape and Mass Random Access Data Storage controllers to detect this condition; the other input-output units will "hang up" if they are not granted access in time.

.2 CONFIGURATION CONDITIONS

I: . . . . without Controller Selector.
II: . . . . with Controller Selector.

.4 RULES

Condition I: Without Controller Selector

Any or all of the following operations can be carried out simultaneously:

Internal processing.
Read card.
Punch card.

And any one of the following:

Type on console typewriter.
Read paper tape.
Punch paper tape.

§ 111.

.4 RULES (Contd.)

Condition II: With Controller Selector

Note: A total of eight controllers (or seven if the Auxiliary Arithmetic Unit is installed) can be connected to the Controller Selector. The types of controllers will dictate the number of simultaneous operations possible, as detailed below, since each controller is capable of only one data transfer operation at any time.

The central processor has a maximum transfer rate of 55,600 words per second, or approximately 167,000 characters per second. It is possible for various combinations of the operations listed below to exceed this capacity, resulting in a loss of data that will be signalled.

Any or all of the following can be in operation simultaneously:

Internal processing.
Read card.
Punch card.
Print a line or advance forms on printer (one per printer controller).
Any number of magnetic tape rewind operations.

.4 RULES (Contd.)

Condition II: With Controller Selector (Contd.)

One magnetic tape input or output operation per Magnetic Tape Controller. ‡
One input or output Mass Random Access Data Storage transfer operation. ‡
Up to four seek operations per Mass Random Access Data Storage Controller.
One input or output operation per Data Transmission Controller.
Two input operations per Magnetic Ink Document Handler Adapter.
Processing in Auxiliary Arithmetic Unit.

And any one of the following:

Type on console typewriter.
Read paper tape.
Punch paper tape.

‡ No more than two 41.6KC tape controllers can operate simultaneously; however, there is no limit with the 15KC tape controller. Only one Mass Random Access Data Storage Controller can operate at a time; or a combination of one 41.6KC Tape Controller and one Mass Random Access Data Storage Controller can operate simultaneously.

§ 121.

INSTRUCTION LIST

INSTRUCTION				OPERATION
Op.	X	Addr.	Octal Code	
				Arithmetic
ADD	M	Y	01.....	(A) + (Y) ⟶ A.
SUB	M	Y	02.....	(A) - (Y) ⟶ A.
MPY	M	Y	15.....	(Q) x (Y) ⟶ A & Q; A must be preset to 0.
DVD	M	Y	16.....	(A & Q) ÷ (Y) ⟶ A; remainder ⟶ Q.
DAD	M	Y	11.....	(A & Q) + (Y & Y + 1) ⟶ A & Q.
DSU	M	Y	12.....	(A & Q) - (Y & Y + 1) ⟶ A & Q.
ADO	-	-	2504032	(A) + 1 ⟶ A.
SBO	-	-	2504112	(A) - 1 ⟶ A.
INX	X	J	14.....	(X) + J ⟶ X,
SET	-	DEC-MODE	2506011	Causes execution of the following instructions in the BCD mode: ADD, DAD, SUB, DSU, ADO, SBO (with DAS only).
SET	-	BIN-MODE	2506012	Causes all instructions to operate in the binary mode (with DAS only).
				Auxiliary Arithmetic Unit
LAQ	A	-	3600002	(QX) ⟶ AX.
MAQ	A	-	3100002	(AX) ⟶ QX; 0 ⟶ AX.
LQA	A	-	3200002	(AX) ⟶ QX.
XAQ	A	-	3500002	Interchange (AX) and (QX).
FLD	M	Y	30.....	(Y & Y + 1) ⟶ AX.
FST	M	Y	33.....	(AX) ⟶ Y & Y + 1.
SET	-	UFL-POINT	3200010	Select unnormalized floating point arithmetic mode.
SET	-	NFL-POINT	3100010	Select normalized floating point arithmetic mode.
SET	-	FIX-POINT	3500010	Select double precision fixed point arithmetic mode.
FAD	M	Y	31.....	(AX) + (Y & Y + 1) ⟶ AX.
FSU	M	Y	32.....	(AX) - (Y & Y + 1) ⟶ AX.
FMP	M	Y	35.....	(QX) x (Y & Y + 1) ⟶ AX & QX.
FDV	M	Y	36.....	(AX & QX) ÷ (Y & Y + 1) ⟶ AX; remainder ⟶ QX.
BAR	7	BAN	2516020	Branch if AAU is not ready for next instruction.
BAR	7	BAR	2514020	Branch if AAU is ready for next instruction.
BAR	7	BPL	2516021	Branch if sign of AX is plus.
BAR	7	BMI	2514021	Branch if sign of AX is minus.
BAR	7	BZE	2514022	Branch if (AX) = 0.
BAR	7	BNZ	2516022	Branch if (AX) ≠ 0.
BAR	7	BOV	2514023	Branch if AAU overflow indicator is on.
BAR	7	BNO	2516023	Branch if AAU overflow indicator is off.
BAR	7	BUF	2514024	Branch if AAU underflow indicator is on.
BAR	7	BNU	2516024	Branch if AAU underflow indicator is off.
BAR	7	BER	2514027	Branch if any AAU error condition.
BAR	7	BNE	2516027	Branch if no AAU error condition.
				Logic
ORY	X	Y	23.....	OR: Place a 1 bit in Y wherever A Register has a 1 bit in corresponding position.
EXT	X	Y	20.....	EXTRACT: Place a 0 bit in A wherever Y has a 1 bit in corresponding position.
LDZ	-	-	2504002	0 ⟶ A.
LDO	-	-	2504022	1 ⟶ A (in least significant bit position).
LMO	-	-	2504102	-1 ⟶ A.
CPL	-	-	2504502	1's complement of (A) ⟶ A.
NEG	-	-	2504522	2's complement of (A) ⟶ A.
CHS	-	-	2504040	Change sign of A Register.
NOP	-	-	2504012	No operation.

§ 121. INSTRUCTION LIST–Contd.

Op.	X	Addr.	Octal Code	OPERATION
SRA	-	K	25100..	Shift (A) right K places; 0's ⟶ vacated positions.
SLA	-	K	25120..	Shift (A) left K places; 0's ⟶ vacated positions.
SCA	-	K	251004.	Shift (A) right K places in circular fashion.
SRD	-	K	25110..	Shift (A & Q) right K places.
SLD	-	K	25122..	Shift (A & Q) left K places.
SCD	-	K	25112..	Shift (A & Q) right K places in circular fashion.
SAN	-	K	25104..	Shift (A & N) together right K places.
SNA	-	K	25101..	Shift (N & A) together right K places.
NAQ	-	K	25111..	Shift (N, A, & Q) together right K places.
ANQ	-	K	25114..	Shift (A) right K places into both N & Q.
				Note: 31 bit places is maximum value of K for all the above shift instructions.
NOR	-	K	25130..	Normalize (A); maximum shift is K places left.
DNO	-	K	25132..	Normalize (A & Q); maximum shift is K places left.
BRU	M	Y	26.....	Branch unconditionally to Y.
SPB	X	Y	07.....	(P) ⟶ X; then branch unconditionally to Y.
				Note: All branch instructions except BRU and SPB (above) result in <u>execution</u> of the next sequential instruction if the tested condition is <u>true</u> or a <u>skip</u> over the next instruction if it is <u>false</u>.
BPL	-	-	2516001	Branch if sign of A is plus.
BMI	-	-	2514001	Branch if sign of A is minus.
BZE	-	-	2514002	Branch if (A) = 0.
BNZ	-	-	2516002	Branch if (A) ≠ 0.
BOD	-	-	2514000	Branch if least significant bit of A = 1.
BEV	-	-	2516000	Branch if least significant bit of A = 0.
BOV	-	-	2514003	Branch if overflow indicator is on.
BNO	-	-	2516003	Branch if overflow indicator is off.
BPE	-	-	2514004	Branch if parity error indicator is on.
BPC	-	-	2516004	Branch if parity error indicator is off.
BXH	X	J	05.....	Branch if (X) ≥ J.
BXL	X	J	04.....	Branch if (X) < J.

CAB	M	Y	21.....	Compare (A) with (Y) (with TWC only):
				If (Y) > (A), execute next instruction;
				If (Y) = (A), skip next instruction;
				If (Y) < (A), skip next two instructions.

DCB	M	Y	22.....	Compare (A & Q) with (Y & Y+1) and branch as in CAB instruction (with TWC only).
SXG	-	G	2506gg3	Select 4-word address modification group G. (0 ≤ G ≤ 31; with AAM only).
SET	-	PST	2506015	Enter automatic priority interrupt mode (with AI only).
SET	-	PBK	2506016	Leave automatic priority interrupt mode (with AI only).
LCA	-	-	2504210	Load Clock from A Register (with RTC only).
LAC	-	-	2504202	Load A Register from Clock (with RTC only).
				<u>Data Transfer</u>
LDA	M	Y	00.....	(Y) ⟶ A.
STA	M	Y	03.....	(A) ⟶ Y.
DLD	M	Y	10.....	(Y & Y + 1) ⟶ A & Q.
DST	M	Y	13.....	(A & Q) ⟶ Y & Y + 1.
LQA	-	-	2504004	(A) ⟶ Q.
LAQ	-	-	2504001	(Q) ⟶ A.
XAQ	-	-	2504005	Interchange (A) and (Q).
MAQ	-	-	2504006	(A) ⟶ Q; 0 ⟶ A.
STO	M	Y	27.....	(A) ⟶ Y; operand address (bits 7-19) only.
STX	X	Y	17.....	(X) ⟶ Y.
LDX	X	Y	06.....	(Y) ⟶ X.
MOV	-	Y	24.....	Move N words starting with (Y) to new location starting at Z, where Z is in A Register and -N is in Q Register. (Available with optional MC only.)

§ 121. **INSTRUCTION LIST—Contd.**

INSTRUCTION				OPERATION
Op.	X	Addr.	Octal Code	
				Input-Output: Console
RCS	-	-	2500011	Place a 1 bit in A wherever the corresponding console control switch is on (down).
TON	-	-	2500007	Turn on console typewriter power and turn off power for PTR & PTP.
BNR	-	-	2514005	Branch if N Register is ready for input-output.
BNN	-	-	2516005	Branch if N Register is not ready for input-output.
TYP	-	-	2500006	Type the 6-bit coded character in N Register.
OFF	-	-	2500005	Turn off power for typewriter, PTR, & PTP.
				Input-Output: Punched Tape
RON	-	-	2500014	Turn on PTR power and turn off power for PTP and typewriter.
RPT	-	-	2500006	Read continuously from punched tape into N Register.
HPT	-	-	2500016	Halt PTR.
PON	-	-	2500015	Turn on PTP power and turn off power for PTR and typewriter.
WPT	-	-	2500006	Punch the 6-bit coded character in N Register.
BNR	-	-	2514005	Branch if N register is ready.
BNN	-	-	2516005	Branch if N register is not ready.
				Input-Output: Punched Cards
RCD	M	Y	250yy00	Read decimal cards continuously, storing data in BCD form as follows: 1st card into Y through Y + 26; 2nd card into Y + 32 through Y + 58; 3rd card into Y + 64 through Y + 90; 4th card into Y + 96 through Y + 122; 5th card into Y through Y + 26; etc.
RCB	M	Y	250yy01	Read 10-row binary cards continuously: 1st card into Y through Y + 39; 2nd card into Y + 64 through Y + 103; 3rd card into Y through Y + 39; etc.
RCF	M	Y	250yy10	Read one 12-row binary card into the 12 least significant bit positions of Y through Y + 79.
HCR	-	-	2500004	Halt card reader.
BCR	-	-	2514006	Branch if card reader is ready.
BCN	-	-	2516006	Branch if card reader is not ready. Note: For all punched card instructions Y must be a multiple of 128 and less than 2048.
WCD	M	Y	250yy02	Punch one decimal card from BCD data in Y through Y + 26.
WCB	M	Y	250yy03	Punch one 10-row binary card from data in Y through Y + 39.
WCF	M	Y	250yy17	Punch one 12-row binary card from the 12 least significant bit positions in Y through Y + 79.
BPR	-	-	2514007	Branch if card punch is ready.
BPN	-	-	2516007	Branch if card punch is not ready.
				Input-Output: Controller Selector
SELP	-	P	2500P20	Select peripheral controller P, transmit contents of next 2 locations to it, and reset its error indicator ($0 \leq P \leq 7$). The SEL P instruction must immediately precede all Printer, Magnetic Tape, Magnetic Ink Document Handler, and Mass Random Access File instructions except conditional branches.
BCS	P	BER	2514P27	Branch if any error condition in controller P.
BCS	P	BNE	2516P27	Branch if no error condition in controller P.

§ 121. **INSTRUCTION LIST–Contd.**

INSTRUCTION				OPERATION
Op.	X	Addr.	Octal Code	
				Input-Output: Printer
WPL	C	Y	2600000 01yyyyy	Print 1 line of BCD data starting from CS location Y.
WFL	- C	M Y	36mmmmm 01yyyyy	Print 1 line of BCD data starting from CS location Y according to format words starting in CS location M. C = N: data is all numeric. C = blank: data is alphameric.
SLW	-	N	0600000 nn00000	Step paper N lines ($0 \leq N \leq 63$).
SLT	-	N	0x00000 xx00000	Skip to punch in track N of paper tape loop.
BCS	P	BPN	2516P20	Branch if printer controller P is not ready.
BCS	P	BPR	2514P20	Branch if printer controller P is ready.
BCS	P	BOP	2514P22	Branch if printer is out of paper.
BCS	P	BNP	2516P22	Branch if printer is not out of paper.
				Input-Output: Magnetic Tape
WTD -	T -	M N	02mmmmm ttnnnnn	Write N BCD words, starting from CS location M, on tape unit T.
WTB -	T -	M N	03mmmmm ttnnnnn	Write N binary words, starting from CS location M, on tape unit T.
WTS -	T -	M N	23mmmmm ttnnnnn	Write N words in "special binary" mode, starting from CS location M, on tape Unit T.
RTD -	T -	M N	04mmmmm ttnnnnn	Read a maximum of N Decimal words on tape unit T into CS starting at M.
RTB -	T -	M N	05mmmmm ttnnnnn	Read a maximum of N binary words on tape unit T into CS starting at M.
RTS -	T -	M N	25mmmmm ttnnnnn	Read a maximum of N "special binary" words on tape unit T into CS starting at M.
RBD -	T -	M N	14mmmmm ttnnnnn	Read N decimal words backward on tape unit T into CS locations M, M-1, M-2, etc.
RBB -	T -	M N	15mmmmm ttnnnnn	Read N binary words backward on tape unit T into CS locations, M, M-1, M-2, etc.
RBS -	T -	M N	35mmmmm ttnnnnn	Read N "special binary" words backward on tape unit T into CS locations M, M-1, M-2, etc.
RWD	T	-	2000000 tt00000	Rewind tape unit T.
WEF	T	-	0200000 tt00000	Write end-of-file character and gap on tape unit T.
BKW	T	-	1600000 tt00000	Backspace tape unit T 1 block and position head for writing.
BCS	P	BTN	2516P20	Branch if tape controller P is not ready.
BCS	P	BTR	2514P20	Branch if tape controller P is ready.
BCS	P	BEF	2514P21	Branch if end-of-file indicator is on.
BCS	P	BNF	2516P21	Branch if end-of-file indicator is off.
BCS	P	BET	2514P22	Branch if end-of-tape indicator is on.
BCS	P	BNT	2516P22	Branch if end-of-tape indicator is off.

§ 121.

INSTRUCTION LIST—Contd.

INSTRUCTION				OPERATION
Op.	X	Addr.	Octal Code	
BCS	P	BRW	2514P23	Branch if any tape unit on P is rewinding.
BCS	P	BNR	2516P23	Branch if no tape unit on P is rewinding.
BCS	P	BPE	2514P24	Branch if parity error indicator is on.
BCS	P	BPC	2516P24	Branch if parity error indicator is off.
BCS	P	BIO	2514P25	Branch if I/O buffer error indicator is on.
BCS	P	BIC	2516P25	Branch if I/O buffer error indicator is off.
BCS	P	BME	2514P26	Branch if mod 3 or 4 error indicator is on.
BCS	P	BNM	2516P26	Branch if mod 3 or 4 error indicator is off.
				Input-Output: Magnetic Ink Document Handler
RSD	D	M	0020000 00mmm00	Read 1 document on MDH unit D into CS locations M + 63, M + 62, etc.; halt MDH.
RDC	D	M	0040000 00mmm00	Read 1 document as above and continue feeding next document.
PKT	D	S	0060000 00000ss	Route document read by MDH unit D to stacker S.
HLT	D	M	0100000 00mmm00	Halt MDH unit D and read last document into CS locations M + 63, M + 62, etc.
ERB	D	-	0120000 0000000	Reset MDH to ready condition after halt.
BCS	P	SKN	2516P20	Branch if MDH unit K is not ready.
BCS	P	SKR	2514P20	Branch if MDH unit K is ready.
BCS	P	NPK	2514P22	Branch if stacker was not selected within required time.
BCS	P	PDK	2516P22	Branch if stacker was selected within required time.
BCS	P	FSK	2514P24	Branch if MDH unit K is feeding.
BCS	P	NFK	2516P24	Branch if MDH unit K is not feeding.
BCS	P	ICK	2514P26	Branch if invalid character indicator is on.
BCS	P	VCK	2516P26	Branch if invalid character indicator is off.
BCS	P	SKE	2514P30	Branch if any error condition in MDH unit K.
BCS	P	SKC	2516P30	Branch if no error condition in MDH unit K. Note: In the above instructions, D or K may be 1 or 2; all octal codes shown are for MDH unit 1 and will differ for unit 2.
				Internal Storage: Mass Random Access File
PRF OCT	F -	- Z	25f0000 zzzzzzz	Position access mechanism on MRAF unit F at address Z ($0 \leq F \leq 3$).
RRF -	F -	N M	12f00nn 00mmmmm	Read N 64-word sectors from MRAF unit F into CS starting at location M($1 \leq N \leq 16$).
WRF	F	N	37f00nn 00mmmmm	Write N 64-word sectors starting from CS location M into MRAF unit F ($1 \leq N \leq 16$).
BCS	P	BRN	2516P20	Branch if MRADS controller P is not ready.
BCS	P	BRR	2514P20	Branch if MRADS controller P is ready.
BCS	P	FKR	2514P2K	Branch if MRADS unit K is ready ($0 \leq K \leq 3$).
BCS	P	FKN	2516P2K	Branch if MRADS unit K is not ready.
BCS	P	BIO	2514P25	Branch if MRADS I/O error indicator is on.
BCS	P	BIC	2516P25	Branch if MRADS I/O error indicator is off.
BCS	P	RPE	2514P26	Branch if MRADS parity error indicator is on.
BCS	P	RPC	2516P26	Branch if MRADS parity error indicator is off.

§ 121.

INSTRUCTION LIST – Contd.

INSTRUCTION				OPERATION
Op.	X	Addr.	Octal Code	
				Input-Output: DATANET-15
RRM	C		100CCCS	Read Remote Message into core storage starting at (Y) address from (S) station for (C) maximum number of characters.
	Y		00YYYYY	
WRM	C		200CCCS	Write Remote Message from core storage starting at (Y) address to (S) station for (C) maximum number of characters.
	Y		00YYYYY	
RRT	C		120CCC0	Read Paper Tape into core storage starting at location (Y) for a maximum of (C) characters.
	Y		00YYYYY	
WRT	C		210CCC0	Punch Paper Tape from core storage location starting at (Y) and stopping when an End of Transmission code is encountered.
	Y		00YYYYY	
SCN	O		1400000	Start the scanning logic and cause the controller to be set in the receive mode.
BCS	P	RCR	2514020	Branch if DATANET-15 is ready.
BCS	P	RCN	2516020	Branch if DATANET-15 is not ready.
BCS	P	RNT	2516021	Branch if DATANET-15 N second Delay did not occur.
BCS	P	RTD	2516021	Branch and interrupt if DATANET-15 second delay occurred.
BCS	P	RAH	2514022	Branch when a command word parity error causes an alert halt condition.
BCS	P	RNA	2516022	Branch if no command word parity error alert halt condition occurs.
BCS	P	REC	2514023	Branch if preselect DATANET-15 error code is not detected.
BCS	P	RDP	2514024	Branch if data parity error is detected on data received by the DATANET-15 from either core storage or the Paper Tape Reader.
BCS	P	RND	2516024	Branch if no parity error is detected.
BCS	P	RCP	2514025	Branch if a command word parity error is detected.
BCS	P	RNP	2516025	Branch if a command word parity error is not detected.
BCS	P	RSP	2514026	Branch if scanner is positioned on station requesting access.
BCS	P	RSN	2516026	Branch if DATANET-15 scanner is not positioned on station requesting access.
BCS	P	RAE	2514027	Branch on DATANET-15 any error if any error code is detected.
BCS	P	RNE	2516027	Branch on DATANET-15 any error if no error code is detected.
BCS	P	REM	2514030	Branch if an end-of-message code is received during a receive command.
BCS	P	RNM	2516030	Branch if no end-of-message code is received during a receive command.
BCS	P	REX	2514031	Branch if an end of transmission code is detected.
BCS	P	RNX	2516031	Branch if an end of transmission code is not detected.
BCS	P	RPH	2514032	Branch when Paper Tape unit is halted.
BCS	P	RPT	2516032	Branch when Paper Tape unit is not halted.
BCS	P	ROV	2514033	Branch if DATANET-15 character counter has overflowed.
BCS	P	RNO	2516033	Branch if DATANET-15 character counter has not overflowed.
BCS	P	RAI	2514034	Branch if DATANET-15 caused an automatic priority interrupt.
BCS	P	RNI	2516034	Branch if DATANET-15 did not cause an automatic priority interrupt.

§ 121.

INSTRUCTION LIST NOMENCLATURE

Symbol	Definition
A:	A Register, or upper accumulator.
AAM:	Additional Address Modification Groups (optional).
AAU:	Auxiliary Arithmetic Unit.
Addr:	Operand address.
AI:	Automatic Interrupt feature (optional).
AX:	AX Register in Auxiliary Arithmetic Unit.
C:	Designator for all-numeric data to be printed.
CS:	Core Storage.
D:	Magnetic Ink Document Handler unit number.
DAS:	Decimal Addition and Subtraction (optional).
F:	Mass Random Access File unit number.
G:	Address Modification Word group number.
I:	Instruction Register.
J:	Bits 7-19 of an instruction used to increment or test an index register.
K:	(1) Length of a shift in bit positions. (2) Unit number of a peripheral device.
M:	(1) When in column X, denotes that the instruction may be modified by indexing. (2) A Core Storage location.
MDH:	Magnetic Ink Document Handler.
MRADS:	Mass Random Access Data Storage.
N:	(1) N Register, a 6-bit I/O buffer. (2) Counter for number of words, lines, records, etc.
Op:	Mnemonic operation code.
P:	Unit number of a peripheral controller attached to the Controller Selector.
(P):	Contents of instruction address sequence counter (P Register).
PTP:	Paper Tape Punch.
PTR:	Paper Tape Reader.
Q:	Q Register, or lower accumulator.
QX:	QX Register in Auxiliary Arithmetic Unit.
S:	Number of selected stacker on Magnetic Ink Document Handler.
T:	Magnetic Tape Unit number.
TWC:	Three-Way Compare Feature (optional).
X:	(1) Bits 5 and 6 of instruction codes. "M" in column X denotes that the instruction may be indexed; otherwise, modification is not permitted or will produce improper results. (2) Index register number (0, 1, 2, or 3).
Y:	A Core Storage location.
Z:	A Mass Random Access File sector address.
( ):	The contents of a register or Core Storage location; e.g., (Y) means "contents of location Y"
}:	Denotes that these two instruction words are transmitted to a peripheral controller and must be preceded by the SEL P instruction to select the appropriate controller.

CODING SPECIMEN: GAP

§ 131.

.1 CODING SHEET

225 CODING SHEET

PROBLEM: Reqn Cost & Labor Pricing

WRITTEN BY:

PAGE 6 of 11

Symbol (1–6)	Opr (8–10)	Operand (12–19)	X (20)	Remarks (22–75)	Sequence (76–80)
	EXT	ZERO		CARD CODE ZERO OR ONE?	
	BNZ				
	BRU	D		CARD CODE 1	
	INX	-28	3	ZERO MODIFICATION WORD 3	
	SPB	BCD BIN	1		
	DEC	4			
	DEC	28		CONVERT AREA TO BINARY	
	DEC	3			
	BRU	ERROR			
	LAQ			MOVE Q TO A	
H	SUB	TAB	3		
	BNZ				
	BRU	TEST		TLU FOR CORRECT AREA	
	INX	1	3	RELATIVE RATE ADDRESS MAINTAINED IN	
	BXL	11	3	MODIFICATION WORD 3	
	BRU	H			
	BRU	ERROR			
TEST	SPB	BCD BIN	1		
	DEC	4			

Reprinted from GE 225 Programming Manual, p. 118.

CODING SPECIMEN: GECOM

§ 132.

.1 SOURCE LISTING

```
     GECOM LISTING OF JTS                                          PAGE 001

             GE CODER                              JUL 17

     S O U R C E   L I S T I N G

1000 IDENTIFICATION DIVISION.

1005 PROGRAM_ID.         JTS.
1010 AUTHOR.             GE CODER.
1015 DATE_COMPILED.      JUL 17.
1020 INSTALLATION.       GE COMPUTER DEPARTMENT IPC PHOENIX ARIZONA.
1025 REMARKS.            SAMPLE PROBLEM

2000 ENVIRONMENT DIVISION.

2005     OBJECT_COMPUTER, 225, MEMORY SIZE 2 MODULES, ASSIGN OBJECT_PROGRAM
2010         TO CARD READER.
2015     FILE_CONTROL, SELECT JOB_FILE ASSIGN TO CARD READER BUFFER,
2020                   SELECT SUMMARY_FILE ASSIGN TO CARD PUNCH BUFFER,
2025                   SELECT DMH_REPORT ASSIGN TO HSP ON PLUG 6.

3000 PROCEDURE DIVISION.

3001          GO TO S3055
3005 WPH SECTION.
3010 BEGIN.
3015          ADVANCE DMH_REPORT TO TOP OF PAGE.
3020          ADD 1 TO PAGE_COUNT.
3025          ADVANCE DMH_REPORT 4 LINES.
3030          WRITE RPT_TITLE.
3035          ADVANCE DMH_REPORT 3 LINES.
3040          WRITE COL_TITLES.
3045          ADVANCE DMH_REPORT 2 LINES.
3050 END WPH SECTION.
3055 S3055.   OPEN ALL FILES.
3060          MOVE 0 TO PAGE_COUNT.
3065          PERFORM WPH SECTION.
3070          MOVE #ZZ# TO LAST_DEPT.
3075 S3075.   READ JOB_FILE RECORD IF END FILE GO TO S3180.
3080          IF DEPT OF JOB_TICKET EQUALS LAST_DEPT GO TO S3125.
3085 SW3085.  GO TO S3090.
3090 S3090.   ALTER SW3085 TO PROCEED TO S3100.
3095          GO TO S3115.
3100 S3100.   TOTAL_HRS  =  ACC_REG_HRS + ACC_OT_HRS.
3105          WRITE SUMMARY CARD.
3107 SW3107.  GO TO S3110.
3110 S3110.   ALTER SW3150 TO PROCEED TO S3155.
3115 S3115    MOVE DEPT OF JOB_TICKET TO LAST_DEPT, DEPT OF WS.
3120          MAN_COUNT = ACC_REG_HRS = ACC_OT_HRS = 0.
3125 S3125.   ADD 1 TO MAN_COUNT.
3130          ADD REG_HRS TO ACC_REG_HRS.
3135          ADD OT_HRS TO ACC_OT_HRS.
3140          IF LINE_COUNT EQUALS 51 GO TO S3170.
```

§ 132.

.1 SOURCE LISTING (CONTD.)

```
      GECOM LISTING OF JTS                                                   PAGE 002

               GE CODER                                         JUL 17

SOURCE LISTING (CONT.)

3145  S3145.   WRITE DETAIL RECORD.                                         0310
3150  SW3150.  GO TO S3155.                                                 0320
3155  S3155.   MOVE SPACES TO DEPT OF WS.                                   0330
3160           ALTER SW3150 TO PROCEED TO S3075.                            0340
3165           GO TO S3075.                                                 0350
3170  S3170.   PERFORM WPH SECTION.                                         0360
3175           GO TO S3145.                                                 0370
3180  S3180.   ALTER SW3107 TO PROCEED TO S3182.                            0380
3181           GO TO S3100.                                                 0390
3182  S3182.   CLOSE JOB_FILE, SUMMARY_FILE.                                0400
3185           STOP RUN #JTS#.                                              0410


4000  DATA DIVISION.


(SEQ  GAP T DATA NAME     QUALIFIER     F  RPT B J E MS LS DATA IMAGE)

4005. FILE SECTION
4010  OUTPUT FILES.
4015  000FD SUMMARY_FILE.
4020  000 R SUMMARY_CARD                P
4021      F LAST_DEPT                                      XX B(5)
4022      F MAN_COUNT                                      999 B(29)
4023      F ACC_REG_HRS                                    9(6)V9 B(4)
4024      F ACC_OT_HRS                                     9999V9 B(5)
4025      F TOTAL_HRS                                      9(7)V9 B(12)
4100  001FD DMH_REPORT.
4105  000 R RPT_TITLE                   P
4110      L                                                BBB #DEPARTMENT MAN HOUR R
4115  -                                                    EPORT#
4120      L                                                B(42) #PAGE#
4125      F PAGE_COUNT                                     B ZZZ9
4130  001 R COL_TITLES
4135      L                                                B(7) #DEPT MAN NUMBER NAME
4140  -                                                    #
4145      L                                                B(18) #JOB REG-HRS OT-HRS#
4150  002 R DETAIL                      P
4155      F DEPT          WS                               B(7) XX BBB
4160      F MAN_NBR                                        X(5) B(6)
4165      F NAME                                           A(21)B
4170      F JOB_CODE                                       XX BB
4175      F REG_HRS                                        ZZZ.9 BBB
4180      F OT_HRS                                         ZZ.9
4500  INPUT FILES.
4505  002FD JOB_FILE.
4510  000 R JOB_TICKET                  P
4515      F MAN_NBR                                        X(5)
4520  00J F DEPT                                           XX BB
4525      F NAME                                           A(21)
4530      F JOB_CODE                                       XX B(7)
4535  05A F REG_HRS                                        999V9
```

§ 132.

.2 OBJECT LISTING AND TABLES

```
GECOM LISTING OF JTS                                                  PAGE 004

          GE CODER                                   JUL 17

R E F E R E N C E   T A B L E S

PROCEDURE NAME TO GAP SYMBOL

  (GAP  PROCEDURE NAME)

   A01  S3055
   A03  S3075
   A07  S3090
   A08  S3100
   A11  S3110
   A09  S3115
   A05  S3125
   A15  S3145
   A13  S3155
   A14  S3170
   A04  S3180
   A16  S3182
   A06  SW3085
   A10  SW3107
   A12  SW3150
   A02  WPH

NAMES OF SUB-ROUTINES REQUIRED

  (GAP  SECTION NAME)

   ADV
   FLX
   FXP
   RCS
   RLC
   TYP
   ZAM
   ZBN
   ZCB
   ZED
   ZNB
   ZNN
   ZOT
   ZSC
   ZSG
   ZUA

GAP SYMBOLIC TO OCTAL LOCATION

  (GAP OCTAL   GAP OCTAL   GAP OCTAL   GAP OCTAL   GAP OCTAL   GAP OCTAL)

   00A 01363   00J 01402   00S 01110 00TCP 01713 00TXT 01712   00U 01646
   00V 01714 00W00 01664  00WE 01675   00W 01664   00X 01406   00Y 01406
 00Z00 02040   01A 01366   01J 01403   01S 01120 01TCP 02006 01TXT 02005
   01U 01737   01V 02007 01W00 02032 01W01 02034 01W02 02036  01WE 01772
   01W 01755   01X 01406 01Z00 02076 01Z01 02120 01Z02 02133   02A 01370
```

§ 132.

.2 OBJECT LISTING AND TABLES (CONTD.)

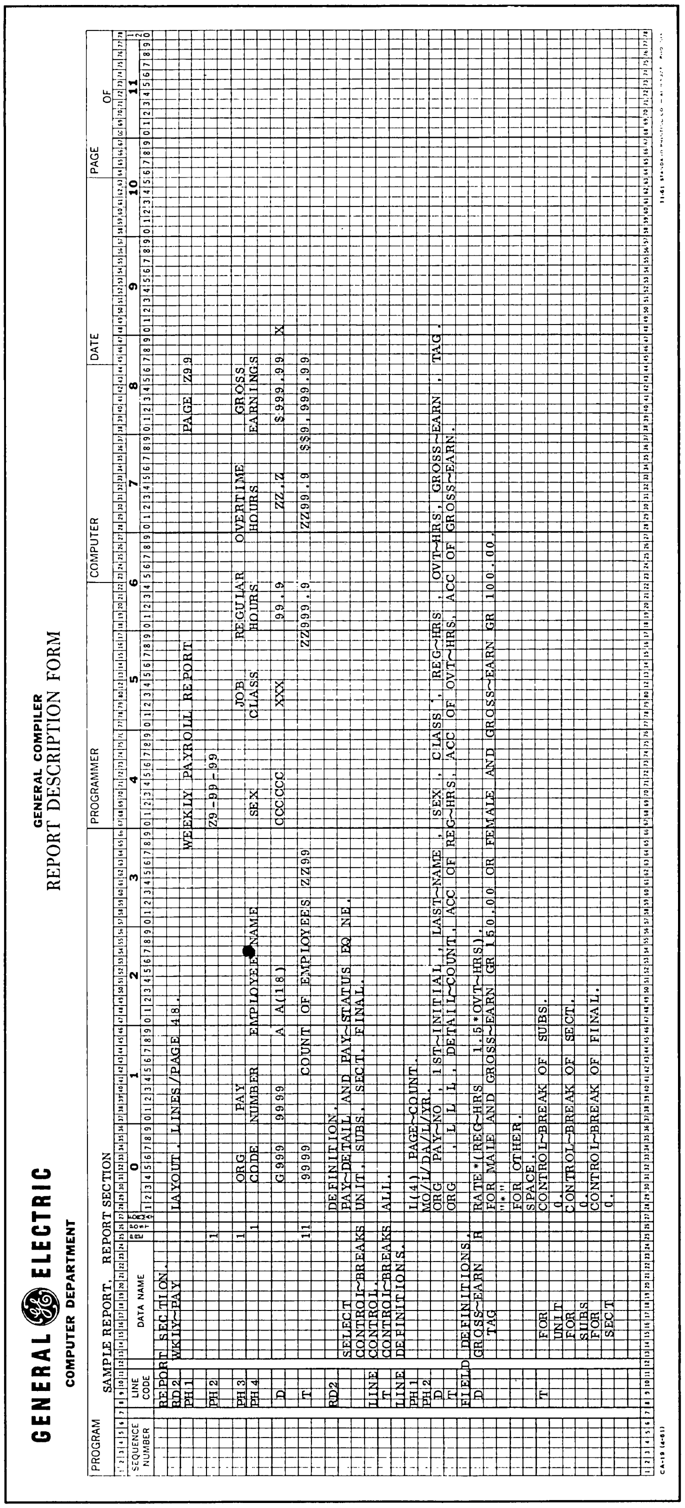
```
     GECOM LISTING OF JTS                                                    PAGE 006

               GE CODER                                        JUL 17

     O B J E C T   L I S T I N G

3001          GO TO S3055.                                                    0010

     01144  2601204            BRU   A01

3005 WPH SECTION.                                                             0020

3010 BEGIN.                                                                   0030

     01145  1420001   A02      INX   1        1
     01146  0000001            LDA   1
     01147  2701203            STO   A02#/@

3015          ADVANCE DMH_REPORT TO TOP OF PAGE.                              0040

     01150  0721142            SPB   ADV      1
              01142   ADV      EQU   TV2-02
     01151  2000006            OCT   2000006
     01152  0000252            LDA   ZER
     01153  0301405            STA   PC6

3020          ADD 1 TO PAGE_COUNT.                                            0050

     01154  0001363            LDA   00A
     01155  0101442            ADD   0J0
     01156  0301363            STA   00A

3025          ADVANCE DMH_REPORT 4 LINES.                                     0060

     01157  0001444            LDA   0J1
     01160  0721142            SPB   ADV      1
     01161  0000006            OCT   0000006
     01162  0001444            LDA   0J1
     01163  0101405            ADD   PC6
     01164  0301405            STA   PC6

3030          WRITE RPT_TITLE.                                                0070

     01165  0722032            SPB   01W00    1

3035          ADVANCE DMH_REPORT 3 LINES.                                     0080

     01166  0001446            LDA   0J2
     01167  0721142            SPB   ADV      1
     01170  0000006            OCT   0000006
     01171  0001446            LDA   0J2
     01172  0101405            ADD   PC6
     01173  0301405            STA   PC6

3040          WRITE COL_TITLES.                                               0090

     01174  0722034            SPB   01W01    1

3045          ADVANCE DMH_REPORT 2 LINES.                                     0100
```

Reprinted from Introduction to GECOM, pp. 60-64.

CODING SPECIMEN: GECOM Report Writer

§ 133.

.1 SOURCE PROGRAM (Report Section only)



GENERAL ELECTRIC
COMPUTER DEPARTMENT

GENERAL COMPILER
REPORT DESCRIPTION FORM

PROGRAM: SAMPLE REPORT, REPORT SECTION

```
REPORT SECTION.
RD 2  WKLY~PAY         LAYOUT, LINES/PAGE 48.
PH 1                                          WEEKLY PAYROLL REPORT                        PAGE Z99
PH 2               1                          Z9-99-99
PH 3               1   ORG    PAY                              JOB    REGULAR   OVERTIME   GROSS
PH 4                1  CODE   NUMBER   EMPLOYEE NAME    SEX    CLASS  HOURS     HOURS      EARNINGS
D                      G999   9999     A A(18)          CCC CCC XXX   99.9      ZZ.Z       $999.99   X
T                  11  9999   COUNT OF EMPLOYEES ZZ99                 ZZ999.9   ZZ99.9  $$9,999.99
RD2                    DEFINITION.
      SELECT           PAY~DETAIL AND PAY~STATUS EQ NE.
      CONTROL~BREAKS   UNIT, SUBS, SECT, FINAL.
LINE  CONTROL.
T     CONTROL~BREAKS   ALL.
LINE  DEFINITIONS.
PH 1                   L(4) PAGE~COUNT.
PH 2                   MO/L/DA/L/YR.
D                      ORG , PAY~NO , 1ST~INITIAL , LAST~NAME , SEX , CLASS , REG~HRS , OVT~HRS , GROSS~EARN , TAG.
T                      ORG , L L L , DETAIL~COUNT, ACC OF REG~HRS, ACC OF OVT~HRS, ACC OF GROSS~EARN.
FIELD DEFINITIONS.
D     GROSS~EARN    R  RATE*(REG~HRS 1.5*OVT~HRS).
        TAG            FOR MALE AND GROSS~EARN GR 150.00 OR FEMALE AND GROSS~EARN GR 100.00.
                       "*"
                       FOR OTHER.
                       SPACE.
T        FOR           CONTROL~BREAK OF SUBS.
         UNIT          0.
         FOR           CONTROL~BREAK OF SECT.
         SUBS          0.
         FOR           CONTROL~BREAK OF FINAL.
         SECT          0.
```

CA-19 (4-61)

§ 133.

.2 SAMPLE REPORT

WEEKLY-PAYROLL REPORT PAGE 28

12-01-61

ORG CODE	PAY NUMBER	EMPLOYEE NAME		SEX	JOB CLASS	REGULAR HOURS	OVERTIME HOURS	GROSS EARNINGS
5484	0671	J JONES		MALE	B01	40.0	10.0	$ 123.44
	0983	A JOHNSON		MALE	A10	37.5		184.01
	1201	B SMITH		FEMALE	C50	40.0	8.0	148.02
	1452	SCHROEDER		MALE	DA2	32.0		84.66
	2352	C BROWN		MALE	D11	40.0	.4	105.19
5484		COUNT OF EMPLOYEES	05			189.5	18.4	645.32
5485	0108	R EDWARDS		MALE	D80	40.0		100.01
	0112	P SMYTHE		FEMALE	B11	35.2		115.55
	1389	A ANDREWS		FEMALE	B01	40.0	8.0	72.06
	1545	R MICHELSON		MALE	A10	40.0	12.0	123.11
	1547	J BERG		MALE	S01	38.2		182.78
	1999	A McMILLAN		FEMALE	C09	40.0	2.2	78.23
	2103	J GWYNN		MALE	B01	40.0	1.8	101.11
5485		COUNT OF EMPLOYEES	07			273.4	24.0	842.85
5480		COUNT OF EMPLOYEES	12			422.9	42.4	1,388.16
5400		COUNT OF EMPLOYEES	33			1302.1	108.0	4,125.29
5501	0133	C STEVENSEN		MALE	E22	40.0		138.06
	0134	L ELLISON		MALE	A09	40.0		149.55
	0222	H MURPHY		FEMALE	C53	40.0		99.99
	2102	J OZER		MALE	B01	40.0		123.02
	2359	A AMBERCROMBIE		MALE	B11	40.0		154.84

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CODING SPECIMEN: TABSOL

§ 134.

.1 SOURCE PROGRAM

GENERAL ELECTRIC
COMPUTER DEPARTMENT, PHOENIX, ARIZONA

GENERAL COMPILER SENTENCE FORM

PROGRAM: SAMPLE DECISION TABLE
PROGRAMMER:
COMPUTER:
DATE:
PAGE:

```
SEQUENCE
NUMBER
    5  PROCEDURE DIVISION.
   10        OPEN INPUT MASTER~FILE.
   15  GET~RECORD. READ MASTER~FILE RECORD IF END FILE GO TO END~RUN.
   20        IF FEMALE GO TO GET~RECORD.
   25        EXPERIENCE = 61 - YR~EMPLOYED + PREV~EXP.

   30  TABLE EXAMPLE. 3 CONDITIONS 2 ACTIONS 5 ROWS.

   35   LEVEL EQ   EXPERIENCE              TITLE                  I   GO TO
   40        6          EQ 2     PROGRAMMER                       1   TYPE~OUT
   45        7          EQ 3     PROGRAMMER OR ANALYST            2      "
   50        8          GR 3     ANALYST                          3      "
   55        9          GR 4     ANALYST OR SR ANALYST            4      "
   60        10         GR 4     SR ANALYST                       5      "

   65        GO TO GET~RECORD.
   70  TYPE~OUT. WRITE DEPARTMENT NAME TITLE LEVEL EXPERIENCE ON TYPEWRITER.
   75        TOTAL (I) = TOTAL (I) + 1.
   80        GO TO GET~RECORD.
   85  END~RUN. CLOSE MASTER~FILE.
   90        WRITE TOTAL (1) TOTAL (2) TOTAL (3) TOTAL (4) TOTAL (5) ON TYPEWRITER.
   95        STOP "END RUN".
```

CA 13 (10/61)

Reprinted from Introduction to GECOM, p. 39.

CODING SPECIMEN: WIZ-II

§ 135.

.1 SOURCE PROGRAM

GENERAL ELECTRIC
COMPUTER DEPARTMENT PHOENIX, ARIZONA

WIZ COMPILER SENTENCE FORM

PROGRAM CURRENT IN AN A.C. SERIES CIRCUIT DATE MAY, 1962
PROGRAMMER W. I. BRANSON PAGE 1 OF 2

SEQUENCE NUMBER	LABEL	@	TYPE	STATEMENT	C	BRANCH 0	+0	+	−	ANY CASE
1 6	7 10	11	12 14	15 59	60	61 64	65 68	69 72	73 76	77 80
0010				$ PROGRAM TO COMPUTE CURRENT IN AN A.C.						
0020				$ SERIES CIRCUIT						
0030				$ W.I. BRANSON MAY, 1962						
0040			D	IARRAY(1000) $ARRAY DIMENSION						
0050			D	SRCH.(5) $SEARCH ROUTINE						
0060			I	PI(3.14159265) $INITIAL PI						
0070	READ		CRD	VOLTS, OHMS, FARADS, HENRYS,	X					
0080				IFREQUENCY, FFREQUENCY, INCREMENT						
0090				J=1 $ARRAY SUBSCRIPT						
0100				FREQUENCY=IFREQUENCY					FIN	
0110			SL	CURRENT IN AN A.C. SERIES CIRCUIT WITH	X					
0120				FREQUENCY VARIED W.I. BRANSON MAY, 1962						
0130			PV	,,						
0140			PL	INPUT PARAMETERS						
0150			PVL	, VOLTS, OHMS, FARADS, HENRYS						
0160			PVL	IFREQUENCY, FFREQUENCY, INCREMENT,,						
0170			PL	CALCULATED RESULTS						
0180			PV	,						
0190	*			XC=1/(2*PI*FREQUENCY*FARADS)						
0200				$CAPACITIVE REACTANCE						
0210				XL=2*PI*FREQUENCY*HENRYS						
0220				$INDUCTIVE REACTANCE						
0230				REACTANCE=XC-XL						
0240				IMPEDANCE=SQRT. (OHMS*OHMS+REACTANCE*	X					
0250				REACTANCE)						
0260				IARRAY(J)=AMPERES=VOLTS/IMPEDANCE						
0270				J=J+1						
0280			PVL	FREQUENCY, AMPERES						
0290				(FREQUENCY=FREQUENCY+INCREMENT) -	X					
0300				FFREQUENCY		*			*	SRCH

Reprinted from WIZ System Reference Manual, pp. E-3, 4.

§ 135.

.1 SOURCE PROGRAM (CONTD.)

SEQUENCE NUMBER 1–6	LABEL 7–10	11	TYPE 12–14	STATEMENT 15–59	C 60	BRANCH 0 61–64	+0 65–68	+ 69–72	− 73–76	ANY CASE 77–80
0310			PV	,,						
0320			PVL	FREQUENCY, LARGEAMPERES,,						READ
0330	SRCH	.		$ SEARCH FOR LARGEST CURRENT CALCULATED						
0340				J=J-1						
0350	*			LARGEAMPERES=IARRAY(J) $REPLACE LARGER						
0360				K=J-1 $SAVE NO. OF LARGEST						
0370	**			J=J-1 $ DO NOT REPLACE, REDUCE		5				
0380				$ELEMENT NO.						
0390				LARGEAMPERES-IARRAY(J) $COMPARE					*	**
0400	5			FREQUENCY=IFREQUENCY+K*INCREMENT						
0410				$FIND FREQUENCY,THEN RETURN						
0420				$ END OF SEARCH ROUTINE						
0430	FIN		PL	END OF PROGRAM						
0440			END	$ END, LOAD NEXT JOB						

CODING SPECIMEN: ZOOM

§ 136.

.1 SOURCE AND OBJECT LISTING

```
          1  NT PROBLEM, TO READ A CARD AND PRINT THE CARD IF ANYTHING
                    PUNCHED IN THE FIRST SIX COLUMNS OTHERWISE NOT

 INPUT - ZOOM

          G  ORG 128. CARD, BSS 40.
           BEGIN, BCN *. RCD CARD. HCR. BCN *.
          Z  IF D CARD EQ SPACE GO BEGIN.
             PT 6 CARD. GO BEGIN.
          Z  ED.

             NT NEED A CHECK PRINT ROUTINE.

 OUTPUT - GAP

         ORG 128
 CARD    BSS 40
 BEGIN   BCN *
         RCD CARD
         HCR
         BCN *
         DLD CARD
         DSU SPACE
         BZE
         XAQ
         BZE BEGIN
         LDA *
         BRU CKPRNT
         SEL 6
         WPL CARD
         BRU BEGIN
 ZERO    DDC 0
 SPACE   ALF
         ALF
 ONE     DEC 1
 TWO     DEC 2
 THREE   DEC 3
 FOUR    DEC 4
 FIVE    DEC 5
 SIX     DEC 6
 SEVEN   DEC 7
 EIGHT   DEC 8
 NINE    DEC 9
 TEN     DEC 10
 XXXXXX  OCT 2777777
 TRUE    EQU ZERO
 FALSE   EQU ONE
 XXXXY1  DDC 0
         END BEGIN
```

Reprinted from ZOOM, a Macro Assembler, p. C-1.

DATA CODE TABLE NO. 1

§141.

.1 USE OF CODE: . . . . . Internal BCD representation and High Speed Printer.

.2 STRUCTURE OF CODE

.21 Character Size: . . . . . 6 bits; 3 characters per word.

.22 Character Structure

.221 More significant pattern: 3 bits; 4-2-1.
.222 Less significant pattern: 3 bits; 4-2-1.

.23 Character Codes

LESS SIGNIFICANT PATTERN	MORE SIGNIFICANT PATTERN							
	0	1	2	3	4	5	6	7
0	0	8	+	H	-	Q	blank	Y
1	1	9	A	I	J	R	/	Z
2	2		B		K		S	
3	3	#	C	.	L	$	T	,
4	4	@	D		M	*	U	%
5	5	-	E		N		V	[
6	6	=	F		O		W	]
7	7		G		P		X	

DATA CODE TABLE NO. 2

§ 142.

.1 USE OF CODE: . . . . . Magnetic tape (BCD mode).

.2 STRUCTURE OF CODE

.21 Character Size: . . . . . . 7 bits; 6 data, 1 even parity.

.22 Character Structure

.221 More significant pattern: 3 bits; 4-2-1.
.222 Less significant pattern: 3 bits; 4-2-1.

.23 Character Codes

LESS SIGNIFICANT PATTERN	MORE SIGNIFICANT PATTERN							
	0	1	2	3	4	5	6	7
0		8	Δ	Y	-	Q	+	H
1	1	9	/	Z	J	R	A	I
2	2	0	S		K		B	
3	3	#	T	,	L	$	C	.
4	4	@	U	%	M	*	D	
5	5		V		N		E	
6	6		W		O		F	
7	7		X		P		G	

DATA CODE TABLE NO. 3

§143.

.1 USE OF CODE: . . . . . Punched card input-output.

.2 STRUCTURE OF CODE

.21 Character Size: . . . . . 1 column.

.23 Character Codes

UNDERPUNCH	OVERPUNCH			
	None	12	11	0
None	Δ			
12	+			
11	-			
0	0			
1	1	A	J	/
2	2	B	K	S
3	3	C	L	T
4	4	D	M	U
5	5	E	N	V
6	6	F	O	W
7	7	G	P	X
8	8	H	Q	Y
9	9	I	R	Z
8-2				
8-3	#	.	$	,
8-4	@		*	%
8-5	-			[
8-6	=			]
8-7				

DATA CODE TABLE NO. 4

§ 144.

.1 USE OF CODE: . . . . internal collating sequence.

.2 STRUCTURE OF CODE

In ascending sequence:

0	-
1	J
2	K
3	L
4	M
5	N
6	O
7	P
8	Q
9	R
#	-0
@	$
—	*
=	blank
+	/
A	S
B	T
C	U
D	V
E	W
F	X
G	Y
H	Z
I	,
+0	%
	[
	]

PROBLEM ORIENTED FACILITIES

§ 151.

.1 UTILITY

.11 Simulators of Other Computers

IBM 650
Reference: . . . . . Programming Manual for the Interpretive Simulation of the IBM 650 on the GE 225.
Date available: . . . simulator for basic 650, November, 1961.

Description:

This routine enables a GE 225 with at least 8,192 words of core storage, card reader, card punch, and console typewriter to simulate an IBM 650 with 2,000 words of drum storage, one 533 card reader and punch, magnetic tapes, core storage, index registers, and floating point arithmetic. Two words of GE 225 core storage are used to represent each ten-digit 650 word, and all internal operations are carried out interpretively in double precision. Plugboard wiring on the 650 is simulated by parameter cards. The routine is designed for fast execution of production programs; the 650 console controls and displays are not fully simulated. A trace option is provided, and a typeout of the 650's register contents occurs whenever the program stops. Average speed for internal processing is about 1 to 2 times as fast as that of the original 650 program.

Royal Precision LGP-30
Reference: . . . . . GE 225 Interpretive Simulation of the Royal McBee LGP-30.
Date available: . . . March, 1962.

Description:

Two separate LGP-30 simulator programs are available. CD255I1.001 is for use with GE 225 systems having 8,192 words of core storage; CD225I1.005 is for use with GE 225 systems having 16,384 words.

The only difference between the two programs is that the 16,384-word version simulates any LGP-30 program without restriction upon program length, and the 8,192-word version requires an LGP-30 program layout to determine the equivalent GE 225 core storage requirement.

Inputs to both simulator programs can be in the form of punched paper tape and/or punched cards. Punched paper tape can be coded in either decimal or hexadecimal.

Both simulator programs are in GE 225 machine language and simulate each of the 16 basic LGP-30 instructions in subroutine form. Upon receiving an LGP-30 instruction, the simulator program decodes the operation and transfers control to the appropriate subroutine for simulation of the operating functions of the LGP-30.

The GE 225 minimum hardware configuration requirements are:

- 8,192- or 16,384-word core storage
- Paper Tape Reader
- Card Reader (optional)
- Console Typewriter
- Paper Tape Punch (optional).

.12 Simulation by Other Computers: . . . . . none.

.13 Data Sorting and Merging

FORWARD Sort/Merge Generator
Reference: . . . . FORWARD Sort/Merge Generator Manual, Edition 1.
Record size: . . . . 1 to 999 words.
Block size: . . . . 1 to 999 words.
Key size: . . . . . 1 to 99 words.
File size: . . . . . 1 reel at a time for sorts; up to 999 reels for merges.
Number of tapes: . . 3 to 8.
Date available: . . September, 1961.

Description:

FORWARD is a generalized tape sorting and merging routine that can be run on a 225 with the minimum 4,096 words of core storage and from three to eight magnetic tape handlers of any speed. It uses the "polyphase" merge technique, wherein the pre-sort generates strings in such a way that the input tapes for the merge process will be exhausted one at a time, and the merge order is always one less than the number of tape handlers used. Parameters for each sort are punched into control cards and used to initialize the generalized routine. Record sizes, key sizes, and blocking factors are pre-set by the parameter cards, but user-coding elements in GAP language may be inserted to handle varying input and output formats or media, to combine or eliminate records having the same control key, or to use non-standard collating sequences. Memory dumps are written at the beginning of each merge phase to facilitate restarts. To avoid complicated tape changing, input to the polyphase sort is limited to one reel at a time. Straightforward merges may be generated to collate from two to 999 input files into a multi-reel output file.

§ 151.

.14 Report Writing

GECOM Report Writer

Reference: . . . . Introduction to GECOM, pp. 33-35.

Date Available: . . June, 1962.

Description:

The Report Writer will be usable in two ways: as an independent routine and as an extension of the GECOM system. When used within a GECOM program, the Report Writer functions primarily as an output subroutine. The Data Division is expanded to include a Report Section made up of detailed specifications for each report to be produced by the object program. A special Report Description Form must be used. In the "non-procedural" mode of operation (report writing only), the source program may consist of an Environment Division, a File Section containing the input file descriptions, and a Report Section; no other entries are required. While reports can be described in the basic GECOM language, the Report Writer will facilitate report preparation and provide better documentation.

GE 225 Card Program Generator

Reference: . . . . . GE 225 Card Program Generator for IBM 407 and IBM 604 Type Equipment.

Date available: . . . currently available.

Description:

The GE 225 Card Program Generator is designed to generate an object program from a set of input parameter cards. The basic design of this program facilitates converting existing plugboard programs for IBM 407 tabulators and IBM 604 calculators into GE 225 programs that produce printed or punched reports from data on punched cards or magnetic tape.

Two versions of the Card Program Generator are available. Program number CD225G1.004 requires a minimum system configuration of 4,096 words of core storage, a card punch, a card reader, and an on-line printer. This program has facilities for card input only.

Program number CD225G1.005 requires the same peripheral devices as the previous program plus 8,192 words of core storage. This version provides facilities for magnetic tape input. Both versions provide facilities for format control, data movement, data conversion, insertion of "own-coding" routines, calling subroutines which are available to "own-coding" portions of program, and card and/or printer output.

.15 Data Transcription

BRIDGE II Service System

Reference: . . . . GE 225 Bridge Service System, CD225J1.001.

Date available: . . . BRIDGE I, December, 1961. BRIDGE II, July, 1963.

.15 Data Transcription (Contd.)

Description:

BRIDGE II is a system of service routines to perform such tasks as the following:

1. Convert binary instruction cards to program tapes.
2. Copy and correct binary tapes.
3. Convert binary or decimal data cards to magnetic tape.
4. Write or check tape labels.
5. Construct and maintain binary program systems tapes.
6. Maintain files containing symbolic source programs or binary object programs.
7. Sequence runs, collect programs, and provide run-to-run linkage. (See also Section 321:191.)

Minimum system configuration is 8,192 words of core storage, card reader, printer, console typewriter, and two magnetic tape units (one for the BRIDGE system tape and one work tape). Operation is controlled by Major Command Cards, which cause the required routines to be loaded, and Minor Command Cards, which provide the parameters for the specific jobs to be done. All data transcription operations are straightforward media conversions with little or no provision for format control or editing.

.16 File Maintenance: . . See BRIDGE II, above.

.17 Other

All of the following routines are available now or will become available during 1963.

1. Routines for solution of simultaneous equations, matrix algebra, linear programming, roots of a polynomial, least squares polynomial fitting, bessel functions, and gamma functions.

2. BANKPAC: A series of generalized routines to handle the demand deposit accounting, installment loan, savings account, personal trust, and transit item functions of a commercial bank. A GE 225 system with at least 8,192 core storage locations, four magnetic tape transports, document handler, printer, card reader, and console typewriter is required.

3. Electric Utility Routines: A series of routines to perform calculations of electrical load flows, optimal loading of a power system, load durations, loading conditions resulting from circuit failures, transient stability, and flows and pressures in a gas system. Required are 8,192 core storage locations, 2 to 5 magnetic tape transports, card reader, punch, and printer.

4. PRONTO: A routine for numerical control of machine tools, designed to control two-dimensional spindle movement of the tool. PRONTO requires a 225 with 8,192 core storage locations, card reader, paper tape punch, card punch, and 4 magnetic tape transports.

§ 151.

.17 Other (Contd.)

5. Critical Path Method (CPM): A routine (similar to PERT) for analyzing the scheduling of a complex project. 8,192 core storage locations, four tape transports, card reader, and printer are required. Capacity is 2,100 activities and 1,000 events. The Project Monitoring and Control Method (PROMOCOM) uses the CPM network model to analyze project performance data, provide up-dated schedules, and identify slippages and bottlenecks.

6. TRIM (Test Rules for Inventory Management): A simulation program for analysis of existing or proposed decision rules for inventory control. The computer model, programmed in TABSOL decision table form, can process demands, estimate future requirements, place and receive replenishment orders, and publish a series of inventory system performance reports. TRIM requires at least 8,192 core storage locations, a card reader, and a printer or card punch.

7. Assembly Line Balancing Program: A routine to balance assembly lines through work element assignment. Adhering to specified constraints upon cycle time, precedence, and zoning, the most efficient balance with a specified number of operators is produced. Up to 225 work elements within up to 19 work zones can be analyzed. Required are 8,192 core storage locations, card reader, and printer.

.17 Other (Contd.)

8. Permuted Index Program Package: A routine to produce an alphabetical index to a body of text, using for indexing purposes only the significant words contained within the text itself; i.e., the Key Word In Context (KWIC) method. The input text must be punched into cards, preferably after manual editing to eliminate indexing difficulties due to punctuation, initials, numerals, etc. An "exclusion dictionary" stores up to 1,494 terms which are considered non-significant and are therefore screened out during the permuting process. The FORWARD Sort/Merge Generator, described in Paragraph .13, is used to arrange the permuted index entries in alphabetical sequence. The output is a list of significant words, with each word shown in context with the line of text (or portion thereof) in which it is found. The present version limits the input to the sort phase to one reel of tape, which will accommodate approximately 5,000 cards of input text. Hardware requirements are 8,192 core storage locations, four magnetic tape transports, card reader, and printer. A card punch is required if punched card output is desired.

.2 PROBLEM ORIENTED LANGUAGES: . . . . none.

PROCESS ORIENTED LANGUAGE: GECOM

§ 161.

.1 GENERAL

.11 Identity: . . . . General Compiler Language GECOM.

.12 Origin:. . . . . General Electric Computer Dept.

.13 Reference:. . . . . . GE 225 GECOM - II Reference Manual.

.14 Description:

GECOM is a pseudo-English process oriented language designed to handle scientific problems as well as general business data processing. The basic language structure is quite similar to that of COBOL61. Capabilities to evaluate complex equations, Boolean expressions, and mathematical functions and to perform computations in floating point arithmetic have been added to the COBOL framework to facilitate the coding of scientific programs. A COBOL 61 to GECOM translator is scheduled for the fourth quarter of 1963.

GECOM differs from COBOL 61 primarily in the areas of data description and procedural organization. GECOM requires all data entities (files, records, groups, fields, and elements) to be described in a fixed format on a standard Data Division form whereas COBOL uses English-language entries for data descriptions. The form of all GECOM fields is defined in the Data Image columns in a manner similar to COBOL's optional PICTURE clause. GECOM permits only five levels of data, whereas up to 51 levels may be defined in COBOL. The valuable COPY, RENAMES, and REDEFINES facilities of Required COBOL 61 are not provided in the GECOM language. In addition to COBOL's File, Working-Storage, and Constant Sections, the Data Division of a GECOM program utilizing the scientific facilities will usually require Array, Integer, True-False, and Common-Storage Sections.

The Procedure Division of a GECOM source program consists of a body of sentences called the main program. The Division may include other groups of sentences called Sections, which are executed as closed subroutines. The PERFORM verb in GECOM can be used only to execute independent Sections, whereas the same verb in COBOL permits execution of any number of consecutive paragraphs or sections according to a variety of criteria. The COBOL verb EXAMINE, which replaces and/or tallies the occurrences of a given character in a data item, is not provided in GECOM. The ENTER verb permits the insertion of GAP symbolic coding into the GECOM source program.

Facilities for TABSOL and report generation are included in the GECOM language. TABSOL is a system for expressing decision logic in a straightforward, tabular form. Each line in a table consists of one or more conditions on the left side and, on the right side, one or more actions to be taken if the specified conditions are true. If the specified conditions are not satisfied, the next line of the table is evaluated. A condition may be a relational or logical expression or a true-false variable, and arithmetic expressions may be used as operands in the relations. Actions may be value assignments or GO TO, PERFORM, STOP, READ, WRITE, OPEN, or CLOSE statements.

Use of the TABSOL format should simplify and systematize the coding of many problems in both the business and scientific areas. See Special Report 23:030 for a general discussion of the formulation and application of decision tables. A sample TABSOL table is shown in Section 321:134.

The GECOM Report Writer facilitates the preparation of printed reports as an integral part of GECOM-coded programs. The GECOM Data Division is expanded to include a Report Section made up of detailed specifications for each report. A special Report Description Form must be used. The facilities of the GECOM Report Writer are described in Section 321:151.14, and a sample Report Description Form and the resulting printed report are shown in Section 321:133.

.15 Publication Date: . . . . initial language specifications: December, 1961
GECOM-II Reference Manual: October, 1962

.2 PROGRAM STRUCTURE

.21 Divisions

Identification: . . . . . . name of author; name and date of program.
Environment: . . . . . . describes target computer, assigns I/O units to files, and specifies computation mode.
Data:. . . . . describes the data items and shows the structure of records, files, working storage and constants.
Procedure:. . . . . describes the procedures in an imperative form.

.22 Procedure Entities

Procedure Division:. . . main program plus sections.
Main Program: . . . . . sentences.
Section: . . . . sentences, performed as a subroutine.
Sentence: . . . . GECOM words.
Segment: . . . . sentences, performed as a separately-compiled subprogram.

§ 161.

.23 Data Entities

File: . . . . records.
Record: . . . . groups.
Group: . . . . fields.
Field: . . . . elements.
Element: . . . . characters.
Number of data levels: . 5, as listed above.

.24 Names

.241 Simple name formation
- Alphabet: . . . . A to Z, 0 to 9, and hyphen.
- Size: . . . . 12 characters max.
- Avoid key words: . . . . yes.
- Formation rule: . . . . at least one letter; no hyphen as first or last character; may not be all numerals and letter E. (Procedure names may be all numeric).

.242 Designators
- Procedures
  - PROCEDURE DIVISION: . . . . . fixed name.
  - Section: . . . . . word "section" is part of name
  - Sentence: . . . . . one word, followed by period.
- Data: . . . . none.
- Equipment: . . . . fixed names or abbreviations for all devices.
- Comments: . . . . begin with key word NOTE.
- Translator control: . . none.

.25 Structure of Data Names

.251 Qualified names
- Example: . . . . TOTAL OF MASTER.
- Multiple qualifiers: . . yes.
- Complete sequence: . . optional.
- Broken sequence: . . . yes.

.252 Subscripts
- Number per item: . . . 0 to 3.
- Applicable to: . . . . . fields, groups.
- Class may be
  - Special index variable: . . . . . . no.
  - Any variable: . . . . . yes.
  - Literal: . . . . yes.
  - Expression: . . . . . yes.
- Form may be
  - Integer only: . . . . . no; also fixed or floating point numbers.
  - Signed: . . . . yes; plus or minus.
  - Truncated fraction: . yes.
  - Rounded fraction: . . no.

.253 Synonyms: . . . . none.

.26 Number of Names: . . . essentially unlimited.

.27 Region of Meaning of Names

.271 Universal names: . . . . only those data names listed in Common-Storage Section.

.272 Local names: . . . . . . all other data names local to main program, section, or segment.

.3 DATA DESCRIPTION FACILITIES

.31 Methods of Direct Data Description

.311 Concise item picture: . . mandatory for each field; DATA IMAGE is similar to COBOL picture.
.312 List by kind: . . . . yes, for integers, arrays, and true-false variables.
.313 Qualify by adjective: . . no.
.314 Qualify by phrase: . . . . no.
.315 Qualify by code: . . . . . yes; format, justification, radix, etc.
.316 Hierarchy by list: . . . . no.
.317 Level by indenting: . . . no.
.318 Level by coding: . . . . . mandatory; TYPE.

.32 Files and Reels

.321 File labels
- Variable layout: . . . . . preset; always 24 words long.
- Control totals: . . . . . own coding.
- Identity control: . . . . description.
- Multi-reel: . . . . description.

.322 Reel sentinels
- Variable layout: . . . . preset; always 24 words long.
- Block count: . . . . . . automatic.
- Multi-files: . . . . . . description.

.33 Records and Blocks

.331 Variable record size: . . preset.
.332 Variable block size: . . . preset.
.333 Record size range: . . . limited only by core storage size.
.334 Block size range: . . . . limited only by core storage size.
.335 Choice of record size: . description.
.336 Choice of block size: . . description.
.337 Sequence control: . . . . none.
.338 In-out error control: . . automatic.
.339 Blocking control: . . . . automatic.

.34 Data Items

.341 Designation of class: . . description.

.342 Possible classes
- Integer: . . . . yes.
- Fixed point: . . . . . . yes.
- Floating point: . . . . . yes.
- Alphabetic: . . . . . . yes.
- Alphameric: . . . . . . yes.

.343 Choice of external radix: . . . . description.

.344 Possible radices
- Decimal: . . . . normal, unless binary is indicated.
- Binary: . . . . alternative.
- Special binary (18 bit): alternative.

.345 Justification: . . . . description, or automatic left for alpha and right for BCD numeric.

.346 Choice of code: . . . . . none.

.348 Item size
- Variable size: . . . . . preset.
- Designation: . . . . . . picture.
- Range
  - Fixed point numeric: . 1 to 11 char. (2 words).
  - Floating point numeric: . . . . 1 to 9 char mantissa; 1 to 2 char characteristic (2 words).
  - Alphameric: . . . . 1 to 83 char.

.349 Sign provision: . . . . . optional.

§ 161.

.35 Data Values

.351 Constants
Possible sizes
Integer: . . . . 1 to 5 char.
Fixed point: . . . . . 1 to 11 char.
Floating point: . . . . 1 to 9 char mantissa.
Alphabetic: . . . . . . 1 to 120 char.
Alphameric: . . . . . 1 to 120 char.
Subscriptable: . . . . . . no.
Sign provision: . . . . . optional.
.352 Literals: . . . . same as Constants, except alphabetics and alphamerics may not exceed 30 characters in Procedure Division literals.
.353 Figuratives
Examples: . . . . ZERO(S), SPACE(S), ONE(S), TWO(S), . . ., NINE(S).
.354 Conditional variables: . . yes.

.36 Special Description Facilities

.361 Duplicate format: . . . . yes.
.362 Re-definition: . . . . . . partial.
.363 Table description
Subscription: . . . . . . mandatory; preset size.
Multi-subscripts: . . . maximum of 3.
Level of item: . . . . . group or field.
Implied subscript at lower level: . . . . no.
.364 Other subscriptable entities: . . . . none.

.4 OPERATION REPERTOIRE

.41 Formulae

.411 Operator List
+ : . . . . addition.
− : . . . . subtraction.
* : . . . . multiplication.
/ : . . . . division.
** : . . . . exponentiation.
SIN: . . . . sine.
COS: . . . . cosine.
ATAN: . . . . arctangent.
SQRT: . . . . square root.
EXP: . . . . exponential.
LOG: . . . . common logarithm.
LN: . . . . natural logarithm.
ABS: . . . . absolute value.
= : . . . . is replaced by.
.412 Operands allowed
Classes: . . . . all numeric.
Mixed scaling: . . . . . yes.
Mixed classes: . . . . no; computation mode is fixed point unless floating is specified.
Mixed radices: . . . . yes.
Literals: . . . . yes.
.413 Statement structure
Parentheses
a - b - c means: . . . (a-b) - c.
a + b x c means: . . . a + (b x c).
a / b / c means: . . . (a/b) /c.
a^{b^c} means: . . . . $((a)^b)^c$.

.413 Statement structure (Contd.)
Parentheses (Contd.)
Size limit: . . . . maximum of 50 operators and/or functions per expression.
Multi-results: . . . . . yes; e.g. X=Y=Z=A+B.
.414 Rounding of results: . . . truncated.
.415 Special cases
x = -x: . . . . x = -x.
x = x + 1: . . . . x = x + 1.
x = 4.7 y: . . . . x = 4.7 * y.
$x = 5 \times 10^7 + y^2$: . . . . x = 5 * 10 ** 7 + y ** 2.
.416 Typical examples: . . . . YTD~FICA = YTD~FICA + (CURR~FICA = GROSS~PAY * 0.3).
X = -B + SQRT (B * B − 4.0 * A * C).

.42 Operations on Arrays: . . none; own coding required.

.43 Other Computation

.431 Operator list
ADD: . . . . addition, to.
SUBTRACT: . . . . subtraction, from.
MULTIPLY: . . . . unrounded multiplication, by.
DIVIDE: . . . . unrounded division, into.
.432 Operands allowed
Mixed scaling: . . . . yes.
Mixed classes: . . . . yes.
Mixed radices: . . . . no.
Literals: . . . . yes.
Restrictions: . . . . . must be pure numeric data; maximum size is 11 digits.
.433 Statement
Mixed verbs: . . . . . . no.
Multi-results: . . . . . . no.
Size limits: . . . . none.
Multi-operand: . . . . . no.
Implied results: . . . . last named operand.
.434 Rounding of results: . . . optional ROUNDED in procedures; else truncated.
.435 Special cases
x = -x: . . . . SUBTRACT X FROM O GIVING X.
x = x + 1: . . . . ADD 1 TO X.
x = x + y: . . . . ADD Y TO X.
x = x ÷ y: . . . . DIVIDE Y INTO X.
x = xy: . . . . MULTIPLY Y BY X.
x = remainder x ÷ y: . . DIVIDE Y INTO X GIVING Z. MULTIPLY Y BY Z. SUBTRACT Z FROM X.
.436 Typical cases
x = y + z: . . . . ADD Y AND Z GIVING X.

.44 Data Movement and Format

.441 Data copy example: . . . MOVE X TO Y.
.442 Levels possible: . . . . . elements, fields, groups, records, arrays.
.443 Multiple results: . . . . MOVE X TO Y, Z.
.444 Missing operands: . . . . none.
.445 Size of operands
Exact match: . . . . . . only groups and records.
Alignment rule
Numbers: . . . . decimal point aligned.
Alpha: . . . . left justified.
Filler rule:
Numbers: . . . . zeros.
Alpha: . . . . spaces.
Truncating rule
Numbers: . . . . at each end.
Alpha: . . . . at right.

§ 161.

.446 Editing possible
- Change class: . . . . . description.
- Change radix: . . . . . yes.
- Delete editing symbols: . . . . no.
- Insert editing symbols
  - Actual point: . . . . . description.
  - Suppress zeroes:. . . description.
  - Insert: . . . . $, . * + − 0 blank.
  - Float: . . . . $ + −.

.447 Special moves: . . . . . none.
.448 Code translation: . . . . none.
.449 Character manipulation: . . . . . indirect.

.45 File Manipulation

- Open:. . . . . OPEN.
- Close: . . . . CLOSE.
- Advance to next record:. . . . . READ, WRITE.
- Step back a record: . . . none.
- Set restart point: . . . . specified in Environment.
- Restart: . . . . no.
- Start new reel: . . . . . no.
- Start new block:. . . . . no.
- Search on key:. . . . . . READ file-name UNTIL condition.
- Rewind: . . . . automatic with CLOSE file.
- Unload: . . . . none.

.46 Operating Communication

.461 Log of progress: . . . . WRITE ... ON TYPEWRITER.
.462 Messages to operator:. . WRITE ... ON TYPEWRITER.
.463 Offer options: . . . . . . own GECOM coding using WRITE ... ON TYPEWRITER and READ ... FROM CONSOLE SWITCHES.
.464 Accept option:. . . . . . READ ... FROM CONSOLE SWITCHES

.47 Object Program Errors

Error	Discovery	Special Actions
Overflow:	IF SIZE ERROR	own GECOM coding.
In-out:	automatic	automatic, followed by own GECOM coding if error persists.

.5 PROCEDURE SEQUENCE CONTROL

.51 Jumps

.511 Destinations allowed: . . sentences, TABSOL tables and table rows.
.512 Unconditional jump:. . . GO TO X.
.513 Switch:. . . . . sentence, named Y, containing only GO TO X.
.514 Setting a switch:. . . . . ALTER Y TO PROCEED TO Z.
.515 Switch on data: . . . . . GO TO X, Y, Z depending on W.

.52 Conditional Procedures

.521 Designators
- Condition: . . . . IF.
- Procedure:. . . . . . . implied.

.522 Simple Conditions
- Expression v Expression: . . . yes.
- Expression v Variable: . . . . yes.
- Expression v Literal: . . . . yes.
- Expression v Figurative:. . . . no.
- Expression v Condition: . . . . yes.
- Variable v Variable:. . . . . yes.
- Variable v Literal: . . . . . yes.
- Variable v Figurative:. . . . no.
- Variable v Condition: . . . . yes.
- Conditional value: . . . . yes.

.523 Conditional relations
- Equal: . . . . IS (NOT) EQUAL TO; EQ; NEQ.
- Greater than: . . . . . IS (NOT) GREATER THAN; GR; NGR.
- Less than: . . . . IS (NOT) LESS THAN; LS; NLS.
- Greater than or equal:. IS NOT LESS THAN; NLS.
- Less than or equal: . . IS NOT GREATER THAN; NGR.

.524 Variable conditions:. . . IS (NOT) POSITIVE.
IS (NOT) NEGATIVE.
IS (NOT) ZERO.

.525 Compound Conditionals
- IF x AND y: . . . . . unlimited; may be mixed with OR.
- IF x OR y:. . . . . . unlimited; may be mixed with AND.
- IF x DO a AND y DO b:. . . . . no.
- IF x DO a OR y DO b:. . . . . no.

.526 Alternative designator: . none; go to next sentence if condition is false.
.527 Condition on alternative: . . . . . . no.
.528 Typical examples:. . . . IF X EQ Y GO TO Z.
IF X IS LESS THAN Y GO TO A, IF EQUAL GO TO B, IF GREATER GO TO C.
IF X GR 10 AND ((A OR B NGR 50) AND C LS D) AND E NEQ F GO TO Z.

.53 Subroutines

.531 Designation
- Single statement: . . . none.
- Set of statements
  - First:. . . . . section-name SECTION.
  - Last: . . . . END section-name SECTION.

.532 Possible subroutines: . . sections, segments.
.533 Use in-line in program:. . . . . optional copy of section as open subroutine.
.534 Mechanism
- Cue with parameters: . PERFORM section-name SECTION USING ... GIVING ...
- Number of parameters: . . . . . essentially unlimited.
- Cue without parameter: . . . . . PERFORM section-name SECTION.
- Formal return: . . . . END section-name SECTION.
- Alternative return: . . none.

§ 161.

.535 Names
Parameter call by value: . . . . none.
Parameter call by name: . . . . PERFORM section-name SECTION USING name-1, name-2, ... GIVING name-3, name-4, ...
Non-local names: . . . those listed in Common-Storage Section.
Local names: . . . . . all others.
Preserved local variables: . . . . . . none.
.536 Nesting limit: . . . . . . no limit.
.537 Automatic recursion allowed: . . . . none.

.54 Function Definition by Procedure

.542 Level of procedure: . . . standard library functions only.
.543 Mechanism
Cue: . . . . X = SIN (Y + Z).
Formal return: . . . . automatic

.55 Operand Definition by Procedure: . . . . . none.

.56 Loop Control

.561 Designation of loop: . . . A. VARY B FROM C BY D UNTIL condition. (Set of one or more sentences) EXIT A.
.562 Control by count: . . . . no.
.563 Control by step
Parameter
Special index: . . . . none.
Any variable: . . . . VARY B FROM 1 BY 1 UNTIL B EQ 5.
Step: . . . . any variable.
Criteria: . . . . any conditional expression.
Multiple parameters: . no.
.564 Control by condition
Example: . . . . UNTIL
Combined with step: . . mandatory.
.565 Control by list: . . . . . no.
.566 Nesting limit: . . . . . . unlimited.
.567 Jump out allowed: . . . . yes.
.568 Control variable exit status: . . . . available always.

.6 EXTENSION OF THE LANGUAGE: . . . none.

.7 LIBRARY FACILITIES

.71 Identity: . . . . GECOM.

.72 Kinds of Libraries

.721 Fixed master: . . . . . . yes.
.722 Expandable master: . . . no.
.723 Private: . . . . no.

.73 Storage Form: . . . . . . magnetic tape.

.74 Varieties of Contents: . . math functions, input-output control routines, radix conversion routines, floating point arithmetic routines.

.75 Mechanism

.751 Insertion of new item: . . no.

.753 Method of call: . . . . . . functions by name; routines by PERFORM routine-name or automatically as required by procedures or data descriptions.

.76 Types of Routine: . . . . closed.

.8 TRANSLATOR CONTROL

.81 Transfer to Another Language: . . . . ENTER GAP permits insertion of GAP coding in GECOM source program.

.82 Optimizing Information Statements: . . . . . . none.

.83 Translator Environment: . . . . . by control card entries.

.84 Target Computer Environment: . . . . . specified in Environment Division.

.85 Program Documentation Control: . . . . by console switches.

.9 TARGET COMPUTER ALLOCATION CONTROL

.91 Choice of Storage Level: . . . . none.

.92 Address Allocation: . . only via Common-Storage assignments.

.93 Arrangement of Items in Words in Unpacked Form: . . . . U in Format column of Data Division.

.94 Assignment of Input-Output Devices: . . . . Environment Division.

.95 Input-Output Areas: . . . block length in Data Division; alternate areas (BUFFER) in Environment Division.

PROCESS ORIENTED LANGUAGE: FORTRAN

§ 162.

.1 GENERAL

.11 Identity: . . . . GE 225 FORTRAN.

.12 Origin: . . . . Computer Techniques Operation.
General Electric Missile and Space Vehicle Division, Valley Forge, Pa.

.13 Reference: . . . . The General Electric 225 FORTRAN System.

.14 Description

The GE 225 FORTRAN language is a restricted but useful version of FORTRAN II, the most widely accepted process oriented language for scientific applications. For a general description of the FORTRAN II language, see Section 408:161. The principal restrictions on the GE 225 FORTRAN language are the limitation of arrays to two dimensions rather than three and the lack of Boolean, complex, and double precision arithmetic. Other restrictions of the GE 225 version relative to IBM 709/7090 FORTRAN II are listed in Paragraph .142 below.

Because of the use of two consecutive 20-bit GE 225 words to represent a floating point number (30 bits plus sign for the fraction and 8 bits plus sign for the exponent), a wider range of numeric magnitudes can be accommodated in the GE 225 than in the IBM 7090. A precision of approximately nine decimal digits is maintained. GE 225 FORTRAN includes a number of other useful extensions to the FORTRAN II language. All are described in Paragraph .143 below.

The minimum equipment configuration for compilation and execution of GE 225 FORTRAN programs is:

Central Processor with 8,192 core storage locations and typewriter.
1 Card Reader.
1 Card Punch.
1 On-Line Printer.
1 Magnetic Tape Controller.
4 Magnetic Tape Transports (i.e., 2 Dual Tape Handlers.
Auxiliary Arithmetic Unit.
Move Command.
Decimal Addition and Subtraction.
Three-Way Compare.
Additional Address Modification Groups.

Object programs can be executed on smaller systems (e.g., no magnetic tape or printer) if certain language facilities are not utilized. If a 16,384-word core store is available, the upper 8,192 locations can be used for data storage but not for object program instructions or subroutines.

.14 Description (Contd.)

In the original version of GE 225 FORTRAN, source programs are read from punched cards and converted into VFAP, an assembly language also developed by GE's Missile and Space Vehicle Division. The VFAP program is then assembled into GE 225 machine language. The object program listing is in both VFAP and absolute octal form. The entire translation process is automatic. The GE 225 FORTRAN system will be modified by the GE Computer Department to use the GAP assembly language (Section 321:171) as an intermediate in place of VFAP. (A punched card FORTRAN II compiler for GE 225 systems without magnetic tape is being developed, but details are not yet available.)

Object programs produced by the GE 225 FORTRAN Compiler differ in two ways from those produced by the 709/7090 FORTRAN II Compiler: arrays are stored "forward" (in increasing storage locations) in the 225, and there are no "in-line" functions in GE 225 FORTRAN. All function references in the source program cause the generation of links to closed subroutines. These compiler differences generally need not concern the FORTRAN programmer.

.141 Availability: . . . . . . March, 1963.

.142 Restrictions

(1) The following statements are not permitted:

Assigned GO TO
ASSIGN
SENSE LIGHT
IF (SENSE LIGHT)
IF QUOTIENT OVERFLOW
READ DRUM
WRITE DRUM.

(2) Boolean, complex, and double precision operations are not permitted.

(3) Arrays are limited to two dimensions (709/7090 FORTRAN II permits three).

(4) The following statements may be included in the source program, but will be ignored:

IF ACCUMULATOR OVERFLOW
IF DIVIDE CHECK
FREQUENCY.

(5) FORMAT specifications cannot be read in at object program execution time.

(6) Alphameric characters are not permitted as arguments in a CALL statement.

(7) Subroutine names are not permitted as arguments in a CALL or SUBROUTINE statement.

§ 162.

.142 Restrictions (Contd.)

(8) Arithmetic statement functions are not permitted.

(9) The only permissible carriage control characters are blank (for single space), 0 (double space), and 1 (skip to hole in channel 1 of printer format tape). These control characters may be used only in PRINT statements, whereas 709/7090 FORTRAN II permits their use in WRITE OUTPUT TAPE statements as well.

(10) In the FORMAT specification Aw, the maximum number of significant alphameric characters per item is three (versus six in 709/7090 FORTRAN II).

(11) In the FORMAT specification Ow, the maximum number of significant octal digits per item is seven (versus twelve in 709/7090 FORTRAN II).

(12) The CHAIN feature, which permits programs too large to fit into core storage to be executed as a series of independent "links," has not been implemented.

.143 Extensions

(1) Larger ranges of numeric magnitudes can be accommodated, as shown in the following table:

System	Floating Point	Fixed Point
GE 225:	10^{-76} to 10^{+76}	1 to 524,287.
IBM 709/7090:	10^{-38} to 10^{+38}	1 to 131,071.

.143 Extensions (Contd.)

(2) Whereas a single statement cannot occupy more than 10 cards in 709/7090 FORTRAN II, there is essentially no limit in GE 225 FORTRAN.

(3) Statement numbers up to 99999 are permitted; the limit is 32767 in 709/7090 FORTRAN II.

(4) Statements in the VFAP assembly language (also developed by the GE Missile and Space Vehicle Division) can be included in the source program. VFAP cards are identified by a "V" punched in column 1.

(5) The abbreviations WOT and RIPT can be substituted for the FORTRAN statements WRITE OUTPUT TAPE and READ INPUT TAPE, respectively.

(6) The statement RCD reads input data from punched cards in a free field format. Fields may be of variable length and are separated by commas. F or X preceding a number denotes conversion to floating or fixed point internal form, respectively.

(7) The COMMON storage area always starts at octal location 17766 and extends downward. In GE 225 systems with 16K core stores, there is another storage area, called "KOMMON," which extends downward from octal location 37766 and is referenced by the added specification statement KOMMON.

PROCESS ORIENTED LANGUAGE: WIZ-II

§ 163.

.1 GENERAL

.11 Identity: . . . . GE 225 WIZ System. WIZ-II.

.12 Origin: . . . . General Electric Computer Department, Phoenix, Arizona.

.13 Reference: . . . . GE 225 WIZ System Reference Manual.

.14 Description

WIZ is a one-pass algebraic compiler for scientific problems. WIZ-coded programs can be compiled and executed on a GE 225 with 8,192 core storage locations and punched card or paper tape input-output. Magnetic tape can be utilized, when available, in either the compilation or execution phase. The WIZ-II translator is described in Section 321:183.

The WIZ language is relatively easy to learn and use, but its capabilities are considerably less extensive than those of FORTRAN or ALGOL. Arithmetic operations are expressed in an "equation" form nearly identical to that of FORTRAN. The left-hand side of every equation is a variable, whose value is determined by evaluating the arithmetic expression on the right side of the equal sign. The WIZ arithmetic operators, the sequence of operations, and the meaning of parentheses are the same as in FORTRAN. Unlike FORTRAN, WIZ permits the use of more than one equal sign (=) in a statement; e.g.

A = B = J + (K = K + 1).

This means "increment the current value of K by 1, add J, and store the result in both B and A."

Arithmetic is performed in either the floating point or integer mode, depending upon the form of the operands in an expression. Whenever mixed mode operands are encountered, the computation is performed in the floating point mode. Two GE 225 word locations are used to represent each variable and constant, providing a floating point precision of 30 binary bits (or about 9 decimal digits) and a range of 10^{-76} to 10^{+76}. Floating point arithmetic is performed by the Auxiliary Arithmetic Unit when it is available; if not, standard subroutines are used. WIZ provides no facilities for complex or extended precision arithmetic or for Boolean operations.

WIZ source programs are written on fixed-format coding sheets (shown on page 321:135.100) that have the following layout:

.14 Description (Contd.)

Columns 1-6:	Sequence Number (optional)
Columns 7-10:	Statement Label
Columns 12-14:	Statement Type
Columns 15-59:	Statement
Column 60:	Statement-Continuation
Columns 61-80:	Branch Fields

Statement labels are usually 2-digit numbers; they may alternatively be alphameric labels of up to 4 characters or strings of 1 to 4 asterisks, in which case special rules of usage apply. If a statement is not referenced as a branch destination, it need not be labeled.

The Statement Type field is left blank for ordinary arithmetic statements. Eleven other statement types, designated by symbols of one to three characters, are provided for control of data input and output, specification of array dimensions, assignment of initial values, and translator control.

The Statement field defines the operation(s) to be performed. It can contain several statements separated by commas, or a single statement can be continued over an "unlimited" number of lines by inserting any non-blank character except $ into Column 60 of each line except the last.

The Branch Fields are the most novel feature of the WIZ language. There are five 4-column Branch Fields, labeled "zero," "non-zero," "plus," "minus," and "any case." A statement label placed in any of these Branch Fields causes a branch to the specified statement if the result of the last expression evaluated satisfies the specified condition. The Branch Fields are examined in sequence, from left to right. The "any case" field denotes an unconditional transfer of control. If all of the Branch Fields are blank, or if none of the specified conditions is true, the next statement in sequence is executed.

Symbolic "Label Equivalents" can be written in the Branch Fields as well as actual statement labels. A Label Equivalent is a variable whose value at the time the Branch Field is examined is considered a numeric statement label. This provides a capability for switches and multi-way transfers of control, as in the Assigned GO TO and Computed GO TO statements of FORTRAN. WIZ provides no explicit facility for initialization and control of loops (such as the DO statement of FORTRAN), but these operations can easily be coded through proper use of the WIZ Branch Fields.

Closed subroutines (called "procedures") can be coded in WIZ and compiled along with the main program or separately. The subroutines are usually

§ 163.

.14 Description (Contd.)

used as functions, in which case up to 49 parameters can be transmitted to the subroutine and a single result is returned to the main program. A library of 10 standard function subroutines is included in WIZPAC, the WIZ object program execution package. GAP-assembled machine language subroutines can be utilized in WIZ programs if they are coded in a prescribed form to utilize the WIZ-generated linkages.

Data input to the WIZ object program is via punched cards or paper tape. Only numeric data in decimal form can be read in. The data can be punched in a free-field format. Each number can be expressed in fixed or floating point form and can be up to 12 characters long. A blank column is used to separate consecutive items. The FORTRAN facility for implied DO loops in input-output statements is not provided in WIZ.

Output from WIZ object programs can be on the printer, the console typewriter, or the card or tape punch, as specified by console switch settings. Magnetic tape input-output can be used as an option. Each data item is normally printed or punched into a 15-character "value block." If desired, the label of each variable can be printed in the value block immediately following its numeric value. Alphameric constants can also be printed to provide titles and column headings. WIZ-produced output data on punched cards can be re-entered as input data to any WIZ-compiled program.

.15 Publication Date: . . . . November 1961; revised in June and December, 1962.

.2 PROGRAM STRUCTURE

.21 Divisions: . . . . no formal divisions.

.22 Procedure Entities

Program: . . . . composed of statements and (optional) procedures.
Procedure: . . . . composed of statements.
Statement: . . . . composed of statement label, statement type, statement body, and branch designators; all parts except statement body may be omitted.

.23 Data Entities

Variable: . . . . a named one-word fixed point or two-word floating point quantity whose value can be changed through computation.
Array: . . . . a one-dimensional set of related variables, referenced by means of the array name followed by a subscript.

.24 Names

.241 Simple name formation (for variables and arrays)
Alphabet: . . . . letters A-Z and numerals 0-9.
Size: . . . . unlimited; first 30 characters must be unique.
Avoid key words: . . . not applicable.
Formation rule: . . . first character must be alphabetic; no punctuation marks allowed; blanks are ignored.

.242 Designators
Procedures
Procedure names: . must begin with letter, contain maximum of 4 characters, and be followed by a period; e.g., SQRT.
Statement labels: . . maximum of 4 characters (usually 2-digit numbers from 10-99), or 1 to 4 asterisks, or blank if not referenced in procedures.
Data: . . . . no designators.
Equipment: . . . . . . not named.
Comments: . . . . . . begin with $ anywhere in statement field.
Translator control: . statement type symbols, composed of 1 to 3 letters.

.25 Structure of Data Names

.251 Qualified names: . . . . not permitted.
.252 Subscripts
Number per item: . . 1.
Applicable to: . . . . any variable.
Class may be
Any variable: . . . . yes.
Literal: . . . . yes.
Expression: . . . . . yes.
Form may be
Integer only: . . . . recommended for maximum efficiency.
Signed: . . . . must be non-negative.
Truncated fraction: . no.
Rounded fraction: . . yes.
.253 Synonyms
Preset: . . . . yes, using EQU statement.
Dynamically set: . . . no.

.26 Number of Names: . . . depends upon size of each name used; approximately 250 4-character names can be handled.

.27 Region of Meaning of Names: . . . . all WIZ names are universal, except for numeric and asterisk statement labels, which are local to the procedure or main program in which they are defined.

.3 DATA DESCRIPTION FACILITIES

.31 Methods of Direct Data Description: . . none.

.32 Files and Reels: . . . . programmer-provided.

§ 163.

.33 Records and Blocks: . . programmer-provided; no facilities in WIZ language.

.34 Data Items

.341 Designation of class: implied by procedures, choice is made automatically at execution time.

.342 Possible classes
- Integer: . . . . yes.
- Fixed point: . . . . . no.
- Floating point: . . . . yes.
- Alphabetic: . . . . . . no.
- Alphameric: . . . . . no.

.343 Choice of external radix: . . . . no; always decimal.

.345 Justification: . . . . . . automatic right justification for integers.

.346 Choice of code: . . . . automatic.

.347 Possible external codes
- Input: . . . . column-decimal card code.
- Output: . . . . column-decimal card code, or printed results in decimal form.

.348 Internal item size
- Variable size: . . . . fixed; 1 word per integer and 2 words per floating point item.
- Range
  - Fixed point numeric: -99,999 to +99,999 (integer only).
  - Floating point numeric: . . . . . 10^{-76} to 10^{+76}.

.349 Sign provision: . . . . . optional.

.35 Data Values

.351 Constants
- Possible sizes
  - Integer: . . . . 1 to 5 decimal digits with no decimal point or exponent.
  - Fixed point: . . . . . none.
  - Floating point: . . . 1 to 8 decimal digits with decimal point and/or decimal exponent, in range 10^{-76} to 10^{+76}.
  - Alphameric: . . . . for output only, 1 line of up to 120 chars or 1 card of up to 80 characters.
- Sign provision: . . . . optional.

.352 Literals: . . . . same as constants.

.353 Figuratives: . . . . . . none.

.354 Conditional variables: . none.

.36 Special Description Facilities: . . . . . . none.

.4 OPERATION REPERTOIRE

.41 Formulae

.411 Operator list
- Arithmetic
  - + : . . . . add.
  - - : . . . . subtract (may be unary).
  - * : . . . . multiply.
  - / : . . . . divide.
  - ** : . . . . exponentiation.
  - = : . . . . is replaced by.

.411 Operator list (Contd.)
- Functions
  - SIN. (E): . . . . . . sine of E.
  - COS. (E): . . . . . . cosine of E.
  - ATAN. (E): . . . . . arctangent of E.
  - SQRT. (E): . . . . . square root of E.
  - LN. (E): . . . . . . natural log of E.
  - EXP. (E): . . . . . . exponential: e^E.
  - ABS. (E): . . . . . . absolute value of E.
  - INT. (E): . . . . . . truncate E to an integer.
  - SWT. (E): . . . . . . test console switch E, where $0 \leq E \leq 19$.
  - MODE. (E): . . . . . select printer, card punch, or typewriter for compiler output.

.412 Operands allowed
- Classes: . . . . numeric only.
- Mixed scaling: . . . . yes.
- Mixed classes: . . . . yes; conversion is automatic.
- Mixed radices: . . . . no.
- Literals: . . . . yes.

.413 Statement structure
- Parentheses
  - a - b - c means: . . (a - b) - c.
  - a + b x c means: . . a + (b x c).
  - a/b/c means: . . . . (a/b)/c.
- Size limit: . . . . . . not specified.
- Multi-results: . . . . no.

.414 Rounding of results: . . truncated.

.415 Special cases
- x = -x: . . . . X = -X.
- x = x + 1: . . . . X = X + 1.
- x = 4.7y: . . . . X = 4.7 * Y.
- x = 5 x 10^7 + y^2: . . . X = 5.T7 + Y*Y.
- x = y integer part: . . X = INT. (Y).

.416 Typical examples: . . . X = (-B + SQRT. (B*B - 4.0 * A * C))/(2.0 * A).
X = Y = K + (J = J + 1).

.42 Operations on Arrays: . by own WIZ coding; no automatic facilities.

.43 Other Computation: . . none.

.44 Data Movement and Format

.441 Data copy example: . . Y = X.

.442 Levels possible: . . . . data items only.

.443 Multiple results: . . . . yes; Z = Y = X.

.444 Missing operands: . . . not possible.

.445 Size of operands: . . . fixed for internal and output operations; variable for input data.

.446 Editing possible
- Change class: . . . . automatic.
- Change radix: . . . . automatic.
- Delete editing symbols: . . . . . . automatic.
- Insert editing symbols
  - Actual point: . . . . automatic.
  - Suppress zeroes: . . automatic; on integer output only.
  - Insert: . . . . no.
  - Float: . . . . no.

.447 Special moves: . . . . . none.

.448 Code translation: . . . automatic.

.449 Character manipulation: . . . . . none.

.45 File Manipulation: . . . none.

§ 163.

.46 Operating Communication

.461 Log of progress: . . . . printer or typewriter messages.
.462 Messages to operator: . printer or typewriter messages.
.463 Offer options: . . . . . printer or typewriter messages.
.464 Accept option: . . . . . test console switch settings.

.47 Object Program Errors

Error	Discovery	Special Actions
Overflow:	automatic	set result to 10^{+76} and continue (no message).
In-out:	automatic	type message and halt.
Invalid data:	automatic	type message, substitute 10^{+76} for the bad data, and continue.
Underflow:	automatic	set result to zero and continue (no message).

.5 PROCEDURE SEQUENCE CONTROL

.51 Jumps

.511 Destinations allowed: . any named statement or procedure.
.512 Unconditional jump: . . to destination specified in columns 77-80 of any executable statement.
.513 Switch: . . . . effected by use of a variable "Label Equivalent" in columns 77-80 in place of an absolute statement label.

.52 Conditional Procedures

.521 Designators: . . . . . . WIZ has no explicit conditional statements. The 5 Branch Designator fields in columns 61-80 can cause jumps to specified statements or procedures if the result of the last expression is:
zero
non-zero
positive
negative
any case.

.53 Subroutines

.531 Designation
Single statement: . . . procedure name in Label field.
Last: . . . . END, or next procedure name.
.532 Possible subroutines: . any number of statements.
.533 Use in-line in program: no.
.534 Mechanism
Cue with parameters: not possible for subroutines; see Paragraph .543 for functions.
Cue without parameter: . . . . . procedure name without terminal period in a branch field.
Formal return: . . . . period in a branch field.
Alternative return: . . none.
.535 Names
Parameter call by value: . . . . no.
Parameter call by name: . . . . no.
Local names: . . . . . only statement labels composed of 2 decimal digits or 1 to 4 asterisks.
Non-local names: . . all other names.
.536 Nesting limit: . . . . . no restriction.
.537 Automatic recursion: . no.

.54 Function Definition by Procedure

.541 Designation
Single statement: . . . procedure name in Label field.
Set of statements
First: . . . . procedure name in Label field.
Last: . . . . END, or next procedure name.
.542 Level of procedure: . . any number of statements.
.543 Mechanism
Cue: . . . . procedure name followed by 1 to 4 parameters enclosed in parentheses; e.g., VOL. (TEMP, PRESS).
.544 Names
Parameter call by value: . . . . yes.
Parameter call by name: . . . . no.
Local names: . . . . . only statement labels composed of 2 decimal digits or 1 to 4 asterisks.

.55 Operand Definition by Procedure: . . . . . . none.

.56 Loop Control: . . . . . WIZ has no explicit loop control facilities (such as DO, FOR, PERFORM, or VARY), but the Branch Designator fields (Paragraph .521) permit effective loop control by count, by step, or by condition.

.6 EXTENSION OF THE LANGUAGE: . . no facilities provided.

.7 LIBRARY FACILITIES

.71 Identity: . . . . WIZ Function Library.

.72 Kinds of Libraries: . . fixed master.

.73 Storage Form: . . . . . punched cards or paper tape.

§ 163.

.74 Varieties of Contents: . 10 standard function subroutines.

.75 Mechanism

.751 Insertion of new item: . no provisions.
.753 Method of call: . . . . . all standard function subroutines are included in WIZPAC and are always present at execution time.

.76 Types of Routine: . . . closed only.

.8 TRANSLATOR CONTROL

.81 Transfer to Another Language: . . . . no.

.82 Optimizing Information Statements: . . . . . . none.

.83 Translator Environment: . . . . . console switches are used to select output device.

.84 Target Computer Environment: . . . . . console switches are used to select output device.

.85 Program Documentation Control: . . . . by console switches.

.9 TARGET COMPUTER ALLOCATION CONTROL: . . . . . . none.

MACHINE ORIENTED LANGUAGE: GAP

§ 171.

.1 GENERAL

.11 Identity: . . . . GE 225 General Assembly Program.
GAP.

.12 Origin: . . . . General Electric Computer Department.

.13 Reference: . . . . GE 225 Programming Reference Manual, CPB 252.

.14 Description

The General Assembly Program is the basic machine oriented language for the GE 225. It is a straightforward symbolic assembly system that permits full utilization of the system's capabilities but provides few refinements. No macro-instructions are provided, and literals are available only for incrementing and testing index registers. Twenty-three pseudo-operations define constants, name and reserve areas, control address allocation, and cause transfer control cards to be punched by the translator. Constants may be written in decimal form for conversion by the translator to floating point or single or double word-length fixed point form. The three-letter mnemonic operation codes are easy to remember, and operand addresses may be either actual (in decimal notation) or symbolic.

.15 Publication Date: . . . . original specifications: March, 1961.

.2 LANGUAGE FORMAT

.21 Diagram: . . . . refer to GE 225 Coding Sheet, 321:171.820.

.22 Legend

SYMBOL: . . . . label for a core storage location.
OPR: . . . . mnemonic operation code for an instruction or pseudo-instruction.
OPERAND: . . . . actual (decimal) or symbolic address of data to be operated upon, including specification of relative addressing if used.
X: . . . . number of an index register (if address modification is to be performed) or of a peripheral unit.
REMARKS: . . . . explanatory comments to be listed but not translated.
SEQUENCE: . . . . . . number for sequencing of the source deck.

.23 Corrections: . . . . . . leaving gaps in sequence numbers permits insertions.

.24 Special Conventions

.241 Compound addresses: . . up to 8 characters of sums and differences of symbols, decimal numbers and/or asterisks.
.242 Multi-addresses: . . . . none.
.243 Literals: . . . . available only for incrementing and testing index registers.
.244 Special coded addresses: * refers to "this address".
.245 Other
Actual core storage addresses: . . . . . . decimal numbers positioned anywhere in operand field.

.3 LABELS

.31 General

.311 Maximum number of labels: . . . . 1,200 with 8K core storage.
.312 Common label formation rule: . . . . yes.
.313 Reserved labels: . . . . none.
.314 Other restrictions: . . . . . none.
.315 Designators: . . . . . . none.
.316 Synonyms permitted: . yes.

.32 Universal Labels

.321 Labels for procedures
Existence: . . . . mandatory if referenced by other instructions.
Formation rule:
First character: . . . any alphameric except +, -, or *.
Others: . . . . any alphameric except +, -, or *.
Number of characters: . . . . 1 to 6; at least one must be non-numeric.
.322 Labels for library routines: . . . . same as Procedures.
.323 Labels for constants: . . same as Procedures.
.324 Labels for files: . . . . . none.
.325 Labels for records: . . . none.
.326 Labels for variables: . . same as Procedures.

.33 Local Labels: . . . . . . none.

§ 171.

.4 DATA

.41 Constants

.411 Maximum size constants
- Integer
  - Decimal: . . . . 6 digits for single-length constant; 12 for double-length, on 2 lines.
  - Octal: . . . . 7 digits.
  - Hexadecimal: . . . . not used.
- Fixed numeric
  - Decimal: . . . . 8 chars/line; may be continued.
  - Octal: . . . . 7 digits.
  - Hexadecimal: . . . . not used.
- Floating numeric
  - Decimal: . . . . 8 chars/line; may be continued.
  - Octal: . . . . not used.
  - Hexadecimal: . . . . not used.
- Alphabetic: . . . . 45 chars/line.
- Alphameric: . . . . . . 45 chars/line.

.412 Maximum size literals: 8,192; for incrementing and testing index registers only.

.42 Working Areas

.421 Data layout
- Implied by use: . . . . no.
- Specified in program: yes.

.422 Data type: . . . . tabulated in program.
.423 Redefinition: . . . . . . yes; EQU pseudo.

.43 Input-Output Areas

.431 Data layout: . . . . specified in program.
.432 Data type: . . . . tabulated in program.
.433 Copy layout: . . . . no.

.5 PROCEDURES

.51 Direct Operation Codes

.511 Mnemonic
- Existence: . . . . mandatory.
- Number: . . . . 278.
- Example: . . . . ADD: $(A) + (Y) \longrightarrow A$.

.512 Absolute: . . . . not used in GAP.

.52 Macro-Codes: . . . . . none.

.53 Interludes: . . . . none.

.54 Translator Control

.541 Method of control
- Allocation counter: . . pseudo-operations.
- Label adjustment: . . . pseudo-operations.
- Annotation: . . . . pseudo-operations.

.542 Allocation counter
- Set to absolute: . . . . ORG (decimal) or LOC (octal) pseudo.
- Set to label: . . . . . . ORG pseudo.
- Step forward: . . . . . ORG pseudo with * in operand.
- Step backward: . . . . ORG pseudo with * in operand.
- Reserve area: . . . . . BSS pseudo.

.543 Label adjustment
- Set labels equal: . . . . EQU pseudo.
- Set absolute value: . . . EQU pseudo.
- Clear label table: . . . no.

.544 Annotation
- Comment phrase: . . . "Remarks" columns of any card.
- Title phrase: . . . . . . REM pseudo.

.6 SPECIAL ROUTINES AVAILABLE

.61 Special Arithmetic

.611 Facilities: . . . . double length multiply and divide, floating point arithmetic, complex floating arithmetic, matrix arithmetic.
.612 Method of call: . . . . . . insert in deck and assemble with source program.

.62 Special Functions

.621 Facilities: . . . . log, exponential, square root, and common trigonometric functions in single-length, double-length, and floating point modes.
.622 Method of call: . . . . . insert in deck and assemble with source program.

.63 Overlay Control: . . . . none.

.64 Data Editing

.641 Radix conversion: . . . . BCD-to-binary and binary-to-BCD.
- Code translation: . . . . paper tape I/0 routines.

.642 Format control: . . . . none; normally handled by Printer Controller circuitry.
.643 Method of call: . . . . . . insert in deck and assemble with source program.

.65 Input-Output Control

.651 File labels: . . . . Symbolic Tape I/0 System.
.652 Reel labels: . . . . Symbolic Tape I/0 System.
.653 Blocking: . . . . Symbolic Tape I/0 System.
.654 Error control: . . . . . Symbolic Tape I/0 System.
.655 Method of call: . . . . . insert I/0 routine and parameter lists behind symbolic deck before assembly.

.66 Sorting:

.661 Facilities: . . . . Short List Internal Sort sequences records of 1 to 50 words.
.662 Method of call: . . . . . insert in deck and assemble with source program.

.67 Diagnostics

.671 Dumps: . . . . selective core storage dumps available for either Console Typewriter or Printer.

§ 171.

.672 Tracers: . . . . TRACE lists, after executing each instruction, the location, instruction, and contents of A, Q, P, I, and index registers.

.673 Snapshots: . . . . Typewriter Memory Dump subroutines permit selective printouts at any point in program.

.7 LIBRARY FACILITIES

.71 Identity: . . . . GE 225 Programming Library.

.72 Kinds of Libraries

.721 Fixed master: . . . . . . no.
.722 Expandable master: . . . yes.
.723 Private: . . . . yes.

.73 Storage Form: . . . . . cards (can be converted to magnetic tape by the BRIDGE Service System).

.74 Varieties of Contents: . . input-output, math, and service routines and numerous problem-oriented routines are available or being developed.

.75 Mechanism

.751 Insertion of new item: . . file in card library.
.752 Language of new item: . . generally GAP.
.753 Method of call: . . . . . insert in deck.

.76 Insertion in Program

.761 Open routines exist: . . . yes.
.762 Closed routines exist: . . yes.
.763 Open-closed is optional: . . . . no.
.764 Closed routines appear once: . . . . yes.

.8 MACRO AND PSEUDO TABLES

.81 Macros: . . . . none.

.82 Pseudos

Code	Description
ALF:	stores a 3-character alphameric constant in BCD form.
BSS:	reserves a block of core storage.
DEC:	stores a decimal number as a single precision binary constant.

.82 Pseudos (Contd.)

Code	Description
DDC:	stores a decimal number as a double precision binary constant.
END:	indicates end of program to be assembled, and punches a transfer control card.
EQO:	specifies the octal address to be assigned to a symbol.
EQU:	specifies the decimal or symbolic address to be assigned to a symbol.
FDC:	stores a decimal number as a two-word floating point constant.
LOC:	sets allocation counter to specified octal address.
ORG:	sets allocation counter to specified decimal or symbolic address.
NAL:	stores 2's complement of 3-character alphameric constant.
OCT:	stores an octal number as a single precision binary constant.
REM:	denotes remarks to be listed but ignored in the assembly.
TCD:	punches a card to transfer control to the specified address.
MAL:	enters alphameric data into as many as 15 consecutive storage locations.
PAL:	same as MAL, except minus sign is entered into last alphameric word.
SBR:	obtains specified subroutine from the GAP II Master Tape.
EJT:	advances printer paper to top of next page.
SEQ:	checks sequence numbers on source program cards.
NAM:	prints name or title on each page of GAP listing.
NLS:	inhibits printer listing of GAP assembly.
LST:	initiates printer listing of GAP assembly after NLS pseudo.
Z(xx):	sets operation bits of an assembled instruction to any specified configuration.

GENERAL ELECTRIC

COMPUTER DEPARTMENT, PHOENIX, ARIZONA

225 GENERAL ASSEMBLY PROGRAM CODING SHEET

PROGRAMMER	PROGRAM	DATE	PAGE / OF

	Symbol (1–6)	Opr (8–10)	Operand (12–19)	X (20)	REMARKS (31–75)	Sequence (76–80)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
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CK-34 (1/62)

MACHINE ORIENTED LANGUAGE: ZOOM

§ 172.

.1 GENERAL

.11 Identity: . . . . ZOOM Macro Assembler.

.12 Origin: . . . . General Electric Computer Department.

.13 Reference: . . . . GE 225 ZOOM: A Macro Assembler, revised May, 1962.

.14 Description

ZOOM is a pre-GAP macro assembly system designed to facilitate machine oriented programming of the GE 225. Input consists of punched cards containing combinations of GAP symbolic coding (described in Section 321:171) and ZOOM statements. Output consists of GAP statements on punched cards or magnetic tape, which serve as direct input to the GAP translator (Section 321:181). A printer listing is optional.

The ZOOM system is an unusual compromise between the generalized, process oriented approach of compiler systems (such as GECOM and WIZ) and the straightforward but time-consuming approach of simple symbolic assembly systems (such as GAP). The objective is to minimize the detail work associated with assembly-level coding while retaining its characteristically high object program efficiencies.

The ZOOM language is made of up a combination of pseudo-English statements, algebraic expressions, and symbolic machine coding. ZOOM was designed primarily to simplify the coding of these types of operations:

- Algebraic expressions
- Logical decisions
- Subscripting of field names
- Data input and output.

The ZOOM source program is punched into 80-column cards. The first six columns can hold an optional sequence number. Column 7 designates one of 5 sentence modes (Z, G, S, F, or A) which are described below. Columns 8 through 80 are used for the ZOOM sentence itself. Sentence-names and field-names consist of one to six alphameric characters. A sentence can be up to 100 words in length, spread over any number of cards and terminated by a period. Each name and each special character (e.g., period, comma, parenthesis) counts as one word. Any field-name or sentence-name can be "tagged" with a 1, 2, or 3 to designate indexing by one of the three index registers. Except in a few special cases, numeric literals cannot be used in ZOOM statements. Constant numeric values must

.14 Description (Contd.)

therefore be referenced by field-names and generated by means of GAP pseudo instructions.

The Z mode includes sentences and expressions which are quite similar in structure and effect to those of the GECOM language, but more abbreviated in format; e.g.:

GECOM - ALTER SEN~1 TO PROCEED TO SEN~2.

ZOOM - AT SEN~1 SEN~2.

There is a ZOOM statement analogous to each GECOM statement, except that READ, WRITE, and the ability to handle multi-dimensional arrays are not provided in ZOOM. Printing and typing can be executed in the Z mode. Other input-output operations are usually handled by standard GE 225 utility subroutines or by specialized, user-coded subroutines. The Z mode sentence types are listed and briefly described in Paragraph .16, below.

The S, F, and A modes are used to code algebraic expressions. S designates fixed point single precision operations, F designates two-word floating point using subroutines, and A designates two-word floating point using the Auxiliary Arithmetic Unit. The normal rules of algebra are followed. Unlike FORTRAN, ALGOL, and GECOM, however, the value of the expression on the left side of the equal sign replaces the single variable on the right side; e.g.:

F SIN(A 2/C + J)*B=J=I 2.

In this example, the expression on the left is evaluated and stored in symbolic address J and in the address developed by adding the contents of index register 2 to symbolic address I. Variable A is also subscripted by index register 2. The index register "tags" are the only permissible subscripts in ZOOM, so the evaluation of complex and/or multi-dimensional subscripts is not automatic (as in FORTRAN), but must be coded in detail. Function linkages can be generated by preceding the argument with the name of the function, as in the above example. The corresponding subroutine must be manually inserted into the object deck. A maximum of twelve pairs of parentheses can be used in a sentence.

The G mode permits the use of GAP assembly language coding at any point in the ZOOM source program. All of the facilities of the GAP language can be utilized. The GAP coding must be written in a free-field format in ZOOM programs, whereas a fixed format (Page 321:171.820) is required for direct input to the GAP translator. GAP fields are separated by commas or blanks, each GAP instruction is

§ 172.

.14 Description (Contd.)

terminated by a period, and more than one instruction can be punched on a card. The G mode cards pass through the ZOOM macro assembly process without translation.

The ZOOM-to-GAP translation may require one or two passes. The second pass is required only if user-defined macro instructions are referenced in the source program. The macro instructions must be defined in GAP coding, either within the ZOOM source program or on separate cards which are read in during the second pass. Wherever a user-defined macro is referenced in the source program, the associated GAP coding is inserted in-line during the second pass. The second pass, when used, also scans the object program in an effort to eliminate excess coding.

There are three versions of the ZOOM translator. The 8K version (Program CD225F1.002) requires a GE 225 with 8,192 core storage locations, a card reader, and a card punch. Use of one magnetic tape drive reduces card handling when the two-pass translation process is required. Four magnetic tape drives permit automatic ZOOM-to-GAP and GAP-to-machine-language translations without operator intervention.

Two different versions of the ZOOM translator are available for 4K GE 225 systems. Program CD225F1.004 uses subroutines for all floating point arithmetic operations, whereas Program CD225F1.005 assembles coding for the Auxiliary Arithmetic Unit. Because of the limited core storage space, the following restrictions apply to both 4K versions:

- The AB, EX, DX, and DO sentence types are not permitted.
- Required constants are not generated automatically; they must be supplied by the user.
- User-defined macro instructions cannot be used.
- No error typeouts are produced during the translation.
- There are minor limitations on G mode (GAP) coding.

.15 Publication Date: . . . . February 1962; revised May 1962.

.16 Z Mode Sentence Types

AB: . . . . takes the absolute value of a single or double precision field; e.g., AB S A.

AD: . . . . denotes double precision addition and/or subtraction; e.g., AD A + B - F = G = H.

AL: . . . . denotes a string of alphameric characters to be typed or printed.

.16 Z Mode Sentence Types (Contd.)

AS: . . . . denotes single precision addition and/or subtraction.

AT: . . . . sets a switch; analogous to the ALTER verb of COBOL.

BG: . . . . begins a ZOOM program.

CA: . . . . performs a three-way comparison of two single or double precision fields, and transfers control accordingly.

DE: . . . . analogous to the "GO TO . . . DEPENDING ON . . . " conditional transfer of COBOL.

DO: . . . . controls the execution of a loop, as in FORTRAN.

DX: . . . . exchanges two double precision fields.

ED: . . . . ends a ZOOM program and causes a string of constants to be written.

EN: . . . . ends a ZOOM program; no constants are written.

ER: . . . . transfers control to designated sentence upon arithmetic overflow.

GO: . . . . transfers control unconditionally to the designated sentence.

IF: . . . . performs logical comparisons and tests; e.g., IF S VAL~1 GR VAL~2 GO SEN~1.

MO: . . . . moves a block of 1 to 999 consecutive words from one core storage area to another.

NT: . . . . designates a note, which will not be reproduced on the GAP output.

PR: . . . . causes a section of coding (see SN) to be performed, after which control is returned to the main program.

PT: . . . . prints a line; control by a format line is optional.

SC: . . . . advances printer paper to specified channel.

SN: . . . . designates a section of coding, performed by a PR sentence.

ST: . . . . causes a processor halt.

SW: . . . . advances printer paper the specified number of lines.

SX: . . . . exchanges two single precision fields.

TY: . . . . types an alphameric message.

VA: . . . . controls the execution of a loop; less specific and less efficient than DO.

*S or *D: . . . . denotes multiplication of two single precision fields; S or D denotes single or double precision result.

/S or /D: . . . . denotes division; divisor and quotient must be single precision; S or D denotes single or double precision dividend.

PROGRAM TRANSLATOR: GAP

§ 181.

.1 GENERAL

.11 Identity: . . . . GE 225 General Assembly Program. GAP.

.12 Description

This translator converts GAP source programs into GE 225 machine language form. Minimum configuration for operation of the translator includes 4,096 words of core storage, console typewriter, and punched card or paper tape input-output units. Three card passes are required to produce a packed (38 instructions per card) binary object program deck. A high speed printer, if available, can be used for on-line listings of the symbolic and machine-language instructions and error indications. Systems with four or more magnetic tape units can utilize the GAP Systems Tape for automatic assemblies without intermediate card handling operations. There is a general one-to-one correspondence between GAP statements and machine-language instructions, except for pseudo-operations, double-length constants, and some input-output and conditional branching operations which require two computer words. All hardware facilities in the target computer can be fully utilized.

.13 Originator: . . . . General Electric Computer Department, Phoenix, Arizona.

.14 Maintainer: . . . . . . as above.

.15 Availability: . . . . . . March, 1961.

.2 INPUT

.21 Language

.211 Name: . . . . GE 225 General Assembly Language (GAP); see Section 321:171.
.212 Exemptions: . . . . . . none.

.22 Form

.221 Input media: . . . . . . punched cards, paper tape, or magnetic tape.
.222 Obligatory ordering: . . according to coding sheet sequence numbers.

.223 Obligatory grouping: . . none.

.23 Size Limitations

.231 Maximum number of source statements: . . limited by target computer storage size.
.232 Maximum size source statements: . . one card containing one instruction or constant.
.233 Maximum number of data items: . . . . total of 1,200 labels with 8K core storage.

.3 OUTPUT

.31 Object Program

.311 Language name: . . . . GE 225 machine language.
.312 Language style: . . . . binary; choice of absolute or relocatable form.
.313 Output media: . . . . . punched cards, 38 instructions per card, or paper tape; when Systems Tape is used, output may be cards, binary magnetic tape, or paper tape.

.32 Conventions

.321 Standard inclusions: . . none.
.322 Compatible with: . . . . BRIDGE II Service System; see Section 321:191.

.33 Documentation

Subject	Provision
Source program: . . .	listing.
Object program: . . .	listing.
Storage map:	listing (label table).
Restart point list: . .	none.
Language errors: . .	listing and typewriter message.

.4 TRANSLATING PROCEDURE

.41 Phases and Passes

Pass 0: . . . . processes mnemonics and analyzes all symbolic labels.
Pass 1: . . . . assigns storage locations to symbolic labels.
Pass 2: . . . . processes operands and prepares object deck and listing.

.42 Optional Modes

.421 Translate: . . . . yes.
.422 Translate and run: . . . no.
.423 Check only: . . . . . . no.
.424 Patching: . . . . no; must alter object deck or reassemble.
.425 Up-dating: . . . . no.

.43 Special Features

.431 Alter to check only: . . no.
.432 Fast unoptimized translate: . . . . no.

§ 181.

.433 Short translate on restricted program: . no.

.44 Bulk Translating: . . . no.

.45 Program Diagnostics: . none.

.46 Translator Library

.461 Identity: . . . . GAP Library.
.462 User restrictions: . . . general.
.463 Form
Storage medium: . . . magnetic tape or cards.
Organization:. . . . . relocatable binary form.
.464 Contents:. . . . . as incorporated by user.
.465 Librarianship
Insertion:. . . . . . . BRIDGE Service System.
Amendment: . . . . . BRIDGE Service System.
Call Procedures: . . . SBR statement calls routine from library tape and forms linkage.

Note: No translator library for paper tape version; required routines must be manually inserted into object program.

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed Overhead

Name	Space	Comment
Symbolic Tape I/O System:	868 words	optional inclusion.

.512 Space required for each input-output file: . . . variable.
.513 Approximate expansion of procedures: . . . . slightly over 1.0.

.52 Translation Time

.521 Normal translating
Card version: . . . . 0.017S minutes for 900-statement program, including card handling time.
Magnetic tape version: 0.005S minutes for 2,500-statement program, using 15,000-char/sec. tape units.

.53 Optimizing Data:. . . . none.

.54 Object Program Performance:. . . . . unaffected; i.e., same as hand coding.

.6 COMPUTER CONFIGURATIONS

.61 Translating Computer

.611 Minimum configuration: . . . . Central Processor with 4,096 words of core storage, card or paper tape reader and punch, and console typewriter.
.612 Larger configuration advantages:. . . . . . printer provides on-line listings; one magnetic tape unit permits use of GAP Systems Tape; four or more tape units permit automatic assembly.

.62 Target Computer

.621 Minimum configuration: . . . . any GE 225 system.
.622 Usable extra facilities:. . . . . . . all.

.7 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Missing entries:	none.	
Unsequenced entries:	optional check	noted in listing.
Duplicate names:	check	noted in listing.
Improper format:	limited checks	noted in listing.
Incomplete entries:	limited checks	noted in listing.
Target computer overflow:	none.	
Inconsistent program:	none.	
Undefined names:	check	noted in listing.
Illegal operations:	check	noted in listing.
Symbol table overflow:	check	type message and stop.

.8 ALTERNATIVE TRANSLATORS: . . . none.

PROGRAM TRANSLATOR: GECOM

§ 182.

.1 GENERAL

.11 Identity: . . . . General Compiler. GECOM.

.12 Description:

The General Compiler translates programs written in the GECOM language (described in Section 321:161) into relocatable GE 225 machine language object programs. The minimum equipment requirements for GECOM compilations are 8, 192 core storage locations, console typewriter, card reader, card punch, printer, and at least 4 magnetic tape transports (i.e., 2 dual tape handlers). One or two additional tape transports can be utilized if available for source program input and/or object program output. GECOM object programs can be executed on any GE 225 system that has the equipment required by the programs themselves. Paper tape input-output and the Three-Way Compare and Decimal Add-Subtract features cannot be utilized.

The compilation process is automatic and consists of four distinct phases:

- Transformer Phase - translates the source program into an intermediate internal language; lists the Identification and Environment Divisions; groups, organizes, and checks the Data and Procedure Divisions; prints error messages on the console typewriter; screens out unnessential words; and initiates preparation of the object program.

- Reformer Phase - calls in and initiates execution of the routines that are required to produce the object program from the generator library on the GECOM master tape.

- Assembler Phase - translates the object program from the intermediate language to GE 225 machine language and outputs it on punched cards or magnetic tape.

- Editor Phase - produces the program documentation, consisting of: a source program listing; reference tables showing the GAP symbol assigned to each programmer-named sentence, the names of all required subroutines, and the octal address assigned to each GAP symbol; and an object program listing in both absolute octal and GAP symbolic form, with source statements interspersed (see Section 321:131).

The GECOM Master Tape includes a library of closed subroutines that are referenced when certain language facilities are used. When the object program is written on magnetic tape, the required

.12 Description (Contd.)

library subroutines are included automatically. When the object program is on punched cards, the required subroutines can be punched as part of the program deck or added manually at load time. Input-output operations are controlled by standard closed subroutines. The characteristics of each file are defined by a "file table," which occupies 44 to 48 words of core storage per magnetic tape file and 8 words per card reader, card punch, and printer file.

Any input item that is referenced by a procedural sentence other than MOVE, EXCHANGE, or WRITE is automatically placed in Process Storage, a compiler-generated extension of the Working Storage Section, when it is read in by the object program. At the same time, mode and radix conversions and unpacking are performed as necessary to insure efficient Procedure Division data manipulation. Two word locations are assigned to each numeric item. If the Computation Mode sentence in the Environment Division specifies the floating point mode, all numerics except integers and true-false variables are stored in floating point binary form; otherwise, all numerics are stored in two-word fixed point binary form. Alphameric fields in Process Storage are in unpacked, left-justified, BCD form.

When the object program executes a WRITE sentence, the output record is assembled by means of moves from input records, Process Storage, and Working Storage. All necessary radix conversions, editing, and packing are performed to achieve the specified output format. The fact that all GECOM computations are performed in the binary mode upon unpacked, fixed-length items makes it essential for the GECOM programmer to follow certain conventions in laying out the Data Division in order to produce efficient object programs:

- Items used in arithmetic computations should be kept in binary form from run to run and converted to decimal form only upon final output. Computational items in master files should be in binary form. Non-computational items should be described as alphameric.

- Items which are moved from input to output without Procedure Division references should be combined into alphameric "throughput strings," which can be moved with maximum efficiency.

- Items of high activity should be kept in unpacked form from run to run.

- Items which are combined in arithmetic operations should be kept at the same binary or decimal scale to minimize scaling operations.

Translation of a 250-card source program for a typical business application required 11 minutes

§ 182.

.12 Description (Contd.)

and generated about 2,000 lines of object coding (listed in GAP symbolic form) exclusive of required library routines. GE asserts that an average program that fills an 8,192-word memory will not require more than 25 minutes for the whole translation process. Data on object program efficiencies is not yet available. Design objectives call for over-all efficiencies of 90 percent on running time and 85 to 90 percent on storage requirements.

.13 Originator: . . . . . . General Electric Computer Dept., Phoenix, Arizona.

.14 Maintainer: . . . . . . as above.

.15 Availability: . . . . . initial version released in March, 1962.

.2 INPUT

.21 Language

.211 Name: . . . . GECOM.
.212 Exemptions . . . . . . use of paper tape I/O, Three-Way Compare, Decimal Add-Subtract.

.22 Form

.221 Input media: . . . . . punched cards, magnetic tape.
.222 Obligatory ordering: . . Identification Division. Environment Division. Data Division. Procedure Division.
.223 Obligatory grouping: . . by division and section.

.23 Size Limitations

.231 Maximum number of source statements: . . limited by target computer storage; overlays can be utilized.
.232 Maximum size source statements: . . unlimited.
.233 Maximum number of data items: . . . . . essentially unlimited.

.3 OUTPUT

.31 Object Program

.311 Language name: . . . . GE 225 machine language.
.313 Output media: . . . . . punched cards or magnetic tape.

.32 Conventions

.321 Standard inclusions: . . loader; other routines as required.
.322 Compatible with:. . . . BRIDGE II Service System.

.33 Documentation

Subject	Provision
Source program: . . .	listing.
Object program: . . .	listing (in GAP symbolic form).
Storage map:.	listing (symbolic label table).
Restart point list: . .	listing.
Language errors:. . .	listing and/or typewriter message.

.4 TRANSLATING PROCEDURE

.41 Phases and passes: . . twelve passes, divided into Transformer, Reformer, Assembler, and Editor phases. See Description, Paragraph .12.

.42 Optional Modes

.421 Translate: . . . . . . yes.
.422 Translate and run: . . . no.
.423 Check only: . . . . . . yes.
.424 Patching: . . . . can translate by segment.
.425 Up-dating: . . . . . . no.

.43 Special Features

.431 Alter to check only: . . no.
.432 Fast unoptimized translate: . . . . . . no.
.433 Short translate on restricted program: . no.

.44 Bulk Translating: . . . yes.

.45 Program Diagnostics: . none.

.46 Translator Library

.461 Identity: . . . . GECOM Library.
.462 User restriction: . . . general.
.463 Form
Storage medium: . . . magnetic tape.
Organization: . . . . ?
.464 Contents
Routines: . . . . . . closed.
Functions:. . . . . . absolute, square root, log, exponential, trig.
Data descriptions: . . none.
.465 Librarianship
Insertion: . . . . . . BRIDGE Service System.
Amendment: . . . . . BRIDGE Service System.
Call procedure: . . . functions by name; standard service routines inserted automatically when required.

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed overhead: . . . . 576 locations, including buffered card read and punch areas.

§ 182.

.512 Space required for each input-output file: . . . alternate areas only if specified in Environment Divisions.

.513 Approximate expansion of procedures: . . . . 8 for typical business routine, exclusive of library subroutines.

.52 Translation Time

.521 Normal translating: . . not more than 25 minutes for average 8, 192-word memory load, according to GE.

.53 Optimizing Data: . . . none.

.54 Object Program Performance

Design objectives (not necessarily achieved in all cases)

Time: . . . . 90 percent.
Space: . . . . 85 to 90 percent.

.6 COMPUTER CONFIGURATIONS

.61 Translating computer

.611 Minimum configuration: 8, 192-word core storage, 4 magnetic tape drives, card reader, card punch, and printer.

.612 Advantages of larger configurations: . . . . source and/or object programs can be on magnetic tape.

.62 Target Computer

.621 Minimum configuration: . . . . any GE 225 system with punched card input-output.

.622 Usable extra facilities: . . . . . up to 16, 384 core storage locations. 15KC and 15/41. 7KC magnetic tape drives, disc storage, off-line printer, Auxiliary Arithmetic Unit, Move Command, Automatic Priority Interrupt.

.7 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Missing entries:	Check	noted in listing.
Unsequenced entries:	Check	noted in listing.
Duplicate names:	Check	noted in listing.
Improper format:	Check	noted in listing.
Incomplete entries:	Check	noted in listing.
Target computer overflow:	Check	noted in listing.
Inconsistent program:	Check	noted in listing.
Undefined names:	Check	noted in listing.
Illegal operations:	Check	noted in listing.

.8 ALTERNATIVE TRANSALTORS: . . . none.

PROGRAM TRANSLATOR: WIZ-II

§ 183.

.1 General

.11 Identity: . . . . GE 225 WIZ System. WIZ-II.

.12 Description

The WIZ-II Compiler program converts source programs coded in the WIZ algebraic language (Section 321:163) into GE 225 machine language object programs in a single pass. Two versions are available, for GE 225 systems with either punched card or paper tape input-output devices. Magnetic tape can be utilized to facilitate both the compilation and execution of WIZ-coded programs. A GE 225 with at least 8,192 core storage locations is required for both the compilation and execution phases. Use of a GE 225 with 16,384 core storage locations permits immediate execution of WIZ-compiled programs. The object program is stored in the upper 8,192 core locations as it is compiled; then it is moved to the lower 8,192 locations for execution.

The main feature of the WIZ system is the rapid compilation it provides. Object programs are compiled and punched into binary cards at the rate of about 1,600 instructions per minute. If the object program is listed on the on-line printer, the over-all rate is about 600 to 700 instructions per minute.

An object program package called WIZPAC must be loaded in order to execute WIZ-compiled programs. WIZPAC occupies about 3,000 core storage locations and contains standard input-output, floating point arithmetic, and library function subroutines. The Auxiliary Arithmetic Unit can be used, if available, for automatic floating point operations. Use of the Auxiliary Arithmetic Unit in place of the floating point arithmetic subroutines can increase object program execution speeds by a factor of up to four.

The principal advantages of the WIZ-II system over its predecessor, WIZ-I, are the reduction of WIZPAC storage requirements from 4,000 to 3,000 locations and an average reduction of 40 to 50 per cent in object program execution times. In addition, successive compilations have been facilitated by a short Re-Initialize deck that makes it unnecessary to reload the entire compiler program; the "compile and execute" capability has been provided for 16K systems; the exponentiation operator has been added; and the data output facilities have been expanded.

.13 Originator: . . . . . General Electric Computer Department, Phoenix, Arizona.

.14 Maintainer: . . . . . as above.

.15 Availability: . . . . . WIZ-I: November, 1961. WIZ-II: December, 1962.

.2 INPUT

.21 Language

.211 Name: . . . . WIZ-II, described in Section 321:163.

.212 Exemptions: . . . . . none.

.22 Form

.221 Input media: . . . . . punched cards or paper tape.

.222 Obligatory ordering: . dimension statements, initial value statements, executable statements (in correct sequence), procedures, END.

.23 Size Limitations

.231 Maximum number of source statements: . . . . . limited by target computer core storage capacity.

.232 Maximum size source statements: . . . . . unlimited.

.233 Maximum number of data items: . . . . limited by target computer storage.

.234 Others

Maximum number of statement labels: . . 90 numeric plus approx. 200 alphameric.

Maximum number of procedure names: . limited by target computer storage.

.3 OUTPUT

.31 Object Program

.311 Language name: . . . GE 225 machine language.

.312 Language style: . . . binary, non-relocatable.

.313 Output media: . . . . punched cards or paper tape.

.32 Conventions

.321 Standard Inclusions: . . none.

.322 Compatible with: . . . WIZPAC object program package, containing input-output, floating point arithmetic, and standard function subroutines.

.33 Documentation

Subject	Provision
Source program: . . .	optional listing.
Object program: . . .	optional listing.
Storage map:	optional listing of symbol and constant tables.
Language errors: . . .	typewriter messages, plus flagging of source program listing.

§ 183.

.4 TRANSLATING PROCEDURE

.41 Phases and Passes: . . one-pass compiler.

.42 Optional Mode

.421 Translate: . . . . . . yes.
.422 Translate and run: . . optional, with 16K core storage only.
.423 Check only: . . . . . yes, by suppressing all output except error messages.
.424 Patching: . . . . . . selective recompilation is possible.
.425 Updating: . . . . . . no.

.43 Special Features

.431 Alter to check only: . . see .423, above.
.432 Fast unoptimized translate: . . . . no.
.433 Short translate on restricted program . no.

.44 Bulk Translating: . . . no, but successive compilations are facilitated by a Re-Initialize deck which is smaller and can be loaded more rapidly than the WIZ-II Compiler deck.

.45 Program Diagnostics

.451 Tracers: . . . . none.
.452 Snapshots: . . . . none.
.453 Dumps: . . . . an octal dump of the A and Q registers and the 4 index registers can be initiated manually, or automatically upon detection of object program errors. Standard console dump program is used if a full core storage listing is required.

.46 Translator Library: . . none (WIZ-coded subroutines can be added to the source deck and compiled with the program. GAP-coded subroutines in the proper format can be assembled separately and loaded into the storage locations assigned by the WIZ-II Compiler).

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed overhead
Name: . . . . WIZPAC.
Space: . . . . 3,000 words.
Contents: . . . . input-output, floating point arithmetic, and standard function subroutines.

.512 Space required for each input-output file: . . . contained in WIZPAC.

.513 Approximate expansion of procedures: . . . 10 (**).

.52 Translation Time

.521 Normal translating: . . 0.8 + 0.016S minutes, where S is number of source program statements, including printed object program listing (**).

(**) Estimate by the Editorial Staff, based on data for typical cases and probably reliable.

.53 Optimizing Data: . . . none.

.54 Object Program Performance: . . . . advertised overall efficiency is 50 to 70 per cent with respect to storage space and 70 to 90 per cent with respect to execution time, compared to good hand-coded routines using the same subroutine package.

.6 COMPUTER CONFIGURATIONS

.61 Translating Computer

.611 Minimum configuration: GE 225 with 8,192 core storage locations.
Card or paper tape reader.
Card or paper tape punch.
Typewriter.
.612 Larger configuration advantages: . . . . . Printer permits on-line listings.
16K core storage permits "compile and execute" operation.

.62 Target Computer

.621 Minimum configuration: GE 225 with 8,192 core storage locations.
Card or paper tape reader.
Typewriter.
.622 Usable extra facilities: Card or paper tape punch.
Printer.
Auxiliary Arithmetic Unit.
Magnetic Tape Units.

.7 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Missing entries:	none.	
Unsequenced entries:	none.	
Target computer overflow:	check	note and type message at end.
Input-output error:	check	type message and halt.
Dimension error:	check	type message.
Syntactical error:	check	type message.
Illegal statement type:	check	type message.
Illegal character:	check	type message.
Symbol table overflow:	check	type message.
Sentence label error:	check	type message.

.8 ALTERNATIVE TRANSLATORS: . . . none.

OPERATING ENVIRONMENT: BRIDGE II

§ 191.

.1 GENERAL

.11 Identity: . . . . BRIDGE II Service System. CD225J1.001.

.12 Description

BRIDGE II is a tape file maintenance and run sequencing program. Operation of BRIDGE II is directed by control cards, and all system functions are performed in the sequence specified by the cards. Although it is not an integrated operating system, BRIDGE II, in combination with other GE utility routines and the user's own coding, can significantly increase an installation's throughput by reducing lost time between runs.

Operation of BRIDGE II consists of two phases. Phase One provides for maintenance of program tape files in binary and symbolic form, and for collection of programs from magnetic tape or cards onto a master run tape in the sequence in which the programs are to be executed. The file maintenance functions of BRIDGE II are described in Section 321:151.15. Additional routines can be added to expand the system's capabilities.

Phase Two provides the necessary run-to-run linkages to load and execute programs with a minimum of operator intervention. The sequence of execution can be established during Phase One, or it can be altered to any desired sequence by control card entries to Phase Two.

BRIDGE II requires at least 8,192 core storage locations, one dual magnetic tape handler, card reader, and printer.

.13 Availability: . . . . . . due for general release in July, 1963; final specifications not published to date.

.14 Originator: . . . . GE Computer Department, Phoenix, Arizona.

.15 Maintainer: . . . . . . as above.

.2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . . from system library tape or previously prepared master run tape, directed by control cards.

.212 Independent programs: from punched cards or magnetic tape, directed by control cards.

.213 Data: . . . . as incorporated in user's programs.

.214 Master routines: . . . . from system library tape.

.22 Library Subroutines: . from system library tape.

.23 Loading Sequence: . . . as specified by control cards; sequence can be established while collecting programs to form master run tape, and can be altered at execution time when necessary.

.3 HARDWARE ALLOCATION: . . . . as incorporated in user's program.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: as incorporated in user's program.

.42 Multi-programming: . . not practical.

.43 Multi-sequencing: . . . not practical.

.44 Errors, Checks and Action

Error	Check or Interlock	Action
Loading input error:	parity checks	type message and halt.
Allocation impossible:	?	
In-out error:	parity checks	type message and halt.
Invalid instruction:	none.	
Arithmetic overflow:	check	indicator & alarm.
Underflow:	check	indicator & alarm.

.45 Restarts: . . . . restart procedure is initiated by a control card.

.5 PROGRAM DIAGNOSTICS

.51 Dynamic

.511 Tracing: . . . . TRACE routine lists, after execution of each instruction: the location, the instruction, and the contents of the A, Q, P, I, and index registers.

.512 Snapshots: . . . . Selective Typewriter Memory Dump subroutines can be incorporated into user's programs.

.52 Post Mortem: . . . . . dump routines are available for printer or console typewriter; automatic full core storage dumps on High Speed Printer can be initiated by pressing a single button.

§ 191.

.6 OPERATOR CONTROL: as incorporated in user's program, using control cards or console switches for input and console typewriter for output.

.7 LOGGING: . . . . as incorporated in user's program, plus error messages produced by BRIDGE II on typewriter. BRIDGE II also logs tape and run labels on printer during run collection and on typewriter during run execution.

.8 PERFORMANCE

.81 System Requirements

.811 Minimum configuration: 8,192 core storage locations.
1 card reader.
1 printer.
1 dual magnetic tape handler (i.e., 2 transports).

.812 Usable extra facilities: all.

.813 Reserved equipment: . ?

.82 System Overhead

.821 Loading time: . . . . . ?

.822 Reloading frequency: . ?

.83 Program Space Available: . . . . . . over 7,000 locations in an 8K system.

.84 Program Loading Time

Cards: . . . . full card reading speed: 228 to 536 instructions per second, depending upon reader model.

Magnetic tape: . . . . . 3,000 or 6,700 instructions per second for standard 200-word blocks at recording density of 200 or 556 rows/inch, respectively.

.85 Program Performance: no running overhead; BRIDGE II only handles run-to-run linkages.

SYSTEM PERFORMANCE

§201.

GENERALIZED FILE PROCESSING (320:201.1)

These problems involve updating a master file from information in a detail file and producing a printed record of each transaction. This application is one of the most typical of commercial data processing jobs and is fully described in Section 4:200.1 of the Users' Guide.

The GE 225 is basically a fixed word-length, binary processor, although an optional feature (included in Standard Configurations I, III, and IV) enables it to perform decimal addition and subtraction. To minimize time-consuming radix conversion and unpacking operations, records in the magnetic tape master file are organized in an unpacked format, with individual fields in either binary or alphameric form depending upon their usage. Each master file record, whose nominal length is 108 characters, occupies 37 GE 225 word locations or 148 magnetic tape rows. (Magnetic tape files containing mixed alphameric and binary data must be read and recorded in the binary mode, in which each computer word occupies four tape rows.)

Standard Configuration I has no magnetic tape units. Therefore, it is assumed that both the master and detail files are on punched cards, in alphameric format, and that the two files have been collated off-line so that each detail card follows its associated master record cards. Since master records with no activity (i.e., no corresponding detail cards) would, in most cases, be removed from the file before the computer run, only the times at an activity factor of 1.0 are plotted for Standard Configuration I. The relatively low speed of the card punch (300 cards per minute) in producing the updated Master File makes the over-all processing time for Configuration I much higher than for Configurations II, III, and IV, which utilize magnetic tape for the master file. It should be noted that the master record length for Standard File Problem A is 108 characters, which necessitates the use of two 80-column cards for each master file record.

In Standard Configurations II, III, and IV, the master file is on magnetic tape, the detail file is on punched cards, and the report file is produced by the on-line printer.

Standard Configuration II is a "stripped-down" magnetic tape system which includes none of the optional features that improve the GE 225's processing capabilities. Because of the lack of automatic facilities for decimal arithmetic, block transfers, and three-way comparisons, internal processing times for Configuration II are nearly twice as high as for Configurations III and IV. Even so, throughput at the lower activity ratios is limited by the effective speed of the 15KC magnetic tape units rather than by the central processor, as indicated by the horizontal segment of each File Processing performance curve for Configuration II. At higher activity ratios, the card reader (rated at 400 cards per minute) becomes the limiting factor. It is significant to note that the GE 225, unlike most computers in its price class, can keep its card reader, card punch, printer, and one magnetic tape unit operating simultaneously at their maximum effective transfer rates - even in a "minimum" configuration such as this one.

Standard Configuration III has more special features and faster magnetic tape units than Configuration II. At activity ratios in the range of 0 to 0.1, these improvements "pay off" by significantly reducing the master file tape times and, therefore, the overall processing times. At higher activity ratios, Configuration III is limited by the same factor as Configuration II - the 400-card-per-minute reader - so the two curves coincide.

Standard Configuration IV adds a second magnetic tape channel, a faster card reader and punch, and more core storage to the facilities of Configuration III. The result is improved performance over the entire activity range. Magnetic tape times for the master file are halved because the second tape channel permits simultaneous read/write/compute

SYSTEM PERFORMANCE (Contd.)

§201.

GENERALIZED FILE PROCESSING (Contd.)

operation. The printer, with an effective speed of 600 lines per minute at the required inter-line spacing of 1 inch, is now the limiting factor on performance at all activity ratios above 0.1.

SORTING (321:201.2)

The standard estimate for sorting 80-character records by straightforward merging on magnetic tape was developed from the time for Standard File Problem A by the method explained in Paragraph 4:200.213 of the Users' Guide. A two-way merge was used in Configuration II (which has only four magnetic tape units) and a three-way merge in Configurations III and IV. The results are shown in Graph 321:201.214.

Graph 321:201.224 is based on published timing data for the manufacturer-developed FORWARD Sort/Merge Generator, described in Section 321:151.13, which uses the complex "polyphase" merge technique. It can be seen that the standard estimating method yields higher times than the manufacturer's routine for Configuration II, and lower times for Configurations III and IV.

MATRIX INVERSION (321:201.3)

In matrix inversion, the object is to measure central processor speed on the straightforward inversion of a non-symmetric, non-singular matrix. No input-output operations are involved. The standard estimate is based on the time to perform cumulative multiplication ($c = c + a_i b_j$) in eight-digit precision floating point, using both standard subroutines and the Auxiliary Arithmetic Unit (see Paragraph 321:051.422). The results are shown in Graph 321:201.313. It can be seen that the inversion speeds are nine times as high when the floating point arithmetic is performed by the Auxiliary Arithmetic Unit as when floating point subroutines are used. This is a reasonable indication of the value of the AAU for engineering and scientific applications.

Published times for manufacturer-developed matrix inversion routines are shown in Graph 321:201.323. The estimated and published inversion times for routines that use the AAU are nearly identical. The estimated times for the routine that uses floating point subroutines, however, are only about half as high as the published times. No obvious explanation for the discrepancy has been found.

GE 225
SYSTEM PERFORMANCE

GE 225 SYSTEM PERFORMANCE

WORKSHEET DATA TABLE 1

Worksheet	Item		Configuration I		Configuration II		Configuration III		Configuration IV		Reference
1 Input-Output Times	Char/block	(File 1)	18.5 words		370 words		370 words		370 words		4:200.112
	Records/block	K (File 1)	0.5		10		10		10		
	msec/block	File 1 = File 2	1 = 40; 2 = 200		111		46.4		46.4		
		File 3	40		150		150		40		
		File 4	100		100		100		100		
	msec/switch	File 1 = File 2									
		File 3									
		File 4									
	msec penalty	File 1 = File 2	1 = 1.5; 2=17.3		8.9		8.9		8.9		
		File 3	1.5		1.5		1.5		1.5		
		File 4	1.5		1.5		1.5		1.5		
2 Central Processor Times	msec/block	a1	0.684		0.684		0.684		0.684		4:200.1132
	msec/record	a2	3.078		6.984		3.078		3.078		
	msec/detail	b6	10.196		10.196		10.196		10.196		
	msec/work	b5 + b9	4.338		4.338		4.338		4.338		
	msec/report	b7 + b8	22.772		56.272		22.772		22.772		
3 Standard Problem A F=1.0	msec/block for C.P. and dominant column.	a1	0.7		0.7		0.7		0.7		4:200.114
		a2 K	1.5		69.9		30.8		30.8		
		a3 K	18.7		708.1		373.1		373.1		
		File 1 Master In	1.5		8.9		8.9		8.9		
		File 2 Master Out	17.3	200	8.9		8.9		8.9		
		File 3 Details	0.8		15.0	1,500	15.0	1,500	15.0		
		File 4 Reports	0.8		15.0		15.0		15.0	1,000	
		Total	41.3	200	826.5	1,500	452.4	1,500	452.4	1,000	
4 Standard Problem A Space	Unit of measure	(words)									4:200.1151
		Std. routines	669		1,119		1,119		1,119		
		Fixed	4		4		4		4		
		3 (Blocks 1 to 23)	150		171		159		159		
		6 (Blocks 24 to 48)	780		840		780		780		
		Files	350		1,614		1,614		1,614		
		Working	50		50		50		50		
		Total	2,003		3,798		3,726		3,726		

SYSTEM PERFORMANCE

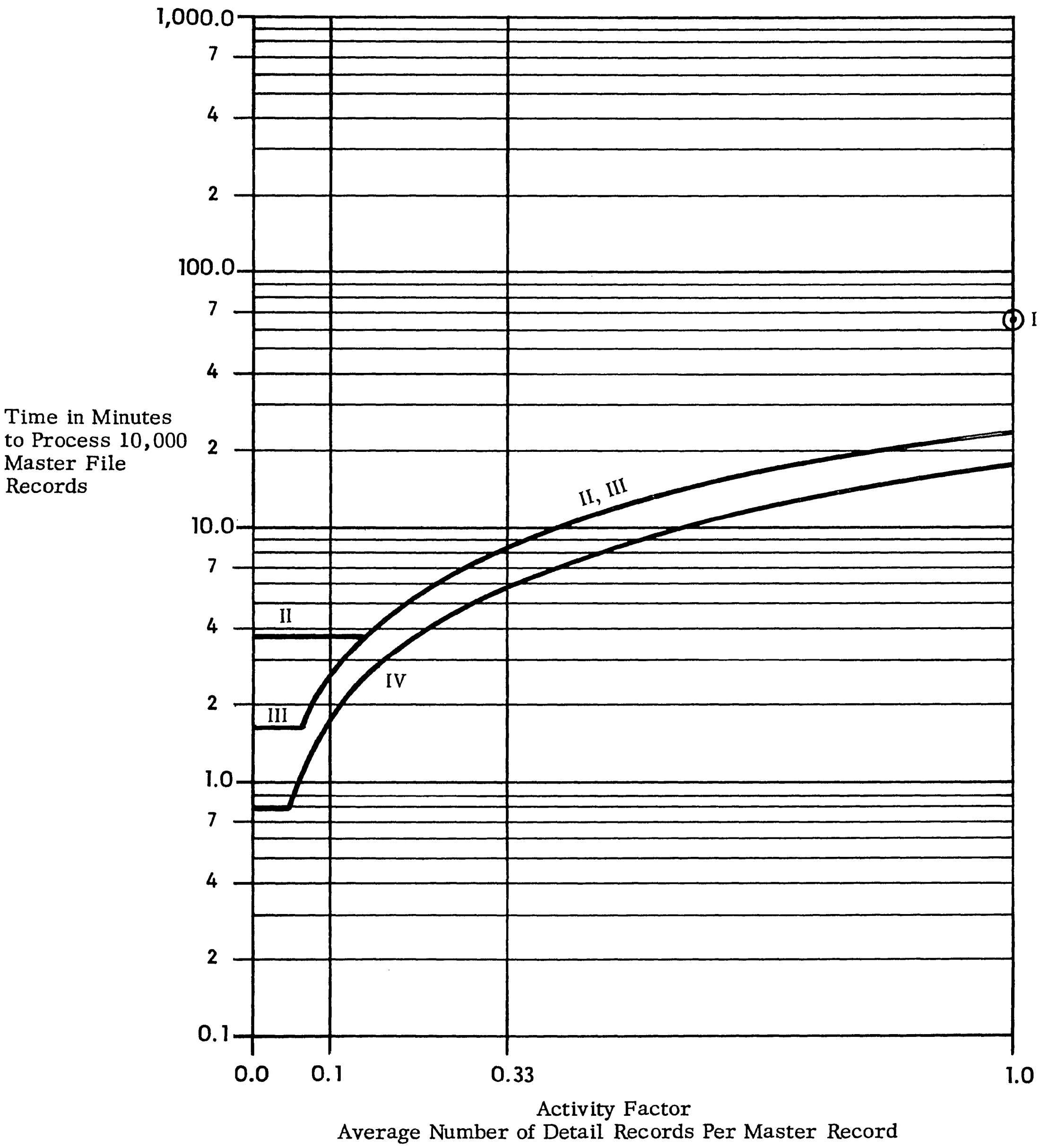
§ 201.

.1 GENERALIZED FILE PROCESSING

.11 Standard Problem A

.111 Record sizes
- Master file: . . . . . 108 characters.
- Detail file: . . . . . . 1 card.
- Report file: . . . . . 1 line.

.112 Computation: . . . . . . standard.
.113 Timing basis: . . . . . . as in 4:200.113.
.114 Graph: . . . . see graph below.
.115 Storage space required
- Configuration I: . . . . 2,000 words.
- Configuration II: . . . 3,800 words.
- Configuration III: . . . 3,730 words.
- Configuration IV: . . . 3,730 words.
- Word: . . . . 20 bits. 3 BCD char.



(Roman numerals denote standard System Configurations.)

§ 201.

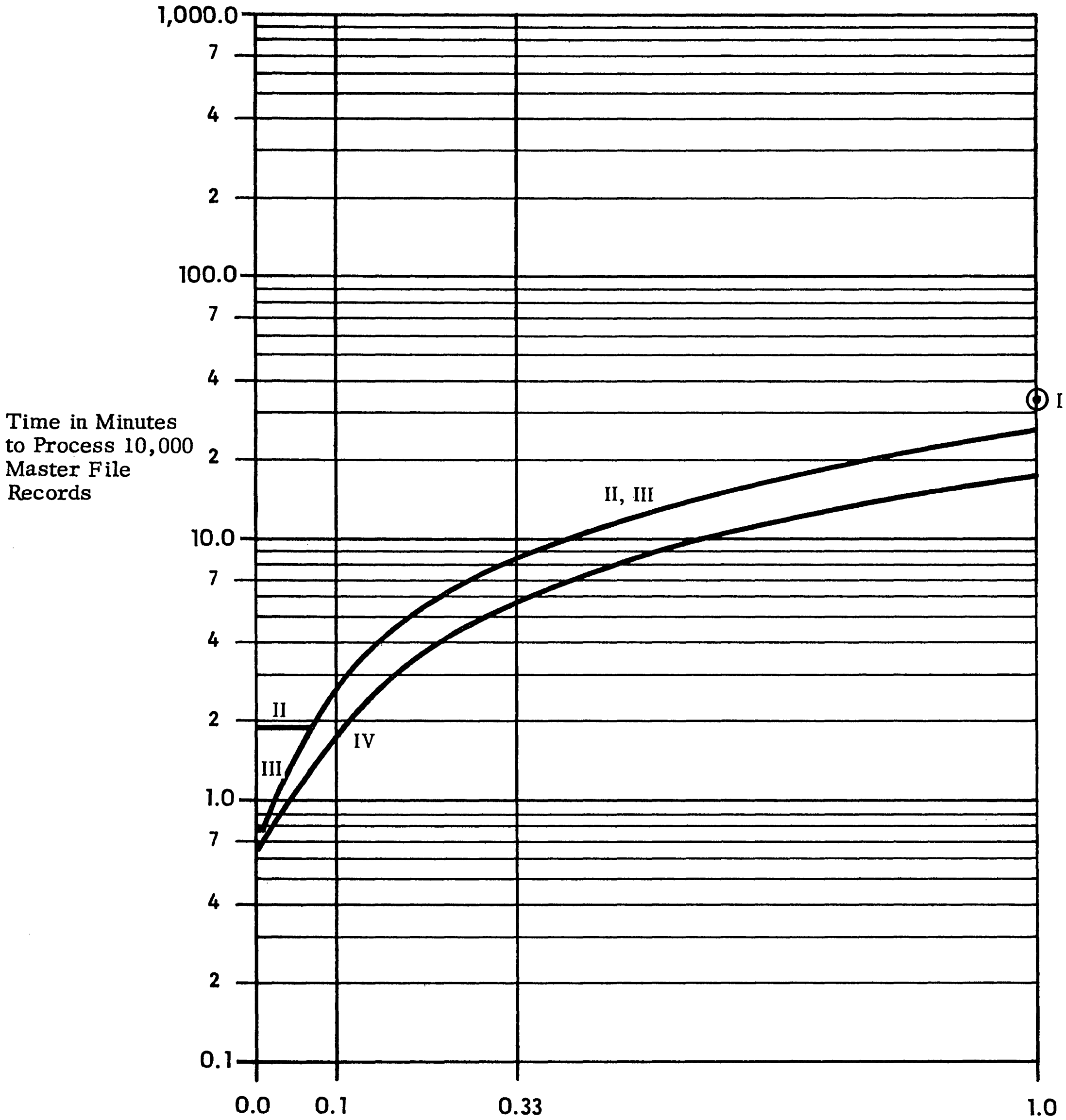
.12 Standard Problem B

.121 Record sizes
Master file: . . . . . 54 characters.
Detail file: . . . . . . 1 card.
Report file: . . . . . . 1 line.

.122 Computation: . . . . . . standard.

.123 Timing basis: . . . . . as in 4:200.12

.124 Graph: . . . . see graph below.



Activity Factor
Average Number of Detail Records Per Master Record

(Roman numerals denote standard System Configurations.)

§ 201.

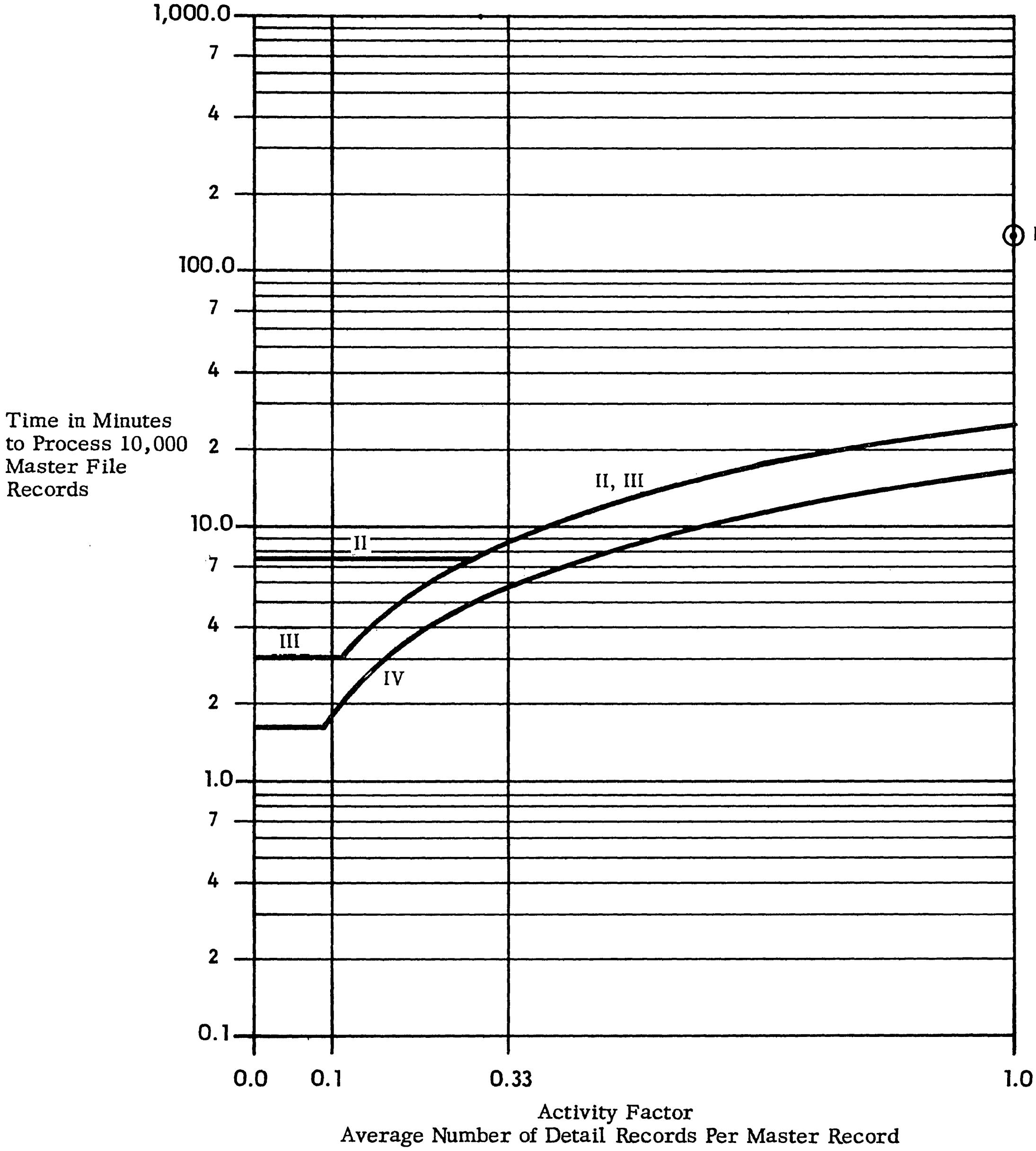
.13. Standard File Problem C Estimates

.131 Record sizes
Master file: . . . . . 216 characters.
Detail file: . . . . . . 1 card.
Report file: . . . . . . 1 line.

.132 Computation: . . . . . . standard.

.133 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide. 4:200.13.

.134 Graph: . . . . see graph below.



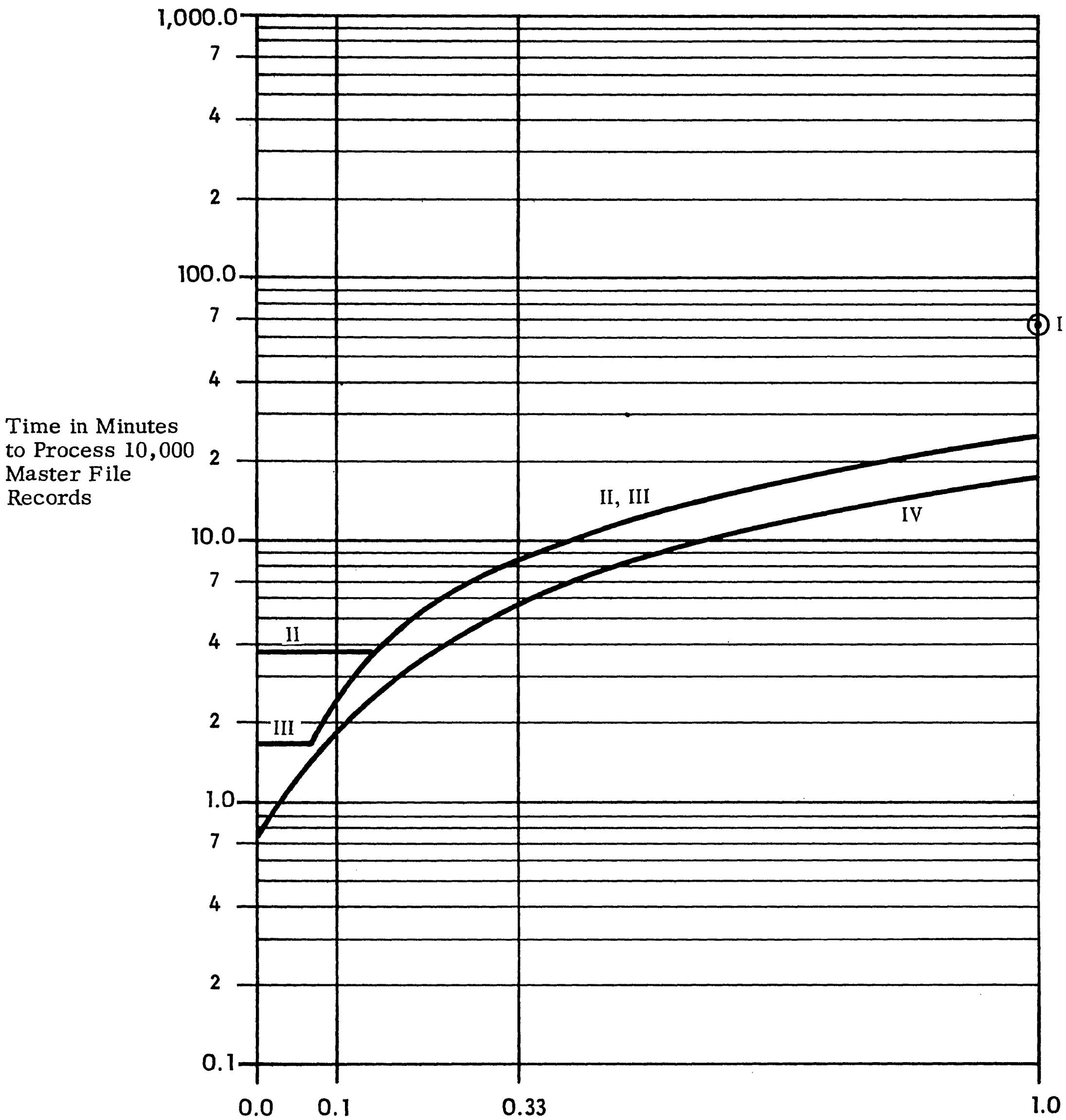
(Roman numerals denote standard System Configurations.)

§ 201.

.14 Standard File Problem D Estimates

.141 Record sizes
Master file: . . . . . . 108 characters.
Detail file: . . . . . . 1 card.
Report file: . . . . . . 1 line.

.142 Computation: . . . . . . trebled.
.143 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.14.
.144 Graph: . . . . see graph below.



Activity Factor
Average Number of Detail Records Per Master Record

(Roman numerals denote standard System Configurations.)

§ 201.

.2 SORTING

.21 Standard Problem

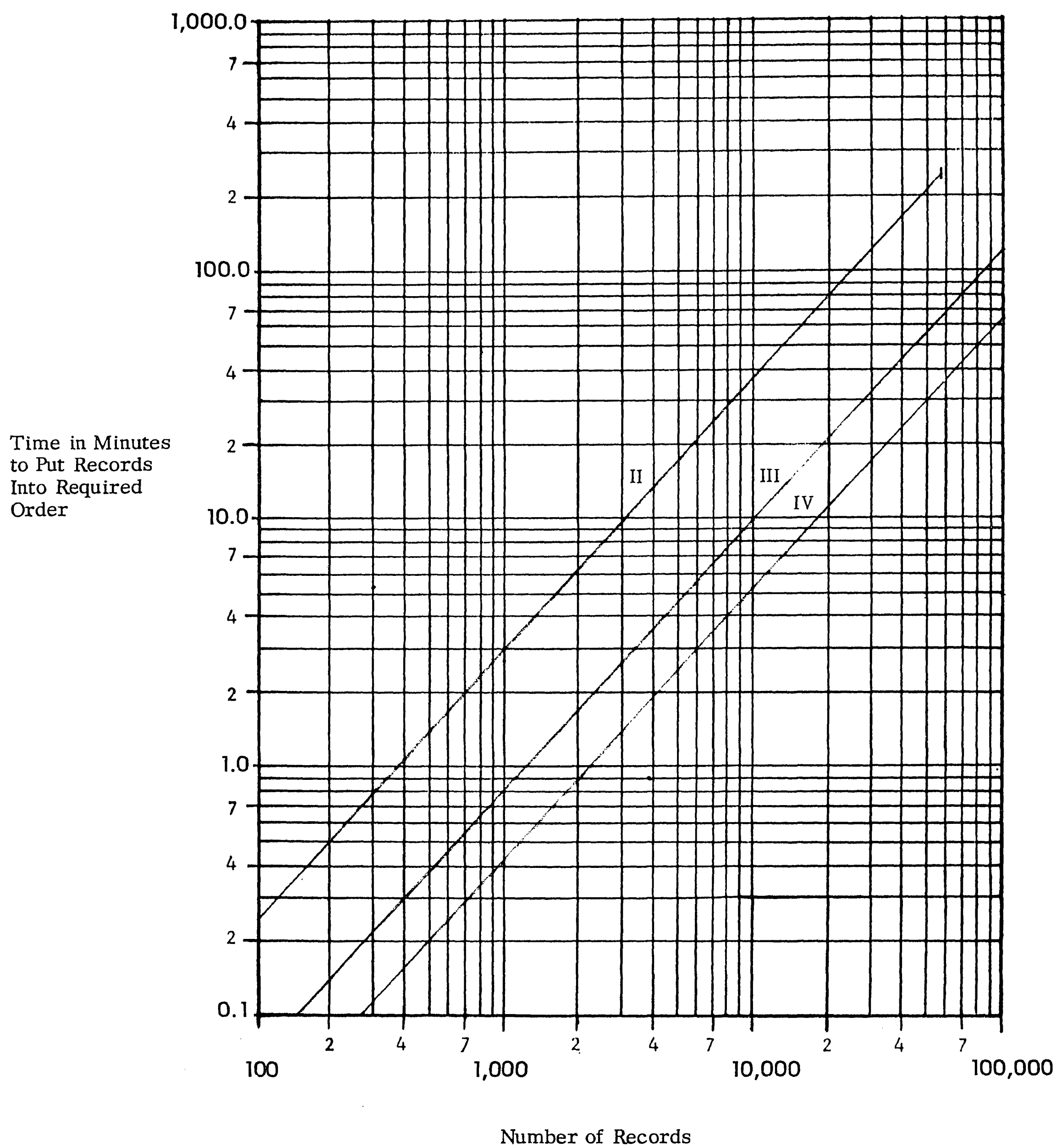
.211 Record size: . . . . . . 80 characters.

.212 Key size: . . . . 8 characters.

.213 Timing basis: . . . . . as in 4:200.213.

.214 Graph: . . . . see graph below.

.215 Capacity of one reel (ten 80-char records per block)
200 char/inch: . . . 57,000 records.
556 char/inch: . . . 125,000 records.



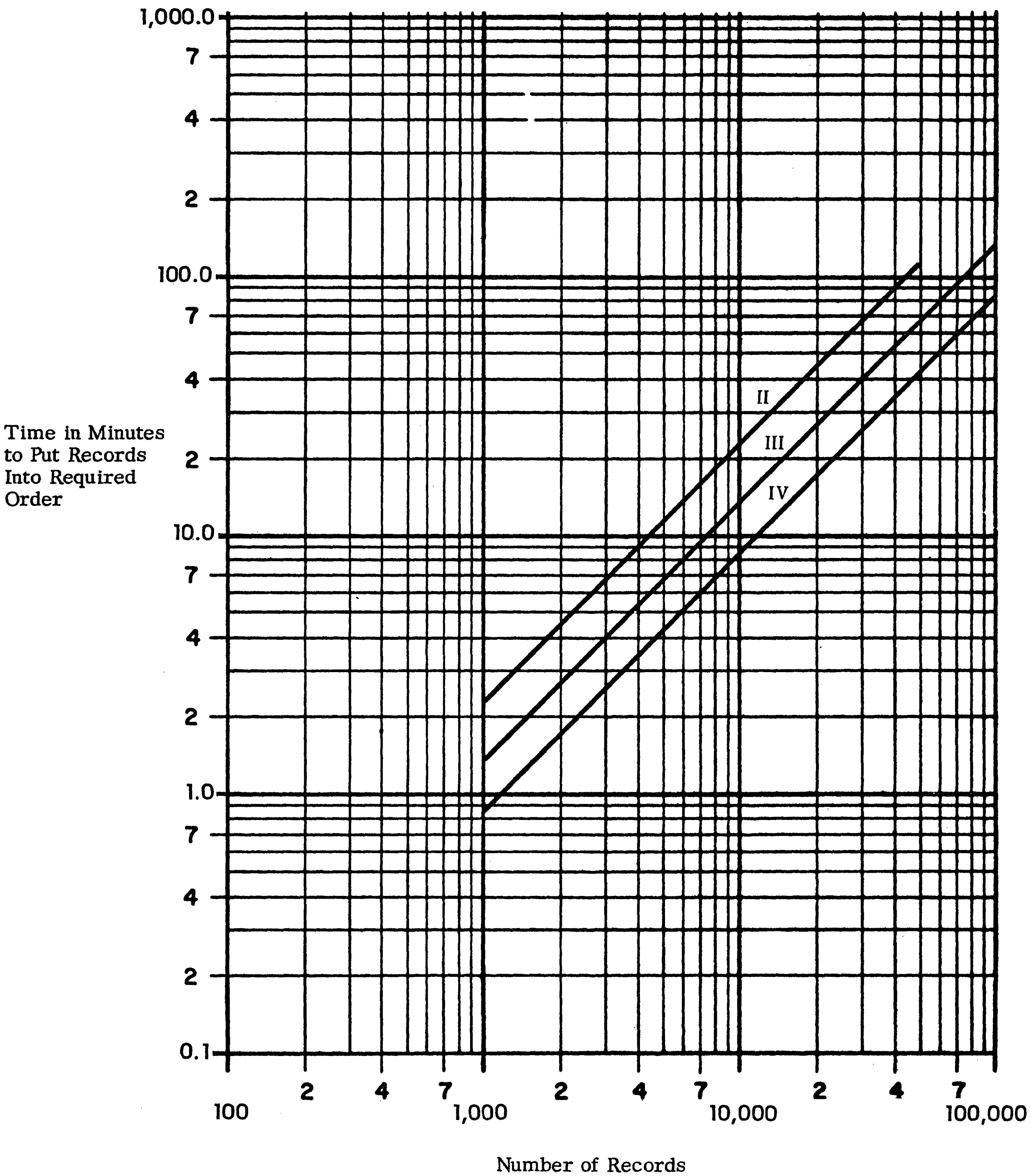
§ 201.

.22 Forward Sort-Merge Generator

.221 Record size: . . . . . . 80 characters.
.222 Key size: . . . . 8 characters.

.223 Timing basis: . . . . . as in 4:200.22. (Timing charts for polyphase merge, using all available tape handlers. According to GE, timing accuracy is ± 20%.)

.224 Graph: . . . . see graph below.



§ 201.

.3 MATRIX INVERSION

.31 Standard Problem

.311 Basic parameters: . . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.312 Timing basis: . . . . . . as in 4:200.312

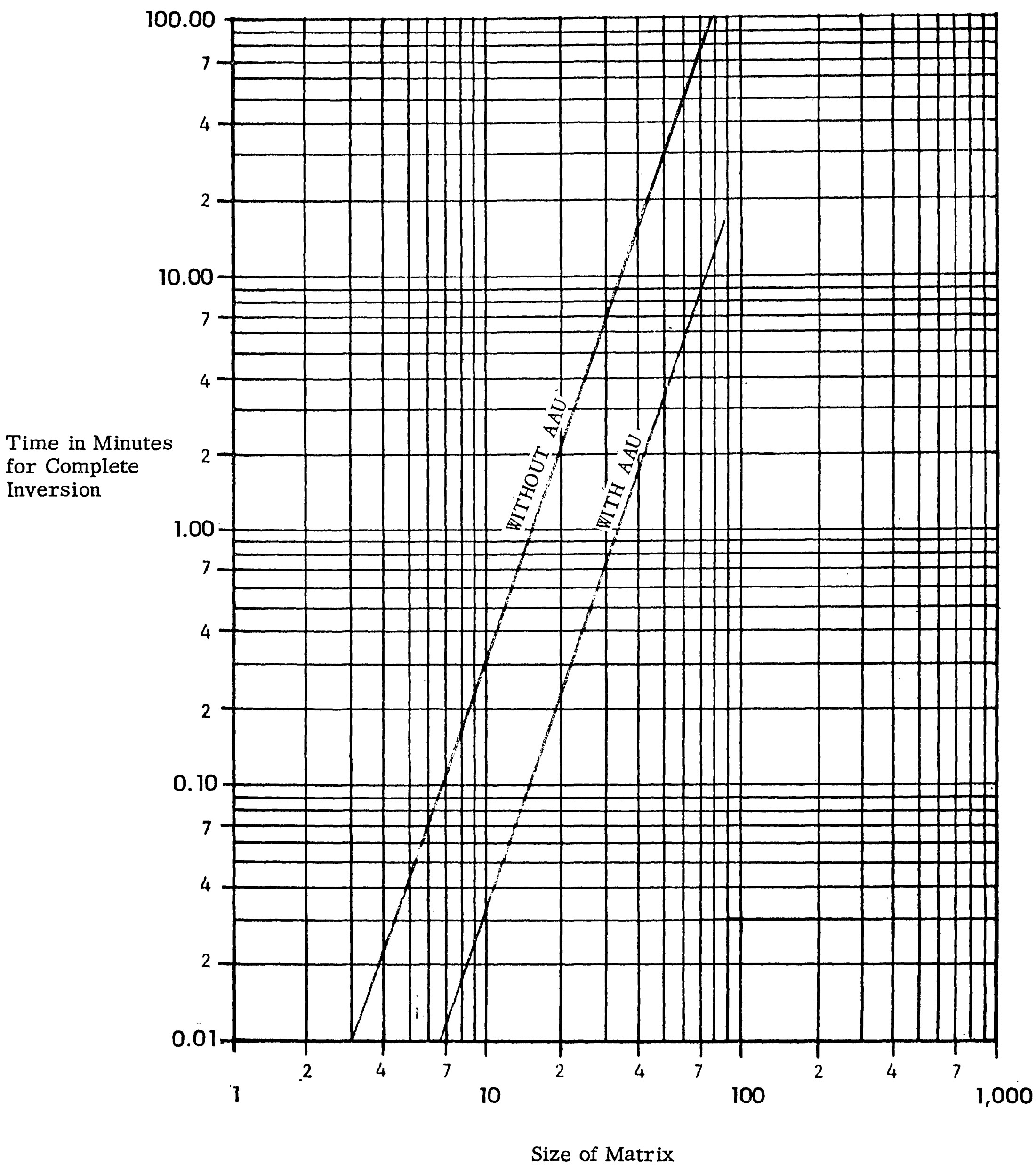
.313 Graph: . . . . see graph below.

.314 Maximum matrix sizes

4,096 core storage locations: . . . . . . 40.

8,192 core storage locations: . . . . . . 60.

16,384 core storage locations: . . . . . . 88.



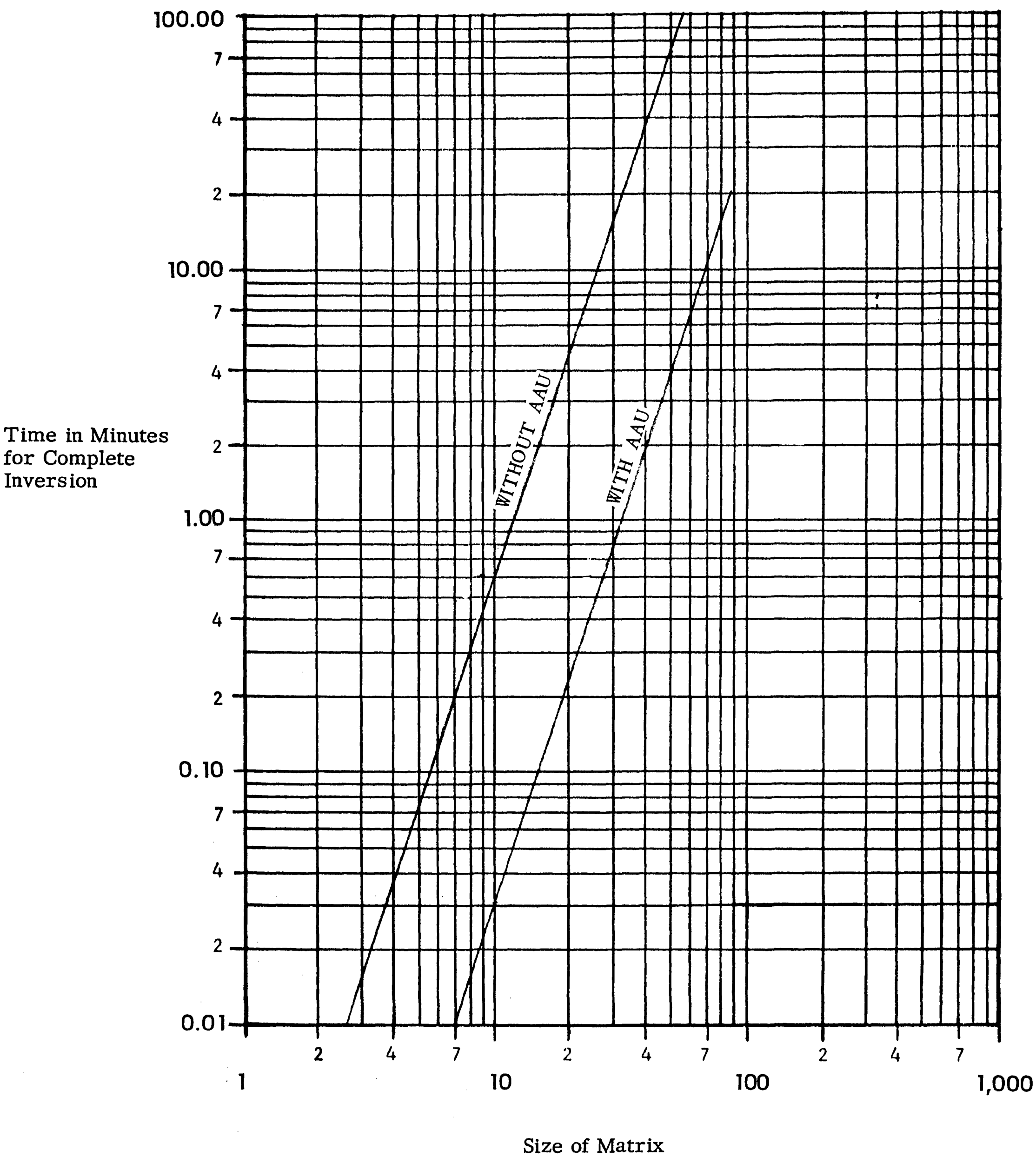
§ 201.

.32 GE 225 Utility Routines CD225D4.9 and CD225D4.10

.321 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.322 Timing basis: 4:200.32

.323 Graph: . . . . see graph below.



GE 225
PHYSICAL CHARACTERISTICS

GE 225 PHYSICAL CHARACTERISTICS

IDENTITY	Unit Name		Central Processor 4K Storage	Central Processor 8K Storage	Central Processor 16K Storage	Auxiliary Arithmetic Unit	Mass Random Access Data Storage	Card Reader (400 CPM)	Card Reader (1,500 CPM)
	Model Number		CA225, CA215	CB225, CB215	CC225	X225A	M640A	D225B	D225F
PHYSICAL	Height × width × depth, inches		76 × 32 × 116	76 × 32 × 116	76 × 32 × 151	76 × 75 × 32	63 × 71 × 38	12 × 25 × 24	37 × 47 × 33
	Weight, pounds		2,065	2,065	2,755	1,185	2,050	67	450
	Maximum cable lengths								
	To Processor		---	---	---	?	?	?	?
	To Power Receptacle		?	?	?	?	?	---	?
	To Indicated Unit		---	---	---	---	---	---	---
ATMOSPHERE	Storage Ranges	Temperature, °F.	0 – 120	0 – 120	0 – 120	0 – 120	–20 – 150	0 – 120	0 – 120
		Humidity, %	0 – 98	0 – 98	0 – 98	10 – 80	0 – 98	10 – 90	10 – 90
	Working Ranges	Temperature, °F.	65 – 85	65 – 85	65 – 85	65 – 85	50 – 105	65 – 85	65 – 85
		Humidity, %	40 – 60	40 – 60	40 – 60	40 – 60	40 – 60	40 – 60	40 – 60
	Heat dissipated, BTU/hr.		11,790	11,790	16,380	7,170	7,524	Included in CP	5,600
	Air flow, cfm.		900	900	1,200	600	0	0	0
ELECTRICAL	Voltage	Nominal	208 or 240	208 or 240	208 or 240	208 or 240	208	Power is supplied by CP	208 or 240
		Tolerance	± 10%	± 10%	± 10%	± 10%	± 10%		± 10%
	Cycles	Nominal	60	60	60	60	60		60
		Tolerance	+0.5 – 1.5	+0.5 – 1.5	+0.5 – 1.5	+0.5 – 1.5	± 1		+0.5 – 1.5
	Phases and lines		3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire		3ϕ, 4-wire
	Load KVA		5.9	5.9	9.0	3.6	5.0	Included in CP	3.6
NOTES			Console desk is 30" high by 87" wide by 24" deep, with 24" by 16" wing for typewriter, and is not included in CP dimensions. Desk and typewriter are included in all other CP characteristics. CP = Central Processor						

GE 225 PHYSICAL CHARACTERISTICS (Contd.)

			Card Punch	Paper Tape System	Printer	Printer Controller	Magnetic Tape Handler	Magnetic Tape Controller	Magnetic Ink Document Handler
IDENTITY	Unit Name		Card Punch	Paper Tape System	Printer	Printer Controller	Magnetic Tape Handler	Magnetic Tape Controller	Magnetic Ink Document Handler
	Model Number		E225K	GA651A	P225A	P225A	MTH680, MTH690	MTC680, MTC690	S12B
PHYSICAL	Height × width × depth, inches		48 × 35 × 33	61 × 38 × 30	51 × 40 × 26	76 × 40 × 32	7,6 × 24 × 32	76 × 35 × 32	42 × 176 × 28
	Weight, pounds		465	250	850	850	670	875	2,255
	Maximum cable lengths								
	To Processor		?	?	---	?	---	?	?
	To Power Receptacle		?	?	---	?	---	?	?
	To Indicated Unit		---	---	---	---	---	---	---
ATMOSPHERE	Storage Ranges	Temperature, °F.	0 – 120	0 – 120	0 – 120	0 – 120	0 – 130	0 – 130	−20 – 135
		Humidity, %	10 – 90	10 – 90	10 – 90	10 – 90	10 – 90	10 – 90	10 – 95
	Working Ranges	Temperature, °F.	65 – 85	65 – 85	65 – 85	65 – 85	65 – 85	65 – 85	65 – 85
		Humidity, %	40 – 60	40 – 60	40 – 60	40 – 60	40 – 60	40 – 60	40 – 60
	Heat dissipated, BTU/hr.		1,810	3,380	5,955	3,875	4,490	5,260	22,572
	Air flow, cfm.		0	300	0	300	300	300	0
ELECTRICAL	Voltage	Nominal	208 or 240	120	208 or 240	208 or 240	208 or 240	208 or 240	208 or 240
		Tolerance	± 10%	± 10%	± 10%	± 10%	± 10%	± 10%	± 10%
	Cycles	Nominal	60	60	60	60	60	60	60
		Tolerance	+0.5 – 1.5	+0.5 – 1.5	+0.5 – 1.5	+0.5 – 1.5	+0.5 – 1.5	+0.5 – 1.5	+0.5 – 1.5
	Phases and lines		3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire
	Load KVA		0.9	1.4	4.8	Included in Printer	2.0	3.0	7.5
NOTES									

GE 225 PHYSICAL CHARACTERISTICS (Contd.)

			Mass Random Access Data Storage (Electronics)	Mass Random Access Data Storage (Controller)	DATANET-15 Data Transmission Controller	Magnetic Ink Document Handler Controller	GE 235 Central Processor	GE 235 Auxiliary Arithmetic Unit
IDENTITY	Unit Name		Mass Random Access Data Storage (Electronics)	Mass Random Access Data Storage (Controller)	DATANET-15 Data Transmission Controller	Magnetic Ink Document Handler Controller	GE 235 Central Processor	GE 235 Auxiliary Arithmetic Unit
	Model Number						CA235	AAU235
PHYSICAL	Height × Width × Depth, in.		76 × 40 × 32	76 × 40 × 32	76 × 40 × 32	76 × 38 × 32	76 × 32 × 75	76 × 40 × 32
	Weight, lbs.		700	450	858	910	1,600	800
	Maximum Cable Lengths							
	To Processor		?	?	?		---	?
	To Power Receptacle		---	?	?		?	?
	To Indicated Unit		?	---	35' to digital sub-sets and Interface adapters.		---	---
ATMOSPHERE	Storage Ranges	Temperature, °F.	0 – 120	0 – 120	?	20 – 135	0 – 120	0 – 120
		Humidity, %	0 – 98	0 – 98	?	10 – 95	0 – 98	0 – 98
	Working Ranges	Temperature, °F.	65 – 85	65 – 85	60 – 85	65 – 85	65 – 85	65 – 85
		Humidity, %	40 – 60	40 – 60	40 – 60	40 – 60	40 – 60	40 – 60
	Heat Dissipated, BTU/hr.		2,220	4,235	3,800	4,250	?	4,406
	Air Flow, cfm.		300	300	300	300	1540	660
ELECTRICAL	Voltage	Nominal	208	208	208	208	208 or 240	208 or 240
		Tolerance	±10%	±10%	±10%	±10%	±10%	±10%
	Cycles	Nominal	60	60	60	60	60	60
		Tolerance	±1	±1	±1	±1	+0.5 – 1.5	+0.5 – 1.5
	Phases and Lines		3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire	3ϕ, 4-wire
	Load KVA		.9	2.0	1.3	2.0	5.3	3.6
NOTES								

PRICE DATA

§ 221.

CLASS	IDENTITY OF UNIT		PRICES (see note below)		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
Central Processor		Central Processor, Console and Typewriter			
		Without Controller Selector			
	CA225C	4, 096 words of core storage	1, 900		135, 000
	CB225D	8, 192 words of core storage	2, 500		165, 000
	CC225B	16, 384 words of core storage	3, 900		221, 000
		With Controller Selector			
	CA225B	4, 096 words of core storage	2, 900		145, 000
	CB225C	8, 192 words of core storage	3, 500		175, 000
	CC225A	16, 384 words of core storage	4, 900		231, 000
		Optional Features			
		Move Command	75		3, 300
		Automatic Interrupt	75		3, 800
		Three-Way Compare, Decimal Addition and Subtraction, and Additional Address Modification Groups	200		4, 410
		Real Time Clock	75		3, 600
	X225A	Auxiliary Arithmetic Unit	650		32, 500
Storage		Core Storage: included in Central Processor			
	M640A	Mass Random Access File	1, 725		76, 000
Input-Output		Paper Tape Punch & Reader			
	GA651A	With Spooler	490		22, 000
	GA651B	Without Spooler	440		19, 800
		Card Reader & Controller			
	D225B	400 cards/min model	375		18, 350
	D225C	1, 000 cards/min model	810		32, 400
		Card Punch & Controller			
	E225K	100 cards/min model	400		21, 460
	E225M	300 cards/min model	825		41, 150
		High Speed Printer and Controller			
	P225A	Standard On-Line	1, 275		61, 500
	P225C	On-Line with FORTRAN character set	1, 295		61, 950
	PA690A	On/Off-Line, for 200 char/inch tape	2, 950		137, 250
	PA690B	On/Off-Line, for 200 or 556 char/inch tape	3, 500		157, 500
	P225D	On-Line 150 LPM Printer	700		33, 000
		Magnetic Tape Handlers			
	MTH680	Dual 15, 000 char/sec.	850		33, 000
	MTH690	Dual 15, 000/41, 600 char/sec.	1, 300		47, 850
	DTC901	DATANET-15	690		30, 000
	S12B	Magnetic Ink Document Handler	1, 750		87, 500
Controllers	M225B	Mass Random Access Controller	900		46, 250
		Magnetic Tape Controller			
	MTC680	For 15, 000 char/sec.	800		37, 500
	MTC690	For 15, 000/41, 600 char/sec.	1, 030		46, 350
		Magnetic Ink Document Handler Adapters			
	SA225A	For 1 Handler	540		21, 600
	SA225B	For 2 Handlers	680		27, 200

Note: These are believed to be the current rental and purchase prices for the GE 225 system components; the manufacturer has neither confirmed nor denied them.

GE 235

General Electric Company

STANDARD

EDP

REPORTS

AUERBACH

AUERBACH INFO, INC.

PRINTED IN U. S. A.

GE 235

General Electric Company

AUERBACH

STANDARD EDP REPORTS

AUERBACH INFO, INC.

PRINTED IN U. S. A.

CONTENTS

* Refer to indicated section of GE 225 report; all GE 225 software is directly usable on the GE 235.

CONTENTS (Contd.)

* Refer to indicated section of GE 225 report; all GE 225 software is directly usable on the GE 235.

INTRODUCTION

§ 011.

The GE 235 is a medium scale, solid-state data processing systen, at is adaptable to a wide range of business and scientific applications. System rentals can range from approximately $4,000 to over $40,000 per month, but most installations will probably fall within the $6,000 to $20,000 range. The GE 235 was announced in May, 1963, and initial customer deliveries are scheduled for mid-1964.

Compatibility

The GE 235 is the largest member of General Electric Computer Department's recently expanded line of general purpose digital computers. The GE 235 is fully program-compatible with the smaller GE 215 and GE 225 systems (Computer System Reports 320 and 321) and offers the same line of peripheral equipment. The central processor and core storage used in the GE 225 have been re-engineered to achieve more than a three-fold increase in internal processing speeds. Scientific problems that utilize the Auxiliary Arithmetic Unit for floating point arithmetic operations may run up to 18 times as fast on the GE 235 as on the 225. The GE 235 thus provides upward expansion without reprogramming for users of the GE 215 and 225 systems. (Because the GE 235 uses the same peripheral equipment as the GE 225, there will obviously be no improvement in the execution times for runs which are limited by the speeds of specific input-output devices.)

The principal differences between the GE 235 and the GE 225 can be summarized as follows:

- Core storage cycle time is 6 microseconds, versus 18 microseconds in the GE 225.
- Execution times for all central processor operations are decreased by a factor of at least three.
- Execution times for Auxiliary Arithmetic Unit operations are decreased by a factor of from 3 to 20.
- Keyboard input via the console typewriter is standard in the GE 235 and optional in the GE 225.
- The optional Dual Access Controller Selector (not available for the GE 225) doubles the potential input-output data transfer rate.

Hardware

Core storage in the GE 235 can consist of 4,096, 8,192, or 16,384 word locations. Each 20-bit location can hold a one-address instruction, a binary data word of 19 bits plus sign, or 3 alphameric characters in 6-bit BCD representation. Core storage cycle time is 6 microseconds. A parity check is performed upon all internal transfer operations.

The central processor provides complete arithmetic facilities for single word-length binary operands. Loading, storing, addition, and subtraction of double-length binary data items can also be performed. An optional feature permits addition and subtraction (but not multiplication or division) of single- or double-length data items in BCD form. This feature can significantly reduce the number of time-consuming radix conversions required in business data processing, but will seldom eliminate the problem completely.

Three index registers and a fourth location that serves as a convenient counter register are standard. An optional feature makes 31 additional 4-word groups in core storage

INTRODUCTION (Contd.)

§ 011.

available as index registers or counters. Only one group, selected by a special instruction, can be active at a time. Other optional features for the central processor are a Move Command (which expedites internal block transfer operations), Three-Way Compare, Automatic Priority Interrupt, and a Real-Time Clock. Instructions are executed at the rate of about 75,000 per second in typical GE 235 routines.

The Auxiliary Arithmetic Unit can perform double-length arithmetic in either fixed or floating point mode under control of the central processor. This optional unit greatly increases the 235's internal processing speeds on scientific problems.

Standard 80-column punched cards can be read at 400 or 1,000 cards per minute and punched at 100 or 300 cards per minute. Paper tape can be read at 250 or 1,000 characters per second and punched at 110 characters per second. A console typewriter provides keyboard input and typed output at 15 characters per second.

All peripheral devices except those mentioned above are connected to the central processor through a seven-way multiplexing device called the Controller Selector, which gives the GE 235 impressive capabilities for simultaneous operations. Up to seven controllers for magnetic tape units, disc storage units, printers, data communication equipment, and magnetic document handlers can be connected to the Controller Selector. One peripheral unit on each controller can operate simultaneously with internal processing and card reading and punching. Accesses to core storage are automatically allocated among the operating units by a straightforward priority system. Maximum gross data transfer rate through the standard Controller Selector is 55,600 words per second; an optional Dual Access Controller Selector increases the maximum rate to 111,000 words (or 333,000 characters) per second.

The printer has a peak speed of 900 alphameric lines per minute and a skipping speed of 25 inches per second. The printer controller provides automatic editing and format control. Special models of the high speed printer are available for use either on-line or for independent off-line tape-to-printer data transcriptions. Another printer with a peak speed of 150 alphameric lines per minute and no automatic format control is offered for use where output volume is relatively low.

Two magnetic tape handlers models are available. One has a peak data transfer rate of 15,000 characters per second at a recording density of 200 rows per inch. The other model offers a choice of 200 or 556 rows per inch, with corresponding peak speeds of 15,000 or 41,667 characters per second. The tape format is compatible with the IBM 727, 729, and 7330 Magnetic Tape Units. Two tape handlers are mounted in a single cabinet, one above the other. Up to eight tape handlers can be connected to each tape controller. The number of simultaneous 15KC tape read or write operations is limited only by the number of tape controllers in the system, but the number of simultaneous 41.6KC tape operations cannot exceed two (or four with the Dual Access Controller Selector).

Each Mass Random Access Data Storage (MRADS) unit provides disc storage for approximately 18.87 million alphameric characters in 98,304 fixed record locations of 64 words (or 192 characters) each. The average total waiting time for access to a randomly-placed record is 225 milliseconds. Up to 294,912 characters per MRADS unit can be transferred without repositioning any of the 16 access arms. A maximum of four MRADS file units can be connected to each MRADS controller, and up to eight controllers can be used in a GE 225 system. Only one MRADS read or write operation can occur at a time.

Magnetically encoded paper documents can be read or sorted at a peak speed of 1,200 documents per minute. Two document handlers can be connected to each controller, providing a peak sorting speed of 2,400 documents per minute.

The DATANET-15 controls the transmission and reception of digital data over telehone and telegraph lines and two-wire cables at speeds ranging from 60 to 2,400 bits per second. Up to 15 data transmission lines and a paper tape reader and punch can be connected to a DATANET-15, but it can control only one data transfer operation at a time.

§ 011. INTRODUCTION (Contd.)

GE's line of data communications equipment also includes:

- The DATANET-30 programmed data communication system.
- The DATANET-600 paper tape terminal.
- The DATANET-90 magnetic-tape-to-computer terminal.
- The DATANET-91 off-line magnetic-tape-to-magnetic-tape terminal.
- A variety of special digital input-output devices.

GE's MOSE (Modification of Standard Equipment) group offers a variety of special-purpose hardware for use with the 235 system, such as peripheral device switching controllers, printer plotting option, plotter interface units, etc.

Software

All of the programs and programming systems that have been developed for the GE 225 are directly usable on similarly equipped GE 235 systems. The available software is summarized below and described in detail in the GE 225 report, Sections 321:151 through 321:191.

The General Assembly Program (GAP) is the basic symbolic assembly system for the GE 235. It permits full utilization of the hardware facilities, is relatively easy to learn and use, but provides few refinements. GAP-coded programs can be assembled on GE 235 systems with punched card, paper tape, or magnetic tape input-output equipment.

ZOOM is a "macro assembly system" designed to facilitate machine oriented programming by reducing the amount of detailed coding required while retaining high object program efficiencies. The ZOOM programmer uses a combination of pseudo-English statements, algebraic expressions, and GAP symbolic statements. These are translated into an all-GAP program which is then assembled in the normal manner. Magnetic tape is not required, but can be utilized to facilitate the translation process.

GECOM is offered as an all-purpose process oriented language. The basic language structure is similar to that of COBOL-61 but is not compatible with it. (A COBOL-61 to GECOM translator will be provided.) GECOM also handles algebraic expressions and mathematical functions, and includes a report writer and TABSOL, a system that permits decision logic to be expressed in a concise tabular format. At least four magnetic tape handlers and 8,192 core storage locations are required for GECOM compilations.

WIZ is a one-pass algebraic compiler for use on punched card or paper tape systems with at least 8,192 core storage locations. WIZ is less powerful than the FORTRAN or ALGOL language, but is easy to learn and provides high compilation speeds.

FORTRAN II is available for GE 235 systems with at least 8,192 core storage locations and 4 magnetic tape units. Arrays are limited to two dimensions, and Boolean, complex, and double precision statements are not permitted. On the other hand, several useful extensions of the FORTRAN II language have been incorporated.

BRIDGE II is a tape file maintenance and run sequencing program whose functions are directed by control cards. FORWARD is a generalized sort/merge generator. Simulation programs are available for simulating the operations of IBM 650 and General Precision LGP-30 computers on the GE 235. The Card Program Generator simplifies the programming of existing punched card tabulator and calculator runs for the GE 235. An adequate library of generalized input-output, diagnostic, and mathematical routines are available, as are special-purpose packages for the banking and electric utility industries, numerical tool control, inventory management, assembly line balancing, critical path scheduling, and information retrieval.

DATA STRUCTURE

§ 021.

.1 STORAGE LOCATIONS

Name of Location	Size	Purpose or Use
Word:	20 bits + parity	basic addressable location.
Sector:	64 words	Mass Random Access Data Storage record location.
Band:	8 or 16 sectors	Mass Random Access Data Storage.
Disc:	512 bands	Mass Random Access Data Storage.

.2 INFORMATION FORMATS

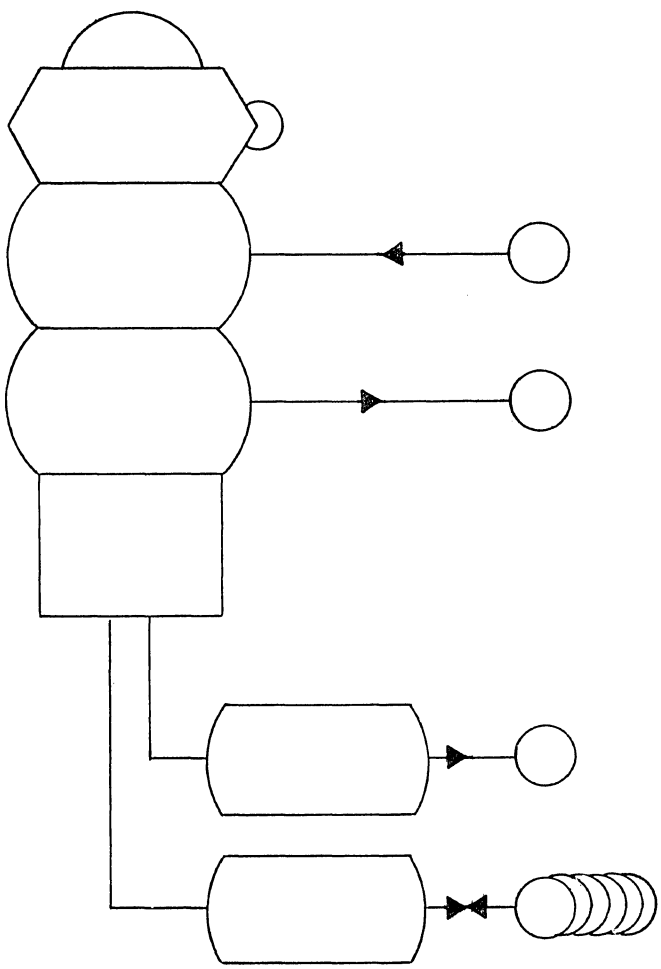
Type of Information	Representation
Numeral (BCD):	three 6-bit characters per word.
Letter (BCD):	three 6-bit characters per word.
Number (BCD):	one or two 3-character words.
Number (binary):	one or two 20-bit words.
Number (floating point):	two words (30 bits + sign for mantissa; 8 bits + sign for exponent).
Instruction:	one word (two words for certain input-output instructions).

SYSTEM CONFIGURATION

§ 031.

.3 6-TAPE BUSINESS SYSTEM (CONFIGURATION III)

Deviations from Standard Configuration: . . . . card reader is 20% slower.
printer is 80% faster.
magnetic tape is 39% faster.
2 more simultaneous non-tape data transfer operations are possible.



Equipment	Rental
Core Storage: 4,096 words; Central Processor, Console, & Typewriter	$3,550
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	1,000
Printer & Controller: 900 lines/min.	1,275
Magnetic Tape Units (6) & Controller: 15,000 or 41,667 char/sec.	4,930

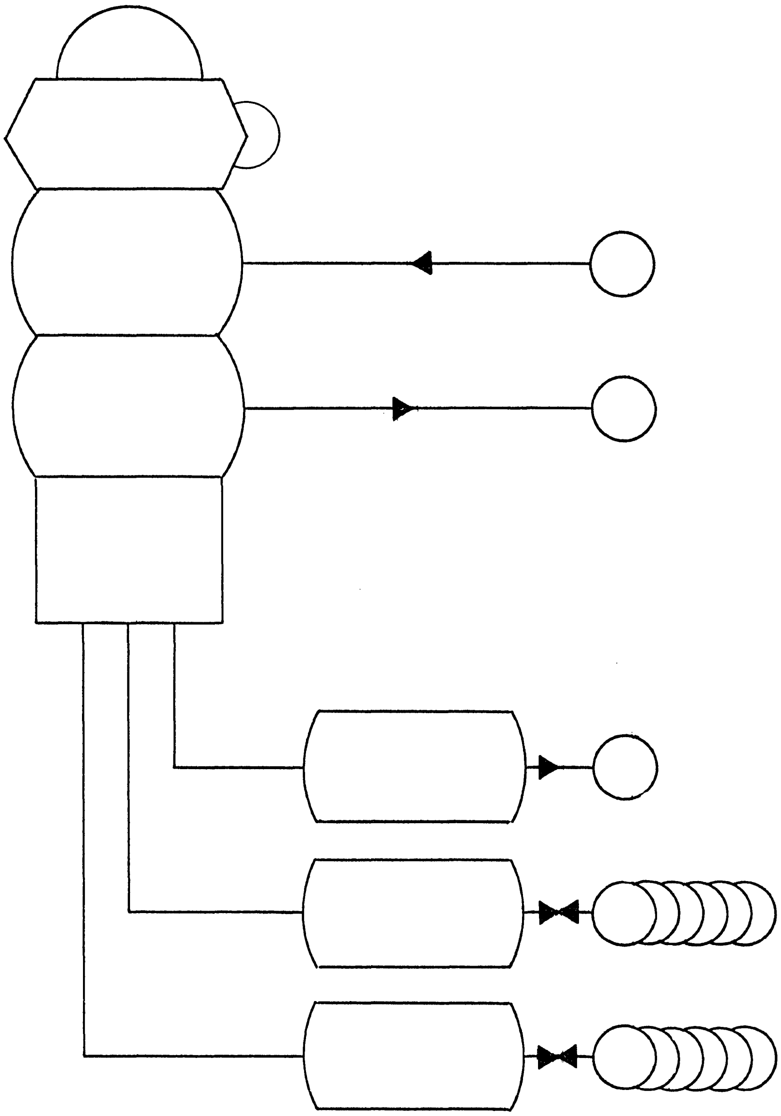
Optional Features Included: . . . .

Move Command.	95
Three-way compare. Decimal addition & subtraction. Additional address modification groups.	245
TOTAL	$11,870

§ 031.

.4 12-TAPE BUSINESS SYSTEM (CONFIGURATION IV)

Deviations from Standard Configuration: . . . . card punch is 50% faster.
magnetic tape is 30% slower.
1 more simultaneous non-tape data transfer operation is possible.



Equipment	Rental
Core Storage: 8,192 words Central Processor, Console, & Typewriter	$4,180
Card Reader & Controller: 1,000 cards/min.	810
Card Punch & Controller: 300 cards/min.	825
Controller Selector	1,000
Printer & Controller: 900 lines/min.	1,275
Magnetic Tape Units (6) & Controller: 15,000 or 41,667 char/sec.	4,930
Magnetic Tape Units (6) & Controller: 15,000 or 41,667 char/sec.	4,930

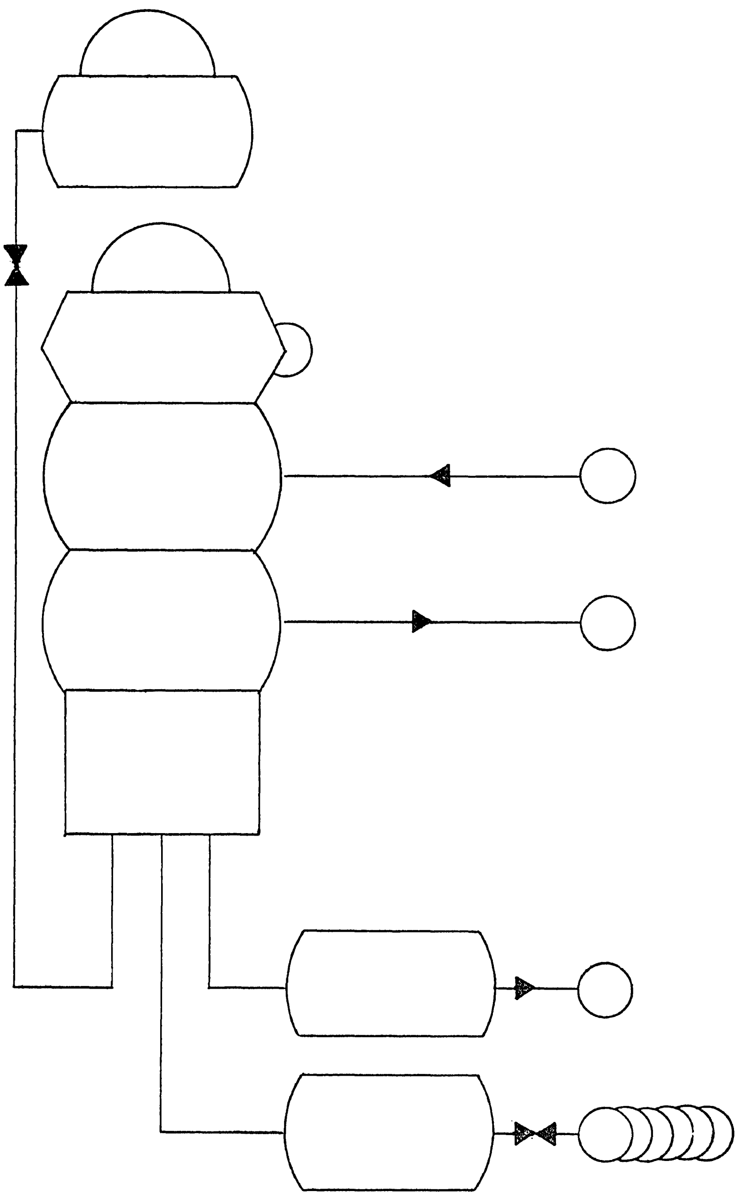
Optional Features Included: . . . .

Feature	Rental
Move Command.	95
Three-Way Compare. Decimal Addition & Subtraction. Additional Address Modification Groups.	245
Automatic Interrupt.	95
TOTAL	$18,385

§ 031.

.5 6-TAPE AUXILIARY STORAGE SYSTEM (CONFIGURATION V)

Deviations from Standard Configuration: . . . .
card reader is 20% slower.
printer is 80% faster.
magnetic tape is 39% faster.
2 more simultaneous non-tape data transfer operations are possible.



Equipment	Rental
Mass Random Access (Disc) Storage & Controller: 18,874,368 characters	$2,625
Core Storage: 4,096 words; Central Processor, Console, & Typewriter	3,550
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	1,000
Printer & Controller: 900 lines/min.	1,275
Magnetic Tape Units (6) & Controller: 15,000 or 41,667 char/sec.	4,930

Optional Features Included: . . . .

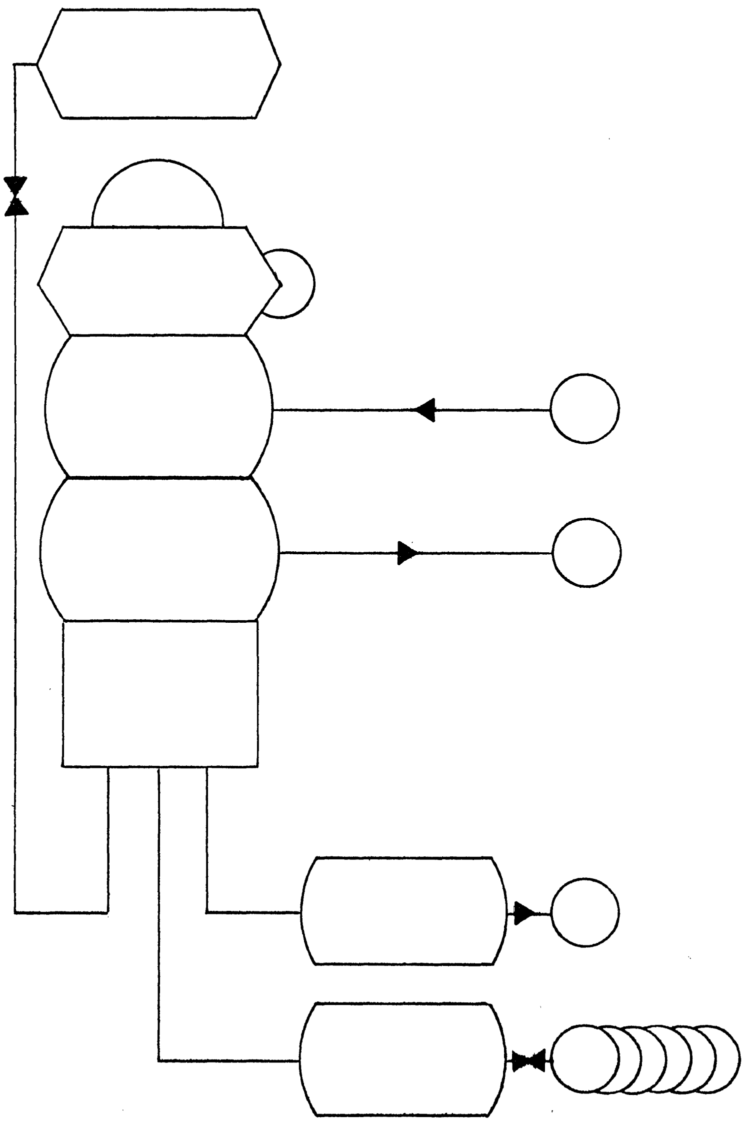
Feature	Rental
Move Command.	95
Three-Way Compare. Decimal Addition & Subtraction. Additional Address Modification Groups.	245
Automatic Interrupt.	95

TOTAL $14,590

§ 031.

.6 6-TAPE BUSINESS/SCIENTIFIC SYSTEM (CONFIGURATION VI)

Deviations from Standard Configuration: . . . . card reader is 20% slower.
printer is 80% faster.
magnetic tape is 39% faster.
2 more simultaneous non-tape data transfer operations are possible.



Equipment	Rental
Auxiliary Arithmetic Unit	$1,500
Core Storage: 16,384 words; Central Processor, Console, & Typewriter	5,300
Card Reader & Controller: 400 cards/min.	375
Card Punch & Controller: 100 cards/min.	400
Controller Selector	1,000
Printer & Controller: 900 lines/min.	1,275
Magnetic Tape Units (6) & Controller: 15,000 or 41,667 char/sec.	4,930

Optional Features Included: . . . .

Feature	Rental
Move Command.	95
Three-Way Compare.; Decimal Addition & Subtraction.; Additional Address Modification Groups.	245
TOTAL	$15,120

INTERNAL STORAGE: CORE STORAGE

§ 041.

.1 GENERAL

.11 Identity: . . . . Core Storage.
MM235A (4,096 locations).
MM235B (8,192 locations).
MM235C (16,384 locations).

.12 Basic Use: . . . . working storage.

.13 Description

Core Storage is housed in the Central Processor cabinet and may consist of 4,096, 8,192, or 16,384 locations. Each storage location consists of twenty data bits and one parity bit and can hold a single-address instruction, a binary data word of nineteen bits plus sign, or three BCD characters. Single or double word-length load and store operations are possible in the basic processor; and internal block transfers of any length are possible with the optional Move Command, at a maximum effective rate of 83,333 words per second.

.14 Availability: . . . . 15 months as of March, 1963.

.15 First Delivery: . . . . 1964.

.16 Reserved Storage

Purpose	No. of Locations	Locks
Index registers and counters:	4 (128 with option)	none.
Arith registers:		
Logic registers:	none.	
I/O control:	none.	

.2 PHYSICAL FORM

.21 Storage Medium: . . . . magnetic core.

.22 Physical Dimensions: . not available.

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by program: . . . . yes.
.242 Data regenerated constantly: . . . . . . no.
.243 Data volatile: . . . . . yes (usually retained).
.244 Data permanent: . . . . no.
.245 Storage changeable: . . no.

.28 Access Techniques

.281 Recording method: . . . coincident current.
.283 Type of access: . . . . uniform.

.29 Potential Transfer Rates

.292 Peak data rates
Unit of data: . . . . . 1 word.
Conversion factor: . . 20 bits per word.
Cycling rate: . . . . . 166,667 cycles/second.
Data rate: . . . . . . 166,667 words/second.

.3 DATA CAPACITY

.31 Module and System Sizes

	Minimum Storage		Maximum Storage
Identity:	MM235A	MM235B	MM235C.
Words:	4,096	8,192	16,384.
Characters:	12,288	24,576	49,152.
Instructions:	4,096	8,192	16,384.
Modules:	1	1	1.

.32 Rules for Combining Modules: . . . . all configurations are shown above.

.4 CONTROLLER: . . . . none.

.5 ACCESS TIMING

.51 Arrangement of Heads: one access device per system.

.52 Simultaneous Operations: . . . . . . none.

.53 Access Time Parameters and Variations

.531 For uniform access
Access time: . . . . . 3 μsec.
Cycle time: . . . . . . 6 μsec.
For data unit of: . . . 1 word.

.6 CHANGEABLE STORAGE: . . . . . . no.

.7 AUXILIARY STORAGE PERFORMANCE

.71 Data Transfer

Pairs of storage units possibilities

With self: . . . . yes.
With Mass Random Access File: . . . . yes (see Section 323:042).

.72 Transfer Load Size

With self: . . . . 1 or 2 words; or, with optional Move Command, 1 to N words, where N is limited by storage capacity.

§ 041.

.73 Effective Transfer Rate

With self, using indexed loop: . . . . . 28,000 words/second.
With self, using optional Move Command: . . . . . . 83,333 words/second.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	none.	
Receipt of data:	parity check	indicator & alarm; optional stop.
Dispatch of data:	send parity bit.	
Conflicting commands:	not possible.	
Recovery of data:	parity check	indicator & alarm; optional stop.
Recording of data:	record parity bit.	

INTERNAL STORAGE: MASS RANDOM ACCESS DATA STORAGE

§ 042.

.1 GENERAL

.11 Identity: . . . . Mass Random Access Data Storage.
M640A.
MRADS.

.13 Description:

Each Mass Random Access file unit consists of sixteen data discs and two checking discs on a common vertical axis. Up to four files can be connected to one MRADS Controller, which occupies one of the seven "hubs" on the Controller Selector. If no other peripheral units were connected into the Controller Selector, it would be possible to connect up to 28 MRADS Units for a system capacity of over five hundred million characters.

Each disc surface is divided into 256 bands. The outer 128 bands contain sixteen sectors each and the inner 128 bands contain eight sectors each. One 64-word block of data (192 alphameric characters) can be stored in each sector, and from one to sixteen sectors can be transferred between disc storage and core storage in a single MRADS read or write operation. Total capacity of each MRADS unit is 98,304 sectors, 6.29 million words, 18.87 million characters, or about 34.6 million decimal digits.

Each disc is served by an individual positioning arm containing eight read-write heads. Four heads serve the top disc surface and the other four serve the bottom surface, so only sixty-four arm positions are required to cover all the bands on a disc. Arm positioning time ranges from 70 to 305 milliseconds, and the average total waiting time for random accessing is 199 milliseconds. Up to 98,304 words per file unit can be transferred without moving any of the positioning arms. Peak transfer rate is 23,700 words per second for data recorded on the outer bands and 11,850 words per second for the inner bands. An effective bulk transfer rate of 20,000 words per second can be obtained with optimum data placement.

A parity bit is recorded and checked for each word. In addition, the sixty-fifth word recorded in each sector is composed of one longitudinal parity check bit for each of the twenty bit positions of the sixty-four data words. This two-way parity check makes it possible to locate and correct, by means of a subroutine, a single-bit error occurring anywhere in a sector. The address of each sector is permanently recorded in a "header" word and used for sector identification and band address confirmation.

.13 Description (Contd.)

Three instruction words are required for each disc seek, read, or write operation. The first word selects the proper controller and transfers to it the next two words, which specify the exact operation and the addresses involved. Simultaneous read or write operations are limited to one per Mass Random Access Controller. Only one head positioning operation at a time may occur in each MRADS unit, or up to four at a time per controller.

.14 Availability: . . . . . . 1 month as of March, 1963.

.15 First Delivery: . . . . 1963.

.16 Reserved Storage: . . . no addressable locations reserved.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . multiple discs.

.22 Physical Dimensions

.222 Disc
Diameter: . . . . . . 31 inches.
Thickness or length: . thin.
Number on shaft: . . . 18 discs (16 for data).

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by program: . . . . yes.
.242 Data regenerated constantly: . . . . . . no.
.243 Data volatile: . . . . . no.
.244 Data permanent: . . . . no.
.245 Storage changeable: . . no.

.25 Data Volume per Band of 1 Track

Words: . . . . 1,024 (outer) or 512 (inner).
Characters: . . . . . . 3,072 (outer) or 1,536 (inner).
Digits: . . . . 5,632 (outer) or 2,816 (inner).
Instructions: . . . . . . 1,024 (outer) or 512 (inner).
Sectors: . . . . 16 (outer) or 8 (inner).

.26 Bands per Physical Unit: 512 (256 per disc surface).

.27 Interleaving Levels: . . 1.

§ 042.

.28 Access Techniques

.281 Recording method: . . . moving heads.

.283 Types of access

Description of stage	Possible starting stage
Move head to selected band: . . .	if new band is selected.
Wait for start of selected sector: . .	if head movement is unnecessary.
Transfer data: . . .	no.

.29 Potential Transfer Rates

.291 Peak bit rates
Cycling rates: . . . . 1,200 rpm.
Bits/inch/track: . . . 400 maximum.
Bit rate per track: . . 500,000 or 250,000 bits/sec/track.

.292 Peak data rates
Unit of data: . . . . . word.
Conversion factor: . . 20 data bits/word.
Gain factor: . . . . . 1.
Data rate: . . . . . . 23,700 (outer) or 11,850 (inner) words/sec.

.3 DATA CAPACITY

.31 Module and System Sizes (See table below)

.32 Rules for Combining Modules: . . . . up to 4 MRADS units per controller; up to 7 controllers per system.

.4 CONTROLLER

.41 Identity: . . . . MRADS Controller. M225B.

.42 Connection to System

.421 On-line: . . . . up to 7; each requires 1 of the 7 Controller Selector hubs.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 4.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to 16 sectors of 64 words each.
.442 Input-output area: . . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Synchronization: . . . . automatic during a read or write operation.
.447 Table control: . . . . . none.
.448 Testable conditions: . . MRADS ready, controller ready.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of stacks
Stacks per system: . . 128 to 512 per controller.
Stacks per module: . . 128.
Stacks per yoke: . . . 8.
Yokes per module: . . 16 (one for each disc).
.512 Stack movement: . . . . in horizontal plane only.
.513 Stacks that can access any particular location: . . . . 1.
.514 Accessible locations
By single stack
With no movement: . 16 or 8 sectors.
With all movement: . 1,024 or 512 sectors.
By all stacks
With no movement: . 1,536 per module.
6,144 per controller.

.515 Relationship between stacks and locations: . least significant 7 bits of MRADS address specify stack and sector.

.52 Simultaneous Operations

A: . . . . waiting for access to specified location.
C: . . . . reading.
D: . . . . recording.

a + c + d = at most 1 per MRADS unit.
c + d = at most 1 per system.

Note: A maximum of one MRADS controller can transfer data at a time.

	Minimum Storage	Single MRADS Unit	Maximum Storage per Controller	Maximum Storage per System
Identity:		M640A	M640A	M640A.
Discs:	0	16	64	448.
Words:	0	6.29×10^6	25.2×10^6	176×10^6.
Characters:	0	18.87×10^6	75.5×10^6	528×10^6.
Instructions:	0	6.29×10^6	25.2×10^6	176×10^6.
Digits:	0	34.60×10^6	138.4×10^6	970×10^6.
Sectors:	0	98,304	393,216	2,752,512.
Modules:	0	1	4	28.

§ 042.

.53 Access Time Parameters and Variations

.532 Variation in access time

Stage	Variation msec.	Example, msec.
Move head to selected band:	0 or 70 to 305	199 (avg.)
Wait for start of selected sector: . . .	0 to 52	26 (avg.)
Transfer 1 sector of data:	3.1 or 6.2	3.1.
Total:	3.1 to 363.2	328.1.

.6 CHANGEABLE STORAGE: . . . . . . no.

.7 AUXILIARY STORAGE PERFORMANCE

.71 Data Transfer

Pair of storage units possibilities

With self: . . . . no.
With core storage: . . yes.

.72 Transfer Load Size

With core storage: . . . 1 to 16 sectors of 64 words each.

.73 Effective Transfer Rate

With core storage: . . . 20,000 words/sec or 60,000 char/sec.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	indicator.
Receipt of data:	parity	indicator.
Dispatch of data:	send parity bit.	
Conflicting commands:	check	indicator.
Recovery of data:	word & sector parity	indicator.
Wrong record selected:	address comparison	indicator.
Recording of data:	generate parity word.	

CENTRAL PROCESSOR

§ 051.

.1 GENERAL

.11 Identity: . . . . Central Processor.
CA235.

Auxiliary Arithmetic Unit.
AAU235.
AAU.

.12 Description

The 235 is a single-address, fixed word-length, sequential processor. The main arithmetic and control circuitry, core storage, and console controls are housed in the processor cabinet. Word length of core memory locations and control registers is twenty bits. One location may contain an instruction, a binary data word consisting of a sign bit and nineteen data bits, or an alphameric data word consisting of three six-bit BCD-coded characters. Complete arithmetic facilities for single word-length binary data are built in.

Because the twenty-bit word is too short for many data processing and scientific applications, standard instructions are provided for double word-length addition, subtraction, and data transfers. In these cases, the combined A and Q Registers serve as a double-length accumulator. In the standard processor, subroutines must be used for double-length binary multiplication and division and for all decimal and floating point arithmetic operations. Optional hardware which can provide many of these arithmetic facilities is described below.

Three index registers and a fourth location that serves as a convenient counter register are standard, and special instructions facilitate incrementing and testing them. A variety of instructions is provided for inter-register transfers, shifting, normalizing, and complementing. These instructions do not require an operand address, so bits 7 through 19, which would normally contain the address, are used to define the exact operation to be performed. Through various combinations of these thirteen bits, the advanced programmer can create many special instructions in addition to those in the standard GE-defined repertoire. This technique is termed "micro-programming".

There are no table look-up facilities, and multi-word internal transfers require the optional Move Command. Editing is accomplished by format control circuitry in the printer controller; this reduces time demands upon the Central Processor while permitting a high degree of flexibility in the printed output. Conditional branch instructions result in execution of the next sequential instruction (which will normally be an unconditional branch) if the tested condition is true; otherwise, the next sequential instruction is

.12 Description (Contd.)

skipped. Since only thirteen operand address bits are contained in an instruction, the top 8,192 words of a 16,384-word core memory can be addressed only through the use of index registers. Program instructions rather than data will normally be loaded into the upper storage bank, since the instruction address counter uses fifteen bits and can address up to 32,768.

Optional Features

Auxiliary Arithmetic Unit (AAU): This independent unit provides complete hardware facilities for double word-length binary arithmetic in either fixed or floating point mode. Data can be transferred directly between the forty-bit AAU accumulator register and core storage. The AAU is connected directly to the Central Processor. Like the other peripheral devices, it can be tested for various error conditions; unlike the others, only one instruction word is required for any AAU operation. A floating point data item is represented by thirty bits plus sign for the mantissa and eight bits plus sign for the exponent. This is the equivalent of 9 decimal digits of precision and an exponent range of 10^{-76} to 10^{+76}.

Decimal Addition and Subtraction: This feature enables the Central Processor to perform single and double-length addition and subtraction on decimal data stored in the six-bit BCD form. A carry indicator facilitates the coding of additions or subtractions of fields more than six characters long, but negative BCD numbers must be stored in the inconvenient ten's complement form. Instructions are provided to shift between the decimal and binary arithmetic modes.

Additional Address Modification Word Groups: This makes a total of thirty-two four-word groups (core storage locations 0000-0127) available as index registers or counters. Only one group, selected by a special instruction, may be active at a time, and only three of the four words are usable for address modification.

Three-Way Compare: Permits branching to the first, second, or third sequential instruction depending upon whether the contents of a specified single or double-length core storage location are greater than, equal to, or less than the contents of the accumulator.

Move Command: Provides a single instruction to transfer any number of successive words from one core storage area to another. The A and Q registers must contain, respectively, the new initial address and the number of words to be moved.

Automatic Priority Interrupt: Provides automatic storing of the sequence counter contents and a transfer of control to core storage location 0132 whenever any selected peripheral controller switches from "not ready" to "ready" status. Interruption from the

§ 051.

.12 Description (Contd.)

console is not possible. The interrupt feature is especially useful for overlapping data transcription operations with independent processing routines.

Real Time Clock: Provides a nineteen-bit binary clock counter that measures time in sixths of seconds from zero to 24 hours. The clock can be set by the stored program or the operator and can be interrogated by the program through a special instruction.

.13 Availability: . . . . . . 15 months as of March, 1963.

.14 First Delivery: . . . . 1964.

.2 PROCESSING FACILITIES

.21 Operations and Operands

	Operation and Variation	Provision	Radix	Size
.211	Fixed point			
	Add-Subtract:	automatic	binary (decimal with option)	1 or 2 words.
	Multiply			
	Short:	none.		
	Long:	automatic	binary	1 word (2 with AAU).
	Divide			
	No remainder:	none.		
	Remainder:	automatic	binary	1 word (2 with AAU).
.212	Floating point			
	Add-Subtract:	subroutine or AAU	binary	30 & 8 bits (2 words).
	Multiply:	subroutine or AAU	binary	30 & 8 bits (2 words).
	Divide:	subroutine or AAU	binary	30 & 8 bits (2 words)
.213	Boolean			
	AND:	none.	binary	
	Inclusive OR:	automatic	binary	1 word.
	Extract:	automatic	binary	1 word.
.214	Comparison			
	Numbers:	subtract & test		1 word.
	Absolute:	none.		
	Letters:	subtract & test		1 word.
	Mixed:	subtract & test		1 word.
	Collating sequence:	0-9, A-Z; special characters interspersed among letters; see 312:144.100.		
	Comment:	Direct high-low equal comparisons on 1 or 2 words of numeric or alpha data are possible with optional Three-Way Compare.		

.215 Code translation

Provision	From	To
subroutine	paper tape	internal.
subroutine	internal	paper tape.

.216 Radix conversion

Provision	From	To
subroutine	BCD	binary.
subroutine	binary	BCD.

.217 Edit format

	Provision	Size
Alter size:	automatic	up to 120 char.
Suppress zero:	automatic	up to 120 char.
Round off:	automatic	up to 120 char.
Insert point:	automatic	up to 120 char.
Insert spaces:	automatic	up to 120 char.
Insert any char: . . .	automatic	up to 120 char.
Float $:	none.	up to 120 char.
Protection:	none.	up to 120 char.

.218 Table look-up: . . . . . . no provision.

.219 Others

	Provision	Comment	Size
Normalize:	automatic	binary	1 or 2 words.
Decimal mode shift:	automatic	optional.	
1's complement:	automatic	binary	1 word.
2's complement:	automatic	binary	1 word.
Select index group:	automatic	optional	1 of 32 groups.

.22 Special Cases of Operands

.221 Negative numbers: . . . 2's complement (10's complement with Decimal Add-Subtract).

.222 Zero: . . . . one form; 0 in all bit positions.

.223 Operand size determination: . . . . fixed.

.23 Instruction Formats

.231 Instruction structure: . 1 word (3 words for certain input-output operations).

.232 Instruction layout:

Part	Op	X	Addr or Op'
Size (bits)	5	2	13

.233 Instruction parts

Name	Purpose
Op:	operation code.
X:	index register specification.
Addr:	operand address.
Op':	extension of operation code in instructions with no operand address.

.234 Basic address structure: 1 + 0.

.235 Literals

Arithmetic: . . . . . . none.

Comparisons and tests: . . . . up to 8,192, on index registers only.

Incrementing modifiers: . . . . . up to 8,192.

.236 Directly addressed operands

.2361 Internal

storage type	Minimum size	Maximum size	Volume accessible
Core:	1 word	2 words*	8,192 words.
Disc:	64 words	1,024 words	total capacity.

* or total capacity with Move Command.

.2362 Increased address capacity

Method	Volume accessible
Indexing:	16,384 words (core).

§ 051.

.237 Address indexing
.2371 Number of methods: . 1.
.2372 Names: . . . . indexing.
.2373 Indexing rule: . . . . . addition, module 32,768.
.2374 Index specification: . . bits 5 & 6 of instruction to be modified.
.2375 Number of potential indexers: . . . . . . 3 (96 optional).
.2376 Addresses which can be indexed: . . . . . operand addresses in arithmetic, load, store, and unconditional branch instructions.
.2377 Cumulative indexing: . none.
.2378 Combined index and step: . . . . . . none.
.238 Indirect addressing: . . none.
.239 Stepping: . . . . index registers.
.2391 Specification of increment: . . . . . in stepping instruction.
.2392 Increment sign: . . . . always positive.
.2393 Size of increment: . . 1 to 8,192.
.2394 End value: . . . . . . specified in test instruction.
.2395 Combined step and test: . . . . no.

.24 Special Processor Storage

.241 Category of storage

Category	Number of locations	Size in bits	Program usage
Central Processor:	1	20	upper accumulator, A.
Central Processor:	1	20	lower accumulator, Q.
Central Processor:	1	20	instruction register, I.
Central Processor:	1	15	sequence counter, P.
Central Processor:	1	6	single char. buffer, N.
Central Processor:	1	20	memory buffer, M.
Central Processor:	1	20	arithmetic buffer, B.
Aux. Arith. Unit:	1	40	upper accumulator, AX.
Aux. Arith. Unit:	1	40	lower accumulator, QX.
Core Storage:	3 (96 with option)	20	index registers.

.242 Category of storage

Category	Total number locations	Physical form	Access time, μ sec	Cycle time μ sec
Central Processor:	7	register	?	6.
Aux. Arith. Unit:	2	register	?	6.
Core Storage:	3 (96 with option)	core	3.0	6.

.3 SEQUENCE CONTROL FEATURES

.31 Instruction Sequencing

.311 Number of sequence control facilities: . . 1.
.314 Special sub-sequence counters: . . . . none.
.315 Sequence control step size: . . . . 1 word.
.316 Accessibility to program: . . . . can be stored in an index register.
.317 Permanent or optional modifier: . . . . no.

.32 Look-Ahead: . . . . . . none.

.33 Interruption: . . . . . . with optional Automatic Priority Interrupt only.

.331 Possible causes
In-out units: . . . . . indirectly, through controller status.
In-out controllers: . . change in status of peripheral controller from "not ready" to "ready".
Storage access: . . . indirectly, through controller status.
Processor errors: . . no.
Other: . . . . none.
.332 Program control
Individual control: . . peripheral controllers.
Method: . . . . "Priority Set" instruction permits selected controller(s) to interrupt.
.333 Operator control: . . . physical switch for each controller permits or locks out interruption by that controller.
.334 Interruption conditions: 1) in "Priority Set" mode. 2) not in priority routine. 3) change in status of any selected controller.
.335 Interruption process
Disabling interruption: automatic.
Registers saved: . . . sequence counter automatic; others by own coding.
Destination: . . . . . fixed jump to location 0132.
.336 Control methods
Determine cause: . . own coding; must test selected controllers.
Enable interruption: . own coding; "Priority Set" instruction.

.34 Multi-running: . . . . . limited capability with Automatic Priority Interrupt feature.

.341 Method of control: . . . own coding.
.342 Maximum number of programs: . . . . . 2 is practical limit.
.343 Precedence rules: . . . own coding.
.344 Program protection
Storage: . . . . none.
In-out units: . . . . . none.

.35 Multi-sequencing: . . . none

.4 PROCESSOR SPEEDS

.41 Instruction Times in μ secs

.411 Fixed point

	Single Precision	Double Precision	Double Precision, with AAU
Add:	12	18	24.
Subtract:	12	18	24.
Multiply:	30 to 138	946 (SR)	30 to 60.
Divide:	154 to 176	1,091 (SR)	96 to 102.

.412 Floating point

	Single Precision	Double Precision	Double Precision, with AAU
Add-subtract:	none	1,170 (SR)	30 to 36.
Multiply:	none	1,884 (SR)	30 to 60.
Divide:	none	4,710 (SR)	72 to 78.

§ 051.

.413 Additional allowance for

	Single Precision	Double Precision	Double Precision, with AAU
Indexing:	6	6	6.
Re-complementing:	none	none	none.

.414 Control

Compare (with Three-Way Compare:	12 to 18	12 to 30.
Branch:	6.	
Test & branch:	12.	

.415 Counter control

Step:	18.
Step & test:	30.
Test:	12.

.416 Edit: . . . . 0 (done in Printer Controller).

.417 Convert

BCD to binary: . . . . 42 + 100D (SR).

Binary to BCD: . . . . 133 to 1,813 (SR, for D = 6, with Decimal Add-Subtract).
333 + 267D (SR, without Decimal Add-Subtract).

.418 Shift: . . . . 15 + 2B (approximate, for shift of B bits).

Note: SR indicates that a programmed subroutine is used.
D is field length in decimal digits.

.42 Processor Performance in μsecs

.421 For random addresses

	Fixed point, single precision	Floating point, with AAU (average)
c = a + b:	36	69.
b = a + b:	36	69.
Sum N items:	12N	33N.
c = ab:	126	87.
c = a/b:	189	111.

.422 For arrays of data

$c_i = a_i + b_j$:	114	147.
$b_j = a_i + b_j$:	114	147.
Sum N items:	84N	117N.
$c = c + a_i b_j$:	210	192.

.423 Branch based on comparison

	Without Three-Way Compare	With Three-Way Compare
Numeric data (19-bit precision): .	114	102.
Alphabetic data (3-char precision): .	114	102.

.424 Switching

Unchecked:	48.
Checked:	120.
List search:	18 + 90N.

.425 Format control per character

Unpack
- Without radix conversion: . . . . 7.
- Including BCD-to-binary conversion: 114 (approx.).

Compose
- Without radix conversion: . . . . 6.
- Including binary-to-BCD conversion: . 233 (approx., without Decimal Add-Subtract).
  133 (approx., with Decimal Add-Subtract).

.426 Table look up per comparison (single precision)

	Without Three-Way Compare	With Three-Way Compare
For a match:	90	84.
For least or greatest:	96	90.
For interpolation point:	90	84.

.427 Bit indicators

Set bit in separate location:	24.
Set bit in pattern: . .	30.
Test bit in separate location:	36.
Test bit in pattern: . .	36.
Test AND for B bits: .	84 ($B \leq 19$).
Test OR for B bits: . .	108 ($B \leq 19$).

.428 Moving data

Single word:	24.
Double-length word: .	36.
N words, using programmed loop: .	12 + 42N.
N words, using optional Move Command:	42 + 12N.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Overflow:	check	indicator & alarm.
Underflow:	check (AAU only)	indicator & alarm.
Zero divisor:	overflow check	indicator & alarm.
Invalid data:	none.	
Invalid operation:	all codes used.	
Arithmetic error:	none.	
Invalid address:	none.	
Receipt of data:	parity check	indicator & alarm. optional stop.
Dispatch of data:	parity check	indicator & alarm. optional stop.

CONSOLE

§ 061.

.1 GENERAL

.11 Identity: . . . . contained in 235 Central Processor cabinet.

.12 Associated Units: . . . Console Typewriter and 400 card per minute Card Reader (if used) stand upon the console desk. (A free-standing 400 cpm card reader is also available.)

.13 Description

The console control panel is mounted vertically at desktop level on the narrower face of the Central Processor cabinet. A wide, L-shaped desk is placed directly in front of the control panel and provides ample working space. The unusual shape of the combined processor cabinet and console desk may make it difficult to arrange the system components for operating convenience in a small room. The control panel contains a fairly typical complement of register displays, alarm lights, and control buttons; these are fully described below.

The Console Typewriter is a modified IBM Selectric model that is cradled in the right-hand wing of the console desk. Data can be entered into the system from the typewriter keyboard, and can be typed out at up to 15 characters per second. Data to be typed, in BCD form, is sent to the unit via the 6-bit N Register, one character at a time. The typewriter character set includes the 26 letters, 10 numerals, and 19 special symbols. Other BCD codes cause the unit to "hang up".

.2 CONTROLS

.21 Power

Name	Form
Power on:	button.
Power off:	button.

.22 Connections: . . . . . . none.

.23 Stops and Restarts

Name	Form	Comment
Start:	button	initiates automatic operation if Auto-Manual switch is in AUTO position.
Auto-Manual:	2-position switch	halts automatic operation when switched to MANUAL.
Stop on Parity Alarm:	2-position switch	when ON, system halts on all parity errors.

.24 Stepping

Name	Form	Comment
Start:	button	initiates a single step if Auto-Manual switch is in MANUAL position.
Word-Instruction:	2-position switch	selects steps of one machine cycle or one full instruction.
Save P:	switch	inhibits normal advance of the sequence counter (P Register), so same instruction is repeated.

.25 Resets

Name	Form	Comment
Reset Alarm:	button	resets all alarms and error indicators.
Reset P:	button	clears sequence counter to location 0000.
Reset A:	button	clears accumulator (A Register).

.26 Loading

Name	Form	Comment
Load Card:	button	reads one binary card into Core Storage starting at location 0000.

.27 Sense Switches

Name	Form	Comment
Bit Switches:	20 3-position center-off toggle switches	used to place 1 bits into any desired positions in the A register (when raised); and to set patterns that can be read into the A register under program control (when lowered) to control program branching.

.28 Special

Name	Form	Comment
A→I	button	transfers contents of the A (accumulator) Register into the I (instruction) Register.
XAQ	button	interchanges contents of the A and Q Registers.

.3 DISPLAY

.31 Alarms

Name	Form	Condition Indicated
Parity:	light	parity error.
Overflow:	light	arithmetic overflow.
Card Reader:	light	error involving Card Reader.
Card Punch:	light	error involving Card Punch.
Echo:	light	peripheral controller unable to respond when addressed.

§ 061.

.32 Conditions

Name	Form	Condition Indicated
Priority:	light	loss of priority by Central Processor to a peripheral controller, alarm condition, or auto-manual switch in manual mode.
Card Reader Ready:	light	reader available for input.
Card Punch Ready:	light	punch available for output.
N Register Ready:	light	N Register available for paper tape or typewriter operation.
AIM:	light	processor in priority interrupt routine.
IX Group:	5 lights	index register group in use.
Decimal Mode:	light	Central Processor operating in decimal mode.
8K:	light	indicates 16K processor is operating in upper 8K.

.33 Control Registers

Name	Form	Comment
P Register:	15 lights	binary display of sequence counter contents.
I Register:	20 lights	binary display of next instruction to be executed.
A Register:	20 lights	binary display of accumulator contents; pressing XAQ will display Q Register contents.
N Register:	6 lights	binary display.

.34 Storage: . . . . no direct display available.

.4 ENTRY OF DATA

.41 Into Control Registers: 20 Bit Switches permit direct data entry into A Register only; A→I and XAQ buttons permit loading of I and Q Registers from A Register.

.42 Into Storage

1. Set Auto-Manual switch to MANUAL.
2. Set "Store A Register" instruction, with desired Core Storage location as operand address, in Bit Switches.
3. Depress A→I button to load the instruction.
4. Set Bit Switches to desired data value.
5. Depress Start button.

.5 CONVENIENCES

.51 Communication: . . . . none.

.52 Clock: . . . . none.

.53 Desk Space: . . . . . . ample free work space is provided on the console desk.

.54 View: . . . . Central Processor cabinet, 32 inches wide by 76 inches high, is directly in front of seated operator; view in other directions is unobstructed.

INPUT-OUTPUT: CARD READER (400 CPM)

§ 071.

.1 GENERAL

.11 Identity: . . . . Card Reader.
CRC235 (Console mounted).
CRF235 (Free-standing).

.12 Description

This is the English-built Elliott reader for standard eighty-column punched cards, extensively modified and improved by GE. The rated 400 card per minute speed is achieved when reading continuously into alternating input areas in core storage. When feeding one card at a time upon demand, the maximum speed is 360 cards per minute. The unit is extremely compact and usually stands upon the console desk; an optional base converts it into a free-standing unit. It provides none of the usual checks upon card reading accuracy such as dual reading stations or hole count checks. Programmed tests can be made to insure only that proper read synchronization was achieved; i.e., that each column was read once and only once. After every card is read, the photocells are checked to ensure that they are working.

Cards are read serially by column, and the input instruction selects one of three data formats:

Column decimal; data in each card column is translated automatically into one internal BCD character, and three characters are stored in each core storage location.

Ten-row binary; data in two successive card columns fills one twenty bit core storage location.

Twelve-row binary; data in each card column fills the twelve least significant bit positions of one core storage location. (Continuous feeding is not possible in this mode.)

The automatic reading of data from successive cards into alternating core storage areas in the column decimal and ten-row binary modes can save Central Processor time through the elimination of internal transfers before the input data is processed.

.13 Availability: . . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . March, 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . none.
.222 Sensing system: . . . . photoelectric.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . . 12.
Method of use: . . . . . 80 columns per card, one at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column cards.
.312 Phenomenon: . . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . 80 columns at standard spacing.
.322 Parallel by: . . . . . . 12 rows at standard spacing.
.324 Track use
Data: . . . . 80.
Total: . . . . 80.
.325 Row use
Data: . . . . 12 (10 for 10-row binary data).

.33 Coding: . . . . Decimal: column code as in Data Code Table No. 3.
10-Row Binary: 2 card columns per 20-bit core storage word.
12-Row Binary: 1 card column per core storage word, into the 12 least significant bit positions.
Read Card Intermixed: permits reading intermixed cards in decimal and 12-row binary modes.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 80-column cards:	not required.

.35 Physical Dimensions: . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Reader Controller.
(housed in Central Processor).

§ 071.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . cannot be used in same system with 1,000-card-per-minute reader.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N cards of 80 columns per card.
.442 Input-output areas: . . core storage; address of first location filled must be a multiple of 128 and less than 2048.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic within a card; by program for successive cards.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation Input: . . . . fixed.

.52 Input-Output Operations

.521 Input: . . . . 1 to N cards forward; cards are read continuously until "halt card reader" command is given.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by processor: column decimal to internal BCD; or 10- or 12-row binary to internal binary.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Offset card: . . . . . . no.
Select stacker: . . . . . no.
Select format: . . . . . no.
Select code: . . . . . . yes, in "read" command.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 400 cards/minute.
.623 Overhead: . . . . asynchronous; reading rate is controlled by program.
.624 Effective speeds: . . . 400 cards/min. when feeding continuously.
360 cards/min. maximum if "halt card reader" instruction is given after each card (demand feeding).

.63 Demands on System

Component	msec. per card, or	Percentage
Core Storage:	0.5	0.33

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls: . . . . none.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	600 cards.
Stacker:	600 cards.

.732 Replenishment time: . . 0.25 to 0.50 mins. reader does not need to be stopped.
.733 Adjustment time: . . . none.
.734 Optimum reloading period: . . . . 1.5 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	none.	
Input area overflow:	none.	
Invalid code:	check	
Exhausted medium:	check	stop reader; alarm.
Imperfect medium:	none.	
Timing conflicts:	none.	
Misfeed:	check	stop reader; alarm.
Stacker full:	check	stop reader; alarm.
Synchronization:	check	set bit indicator in core storage.

INPUT-OUTPUT: CARD READER (1,000 CPM)

§ 072.

.1 GENERAL

.11 Identity: . . . . Card Reader.
CRD235.

.12 Description

This unit has been developed by GE to provide high speed punched card input to the 225 system. Currently rated at 1,500 cards per minute when feeding continuously, it is said to be capable of higher speeds. When cards are fed singly on demand, the rated maximum speed drops to 890 cards per minute. A character validity check (on decimal coded data only) and a read error check provide checks on reading accuracy. The unit reads standard eighty-column cards only, and the hopper and single stacker have capacities of 2,000 cards each. Cards are fed singly by a vacuum pick-off and transported by a moving belt past the photoelectric read heads. Input instructions, card data formats, and code translation facilities are identical to those for the slower reader, so there is a high degree of upward compatibility between the two units.

.13 Availability: . . . . . . 9 months as of March, 1963.

.14 First Delivery: . . . . March, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . moving belt friction.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . none.
.222 Sensing system: . . . . photoelectric (solarcells).

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . . 12.
Method of use: . . . . . 80 columns per card, one at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column cards.
.312 Phenomenon: . . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . 80 columns at standard spacing.
.322 Parallel by: . . . . . . 12 rows at standard spacing.
.324 Track use
Data: . . . . 80.
Total: . . . . 80.
.325 Row use
Data: . . . . 12 (10 for 10-row binary data).

.33 Coding: . . . . Decimal: column code as in Data Code Table No. 3.
10-Row Binary: 2 card columns per 20-bit core storage word.
12-Row Binary: 1 card column per core storage word, into the 12 least significant bit positions.
Read Card Intermixed: permits reading cards in decimal and 12-row binary modes intermixed.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 80-column cards:	not required.

.35 Physical Dimensions: . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Reader Controller (housed in Central Processor).

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . cannot be used in same system with 400-card-per-minute reader.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N cards of 80 columns per card.

.442 Input-output areas: . . core storage; address of first location filled must be a multiple of 128 and less than 2048.

§ 072.

.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic within a card; by program for successive cards.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation Input: . . . . fixed.

.52 Input-Output Operations

.521 Input: . . . . 1 to N cards forward; cards are read continuously until "halt card reader" command is given.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by processor: column decimal to internal BCD; or 10- or 12-row binary to internal binary.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Offset card: . . . . . . no.
Select stacker: . . . . . no.
Select format: . . . . . no.
Select code: . . . . . . yes, in "read" command.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.
End of file: . . . . yes.
Invalid character (Hollerith): . . . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 1,000 cards/minute nominal.
.623 Overhead: . . . . asynchronous; reading rate is controlled by program.
.624 Effective speeds: . . . 1,500 cards/min. when feeding continuously.
890 cards/min. maximum if "halt card reader" instruction is given after each card (demand feeding).

.63 Demands on System

Component	Msec per card	or	Percentage
Core Storage:	0.5		1.25 max.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls

Function	Form	Comment
Clear read error:	button	resets error alarms.
End of file:	button	sets bit indicator when last card is read.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	2,000 cards.
Stacker:	2,000 cards.

.732 Replenishment time: . . 0.25 to 0.50 min. reader does not need to be stopped.
.733 Adjustment time: . . . none.
.734 Optimum reloading period: . . . . 1.3 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	read check	set bit 18.
Input area overflow:	none.	
Invalid code:	check (BCD data only)	set bit 17.
Exhausted medium:	check	set bit 19.
Imperfect medium:	none.	
Timing conflicts:	none.	
Misfeed:	check	stop reader.
Stacker full:	check	set bit 16.
End of file:	check	set bit 1.
Synchronization:	check	set bit pattern.

Note: "Set bit" denotes that the indicated bit in the "synchronization word" (first, second, or fourth core location after the last word read from the card) is set to 0 if the associated error occurs and to 1 if it does not. The bit configuration of this word must be tested by the program.

INPUT-OUTPUT: CARD PUNCH

§ 073.

.1 GENERAL

.11 Identity: . . . . Card Punch.
E225K (100 cards/min.).
E225M (300 cards/min.).

.12 Description

Designed and built by General Electric, these units punch standard 80-column cards at peak speeds of 100 and 300 cards per minute. They are compatible with the IBM Model 523 and 544 punches that were used in early GE 225 systems. Cards can be punched in column decimal code from alphameric data stored in the BCD form, or in ten-row or twelve-row binary modes. The output instruction specifies the mode to be used. The starting core storage address of the data to be punched must be a multiple of 128 and less than 2,048.

The only available check on punched output of the 100 card per minute model is a plugboard-wired check for double punches and blank columns; it can check up to 30 columns and is effective only on decimal-coded numeric data. Check sums are usually punched into binary cards to make possible a programmed check on punching and reading accuracy when the data is re-entered. The 300 card per minute model checks the complete card by the read-after-punch technique, by counting the holes in each card row.

.13 Availability: . . . . . . Model E225K: 3 months as of March, 1963.
Model E225M: 12 months as of March, 1963.

.14 First Delivery

E225K: . . . . April, 1962.
E225M: . . . . September, 1963.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . die punch.
.222 Sensing system: . . . . brush.
.223 Common system: . . . no.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . punching.
Stacks: . . . . 1.
Heads/stack: . . . . . . 80.
Method of use: . . . . . one row at a time.

Use of station: . . . . . checking.
Stacks: . . . . 1.
Heads/stack: . . . . . . 80.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . standard 80-column punch cards.
.312 Phenomenon: . . . . . . rectangular holes.

.32 Positional Arrangement

.321 Serial by: . . . . 12 rows at standard spacing.
.322 Parallel by: . . . . . . 80 columns at standard spacing.
.324 Track use: . . . . all for data.
.325 Row use: . . . . all for data.

.33 Coding

Decimal: . . . . column code as in Data Code Table No. 3.
10-Row Binary: . . . . 2 card columns per 20-bit core storage word.
12-Row Binary: . . . . 1 card column per core storage word, from the 12 least significant bit positions.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 80-column cards:	not required.

.35 Physical Dimensions: . standard 80-column cards.

.4 CONTROLLER

.41 Identity: . . . . Card Punch Controller. (housed in Central Processor).

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . usable for independent gang-punching.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

§ 073.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 card of 80 columns.
.442 Input-output areas: . . core storage; address of first word punched must be a multiple of 128 and less than 2,048.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 card.
.512 Block demarcation: . . fixed size.

.52 Input-Output Operations

.521 Input: . . . . none.
.522 Output: . . . . 1 card forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic; internal BCD to column decimal or internal binary to 10- or 12-row binary.

.54 Format Control

Control: . . . . plugboard; seldom used.
Format alternatives: . undefined.
Rearrangement: . . . . yes.
Suppress zeros: . . . . no.
Insert point: . . . . . . yes.
Insert spaces: . . . . . yes.
Section sizes: . . . . . no.
Select columns to be checked: . . . . yes (on 100 card per minute model only).

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Offset card: . . . . . . no.
Select stacker: . . . . . no.
Select format: . . . . . no.
Select code: . . . . . . yes, in "punch" command.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . yes.

.6 PERFORMANCE

.61 Conditions

I: . . . . Model E225K Card Punch.
II: . . . . Model E225M Card Punch.

.62 Speeds

.621 Nominal or peak speed
I: . . . . 100 cards/minute.
II: . . . . 300 cards/minute.
.622 Important parameters
Clutch cycle
I: . . . . 600 msec.
II: . . . . 200 msec.
.623 Overhead
Clutch points per cycle
I: . . . . 14.
II: . . . . 1.
.624 Effective speeds: . . . peak speeds are maintained if "punch" instruction occurs within 10 msec after punching of previous card is completed.

.63 Demands on System

Component	Condition	Msec per card	or Percentage
Core Storage:	I	5.8	1.0
	II	5.8	2.9

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls

Function	Form	Comment
Reset:	button	resets error alarms.

.73 Loading and Unloading

.731 Volumes handled

Storage	Condition I	Condition II
Hopper:	800 cards	3,500 cards.
Stacker:	800 cards	3,500 cards.

.732 Replenishment time: . . 0.25 to 0.50 min. punch does not need to be stopped.
.733 Adjustment time: . . . none.
.734 Optimum reloading period
I: . . . . 8.0 mins.
II: . . . . 11.3 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording (Model E225K):	double punch, blank column *	stop punch; alarm.
Recording (Model E225M):	read after punch	stop punch; alarm.
Output block size:	fixed.	
Invalid code:	all codes valid.	
Exhausted medium:	check	stop punch; alarm.
Imperfect medium:	none.	
Timing conflicts:	check	stop punch; alarm.
Misfeed:	check	stop punch; alarm.
Stacker full:	check	stop punch; alarm.

* For decimal-coded numeric data only; checks up to 30 columns on "225K.

INPUT-OUTPUT: PAPER TAPE READER

§ 074.

.1 GENERAL

.11 Identity: . . . . Paper Tape System. (Reader only).

.12 Description

The Paper Tape System is a free-standing unit housing a reader, punch, and control circuitry for perforated tape input-output. Individual reader and punch units also are available. The reader and punch are mechanically independent of one another and are covered in separate sections of this report.

The reader offers a choice of speeds of 250 or 1,000 characters per second on five-, six-, seven-, or eight-track tape. At 250 characters per second, it can stop on a single character and handle spooled tape. At the higher speed, only unspooled strips can be handled, and one additional character is read after a "halt" reader instruction is given. Data from five or six tracks is read continuously into the six-bit N Register, one character at a time. Synchronization and code translation must be provided by the stored program. Input parity checks are made on seven- and eight-track codes, but the parity bit is not transmitted to the processor. The Paper Tape Reader may not be turned on at the same time as either the Paper Tape Punch or the Console Typewriter, since they all use the same input-output instructions. A delay of 200 milliseconds must be programmed between the "reader on" instruction and the first paper tape input instruction.

Optional Feature

Eight-Bit N Register: Provides two additional bits in the N Register, enabling data from as many as eight tracks to be read into the Central Processor.

.13 Availability: . . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . October, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs
Number: . . . . 2.
Form: . . . . swinging arm.
Capacity: . . . . 12 inches.
.213 Feed drive: . . . . . . motor.
.214 Take-up drive: . . . . . motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . none.
.222 Sensing system: . . . . photoelectric.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . reading.
Stacks: . . . . 1.
Heads/stack: . . . . . . 8.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . . punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 10 per inch.
.322 Parallel by: . . . . . . 5, 6, 7 or 8 tracks at standard spacing.
.324 Track use
Data: . . . . 5 or 6 (up to 8 with Eight-Bit N Register option).
Redundancy check: . . 1 (7- & 8-track tape only).
Timing: . . . . 1 (sprocket holes).
Control signals: . . . 1 (8-track tape only).
Total: . . . . 5 to 8 plus sprocket track.
.325 Row use: . . . . all for data (1-row inter-block gaps required for reading at 1,000 char/sec).

.33 Coding: . . . . any 5, 6, 7 or 8-track code with up to 6 data tracks (up to 8 with Eight-Bit N Register option) can be read.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 5-, 6-, 7-, or 8-track paper tape:	programmed.

.35 Physical Dimensions

.351 Overall width: . . . . . 11/16, 7/8, or 1 inch.
.352 Length: . . . . up to 1,000 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . built into Paper Tape System.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

§ 074.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to N characters.
.442 Input-output areas: . . N register, a single-character I/O buffer.
.443 Input-output area access: . . . . contents can be shifted into A register only.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . by program.
.447 Synchronizing aids: . . test for "N Register ready".

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 to N characters.
.512 Block demarcation
Input: . . . . any selected character, or programmed counter.

.52 Input-Output Operations

.521 Input: . . . . read forward continuously until halted by program command.
.522 Output: . . . . see Paper Tape Punch section, 323:075
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . programmed.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . no.
Select format: . . . . . no.
Select code: . . . . . . no.
Rewind: . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . no.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Busy I/O register: . . . yes.
Exhausted: . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 250 or 1,000 char/sec. (higher speed usable on tape strips only.)
.622 Important parameters
Tape speed: . . . . . 25 or 100 inches/sec.
Maximum stop distance
At 25 inches/sec: . . 0.025 inch.
At 100 inches/sec: . 0.150 inch.
Start time (to first char).
At 25 inches/sec: . . 1.5 msec.
At 100 inches/sec: . 0.5 msec.
.624 Effective Speeds
At 25 inches/sec: . . $\frac{250N}{(N+1)}$ char/sec.
At 100 inches/sec: . . $\frac{1,000N}{(N+2)}$ char/sec.

where N = number of characters per block.

.63 Demands on System

Component	Msec per char	or Percentage
Central Processor:	0.036	0.9 or 3.6

Comment: This is the time required to test "N Register ready" and shift the six data bits from N to A Register; code translation time is not included.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Number of tracks:	rotary switch	5, 6, 7, or 8 tracks.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Reel:	1,000 feet, or up to 120,000 char.

.732 Replenishment time: . . 1.0 to 1.5 mins. reader needs to be stopped.
.733 Adjustment time: . . . 1.5 to 2.0 mins.
.734 Optimum reloading period: . . . . 8.0 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	parity (7- or 8-track tape)	indicator & alarm.
Input area overflow:	none.	
Invalid code:	none.	
Exhausted medium:	check	will remain "busy".
Imperfect medium:	none.	
Timing conflicts:	none.	

INPUT-OUTPUT: PAPER TAPE PUNCH

§ 075.

.1 GENERAL

.11 Identity: . . . . Paper Tape System (Punch only).

.12 Description

This is the Teletype 110-character-per-second punch, housed in the Paper Tape System cabinet along with the reader and control circuitry. Individual reader and punch units also are available. Paper tape with five, six, seven, or eight tracks can be punched. One punch model is available for punching 5-track tape only; another model permits punching 6, 7, or 8-track tape codes only. Tape codes to be punched are set up by the program in the Central Processor's six-bit N Register, and odd parity bits are generated automatically for seven or eight-track codes. Each paper tape output instruction causes a single character to be punched. The punch cannot be turned on at the same time as either the Paper Tape Reader or the Console Typewriter, and a delay of five hundred milliseconds must be programmed between the "punch on" instruction and the first paper tape output instruction.

Optional Feature

Eight-Bit N Register: Provides two additional bits in the N Register, enabling data to be punched in up to eight tracks.

.13 Availability: . . . . . . 3 months as of March, 1963.

.14 First Delivery: . . . . October, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . die punches.
.222 Sensing system: . . . . none.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . punching.
Stacks: . . . . 1.
Heads/stack: . . . . . . 8.
Method of use: . . . . . one row at a time

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . . punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 row at 10 per inch.
.322 Parallel by: . . . . . . 5, 6, 7, or 8 tracks at standard spacing.
.324 Track use
Data: . . . . 5 or 6 (up to 8 with Eight-Bit N Register option).
Redundancy check: . . 1 (7 & 8 track tape only).
Timing: . . . . 1 (sprocket holes).
Control signals: . . . 1 (8 track tape only).
Total: . . . . 5 to 8 plus sprocket track.
.325 Row use: . . . . all for data (1-row inter-block gaps required if tape is to be read at 1,000 char/sec).

.33 Coding: . . . . any 5, 6, 7, or 8-track code with up to 6 data tracks.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 5, 6, 7, or 8-track paper tape: .	programmed.

.35 Physical Dimensions

.351 Overall width: . . . . . 11/16, 7/8, or 1 inch.
.352 Length: . . . . up to 1,000 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . built into Paper Tape System.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 character.
.442 Input-output areas: . . N register, a single-character I/O buffer.

§ 075.

.443 Input-output area access: . . . . loaded by shift from A register only.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . by program.
.447 Synchronizing aids: . . test for "N Register ready".

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 to N characters.
.512 Block demarcation Output: . . . . as programmed.

.52 Input-Output Operations

.521 Input: . . . . see Paper Tape Reader section, 323:074.
.522 Output: . . . . punch 1 row forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . programmed.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . no.
Select format: . . . . . no.
Select code: . . . . . . no.
Rewind: . . . . no.

.56 Testable Conditions

Disabled: . . . . no.
Busy device: . . . . . . no.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: no.
Busy I/O register: . . . yes.
Exhausted: . . . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 110 char/sec.
.622 Important parameters Tape speed: . . . . . 11 inches/sec.
.624 Effective speeds: . . . 110 char/sec if not more than 9 msec elapse between successive "punch" instructions.

.63 Demands on System

Component	Msec per char	or Percentage
Central Processor:	0.036	0.4

Comment: This is the Processor time required to test "N Register ready", shift the six data bits from A to N Register, and punch a row; code translation is not included.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Number of tracks:	rotary switch	for 6, 7, or 8 tracks only.

.72 Other Controls

Function	Form	Comment
Simulator switches:	6 switches	set up bit pattern for manual punching.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Reel:	1,000 feet, or up to 120,000 characters.

.732 Replenishment time: . . 2.0 to 3.0 mins. punch needs to be stopped.
.733 Adjustment time: . . . 3.0 to 4.0 mins.
.734 Optimum reloading period: . . . . 18.1 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	none.	
Invalid code:	all codes punched.	
Exhausted medium:	check	will remain "busy".
Imperfect medium:	none.	
Timing conflicts:	none.	

INPUT-OUTPUT: PRINTER

§ 081.

.1 GENERAL

.11 Identity: . . . . High Speed Printer. P225A, PA690A, PA690B.

.12 Description

The High Speed Printer utilizes the well-known Anelex Series 4 drum printing mechanism, with a rated peak speed of 900 alphameric lines per minute at single spacing and 601 lines per minute at an average line spacing of one inch. There are 120 printing positions and 50 printable characters. Skipping speed is 25 inches per second, and the print instruction may include a skip to any of 8 channels in the paper tape control loop or a step of zero to 63 lines.

One printer and its controller may be attached to any of the seven hubs on the Controller Selector. The controller includes automatic format control circuitry which uses a block of format words in Core Storage to control zero suppression, insertion of any desired format characters, and deletion of data characters in any desired positions. Dollar field editing is automatic, but no automatic provision is made for check protection or for floating dollar, plus, or minus signs. Each printer output operation requires three instruction words. The first word selects the appropriate Controller Selector hub and causes the next two words to be transferred to the Printer Controller, which then assumes control of the operation. It causes from one to forty BCD-coded data words and the corresponding format words to be transferred from Core Storage, performs the specified editing functions, and causes the line to be printed. This system minimizes time demands upon the Central Processor during printing.

The Printer Controller includes a manual control button that initiates an octal dump of the entire contents of Core Storage. A parity check is made on data received by the controller for printing, and a print cycle check detects synchronization errors.

Two 900 lines-per-minute off/on-line printer models are available. Model PA690A utilizes input from a 15KC tape unit (200 bits per inch tape density) and Model PA690B utilizes either a 15KC tape unit (200 bits per inch tape density) or a 41.6K tape unit (556 bits per inch tape density) by simply setting a hi-low density recording switch located on the tape unit. These two models permit printing up to seven different types of report formats.

The balance of the material in this section refers to the 900 lines-per-minute on-line printer, Model P225A.

.12 Description (Contd.)

Optional Features

FORTRAN Printer: This is the same printer equipped with the FORTRAN character set.

Plotter Feature: Permits use of the printer for graph plotting on rectangular coordinates in increments of 0.050 inch along both axes.

.13 Availability: . . . . . . 4 months as of March, 1963.

.14 First Delivery: . . . . March, 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive - paper punched both sides.

.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . on-the-fly hammer stroke against engraved drum.

.222 Sensing system: . . . . none.

.23 Multiple Copies

.231 Maximum number
Interleaved carbon: . 5.

.233 Types of master
Multilith: . . . . yes.
Xerox: . . . . yes.
Spirit: . . . . yes.

.24 Arrangement of Heads

Use of station: . . . . . printing.
Stacks: . . . . 1.
Heads/stack: . . . . . . 120.
Method of use: . . . . . prints 1 full line at a time.

.25 Range of Symbols

Numerals:	10	0 - 9.
Letters:	26	A - Z.
Special:	14	+. - $ * %_ / =, [ ] # @
Alternatives:		any character set can be requested as a standard modification.
FORTRAN set:		optional.
Req. COBOL set: . . .		by request.
Total:	50 and blank.	

§ 081.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . continuous fan-fold sprocket-punched stationery.
.312 Phenomenon: . . . . . . printing.

.32 Positional Arrangement

.321 Serial by: . . . . 1 line at 6 per inch (6 or 8 lines/inch available as an option).
.322 Parallel by: . . . . . . 120 columns at 10 per inch.
.324 Track use
Data: . . . . 120.
Total: . . . . 120.
.325 Row use: . . . . all for data.

.33 Coding: . . . . engraved character font. (Internal coding as in Data Code Table No. 1).

.34 Format Compatibility: . none.

.35 Physical Dimensions

.351 Overall width: . . . . . 3.5 to 19.5 inches by vernier.
.352 Length: . . . . up to 22.0 inches per sheet, by 1/6-inch increments.
.353 Maximum margins
Left: . . . . 3.875 inches.
Right: . . . . 3.875 inches.

.4 CONTROLLER

.41 Identity: . . . . Printer Controller.

.42 Connection to System

.421 On-line: . . . . up to 7; each requires 1 of the 7 Controller Selector hubs.
.422 Off-line: . . . . none (Off/On-Line Printer and Controller are available).

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 line of 3 to 120 characters.
.442 Input-output areas: . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 line of 3 to 120 characters.
.512 Block demarcation
Output: . . . . 1-bit in sign position of last word to be printed. (not required when full 40-word line is printed).

.52 Input-Output Operations

.521 Input: . . . . none.
.522 Output: . . . . 1 line forward, with automatic format control optional.
.523 Stepping: . . . . step 0 to 63 lines; may be combined in "print then step".
.524 Skipping: . . . . skip to 1 of 8 channels in paper tape loop; may be combined in "print then skip".
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic, by controller (from internal BCD code only).

.54 Format Control

Control: . . . . program or automatic, using format words.
Format alternatives: . unlimited.
Rearrangement: . . . . by program only.
Suppress zeros: . . . . yes.
Insert point: . . . . . . yes.
Insert spaces: . . . . . yes.
Section sizes: . . . . . yes.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with optional Automatic Priority Interrupt.
Select format: . . . . . yes.
Select code: . . . . . . no.
Select controller: . . . yes.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . yes.
End of medium marks: no.
Exhausted medium: . . yes.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: 900 lines/min.
.622 Important parameters
Skipping speed: . . . . 25 inches/sec.
.623 Overhead: . . . . 6.7 msec per single line step.

§ 081.

.624 Effective speeds

Average spacing, inches	Effective speed, lines/min.
1/6:	900
2/6:	819
3/6:	752
1:	601
2:	430
3:	334
4:	263
5:	231

(See also Graph 321:081.801.)

.63 Demands on System

Basis: Printing full lines with automatic format control, at single spacing.

Component	Msec per line	or	Percentage
Core Storage:	0.50		0.75

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method
Forms width:	sliding forms tractors.
Vertical forms positioning:	knob.
Forms tension:	knob.
Penetration control:	knob.

.72 Other Controls

Function	Form	Comment
On or off-line:	button.	
Skip to top of page:	button.	
Memory dump:	button	prints entire Core Storage contents in octal form.
Manual clear:	button	halts printer operation.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Hopper:	30-inch stack.
Stacker:	30-inch stack.

.732 Replenishment time: . . 1 to 2 mins.
Printer needs to be stopped.

.733 Adjustment time: . . . 3 to 5 mins.

.734 Optimum reloading period: . . . . 74 minutes.
Basis: . . . . 2-part forms, 17 inches long, at 1-inch line spacing.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	automatic cut-off.	
Invalid code:	none	print space.
Exhausted medium:	check	indicator and alarm.
Imperfect medium:	none.	
Timing conflicts:	check	stop printer.
Receipt of data:	parity	indicator and alarm.
Hammer fuses:	check	indicator and alarm.
Synchronization:	print cycle check	stop printer.

INPUT-OUTPUT: LOW SPEED PRINTER

§ 082.

.1 GENERAL

.11 Identity: . . . . Low Speed Printer.
P225D.

.12 Description

The Low Speed Printer is designed for use where printed output at a speed intermediate between the 900 lines per minute of the High Speed Printer and the 15 characters per second of the console typewriter is desirable, as in many scientific applications. Rated peak speed is 150 lines per minute, using a 50-character set identical to that of the High Speed Printer. There are 120 print positions, spaced 10 per inch. Vertical spacing is 6 lines per inch. Skipping speed is 15 inches per second.

The Low Speed Printer is connected to the N-Register of the central processor via the Peripheral Interface Unit, an optional feature. The Controller Selector is not required. Data to be printed is transferred, one character at a time, from the N-Register to a 240-character printer buffer. A separate "transfer character" instruction is required to transfer each character. The print buffer can store two full lines of data to be printed; therefore, one line can be printed while the data for the next line is being loaded into the other half of the buffer. Special character codes initiate the following control functions: print and step 1 line, print without stepping, step 1 line, skip to top of page, clear printer buffer. The automatic format control of the GE High Speed Printer is not provided in the Low Speed Printer; it must be simulated by the stored program, and a special subroutine will be made available for this purpose.

.13 Availability: . . . . . . 6 months as of May, 1963.

.14 First Delivery: . . . . late 1963.

INPUT-OUTPUT: MAGNETIC TAPE HANDLERS

§ 091.

.1 GENERAL

.11 Identity: . . . . Magnetic Tape Handler.
MTH680 (dual 15,000 char/sec unit).
MTH690 (dual 15,000 or 41,667 char/sec unit).

.12 Description

Each dual Magnetic Tape Handler consists of two modified Ampex digital tape transports mounted one above the other in a single cabinet. The two handlers differ only in number of recording densities, as shown in the following table.

Model	Tape speed, inches/sec	Density, rows/inch	Peak transfer rate, char/sec
MTH680 (dual):	75	200	15,000
MTH690 (dual):	75	200	15,000
		556	41,667

The two models are fully compatible with each other and with the IBM 727, 729, and 7330 Magnetic Tape Units. Record lengths are variable, and tapes can be read backward as well as forward. Magnetic Tape Controllers can be connected to any or all of the seven Controller Selector hubs, and up to eight transports can be connected to each controller. A variety of checking features is incorporated, including read-after-write, lateral and longitudinal parity checks on both reading and recording, and checks for loss of data due to timing errors.

Data can be recorded in any of three modes:

1. BCD - three tape rows per GE 235 word (sign and "1" bit are ignored, and some internal codes are converted to achieve IBM compatibility).
2. Binary - four tape rows per word (zeros are inserted into four excess bit positions in the fourth row). This mode must be used when a record contains both BCD and binary data.
3. Special binary - three tape rows per word (sign and "1" bit are ignored).

.13 Availability: . . . . . . 3 months as of March, 1963.

.14 First Delivery

MTH680: . . . . March, 1961.
MTH690: . . . . March, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs
Number: . . . . 2 per transport.
Form: . . . . vacuum pocket.
Capacity: . . . . about 8 inches each.
.213 Feed drive: . . . . . . motor.
.214 Take-up drive: . . . . . motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . magnetic head.
.222 Sensing system: . . . . magnetic head.
.223 Common system: . . . two-gap head provides read-after-write checking.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . recording.
Stacks: . . . . 1.
Heads/stack: . . . . . . 7.
Method of use: . . . . . one row at a time.

Use of station: . . . . . sensing.
Stacks: . . . . 1.
Heads/stack: . . . . . . 7.
Method of use: . . . . . one row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . plastic tape with magnetizable surface.
.312 Phenomenon: . . . . . . magnetization.

.32 Positional Arrangement

.321 Serial by: . . . . 3 to N rows at 200 or 556 rows/inch; N limited by available core storage.
.322 Parallel by: . . . . . . 7 tracks.
.324 Track use
Data: . . . . 6.
Redundancy check: . . 1.
Timing: . . . . 0 (self-clocking).
Control signals: . . . 0.
Unused: . . . . 0.
Total: . . . . 7.
.325 Row use
Data: . . . . 3 to N.
Redundancy check: . . 1 per block.
Timing: . . . . 0.
Control signals: . . . 0.
Unused: . . . . 0.
Gap: . . . . 0.75 inch inter-block; 3.75 inch end of file.

§ 091.

.33 Coding: BCD mode: one tape row per character, as in Data Code Table No. 2.
Binary mode: 4 tape rows per 20-bit word.
Special Binary mode: 3 tape rows per word; sign bit and highest-order data bit are ignored.

.34 Format Compatibility

Other device or system	Code translation
IBM 727, 729, 7330 tape units at 200 and 556 rows/inch:	generally not required.
GE 215/225 systems:	not required.

.35 Physical Dimensions

.351 Overall width: 0.50 inch.
.352 Length: 2,400 feet per reel.

.4 CONTROLLER

.41 Identity: Magnetic Tape Controller.
MTC680 (for MTH680 handlers).
MTC690 (for MTH690 handlers).

.42 Connection to System

.421 On-line: up to 7; each requires 1 of the 7 Controller Selector hubs.
.422 Off-line: none.

.43 Connection to Device

.431 Devices per controller: 4 dual handlers (8 tape transports).
.432 Restrictions: none.

.44 Data Transfer Control

.441 Size of load: 1 to N words, limited by available core storage.
.442 Input-output areas: core storage.
.443 Input-output area access: each word.
.444 Input-output area lockout: none.
.445 Table control: none.
.446 Synchronization: automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: 1 to N words; 3 or 4 tape rows per word.
.512 Block demarcation
Input: gap on tape; maximum N specified in "read" instruction.
Output: N specified in "write" instruction.

.52 Input-Output Operations

.521 Input: 1 block forward or backward.
.522 Output: 1 block forward.
.523 Stepping: none.
.524 Skipping: 1 block backward (backspace).
.525 Marking: inter-block gap, 0.75 inch long.
end-of-file character and 3.75-inch gap.
.526 Searching: none.

.53 Code Translation: automatic, by controller.

.54 Format Control: none.

.55 Control Operations

Disable: yes.
Request interrupt: yes, with optional Automatic Priority Interrupt.
Select format: no.
Select code: yes, in I/O instruction.
Rewind: yes.
Unload: no.
Select density: yes, with dual-density transports.

.56 Testable Conditions

Disabled: yes.
Busy device: yes.
Output lock: no.
Nearly exhausted: no.
Busy controller: yes.
End of medium marks: yes.
End of file mark: yes.
Any tape rewinding: yes.

.6 PERFORMANCE

.61 Conditions

I: MTH680 at 200 rows/inch.
II: MTH690 at 200 rows/inch.
III: MTH690 at 556 rows/inch.

.62 Speeds

.621 Nominal or peak speed
I: 15,000 char/sec.
II: 15,000 char/sec.
III: 41,667 char/sec.
.622 Important parameters
Tape speed: 75 inches/sec.
Start + stop time: 12.0 msec.
Full rewind time: 2.5 minutes.
Inter-block gap: 0.75 inch.
End-of-file gap: 3.75 inches.
.623 Overhead: 12.0 msec/block.
.624 Effective speeds
I: 15,000N/(N + 180) char/sec.
II: 15,000N/(N + 180) char/sec.
III: 41,667N/(N + 450) char/sec.

where N = char/block.
(See also Graphs 321:091.801 and .802).

§ 091.

.63 Demands on System

Component	Condition	Msec per block	or	Percentage of transfer time
Core Storage:	I	0.018+0.002N		3.0
	II	0.018+0.002N		3.0
	III	0.018+0.002N		8.3
Tape Controller:	I	12.0+0.067N		100.0
	II	12.0+0.067N		100.0
	III	12.0+0.024N		100.0

where N is number of characters per block

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Recording density:	switch	200 or 556 rows/inch (not on MTH680).

.72 Other Controls

Function	Form	Comment
Address selection:	rotary switch	addresses 0 - 7.
File protection:	ring on reel	ring permits writing.
Rewind:	button.	
Manual transport control:	3 buttons	forward/reverse/ stop.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Reel:	2,400 feet; 11,300,000 char at high density and 5,000,000 char at low density for 1,000-char blocks.

.732 Replenishment time: . . 0.5 to 1.0 minute. tape unit needs to be stopped.

.734 Optimum reloading period: . . . . 6.4 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	lateral & longitudinal parity	indicator & alarm.
Reading:	lateral & longitudinal parity	indicator & alarm.
Input area overflow:	check	stop transfer; set bit.
Output block size:	preset.	
Invalid code:	all codes valid.	
Exhausted medium:	reflective spot on tape	indicator & alarm.
Imperfect medium:	none.	
Timing conflicts:	I/O register exhaust or overflow check	indicator & alarm.
Incorrect number of characters per word:	modulo 3 or 4 check	indicator & alarm.

INPUT-OUTPUT: DOCUMENT HANDLER

§ 101.

.1 GENERAL

.11 Identity: . . . . Magnetic Ink Document Handler. S12B, S12C.

.12 Description

The Document Handler reads and sorts magnetically encoded paper documents at a peak rate of 1, 200 documents per minute. It can operate on-line with the GE 235 system or off-line as a sorter only. One or two Document Handlers can be connected to a single Controller Selector hub through a Document Handler Adapter; the dual input model permits simultaneous operation of the two Document Handlers.

The unit will feed, transport, and stack documents of intermixed sizes within the following ranges:

Length:	5.75 to 8.75 inches
Width:	2.50 to 3.75 inches
Thickness:	0.0027 to 0.0070 inch

It reads a single line of magnetic ink characters printed in Font E-13B (adopted as standard by the American Bankers' Association). Recognizable characters are limited to the ten numerals and four cue characters.

In on-line operation, data read from the document is stored as one BCD character per core storage location, in the six low-order bit positions. Invalid or unrecognizable characters cause an indicator to be set and an asterisk to be transmitted to storage. One of the twelve stacker pockets must be selected by the stored program. To achieve the peak rate, documents must be fed continuously and synchronization controlled by the program. When documents are fed singly upon demand, the maximum rate drops to six hundred documents per minute. Three instruction words are required to initiate each Document Handler input or control operation.

When operating off-line, the Document Handler is controlled by the manual control panel and a wired plugboard. The plugboard can define the format of up to twelve sort fields, each containing up to ten digits. The desired field and digit position for sorting are selected by push buttons. A "Zero Suppression" feature eliminates repeated handling of documents which are already properly sorted by routing them to the Special pocket. The alternative "Multiple Digit Selection" feature causes documents which contain a field of up to ten characters whose value is equal to a corresponding field defined by plugboard wiring to be sent to the Special pocket.

.13 Availability: . . . . . . 10 months as of March, 1963.

.14 First Delivery: . . . . March, 1962.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . moving belt friction; document feeding and pocket selection by "vacuum pickup".

.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.222 Sensing system: . . . . magnetic heads.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station:	reading.
Stacks:	1.
Heads/stack:	?
Method of use:	?

.25 Range of Symbols

Numerals:	10	0 - 9.
Letters:	none.	
Special:	4	amount, dash, transit, on-us.
Alternatives:	none.	
Total:	14.	

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper documents.
.312 Phenomenon: . . . . . . magnetic ink imprinting.

.32 Positional Arrangement

.321 Serial by: . . . . character; up to 64 characters per document.
.322 Parallel by: . . . . . . ? tracks.
.323 Bands: . . . . one, consisting of visually readable imprinted characters.
.324 Track use: . . . . all for data.
.325 Row use: . . . . all for data.

.33 Coding: . . . . Font E-13B magnetic ink characters.

.34 Format Compatibility

Other device or system	Code translation
All equipment using Font E-13B characters in standard A.B.A. format:	none required.

§ 101.

.35 Physical Dimensions

.351 Overall width: . . . . . 2.50 to 3.75 inches.
.352 Length: . . . . 5.75 to 8.75 inches.
.353 Maximum margins
Distance of leading edge of first symbol from edge of document: . . . . . . 0.3125 ± 0.0625 inch.

.4 CONTROLLER

.41 Identity: . . . . Document Handler Adapter. SA225 (single input). SB225 (dual input).

.42 Connection to System

.421 On-line: . . . . up to 7; each requires 1 of the 7 Controller Selector hubs.
.422 Off-line
Use — Associated equipment
Document sorting: none.

.43 Connection to Device

.431 Devices per controller: 1 per SA225 Adapter; 2 per SB225 Adapter.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 document.
.442 Input-output areas: . . core storage; base address, M, must be a multiple of 64; one character is read into the least significant 6 bits of each location, starting at M + 63 and continuing downward.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic within a document; by program for successive documents.
.447 Synchronizing aids: . . tests for sorter ready, sorter feeding, late pocket decision.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . up to 64 characters per document.
.512 Block demarcation
Input: . . . . plugboard wiring.

.52 Input-Output Operations

.521 Input: . . . . read 1 document and halt; or read 1 document and continue feeding next document.
.522 Output: . . . . none.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . automatic by controller.

.54 Format Control

Control: . . . . plugboard and program.
Format alternatives: . undefined.
Rearrangement: . . . . by program.
Suppress zeros: . . . . by program.
Insert point: . . . . . . no.
Insert spaces: . . . . . no.
Section sizes: . . . . . plugboard.
Select fields for off-line sorting: . . . plugboard and control panel.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . yes, with Automatic Priority Interrupt.
Select stacker: . . . . . yes.
Select format: . . . . . no.
Select code: . . . . . . no.
Halt continuous feeding: yes.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . . yes.
Nearly exhausted: . . . no.
Busy controller: . . . . yes.
Feeding documents: . . yes.
Late pocket decision: . yes.
Invalid character read: yes.
Hopper empty: . . . . . yes.
Stacker full: . . . . . . no.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: . . . . 1,200 documents/minute.
.622 Important parameters
Space between documents: . . . . . variable (synchronous feed).
Time for pocket selection: . . . . . . 47 msec max. after completion of reading.
.624 Effective speeds: . . . 1,200 documents/minute when feeding continuously.
600 documents/minute maximum when feeding on demand ("read 1 document and halt").

.63 Demands on System

Component	Msec per character
Core storage:	0.006.

§ 101.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none required (feeds intermixed documents of varying sizes.

.72 Other Controls

Function	Form	Comment
Sort field selection:	12 buttons	for off-line sorting only.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Feed hopper:	12 inch stack (approx. 2,500 documents).
Stackers (12):	10 inch stack each.

.732 Replenishment time: . . 0.5 to 1.0 minute. reader needs to be stopped.

.734 Optimum reloading period: . . . . 2 minutes.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	see "Invalid code."	
Input area overflow:	none.	
Invalid code:	validity check	transmit to storage & set indicator.
Exhausted medium:	check	indicator & alarm.
Imperfect medium:	none.	
Timing conflict:	none.	
Full stacker:	check	halt reader.
Misfeed:	check	halt reader.
Late pocket selection:	check	indicator & alarm.

INPUT-OUTPUT: DATANET-15

§ 102.

.1 GENERAL

.11 Identity: . . . . DATANET-15.

.12 Description

The DATANET-15 links telecommunication terminals to the GE 235 Central Processor via the Controller Selector. The Automatic Priority Interrupt feature is required on all GE 235s using the DATANET-15. This feature permits the DATANET-15 to operate concurrently with and time-share the core storage facilities with other peripheral devices and internal processing. The manufacturer estimates that less than 1 per cent of the central processor time will be used for normal communications storage accesses.

The basic DATANET-15 controller receives and sends digital data over a maximum of two teletype or telephone grade transmission facilities. Therefore, the basic model is called a "two-channel" controller, even though data can be transferred over only one of the two connected transmission facilities at a time. Optional features, described below, permit connection of up to 15 transmission units and 1 Paper Tape Unit, with the same restriction to 1 data transfer operation into core storage at a time.

Transmission speeds of 75, 110, or 1,050 bits per second are the standard options, but any transmission speed between 60 and 2,400 bits per second is available upon request. The transmission speed is controlled by a timing plug which emits a pulse to coincide with each bit. The transmission speed of a facility can be changed at any time by replacing the existing timing plug with one corresponding to the speed desired. Only one speed, for all of the channels on a DATANET-15, is possible at one time. Any serial five-, six-, seven-, or eight-bit data code using start-stop bits to indicate the beginning and end of each transmitted or received character will be accepted by the DATANET-15. The start-stop bits are stripped off and added by the DATANET-15 for each character as needed.

Data are transferred serially by character and in parallel by bit between the DATANET-15 and the GE 235 computer and between the DATANET-15 and the Paper Tape Unit. Data transfers are serial by bits, using start-stop bits, between the DATANET-15 and remote units.

Each character is represented in core storage in the five, six, or seven least significant bits of a GE 235 word, depending on the code used. There is no automatic code conversion, but a plugboard allows rearrangement of the bit structure in any way desired, thus effectively allowing conversion to any desired character code. When using the five-bit character code for receiving data, a bit is automatically

.12 Description (Contd.)

generated in the sixth bit position to indicate that the character is either a letter or a numeral. In the transmit mode, only five bits are transferred to the DATANET-15; therefore, the message must be programmed so the letter or numeric shift code is inserted into the proper position within the message.

The DATANET-15 has two modes of operation: the Receive mode and the Transmit mode. In the Receive mode, a request-for-access signal from a remote station is stored in a flip-flop indicator for that station. Once every 300 microseconds, a scanner within the DATANET-15 interrogates the status of the flip-flop indicators for each channel until either a request-for-access signal is detected, a branch select is executed, or the computer initiates a transmission. When a request-for-access signal is detected, the scanner stops on the requesting channel, causes an automatic program interrupt to service it, and locks out all other channels. After servicing the request, scanning is resumed by a start-scanning instruction. After a scan instruction has been executed, a total of 250 milliseconds elapses and the controller is interlocked before the scanning operation is resumed, unless the previous instruction was a scan instruction.

A 250 millisecond delay is encountered whenever the mode of the DATANET-15 is changed, allowing time for the communication channel to change modes. The transmit mode is entered when a transmit instruction is executed. In this mode, the scanner is positioned on the channel specified in the instruction, enabling data to be transmitted character by character from core storage to the remote station via the DATANET-15.

The instructions required to activate the DATANET-15 are identical in format for either mode and consist of three instruction words which contain the address of the remote station, the core storage address, and the character count of the message. The character count is placed in the character counter, which provides a means for controlling the length of each message transferred between core storage and the DATANET-15. The counter can count up to 2,048 characters. When the specified number of characters has been counted, the character counter automatically terminates data transfer between the DATANET-15 and core storage until a new command is executed. Messages can also be terminated by sensing an end of message or end of transmission character. It is possible to transmit messages longer than 2,048 characters by breaking the message down into blocks of fewer than 2,048 characters each. Reception of messages containing more than 2,048 characters can occur without the loss of a character by issuing another receive instruction within half the time required to receive a bit. (When transmitting at a rate of 75 bits per second, the new receive

§ 102.

.12 Description (Contd.)

instruction must be issued within 6.7 milliseconds after the indication of the character counter overflow.)

Odd parity checks are automatically performed by the DATANET-15 on all input data which contains provisions for an odd parity bit. If this parity bit is in error, the DATANET-15 corrects the parity and sets a program-testable indicator.

Optional Features

Five-Channel Operation: Permits serial five-bit data codes with start and stop bits to be received or transmitted.

Six-, Seven-, or Eight-Channel Operation: Permits any single serial six-, seven-, or eight-bit data code with start and stop bits to be received or transmitted.

.12 Description (Contd.)

75-Baud Data Speed Plug: Permits transmission and reception of data at 75 bits per second.

110-Baud Data Speed Plug: Permits transmission and reception of data at 110 bits per second.

1,050-Baud Data Speed Plug: Permits transmission and reception of data at 1,050 bits per second.

Special Data Speed Plug: Permits transmission and reception of data at any other single bit rate between 60 and 2,400 bits per second.

Paper Tape Adapter: Provides the capacity to connect and control a GE free-standing Paper Tape Unit.

Four Additional Channels: Provides the capacity for accommodating up to six transmission facilities.

Thirteen Additional Channels: Provides the capacity for accommodating up to 15 transmission facilities.

Interface Adapter: Adapts the controller voltage and current levels to those needed for low-speed telegraphic operation.

SIMULTANEOUS OPERATIONS

§ 111.

.1 SPECIAL UNITS

.11 Identity: . . . . Controller Selector (optional).
Priority Access Control (standard).

.12 Description

There are 10 input-output channels in the GE 235 system. The card reader is connected to Channel 8 and requires one access to core storage for each column read (80 accesses per card). The card punch is connected to Channel 9 through an 80-bit shift register and requires 960 accesses to core storage for each card punched. Synchronization of data transfers between the card input-output units and core storage is automatic, and card reading and punching can always be overlapped with internal processing.

The console typewriter and paper tape reader and punch are connected to the 6-bit N Register in the Central Processor, which forms the tenth input-output channel. Only one character is transferred at a time, and synchronization must be controlled by the stored program. These three units share the same power supply, and only one can be operated at a time.

All other peripheral devices must be connected to Channels 1 through 7. These seven channels are called the Controller Selector.

Controller Selector: This optional unit, housed in the Central Processor cabinet, serves as a common control and data transfer point between the processor and the controllers for data transmission, printers, magnetic tape units, Magnetic Document Handlers, Mass Random Access Data Storage, and the Auxiliary Arithmetic Unit. The Controller Selector contains seven "hubs." One peripheral controller can be plugged into each hub and assumes the address of that hub. The Controller Selector automatically controls the time-sharing of core storage accesses among all of the attached peripheral devices. One device on each peripheral controller can therefore operate simultaneously. Data is transferred through the standard Controller Selector at the rate of 55,600 words per second. The optional Dual Access Controller Selector increases the potential gross data transfer rate to 111,000 words (or 333,000 characters) per second.

Requests for access to core storage are automatically served by the Priority Access Control according to the following priority order. The unit with the highest priority is listed first.

.12 Description (Contd.)

1. Controller Selector (Channels 1-7).
   a. Mass Random Access File Controller(s).
   b. Magnetic Tape Controller(s).
   c. Magnetic Document Handler Adapter(s).
   d. Data Transmission Controller(s).
   e. High Speed Printer(s).
2. Card Reader (Channel 8).
3. Card Punch (Channel 9).
4. Central Processor, with paper tape and typewriter input-output (Channel 10).
5. Auxiliary Arithmetic Unit.

The criteria for establishing this priority order are the repetition rate of memory access demands and the consequences of not gaining access in time; the central processor and AAU can wait indefinitely without danger of error or loss of information. Priority order for the devices attached to the Controller Selector is determined by the numbers of the hubs to which they are attached and can be changed to meet changing system requirements.

This method of handling simultaneous operations is straightforward and powerful. When several high-speed peripheral units are operating simultaneously it is possible, though unlikely, that requests for memory access will occur faster than the processor can serve them, resulting in loss of data. There are error indicators in the magnetic tape and Mass Random Access Data Storage controllers to detect this condition; the other input-output units will "hang up" if they are not granted access in time.

.2 CONFIGURATION CONDITIONS

I: . . . . without Controller Selector.
II: . . . . with Controller Selector.

.4 RULES

Condition I

Any or all of the following operations can be carried out simultaneously:

Internal processing.
Read card.
Punch card.

And any one of the following:

Type on console typewriter.
Read paper tape.
Punch paper tape.

§ 111.

.4 RULES (Contd.)

Condition II

A total of seven controllers can be connected to the Controller Selector. The types of controllers will dictate the number of simultaneous operations possible, as detailed below, since each controller is capable of only one data transfer operation at any time.

The standard Controller Selector has a maximum gross data transfer rate of 55,600 words per second, or approximately 167,000 characters per second. With the optional Dual Access Controller Selector, these maximum rates are doubled. It is possible for various combinations of the operations listed below to exceed these capacities, resulting in a loss of data that will be signalled.

Any or all of the following can be in operation simultaneously:

Internal processing.

Read card.

Punch card.

.4 RULES (Contd.)

Condition II (Contd.)

Print a line or advance forms on printer (one per printer controller).

Any number of magnetic tape rewind operations.

One magnetic tape input or output operation per Magnetic Tape Controller.

One input or output Mass Random Access Data Storage transfer operation.

Up to four seek operations per Mass Random Access Data Storage Controller.

One input or output operation per Data Transmission Controller.

Two input operations per Magnetic Ink Document Handler Adapter.

Processing in Auxiliary Arithmetic Unit.

And any one of the following:

Type on console typewriter.
Read paper tape.
Punch paper tape.

SYSTEM PERFORMANCE

§ 201.

GENERALIZED FILE PROCESSING (323:201.1)

These problems involve updating a master file from information in a detail file and producing a printed record of each transaction. This application is one of the most typical of commercial data processing jobs and is fully described in Section 4:200.1 of the Users' Guide.

The GE 235 is basically a fixed word-length, binary processor, although an optional feature (included in the Standard Configurations considered in this report) enables it to perform decimal addition and subtraction. To minimize time-consuming radix conversion and unpacking operations, records in the magnetic tape master file are organized in an unpacked format, with individual fields in either binary or alphameric form depending upon their usage. Each master file record, whose nominal length is 108 characters, occupies 37 GE 235 word locations or 148 magnetic tape rows. (Magnetic tape files containing mixed alphameric and binary data must be read and recorded in the binary mode, in which each computer word occupies four tape rows.)

In Standard Configurations III and IV, the master file is on magnetic tape, the detail file is on punched cards, and the report file is produced by the on-line printer.

Overall processing time for Standard Configuration III is limited at low activity ratios by the magnetic tape time for input and output of the master file, as shown by the horizontal segment at the left side of each Standard File Problem performance curve. At higher activity ratios, the card reader (rated at 400 cards per minute) becomes the limiting factor.

Standard Configuration IV adds a second magnetic tape channel, a faster card reader and punch, and more core storage to the facilities of Configuration III. The result is improved performance over the entire activity range. Magnetic tape times for the master file are halved because the second tape channel permits simultaneous read/write/compute operation. The printer, with an effective speed of 600 lines per minute at the required interline spacing of 1 inch, is now the limiting factor on performance at all activity ratios above 0.1. The central processor speed is in no case the limiting factor on overall processing time.

SORTING (323:201.2)

The standard estimate for sorting 80-character records by straightforward merging on magnetic tape was developed from the time for Standard File Problem A by the method explained in Paragraph 4:200.213 of the Users' Guide. A three-way merge was used in Configurations III and IV. The results are shown in Graph 323:201.214.

MATRIX INVERSION (323:201.3)

In matrix inversion, the object is to measure central processor speed on the straightforward inversion of a non-symmetric, non-singular matrix. No input-output operations are involved. The standard estimate is based on the time to perform cumulative multiplication ($c = c + a_i b_j$) in eight-digit precision floating point, using both standard subroutines and the Auxiliary Arithmetic Unit (see Paragraph 323:051.422). The results are shown in Graph 323:201.313. It can be seen that the inversion speeds are about 15 times as high when the floating point arithmetic is performed by the Auxiliary Arithmetic Unit as when floating point subroutines are used. This is a reasonable indication of the value of the AAU for engineering and scientific applications.

GE 235
SYSTEM PERFORMANCE

GE 235 SYSTEM PERFORMANCE

WORKSHEET DATA TABLE 1

Worksheet	Item		Configuration III		Configuration IV			Reference
1 Input-Output Times	Char/block	(File 1)	370 words		370 words			4:200.112
	Records/block	K (File 1)	10		10			
	msec/block	File 1=File 2	46.4		46.4			
		File 3	150		40			
		File 4	100		100			
	msec/switch	File 1= File 2						
		File 3						
		File 4						
	msec penalty	File 1= File 2	3.0		3.0			
		File 3	0.5		0.5			
		File 4	0.5		0.5			
2 Central Processor Times	msec/block	a1	0.228		0.228			4:200.1132
	msec/record	a2	1.026		1.026			
	msec/detail	b6	3.399		3.399			
	msec/work	b5 + b9	1.446		1.446			
	msec/report	b7 + b8	7.591		7.591			
3 Standard Problem A F = 1.0	msec for C. P. and dominant column.	a1	0.2		0.2			4:200.114
		a2 K	10.3		10.3			
		a3 K	124.4		124.4			
		File 1 Master In	3.0		3.0			
		File 2 Master Out	3.0		3.0			
		File 3 Details	5.0	1,500	5.0			
		File 4 Reports	5.0		5.0	1,000		
		Total	150.9	1,500	150.9	1,000		
4 Standard Problem A Space	Unit of measure	(words)						4:200.1151
		Std. routines	1,119		1,119			
		Fixed	4		4			
		3 (Blocks 1 to 23)	159		159			
		6 (Blocks 24 to 48)	780		780			
		Files	1,614		1,614			
		Working	50		50			
		Total	3,726		3,726			

SYSTEM PERFORMANCE

§ 201.

.1 GENERALIZED FILE PROCESSING

.11 Standard File Problem A

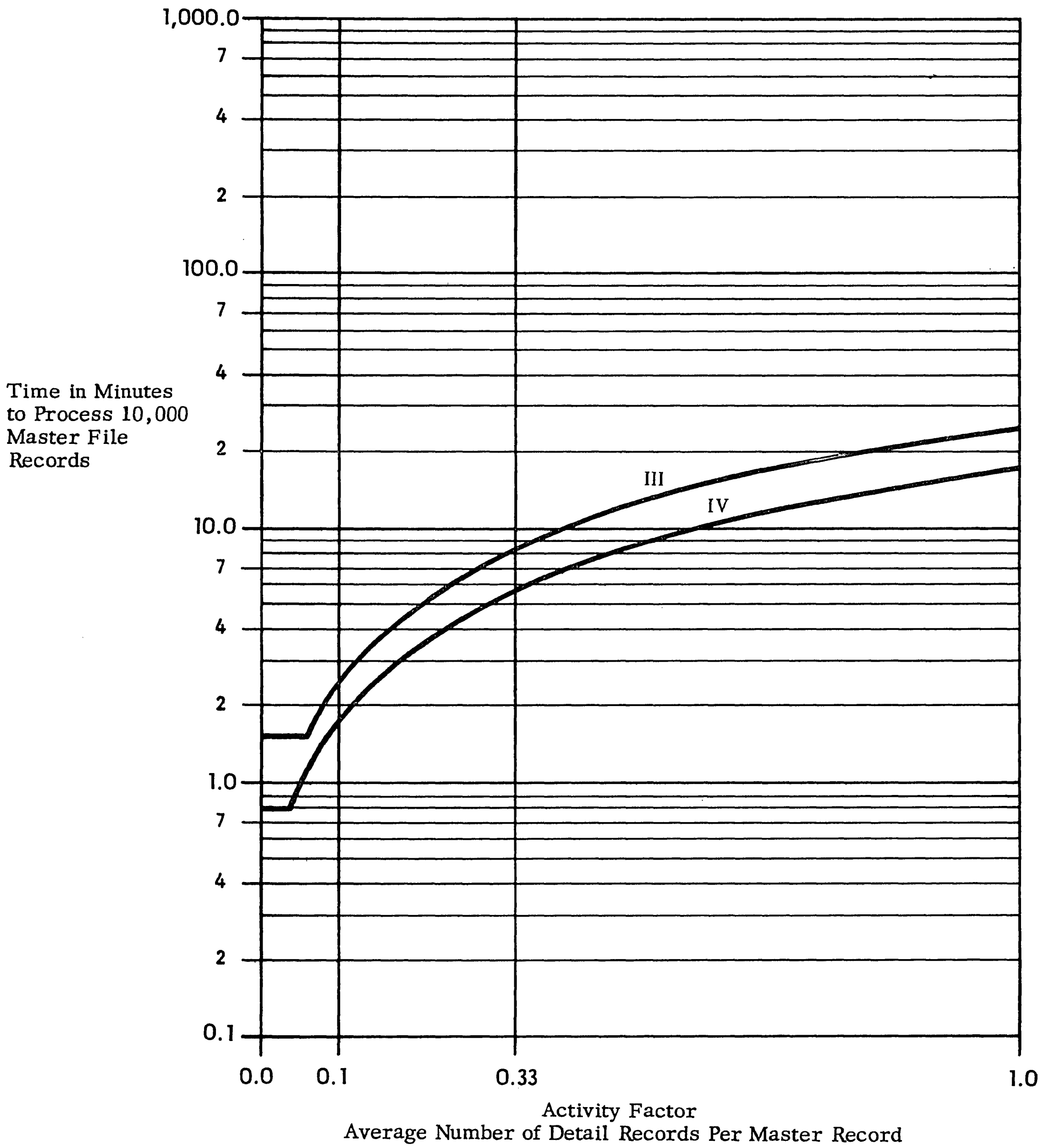
.111 Record sizes
Master file: . . . . . . 108 characters.
Detail file: . . . . . . 1 card.
Report file: . . . . . . 1 line.

.112 Computation: . . . . . standard.

.113 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.113.

.114 Graph: . . . . see graph below.

.115 Storage space required
Configuration III: . . . 3,726 words.
Configuration IV: . . . 3,726 words.



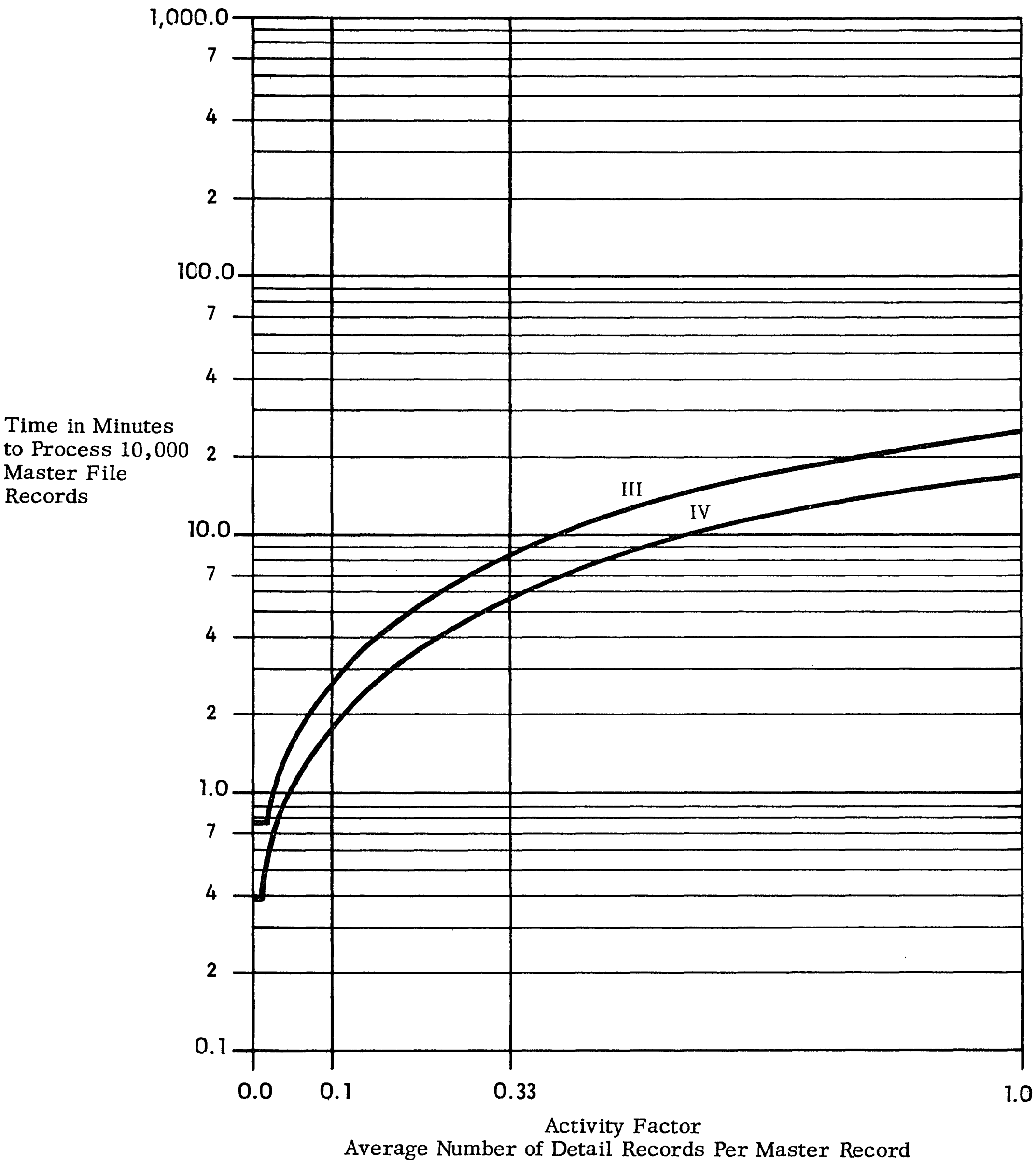
(Roman numerals denote standard System Configurations.)

§ 201.

.12 Standard File Problem B

.121 Record sizes
Master file: . . . . . 54 characters.
Detail file: . . . . . 1 card.
Report file: . . . . . 1 line.

.122 Computation: . . . . . standard.
.123 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.12.
.124 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

§ 201.

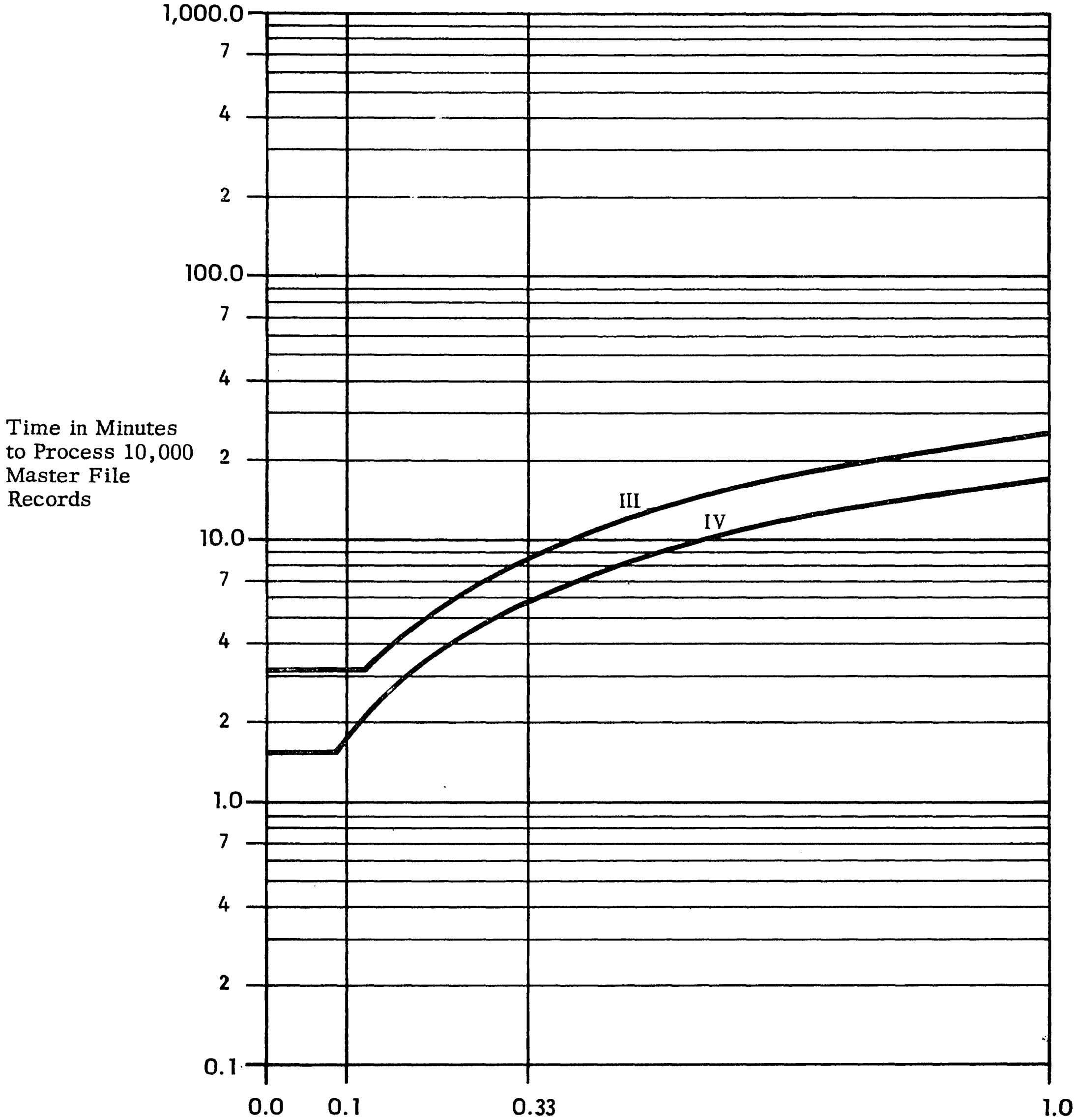
.13 Standard File Problem C

.131 Record sizes
Master file: . . . . . 216 characters.
Detail file: . . . . . 1 card.
Report file: . . . . . 1 line.

.132 Computation: . . . . . standard.

.133 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.13.

.134 Graph: . . . . see graph below.



Activity Factor
Average Number of Detail Records Per Master Record

(Roman numerals denote standard System Configurations.)

§ 201.

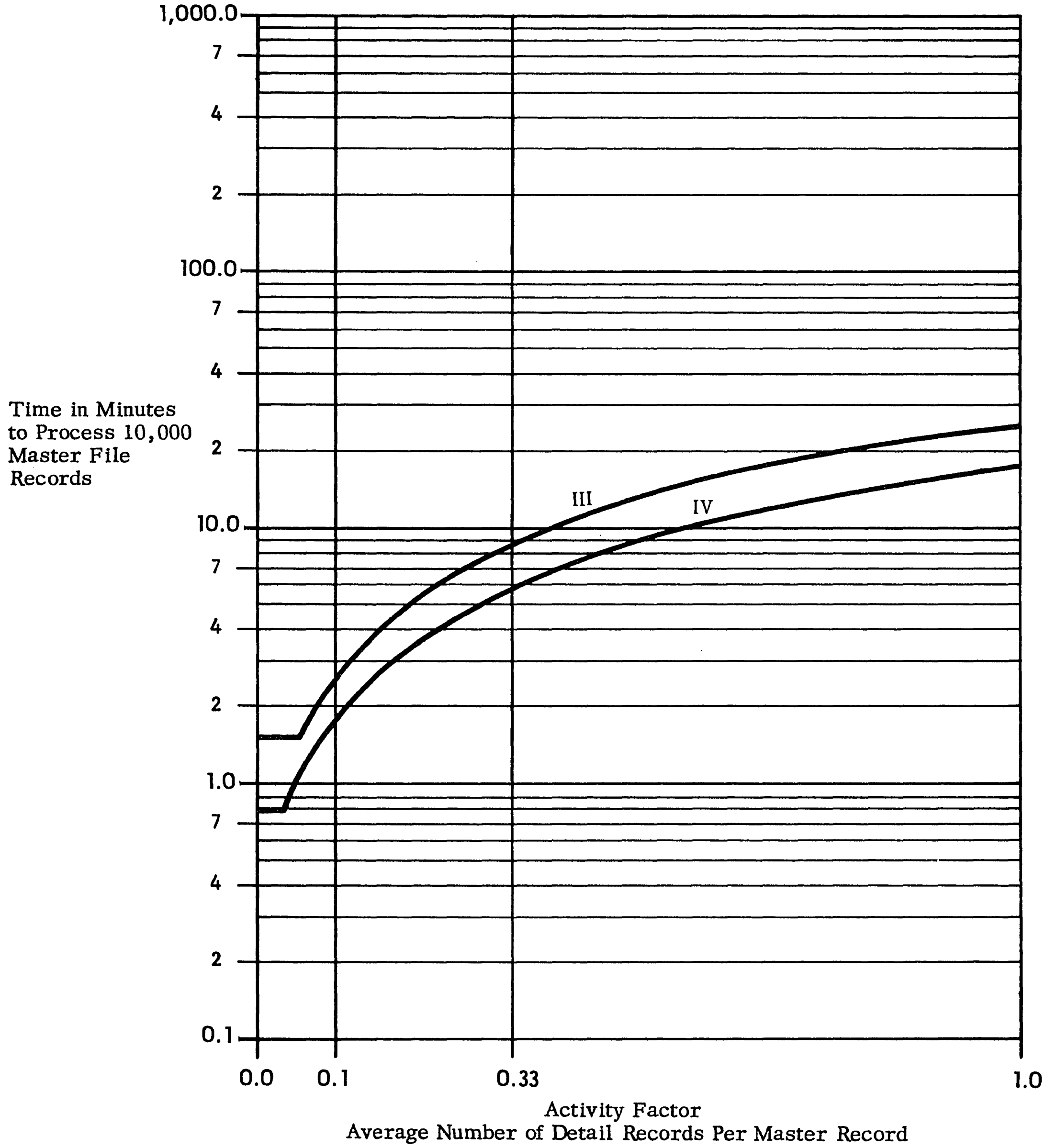
.14 Standard File Problem D

.141 Record sizes
- Master file: . . . . . . 108 characters.
- Detail file: . . . . . . 1 card.
- Report file: . . . . . . 1 line.

.142 Computation: . . . . . trebled.

.143 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.14.

.144 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

§ 201.

.2 SORTING

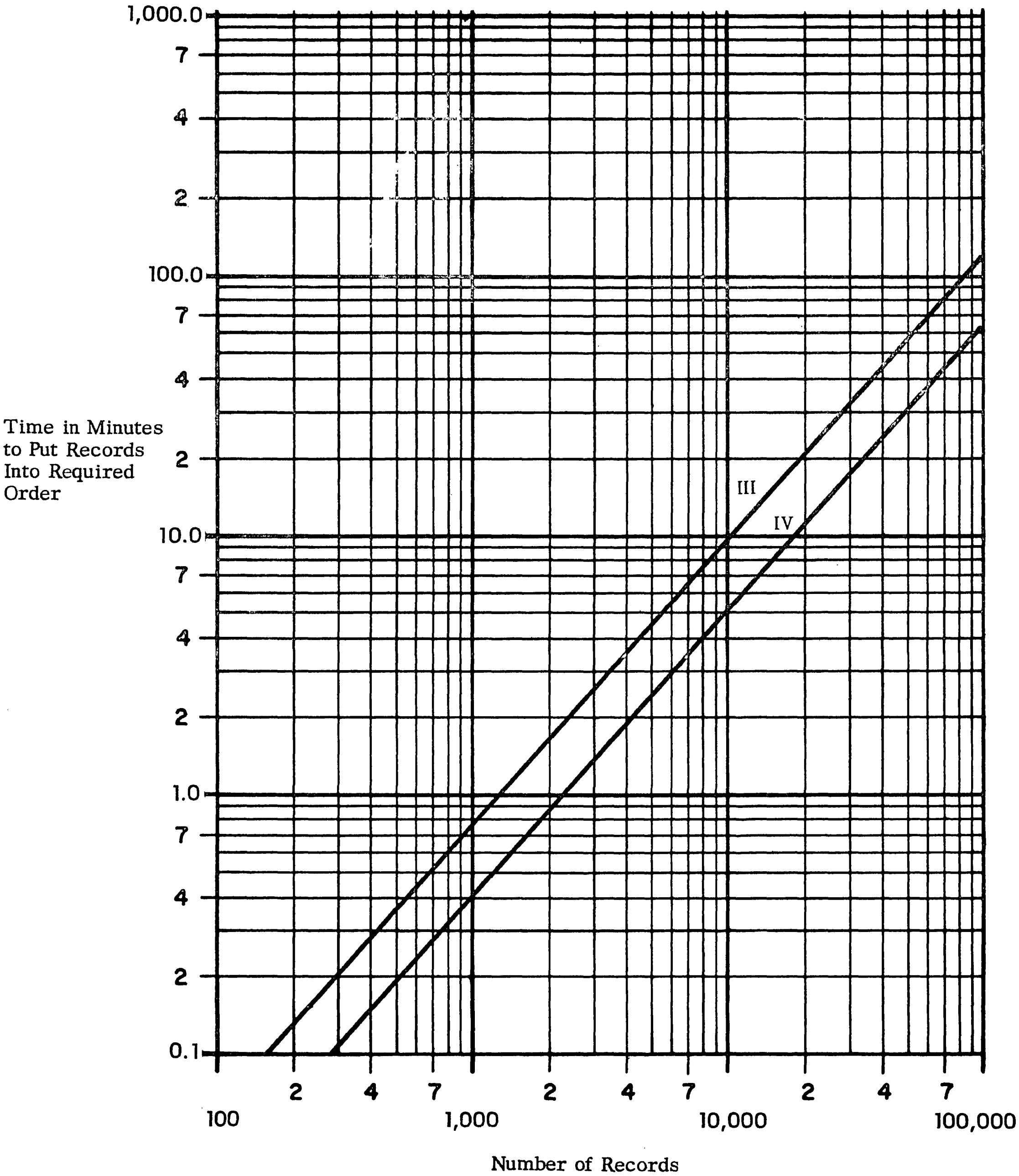
.21 Standard Problem Estimates

.211 Record size: . . . . . . 80 characters.

.212 Key size: . . . . 8 characters.

.213 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.213.

.214 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations)

§ 201.

.3 MATRIX INVERSION

.31 Standard Problem Estimates

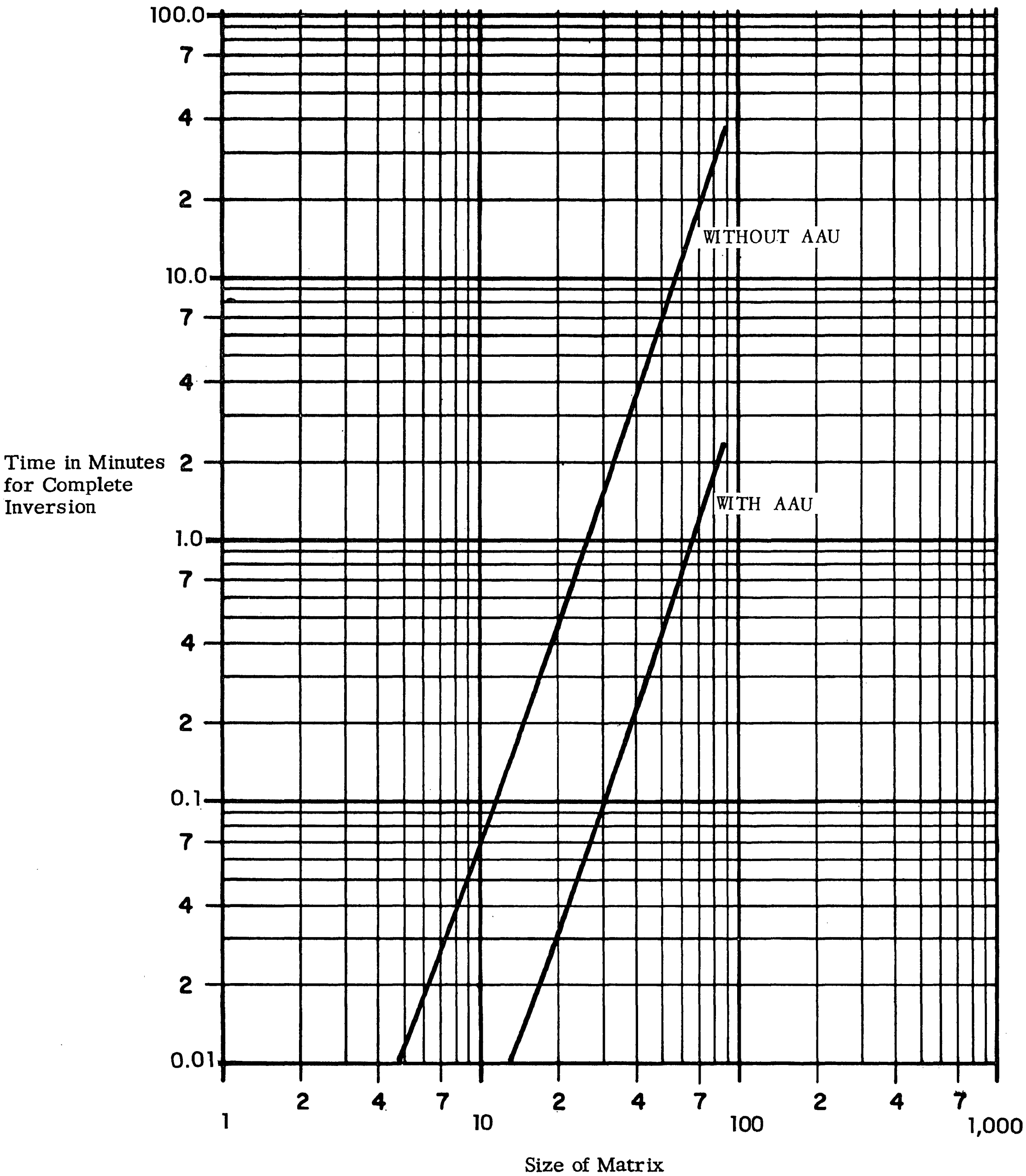
.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.312 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.312.

.313 Graph: . . . . see graph below.

.314 Maximum matrix sizes

4,096 core storage locations:	40.
8,192 core storage locations:	60.
16,384 core storage locations:	88.



PRICE DATA

§221.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
Central Processor	CA235	Central Processor, Console, and Input Typewriter	2,880		144,000
		Controller Selector			
	CSS235	Single Access	1,000		24,000
	CSD235	Dual Access	2,280		54,700
		Optional Features			
		Move Command	95		4,500
		Automatic Priority Interrupt	95		4,500
		Three-Way Compare, Decimal Addition and Subtraction, and Additional Address Modification Groups	245		4,900
		Real Time Clock	95		4,400
	AAU235	Auxiliary Arithmetic Unit	1,500		60,000
Internal Storage		Core Storage			
	MM235A	4,096 word locations	670		32,200
	MM235B	8,192 word locations	1,300		62,400
	MM235C	16,384 word locations	2,420		108,900
	M640A	Mass Random Access Data Storage Unit	1,725		76,000
Input-Output		Paper Tape Punch & Reader			
	GA651A	With Spooler	490		22,000
	GA651B	Without Spooler	440		19,800
		Card Reader & Controller			
	CRC235	400 cards/minute	375		18,350
	CRD235	1,500 cards/minute	810		32,400
		Card Punch & Controller			
	CPA235	100 cards/minute	400		21,460
	CPD235	300 cards/minute	825		41,150
		High Speed Printer & Controller			
	P225A	Standard On-Line Model	1,275		61,500
	P225C	On-Line, with FORTRAN Character Set	1,295		61,950
	PA690A	On/Off-Line, for 200 char/inch tape	2,950		137,250
	PA690B	On/Off Line, for 200 or 556 char/inch tape	3,500		157,500
		Optional Feature			
		Printer Plotter Feature	140		10,000
	P225D	Low Speed Printer	700		33,000
		Dual Magnetic Tape Handlers			
	MTH680	15,000 char/sec.	850		33,000
	MTH690	15,000/41,667 char/sec.	1,300		47,850
	S12B	Magnetic Ink Document Handler	1,750		87,500
	DTC901	DATANET-15	690		30,000

PRICE DATA (Contd.)

§ 221.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance $	Purchase $
Controller	M225B	Mass Random Access Data Storage Controller	900		46, 250
		Magnetic Tape Controllers			
	MTC680	For 15, 000 char/sec.	800		37, 500
	MTC690	For 15, 000/41, 667 char/sec.	1, 030		46, 350
		Magnetic Ink Document Handler Adapters			
	SA225A	For 1 Handler	540		21, 600
	SA225B	For 2 Handlers	680		27, 200
		Peripheral Switch Console	180		8, 500
		Peripheral Switch Control Unit	95		4, 200

GE 400 SERIES

General Electric Company

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CONTENTS

Report 330: GE-400 Series — General

Report 332: GE-415

Report 333: GE-425

Report 334: GE-435

INTRODUCTION

.1 SUMMARY

New hardware capabilities, such as floating-point arithmetic, a memory-protect feature, and new random-access and communications devices, have enlarged the potential scope of applications for the GE-400 Series, a program-compatible family of medium-scale data processing systems. Originally announced in December, 1963, the GE-400 Series currently includes three systems: the GE-415, the GE-425, and the GE-435. These systems utilize different core storage units but share the same processor and peripheral devices. Monthly rentals can range from approximately $4,300 for a card-oriented GE-415 system to over $25,000 for an expanded GE-435 system. First customer delivery of a GE-415 system occurred in May, 1964, and the first GE-425 and GE-435 systems were delivered in June, 1964, and October, 1964, respectively.

In February, 1965, GE reduced the core storage cycle time of the GE-415 from 9.2 microseconds to 5.8 microseconds, at no increase in rental. In April, 1965, GE announced a corresponding reduction of the GE-425's cycle time from 5.1 to 3.9 microseconds. All GE-415 and GE-425 systems now in the field or on order will be upgraded to the faster cycle times. The core storage cycle time remains at 2.7 microseconds for the GE-435. Thus, the overall performance span of the GE-400 Series has been reduced to approximately two to one — much smaller than the performance ranges of other recently-announced "families" of computer systems. The GE-455 and GE-465, previously announced as future large-scale members of the GE-400 Series, have been withdrawn from the line. Many of the features originally announced for these two systems are included in the new announcements for the current members of the GE-400 Series.

In order to emphasize the similarities among the various members of the GE-400 Series, the AUERBACH Standard EDP Reports analysis of this series of computer systems has been reorganized into a format similar to that used for other computer families such as the IBM System/360 and the GE-600 Series. The main body of general description and analysis is presented in this Computer System Report (330), with subreports (332 for the GE-415, 333 for the GE-425, and 334 for the GE-435) providing detailed information about the performance of the individual systems in the line.

.2 COMPATIBILITY

All members of the GE-400 Series utilize the same instruction repertoire, and all hardware options and peripheral equipment are available for each member. Thus, programs can be freely interchanged among GE-400 Series systems having equivalent peripheral devices, memory capacities, and special features. Care should be taken, however, to observe the programming rules set by GE, since some of the optional features make special use of certain bit positions. There is no direct program compatibility between the GE-400 Series computer systems and other GE computer systems (the older GE-200 Series and the large-scale GE-600 Series).

Because a large number of IBM 1401 installations are becoming candidates for replacement, strong emphasis is currently being placed by computer manufacturers on hardware and software facilities designed to minimize the amount of reprogramming effort required to convert from an IBM 1401 to a different system. GE presently offers two 1401 compatibility techniques, both aimed at direct simulation; i.e., little or no alterations need be made to a 1401 program in order to run it on a GE-400 Series system.

One method, the IBM 1401 Simulator Program, is a software simulation routine that requires only one control card and a format control loop for the printer in addition to the IBM 1401 object program. This routine will handle programs written for IBM 1401 systems with a 1402 Card Read/Punch, a 1403 Printer, up to six magnetic tape handlers, and up to 16,000 locations of core storage.

The 1401 Simulator Program requires a GE-400 Series computer with at least 8,192 core storage locations (32,768 characters) and peripheral devices as needed by the 1401 programs to be simulated. In general, to run a 1401 program, a GE-400 Series system must have about eight times the core storage capacity required on the 1401; e.g., a 4,000-character 1401 program would require a GE-400 Series core storage unit

.2 COMPATIBILITY (Contd.)

of at least 8,192 word locations. IBM 1401 peripheral devices not mentioned above, and all RPQ items, cannot be simulated. In addition there are some restrictions on the size of operands in multiply and divide operations. GE estimates that execution times for typical programs will be from one-half to four times as long on a GE-400 Series computer system using the 1401 Simulator Program as on the original 1401.

The second method for achieving 1401 compatibility is a hybrid hardware-software approach which replaces the previously-announced Capacitrix Memory option. The 1401 Compatibility Option enables 4,096 24-bit words of a GE-400 Series core storage unit to be addressed as 12,288 8-bit character positions. Six of the eight bits are used for data, the seventh is unused, and the eighth is used as a word mark as in the 1401. With this option, one I/O channel (assigned to a magnetic tape handler) is modified to transfer data between the 8-bit character-addressable locations of core storage and the tape handler connected to that channel. The related software routine utilizes the character-addressable segment of core storage to hold the 1401 object program and simulates the 1401 operations in a manner similar to the 1401 Simulator Program mentioned above.

The 1401 Compatibility Option permits direct execution of 1401 programs using up to 12,000 core positions, a 1402 Card Read/Punch, a 1403 Printer, and up to six magnetic tape units on a GE-400 Series system having at least 8,192 words of core storage and peripheral devices as needed by the 1401 program. The chief advantages of the 1401 Compatibility Option over the 1401 Simulator Program are the reduced core storage requirement and increased performance. GE estimates that typical 1401 programs that can be run on a GE-400 Series system with this option take from about one-half to twice the time required by the original 1401. Full advantage of the GE-400 systems' increased internal performance, peripheral speeds, and simultaneity can be obtained only through complete reprogramming. A discussion of the problems involved in converting from an IBM 1401 to a GE-400 Series computer system is presented in Section 330:131 of this report.

.3 CENTRAL PROCESSORS

A GE-400 Series computer system has extensive data-manipulating capabilities that make it particularly suitable for many business applications. For example, there are 18 different data transfer instructions, 72 variations of the Shift command, scatter-read and gather-write facilities, two indexing methods, and multilevel indirect addressing. The scatter-gather techniques reduce the need for internal data movement operations and permit tighter packing of data on tape. When combined with indirect addressing, gather-write facilitates sorting and merging by enabling the user to sort only the addresses of data keys instead of the entire data record.

A GE-400 Series system is capable of a relatively high degree of simultaneity. Up to 12 buffered input-output data channels are available, so that multiple read-write operations can be executed while internal processing continues. In addition, a 400 Series system's random access and data communications capabilities make it suitable for many real-time processing requirements.

The core storage unit is housed in one wing of the GE-400 Series processor cabinet. Core storage capacities of 8,192, 16,384, and 32,768 words of 24 data bits (plus one parity bit) are available for each member of the GE-400 Series. A 4,096-word unit is available for the GE-415 only. Core storage cycle times per access of one 24-bit word are:

- GE-415 — 5.8 microseconds.
- GE-425 — 3.9 microseconds.
- GE-435 — 2.7 microseconds.

Each data word can hold four BCD characters, four decimal digits, or a 24-bit binary operand. Instructions are stored in binary form for maximum efficiency.

The central processor is essentially a single-address, fixed word-length, sequential processor. It does, however, have the ability to handle a group of two-address instructions and to manipulate operands that range from one to four words (4 to 16 characters) in length. An adequate complement of instructions is available for manipulating each kind of word format. Both decimal and binary add/subtract instructions are provided, but there are no facilities for fixed-point binary multiply/divide operations. Business

(Contd.)

.3 CENTRAL PROCESSORS (Contd.)

data processing computations will generally be performed in the decimal mode. The decimal multiply and divide instructions are of the single-step variety and require programmed loops to handle multipliers or quotients greater than one digit in length.

Each binary instruction word consists of a 6-bit operation code, a 3-bit address control field, and a 15-bit storage address field. The two-address capability is implemented either by using the address control field to specify a fixed index register which contains the address of the second operand, or by using the next consecutive word in the instruction sequence to specify the second address.

A feature of the processor is the ability to change both the size (one to four words) and location (anywhere in core storage) of the accumulator. Adjusting the accumulator length to fit the data allows faster execution times on shorter fields, while still handling larger fields with one instruction. Tasks of the load-add-and-store type can be accomplished in less time by means of the relocatable accumulator feature.

The recently-announced Floating Point Option provides a complete set of floating-point operations including addition, subtraction, multiplication, division, comparison shifting, and storing or loading of the fraction and exponent, separately or together. Each floating-point operand is 48 bits long (two core storage locations); the fraction consists of 38 data bits plus sign bit, while the exponent consists of 8 data bits plus sign bit. Thus, the range of numbers that can be represented is approximately $\pm 1 \times 10^{\pm 78}$, with a precision of 11.4 decimal digits.

The floating-point hardware consists of a group of registers and logic circuits housed in an additional wing of the central processor cabinet. The execution of floating-point operations proceeds independently of other processor functions. Thus, the fetch and address modification of the next instruction can be overlapped with the execution time of some of the longer floating-point operations such as multiplication or division. The resultant effective execution times are quite fast relative to other systems in this price range. However, no radix conversion instructions are provided; conversions between the BCD format and the binary floating-point format must be accomplished by subroutines. In some applications the cost of these conversions can be very significant.

Address modification can be accomplished by means of six conventional fixed index registers, or through the use of an "address modification sequence" wherein any word in storage can be used as a modifier. Indirect addressing can be specified in conjunction with an address modification sequence. The second address of a two-address instruction cannot be modified but can be determined by a second-address-sequence, which also allows multiple levels of indirect addressing. Savings in total storage space and processing time can be realized through skillful use of these flexible addressing techniques.

The capabilities of a GE-400 Series computer system for operating in a multiprogramming mode or in a remote-inquiry processing mode have been enhanced through the introduction of the Direct Access Option. The features included in this option are Memory Protection, an Interval Timer, a Second-Level Interrupt, a Symbol-Controlled Move instruction, a Non-Stop Mode, and Channel Expansion. The Memory Protection feature provides individual base address and limit registers for core storage and for each I/O channel. In addition, a special mode of operation, the master mode, is implemented. In the normal (user) mode, references by programs to addresses outside their own segments result in interrupts. In the master mode, all of memory is accessible; the base address and limit registers can be altered only in this mode. Separate index registers and control word areas are maintained for each program. Each program area is protected from the effects of an I/O operation initiated by a second program residing in core storage at the same time.

The Interval Timer is program-addressable and is decremented every millisecond; a unique interrupt occurs if the timer is decremented past zero. The Second-Level Interrupt feature allows a peripheral device on a special I/O channel (usually a DATANET-70) to gain immediate access to memory even if another interrupt is being processed. The Symbol-Controlled Move instruction allows data transfers to be stopped upon recognition of a specified character; this feature facilitates the handling of data fields of unknown or variable lengths. The Non-Stop Mode feature prevents a program in the user mode from halting the processor and thereby inhibiting the recognition of interrupts from another program. The Channel Expansion feature permits up to four additional I/O channels (a total of 12) to be added to a GE-400 Series System. The Symbol-Controlled Move and Channel Expansion features are available separately if desired.

.3 CENTRAL PROCESSORS (Contd.)

The basic input-output control section of the central processor has the ability to control up to eight peripheral operations concurrently with internal processing. The logic for controlling an additional four channels is provided by the optional Channel Expansion feature. Several types of data channels are available; they differ in maximum data transfer rate and buffering capabilities. All peripherals operate on a priority interrupt basis. The program interrupt facility causes a transfer of control to a fixed core storage location upon completion of an input-output operation, upon occurrence of certain processor conditions, or upon request.

.4 PERIPHERAL EQUIPMENT

Six different models of magnetic tape units are available for use with the GE-400 Series systems, and each is offered in both a 7-track and a 9-track version. Peak data transfer rates range from 7,500 to 160,000 characters per second. All six models are compatible with one another with respect to both programming and tape format. The tape format of the 7-track versions is also compatible with that of the IBM 729 and 7330 tape units in either BCD or binary mode. The tape format of the 9-track versions is compatible with that of the IBM 2400 Series tape units used in the System/360. Tape recording is checked by a read-after-write parity check. Single- and dual-channel controllers are available for handling up to 8 or 16 tape units, respectively. Intermixing of 7-track and 9-track tape handlers on a 9-track controller is permitted. The dual-channel controllers can significantly improve operating flexibility and system throughput by permitting simultaneous read-write, read-read, or write-write operations on any two of the connected tape units.

Punched card equipment includes a 900-card-per-minute reader and 100- and 300-card-per-minute punches for standard 80-column cards. The line printer operates at single-spaced speeds of 949 lines per minute for the full 64-character set or 1,200 lines per minute when a limited set of 46 contiguous alphameric characters is used. A multiple-tape lister has six independent forms-advancing mechanisms and can perform numeric listing at up to 2,000 single-spaced lines per minute.

A wide selection of mass storage units is now available for GE-400 Series systems. The DS-20 Disc Storage Unit (the only disc file originally announced for the series) contains either 4, 8, 12, or 16 discs. A 16-disc file has a capacity of 23.5 million 6-bit characters, and up to four 16-disc files can be connected to one DSC-20 Controller. The controller contains an addressable 1024-character buffer that permits efficient handling of searching and linking operations. Each disc has a separate positioning arm, and average random access time to a disc record is 225 milliseconds. Optionally, four or eight discs can have fixed arms to provide a 26-millisecond average access time to high-priority data.

The DS-15 Removable Disc Storage Drive is a newly-announced unit that features replaceable disc cartridges consisting of a single disc that can store up to 7.8 million characters of data. From one to eight drives can be connected to a single controller. There is one access mechanism per disc drive. All access mechanisms move independently of one another, and multiple seeks can be overlapped with one DS-15 read or write operation. The average random access time to any sector is 95 milliseconds, and the peak data transfer rate is 260,000 characters per second; this high rate requires the use of a High Speed Data Channel for connecting the DS-15 subsystem to the processor.

The DS-25 Disc Storage Unit is a recently-announced, large-capacity, high-performance disc storage unit. One to four File Units comprise a DS-25 subsystem that provides a maximum storage capacity of 805 million characters. There is one access mechanism for every two discs (four surfaces), and there are 16, 24, or 32 discs per File Unit. All access mechanisms move independently of one another, and multiple seeks can be overlapped with one DS-25 read or write operation. Average access time is 116 milliseconds, and the peak data transfer rate is 300,000 characters per second. A High Speed Data Channel is required to connect this subsystem to a GE-400 Series processor. An unusual feature of the DS-25 is its capability to supply the angular position of a particular file unit in reply to a program status request.

The MS-40 Mass Storage Subsystem uses IBM 2321 Data Cell Drives with a controller manufactured by GE. This subsystem provides economical on-line random-access storage for extremely large volumes of data in applications where relatively slow access

(Contd.)

.4 PERIPHERAL EQUIPMENT (Contd.)

times can be tolerated. The average random access time is approximately 500 milliseconds. As used in the GE-400 Series, the capacity of each MS-40 Data Cell Drive is 532 million 6-bit characters. Up to eight Data Cell drives can be connected to a single controller, providing a storage capacity of 4.26 billion characters per subsystem. Peak data transfer rate is 73,300 characters per second.

A magnetic drum is being developed for GE-400 Series systems, but its specifications are not available to date.

The DATANET-30 Data Communications Processor can be connected to a GE-400 Series system to provide access to a communications network and handle simultaneous input-output from many remote stations. In addition, the DATANET-20 and DATANET-21 Single Line Transmission Controllers can handle data communications on a single-line basis. In this case, an operator can dial any remote station using a digital subset, or an Automatic Calling Unit can enable the computer to initiate the call, send data, and terminate the call. The DATANET-25 Multiple Processor Adapter permits direct computer-to-computer communications on a local basis.

A newly-announced communications controller, the DATANET-70, has the capability for handling up to 248 communications lines. All lines can be active simultaneously. Adapters are available for connecting various types of communications facilities to the DATANET-70, such as teletype lines, voice-grade lines (either synchronous or asynchronous), and Telpak A lines. An automatic calling unit adapter is also available. The DATANET-760 Display Terminal has just been announced for GE-400 Series systems. This device will provide local or remote alphanumeric or graphical displays; details are not currently available.

The recently-announced GE-115 computer system can be connected, via communications links, to a GE-400 Series system. The GE-115 is a small-scale, character-oriented system manufactured by Olivetti-GE in Italy. Peripheral equipment available for the GE-115 includes card readers, card punches, printers, punched paper tape readers and punches, and a small-capacity, removable-cartridge disc storage unit. A summary of the characteristics and performance of the GE-115 system is presented in Computer System Report number 310.

.5 SOFTWARE

The following programs and programming systems are or will be provided by GE. Except where otherwise noted, the software is currently available.

- The Macro Assembly Program (MAP) is the basic symbolic programming system for the GE-400 Series. It consists of the Basic Assembly Language, which is machine-oriented and supplies assembly-control pseudo-operations, and the Macro Assembly Program language, which is field-oriented and uses COBOL-like data descriptions and sequencing. The Macro Assembly Program language supplies macro-instructions for communication with the Basic and Extended Input-Output Systems, which facilitate the coding of input and output operations. Macro-instructions for arithmetic, data movement, and procedure control operations help to minimize the amount of tedious hand coding that must be done and reduce coding errors. At least 8,192 words of core storage, 4 magnetic tape units, card reader, punch, and printer are required for MAP assemblies.

- The GE-400 Series COBOL compiler can translate source programs that use all of Required COBOL-61 and selected elements of Elective COBOL. Equipment required for COBOL compilation is the same as for the Macro Assembly Program.

- A Basic FORTRAN IV Compiler, available in June, 1965, facilitates the programming of scientific applications. The principal restriction upon this version of FORTRAN IV is the lack of capabilities for handling complex, logical, and double-precision operations. Equipment requirements are the same as for the Macro Assembly Program.

- The IBM 1401 Simulator Program and the IBM 1401 Compatibility Option routine enable a GE-400 Series computer system to run IBM 1401 object programs. See the paragraph on COMPATIBILITY (page 330:011.100) for a description of these two simulation methods.

.5 SOFTWARE (Contd.)

- The Tape Operating System is an integrated set of three routines: the Program Monitor, Loader, and I/O Supervisor. The Program Monitor can speed up run-to-run changeovers in both debugging and production operations. In the debugging function, the Systems Tape, which contains all language processors and debugging aids, is used as the operating tape, providing a "compile and run" capability. The Program Monitor can also use a library tape of production programs as the operating tape. GE is developing versions of the Tape Operating System to run multiple programs concurrently in a multiprogramming mode, using the Direct Access Option.

- The Card Operating System provides all the facilities of the Tape Operating System except the Systems Tape; language translations cannot be performed while using this version of the Operating System.

- The Report Program Generator provides for the preparation of reports or records from files on punched cards, punched tape, or magnetic tape. Output may be assigned to magnetic tape, printer, and/or card punch.

- The GE-400 Series Sort and Merge Generators produce programs for efficient sorting and merging of magnetic tape files. User-coding options permit pre-sort and post-sort editing.

- Service routines for debugging, program library maintenance, media conversion, recovery for reruns, program loading, and other utility functions will be provided.

DATA STRUCTURE

.1 STORAGE LOCATIONS

Name of Location	Size	Purpose or Use
Word:	24 bits + parity	basic addressable storage unit (data or instruction).
DS-20 —		
Sector:	240 characters	Disc Storage record location.
Track:	8 or 16 sectors.	
Disc:	512 tracks.	
DS-25 —		
Sector:	192 characters	Disc Storage record location.
Band:	64 sectors.	
Disc:	512 bands.	
DS-15 —		
Sector:	192 characters	Disc Storage record location.
Track:	64 sectors.	
Disc:	320 tracks.	
MS-40 —		
Track:	2,664 characters	Data Cell record location.
Strip:	100 tracks.	
Cell:	200 strips.	

.2 INFORMATION FORMAT

Type of Information	Representation
Alphameric data word:	four 6-bit BCD characters.
Decimal arithmetic word:	four 4-bit BCD digits plus 2 sign bits.
Floating-point word:	48 bits (2 core storage locations); 8-bit exponent plus sign bit, 38-bit fraction plus sign bit.

SYSTEM CONFIGURATION

Every GE-400 Series Computer System includes the following units:

- Central Processor — includes eight I/O channels (except High Speed Channels).
- Core Storage Unit.
- Control Console — includes an I/O Typewriter.

The storage capacities of the available core storage units range from 8,192 to 32,768 words (32,768 to 131,072 characters). In addition, a 4,096-word (16,384-character) core storage unit is available for the GE-415 only. Cycle times per access of one 24-bit word are as follows:

GE-415 — 5.8 μsec.
GE-425 — 3.9 μsec.
GE-435 — 2.7 μsec.

Every GE-400 Series system can have up to 12 input-output channels for the connection of punched card, punched paper tape, magnetic tape, printer, MICR sorter/reader, random access, or data communication subsystems. The number of devices making up a subsystem is explained in the report section describing each individual type of device. (See Sections 330:042 through 330:046 and Sections 330:071 through 300:105.)

In general, one subsystem can be connected to each I/O channel. A magnetic tape subsystem can be connected to two I/O channels through a dual-channel controller. Two peripheral subsystems can share a single I/O channel through the use of the Manual Peripheral Switch. A single peripheral subsystem can be shared between two GE-400 Series systems by means of the Manual Peripheral Switch or the Programmed Peripheral Switch.

Several different types of I/O channels are available; they differ in maximum data transfer capability, amount of buffering, and method of operation. Section 330:111, Simultaneous Operations, describes each type of channel the restrictions on combinations of the various types, and the type of channel usually assigned to each type of peripheral subsystem.

Standard Configurations

Representative standard configurations (as defined in Section 4:031, System Configuration, of the Users' Guide) are shown in the System Configuration sections of the subreports on the individual GE-400 Series models:

GE-415: . . . . Section 333:031.
GE-425: . . . . Section 334:031.
GE-435: . . . . Section 335:031.

INTERNAL STORAGE: CORE STORAGE

.1 GENERAL

.11 Identity: . . . . Core Storage. Part of each GE-400 Series processor.

.12 Basic Use: . . . . working storage.

.13 Description

The core storage unit is housed in one or two wings of a GE-400 Series processor cabinet. The capacities and performance of the units available for the individual GE-400 Series computer systems are shown in Table I.

Each word position in core storage is directly addressable. Internal storage addressing is binary and instruction word address fields always consist of 15 bits. (To simplify references to storage locations, decimal or symbolic addresses are used in the assembly programs.)

Although the size of each storage location is fixed, the contents of a word location can be in any of the following formats:

- four 6-bit alphameric characters;
- four decimal digits, using only the four numeric bits of each character position except the rightmost one, in which the two zone bits denote the sign of the field; or
- 24 binary bits (unsigned).

Several instructions can operate on selected characters within a word (e.g., Explode and Implode). The binary formats are normally used for instruction words and for "second address sequence" words used for address modification control. Single, double, triple, and quadruple word-length operations are possible for many instructions. Internal block transfers up to 512 words can be performed with the Move command.

Sixty-five of the first 72 storage locations are special locations whose use by the programmer is restricted. Some of these locations have special processor-oriented functions during operation, such as index words and input-output control words; other locations cannot be used by programs if full program compatibility within the GE-400 Series is to be maintained.

.14 Availability: . . . . with processor.

.15 First Delivery: . . . . . with processor.

.16 Reserved Storage

Purpose	Number of Locations	Locks
Accumulators (relocatable):	4	none.
Index words:	6	none.
Central processor control:	3	these locations cannot be used by programmer for any other purpose.
I/O control:	48	these locations cannot be used by programmer for any other purpose.
Reserved for future use:	8	none (should not be used if full GE-400 Series program compatibility is to be maintained).

TABLE I: GE-400 SERIES CORE STORAGE UNITS

Processor Model	GE-415	GE-425	GE-435
Available Capacities, words	4,096; 8,192; 16,384; 32,768	8,192; 16,384 32,768	8,192; 16,384; 32,768
Access Time, μsec per word	3.2	2.0	1.5
Cycle Time, μsec per word	5.8	3.9	2.7
Cycling Rate, cycles/sec.	172,500	256,400	370,000
Peak Data Rate, words/sec.	172,500	256,400	370,000
Effective Transfer Rate, words/sec	86,000	128,000	192,000

.2 PHYSICAL FORM

.21 Storage Medium: . . . . magnetic core.

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . . . yes.
.242 Data regenerated constantly: . . . . no.
.243 Data volatile: . . . . . . no.
.244 Data permanent: . . . . no.
.245 Storage changeable: . . no.

.27 Interleaving Levels: . . no interleaving.

.28 Access Technique: . . . coincident current.

.29 Potential Transfer Rates: . . . . see Table I.

.3 DATA CAPACITY: . . see Table I. (Each word location contains 24 data bits and one parity bit, and can hold four 6-bit alphameric characters or four decimal digits.)

.4 CONTROLLER: . . . . no separate controller is required.

.5 ACCESS TIMING:. . . . see Table I.

.6 CHANGEABLE STORAGE: . . . . none.

.7 PERFORMANCE

.72 Transfer Load Size: . . 1 to 512 words.

.73 Effective Transfer Rate: . . . . see Table I.

.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	set indicator and interrupt; halt if already in an interrupt routine.
Receipt of data:	generate parity bit.	
Recording of data:	record parity bit.	
Recovery of data:	parity check	set indicator and halt.
Timing conflicts:	none.	
Reference to locked area:	none.	

INTERNAL STORAGE: DS-20 DISC STORAGE UNIT

.1 GENERAL

.11 Identity:. . . . . DS-20 Disc Storage Unit. DSC-20 Disc Storage Controller.

.12 Basic Use: . . . . auxiliary storage.

.13 Description

The DS-20 Disc Storage Unit consists of up to 16 data discs (32 recording surfaces) capable of storing up to 23.5 million characters. From 1 to 4 of these units can be connected to the DSC-20 Disc Storage Controller to provide a total random access storage capacity of 94 million characters per controller. The combination DS-20 and DSC-20 is referred to by the manufacturer as the Disc Storage Subsystem and requires one double-word-buffered I/O channel.

Each disc surface is divided into two 128-track parts called the outer and inner zones. Each circumferential track is, in turn, divided into a number of addressable sectors; 16 sectors per outer-zone track and 8 per inner-zone track. This arrangement yields a total of 3,072 fixed addressable sector positions on each disc surface at which the reading or writing of data can begin. A sector has a fixed capacity of 240 six-bit characters plus a six-bit modulo-64 check character.

Each disc is served by an individual positioning arm containing 8 read-write heads (4 per surface) so that only 64 arm positions are required to cover all the tracks on a disc. Arm positioning time ranges from 70 to 305 milliseconds, and the total average waiting time for random accessing is 225 milliseconds. Up to 368,000 characters (92,000 words) per Disc Storage Unit can be transferred with no movement of the access arms. Peak data transfer rate is 41,700 (inner zone) or 83,400 (outer zone) characters per second. An effective bulk transfer rate of 50,000 characters per second can be obtained.

The DSC-20 Controller contains a 1,024-character addressable buffer which facilitates the serial-to-parallel conversion process between the Disc Storage Unit and core storage. The buffer arrangement also permits the simultaneous transfer of data between core storage and one section of the buffer, and between another section of the buffer and any one Disc Storage Unit. Under program control, information written onto the discs can be read back and a character-by-character comparison made with the data image as it appears in the controller buffer. Thus a verification check can be made to insure that data was recorded correctly.

The 1,024-character addressable core buffer can hold up to four 240-character disc records (sectors) at a time. This feature, coupled with the system's scatter-read, gather-write capabilities, lets the user transfer only the fields he needs for updating into and out of core memory, without moving the whole record. This can result in faster file updating operations and reduced core memory space requirements.

The ability to search up to 32 consecutive disc sectors with one instruction makes it possible to locate the desired sector on the basis of its content rather than its specific address. This capability can save processing time by reducing or eliminating the need to pre-sort input records that would normally require separate disc look-up operations.

A parity check is made on each word transferred to or from the controller buffer. In addition, each 240-character sector has an associated check character to help increase reading and writing accuracy. The detection of a parity error results in the termination of the disc operation. The address of each sector is permanently recorded in a "header" word and used for sector identification and track address confirmation.

A large complement of read-write disc storage instructions is available for performing individual operations or a combination of different operations. For example, the following group of instructions pertain to read operations only:

Read File.

Seek-Read File.

Seek-Read File and Release Seek.

Read File and Release Seek.

Seek-Read File and Increment Address.

Read File Continuous and Release Seek.

Useful instructions are also provided for searching and linking on the basis of data content, when the address of the desired sector is not known.

The Disc Storage Unit will be available in increments of 4, 8, 12 or 16 discs. A Fast Access option provides high-speed (26 milliseconds) access to high-priority data for program overlay routines, address dictionaries, subroutines, tables, and key data for fast record updating. It is estimated that use of Fast Access storage for tables and subroutines can reduce unit record update cycle times by 50% or more.

This high-speed access is provided by locking the read-write arms on 4 or 8 discs, eliminating positioning and track verification time. Access time is thus only the disc latency time — an average of 26 milliseconds. Storage capacity of each Fast

.13 Description (Contd.)

Access disc is only 96 sectors (23,040 characters). The total number of discs (standard plus Fast Access) in a DS-20 Disc Storage Unit cannot exceed 16.

In each Disc Storage Subsystem, data can be simultaneously transferred between the central processor and the disc file buffer, and between the buffer and any one Disc Storage Unit. See Section 330:111, Simultaneous Operations, for detailed information on the input-output process, I/O channel requirements, and the demands on the central processor made by this unit.

.14 Availability: . . . . 11 months.

.15 First Delivery: . . . . . April, 1964.

.16 Reserved Storage: . . . none.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . multiple discs.

.22 Physical Dimensions

.222 Disc —
Diameter:. . . . . 31 inches.
Number on shaft: . . . 16.

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . . . yes.
.242 Data regenerated constantly: . . . . no.
.243 Data volatile: . . . . . . no.
.244 Data permanent: . . . . no.
.245 Storage changeable: . . no.

.25 Data Volume per Band of 1 track

	Inner Zone	Outer Zone
Words:	480	960.
Characters:	1,920	3,840.
Digits:	1,920	3,840.
Instructions:	480	960.
Sectors:	8	16.

.26 Tracks per Physical Unit: . . . . 512 (256 per disc surface).

.27 Interleaving Levels: . . 1.

.28 Access Techniques

.281 Recording method: . . . moving heads.
.283 Type of access

Description of Stage	Possible Starting Stage
Move head to selected track:	if new track is selected.
Wait for start of selected sector:	if same track was previously selected.
Transfer data:	no.

.29 Potential Transfer Rates

.291 Peak bit rates —
Cycling rate: . . . . . . 1,170 rpm.
Bit rate per track: . . 250,000 or 500,000 bits/sec/track.

.292 Peak data rates —
Unit of data: . . . . . . character.
Conversion factor: . . 6 bits/char.
Data rate: . . . . 41,700 (inner zone) or 83,400 (outer zone) char/sec.

.3 DATA CAPACITY

.31 Module and System Sizes

	Minimum Storage	Maximum Storage
Identity:	DS-20	DS-20.
Storage Units:	1	4.
Discs:	4	64.
Words:	1,466,000	23,500,000.
Characters:	5,898,000	94,000,000.
Instructions:	1,466,000	23,500,000.
Sectors:	24,576	393,216.

.4 CONTROLLER

.41 Identity: . . . . DSC-20 Disc Storage Controller.

.42 Connection to System

.421 On-line: . . . . one controller per available word-buffered I/O channel.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: . . . . 1 to 4 storage units (4 to 64 discs).
.432 Restrictions: . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . 1 to 32 sectors of 240 characters each.
.442 Input-output area: . . . core storage, via addressable 1,024-character buffer.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Synchronization: . . . . automatic.
.447 Table control: . . . . . . yes; scatter-read and gather-write are available at programmer's option.
.448 Testable conditions: . . device-controller ready: device busy; error condition.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of Stacks
Stacks per system: . . 32 to 512 per controller.
Stacks per unit: . . . . 32 to 128.
Stacks per yoke: . . . 8.
Yokes per unit: . . . . 4 to 16 (one for each disc).

(Contd.)

.512 Stack movement: . . . . horizontal only.

.513 Stacks that can access any particular location:. . . . . 1.

.514 Accessible locations:
- By single stack —
  - With no movement:. 8 or 16 sectors.
  - With all movement: 512 or 1,024 sectors.
- By all stacks —
  - With no movement:. 1,536 sectors per unit. 6,144 sectors per controller.

.515 Relationship between stacks and locations: least significant 7 bits of disc address specify stack and sector.

.52 Simultaneous Operations:. . . . . . . data can be simultaneously transferred between the central processor and disc file buffer, and between the buffer and any one Disc Storage Unit.

.53 Access Time Parameters and Variations

.532 Variation in access time —

Stage	Variation (msec)	Average (msec)
Move head to selected track:	0 or 70 to 305	199.
Wait for selected sector:	0 to 52	26.
Transfer 1 sector:	3.2 or 6.4	3.2
Total:	3.2 to 363.4	228.2

.6 CHANGEABLE STORAGE: . . . . none.

.7 PERFORMANCE

.72 Transfer Load Size

With core storage: . . . 1 to 32 sectors; maximum of 240 characters per sector.

.73 Effective Transfer Rate

A "cylinder" is defined as the amount of data that can be transferred with one positioning of the access mechanisms. The rates presented in this paragraph indicate the performance of this unit when transferring large blocks of data. Typical applications for this type of operation include loading of programs or routines, core storage dumps, and restarts. Paragraphs .74 and .75 below present the performance of this unit in a random processing environment where only one record at a time is accessed for processing.

Cylinder mode: . . . . . 35,900 char/sec; based on random access and transfer of 96 sectors (23,040 characters), with data ordered sequentially.

Bulk mode: . . . . 50,000 char/sec; based on random access and transfer of 131,072 characters (maximum core storage load), with data ordered sequentially.

.74 Update Cycle Rate: . . 3.0 references/sec.

Note: Based on random accessing of one 240-character record (1 sector); reading, updating, and rewriting that record; and rereading for verification of recording.

.75 Read-Only Reference Cycle Rate:. . . . . . . 4.4 references/sec.

Note: Based on random accessing and reading of one 240-character record (1 sector), with no updating or rewriting.

.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	interrupt.
Invalid code:	check	interrupt.
Receipt of data:	parity check	interrupt.
Recording of data:	generate check character.	
Recovery of data:	character and sector parity check	interrupt.
Dispatch of data:	send parity bit.	
Timing conflicts:	check	interrupt.
Wrong record selected:	address comparison	interrupt.

INTERNAL STORAGE: DS-25 DISC STORAGE UNIT

.1 GENERAL

.11 Identity: . . . . DS-25 Disc Storage File Unit.
DS-25 Disc Storage Controller.

.12 Basic Use: . . . . random-access auxiliary storage.

.13 Description

The DS-25 Disc Storage File Unit is a large-capacity unit developed and manufactured by GE. A DS-25 Disc Storage Subsystem consists of a controller and one to four File Units and provides a maximum storage capacity of 805 million characters per subsystem.

Average access time is 116 milliseconds. The effective access time can be substantially lowered in some applications through utilization of overlapped seeks and angular position read-outs. Peak data transfer rate is 300,000 characters per second. A DS-25 subsystem is connected to one High Speed I/O Channel. A GE-400 Series computer system is limited to only one DS-25 Subsystem due to the high data transfer rate.

Each DS-25 Disc Storage File Unit consists of 16, 24, or 32 discs mounted on a central shaft, providing up to 64 surfaces for data recording per File Unit. There are 512 tracks per disc surface — 256 in the "outer zone" and 256 in the "inner zone." One track from each of the two zones is used to record each segment of data, permitting uniform transfer rates for all portions of the disc, in contrast to the DS-20 (Section 330:042).

Thus, there are 256 bands (or logical tracks) on each disc surface. Each band holds 64 sections of 192 characters each. Data is addressed by sector, and all sections are numbered sequentially. A check code is recorded for each sector.

There is one access mechanism (positioning actuator arm) for every two discs. Eight read/write heads service each disc surface. Thus, in any one position, up to 16 bands (1,024 sectors or 196,608 characters) can be read or written sequentially by each access mechanism. Each access mechanism can move to any of 64 discrete positions. Positioning time varies from 40 to 120 milliseconds, with an average of 90 milliseconds.

Each access mechanism moves independently, permitting up to 64 simultaneous seek operations in a fully-expanded DS-25 Disc Storage Subsystem. Each subsystem can be equipped with up to four independent data channels, and any data channel can service any access mechanism. In GE-400 Series computer systems, only one data channel from a DS-25 Subsystem can be connected to any one central processor. Note, however, that it is possible to obtain up to four simultaneous data transfers when several GE-400 Series processors share a single DS-25 Disc Storage Subsystem.

One interesting and potentially useful feature of this device is the capability for requesting the status of each positioning arm. The status word returned as a result of this inquiry by the central processor indicates: (1) whether or not the addressed arm is positioned, and (2) the angular position, in terms of an absolute disc address, of the related set of discs. This facility enables a subroutine to determine which data segment can be accessed with the least rotational delay. In an environment which permits extensive queuing of requests for disc storage accesses, the overlapping of seeks and the angular read-out could be used to reduce significantly the delay between successive processed records. GE has not yet released any details about standard routines for utilizing these features of the DS-25 Subsystem.

The Block Count feature can provide a measure of file protection when multiple files are contained in a single DS-25 Disc Storage Subsystem. A block count is transmitted with each Seek command, and the count is decremented by one for each sector read or written in the subsequent data transfer operation. A data transfer operation is ended if the block count is decremented to zero. The block count must be determined and set by the programmer through his own coding or standard software routines.

Only four basic commands are provided for a DS-25 Disc Storage Subsystem: Seek, Read, Write, and Write Check. Data transfers are controlled in the same manner as other GE-400 Series input-output operations. A description of the input-output process and the demands upon the central processor is presented in Section 330:111, Simultaneous Operations.

.14 Availability: . . . . 24 months.

.15 First Delivery: . . . . . third quarter, 1966.

.16 Reserved Storage: . . . none; note that one sector per track is reserved for diagnostic testing, but is not available to the programmer.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . multiple discs.

.22 Physical Dimensions

.222 Disc —
Diameter:. . . . . 21 inches.
Number on shaft: . . . 16, 24, or 32.

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . . . yes.
.242 Data regenerated constantly: . . . . no.
.243 Data volatile: . . . . no.
.244 Data permanent: . . . . . no.
.245 Storage changeable: . . no.

.25 Data Volume per Band of 2 Tracks

Words: . . . . 3,072.
Characters: . . . . 12,288.
Digits: . . . . 12,288.
Instructions: . . . . 3,072.
Sectors: . . . . 64.

.26 Bands per Physical Unit: . . . . 512 per disc.

.27 Interleaving Levels: . . 1; i.e., no interleaving.

.28 Access Techniques

.281 Recording method: . . . movable heads.
.283 Type of access —

Description of stage	Possible starting stage
Move heads to selected band:	if repositioning of access arm is necessary.
Wait for start of sector:	if no repositioning is necessary.
Transfer data:	no.

.29 Potential Transfer Rates

.291 Peak bit rates —
Cycling rate: . . . . . . 1,200 rpm.
Track/head speed: . . variable.
Bits/inch/track: . . . variable.
Bit rate per track: . . 900,000 bits/sec/track.

.292 Peak data rates —
Unit of data: . . . . . . character.
Conversion factor: . . 6 bits per character.
Gain factor (tracks per band): . 2.
Loss Factor (degree of interleaving): . . . 1.
Data rate: . . . . 300,000 char/sec.

.3 DATA CAPACITY

.32 Rules for Combining Modules: . . . . Each Disc File Unit can have 16, 24, or 32 discs. Each Controller can have up to 4 Disc File Units connected to it.

.4 CONTROLLER

.41 Identity: . . . . DS-25 Disc Storage Controller.

.42 Connection to System

.421 On-line: . . . . 1 controller (requires High Speed I/O channel).
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: . . . . 1 to 4 Disc Storage File Units.
.432 Restrictions: . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . 1 to 196,608 characters (1,024 sectors).
.442 Input-output area: . . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Synchronization: . . . . automatic.
.447 Table control: . . . . . . yes; scatter-read and gather-write facilities are available. See Section 330:111, Simultaneous Operations.
.448 Testable conditions: . . Controller ready.
Controller busy.
Access mechanism ready.
Access mechanism busy.
Error conditions.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of stacks —
Stacks per File Unit: 128 to 256 (8 per disc).
Stacks per yoke: . . . 16.
Yokes per File Unit: . 8 to 16 (1 access mechanism per 2 discs).

.31 Module and System Sizes

	Minimum Storage			Maximum Storage per Subsystem
Identity:	DS-25 File Unit	DS-25 File Unit	DS-25 File Unit	4 DS-25 File Units
Physical Units:	1	1	1	4
Discs:	16	24	32	128
Words:	25,165,824	37,748,761	50,331,648	201,326,592
Characters:	100,663,296	150,994,944	201,326,592	805,306,368
Instructions:	25,165,824	37,748,761	50,331,648	201,326,592
Sectors:	524,288	786,432	1,048,576	4,194,304
Tracks:	8,192	12,288	16,384	65,536

.512 Stack Movement: . . . . horizontal, to one of 64 discrete positions.

.513 Stacks that can access any particular location:. . . . . 1.

.514 Accessible locations:
By single stack —
With no movement:. 1 band.
With all movement:. 64 bands.
By all stacks —
With no movement:. 128 to 256 bands per File Unit.
1,024 bands per fully-expanded subsystem.

.52 Simultaneous Operations

A read, write, or seek operation using one access mechanism can be overlapped with seek operations taking place on any or all other access mechanisms. Up to four simultaneous data transfers involving four different access mechanisms are possible, but only one data transfer operation at a time is permitted to or from an individual GE-400 Series central processor.

.532 Variation in access time —

Stage	Variation, msec	Average, msec
Move head to selected band:	0 or 40 to 120	90
Wait for beginning of selected sector:	0 to 52	26
Transfer data:	52 per band	52
Total:		168

.7 AUXILIARY STORAGE PERFORMANCE

.72 Transfer Load Size: . . 1 to 196,608 characters (1,024 sectors).

.73 Effective Transfer Rate: . . . . 195,500 char/sec; based on random access and transfer of 131,072 characters (maximum core storage load), with data ordered sequentially.

Note: The rate presented in Paragraph .73 indicates the performance of this unit when transferring large blocks of data. Typical applications for this type of operation include loading of programs or routines, core storage dumps, and restarts. Paragraphs .74 and .75 below present the performance of this unit in a random processing environment where only one record at a time is accessed for processing.

.74 Update Cycle Rates

With no overlapping of seek times:. . . . . . . 4.5 references/sec.
With maximum overlapping of seek times: 7.6 references/sec.

Note: Based on random accessing of one 192-character record (1 sector); reading, updating, and writing that record; and re-reading for verification of recording.

.75 Read-Only Reference Cycle Rates

With no overlapping of seek times:. . . . . . . 8.6 references/sec.
With maximum overlapping of seek times: 37.3 references/sec.

Note: Based on random accessing and reading of one 192-character record (1 sector), with no updating or rewriting.

.8 ERRORS, CHECK, AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	interrupt.
Invalid code:	all 6-bit codes are valid.	
Receipt of data:	parity check	set status.
Recording of data:	generate check code.	
Recovery of data:	check code	set status.
Dispatch of data:	send parity bit.	
Timing conflicts:	check	interrupt.
Refer to locked area:	check	interrupt.
Wrong sector:	check (address comparison)	interrupt.

INTERNAL STORAGE: DS-15 DISC STORAGE DRIVE

.1 GENERAL

.11 Identity: . . . . DS-15 Removable Disc Storage Drive.
DS-15 Disc Storage Controller.
DS-15 Disc Cartridge.

.12 Basic Use: . . . . random-access, interchangeable cartridge, auxiliary storage.

.13 Description

The DS-15 Removable Disc Storage Subsystem is a new unit developed and manufactured by GE. It is basically a disc storage unit with replaceable disc cartridges. Each cartridge consists of a single 16-inch disc capable of storing up to 7.8 million characters of data. The on-line disc cartridge can be removed and replaced by another cartridge in less than one minute.

Each disc storage drive accepts one cartridge. One or two drives are housed in a single cabinet. Up to eight DS-15 Disc Storage Drives can be connected to a controller, providing up to 62.4 million characters of on-line storage per subsystem. Each subsystem is connected to one High Speed I/O Channel. The peak data transfer rate is 260,000 characters per second, and the average random access time to any sector is 95 milliseconds.

There is one access mechanism (arm) per disc drive. Each arm holds eight read/write heads (four per surface) and can move to any of 80 discrete positions. Thus, there are 640 tracks per disc (320 per surface). Each track is divided into 64 sectors which can contain up to 192 characters of data each. Addressing is by sector and is sequential; i.e., all 512 sectors (98,304 characters) at a particular position of the access arm can be read or written sequentially without repositioning the arm.

The access arm in each drive can be repositioned independently of the access arms in other DS-15 drives. Thus, in a fully-expanded subsystem (eight disc drives), a data transfer operation (read or write) can be performed simultaneously with positioning of the seven other access mechanisms. Only one data transfer operation at a time is possible.

Optimum programming in some applications could effectively reduce the average access time to the latency (rotational delay) time alone. No details are currently available on standard software by GE for utilizing this feature.

In contrast to the large variety of instructions implemented for the DS-20 Disc Storage Unit (Section 330:042), only three basic commands are provided for the DS-15: Seek, Read, and Write. Data transfers are controlled in the same manner as other GE-400 Series input-output operations. A description of the input-output process and the demand upon the central processor is presented in Section 330:111, Simultaneous Operations.

Optional Features

A DS-15 Removable Disc Storage Controller can optionally be equipped with a second channel for communication with a second GE-400 Series processor or with a GE-600 Series processor. The second channel enables two computer systems to share a single DS-15 Subsystem, but does not permit two simultaneous data transfers to or from the disc drives in the shared subsystem.

The optional Block Count feature can provide a measure of file protection when multiple files are contained on one DS-15 cartridge. With this feature, a block count is transmitted with each Seek command. The block count is decremented by one for each sector read or written in the subsequent data transfer operation. A data transfer operation is ended if the block count is decremented to zero. The block count must be determined and set by the programmer through his own coding or by using standard software routines.

.14 Availability: . . . . 18 months.

.15 First Delivery: . . . . . third quarter, 1966.

.16 Reserved Storage: . . . none.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . interchangeable disc.

.22 Physical Dimensions

.222 Disc —
Diameter: . . . . 16 inches.
Number on shaft: . . . 1.

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . . . yes.
.242 Data regenerated constantly: . . . . no.
.243 Data volatile: . . . . . . no.
.244 Data permanent: . . . . no.
.245 Storage changeable: . . yes.

.25 Data Volume per Band of 1 Track

Words: . . . . 3,072.
Characters: . . . . 12,288.
Digits: . . . . 12,288.
Instructions: . . . . 3,072.

.26 Bands per Physical Unit: . . . . 640.

.27 Interleaving Levels: . . 1; i.e., no interleaving.

.28 Access Techniques

.281 Recording method: . . . magnetic heads which move horizontally in unison on a single arm.

.283 Type of access —

Description of stage	Possible starting stage
Move arm to selected track:	if repositioning of access arm is necessary.
Wait for start of selected sector:. . .	if no repositioning is necessary.
Transfer data:.	no.

.29 Potential Transfer Rates

.291 Peak bit rates —
Cycling rates: . . . . . 1,200 rpm.
Track/head speed: . . variable.
Bits/inch/track: . . . variable.
Bit rate per track: . . 1,560,000 bits/sec/track.

.292 Peak data rates —
Unit of data: . . . . . . character.
Conversion factor: . . 6 bits per character.
Data rate:. . . . . 260,000 char/sec.

.3 DATA CAPACITY

.31 Module and System Sizes

	Minimum Storage	Maximum Storage
Identity:	1 drive	8 drives
Access arms:	1	8
Discs:	1	8
Words:	1,966,080	15,728,640
Characters:	7,864,320	62,914,560
Instructions:	1,966,080	15,728,640
Sectors:	20,480	163,840
Cartridges on-line:	1	8

.32 Rules for Combining Modules: . . . . 1 to 8 disc drives per controller.

.4 CONTROLLER

.41 Identity: . . . . DS-15 Disc Storage Controller.

.42 Connection to System

.421 On-line: . . . . 1 controller per available High Speed I/O Channel.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1 to 8 disc drives.
.432 Restrictions: . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . 1 to 512 sectors of 192 characters each.
.442 Input-output area:. . . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Synchronization: . . . . automatic.
.447 Table control: . . . . . . yes; scatter-read and gather-write; see Section 330:111, Simultaneous Operations.
.448 Testable conditions: . . available.
busy.
error condition.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of stacks —
Stacks per subsystem: . . . . 8 to 64.
Stacks per drive: . . . 8.
Stacks per yoke: . . . 8.
Yokes per drive: . . . 1.
.512 Stack movement: . . . . horizontally across disc surface, to one of 80 discrete positions.
.513 Stacks that can access any particular location: . . . . 1.
.514 Accessible locations:
By single stack —
With no movement:. 1 track.
With all movement: 80 tracks.
By all stacks —
With no movement: 8 tracks per drive.
64 tracks per subsystem of 8 drives.

.52 Simultaneous Operations

A read, write or seek operation on one disc drive can be overlapped with seek operations taking place in any or all other disc drives. Only one read or write operation can take place at a time in a DS-15 subsystem.

.53 Access Time

.532 Variation in access time —

Stage	Variation, msec	Average, msec
Move head to selected track:	0 or 35 to 100	79.0
Wait for selected sector:.	0 to 50	25.0
Transfer data:	50 per track	50.0
Total:		145.0

.6 CHANGEABLE STORAGE

.61 Cartridge (Disc Cartridge)

.611 Cartridge capacity: . . 7,864,320 characters (1 disc).
.612 Cartridges per drive: . 1.
.613 Interchangeable: . . . . yes.

(Contd.)

.62 Loading Convenience

.621 Possible loading —
- While computing system is in use: . . . . yes.
- While disc drive is in use: . . . . no.

.622 Method of loading: . . . operator.
.623 Approximate change time: . . . . 1 minute.
.624 Bulk loading: . . . . none.

.7 PERFORMANCE

.72 Transfer Load Size: . . 1 to 98,304 characters (512 sectors).

.73 Effective Transfer Rates

A "cylinder" is defined as the amount of data that can be transferred with one positioning of the access mechanisms. The rates presented in this paragraph indicate the performance of this unit when transferring large blocks of data. Typical applications for this type of operation include loading of programs, core storage dumps, and restarts. Paragraphs .74 and .75 below present the performance of this unit in a random processing environment where only one record at a time is accessed for processing.

Cylinder mode: . . . . . 199,000 char/sec; based on random access and transfer of 512 sectors (12,288 characters) with data ordered sequentially.

Bulk mode: . . . . 190,600 char/sec; based on random access and transfer of 131,072 characters (maximum core storage load) with data ordered sequentially. All seeks subsequent to the initial seek are considered to be overlapped with the initial seek and data transfer time.

.74 Update Cycle Rates

With no overlapping of seek times: . . . . 5.1 references/sec.
With maximum overlapping of seek times: 8.0 references/sec.

Note: Based on random accessing of one 192-character record (1 sector); reading, updating, and writing that record; and rereading for verification of recording.

.75 Read-Only Reference Cycle Rates

With no overlapping of seek times: . . . . . 14.5 references/sec.
With maximum overlapping of seek times: 38.8 references/sec.

Note: Based on random accessing and reading of one 192-character record (1 sector), with no updating or rewriting.

.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	set status.
Invalid code:	all 6-bit codes are valid.	
Receipt of data:	parity check	set status.
Recording of data:	generate check character for each sector.	
Recovery of data:	check sector check character	set status.
Dispatch of data:	send parity bit.	
Timing conflicts:	check	set status.
Physical record missing:	same as invalid address.	

INTERNAL STORAGE: MASS STORAGE SUBSYSTEM

.1 GENERAL

.11 Identity: . . . . MS-40 Storage Cell Drive (IBM 2321 Data Cell Drive). MS-40 Controller.

.12 Basic Use: . . . . random-access auxiliary storage.

.13 Description

The MS-40 Mass Storage Subsystem uses the new IBM 2321 Data Cell Drives (described in Section 420:045) with a controller manufactured by GE. This subsystem provides economical on-line random-access storage for extremely large volumes of data in applications where relatively slow access times can be tolerated. As implemented for GE-400 Series computer systems, each Data Cell Drive is capable of storing over 532 million 6-bit characters of data in 10 removable, interchangeable Data Cells with a capacity of over 53 million characters each. From one to eight Data Cell Drives can be connected to an MS-40 controller. Each controller fully occupies one double-word-buffered input-output channel.

The GE recording format is a restricted version of the flexible multiple-records-per-track format available with the IBM 2321. Each track of the MS-40 can contain 1, 2, 3, 4, or 6 individually-addressable blocks of data. The number of blocks per track and the block addressed are specified by the I/O command. No key is permitted in the MS-40 format.

The formats of the MS-40 and the IBM 2311 are compatible with the following restrictions:

- Key length must be zero.
- Data must be organized into one of the permissible MS-40 blocking formats.

If these restrictions are met, GE states that Data Cells can be exchanged between the MS-40 and the IBM 2311. Note that a program would be required to translate between the 6-bits-per-character GE format and the 8-bits-per-byte IBM format.

Data is recorded on magnetic strips which are held in Data Cells mounted vertically around the circumference of a cylinder or "tub file" which can be rotated. Each of the 10 Data Cells is divided into 20 subcells, and each subcell contains 10 magnetic strips. A bidirectional rotary positioning system positions the selected subcell beneath an access station. The selected strip is withdrawn from the Data Cell, placed on a separate rotating drum, and moved past the read/write head assembly, where reading or recording takes place. The strip is returned to its original location in the Data Cell if:

(1) a Restore instruction is issued;

(2) a Seek instruction references a new strip; or

(3) 400 milliseconds elapse between successive Data Cell instructions. (This is a safeguard to protect the flexible magnetic strips from unnecessary wear.)

Each magnetic strip is 13 inches long, 2.25 inches wide, and 0.005 inch thick; has an iron-oxide coating on one side and a carbon anti-static coating on the other; has a pair of coding tabs to identify its position in the cell; and provides 100 addressable recording tracks. Each track has a maximum data capacity of 2,664 six-bit characters when recorded in a single block. Multiple blocks per track reduce the number of usable data characters per track.

The physical components of each Data Cell Drive are arranged in an L-shaped cabinet whose sides measure about four feet by six feet in length. The components include an electronics section and pneumatic, hydraulic, and mechanical equipment.

The read/write head assembly contains 20 heads and can be moved to any of 5 discrete positions in order to serve the 100 data tracks on each strip. Recording is serial by bit, strip velocity is 250 inches per second, and data transfer rate is about 73,300 characters per second. With the use of chained commands, it is possible to read or write up to 20 successive tracks (cylinder mode) during 20 successive read/write drum rotations without repositioning heads.

When a previously addressed strip is on the drum, access time to data on a different strip varies from 375 to 600 milliseconds. When no strip is on the drum, access time varies from 175 to 400 milliseconds. When the proper strip is already on the drum, access time averages 95 milliseconds if repositioning of the read/write head assembly is required. Drum rotation time is 50 milliseconds, and an entire data track passes under the heads in 41.8 milliseconds. Only 100 microseconds are required for head switching.

Each Data Cell can be removed and interchanged with any other Data Cell in any 2321 Data Cell Drive. A combination handle-cover facilitates removal and protects the magnetic strips during handling. A covered Data Cell containing 200 strips weighs only about 3 pounds. One Data Cell can be removed and replaced by another in less than 30 seconds. When less than a full complement of 10 Data Cells is required, ballast cells are used to balance the rotating array.

Data transfers are controlled in the same manner as other GE-400 Series input-output operations. A description of the input-output process and the

.13 Description (Contd.)

demand upon the central processor is presented in Section 330:111, Simultaneous Operations.

Optional Features

An MS-40 Mass Storage Controller can be optionally equipped with a second channel for communication with a second GE-400 Series processor or with a GE-600 Series processor. The second channel enables two computer systems to share a single MS-40 subsystem, but does not permit two simultaneous data transfers to or from the shared MS-40 Subsystem.

.14 Availability: . . . . 24 months.

.15 First Delivery: . . . . . July, 1965.

.16 Reserved Storage: . . . none.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . magnetic strips.

.22 Physical Dimensions

.223 Magnetic strip
Length: . . . . 13 inches.
Width: . . . . 2.25 inches.
Thickness: . . . . 0.005 inches.
Number: . . . . 200 per Data Cell.

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . . . yes.
.242 Data regenerated constantly: . . . . no.
.243 Data volatile: . . . . no.
.244 Data permanent: . . . . no.
.245 Storage changeable: . . yes, in units of 200 strips (1 Data Cell).

.25 Data Volume per Band of 1 Track

Words: . . . . 666.
Characters: . . . . 2,664.
Digits: . . . . 2,664.
Instructions: . . . . 666.

.26 Bands per Physical Unit: . . . . 100 per strip.

.27 Interleaving Levels: . . 1; i.e., no interleaving.

.28 Access Techniques

.281 Recording method: . . . magnetic strip passes by heads.
.283 Type of access: . . . . . see Paragraphs .12 and .532.

.29 Potential Transfer Rates

.291 Peak bit rates —
Cycling rates: . . . . . 1,200 rpm (50 msec/rev).
Track/head speed: . . 250 inches/sec.
Bits/inch/track: . . . 1,750.
Bit rate per track: . . 438,000 bits/sec/track.
.292 Peak data rates —
Unit of data: . . . . . . character
Conversion factor: . . 6 bits per character.
Data rate: . . . . 73,300 char/sec.

.3 DATA CAPACITY

.31 Module and System Sizes (See table below.)

.32 Rules for Combining Modules: . . . . any number up to 8 Data Cell Drives per MS-40 Controller.

.4 CONTROLLER

.41 Identity: . . . . MS-40 controller.

.42 Connection to System

.421 On-line: . . . . one controller per available double-word-buffered I/O Channel.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: . . . . 1 to 8 drives.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . 1 to 2,664 characters (1 track).
.442 Input-output area: . . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Synchronization: . . . . automatic.
.447 Table control: . . . . . . gather-write and scatter-read facilities are available to the programmer; see Section 330:111, Simultaneous Operations.

Identity:	Minimum Storage: 1 Data Cell	1 Data Cell Drive	Maximum Storage per Control: 8 Data Cell Drives.
Data Cells:	1	10	80.
Strips:	200	2,000	16,000.
Bands:	20,000	200,000	1,600,000.
Cylinders:	1,000	10,000	80,000.
Characters:	53,280,000	532,800,000	4,262,400,000.
Words:	13,320,000	133,200,000	1,065,600,000.
Modules:	1	1	8.

.448 Testable conditions: . . available.
busy.
not operational.
performing operation with interruption pending.
track address compare.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of stacks
Stacks per module: . . 1 per drive.
Heads per stack: . . . 20.
.512 Stack movement: . . . . across strip width to any one of 5 positions.
.513 Stacks that can access any particular location: . . . . 1.
.514 Accessible locations:
By single stack —
With no movement: . 20 tracks of the strip on read/write drum (1 cylinder).
With all movement: . 100 tracks of the strip on read/write drum.

.52 Simultaneous Operations: . . . . a read, write, or seek operation on any one Data Cell Drive can be overlapped with seek operation on other drives. Only one read or write operation can take place at a time on each I/O channel.

.53 Access Time Parameters and Variations

.532 Variation in access time: . . . . refer to Paragraph 420:045.532, in the IBM System/360 report.

.6 CHANGEABLE STORAGE

.61 Cartridges (Data Cells)

.611 Cartridge capacity: . . . 53,280,000 characters
.612 Cartridges per module: . . . . 10.
.613 Interchangeable: . . . . yes.

.62 Loading Convenience

.621 Possible loading—
While computing system is in use: . . . . yes.
While storage system is in use: . . . . yes (if individual Data Cell Drive unit is free).
.622 Method of loading: . . . . operator procedure.
.623 Approximate change time: . . . . 30 seconds.
.624 Bulk loading: . . . . no; 1 Data Cell at a time.

.7 PERFORMANCE

.72 Transfer Load Size

Single access: . . . . . . 1 to 2,664 characters (1 track).
Cylinder access: . . . . up to 53,280 characters (20 tracks per cylinder).

.73 Effective Transfer Rate: . . . . 43,700 char/sec; based on random accessing of 1 strip with drum empty, and transferring 131,072 characters (maximum core storage load).

NOTE: The rate presented in Paragraph .73 indicates the performance of this unit when transferring large blocks of data. Typical applications for this type of operation include loading of programs or routines, core storage dumps, and restarts. Paragraph .74 presents the performance of this unit in a random processing environment where only one record at a time is accessed for processing.

.74 Update Cycle Rate

Reference to strip already on drum: . . . . 5.1 references/sec.
Reference to new strip: . . . . 1.5 references/sec.

NOTE: Based on random accessing of 1 record; reading, updating, and rewriting that record; and rereading for verification of recording.

.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	set status.
Invalid code:	all 6-bit codes are valid.	
Receipt of data:	parity check	set status.
Recording of data:	generate block check code.	
Recovery of data:	check block check code.	set status.
Dispatch of data:	send parity bit for each character.	
Timing conflicts:	check	set status.
Physical record missing:	check (address comparison)	set status.
Reference to locked area:	check (write inhibit switches)	set status.
Wrong strip:	check (address comparison)	set status.
Wrong track:	check (address comparison)	set status.
Invalid format:	check	set status.

CENTRAL PROCESSOR

.1 GENERAL

.11 Identity: . . . . GE-400 Series Central Processor.

.12 Description

The same processor unit is used for all current members of the GE-400 Series, with slight modifications to the circuitry for interfacing with core storage units of different speeds. The GE-400 Series Central Processor is essentially a single-address, fixed word-length, sequential processor. It does, however, have the capability to execute a group of two-address instructions and to manipulate variable-length operands that range from one to four words (1 to 16 characters) in length. The processor consists of three major functional units: core storage, arithmetic and logical unit, and input-output control unit. An optional unit, the Floating Point Option, provides the capability for executing a full range of floating-point arithemtic operations.

Word length of each core storage location is 24 bits. One location can contain an instruction, a binary or decimal data word, or an alphanumeric data word consisting of four 6-bit characters. An adequate complement of instructions is available for manipulating each kind of format. The binary instruction words consist of a 6-bit operation code, a 3-bit address modification control field (ACF), and a 15-bit core storage address field. The two-address capability is implemented either by using the ACF to specify a fixed index register which contains the address of the second operand, or by using the next consecutive word in the instruction sequence to specify the second address.

A feature of the arithmetic and logic unit is the capability to manipulate both the size and the location of the accumulator. The size can be from one to four words, with the most significant word located in any core storage location that is a multiple of four. Adjusting the accumulator length to fit the data allows faster execution times on shorter fields while still handling larger fields with one instruction. The relocatable concept can result in significant time reductions for the load-add-and-store type of operation.

Fixed-point multiply and divide instructions are included as part of the standard instruction repertoire, but they are of the single-step variety. A single execution of the Multiply instruction results in a nine-digit product through multiplication of a two-word (eight-digit) multiplicand by a single digit of a multiplier. A single execution of the Divide instruction results in a one-digit quotient through division of a two-word dividend by a two-word divisor. Both instructions include automatic provisions for shifting the operands and results to facilitate the use of multiple-digit multipliers or quotients. If the full two-word capability is not used, the results may need to be shifted for proper positioning of the product or quotient.

The Branch On Count instruction provides a convenient method of programming the loops necessary for handling multiple-digit multipliers or developing multiple-digit quotients.

Address modification facilities are quite extensive. In addition to six standard fixed index registers located in core storage, an address modification sequence (AMS) can specify the use of any word in storage as a modifier. Basically, an AMS operates in the following manner:

- The address control field (ACF) in the instruction word specifies an AMS.
- The next sequential word in the instruction sequence (called an auxiliary word) is interpreted as being either an index, index pointer, or index link.
- If it is an index, the address field of the auxiliary word is used as the modifier.
- If it is an index pointer, the address field of the auxiliary word specifies the location of the modifier.
- If it is an index link, the address field of the auxiliary word specifies the location of another index, index pointer, or index link.

The address developed by an AMS can be specified to be an indirect address. The address obtained from the indirect location can be used as an operand address, or it can be modified by another AMS. Multiple levels of AMS and indirect addressing are permitted. The second address of a two-address instruction is determined by a Second Address Sequence (SAS), which is similar to the AMS but without indexing. These addressing features require a high level of programming skill for full utilization, but they can be useful in reducing storage space and total processing time.

Editing operations are designed primarily to prepare data for output. A control field including all symbols to be inserted is set up in the working accumulator. Up to 16 characters can then be edited by one operation which handles zero suppression, floating dollar sign, asterisk protection, character deletion, and comma and decimal point insertions. Two unusual and valuable instructions are "Explode," which distributes the characters in a specified core location into the low-order character position of each word in the working accumulator, and "Implode," which gathers the least significant character of each accumulator word into a single core location. A variety of shift operations are available involving either characters or bits, left or right movement,

.12 Description (Contd.)

and with or without circular rotation. The Move instruction can handle internal block transfers of up to 512 words.

The basic input-output control section of the central processor has the ability to control up to eight peripheral operations concurrently with internal processing. The logic for controlling four additional channels is optional. Several types of channels are available; see Section 330:111, Simultaneous Operations, for a discussion of the characteristics of each type of channel.

Automatic control of data transfers between peripheral devices and core storage is furnished by four Channel Control Words for each channel. These words, located in fixed core storage locations, control storage addressing and character counting during each storage access. The manner in which the input-output control is implemented can provide automatic scatter-read and gather-write capabilities at the programmer's option. See Simultaneous Operations (Section 330:111) for further details on input-output control.

Upon completion of a data transfer operation by a peripheral device, the main program is interrupted, information concerning the present condition of the peripheral subsystem is stored in a "status" word, and a basic address provided by the program is used to transfer control to the appropriate interrupt subroutine.

The main program will also be interrupted due to an arithmetic overflow, a central processor error, (such as detection of an illegal address or operation code), or an operator request entered at the control console. Detection of one of the above conditions results in an immediate branch to a fixed location in core storage. The Processor Status Word, held in a fixed location in core storage, contains the status of the various processor indicators. This word can be examined to determine the cause of the interrupt.

Optional Features

The Floating Point Option provides the programmer with a full range of floating-point operations. This option is similar to the Auxiliary Arithmetic Unit for the GE-200 Series; it consists of several registers and logic circuits housed in a separate wing of a GE-400 Series Processor. Each floating-point operand is stored in two 24-bit core storage locations. The fractional portion consists of 38 bits plus sign bit, and the exponent portion consists of 8 bits plus sign bit. The resulting range of permissible floating-point numbers is about $10^{\pm 78}$, with a precision of about 11.4 decimal digits. The internal representation of floating-point operands is absolute binary, requiring radix conversions by subroutines in many applications.

Facilities are provided for both normalized and unnormalized addition, subtraction, multiplication, and division. Division remainders and the least significant half of multiplication products are accessible by the programmer, which facilitates writing multi-word-precision routines. Facilities are provided for floating-point comparisons, for single- or double-length shifts, and for loading and storing the exponent and fractional parts independently.

The machine operation codes used for the floating-point operations are in many cases identical with existing operation codes for other instructions in the GE-400 Series repertoire. A floating-point operation is indicated if the floating-point mode bit in the Processor Status Word is set to one by one of the Set Status instructions. This bit is set automatically by the Load Floating Point instruction. To revert to the fixed-point mode, the bit must be reset to zero.

Indicators are provided for the results of floating-point comparisons, normalize mode, overflow, underflow, and divide check. The status of these indicators is stored in a specified location in core storage and can be altered or set to a desired arrangement.

The capabilities of a GE-400 Series computer system for operating in a multiprogramming mode or in a remote inquiry processing mode have been enhanced through the development of the Direct Access Option. This optional package includes the following features:

- Memory Protection
- Interval Timer
- Second Level Interrupt
- Symbol Controlled Move
- Non-Stop Mode
- Channel Expansion

Memory protection is implemented by a base address and limit check technique similar to that employed in the larger GE-600 Series systems. All programs are assembled in a relocatable format relative to the zero address. This is the standard relocatable binary format used by the present standard GE-400 Series software.

To further facilitate multiprogramming, a master/user mode of operation is implemented. In the user mode, all references to memory are indexed by the contents of the Base Address Register (BAR) and then checked against the contents of the Block Limits Register (BLR). An out-of-limits address causes an interrupt.

The starting or base address and the size of the user program are assigned by a supervisor program, both in increments of 512 words. All facilities of the processor are available to a program in the user mode except the General (I/O), Halt, and Set Memory Protect instructions. When in the user mode, these instructions, as well as an attempt to set certain bits of the Processor Status Word, are treated as invalid instructions, and an interrupt and automatic shift to the master mode results.

In the master mode, all instructions are valid and all addressing is absolute; i.e., the BAR and BLR are ignored.

(Contd.)

.12 Description (Contd.)

There is also a BAR and a BLR associated with each input-output channel. Thus, I/O operations for multiple programs can proceed concurrently without danger of accessing an area of memory outside of that assigned to the individual programs.

The first 72 locations of each program area are reserved for the fixed index words, the interrupt control words, and the input-output channel control words. Thus, to preserve the status of a program when switching between programs, only the Instruction Counter and the Processor Status Word need be stored.

The base address indexing and limits checking requires an additional 0.35 microsecond for each reference to memory in the user mode. Thus, a Branch instruction with three address modification cycles would require an additional 1.4 microseconds to execute. This penalty is not present in the master mode, since all memory references are then considered absolute.

The Interval Timer is a program-addressable clock that is decremented every millisecond. A second-level interrupt occurs when the clock is decremented past zero. The timer can be initially set by the program to a maximum interval of 4 hours.

A second-level interrupt occurs as a result of one of the following conditions:

(1) The processor becomes locked in an instruction execution loop.

(2) A peripheral device fails to respond during the middle of an initialization sequence.

(3) The interval timer overflows.

(4) A peripheral device requires immediate access to memory.

The first three conditions are recognized by the overflow of the interval timer. If the timer overflows and an interrupt is not granted within one millisecond, one of the first two conditions is assumed to exist.

A second-level interrupt is serviced immediately, even if a normal program interrupt is currently being serviced. Special I/O channels, such as the one for connecting the DATANET-70, can request a second-level interrupt. This insures immediate access to memory for certain peripheral devices that otherwise could encounter a timing error if they were forced to wait while another interrupt was serviced.

Upon recognition of a second-level interrupt, the processor is placed in the master mode and a branch occurs to one of two locations, depending on whether the interrupt condition was a timer overflow or an I/O request.

The Symbol Controlled Move feature is a special form of the Move Instruction. Instead of specifying the number of words to be moved, the programmer can specify a symbol to stop the data transfer. A data transfer will proceed until the specified character is encountered in the data being moved. This feature facilitates the programming of data transfers within core storage when the length of the block to be moved is unknown to the program.

The Non-Stop Mode feature alters the execution of the Halt instruction, console halt facilities, and error halt conditions. In the user mode, all conditions which would cause the processor to halt in a system without the Direct Access Option will instead cause an interrupt and a shift into the master mode. In the master mode, the Halt instruction, console facilities, and error checks function as before.

The Channel Expansion feature increases to 12 the number of I/O channels available in a GE-400 Series computer system. See Section 330:111, Simultaneous Operations, for the restrictions on combinations of the various types of channels.

The Symbol Controlled Move and Channel Expansion features are available separately if desired.

See Section 330:191, Operating System, for a brief description of the software facilities GE intends to provide for utilization of these features.

The 1401 Compatibility Option enables 4,096 locations of core storage to be addressed by character. Each 24-bit location is logically divided into three 8-bit characters; six bits for data, one for the word mark, and one unused. A special input-output channel is also provided for magnetic tape operations. In the compatibility mode, data is transferred between one 8-bit character position in the special area of core storage and one 6-bit tape row position. When not in the compatibility mode, this I/O channel functions as a double-word-buffered channel.

These features are used in conjunction with a software routine to run many IBM 1401 programs on GE-400 Series computer systems without reprogramming or prior translation. Section 330:131 contains a detailed analysis of the significance of the 1401 Compatibility Option and the associated software. The 1401 Compatibility Option Program is discussed in Paragraph 330:151.11.

.13 Availability: . . . . 12 months.

.14 First Delivery: . . . . . June, 1964.

.2 PROCESSING FACILITIES

.21 Operations and Operands

	Operation and Variation	Provision	Radix	Size
.211	Fixed point —			
	Add-subtract:	automatic	decimal	1 to 4 words.
		automatic	binary	24 bits.
	Multiply			
	Short:	none.		
	Long:	step instruction.	decimal	1 multiplier digit at a time.
	Divide			
	No remainder:	none.		
	Remainder:	step instruction	decimal	1 quotient digit at a time.
.212	Floating point —			
	Add-subtract:	automatic*	binary	38 & 8 bits.
	Multiply:	automatic*	binary	38 & 8 bits.
	Divide:	automatic*	binary	38 & 8 bits.

* With Floating Point Option

	Operation and Variation	Provision	Radix	Size
.213	Boolean —			
	AND:	automatic	binary	24 bits (1 word).
	Inclusive OR:	automatic	binary	
	Exclusive OR:	automatic	binary	
.214	Comparison —			
	Numbers			
	Fixed point:	automatic		1 to 4 words.
	Floating point:	automatic*		38 & 8 bits.
	Absolute:	automatic		1 to 4 words.
	Letters:	automatic		1 to 4 words.
	Mixed:	automatic		1 to 4 words.
	Collating sequence:	binary sequence of character codes (see Page 330:141.100).		

* With Floating Point Option.

.215 Code translation: . . . . none (subroutines are used).
.216 Radix conversion: . . . . none (subroutines are used).
.217 Edit format

	Provision	Size
Alter size:	automatic	up to 16 characters
Suppress zero:	automatic	
Insert point:	automatic	
Insert spaces:	automatic	
Insert any character:	automatic	
Float dollar:	automatic	
Protection:	automatic	

.218 Table look-up: . . . . . . none.
.219 Others

	Provision	Comment	Size
Shift:	automatic	left, right, and circular	1 to 16 characters.

(Contd.)

.219 Others (Contd.)

	Provision	Comment	Size
Binary Shift:	automatic	right and circular	48 bits.
Add-to-Memory:	automatic	decimal	1 to 4 words.
Set Accumulator:	automatic	selects location and length	1 to 4 words.
Explode, Implode:	automatic	isolates or compresses characters	1 to 4 words.

.22 Special Cases of Operands

.221 Negative numbers: . . . indicated by zone bits in least significant character of least significant word (decimal only). Binary data words are always treated as positive numbers.

.222 Zero: . . . . one form.

.223 Operand size determination: . . . . number of words is specified by instruction or set by accumulator length.

.23 Instruction Formats

.231 Instruction structure: 1 word.

.232 Instruction layout:

Normal Instructions —

Part:	OP	ACF	Address
Size (bits):	6	3	15

General Instruction (I/O) —

Part:	OP	ACF	C	D	F
Size (bits):	6	3	4	5	6

.233 Instruction parts —

Name	Purpose
OP:	operation code (always 07, octal, for General Instruction).
ACF:	address modification control field.
Address:	operand address field.
C:	specifies I/O channel.
D:	specifies a particular peripheral device when multiple units are connected to a single I/O channel.
F:	specifies particular peripheral operation to be performed.

.234 Basic address structure: . . . . 1 + 0.

.235 Literals

Arithmetic: . . . . 15 bits.

Comparisons and tests: . . . . 15 bits.

Incrementing modifiers: . . . . . . 15 bits.

Directly addressed operands—

Internal storage type: . . . . core storage.

Minimum size: . . . . 1 word.

Maximum size: . . . . 4 words; up to 512 words with Move command.

Volume accessible: . all of core storage.

.237 Address indexing—

.2371 Number of methods: 2.

.2372 Names: . . . . Fixed Index Words, Any-Word Indexing.

.2373 Indexing rule: . . . . . addition.

.2374 Index specification: . bits 15, 16, and 17 of instruction word.

.2375 Number of potential indexers: . . . . 6 fixed index words; number of any-word indexers is limited only by core storage capacity.

.2376 Addresses which can be indexed: . . . first address only.

.2377 Cumulative indexing: address modification sequence can specify an unlimited number of modifiers.

.2378 Combined index and step: . . . . none.

.238 Indirect addressing—

.2381 Recursive: . . . . yes.

.2382 Designation: . . . . . . bit in address modification sequence word.

.2383 Control: . . . . absence of bit in address modification sequence word, or last indirect address is marked.

.2384 Indexing with indirect addressing: . address modification occurs first. Indirect addresses can be further modified.

.239 Stepping: . . . . Branch on Count instruction.

.2391 Specification of increment: . . . . . . always 1.

.2392 Increment sign: . . . . positive.

.2393 Size of increment: . . always 1.

.2394 End value: . . . . implied as zero (initial value is in complement form).

.2395 Combined step and test: . . . . yes.

.24 Special Processor Storage

.241

Category of storage	Number of locations	Size in bits	Program usage
Program counter:	1	15	contents can be stored in specified location.
Accumulator location register:	1	13	controls location of accumulator.
Accumulator length register:	1	2	controls working length of accumulator.
Floating-point accumulator*	1	48	holds results of floating-point operations.
Q register:*	1	39	holds least significant half of product or double-precision shift, or division remainder.

*With Floating Point Option

.3 SEQUENCE CONTROL FEATURES

.31 Instruction Sequencing: sequential.

.32 Look-Ahead: . . . . none.

.33 Interruption

.331 Possible causes—

In-out units: . . . . . . indirectly, through I/O channel status.

In-out controllers: . . change in status of I/O channel from "busy" to "ready." (Ready condition results from termination of I/O operation).

Processor errors: . . instruction code and address errors; overflow if Overflow Mode indicator is on.

Other: . . . . manually, by operator request.

.332 Control by routine: . . . program interrupts are automatically granted to the processor and I/O channels on a priority basis.

.333 Operator control: . . . . manual interrupt request from console is possible.

.334 Interruption conditions: . . . . 1) no other interrupt being serviced.
2) no higher-priority interrupt requests outstanding.
3) current instruction completed.

.335 Interruption process—

Disabling further interruptions: . . . . automatic.

Registers saved: . . . program (sequence) counter must be stored by program or error occurs.

Destination: . . . . . . automatic branch to program interrupt word (PIW) for channel causing the interrupt.

.336 Control methods—

Determine cause: . . . test status of channel causing the interrupt.

Enable further interruptions: . . . . own coding; reset interrupt indicator.

(Contd.)

.34 Multiprogramming: . . limited ability without Direct Access Option through interrupt facilities mentioned above. GE will provide software for running multiple programs concurrently in a multiprogramming mode using the additional facilities provided by the Direct Access Option (see the Description, Paragraph .12).

.35 Multi-sequencing: . . . none.

.4 PROCESSOR SPEEDS

The fixed-point processor speeds for each GE-400 Series system are presented in the Central Processor sections of the individual subreports:

GE-415: . . . . 332:051.
GE-425: . . . . 333:051.
GE-435: . . . . 334:051.

The execution times of the optional floating-point instructions, excluding instruction fetch time and address modification time, are the same for all members of the GE-400 Series. The total floating-point execution times for the standard measures of performance (including instruction fetch, address modification, and overlapping when appropriate) are presented in the individual subreports listed above. The general timing formula and parameters are as follows:

$$T = 3M + N_1M + (E_t - (M + N_2M))$$

where T = Total instruction execution time, μsec;
M = Memory cycle time, μsec;
N_1 = Number of address modification cycles, this instruction;
N_2 = Number of address modification cycles, next instruction;
E_t = Floating-point operation execution time.

Note that the quantity (E_t - (M + N_2M)) is not subtracted if it is negative; i.e., the fetching and address modification of one instruction cannot overlap the fetching or address modification of the previous instruction. Some of the more important floating-point execution times, E_t, are shown below.

Floating-point operation	E_t, * μsec
Add, subtract:	4.2.
Multipy:	12.2.
Divide:	24.5
Normalize:	1.4 + 0.35N.
Shift Left:	1.75 + 0.35N.
Shift Right:	2.45 + 0.09N.
Load:	0.
Store:	0.

* Average execution time of floating-point operations, exclusive of instruction fetch, address modification, and overlapping.

N = Number of bit positions shifted.

.5 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Overflow:	check	set indicator; optional interrupt.
Floating-point overflow or underflow:	check*	set indicator; optional interrupt.
Zero divisor:	causes overflow.	
Invalid data:	none.	
Invalid operation:	check	set indicator and interrupt or halt.
Invalid address:	check	set indicator and interrupt or halt.
Arithmetic error:	none.	

* With Floating-Point Option.

CONSOLE

.1 GENERAL

.11 Identity: . . . . GE-400 Series Control Console.

.12 Associated Unit: . . . . Input-Output Typewriter.

.13 Description

The Control Console consists of an operating desk holding a vertical control panel which contains a small complement of back-lighted pushbutton switches (Figure 1). The Input-Output Typewriter is located near the left end of the operating desk, and permits direct communication between operator and system. A covered maintenance panel is also situated on the console desk and, although it is intended for maintenance personnel, can be useful to programmers during program testing.

The operating panel is divided into two groups of control switches called Computer Control and Typewriter Control. The computer controls enable the operator to:

- Start execution of the program.
- Reset mode and error indicators.
- Cause a program interrupt.
- Manually control progress of the program for debugging purposes.
- Bring the program to an orderly halt.
- Select an input unit for initial loading of a "bootstrap" program.
- Apply and remove central processor and console power.

The Input-Output Typewriter provides two-way communication between the operator and central processor through one of the regular character-buffered input-output channels. All 64 characters of the GE-400 Series standard character set (see Page 330:141.100) can be transmitted. The standard output typing rate is 15 characters per second. The typewriter controls on the operating panel enable manual type-ins and type-outs, in alphanumeric or octal format, of certain processor registers or core storage locations. The stored program can initiate automatic type-outs or requests for type-ins in either alphanumeric or octal format.

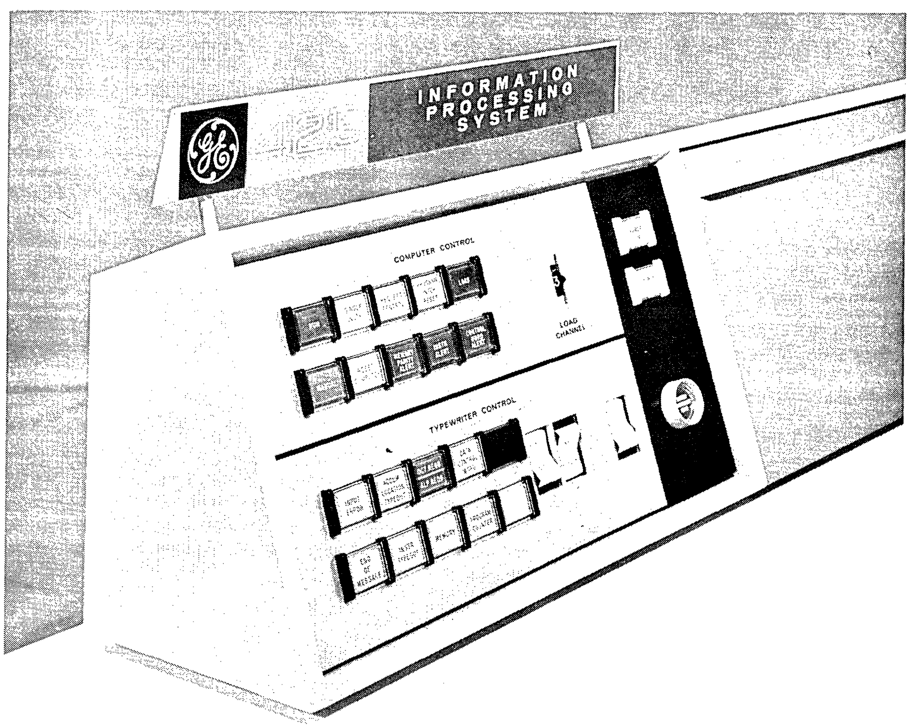


Figure 1: GE-400 Series Operating Panel.

INPUT-OUTPUT: CARD READER

.1 GENERAL

.11 Identity: . . . . CR-20 Card Reader.
CR-21 Card Reader.

.12 Description

The CR-21 is an improved version of the CR-20 Card Reader that is currently being installed with GE-400 Series and GE-600 Series computer systems. The CR-20 will be gradually phased out and replaced by the CR-21 in future GE-400 and GE-600 Series systems. The peak speed when reading standard 80-column cards is 900 cards per minute for both models. In addition, the CR-21 can optionally be equipped to read 51-column cards at 1,200 cards per minute.

A new read instruction must be received within one millisecond after completion of reading of the previous card in order to maintain the maximum reading rate. If the delay in receiving a new read instruction is longer than one millisecond, the reading rate drops in proportion to the delay, due to the use of an infinite clutch which permits a card to be fed at any time.

Some important characteristics of the CR-20 and CR-21 Card Readers are:

- Two 6-bit buffers internal to the card reader.
- 2,000-card input hopper and output stacker capacity.
- Binary image reading capability, compatible with the binary punching format of the CP-10 and CP-20 Card Punches.
- Generation and transmission of a parity bit (not stored) for each character.
- Solar cell reading mechanism, checked for proper functioning during each card cycle.
- Column count check.
- Character validity check when reading in the Hollerith mode.
- Solar cell checks to insure that a card has been fed, transported properly, and stacked successfully.
- Last Batch switch permits choice of either an "end of file" status indication or an "empty input hopper" alert after the last card of a deck has been read.
- Loading and unloading can be accomplished while the reader is operating.
- Accepts square- or round-cornered cards (can be intermixed).

Additional facilities provided in Model CR-21 include:

- An 800-card capacity, program-selectable, auxiliary stacker.
- A second reading station for checking purposes.
- An option for reading 51-column cards at a peak rate of 1,200 cards per minute.

The two models have the same programming characteristics except for the auxiliary stacker of the CR-21.

Three modes of reading are available to the programmer: Hollerith (decimal), binary, and mixed. When reading in the Hollerith mode, the 80 columns of each card are stored in 20 words of core memory (4 characters to the word). Translation from Hollerith card code to GE-400 Series internal code is automatic, and a validity check is made upon each character as it is read from the card.

In the binary mode, each card column is regarded as containing two 6-bit binary characters, and the 80 columns of each card are stored in 40 words of core memory.

In the mixed mode, the contents of the first column of the card determine whether the card will be read in the Hollerith or binary mode. A unique configuration in the first column (7 and 9 punch), which is not found in any Hollerith code character, identifies that card as a binary card. A parity bit is generated and transmitted with each character (Hollerith or binary) but is not stored.

Special conditions (such as successful completion of a card read operation, full output stacker, card jam, invalid punch configuration, invalid command, etc.) cause an interrupt and, normally, a transfer to a specific subroutine for the appropriate I/O channel. The condition causing the interrupt can be determined by an examination of the status word for that channel. The card reader fully occupies one I/O channel of the character-buffered type. A more complete description of the input-output process and the demands on the central processor is presented in Section 330:111, Simultaneous Operations.

INPUT-OUTPUT: CARD PUNCHES

.1 GENERAL

.11 Identity: . . . . CP-10 Card Punch (100 cards per minute).
CP-20 Card Punch (300 cards per minute).

.12 Description

CP-10

The CP-10 Card Punch has a peak punching speed of 100 cards per minute. Punching is done in row-by-row fashion by a set of 80 die punches. Each row to be punched requires a separate GE-400 Series instruction. The punch instruction for a row must be received within 28.4 milliseconds after the preceding row has been punched; otherwise, a timing error will occur. The standard software provides subroutines for handling these timing considerations. In addition, a new punch instruction must be received within 43 milliseconds after completion of the previous cycle to maintain the maximum rate of punching. The rate of punching drops 7 cards per minute for each 43-millisecond period (or fraction thereof) of delay after the initial one.

CP-20

The CP-20 Card Punch is a new unit, developed by GE. Its peak punching speed is 300 cards per minute. Punching by the CP-20 is also done in row-by-row fashion, but only one instruction is required to punch an entire card due to the presence of an 80-bit buffer in the CP-20. A new punch command must be received within 10 milliseconds after completion of the previous cycle to maintain the maximum rate of punching. If the 10-millisecond period is exceeded, the rate of punching drops to half-speed (150 cards per minute).

Characteristics

Either card punch fully occupies one I/O channel of the character-buffered type.

Automatic translation into Hollerith code can be performed in either an unedited or edited mode. In the edited mode, "ignore" characters are deleted without skipping a column.

Some important characteristics of the two GE card punches are:

- An 80-bit buffer (CP-10) or a full-card-image buffer (CP-20) internal to the card punch.
- 800-card input hopper and output stacker capacity in the CP-10; 3500-card hopper and 3000-card stacker in the CP-20.
- Only one output stacker.
- Punches 80-column cards row-by-row.
- Loading and unloading can be done during operation.
- Accepts either square- or round-cornered cards (can be intermixed).
- Column binary punching capability.
- Post-punch row parity check.
- Parity check on data received for punching.

Special conditions (such as successful completion of an operation, full output stacker, card jam, invalid command, etc.) cause an interrupt and, normally, a transfer to a specific subroutine for the appropriate channel. The condition causing the interrupt can be determined by an examination of the status word for that channel. A more complete description of the input-output process and the demands on the central processor is presented in Section 330:111, Simultaneous Operations.

INPUT-OUTPUT: PUNCHED TAPE EQUIPMENT

.1 GENERAL

.11 Identity: . . . . TS-20 Perforated Tape Reader/Punch.

.12 Description

The TS-20 Tape Reader/Punch is a free-standing unit housing a reader, punch, and control circuitry for punched tape input and output. The reader and punch are mechanically independent, and the user may order the reader and its spooler mechanisms only (Model TR-20) or the punch and its spooler only (Model TP-20). Punched tape with standard or special 5-, 6-, 7-, or 8-level character code configurations can be read or punched. The Tape Reader/Punch can also be used off-line for duplicating or verifying tapes.

Reader

The reader operates at a peak speed of 500 characters per second, using standard paper or plastic tape with fully-punched holes. Reading is by means of photoelectric diodes. There is only one reader command, which causes continuous feeding and reading of tape in a channel mode established by the removable plugboard. The plugboard has provisions for recognizing stop or end-of-file characters. The bit configuration of these characters is determined by plugboard wiring and can be either single characters or groups. The plugboard also controls parity checking (odd, even, or none) and deletion of plugboard-specified characters. In addition, a plugboard identification configuration (6-bits) can be wired and is part of the normal Subsystem Ready Status Return. The plugboard must be in place prior to initiating a punched tape read instruction.

Characters can be transmitted to storage either in their tape format or in a format rearranged by plugboard wiring. Each 24-bit word in storage can hold up to four characters of a 5- or 6-level tape code or two characters of a 7- or 8-level tape code. Conversion to the internal BCD character code, when necessary, must be accomplished by programming through the use of a translating routine and suitable translation tables.

Punch

The punch has a peak speed of 150 characters per second, and the on-line operating modes are under program control at all times. The following instructions are available:

- Punch — feed and punch 7-channel tape with odd parity punched in channel 5. Each word in storage produces 4 tape characters.
- Punch Edited — same as Punch, except delete any Ignore characters in the output data.
- Punch Single — feed and punch 5- or 6-channel tape with no parity bit punched. Each word in storage produces 4 tape characters.
- Punch Double — feed and punch 7- or 8-channel tape with no parity bit punched. Each word in storage produces 2 tape characters.

Accuracy control consists of a parity check on each character received from core memory and a transfer timing check which detects an error if a data character is not received within 10 milliseconds after it is requested by the punch. Either of these errors results in terminating the current operation and in transmitting a "data alert" signal to the processor.

A TS-20 fully occupies one I/O channel, usually of the character-buffered type. Punched tape reading and punching cannot occur simultaneously in the same unit, but either reading or punching can be overlapped with other input-output operations and with processing. Special conditions (such as successful completion of an operation, out-of-tape, invalid command, etc.) cause an interrupt and, normally, a transfer to a specific subroutine for the appropriate channel. The condition causing the interrupt can be determined by an examination of the status word for that channel. A description of the input-output process and the demands upon the central processor are presented in Section 330:111, Simultaneous Operations.

INPUT-OUTPUT: PRINTER

.1 GENERAL

.11 Identity: . . . . PR-20 Printer.
PR-21 Printer.

.12 Description

The PR-21 is an improved version of the PR-20 Printer currently being installed with GE-400 Series systems. The PR-20 will be gradually phased out and replaced by the PR-21 in future GE-400 Series and GE-600 Series systems. The primary differences between the PR-21 and PR-20 are increased programmer and operator facilities; the basic speed and forms-handling capabilities remain the same.

The maximum rate of printing single-spaced lines is 1,200 lines per minute using any contiguous 46-character set and 949 lines per minute using the full 64-character set. The 46 "most common" characters are arranged in a contiguous set, which includes the letters A through Z, the numerals 0 through 9, and 10 special symbols. Effective printing rates for multi-line spacings are shown in Table I for both a 46-character set and the full 64-character set.

Some important characteristics of the PR-20 and PR-21 Printers are as follows:

- The printer is fully buffered.
- Printing is done by pressing the ribbon and paper against the rotating drum by an on-the-fly hammer stroke.
- 136 print positions.
- Up to 4 copies plus original can be made.
- Paper stock can be from 3 to 19 inches in width.
- Vertical spacing can be 6 or 8 lines per inch at the option of the operator.

Continuous skipping is at the rate of 27.5 inches per second after the first two lines, which take 14 milliseconds and 6 milliseconds, respectively. Automatic skipping can be initiated and stopped by appropriate punches in the Vertical Format Control (VFU) tape. Single spacing, double spacing, or skipping to the top of a page can be initiated by programmed commands. Alternatively, a skip of up to 15 lines following the printing of a line can be specified by the inclusion of special "slew characters" in the formation of the print line. Other editing characters can cause deletion of a character, printing of an editing character, skipping to a particular point on the Vertical Format Control (VFU) tape, skipping to the top of a page, insertion of one blank in the print line, or insertion of up to 120 blanks (in multiples of 8) in the print line.

Two modes of printing are available. In the edit mode, the special editing characters cause the actions described above, but, in general, are not printed. In the nonedit mode, the print line is printed just as it is received by the printer buffer.

Additional facilities provided in the new PR-21 Printer include: a single-cycle switch that permits printing one line at a time, a switch that causes a full line of E's to be printed to facilitate forms set-up, and an optional Changeable Code Wheel that permits any 6-bit, 64-character data code to be printed.

The printer fully occupies one I/O channel of the character-buffered type. Abnormal conditions cause a program interrupt and transmission to the processor of a status word that identifies the condition causing the interrupt. A description of the input-output process and the demand upon the central processor is presented in Section 330:111, Simultaneous Operations.

TABLE I: EFFECTIVE SPEED OF PR-20 AND PR-21 PRINTERS

Lines Advanced per Line Printed (6 lines per inch)	Printed Lines per Minute Using 46-Character Set	Printed Lines per Minute Using 64-Character Set
1	1200	949
2	900	864
3	800	800
4	800	746
5	720	700
6 (1 inch)	665	655
12 (2 inches)	485	485
18 (3 inches)	400	380
24 (4 inches)	320	315
30 (5 inches)	275	270

INPUT-OUTPUT: MULTIPLE TAPE LISTER

.1 GENERAL

.11 Identity: . . . . ML-20 Multiple Tape Lister.

.12 Description

An ML-20 Multiple Tape Lister Subsystem consists of one or two free-standing Lister Units. Each unit has 6 independent forms-movement mechanisms, providing a total of 6 or 12 lists. The leftmost list in the first unit is designated the master list; the remaining 5 or 11 lists are designated detail lists. A line of up to 24 characters can be printed on the master list only, on one detail list only, or simultaneously on the master list and any one detail list. The peak printing rate is 2,000 single-spaced lines per minute. This rate can be maintained if a line of print is received by the subsystem within 12 milliseconds after completion of the previous print operation.

Forms movement is limited to skipping one line at a time or skipping to the top of the next page. Skipping can be specified by the command code or by the inclusion of special, non-printing "slew characters" within the data itself. When skipping is specified by command code, the master list and one detail list can be advanced independently or jointly. Skipping of one line requires 12 milliseconds; continuous skipping is at the rate of 23 inches per second.

There are 16 printable characters, including the 10 numerals, 5 special characters, and space. These characters are a subset of the standard GE-400 Series character set and are listed in Table I.

In addition to the slew characters, there are two other special, non-printing characters which permit a limited amount of format control. These characters can be used to inhibit the printing of any portion of the print line on the detail list.

Special conditions (such as successful completion of an operation, invalid character, invalid command, etc.) cause an interrupt and, normally, a transfer to a specific subroutine for the appropriate channel. The condition causing the interrupt can be determined by an examination of the status word for that channel. Each ML-20 Multiple Tape Lister Subsystem fully occupies one I/O channel and is usually connected to a channel of the character-buffered type. A description of the input-output process and the demands upon the central processor is presented in Section 330:111, Simultaneous Operations.

TABLE I: ML-20 MULTIPLE TAPE LISTER CHARACTER SET

Octal Code	Printed Character
00	0
01	1
02	2
03	3
04	4
05	5
06	6
07	7
10	8
11	9
13	#
33	.
53	$
54	*
73	,
20	space

INPUT-OUTPUT: 7-TRACK MAGNETIC TAPE HANDLERS

.1 GENERAL

.11 Identity: . . . . 7-Track Magnetic Tape Handlers:
MT-17 (20.9 KC)
MT-19 (30 KC)
MT-21 (42 KC)
MT-23 (60 KC)
MT-24 (83 KC)
MT-26 (120 KC).

.12 Description

General Electric currently offers three families of magnetic tape units (12 models in all) for its computer systems. All of these models are available for the GE-400 Series systems. Each family is based on one tape handler; the differences are in recording densities and the number of data tracks. Both 7-track and 9-track models are available in each family. The characteristics and performance of each 7-track tape handler are presented in this section. For information about the 9-track handlers, see Section 330:092.

All 7-track tape handlers described in this section are compatible with the tape units used in previous GE systems and with the IBM 729 and 7330 Magnetic Tape Units.

.121 MT-17 and MT-19

The MT-17 and MT-19 Magnetic Tape Handlers are improved versions of the GE-developed economy-model magnetic tape handlers first introduced as the MTH-200 and MTH-300, respectively. Forward tape speed has been increased to 37.5 inches per second (36 inches per second previously), and rewind speed has been increased to 300 inches per second (110 inches per second previously).

The most significant difference between the MT-17 and MT-19 is that the MT-19 can read and write at a density of 800 characters per inch in addition to the 200 and 556 characters-per-inch densities available in the MT-17. Peak data transfer rate for the MT-17 is 20,900 characters per second; peak data transfer rate for the MT-19 is 30,000 characters per second.

.122 MT-21 and MT-23

The MT-21 and MT-23 are two versions of a new GE-developed magnetic tape handler designed to supplant the Ampex units (MTH-201 and MTH-301) formerly used as the medium-speed magnetic tape units in the GE line. Mechanical design is similar to that of the MT-17 and MT-19 mentioned above. Forward tape speed is 75 inches per second and rewind speed is 300 inches per second.

The most significant difference between the two models is that the MT-23 can read and write at a density of 800 characters per inch in addition to the 200 and 556 characters-per-inch densities available in the MT-21. Peak data transfer rate is 42,000 characters per second for the MT-21 and 60,000 characters per second for the MT-23.

.123 MT-24 and MT-26

The MT-24 Magnetic Tape Handler was first introduced as the MTH-202, with recording densities of 200 and 556 characters per inch. The MT-26 is the same basic unit with an additional recording density of 800 characters per inch. These two magnetic tape units feature:

- Photoelectrically controlled tape bins (approximately 30 feet of tape) instead of the usual vacuum columns;
- 150 inches per second forward tape speed;
- 300 inches per second rewind speed;
- Tape drive by means of two vacuum capstans;
- Permanent, quick-connect tape leader.

Peak data transfer rate is 83,000 characters per second for the MT-24 and 120,000 characters per second for the MT-26.

.124 Controllers

Two controllers are available for the magnetic tape units: a single-channel model which can control up to 8 tape units, and a dual-channel model, which can control up to 16 tape units. Each single-channel controller fully occupies one I/O channel; each dual-channel controller fully occupies two. See Section 330:111, Simultaneous Operations, for the type of I/O channel required by each tape handler model.

A dual-channel controller can permit simultaneous read-read, read-write, or write-write operations by any two magnetic tape units connected to the same controller, or it can permit either of two computer systems access to all tape units connected to that controller. Simultaneous operations can also be performed utilizing two tape units connected to different single-channel controllers. Any combination of the tape units described in this section can be connected to the same controller.

.125 Programming Characteristics

All of the magnetic tape units described in this section are functionally identical; i.e., it makes no difference to the programmer which model tape

.125 Programming Characteristics (Contd.)

unit is being used. Instructions are available for reading or writing one block (forward only) in either BCD or binary mode, spacing backward or forward over either 1 to 63 logical records or one file, selecting high or low density, rewinding, writing an end-of-file character, and erasing 8.5 inches forward.

The contents of each 24-bit word are written as four tape rows in both the BCD and binary modes. In the binary mode, the data is written on tape exactly as it appears in storage; in the BCD mode, an automatic code translation is performed between GE-400 internal code and the IBM BCD tape code as used in IBM 7090/7094 systems.

A dual-gap head provides read-after-write checking; both lateral (row) and longitudinal (block) parity are checked. A check is also made for loss of data due to timing errors.

A detailed description of the input-output process is presented in Section 330:111, Simultaneous Operations. Magnetic tape operations can be overlapped with other input-output operations and with processing. Detailed considerations for simultaneity, including time demands on the system, are also presented in the Simultaneous Operations Section.

.14 First Delivery: . . . . . November, 1965.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . single capstan (MT-24 and MT-26 use 2 vacuum capstans).

.212 Reservoirs —
Number: . . . . 2.
Form: . . . . vacuum columns (MT-24 and MT-26 use photo-electrically controlled tape bins).
Capacity: . . . . about 10 inches (MT-24 and MT-26: about 30 feet).

.213 Feed drive: . . . . proportional servo motor.
.214 Take-up drive: . . . . . . proportional servo motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . magnetic head.
.222 Sensing system: . . . . . magnetic head.
.223 Common system: . . . . two-gap head provides read-after-write parity check.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . . recording.
Stacks: . . . . 1.
Heads/stack: . . . . 7.
Method of use: . . . . . . 1 row at a time.

Use of station: . . . . . . reading.
Distance: . . . . 0.3 inch.
Stacks: . . . . 1.
Heads/stack: . . . . 7.
Method of use: . . . . . . 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . plastic tape with magnetizable surface.
.312 Phenomenon: . . . . magnetization.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 200, 556, or (in some models) 800 rows/inch; N is limited only by available core storage.
.322 Parallel by: . . . . 7 tracks.
.324 Track use —
Data: . . . . 6.
Redundancy check: . . . 1.
Timing: . . . . 0.
Control signals: . . . . . 0.
Unused: . . . . 0.
Total: . . . . 7.

.325 Row use —
Data: . . . . 1 to N.
Redundancy check: . . . 1 per block.
Timing: . . . . 0.
Control signals: . . . . . 0.
Unused: . . . . 4.
Gap: . . . . 0.75 inch inter-block; 3.78 inches end-of-file.

.33 Coding: . . . . 1 tape row per character, or 4-tape rows per GE-400 word. Automatic translation between IBM BCD tape code and GE-400 internal code in BCD mode; no translation in binary mode.

.34 Format Compatibility

Other device or system	Code translation
IBM 729 and 7330 tape units:	not required, except for a few special characters.
GE-200 or 600 Series systems using 7-track tape units:	not required.

.35 Physical Dimensions

.351 Overall width: . . . . . . 0.50 inch.
.352 Length: . . . . 2,400 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . Single channel controller.
Dual channel controller.

(Contd.)

.42 Connection to System

.421 On-line: . . . . depends on type of controller and type of tape handler; see Section 330:111, Simultaneous Operations.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1 to 8 (single channel). 1 to 16 (dual channel).
.432 Restrictions: . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . 1 to N words.
.442 Input-output areas: . . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . . yes; scatter-read and gather-write are available at programmer's option, as described in Section 330:111, Simultaneous Operations.
.446 Synchronization: . . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . 1 to N words.
.512 Block demarcation —
Input: . . . . gap on tape or exhausted Data Control List.
Output: . . . . Data Control List specifies number, length, and core locations of data fields comprising a tape block.

.52 Input-Output Operations

.521 Input: . . . . read 1 block forward.
.522 Output: . . . . write 1 block forward. write end-of-file record. erase 8.5 inches forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . forward or backward space: one file or 1 to 63 logical records.
.525 Marking: . . . . inter-block gap. end-of-file character and gap. 1 to 62 multi-purpose block delimiters.
.526 Searching: . . . . none.

.53 Code Translation: . . . . automatic in BCD mode. no translation in binary mode.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . yes.
Select density: . . . . . . yes.
Select code: . . . . yes.
Rewind: . . . . yes.
Unload: . . . . yes.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . yes.
Output lock: . . . . yes.
Nearly exhausted: . . . . yes (1200 inches from physical end).
Busy controller: . . . . . yes.
End-of-file marks: . . . yes.
End-of-medium marks: . . . . yes.

.6 PERFORMANCE

.62 Speeds

.621 Nominal or peak speed: . . . . see Table I.
.622 Important parameters: see Table I.
.623 Overhead: . . . . see Interblock Gap Lengths, Table I.
.624 Effective speeds: . . . . see Table I and graphs.

.63 Demands on System: . . see Section 330:111, Simultaneous Operations.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment: . . . . recording density.
Method: . . . . switch.

.72 Other Controls

Function	Form	Comment
Address selection:	rotary switch	assign logical address (0 through 7 and 8 through 15).
Rewind:	push button.	
File protection:	ring on reel	absence of ring inhibits writing.

.73 Loading and Unloading

.731 Volumes handled —
Capacity per 2,400-foot reel (for 1000-character blocks): . . . . 5 million characters at 200 rows/inch. 11.3 million characters at 556 rows/inch. 14.4 million characters at 800 rows/inch.
.732 Replenishment time: . . 0.5 to 1.0 minute (approximately 0.3 minute for MT-24 and MT-26); tape unit needs to be stopped.
.734 Optimum reloading period: . . . . 3.2 to 12.8 minutes to read or write a full reel at peak speed, depending upon model.

TABLE I: CHARACTERISTICS OF 7-TRACK MAGNETIC TAPE HANDLERS

Model No.	Tape Speed, inches per sec	Recording Density, bits per inch	Peak Speed, char per sec	Interblock Gap Lengths			Efficiency, % (3)		Rewind Speed, inches per sec	Rated Start + Stop Time, msec (7)
				inches	msec (1)	chars (2)	100-char blocks	1,000-char blocks		
MT-17	37.5	200 556	7,500 20,900	0.75 0.75	21 21	157 437	38.9 18.6	86.4 69.6	300	12
MT-19	37.5	800(4)	30,000	0.75	21	629	13.7	61.4	300	12
MT-21	75	200 556	15,000 42,000	0.75 0.75	11 11	165 459	37.8 17.9	85.8 68.5	300	6
MT-23	75	800(5)	60,000	0.75	11	660	13.2	60.2	300	6
MT-24	150	200 556	30,000 83,000	0.75 0.75	5.3 5.3	159 441	38.6 18.5	86.2 69.4	300	3
MT-26	150	800(6)	120,000	0.75	5.3	636	13.6	61.2	300	3

(1) Time in milliseconds to traverse each interblock gap when reading or writing consecutive blocks.
(2) Effective number of character positions occupied by each interblock gap.
(3) Effective speed at the indicated block size, expressed as a percentage of peak speed.
(4) Performance of the MT-19 at 200 and 556 bits per inch density is the same as that of the MT-17.
(5) Performance of the MT-23 at 200 and 556 bits per inch density is the same as that of the MT-21.
(6) Performance of the MT-26 at 200 and 556 bits per inch density is the same as that of the MT-24.
(7) Rated time when following a read with a write operation, with tape stopping between operations.

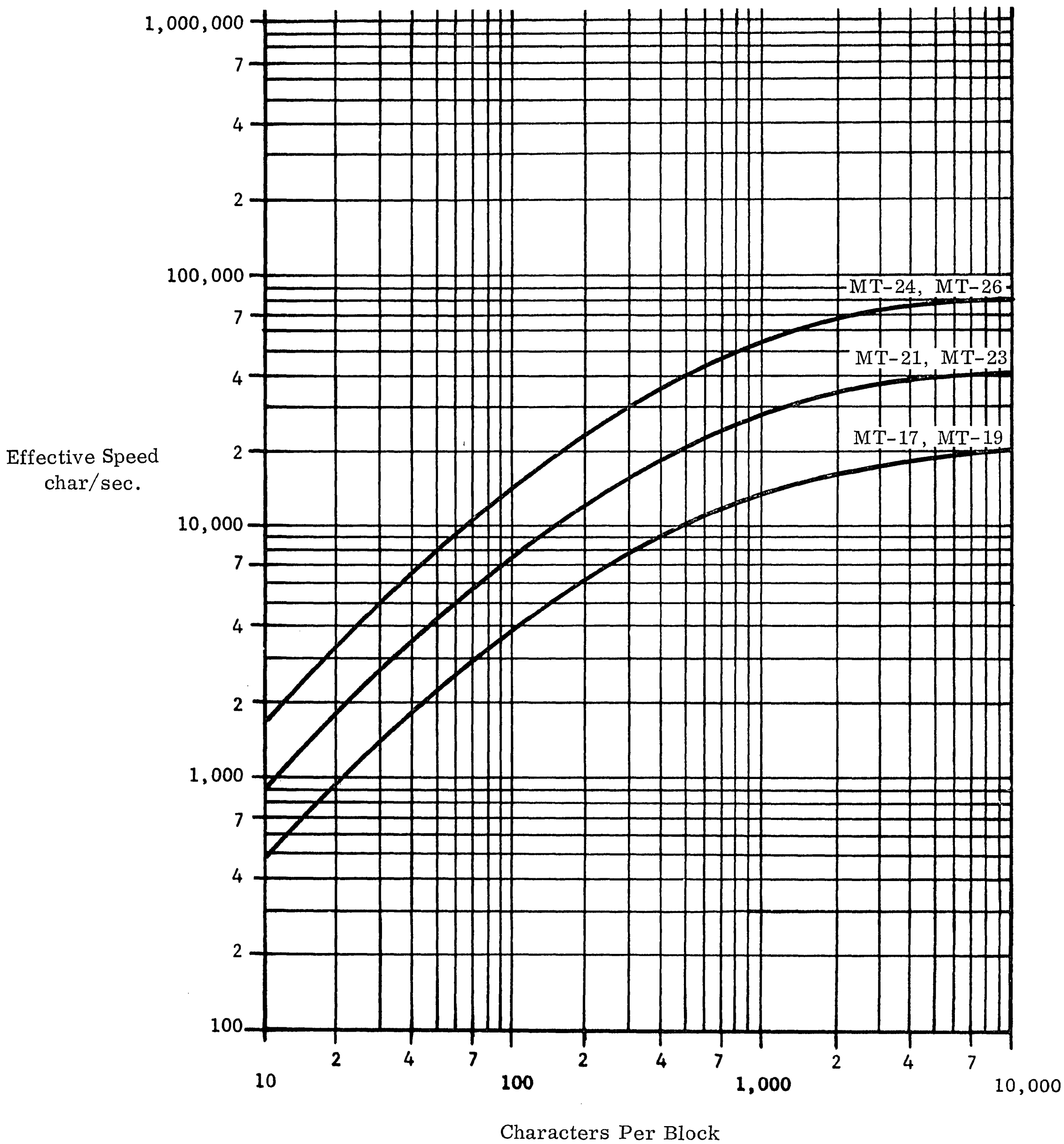
.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Recording:	read-after-write parity check	*
Reading:	lateral and longitudinal parity check	*
Input area overflow:	check	*
Output block size:	preset.	
Invalid code:	all codes valid.	
Exhausted medium:	reflective marker on tape	*
Imperfect medium:	none, but read and write parity checks will pick up many imperfections.	

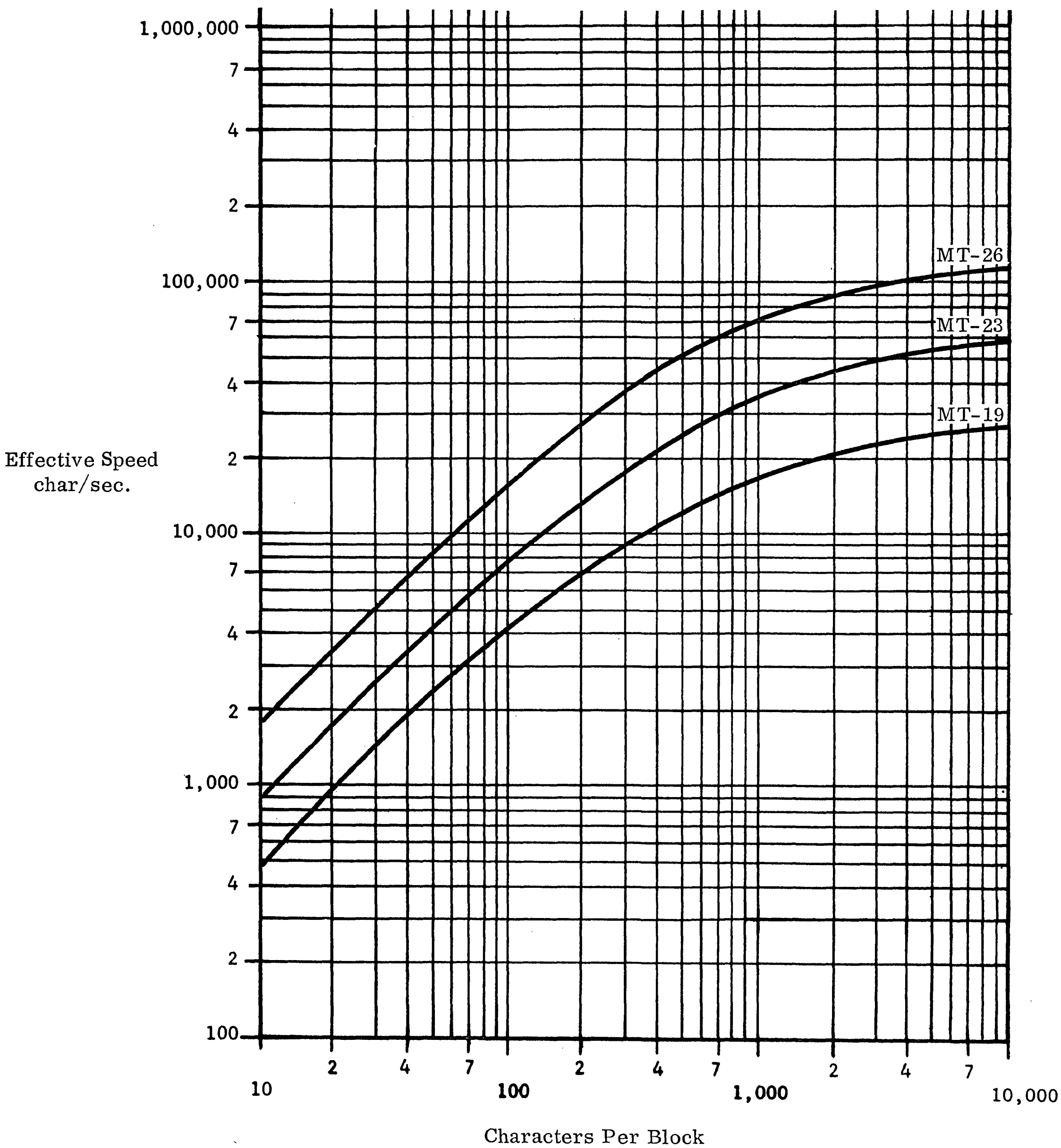
* Occurrence of these and other abnormal conditions causes an interrupt and a branch to a specified location. Information as to the channel, device, and particular condition is contained in a status word which is stored in a specified location in memory.

(Contd.)

EFFECTIVE SPEED:
7-TRACK MAGNETIC TAPE HANDLERS
(556 bits per inch)



EFFECTIVE SPEED:
7-TRACK MAGNETIC TAPE HANDLERS
(800 bits per inch)



INPUT-OUTPUT: 9-TRACK MAGNETIC TAPE HANDLERS

.1 GENERAL

.11 Identity: . . . . 9-Track Magnetic Tape Handlers:
MT-17 (28 KC)
MT-19 (40 KC)
MT-21 (56 KC)
MT-23 (80 KC)
MT-24 (111 KC)
MT-26 (160 KC).

.12 Description

General Electric offers a 9-track version of each 7-track magnetic tape handler described in Section 330:091 (including the models having a maximum recording density of 556 bits per inch). The basic characteristics of corresponding models are similar. Some of the more significant differences between the 7-track and 9-track magnetic tape units are:

- In the 9-track unit, one 24-bit word is recorded on three rows of tape exactly as it appears in core storage.
- Interblock and end-of-file gaps are both reduced to 0.6 inch.
- A Cyclic Redundancy Check (CRC) is made by the 9-track controller in addition to lateral and longitudinal parity checks, permitting the automatic correction of single-track errors.

The 9-track tape units are compatible with the IBM 2400 Series units. Any combination of 9-track and/or 7-track tape handlers can be connected to 9-Track Controller.

Please refer to Section 330:091, 7-Track Magnetic Tape Handlers, for additional information about these tape handlers; only the differences between the 7-track and 9-track versions are presented in this section.

.13 Availability: . . . . 12 months.

.14 First Delivery: . . . . . first quarter, 1966.

.24 Arrangement of Heads

Use of station: . . . . . . recording.
Stacks: . . . . 1.
Heads/stack: . . . . 9.
Method of use: . . . . . . 1 row at a time.

Use of station: . . . . . . reading.
Distance: . . . . 0.15 inch.
Stacks: . . . . 1.
Heads/stack: . . . . 9.
Method of use: . . . . . . 1 row at a time.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 200, 556, or (in some models) 800 rows/inch; N is limited only by available core storage.
.322 Parallel by: . . . . 9 tracks.
.324 Track use —
Data: . . . . 8.
Redundancy check: . . 1.
Timing: . . . . 0.
Control signals: . . . . 0.
Unused: . . . . 0.
Total: . . . . 9.
.325 Row use —
Data: . . . . 1 to N.
Redundancy check: . . 2 per block.
Timing: . . . . 0.
Control signals: . . . . 0.
Unused: . . . . 6.
Gap: . . . . 0.6 inch inter-block; 0.6 inch end-of-file.

.33 Coding: . . . . 3 tape rows per 24-bit word.

.34 Format Compatibility

Other device or system	Code translation
IBM 2400 Series tape units:	not required.
GE-200 or 600 Series systems using 9-track tape units:	not required.

.6 PERFORMANCE

.62 Speeds

.621 Nominal or peak speed: . . . . see Table I.
.622 Important parameters: see Table I.
.623 Overhead: . . . . see Interblock Gap Lengths, Table I.
.624 Effective speeds: . . . . see Table I and graph.

.63 Demands on Systems: . see Section 330:111, Simultaneous Operations.

.7 EXTERNAL FACILITIES

.73 Loading and Unloading

.731 Volumes handled —
Capacity per 2,400 foot reel (for 1000-character blocks):
9-track ASCII: . . . . 5 million characters at 200 rows/inch.
11.3 million characters at 556 rows/inch.
14.4 million characters at 800 rows/inch.

TABLE I: CHARACTERISTICS OF 9-TRACK MAGNETIC TAPE HANDLERS

Model No.	Tape Speed, inches per sec	Recording Density, bits per inch	Peak Speed, char per sec	Interblock Gap Lengths			Efficiency, % (3)		Rewind Speed, inches per sec	Rated Start + Stop Time, msec (7)
				inch	msec (1)	chars (2)	100-char blocks	1,000-char blocks		
MT-17	37.5	200 556	10,000 28,000	0.6 0.6	21	210 583	32.3 14.7	82.7 63.1	300	10
MT-19	37.5	800(4)	40,000	0.6	21	839	10.7	54.4	300	10
MT-21	75	200 556	20,000 56,000	0.6 0.6	11	220 612	31.3 14.0	82.0 62.0	300	5
MT-23	75	800(5)	80,000	0.6	11	880	10.2	53.1	300	5
MT-24	150	200 556	40,000 111,000	0.6 0.6	5.3	212 589	32.0 14.5	82.3 62.9	300	2.5
MT-26	150	800(6)	160,000	0.6	5.3	848	10.5	54.1	300	2.5

NOTE: All peak speeds in this table refer to 6-bit characters.

(1) Time in milliseconds to traverse each interblock gap when reading or writing consecutive blocks.
(2) Effective number of character positions occupied by each interblock gap.
(3) Effective speed at the indicated block size, expressed as a percentage of peak speed.
(4) Performance of the MT-19 at 200 and 556 bits per inch density is the same as that of the MT-17.
(5) Performance of the MT-23 at 200 and 556 bits per inch density is the same as that of the MT-21.
(6) Performance of the MT-26 at 200 and 556 bits per inch density is the same as that of the MT-24.
(7) Rated time when following a read with a write operation, with tape stopping between operations.

.73 Loading and Unloading (Contd.)

9-track non-ASCII: . 6.4 million characters at 200 rows/inch.
13.7 million characters at 556 rows/inch.
17.1 million characters at 800 rows/inch.

.8 ERRORS, CHECKS, AND ACTION

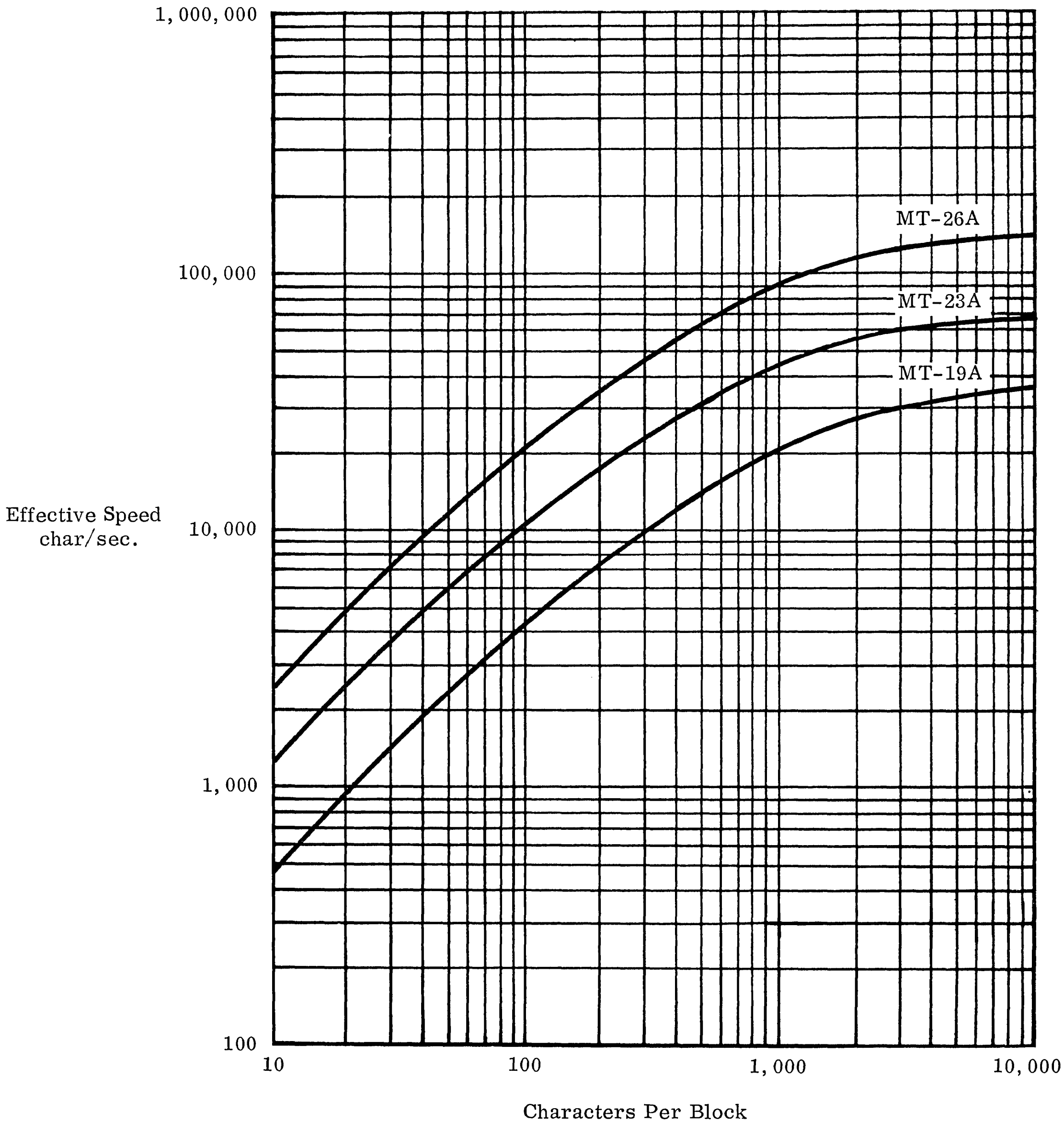
Error	Check or Interlock	Action
Recording:	read-after-write parity check	*
Reading:	lateral, longitudinal, and cyclic parity check †	*
Input area overflow:	check	*
Output block size:	preset.	
Invalid code:	all codes valid.	
Exhausted medium:	reflective marker on tape	*
Imperfect medium:	none, but read and write parity checks will pick up many imperfections.	

* Occurrence of these and other abnormal conditions causes an interrupt and a branch to a specified location. Information as to the channel, device, and particular condition is contained in a status word which is stored in a specified location in memory.

† The 9-track controllers provide single-track error correction.

(Contd.)

EFFECTIVE SPEED:
9-TRACK MAGNETIC TAPE HANDLERS
(800 bits per inch)



NOTE: The effective speed is shown here in terms of 6-bit characters. Performance using 8-bit characters is the same as shown in the graph on page 330:091.901.

INPUT-OUTPUT: MAGNETIC READER/SORTER

.1 GENERAL

.11 Identity: . . . . MR-20 Magnetic Reader/Sorter.

.12 Description

The MR-20 Reader/Sorter reads and sorts magnetically encoded paper documents at a peak rate of 1,200 mixed-size documents per minute. It can operate on-line, with pocket selection under program control or off-line as a sorter only. Each reader/sorter requires a special type of input-output data channel in the central processor. This channel replaces a word-buffered channel and has essentially the same timing characteristics. The demand on the central processor is shown in Section 330:111, Simultaneous Operations.

At its full rated speed of 1,155 documents per minute, the reader/sorter can feed, transport, and stack documents of intermixed sizes within the following ranges:

Length: . . . . 5.25 to 9.0 inches.
Width: . . . . 2.50 to 3.75 inches.
Thickness: . . . . . 0.003 to 0.010 inches.

It reads a single line of magnetic ink characters printed in Font E-13B (adopted as standard by the American Bankers' Association). Recognizable characters are limited to the ten numerals and four cue characters.

In on-line operation, data read from the document is stored as four BCD characters per 24-bit core storage location, starting in the low-order character position. Each cue character is stored in sequence in a separate word location. Invalid or unrecognizable characters cause an indicator to be set and a pound sign (#) to be transmitted to storage in place of the bad character. One of the 12 stacker pockets must be selected by the stored program. To achieve the peak rate, documents must be fed continuously, with synchronization controlled by the program. When documents are fed singly upon demand, the maximum reading rate drops to 400 documents per minute.

When operating off-line, the reader/sorter is controlled by the manual control panel and a wired plugboard. The plugboard can define the format of up to 10 sort fields, each containing up to 12 digits. The desired field and digit position for sorting are selected by push buttons. A "Zero Suppression" feature eliminates repeated handling of documents which are already properly sorted by routing them to a Special pocket. The alternative "Multiple Digit Selection" feature causes documents to be sent to the Special pocket if they contain a field of up to ten characters whose value is equal to a corresponding field defined by the plugboard wiring.

Accuracy control includes parity checks on data sent to the central processor, symbol checks for the presence and proper reading of symbol markers, and rejection of documents with missing, unreadable, or marginally-read digits. The input hopper can handle up to 2,500 documents, while each output stacker has a capacity of 1,600 documents; a counter which can be reset by the operator is provided for the hopper and each stacker.

Optional features that are available for use with the MR-20 include an Endorser, which prints an endorsement on documents during operation, and a Transposition Check Digit Verifier, which checks for transposed digits in account numbers.

INPUT-OUTPUT: DATANET-20 AND DATANET-21

.1 GENERAL

.11 Identity: . . . . DATANET-20 Data Transmission Channel Controller.
DATANET-21 Data Transmission Channel Controller.

.12 Description

The DATANET-20 and DATANET-21 are designed for use in systems where the data communication volume is too low to warrant installation of the more powerful and versatile DATANET-30 (Section 330:104) or DATANET-70 (Section 330:105). Only two of these units can be connected to a GE-400 Series system. The arrangement can be one DATANET-20 and one DATANET-21, two DATANET-20's, or two DATANET-21's.

DATANET-20

The DATANET-20 controls communication between a GE-400 Series computer and one or more remote terminals connected to a single half-duplex telephone or telegraph line. The remote equipment may be a teletype unit, a DATANET-30 Communications Processor, a DATANET-15 Communications Controller, or another GE-400 Series computer.

Transmission speed is determined by the line quality and the equipment at the remote terminal; maximum speed is 1,200 bits per second in an asynchronous mode. This unit recognizes the interchange signals as recommended by the EIA Standard Interface. Control characters can also be detected. The DATANET-20 operates with 103 A and F, 202C and D, and VCA modems.

Operation of the DATANET-20 can be fully automatic. The computer can control the dialing of remote terminals, using a Bell System Model 801A Automatic Calling Unit in conjunction with a Data-Phone subset. After the called station has answered, the computer controls the communication line until the data transfer has been completed.

When a remote terminal initiates a call, it is answered by the Data-Phone subset connected to the DATANET-20. If the DATANET-20 is communicating with another remote terminal, the calling station receives a busy signal and must terminate the call and try again later.

The DATANET-20 requires one special data communications channel, which can be used in place of one of the standard GE-400 Series input-output channels. One character at a time is transferred between the DATANET-20 and core storage. Five-, six-, seven- or eight-level codes with stop-start bits can be accommodated, and any required code translation must be performed by the computer program. Parity checking is optional. A program subroutine will be used to service the data communication line's input-output area in core storage.

DATANET-21

The DATANET-21 is similar to the DATANET-20 except that it handles data transfers in a serial-synchronous mode. Data characters can be up to eight bits in size. Parity is checked on each character, and an additional parity check is performed on each message block. The DATANET-21 can be connected to Bell System Data-Phone Subsets 201A and 301B. The Automatic Calling Unit 801A1 or 801A4 can be used in conjunction with the 201A. The maximum data transfer rate is 2,000 bits per second when using dial-up lines, and up to 40,800 bits per second when using private line facilities.

INPUT-OUTPUT: DATANET-25

.1 GENERAL

.11 Identity: . . . . DATANET-25 Multiple Processor Adapter.

.12 Description

The DATANET-25 Multiple Processor Adapter permits direct computer-to-computer communication between two members of the GE-400 Series (or other systems that meet the interface requirements). The primary purpose of the DATANET-25 is to adapt one GE-400 Series computer to operate as an on-line auxiliary system for another GE-400 Series computer. The auxiliary system can handle all media conversion and data manipulation operations, thereby freeing the main computer for efficient performance of its internal processing workload.

The DATANET-25 occupies one input-output channel. The main computer system treats the auxiliary system as a peripheral device, using a standard complement of peripheral instructions. The DATANET-25 has the characteristics of a word buffered channel. It provides buffer storage for one 4-character word and transfers one word at a time to and from core storage.

The data transfer rate depends upon the internal speed of the auxiliary system. If a GE-425 computer (with 3.9-microsecond core storage cycle time) is linked with a GE-435, for example, the data transfer rate will be 214,000 characters per second.

INPUT-OUTPUT: DATANET-30

.1 GENERAL

.11 Identity: . . . . Datanet-30 Data Communications Processor.

.12 Description

The Datanet-30 is a stored program data communications processor that can be used independently or connected on-line to any GE 200, 400, or 600 Series computer. It is particularly useful for message switching, data collection and distribution, and integrated information handling systems. The Datanet-30 can scan up to 128 communication lines, receive and temporarily store data, evaluate it for priority, and then send it on to the proper destination. The Datanet-30's principal components and their functions are summarized below.

The Processor

The Datanet-30 processor controls the flow of input and output data and manipulates the data as directed by the stored program. There are over 78 basic instructions, some of which offer many variations. The instructions can be classified into the following groups: load, store, arithmetic, logical, register transfer, branch, special, Buffer Selector (to service the input-output buffers), and Controller Selector (to control computer peripheral devices).

Arithmetic capabilities are limited to nine different binary addition instructions and a "subtract one" instruction. Logical AND, inclusive OR, and exclusive OR instructions are available. The register transfer instructions permit the contents of up to six specified registers to be "ORed" together, manipulated in one of several ways, and transferred to any combination of up to four specific registers.

Each instruction is one 18-bit word in length. Six different modes of addressing are available; three of these modes use direct addresses (contained in the instructions), and the other three use indirect addresses (contained in the memory locations specified in the instructions). All instructions that specify memory addresses use 6 bits for the operation code, 3 bits to specify the addressing mode, and 9 bits to specify the memory address itself. A symbolic assembly program is available to simplify the coding of Datanet-30 programs.

Core Memory

The Datanet-30 can contain 4,096, 8,192, or 16,384 word locations of magnetic core memory. Memory cycle time is 6.94 microseconds for each access of one 18-bit word. Each word location can hold one instruction, three 6-bit alphanumeric characters, or a numeric data word in the form of an 18-bit binary integer. Negative numbers are represented in two's complement form. Eight-level transmission codes can be stored conveniently in memory in the form of 6-bit character codes because special instructions are provided to strip off and check the parity and control bits when a character is received, and to regenerate and insert these two bits when the character is to be transmitted.

Input-Output Buffers

The Datanet-30 can address a total of 128 buffers. Each buffer is connected to a digital subset or teletype line relay which changes signals to or from the form required for the communications facilities being used. Four standard types of buffers are available:

- Bit Buffer Channel — buffers one bit at a time between the Datanet-30 and one full duplex, half duplex, or simplex transmission line. The Bit Buffer Channel is used on low-speed teletype lines at standard transmission speeds of 45 to 150 bits per second. Codes of 5, 6, 7, or 8 levels with stop-start bits can be accommodated. The program must store away each individual bit of received data before the next bit arrives. The maximum number of lines that can operate simultaneously varies with transmission speed, message volume, and a number of other factors.

- Character Buffer Channel — buffers one character of 5, 6, 7, or 8 bits at a time between the Datanet-30 and one half-duplex transmission line. The Character Buffer Channel is required by system timing considerations on lines operating at or above 300 bits per second; it can accommodate speeds up to 2,400 bits per second.

- Word Buffer Channel — buffers one 20-bit Datanet-30 word (18 data bits plus start and stop bits) to permit communication between two Datanet-30's via a half-duplex transmission line. Transmission speeds of 300 to 2,400 bits per second can be accommodated.

- Sychronous Buffer Channel — buffers 5-, 6-, 7-, or 8-bit characters between the Datanet-30 and one half-duplex transmission line. Transmission speed is determined by the digital subset and is usually 2,000 or 2,400 bits per second.

- Dial Adapter Unit — provides for connection of up to 10 Automatic Call Units, 801A or C, to a Datanet-30.

Controller Selector Unit (CSU)

The CSU permits connection of standard GE computer peripheral devices to a Datanet-30. Disc

.12 Description (Contd.)

storage units, magnetic tape subsystems, and other peripheral devices can be connected.

Computer Interface Unit (CIU-931)

The CIU-931 is an 18-bit buffer that provides the connecting link between a GE-400 Series computer system and an on-line Datanet-30. The CIU-931 is housed within the Datanet-30, where it is addressed as an input-output buffer, and is connected to a standard input-output channel of the GE-400 Series system. Data transfer rate is determined by the Datanet-30 program and can be up to 43,200 characters per second. Both the Datanet-30 and the GE-400 Series computer can execute independent programs while data is being transferred between them in either direction.

Data transfers between the Datanet-30 and the CIU-931 are parallel by 18-bit word, with no parity bit. Data transfers between the CIU-931 and the GE-400 Series computer are parallel by character, with each character consisting of 6 data bits plus an odd parity bit. The CIU-931 performs the necessary conversions between the word and character modes, adding or deleting parity bits as required. Data received from the 400 Series computer is checked for proper parity. Status indicators can be interrogated by either the Datanet-30 or the 400 Series computer for the following conditions: ready, intermediate, channel busy, data alert, and command reject.

Computer Interrupt Unit (PIU-930)

The PIU-930 module controls the transfer of data between two Datanet-30's located in the same installation.

INPUT-OUTPUT: DATANET-70

.1 GENERAL

.11 Identity: . . . . DATANET-70.

.12 Description

The DATANET-70 is a new communications device for controlling the transmission of digital data over public or leased teletype or telephone-grade transmission lines, or through manual or automatic public dial-up services. A total of up to 248 communications lines can be controlled by a single DATANET-70 at transmission rates of up to 40,800 bits per second. An additional seven lines are provided for diagnostic functions, and one additional line is provided for control functions. All lines can be active simultaneously. The diagnostic lines provided are used to check the functioning of the DATANET-70. These diagnostic facilities have not been completely defined to date.

The DATANET-70 consists of a Multi-Line Controller or MLC, and a number of communications buffers. The buffers are packaged in modules and mounted on one to three "option doors." Each door can hold up to 9 rows of modules. Each door containing other than teletype buffers must use a one-row common section. Buffers can be added or replaced in the field. The buffers currently available, the facilities they service, and the space they require are as follows:

- Teletype Buffer — Terminates up to 32 half-duplex telegraph-grade lines in a three-row module. Standard bit rates between 45 and 150 baud are plug-selectable. The lines interface with the GE-VCA, the Bell 103 Series Data Sets, or similar modems. Five-, six-, seven-, or eight-level codes are plug-selectable. All lines within a buffer module operate at the same speed and code level. Double-character buffering is provided by a delay line. An echoplex mode of operation permits retransmission of received bits; a full-duplex communication line is required for this mode. Start and stop bits are added to the characters for transmission and stripped when received.

- Synchronous Serial Character Buffer — Terminates up to three half-duplex voice-grade lines in a two-row module. The bit rate depends on timing from the data set and is independent for each line. The lines interface with the Bell 201 Series Data Sets or similar modems. Five-, six-, seven-, or eight-level codes are plug-selectable for each line, as is the sync character code. Double-character buffering is provided for each line.

- Asynchronous Serial Character Buffer — Terminates up to three half-duplex voice-grade lines in a two-row module. Standard bit rates between 150 and 2,400 baud are plug-selectable. The lines interface with Bell 103B or F, the 202 Series Data Sets, or similar modems. Five-, six-, seven-, or eight-level codes are plug-selectable. All lines within a buffer module operate at the same speed and code level. Double-character buffering is provided for each line. Start and stop bits are added to the characters for transmission and stripped when received.

- Dialing Buffer — Provides up to five dialing lines in a one-row module. The dialing rate depends on timing from the attached Automatic Call Unit and is independent for each line. The lines interface with the Bell 801 Series ACU's or similar units. The dialing digits are single-buffered for each line. One dialing line is required for each data channel terminating a dial-out line.

- Synchronous Serial Word Buffer — Terminates one half-duplex voice-grade or Telpak A line in a one-row module. The bit rate depends on the timing from the data set. The line can interface with the Bell 201 Series and 301B Data Sets or similar modems. Two interfaces will be available: the standard EIA interface and the current interface to operate the 301B. The code level is 24 bits. The sync character code is plug-selectable. Block error detection will be provided. Double-word buffering is provided for each line.

Data can be stored in core storage in one of three formats: 24-bit word, three 8-bit characters per word, or four 6-bit characters per word. The format is controlled by plugboard wiring for each buffer.

DATANET-70 input-output operations are controlled in a somewhat different manner than other GE-400 Series peripheral devices. The Data Control Word and Data Control List facilities associated with each I/O channel are not used, although the Program Interrupt Words are used.

Associated with each of the 256 lines is a group of four control words. The group reserved for the controller contains the External Function Word, the First Control Word, and two Diagnostic Words for use by diagnostic routines. The External Function Word contains the command to be executed by the DATANET-70. The First Control Word is the first Data Control Word used in a data transfer operation.

The four-word control groups associated with the rest of the lines contain two Data Control Words, a Character Control Word, and a Status Control Word. Prior to the execution of a General instruction, the proper External Function Word and First

.12 Description (Contd.)

Control Word (when transmitting only) must be stored. When the appropriate General instruction is executed, the DATANET-70 accesses the External Function Word and the First Control Word. The First Control Word is loaded in the first Data Control Word location for the indicated line. Data transfer operations are controlled by the First Control Word and the second Data Control Word for each line. Control is alternated between the two Data Control Words, permitting effective buffer alternation.

In addition, two queues are maintained to service the various lines. A Data Status Word which identifies the line involved is stored in the DSW queue each time a line requests service due to completion of a data transfer, recognition of a control character, or readiness to initiate a data transfer. An interrupt is also generated at this time. Under emergency conditions, such as memory parity error or DSW queue overflow, the status word is stored in an Emergency Status Word queue to prevent loss of status information. A particular bit is set by the hardware in each status word when stored in one of the queues, and standard software resets this bit after processing the status word.

When two or more buffers request service at the same time, priority is determined by plugboard wiring. Outstanding requests are thus clearly identified. In a fully-expanded DATANET-70, 2,304 words of core storage are required to hold the control words and queues.

Odd or even parity can be checked on 7- or 8-level codes. Parity checking is determined by plugboard wiring. Presence of a character parity error within a message or block of data is indicated by a bit in the status word. Characters received in the 5-level Baudot code are stored as 6-bit characters, with the sixth bit representing the figures or letters shift. The FIGS and LTRS control characters are recognized automatically without need for a control character check. When transmitting, the FIGS and LTRS control characters must be supplied by the user's program.

Incoming data can be checked for the occurrence of one or two control characters defined in the command. Checking can be for only one character, for either character, or for the two characters in sequential order. Control characters of up to 8 bits, including ASCII control characters, can be recognized.

The Operator's panel contains the switches and indicators necessary for set-up and operation. In addition to the usual off/on switches, a group of switches are provided to set the addresses of the control words and queues. The maintenance panel includes facilities for off-line testing of the DATANET-70. Data flow from memory or from the communications buffers can be simulated and monitored.

From two to eight core storage cycles are required to transfer one character of data (one word for some buffers) between the DATANET-70 and core storage. The additional time required for some data transfers is due to checking for control characters.

INPUT-OUTPUT: PERIPHERAL SWITCHING EQUIPMENT

.1 GENERAL

.11 Identity: . . . . Manual Peripheral Switch Console, Model DSC-200.
Manual Peripheral Switch Unit, Model OPT 510.

Programmed Peripheral Switch, Model PS-60.

.12 Description

Two devices are available for the purpose of sharing one peripheral subsystem between two computer systems. In addition, the manual switch allows two peripheral subsystems to share the same I/O channel. The Manual Peripheral Switch is operated manually and is under control of the operator, while the PS-60 Programmed Peripheral Switch is under control of the programmer.

Manual Peripheral Switch

The Manual Peripheral Switch Console contains space for up to 16 switching units and contains the necessary controls and lights to operate the switches and indicate their status. Each switching unit can either: (1) switch one peripheral subsystem between two GE-400 Series I/O Channels (normally two different computer systems), or (2) switch one I/O channel between two peripheral subsystems. Peripheral commands directed to a peripheral device that has been switched to another I/O channel cause Absent/Off-Line or Command Reject status indications to be returned to the processor. Commands directed to the non-connected member of a pair of peripheral subsystems being switched to the same I/O channel are received and attempted by the connected subsystem; the results depend upon the particular pair of subsystems being alternated. Total cable length from a GE-400 Series processor through a peripheral switch to a peripheral controller cannot exceed 150 feet.

PS-60 Programmed Peripheral Switch

The Programmed Peripheral Switch is a free-standing, program-controlled electronic switching device for connecting either of two processors to a single peripheral subsystem controller. The two processors can be any combination of a GE-400 Series Central Processor, a GE-600 Series Processor Module, or a DATANET-30. The switch consists of a self-contained power supply, three sets of input-output lines for communicating with the two processors and the peripheral controller, and the necessary electronics for the logic and timing functions.

Both processors are always aware of all activity by the I/O controller connected to the Programmed Switch; all status returns are made to both systems. The switch is always either connected to one of the two processors or in a disconnected state. While the switch is in the disconnected state, a valid I/O command from either processor results in a connection to that processor and an initiation of the command. The switch remains connected to that processor until it is disconnected by the program.

The normal method of disconnection is through the issuance of a Disconnect command by the connected processor. Alternatively, the non-connected processor can issue a Connect command, which will immediately disconnect the switch from the other processor and place it in a disconnected state.

Since all switching is by electronic means, delays due to switching are relatively short.

SIMULTANEOUS OPERATIONS

The GE-400 Series systems are capable of a relatively high degree of simultaneity. Buffered input-output data channels are available for the peripheral units connected to the system, so that multiple read-write operations can be carried out with concurrent internal processing. As many as 12 input-output channels can be connected to the input-output control section of the central processor, and all can operate simultaneously. Each channel provides communication between the central processor and one peripheral subsystem; a subsystem may have one or more input-output devices, such as four DS-20 Disc Storage Units or eight magnetic tape handlers. The relationship between input-output channels and peripheral subsystems is fixed, but enough channels can be installed so that this lack of flexibility should not be a significant limitation.

Data transfer between a channel and its associated subsystem is always serial (one character at a time). Data transfer between a channel and core storage can be either one character or one word at a time, depending on the type of channel. Four standard types of I/O channels are available. Table I presents some of the important characteristics of each type of standard channel. Some devices (such as communications equipment and the MICR Sorter/Reader) require special channels or adaptations of the standard channels. Up to eight I/O channels, exclusive of High Speed Channels, are provided at no extra charge with the original installation. The Channel Expansion Option provides the capability for adding up to four additional channels. Due to space requirements, fixed wiring, and marketing considerations, there are some restrictions on the number and combinations of I/O channels, as indicated in Table II.

Data flow between peripheral devices and core storage is controlled by a group of four channel control words associated with each channel. The channel control words are stored in reserved locations in core storage. Each four-word group consists of:

- A List Pointer Word, which indicates a specific location in a Data Control List and specifies the total number of words in the list. Each entry in the Data Control List, in turn, specifies the number of characters in a data field (from 1 to 512) and the starting core storage address of the field.
- A Data Control Word, which defines the size of the data field currently being transferred and its starting address in core storage.
- Two Program Interrupt Words, which contain a two-address instruction that is executed whenever an interrupt occurs upon completion of a peripheral operation on the associated channel.

Every input or output operation is initiated by a General instruction that indicates the desired operation, the device number, and the channel number. For conventional peripheral devices, data fields are then transferred in accordance with the sequence, lengths, and core storage locations specified in the Data Control List. This means that successive data fields need not be taken from nor placed into consecutive core storage locations. The

TABLE I: CHARACTERISTICS OF STANDARD GE-400 SERIES I/O CHANNELS

Type of Channel	Maximum Data Rate Capacity, char/sec	Unit of Data Transferred to Core Storage
Character-buffered	27,000	1 character
Word-buffered	96,000	1 word
Double-word-buffered	160,000	1 word
High Speed	400,000	1 word

TABLE II: GE-400 SERIES I/O CHANNEL PACKAGES

Channels (1)	Number of Rows (2)
1 SWC	1
2 DWC and 1 SCC	3
1 HSC and 1 SCC	2
1 SLC and 1 SCC	3
1 MLC	1
1 PMC and 1 SCC	2
1 DHC	1
1 DWC and 4 SCC	fixed

(1) The channel abbreviations are:

SCC — Character-buffered channel;
SWC — Word-buffered channel;
DWC — Double-word-buffered channel;
HSC — High Speed Channel;
SLC — Single-Line Controller Channel (DATANET-20 or -21);
MLC — Multi-Line Controller Channel (DATANET-70):
PMC — Packed Mode Channel (functions as a double-word-buffered channel when not in 1401 compatibility mode);
DHC — Document Handler Channel (MR-20; functionally similar to a word-buffered channel).

(2) A total of seven rows of I/O channel packages can be incorporated in a GE-400 Series system in addition to the fixed package. Note that the inclusion of more than 8 I/O channels requires the Channel Expansion Option.

result is a powerful scatter-read, gather-write facility that can significantly reduce programming time, execution time, and memory space requirements.

Execution of any peripheral instruction (or a Request Status or Reset Status instruction) causes a Status Word indicating the condition of the peripheral subsystem to be placed in a core storage location for subsequent examination by the stored program. This examination will usually be made by the standard input-output routines. The Status Word indicates one of 11 general conditions (ready, busy, inoperable, end of file, error, etc.) and may also include a "substatus" indication of the specific reason for the condition.

Input-output operations involving the DATANET-70 are handled differently, as described in Section 330:105.

For conventional peripheral devices, there are four timing factors to be considered when determining the load placed on the central processor by data transfer operations:

- Initiate Sequence — includes accessing the first DCW.
- Data Transfer Sequence — transfers one unit of data (either one character or one word) and updates the DCW.
- DCW Change Sequence — obtains new DCW.
- Terminate Sequence — reinitializes the LPW.

The processor demand (or "interference") timing factors for the various members of the GE-400 Series are presented in Table IV. These factors are the same for all of the standard I/O channels except the High Speed Channel. For this channel, the current Data Control Word is retained in the channel rather than in core storage. This reduces the time for each data transfer sequence by about one core storage cycle. The other factors for the High Speed Channel

(Contd.)

are as presented in Table IV. The demand imposed on the central processor by a data transfer operation is the sum of: one initiate sequence, one data transfer sequence for each unit of data transferred, one DCW change sequence for each additional DCW used, and one terminate sequence. Note that the CP-10 Card Punch, lacking a full-card-image buffer, requires that each character of data to be punched be accessed once for each of the 12 rows -- a total of 960 data transfer sequences per fully-punched 80-column card.

The demands imposed on the central processor by data transfer operations involving the DATANET-20, -21, and -70 vary between two and eight core storage cycles per character of data transferred. The additional time is required for the control character checks.

The type of channel normally assigned to each type of peripheral device is shown in Table III.

TABLE III: STANDARD PERIPHERAL CHANNEL ASSIGNMENTS

Type of Channel	Peripheral Subsystem
Character-buffered	CR-21 Card Reader CP-10 Card Punch PR-21 Printer TS-20 Punched Tape Subsystem Console Typewriter ML-20 Lister
Word-buffered	MR-20 MICR Sorter/Reader DATANET-25 DS-20 Disc Storage Subsystem DATANET-30
Double-word-buffered	MT-19, MT-21, MT-23, MT-24 Magnetic Tape Subsystems MS-40 Mass Storage Subsystem
High Speed Channel	DS-15 Disc Storage Subsystem DS-25 Disc Storage Subsystem MT-26 Magnetic Tape Subsystem
Single-Line Controller Channel (character-buffered)	DATANET-20 DATANET-21
Multi-Line Controller Channel (double-word-buffered)	DATANET-70

Additional internal buffering is provided by the printer controller (storage for a full line of 136 characters), the DS-20 Disc Storage Controller (a 1,024-character addressable buffer), and the CP-20 Card Punch (full card image buffer). An optional dual-channel controller can be used with the magnetic tape subsystems and can simultaneously control any combination of tape operations (read-write, read-read, etc.) on any two of the tape handlers connected to it. Each dual-channel tape controller permanently occupies two of the input-output channels.

Input-output requests for access to core storage are automatically sequenced and controlled by a priority control network in the central processor. In general, peripheral subsystems with higher priorities (higher data transfer rates) are assigned to the lower-numbered channels. An exception to this arrangement is the console input-output typewriter, which is connected to the lowest channel (channel 0) and is assigned lowest priority. Another exception is the Second-Level Interrupt feature of the Direct Access Option. With this feature, a special I/O channel (usually assigned to a DATANET-70) can request and get immediate access to memory.

The example in Table V illustrates the amount of computing time available while the indicated input-output operations are simultaneously in progress. The indicated results are based on the listed number of noncontiguous data fields per record, the normal channel assignment (TABLE III), and the processor demand timing factors (Table IV).

TABLE IV: GE-400 SERIES PROCESSOR DEMAND TIMING FACTORS (1)

Model:	GE-415	GE-425	GE-435
Initiate Sequence, μsec	16.8	12.6	10.5
Data Transfer Sequence, μsec(2)	11.2	8.05	6.65
DCW Change Sequence, μsec	22.4	16.95	13.65
Terminate Sequence, μsec	20.65	15.75	12.60

(1) Does not apply to Single-Line and Multi-Line Controller Channels (see text).

(2) Except High Speed Channel (see text).

TABLE V: EXAMPLE OF DEMANDS ON PROCESSOR AND AVAILABLE COMPUTING TIME

Device and Operation	Per Cent Demand on Central Processor		
	GE-415	GE-425	GE-435
CR-21; reading 80-character records at 900 cpm; 5 fields per card	1.6	1.1	0.9
MT-26; reading 500-character records at 120,000 cps; 3 fields per record	8.2	6.0	4.2
MT-26; writing 500-character records at 120,000 cps; 3 fields per record	8.2	6.0	4.2
PR-21; printing 136-character records at 1,200 lpm; 9 fields per line	3.5	2.6	2.1
Total central processor load:	21.1	15.7	11.4
Available for internal processing:	78.9	84.3	88.6

INSTRUCTION LIST

MNEMONIC	INSTRUCTION	OCTAL
ABM (2a)	Add Binary to Memory	34
ABX (2a)	Add Binary to Index	34
ADD	Add Decimal Double	51
ADQ	Add Decimal Quadruple	53
ADS	Add Decimal Single	50
ADT	Add Decimal Triple	52
AIM (2a)	Add Immediate to Memory	33
AIX (2a)	Add Immediate to Index	33
AMD	Add to Memory Double	55
AMQ	Add to Memory Quadruple	57
AMS	Add to Memory Single	54
AMT	Add to Memory Triple	56
ANM (2a)	AND to Memory	24
ANX (2a)	AND to Index	24
BRC (2a)	Branch on Count	16
BRE	Branch if Equal	13
BRG	Branch if Greater	12
BRL	Branch if Less	14
BRM	Branch if Minus	11
BRU	Branch Unconditionally	10
BRZ	Branch if Zero	15
BXC (2a)	Branch on Index Count	16
CAA	Compare Alphanumeric Accumulator to Memory	03
CDA	Compare Decimal Accumulator to Memory	02
CMI (2a)	Compare Memory to Immediate	01
CMM (2a)	Compare Second to First Memory	04
CXI (2a)	Compare Index to Immediate	01
CXM (2a)	Compare Index to Memory	04
EDT	Edit	05
EXP	Explode	20
GEN (2a)	General	07
HLT	Halt	00
IMP	Implode	21
LAL	Load Accumulator Location	36
LBT	Low Bit Test	22
LDD	Load Double	41
LDQ	Load Quadruple	43
LDS	Load Single	40
LDT	Load Triple	42
LDX (2a)	Load Index	30
LXI (2a)	Load Index with Immediate	31
MFI (2a)	Move from Immediate	31
MFM (2a)	Move from First Memory	30
MOV (2a)	Move	06
MTA (2a)	Move to First Address Field	32
MXC (2a)	Move on Index Control	06
PXB (2a)	Program Counter to Index and Branch	17
RALD	Reset Accumulator Length Double	22X06000
RALQ	Reset Accumulator Length Quadruple	22X04000
RALS	Reset Accumulator Length Single	22X02000
RALT	Reset Accumulator Length Triple	22X07000
RIM (2a)	OR Inclusive to Memory	23
RIX (2a)	OR Inclusive to Index	23
RLDA	Rotate Left Double Alpha	22X122NN
RLDAS	Rotate Left Double Alpha, Set	22X162NN
RLDD	Rotate Left Double Decimal	22X522NN
RLDDS	Rotate Left Double Decimal, Set	22X562NN
RLQA	Rotate Left Quadruple Alpha	22X102NN
RLQAS	Rotate Left Quadruple Alpha, Set	22X142NN
RLQD	Rotate Left Quadruple Decimal	22X502NN
RLQDS	Rotate Left Quadruple Decimal, Set	22X542NN
RLSA	Rotate Left Single Alpha	22X132NN
RLSAS	Rotate Left Single Alpha, Set	22X172NN
RLSD	Rotate Left Single Decimal	22X532NN
RLSDS	Rotate Left Single Decimal, Set	22X572NN
RLTA	Rotate Left Triple Alpha	22X112NN
RLTAS	Rotate Left Triple Alpha, Set	22X152NN
RLTD	Rotate Left Triple Decimal	22X512NN
RLTDS	Rotate Left Triple Decimal, Set	22X552NN
RQS (2a)	Request Status	07X00000
RQSP (2a)	Request Status of Processor	67X00000
RQST	Request Status of Typewriter	07X00000
RRD	Rotate Right Double	22X320NN
RRDA	Rotate Right Double Alpha	22X120NN
RRDAS	Rotate Right Double Alpha, Set	22X160NN
RRDD	Rotate Right Double Decimal	22X520NN
RRDDS	Rotate Right Double Decimal, Set	22X560NN
RRDT	Rotate Right Double, Test	22X324NN
RRQA	Rotate Right Quadruple Alpha	22X100NN
RRQAS	Rotate Right Quadruple Alpha, Set	22X140NN
RRQD	Rotate Right Quadruple Decimal	22X500NN
RRQDS	Rotate Right Quadruple Decimal, Set	22X540NN
RRS	Rotate Right Single	22X330NN
RRSA	Rotate Right Single Alpha	22X130NN
RRSAS	Rotate Right Single Alpha, Set	22X170NN
RRSD	Rotate Right Single Decimal	22X530NN
RRSDS	Rotate Right Single Decimal, Set	22X570NN
RRST	Rotate Right Single, Test	22X334NN
RRTA	Rotate Right Triple Alpha	22X110N
RRTAS	Rotate Right Triple Alpha, Set	22X150NN
RRTD	Rotate Right Triple Decimal	22X510NN
RRTDS	Rotate Right Triple Decimal, Set	22X550NN
RSS (2a)	Reset Status	07X00040
RXM (2a)	OR Exclusive to Memory	25
RXX (2a)	OR Exclusive to Index	25
SAL	Store Accumulator Location and Length	37
SBM (2a)	Subtract Binary from Memory	35
SBX (2a)	Subtract Binary from Index	35
SDD	Subtract Decimal Double	61
SDQ	Subtract Decimal Quadruple	63
SDS	Subtract Decimal Single	60
SDT	Subtract Decimal Triple	62
SLDA	Shift Left Double Alpha	22X022NN
SLDAS	Shift Left Double Alpha, Set	22X062NN
SLDD	Shift Left Double Decimal	22X422NN
SLDDS	Shift Left Double Decimal, Set	22X462NN
SLQA	Shift Left Quadruple Alpha	22X002NN
SLQAS	Shift Left Quadruple Alpha, Set	22X042NN
SLQD	Shift Left Quadruple Decimal	22X402NN
SLQDS	Shift Left Quadruple Decimal, Set	22X442NN
SLSA	Shift Left Single Alpha	22X032NN
SLSAS	Shift Left Single Alpha, Set	22X072NN
SLSD	Shift Left Single Decimal	22X432NN
SLSDS	Shift Left Single Decimal, Set	22X472NN
SLTA	Shift Left Triple Alpha	22X012NN
SLTAS	Shift Left Triple Alpha, Set	22X052NN
SLTD	Shift Left Triple Decimal	22X412NN
SLTDS	Shift Left Triple Decimal, Set	22X452NN
SPB (2a)	Store Program Counter and Branch	17
SRD	Shift Right Double	22X220NN
SRDA	Shift Right Double Alpha	22X020NN

Note: (2a) indicates two-address instructions.

MNEMONIC	INSTRUCTION	OCTAL
SRDAS	Shift Right Double Alpha, Set	22X060NN
SRDD	Shift Right Double Decimal	22X420NN
SRDDS	Shift Right Double Decimal, Set	22X460NN
SRDT	Shift Right Double, Test	22X224NN
SRQA	Shift Right Quadruple Alpha	22X000NN
SRQAS	Shift Right Quadruple Alpha, Set	22X040NN
SRQD	Shift Right Quadruple Decimal	22X400NN
SRQDS	Shift Right Quadruple Decimal, Set	22X440NN
SRS	Shift Right Single	22Z230NN
SRSA	Shift Right Single Alpha	22X030NN
SRSAS	Shift Right Single Alpha, Set	22X070NN
SRSD	Shift Right Single Decimal	22X430NN
SRSDS	Shift Right Single Decimal, Set	22X470NN
SRST	Shift Right Single, Test	22X234NN
SRTA	Shift Right Triple Alpha	22X010NN
SRTAS	Shift Right Triple Alpha, Set	22X050NN
SRTD	Shift Right Triple Decimal	22X410NN
SRTDS	Shift Right Triple Decimal, Set	22X450NN
SSA (2a)	Set Status by ANDing *	67X00002
SSL (2a)	Set Status by Loading *	67X00003
SSO (2a)	Set Status by ORing *	67X00001
STD	Store Double	45
STQ	Store Quadruple	47
STS	Store Single	44
STT	Store Triple	46
SXA (2a)	Store Index in Address Field	32
VLD	Variable Length Divide	26
VLM	Variable Length Multiply	27

* Treated as an invalid instruction if an attempt is made to change certain bits of the Processor Status Word while the processor is in the optional User Mode.

MNEMONIC	INSTRUCTION	OCTAL
	Floating Point Instructions (Optional)	
FLD	Load FPAC	70
FST	Store FPAC	50
FAD	Floating Point Add	72
FSB	Floating Point Subtract	73
FMP	Floating Point Multiply	75
FDV	Floating Point Divide	76
FDI	Floating Point Divide Inverted	77
FPO	Floating Point Operation	66
FCP	Floating Point Compare	71
BRM	Branch FPAC Minus (mantissa)	11
BRG	Branch FPAC Greater	12
BRE	Branch FPAC Equal	13
BRL	Branch FPAC Less	14
BRZ	Branch FPAC Zero (mantissa)	15
MTE	Move to Exponent	52
MFE	Move from Exponent	51
ADE	Add to Exponent	53
SBE	Subtract from Exponent	54
SSP	Set FPAC Sign Plus (mantissa)	55003000
SSM	Set FPAC Sign Minus (mantissa)	55004000
SLB	Shift Left Binary	55002XXX
SRB	Shift Right Binary	55001XXX
CHS	Change Sign (mantissa)	55005000
NRM	Normalize FPAC	55000000
XQA	Exchange Q and A	55006000

Note: FPAC represents the Floating Point Accumulator.

MNEMONIC	INSTRUCTION	OCTAL
	Restricted Instructions** (Direct Access Option)	
HLT	Halt	00
GEN	General (I/O)	07
SMP	Set Memory Protect	64

** In the Optional User Mode, these instructions will be treated as invalid.

General (I/O Instruction)

All peripheral operations are initiated by the General instruction. The format of this instruction is 07XYYYFF, where:

X: . . . . ACF field, specifies address modification.
YYY: . . . . specifies the channel number and device number.
FF: . . . . command code; specifies the particular peripheral operation to be performed.

In general, the standard software for the GE-400 Series employs a different mnemonic code for each command code for each type of peripheral device. This effectively expands the instruction repertoire and facilitates the programming of peripheral operations using the assembly languages.

COMPATIBILITY: WITH IBM 1401

.1 GENERAL

Two standard techniques are available to aid users desiring to convert from an IBM 1401 to a GE-400 Series computer system. Both techniques employ direct simulation and are designed to allow an installation to remain productive while reprogramming and retraining are in progress. The 1401 Simulator program is a purely software approach that requires no special equipment beyond the core storage capacity and peripheral equipment needed to simulate a particular 1401 program. The 1401 Compatibility Option is a hybrid approach that requires a special hardware feature, the 1401 Compatibility Option, in connection with a special software routine. (The Capacitrix, an optional read-only memory containing a permanently-stored IBM 1401 simulation routine, has been withdrawn from the GE line.)

Both simulation techniques are fully described (and their limitations analyzed) in Paragraph 330:151.11 of the report section on Problem Oriented Facilities. Briefly, both techniques are capable of simulating an IBM 1401 with a 1402 Card Read Punch, a 1403 Printer, up to six magnetic handlers, and many of the more common special features.

The 1401 Simulator program requires a GE-400 Series core storage capacity of about eight times the size of the 1401 program. This routine is slow; estimates from GE indicate typical GE-400 Series running times of one-half to four times the 1401 run times, depending on the program and on the particular GE-400 Series model. GE also estimates that approximately 85% of the programs in a typical IBM 1401 business data processing installation can be run without alteration on a GE-400 Series system by use of the Simulator program.

The Compatibility Option requires 8,192 words (32,768 characters) of core storage to simulate a 1401 program of up to 12,000 characters. The special hardware features enable a 4,096-word segment of core storage to be addressed as a 12,288-character block of 8-bit characters (6 data bits, 1 word mark bit, and 1 unused bit per character). The capability to address the simulated 1401 program area by character speeds the isolation of the component parts of 1401 instructions and the ensuing simulation process, but the overall process is still relatively slow. GE estimates that run times of simulated programs on a GE-400 Series system will typically be from one-half to twice the run time on a IBM 1401. GE also estimates that about 90% of the programs in a typical IBM 1401 business data processing installation can be run without alteration on a GE-400 Series system with the Compatibility Option. Programs simulated with the 1401 Compatibility Option are interfaced with the standard operating system and can be run in the regular batch mode without special set-up techniques.

.2 CONVERSION OF DATA

.21 Punched Card Data

Existing IBM 1401 punched card files can be used without modification with the GE-400 Series.

.22 Magnetic Tape Files

Except for Compressed Tape Operations using magnetic tape files generated by or for an IBM 7070/7074, which cannot be simulated, the magnetic tape files used with an IBM 1401 can be used with the GE-400 Series with no difficulties.

.23 Collating Sequence

Both simulation techniques use the IBM 1401 collating sequence.

.3 CONVERSION OF PROGRAMS

In general, any 1401 object program within the limitations of the respective simulation methods can be simulated on a GE-400 Series computer system. In addition to the 1401 object program that is to be simulated, only one control card and a vertical format control tape for the GE printer are required. (The 1401 Compatibility Program requires additional control cards to identify the simulation routine on the systems tape and to permit linkage to the next job.)

In most cases, IBM 1401 source programs written in COBOL or FORTRAN will need to be modified slightly to enable them to be compiled by the GE-400 Series compilers. A test compilation will usually identify the areas that need rephrasing. Personnel now programming in COBOL and FORTRAN should experience little difficulty in converting, since these languages are largely independent of machine languages. Sections 330:161 and 330:162 present a description of the COBOL and FORTRAN languages as implemented for the GE-400 Series.

.4 CONVERSION OF PERSONNEL

The programming facilities of the GE-400 Series are quite different from those of the IBM 1401. Some of the features that will be new to personnel familiar only with an IBM 1401 computer system include:

- Relocatable, variable-length accumulator.
- Fixed word-length.
- Complex address modification techniques.
- Extensive program interrupt facilities.
- Scatter-gather input-output techniques.
- Capabilities for multiple simultaneous operations.

.4 CONVERSION OF PERSONNEL (Contd.)

The above features add greatly to the programming flexibility of the GE-400 Series systems, but they also require highly-trained personnel to make full use of the available capabilities. However, a detailed knowledge of GE-400 programming is not required to run 1401 object programs on a GE-400 system by one of the simulation techniques described here.

.5 OPERATING PROCEDURES

The same general operating procedures are followed on a GE-400 Series system as on a 1401. IBM 1401 displays and console operations, including sense switches, are simulated by means of the GE-400 Console Typewriter.

.6 SPECIAL TECHNIQUES

.61 Stacker Select Instructions

No provisions are made in either 1401 simulation technique for physically selecting out individual cards as a result of 1401 Stacker Select instructions. In the 1401 Simulator Program, the Stacker Select instruction is accepted but ignored. With the 1401 Compatibility Option, a user can elect either to ignore the instruction or to branch to an own-coded section that writes the selected records on magnetic tape for later punching and collation. Some reprogramming will probably be necessary wherever the logic of an existing 1401 program depends upon the Stacker Select facility.

.7 OPERATIONAL EFFICIENCY

Compared with the older IBM 1401, the GE-400 Series computer systems feature powerful, flexible facilities for simultaneous operations and high internal speeds. For typical business data processing, they are roughly 20 to 40 times as fast internally as the 1401. However, much of this speed advantage is lost when running 1401 object programs on a GE-400 system by simulation, due to the heavy demands for handling variable-length data fields and instructions on a basically fixed-word-length machine and the need for converting each address from the 1401 decimal format to the GE-400 Series binary format. The lack of a radix conversion instruction makes the latter a particularly time-consuming operation. Thus, the majority of 1401 programs run by simulation will probably be processor-limited, and it will clearly be advisable for the user to recode his main production runs at the earliest opportunity.

For more information on the performance of the two IBM 1401 simulation techniques for the GE-400 Series, see pages 330:131.100 (over) and 330:151.100 (Problem Oriented Facilities).

DATA CODE TABLE

Character	Hollerith Code	Six-Bit Code
0	0	000000
1	1	000001
2	2	000010
3	3	000011
4	4	000100
5	5	000101
6	6	000110
7	7	000111
8	8	001000
9	9	001001
A	12-1	010001
B	12-2	010010
C	12-3	010011
D	12-4	010100
E	12-5	010101
F	12-6	010110
G	12-7	010111
H	12-8	011000
I	12-9	011001
J	11-1	100001
K	11-2	100010
L	11-3	100011
M	11-4	100100
;	11-6-8	101110
:	5-8	001101
"	0-6-8	111110
'	11-7-8	101111
(	12-5-8	011101
)	11-5-8	101101
=	0-5-8	111101
!	0-7-8	111111
?	7-8	001111

Character	Hollerith Code	Six-Bit Code
N	11-5	100101
O	11-6	100110
P	11-7	100111
Q	11-8	101000
R	11-9	101001
S	0-2	110010
T	0-3	110011
U	0-4	110100
V	0-5	110101
W	0-6	110110
X	0-7	110111
Y	0-8	111000
Z	0-9	111001
.	12-3-8	011011
,	0-3-8	111011
%	0-4-8	111100
[	2-8	001010
-	11	101010
$	11-3-8	101011
*	11-4-8	101100
&	12	011010
/	0-1	110001
+	12-0	110000
Space	(Blank)	010000
#	3-8	001011
@	4-8	001100
>	6-8	001110
<	12-6-8	011110
\	12-7-8	011111
↑	11-0	100000
←	0-2-8	111010
]	12-4-8	011100

Reprinted from PR-20 Printer Reference Manual, page V-15.

PROBLEM ORIENTED FACILITIES

.1 UTILITY ROUTINES

.11 Simulators of Other Computers

1401 Simulator

Availability: . . . . currently in use.
Description:

The 1401 Simulator program is designed to enable a GE-400 Series computer system to execute directly, without need for translation or other alteration, certain programs written for an IBM 1401 computer system. The maximum 1401 configuration that can be simulated is:

- 16,000 character positions of core storage.
- Six magnetic tape handlers (any model except 7340 Hypertape).
- One 1402 Card Read Punch.
- One 1403 Printer.

All standard instructions can be simulated except stacker select and those dealing with peripheral devices not listed above. The Stacker Select instruction will be accepted but ignored. The 1401 collating sequence is simulated, so the results of comparisons in the simulation mode will be the same as in the 1401.

The following 1401 special features can be simulated:

Multiply-Divide (with field-length restrictions).
Additional Print Control.
Expanded Print Edit.
Indexing.
Store Address Register.
Move Record.
High-Low-Equal Compare.
Sense Switches.

The Start Read Feed and Start Punch Feed instructions, which require a 1401 Special Feature, are accepted but ignored. The branch option for these instructions is treated as an unconditional branch. In general, GE states that no difficulty is encountered in simulating 1401 programs making use of these special features on a GE-400 Series system.

The following 1401 special features cannot be simulated and cause unpredictable results when encountered:

Compressed Tape Operations.
Column Binary (except Branch on Bit Equal).
Numerical Print.
Interchangeable Chain Cartridge Adaptor.
Processing Overlap.
All "RPQ" (Request Price Quotation) features and peripheral devices.

There are several other restrictions on IBM 1401 programs to be simulated. These include the following:

- The product resulting from a Multiply instruction is restricted to a length of 80 digits. If this length is exceeded, a message will be typed on the console typewriter, the fields adjusted to produce the high-order 80 characters of the product, and the program continued.
- The dividend and divisor of a Divide instruction cannot exceed 16 digits. The simulation routine uses only the low-order 16 digits of each field, and the results developed could be erroneous. This condition is not flagged in any way.
- The combined lengths of all magnetic tape blocks specified on the control card must not exceed:

  2,500 characters for an 8K GE-400.
  16,600 characters for a 16K GE-400, or
  49,920 characters for a 32K GE-400.

  If these limits are exceeded, a message is typed on the console typewriter and the job is halted.
- The Branch on Channel 9 instruction is simulated the same as the Branch on Channel 12 instruction.

Simulation of an IBM 1401 program on a GE-400 Series computer having the required complement of peripheral devices requires only the 1401 object program deck, including clear storage and loader cards, a vertical format control loop for the printer, the 1401 Simulator deck, and one control card. The control card specifies the maximum block lengths for each magnetic tape file, the initial sense switch settings, the channel assignments for the peripheral devices, and the maximum number of characters per line to be typed on the console typewriter.

All operating instructions used when running a program on a 1401 apply when simulating it on a GE-400 Series system. The current settings of sense switches can be printed out on the console typewriter, and the settings can be changed by means of the keyboard. Programmed halts in a 1401 program cause the current I, A, and B addresses to be typed out in decimal form on the console typewriter.

The 1401 Simulator contains a built-in core storage dump routine that is available to the operator. When using the dump routine, all of core storage is output to the printer in two formats. The core storage area outside the simulated 1401 program area

.11 Simulators of Other Computers (Contd.)

is dumped in a format similar to that of the standard GE Post-Mortem Memory Dump Routine. The simulated 1401 memory area is dumped in a format similar to that produced by 1401 machine-language core dump programs; i.e., two lines are printed per 100 simulated 1401 characters. The first line contains the 1401 address of the low-order memory location on that line and 100 BCD characters; the second line contains the octal simulator address of the low-order memory location and a "1" under each character which has a word mark associated with it.

This dump routine is not available when a 1401 program using magnetic tape is simulated on a GE-400 Series system with only 8,192 words of core storage. A 1401 machine-language core dump program can be used in this situation to dump the simulated 1401 memory area.

The core storage capacity of the GE-400 Series computer must be approximately eight times the size of the program to be simulated; e.g., a 1401 program requiring 4,000 character positions of core storage would require a GE-400 Series core storage capacity of approximately 32,000 characters, or 8,000 words.

The simulation technique is similar to that used in the 1401 Compatibility Option Program described later in this section.

The 1401 Simulator program is not compatible with the operating systems available for the GE-400 Series computers. Thus, when alternating between simulated 1401 programs and regular GE-400 Series programs, the operating system must be reinitialized each time.

The impact of the 1401 Simulator program on the problem of converting from an IBM 1401 to a GE-400 Series computer system is discussed in Section 330:131, "Compatibility with the IBM 1401." GE estimates that the total run time of an IBM 1401 program on a GE-400 Series computer system will typically be one to four times longer than on the 1401. For additional information on the performance of a GE-400 Series computer system when simulating an IBM 1401, see Section 330:131.

IBM 1401 Compatibility Option Program

Availability: . . . . currently in use.
Description:

The Compatibility Option Program is a simulation program that is used in conjunction with the Compatibility Option hardware features described in Paragraph 330:051.12 to simulate an IBM 1401 on a GE-400 Series computer system. Briefly, these features provide an alternate mode of operation, the compatibility mode. In this mode, one 4,096-word segment of a GE-400 Series core storage unit is addressed as a 12,288-character block of 8-bit characters, and one I/O channel, assigned to a magnetic tape controller, is used to transfer data between magnetic tape and the modified segment of core storage in the modified format.

The maximum IBM 1401 configuration that can be simulated by a GE-400 Series system using the Compatibility Option is as follows:

- 12,000 characters of core storage.
- Six magnetic tape handlers (any model except 7340 Hypertape).
- One 1402 Card Read Punch.
- One 1403 Printer.

All standard instructions can be simulated except those dealing with peripheral devices not listed above. In the case of the Stacker Select instruction, the user has the option of ignoring the instruction or of writing a routine that outputs the selected unit records on magnetic tape for later punching and collation. The normal 1401 collating sequence is simulated and used to determine the results of compare operations. The following 1401 special features can be simulated by the 1401 Compatibility Option:

Advanced Programming (includes Indexing, Store A Address, Store B Address, and Move Record).
Bit Test.
High-Low-Equal Compare.
Multiply-Divide.
Processing Overlap.
Sense Switches.
Read Punch Release.
Early Card Read.
Expanded Print Edit.
Additional Print Control.
Print Storage.
Space Suppression.
800 CPI Feature.
Tape Intermix.

The following 1401 special features cannot be simulated by the 1401 Compatibility Option:

Column Binary.
51-Column Feed Adapter.
Punch Feed Read Control.
Selective Tape Listing Feature.
Interchangeable Chain Cartridge.
Compressed Tape.
All "RPQ" (Request Price Quotation) features and peripheral devices.

The 1401 Compatibility Program occupies the low-order 4,096 words of core storage. Space is reserved in this area for input and output areas for the card reader, card punch, and printer. Card reading, card punching, and printing proceed independently of the 1401 program to permit maximum use of the simultaneity of I/O operations in a GE-400 Series computer system. Card and print line images are transferred to and from the 1401 program area upon demand by the program. Magnetic tape records are transferred directly between the character-addressable core storage area holding the 1401 program and the tape handlers.

The processor is delayed for the entire duration of all magnetic tape operations except rewinds.

(Contd.)

.11 Simulators of Other Computers (Contd.)

The simulation technique includes establishing pseudo-registers for the A address, B address, I address, d modifier, etc. Once the Compatibility Option Program and the IBM 1401 program have been loaded, the pseudo-I-address register is loaded with the starting address of the 1401 program. Each 1401 instruction is examined character by character to isolate the operation code, addresses, and d modifier. The address fields, if any, are converted into the equivalent addresses in the character-addressable memory and are modified if called for. A branch is then made to a subroutine that simulates the specified 1401 operation code. There is approximately one subroutine for each 1401 function. The desired operation is carried out on the 1401 data fields through execution of GE-400 instructions in the compatibility mode.

The 1401 Compatibility Option requires the use of the Basic Input/Output Supervisor to provide I/O control for the card reader, card punch, and printer. The minimum configuration of a GE-400 Series computer system for simulation of an IBM 1401 via the 1401 Compatibility Option is:

- GE-400 Series processor with 8,192 words of core storage and the 1401 Compatibility Option.
- One card reader.
- One card punch.
- One printer.
- Magnetic Tape Handlers as required by the IBM 1401 program being simulated.

The above system is limited to the use of the Card Operating System (see Paragraph 330:191.12). If the Tape Operating System is to be used, one additional tape handler must be available to accommodate the System Tape. The 1401 Compatibility Option Program interfaces with the standard GE-400 Series Operating Systems and can be loaded via a card reader or from the System Tape. The 1401 program can also be loaded from cards or magnetic tape. The Operating System provides run-to-run supervision, permitting 1401 programs to be interspersed with regular GE-400 programs with minimum set-up time.

All operating instructions used when running a program on a 1401 apply when simulating it on a GE-400 Series system. The initial settings of the sense switches are specified on a control record, and the current settings can be printed out or changed by means of the console typewriter. All usual displays normally found on an IBM 1401 are simulated by printouts on the console typewriter whenever a Halt instruction is encountered in the 1401 program. In addition, the following 1401 console operations can be initiated by typing the appropriate control code:

Tape selection.
Load card or load tape.
Move characters to memory.
Load characters to memory.
Write characters from memory.
Branch.
Rewind magnetic tape.
Backspace magnetic tape.

Several service and diagnostic routines are contained within the 1401 Compatibility Option and are available to the operator. These include:

Memory dump (including edited 1401 memory).
Initiate trace.
Halt trace.

The 1401 Compatibility Option provides the capability to simulate the 1401 Systems Tape Operation and its associated software. GE indicates that Autocoder assemblies and other 1401 software functions can be simulated if a program requires changes that cannot be handled by patching at object level. Autocoder assemblies take from two to three times as long as on the 1401.

GE estimates that, in a typical installation, about 90% of the programs can be simulated directly without any alterations, and that execution of the simulated programs will typically take from about the same time to twice the time they required on a 1401.

The impact of the 1401 Compatibility Option on the problem of converting from an IBM 1401 to a GE-400 Series computer system is discussed in Section 330:131, Compatibility with the IBM 1401.

.12 Simulation by Other Computers: . . . . none.

.13 Data Sorting and Merging

GE 400 Series Sort Generator

Reference: . . . . Reference Manual CPB-356.
Record size: . . . . . . 4 to 512 words.
Block size: . . . . 4 to N words.
Key size: . . . . 1 to 2,048 characters.
File size: . . . . 1.25 reels (unlimited if Merge is used afterwards).
Number of merge tapes: . . . . 3 to 8.
Data available: . . . . June, 1964.

Description:

The Sort Generator can be run on a GE-400 Series system with a minimum of 8,192 words of core storage, 4 magnetic tape units, a card reader, and a printer. The Sort routine generates an object program that sorts data files according to descriptive parameters specified in punched cards. It can accept either basic (BAL) or macro (MAP) assembly coding prepared by the user for inclusion in the Sort object program. The user's coding can be used to preprocess input files, to combine or eliminate duplicate records, and to process output data. Each generated sort routine is tailored for a specific job, and each of the following factors can reduce the overall time required for the sort:

- Higher tape speed and/or density.
- More tape units.

.13 Data Sorting and Merging (Contd.)

- More core storage.
- Smaller key size.
- Smaller record size.
- Larger input-output blocking factors.
- Dual-channel tape controller.

GE 400 Series Merge Generator

Reference: . . . . Reference Manual CPB-357.
Record size: . . . . . . 4 to 512 words.
Block size: . . . . 4 to N words.
Key size: . . . . 1 to 2,048 characters.
File size: . . . . unlimited.
Number of tapes: . . . 4 to 16.
Data available: . . . . June, 1964.
Description:

The Merge Generator is a generalized routine that produces merge programs tailored to specific applications on the GE-400 Series systems. Merge, which complements the Sort Generator's functions, generates object programs that merge data files according to descriptive parameters. It can accept either basic or macro language symbolic coding prepared as separate segments by the user for inclusion in the Merge object program.

The output of the Merge generator is symbolic. Merge calls in the Macro Assembly Program to process the symbolic output and produce an object program.

Minimum configuration requirements for the Merge Generator are 8,192 words of core memory, 4 magnetic tape handlers, 1 card reader, 1 printer, and 1 card punch.

.14 Report Writing

Report Program Generator

Reference: . . . . GE-425 System Manual, CPB-309.
Date available: . . . . . June, 1964.
Description:

The machine language programs created by the Report Program Generator can perform the following functions:

- Print a variable number of heading, control, detail, total, and footing lines.
- Maintain page overflow control.
- Provide page numbering.
- Provide up to nine levels of total lines plus final totals.
- Provide data editing.
- Accumulate input field values.
- Count selected input records and/or detail conditions.
- Emit literal values.
- Bypass the printing of a line.
- Provide multiple insert points for manually-coded routines supplied by the user.
- Provide group indication in detail lines.
- Assign certain records or lines to alternative or additional output devices.
- Assign multiple reports to a single tape for selective deferred printing or punching.

Input data records can be from a file on a card reader or magnetic tape. Output records can be assigned to the printer, card punch, or to magnetic tape for later media conversion.

The Report Program Generator is integrated with the Macro Assembly Program. The source program contains Identification, Environment, and Data Divisions as in the Macro Assembly Program. An added Report Division specifies the report layout, line definitions, control breaks, and line or item print control. The source program is read from cards or tape by the generator, which uses the Macro Assembly Program to assemble the object program from the generated macros. Object program output can be on tape (for immediate execution) or cards.

Four magnetic tape units, 8,192 core storage locations, 1 card reader, 1 card punch, and 1 printer are required for report program generation.

.15 Data Transcription

Media Conversion Service Routines

Reference: . . . . GE-425 System Mannual, CPB-309.
Date available: . . . . . June, 1964.
Description:

The Media Conversion package will include routines to perform the following operations:

- Card to tape
- Tape to card
- Tape to printer
- System Output Tape to printer.
- Card to Input Stack Tape.

Blocking and unblocking of files can be specified by parameters. Editing of fields, including selecting and eliminating specified fields, can be performed by user-coded inclusions. There are no current provisions for running media conversion routines concurrently with other programs; but see Paragraph 330:091.12, Operating Environment.

(Contd.)

.16 File Maintenance

Librarian

Reference: . . . . GE-425 System Manual, CPB-309.
Date available: . . . . . June, 1964.
Description:

The Librarian service routine provides for run collection on magnetic tape and for creation and maintenance of System Tapes and Master Instruction Tapes.

General Purpose Service Routines

Reference: . . . . GE-425 System Manual, CPB-309.
Date available: . . . . . June, 1964.
Description:

The General Purpose Service Routines include programs such as Disc Unload to Tape, Disc Load from Tape, Disc Dump to Tape or Printer, Tape Compare, and Tape Copy.

Integrated Data Store (I-D-S)

Reference: . . . . Introduction to Integrated Data Store.
Data available: . . . . . third quarter, 1965.
Description:

I-D-S is a GE-developed technique for the organization and manipulation of files for disc storage devices. Files are organized into a series of chains of logical records, one chain for each major type of record. Each chain contains one master record and one or more detail records. Each logical record, as stored on the magnetic disc unit, can optionally contain links to the master record or prior detail record, and will always contain a link to the next detail record. The chains are closed loops – the last detail record references the master record as the next record. Any record can be either a detail or master type and can be linked into any number of chains; however, there can be only one master record per chain. Information common to all detail records of a chain can be stored in the master record of that chain. The effect of this organization is to minimize the amount of information that needs to be stored in duplicate.

A set of Data Description entries defines each record. Information specified in these entries includes symbolic names for the record and individual fields, the symbolic name of each chain with which the record is to be linked, the relationship of the record to each chain (master or detail), the prime chain for the record, and various control fields required for record retrieval. All chains are ordered in one of three methods specfied in the control fields of the Data Description entries.

- Sorted – The detail records in a sorted chain are arranged in sequence based on one or more keys specified in the Data Description entries. Each key can be treated in either ascending or descending sequence.
- First-In/First-Out (FIFO) -- A new record is added to a chain by inserting it at the end of the chain, just prior to the master record.
- Last-In/First-Out (LIFO) – A new record is added to a chain by inserting it immediately after the master, making it the first detail record in the chain.

Individual records can be members of different chains using different sequencing methods.

The logical records are packed automatically into blocks (based on prime chains) for storage. Data is retrieved by blocks and transferred to buffers in core storage; individual records are then moved to working areas. Only the records in the working area are accessible to a programmer. Multiple blocks of data are maintained in core storage, based upon the amount of core storage available and the frequency of use of the data blocks. Each time a new block of data is called into core storage, the block that had the least previous usage is returned to the disc unit, provided any of the records it contains has been modified. Only record fields that have been modified are rewritten on the disc unit. Working areas for each type of record are maintained, and records become unavailable only when another record of the same type (name) has been called.

Four macro-instructions, in a format similar to COBOL verbs, are provided for manipulation of disc records:

- STORE – Links new records into a chain in accordance with its Data Description.
- RETRIEVE – Retrieves a record and unpacks it into a working area.
- MODIFY – Uses the contents of specified fields in a working storage area to modify (add to or subtract from only) or to replace the corresponding fields of a record.
- DELETE – Causes a record to be deleted from a file and the links to be reformed. In general, when a master record is deleted, all the associated detail records are also deleted. If one of these detail records happens to be a master record for a second chain, the details in the second chain are also eliminated. This process continues until all dependent detail records have been deleted. If desired, the records deleted can be printed out, or the deletion process can be aborted with no resultant deletions if a specified detail record is encountered.

Except for the STORE command, the record involved can be specified to be the current, next, previous, or master record of a chain. Conditional phrases are provided, permitting a transfer to a program step or the performance of a series of program steps out of the normal sequence with return to the step immediately following the branch, based on the record name of the record accessed. Other control phrases permit the processing of alternate records if retrieved, execution of subroutines, and error checking.

.16 File Maintenance (Contd.)

I-D-S provides mass storage facilities for GE-400 Series COBOL programs, although it does not follow the format of the ASA COBOL preliminary standard for mass storage facilities as stated in ASA X-3.4 COBOL Information Bulletin #4. I-D-S cannot be used with the other GE-400 Series programming languages. The minimum system configuration capable of using I-D-S is as follows:

- 16,384 words of core storage.
- Disc Storage Subsystem (DS-20, DS-15, or DS-25).
- 4 magnetic tape handlers.
- 1 card reader, 1 card punch, and 1 printer.

.17 Other

GE-400 Series Loader

Reference: . . . . Reference Manual CPB-354.
Data available: . . . . . June, 1964.
Description:

The GE-400 Series Loader is designed to operate within an operating system environment or independently. It has a modular construction. Input to the loader must be from a single source; binary segments from a library tape may be included, however, The loader allows the processing of a program which contains overlays with a minimum amount of instruction from the programmer.

Debugging Aids

Reference: . . . . GE-425 System Manual, CPB-309.
Date available: . . . . . June, 1964.
Description:

The following debugging aids are provided:

- Dynamic Debugging Aids — selective memory dump and selective trace (executed during object program testing).
- Post-Mortem Debugging Aids — post mortem memory dump and tape dump (executed upon conclusion of object program testing).
- Test Data Dispersion — creates magnetic tape files containing data for testing programs.
- Debug Segment — inserts exits to selective dump or trace routines into programs being tested.
- Checkpoint Recovery — permits restarting of interrupted production runs.

PROBLEM ORIENTED LANGUAGE: COBOL/400

.1 GENERAL

.11 Identity: . . . . COBOL/400.

.12 Origin: . . . . GE Computer Dept.

.13 Reference: . . . . GE Advance Publication CPA-1001.

.14 Description

COBOL-61 is the most widely implemented pseudo-English common language for business applications. The COBOL/400 language for GE-400 Series computer systems consists of Required COBOL-61, except for a few exceptions and extensions listed below, and most of the features of Elective COBOL-61. Neither the SORT nor Report Writer extensions to COBOL-61 have been implemented. Mass storage facilities have been implemented, although in a non-standard way. (See the description of I-D-S in Paragraph 330:151.16.)

Several interesting extensions to COBOL-61 are provided in COBOL/400. One option of the NOTE clause allows a limited range of diagnostic statements to be inserted into the program when compiling in the Object Program Debug Mode. When compiling in the Normal Compilation Mode, these diagnostic statements appear only on the listing. Facilities available in this option of the NOTE clause include the ADD, SUBTRACT, DISPLAY, and MOVE verbs. A special verb usable only in this format is PRINT, which causes the values of a list of variables to be printed on a specified line printer.

Another extension, the PACKING and UNPACKING TECHNIQUE options of the I-O-Control clause, can ease the problem of efficiently storing information on magnetic tape or punched card files, which is often encountered on fixed word-length computers. The flexible scatter-gather I/O facilities of the GE-400 Series computer are used to eliminate non-significant portions of data words. This technique can be used only with files containing a single type of data record.

The DCW EXCHANGE TECHNIQUE option of the I-O-Control clause allows input and output areas to be alternated by switching the Data Control Words. This eliminates the necessity to move data from an input area to an output area. The files involved in this operation must have the same record length and blocking factor.

The COMPUTE verb is a valuable COBOL-61 elective that is included in COBOL/400. This verb permits arithmetic operations to be expressed in a concise formula notation similar to that of FORTRAN. For example, the COBOL operations:

SUBTRACT B FROM A GIVING T

DIVIDE C INTO T GIVING X

can alternatively be expressed as:

COMPUTE X = (A-B)/C.

Other electives of COBOL-61 that are provided include the ENTER verb, which permits the inclusion of BAP symbolic language anywhere in a COBOL source program, and rerun facilities.

The most important COBOL-61 electives not currently implemented are the INCLUDE verb, which would permit the use of program libraries, and the Segmentation feature, which would provide techniques for handling programs too large to fit into core storage at one time. Segmentation facilities are being developed by GE for COBOL/400, but they will not follow the standard of COBOL-61. Detailed lists of the restrictions, extensions, and electives provided in COBOL/400 are included at the end of this description.

COBOL/400 programs are compiled and run under the control of the Tape Operating System (see Section 330:191). Section 330:182 describes the COBOL compiler for the GE-400 Series computer systems, which accepts source programs written in the language described here.

.141 Availability

Language (COBOL/400): April, 1964.
Compiler: . . . . May, 1965.

.142 Deficiencies with Respect to Required COBOL-61

(1) Only one dividend or multiplicand can be specified in a single DIVIDE or MULTIPLY clause.

.143 Extensions to COBOL-61

(1) One option of the NOTE clause provides the optional capability to compile diagnostic statements.

(2) The PACKING and UNPACKING TECHNIQUE options of the I-O-Control clause permit the information in files containing records of the same data type to be efficiently packed by omitting the non-significant portions of data words.

(3) The DCW EXCHANGE TECHNIQUE option of the I-O-Control clause can eliminate movement of data from an input area to an output area if the respective files have the same record length and blocking factor.

(4) The I-D-S technique (Paragraph 330:151.16) provides mass storage facilities for COBOL/400 programs, though not in accordance with COBOL-61 Extended.

.144 COBOL-61 Electives Implemented (see Paragraph 4:161.3 in Users' Guide)

Key No.	Elective	Comments
	Characters and Words	
1	Formula characters	Formulas are allowed.
2	Relationship characters	The symbols <, >, = are allowed.
3	Semicolon	A semicolon is in the character set.
4	Long literals	The maximum size is 132 characters.
	File Description	
8	BLOCK CONTAINS	A range of block sizes can be given.
9	FILE CONTAINS	The approximate size of the file can be shown.
11	SEQUENCED ON*	Key fields can be listed for documentation only.
	Record Description	
13	Table-length	Lengths of tables and arrays may vary.
16	RANGE IS	Value range of items can be shown.
17	RENAMES	Alternative groupings of elementary items can be specified.
20	Conditional ranges	VALUES can be ascribed to conditionals.
21	Label handling	Special label procedures may be used.
	Verbs	
22	COMPUTE	Algebraic formulas may be used.
24	ENTER	BAP symbolic language can be used in a program.
26	USE	Non-standard auxiliary I/O error-handling or label-handling routines can be inserted.
	Verb Options	
27	LOCK	A rewound tape can be optionally locked.
28	MOVE CORRESPONDING	Commonly-named items in a group can be handled together.
30	ADVANCING	Specific paper advance instructions can be given.
31	STOP provision	Information can be printed on the Console Typewriter.
32	Formulas	Algebraic formulas may be used.
33	Operand size	Operands can be up to 16 digits in length.
34	Relationship	IS EQUAL TO, EQUALS, EXCEEDS relationships are allowed.
35	Tests	IF x IS NOT ZERO test is allowed.
36	Conditionals	Implied subjects with implied objects are allowed.
37	Complex conditionals	ANDs and ORs may be intermixed.
38	Complex conditionals	Nested conditionals are permitted.
39	Conditional statements	IF, SIZE ERROR, AT END, ELSE (OTHERWISE) may follow an imperative statement.
	Environment Division	
40	SOURCE-COMPUTER	Computer description can be given.
41	OBJECT-COMPUTER	Computer description can be given.
44	PRIORITY IS	Priorities can be assigned to files.
46	I-O-CONTROL	A full range of rerun techniques is available.
	Identification Division	
47	DATE-COMPILED	The current date is inserted automatically.
	Special Features	
49	Segmentation	Facilities will be provided later, but in a non-standard manner.

* The compiler will accept but ignore this clause.

(Contd.)

.145 COBOL-61 Electives Not Implemented

Key No.	Elective	Comments
	Characters and Words	
5	Figurative constants	HIGH or LOW BOUND(S) are not available.
6	Figurative constants	HIGH or LOW VALUE(S) are not available.
7	Computer-name	No alternative object computers.
	File Description	
10	Label formats	Labels must be standard, omitted, or completely programmed.
12	HASHED	Hash totals cannot be created.
	Record Description	
14	Item-length	Variable length items cannot be specified.
15	BITS option	Items cannot be specified in binary.
18	SIGN IS	No separate signs allowed.
21	Label handling	Only standard labels (or none) may be used.
	Verbs	
23	DEFINE	The user cannot define new verbs.
25	INCLUDE	No library routines available automatically.
	Environment Division	
42	SPECIAL-NAMES	Hardware devices, and their status conditions, cannot be given special names by the program.
43	FILE-CONTROL	File naming and description of desired control method cannot be taken from the library.
45	I-O-CONTROL	Input-Output control cannot be taken from the library.
	Special Features	
48	Library	Library facilities for the procedure division are not available.

PROBLEM ORIENTED LANGUAGE: BASIC FORTRAN IV

.1 GENERAL

.11 Identity: . . . . GE-400 Series Basic FORTRAN IV.

.12 Origin: . . . . GE Computer Dept.

.13 Reference: . . . . GE Advanced Information Publication #CPB-1086, January, 1965.

.14 Description

GE-400 Series Basic FORTRAN IV is an implementation of the Basic FORTRAN language as proposed by the X.3.4.3 FORTRAN Group of the American Standards Association, and as published in the Communications of the ACM, October, 1964. A few extensions have been included from the full FORTRAN language as proposed by the same A.S.A. group and published side-by-side with the Basic FORTRAN specifications. The extensions include the appropriate parts of Paragraphs 7.1.1.3, 7.1.2.1.2, 7.1.3.3, 7.2.1.5, 7.2.1.6, 7.2.3.5, and 7.2.3.10 of the published document referenced above. The facilities provided by these extensions include: the Assigned GO TO, EXTERNAL, and TYPE statements; the capability to specify the line spacing by the first character (non-printing) of a record to be printed; the capability to specify scale factors for FORMAT statements; and the capability to specify an array name in an input-output list.

In essence, the GE-400 Series Basic FORTRAN IV language is a restricted version of the FORTRAN IV language as implemented for the IBM 7090/7094. A general description of the IBM 7090/7094 FORTRAN IV language is presented in Section 408:162. The principal restrictions upon the GE-400 Series FORTRAN IV language are the lack of double precision, complex, and logical capabilities, and the inability to modify programs at object time. The restrictions and extensions of the GE-400 Series version relative to IBM 7090/7094 FORTRAN IV are listed in Paragraphs .141 and .142, respectively.

See Section 330:183 for a description of the GE-400 Series Basic FORTRAN IV Translator, which compiles programs written in the language described in this section.

.141 Restrictions Relative to IBM 7090/7094 FORTRAN IV

(1) The following statements are not provided:

BLOCK DATA
DATA
IF (t)s.

(2) No facilities are provided for COMPLEX, DOUBLE PRECISION, or LOGICAL operations.

(3) The maximum size of integer constants is 2^{23}-1 in GE-400 FORTRAN IV as compared to 2^{35}-1 in 7090/7094 FORTRAN.

(4) FORMAT statements cannot be read at object time.

(5) Variables cannot appear as subscripts in DIMENSION statements; i.e., adjustable dimensions are not allowed.

(6) Block names are not permitted in COMMON statements.

(7) In the FORMAT specification Aw, the maximum number of significant alphameric characters per item is four (versus six in 7090/7094 FORTRAN IV).

.142 Extensions Relative to IBM 7090/7094 FORTRAN IV

(1) Variables can have up to three levels of subscripting in EQUIVALENCE statements.

(2) Type statements can be used to dimension variables.

(3) The range of REAL numbers in GE-400 Series FORTRAN IV is $10^{\pm 127}$ versus $10^{\pm 35}$ in IBM FORTRAN IV. (Precision is the same: 8 digits.)

MACHINE ORIENTED LANGUAGE: BASIC ASSEMBLY LANGUAGE

.1 GENERAL

.11 Identity: . . . . GE-400 Series Basic Assembly Lanugage. BAL.

.12 Origin: . . . . GE Computer Dept., Phoenix, Arizona.

.13 Reference: . . . . GE-400 Series Reference Manual CPB-351.

.14 Description

The Basic Assembly Language (BAL) is a subset of the more powerful and versatile Macro Assembly Program (MAP) Language (Section 330:172), and is translated by the Macro Assembly Program (Section 330:181). Although BAL can be used to code an entire program, it will usually be combined with the more flexible MAP language, within which all BAL facilities are available.

The Basic Assembly Language was designed to provide:

- A symbolic representation of the entire GE-400 Series instruction repertoire.
- A set of pseudo-operations for the reservation of memory areas, for the handling of decimal and octal constants, and for program segmentation.
- The optional capability of referencing a program in a subroutine library.
- Compatibility with the Macro Assembly Program Language.
- A symbol analyzer at the termination of the assembly.
- A convenient coding form identical to that used for the Macro Assembly Program language.

Featured in BAL is a program segmentation facility that allows individual operations to be tested separately, simplifies debugging, and permits overlaying of areas in core memory. Segments are assembled with relocatable addresses and communicate with the main program or other segments by means of global symbols. There are two types of global symbols: internal and external. A global symbol is "internal" to the segment in which it is defined and "external" to any segment in which it is referenced except that segment in which it is defined. Global symbols are indicated by means of pseudo-operations. Symbols which are referenced only within the segment in which they are defined are called local labels.

Programs written in the Basic Assembly Language can use the Basic Input/Output Supervisor, (see Paragraph 330:191.12), which is a set of routines, constants, and tables that are in core memory during the execution of each program. In general, the main program communicates with the I/O system by constructing a file parameter list for each device and executing a Store Program Counter and Branch (PXB) instruction whenever an I/O operation is required.

.15 Publication Date: . . . . December, 1963.

.2 LANGUAGE FORMAT

.21 Diagram: . . . . refer to coding form, Page 330:171.820.

.22 Legend

Sequence: . . . . sequence numbers; checked using GE 400 series collating sequence (optional).
Type:. . . . . indicates a comments line.
Reference Symbol: . . . enables assignment of symbols to instructions, constants, etc.
Operation: . . . . mnemonic or absolute code indicating machine or pseudo operations.
Operation Parameters: parameters needed to complete the function (symbolic or absolute address, an expression, a literal, or a value) and comments.
Indentification: . . . . . identifies the program on the printed assembly listings.

.23 Corrections: . . . . no special provisions.

.24 Special Conventions

.241 Compound addresses: . expression — a series of symbols and/or integers connected by +, -, * and /.

.242 Multi-addresses: . . . . two lines are used for the machine instructions that require 2 addresses.

.243 Literals: . . . . preceded by #, #O, #B, #S, #F, or " and followed by #, blank, comma, or " (see Paragraph .412).

.244 Special coded addresses: . . . . * refers to the current value of the location counter.

.245 Other — Immediate Value Literals: . . . . value of literal is placed in the address portion of the instruction itself.

.245 Other (Contd.)

Complementary Instruction Words: . . special mnemonic codes to set up counters, list pointers, data control words, address modification, second addresses, and input-output control.

.3 LABELS

.31 General

.311 Maximum number of labels: . . . . 1,200.
.312 Common label formation rule: . . . . . . yes.
.313 Reserved labels: . . . . special characters are used for standard routines.
.314 Other restrictions: . . . at least one character must be alphabetic.
.315 Designators: . . . . none.
.316 Synonyms permitted: . yes; EQU pseudo.

.32 Univeral (Global) Labels: . . . . indicated by pseudo operations; see Paragraph .12 above.

.321 Labels for procedures —
Existence: . . . . mandatory if referenced in another segment (internal) or if defined in another segment and referenced by current segment (external).
Formation rule —
First character: . . alphanumeric; A-Z, 0-9.
Others: . . . . same.
Number of characters: . . . . 1 to 8 characters; at least one must be alphabetic. (Note: blanks are deleted.)
.322 Labels for library routines: . . . . same as procedures.
.323 Labels for constants: . same as procedures.
.324 Labels for files: . . . . same as procedures.
.325 Labels for records: . . same as procedures.
.326 Labels for variables: . same as procedures.
.327 Labels for Basic I/O subroutines —
Existence: . . . . mandatory if Basic I/O System is used.
Formation rule —
First two characters: . . . . B%.
Other: . . . . alphanumeric; A-Z, 0-9.
Number of characters: . . . . 1 to 8.

.33 Local Labels

.331 Region: . . . . local to segments in which they are defined.
.332 Labels for procedures —
Existence: . . . . mandatory if referenced within the segment.
Formation rule —
First character: . . alphanumeric A-Z, 0-9.
Others: . . . . same.
Number of characters: . . . . 1 to 8 characters; at least one must be alphabetic. (Note: blanks are deleted.)
.333 Labels for library routines: . . . . see Universal Labels, above.
.334 Labels for constants: . same as procedures.
.335 Labels for files: . . . . same as procedures.
.336 Labels for records: . . same as procedures.
.337 Labels for variables: . same as procedures.

.4 DATA

.41 Constants

.411 Maximum size constants —
Integer:
Decimal: . . . . 16 digits plus sign.
Octal: . . . . 32 octal digits.
Fixed numeric: . . . . own coding (octal).
Floating numeric: . . 8 decimal digits for fraction and 3 for exponent; exponent must be less than 128.
Alphabetic: . . . . 13 words (52 characters).
Alphameric: . . . . . . 13 words (52 characters).
.412 Maximum size literals —
Integer:
Decimal: . . . . 16 digits plus sign (preceded by # and followed by #, comma, or a blank).
Binary: . . . . decimal integer from 0 to 16, 777, 215 (preceded by #B and followed by #, blank, or a comma).
Octal: . . . . 32 octal digits (preceded by #0 and followed by #, two blanks, or a comma).
Fixed numeric: . . . no provision.
Floating numeric: . 8 decimal digits for fraction, 3 for exponent; exponent must be less than 128; (preceded by #F and followed by #, two blanks, or a comma).
Alphabetic: . . . . . . 16 characters (preceded and followed by ").
Alphameric: . . . . . 16 characters (preceded and followed by ").

.5 PROCEDURES

.51 Direct Operation Codes

.511 Mnemonic —
Existence: . . . . alternative.
Number: . . . . 247.
Example: . . . . ADS = Add Decimal Single.
Comment: . . . . 119 of the 247 are two-address instructions.
.512 Absolute —
Existence: . . . . alternative.
Number: . . . . 67 (octal).
Example: . . . . 50 = Add Decimal Single.

.52 Macro-Codes: . . . . . . none in BAL (see MAP language, Section 330:172).

(Contd.)

.53 Interludes: . . . . none.

.54 Translator Control

.541 Method of control —
Allocation counter:. . pseudo-operation.
Label adjustment: . . pseudo-operation.
Annotation: . . . . pseudo-operation, special cards, and notes.

.542 Allocation counter —
Set to Absolute: . . . . ORG, ORGO, SGMT.
Set to label: . . . . . . ORG.
Step forward: . . . . . ORG.
Step backward: . . . . ORG.
Reserve area: . . . . BSS, BSSL, BPS, BPSL, LSB, LSBL, ACUM, ARP, ARPL.

.543 Label adjustment —
Set labels equal: . . . EQU, EQUG.
Set absolute value: . . EQU, EQUG, EQUO.
Clear label table: . . . none.

.544 Annotation —
Comment phrase: . . . special card or notes after instruction line.
Title phrase: . . . . . . TTL, pseudo.

.545 Other: . . . . see table of pseudos, Paragraph .82.

.6 SPECIAL ROUTINES AVAILABLE

.61 Special Arithmetic

.611 Facilities: . . . . single and double precision fixed-point multiply and divide; normalized floating-point add, subtract, inverse subtract, multiply, divide, and inverse divide; un-normalized floating-point add, subtract, and multiply.

.612 Method of call: . . . . . CALL, INCL, or INCS pseudo-instructions.

.62 Special Functions: . . . see Basic Input/Output Supervisor, Paragraph .14.

.63 Overlay Control: . . . . provided by Basic Input/Output Supervisor.

.64 Data Editing

.641 Radix conversion: . . . BCD-to-binary and binary-to-BCD.
Code translation: . . . . none to date (ASA standard character codes are used).

.642 Format control —
Zero suppression: . . hardware Edit instruction.
Size control: . . . . . . hardware Edit instruction.
Sign control: . . . . . . hardware Edit instruction.
Special characters: . hardware Edit instruction.

.65 Input-Output Control

.651 File labels: . . . . none. *
.652 Reel labels: . . . . none. *
.653 Blocking: . . . . none. *
.654 Error control: . . . . . . Basic I/O System.

* These are functions of the Extended I/O Supervisor, described in Paragraph 330:091.12.

.655 Method of call: . . . . . PXB (Program Counter to Index and Branch) to appropriate Basic I/O routine.

.66 Sorting: . . . . GE-400 Series Sort and Merge Generators (see Section 330:151).

.67 Diagnostics

.671 Dumps: . . . . post-mortem memory dumps and tape dump.
.672 Tracers: . . . . selective trace.
.673 Snapshots: . . . . selective memory dump.

.7 LIBRARY FACILITIES

.71 Identity: . . . . Service Routines Library on Systems Tape or separate Library Tape.

.72 Kinds of Libraries: . . expandable master.

.73 Storage Form: . . . . . . magnetic tape.

.74 Varieties of Contents: . routines, subroutines, and macro generators.

.75 Mechanism

.751 Insertion of new item: . Librarian routine.
.752 Language of new item: machine or assembly language.
.753 Method of call: . . . . . CALL, INCL, or INCS pseudo-instructions.

.76 Insertion in Program

.761 Open routines exist: . . yes.
.762 Closed routines exist: . yes.
.763 Open-closed is optional: . . . . no.
.764 Closed routines appear once: . . . . yes.

.8 MACRO AND PSEUDO TABLES

.81 Macros: . . . . none in BAL (see Macro Assembly Program Language, Section 330:172).

.82 Pseudos

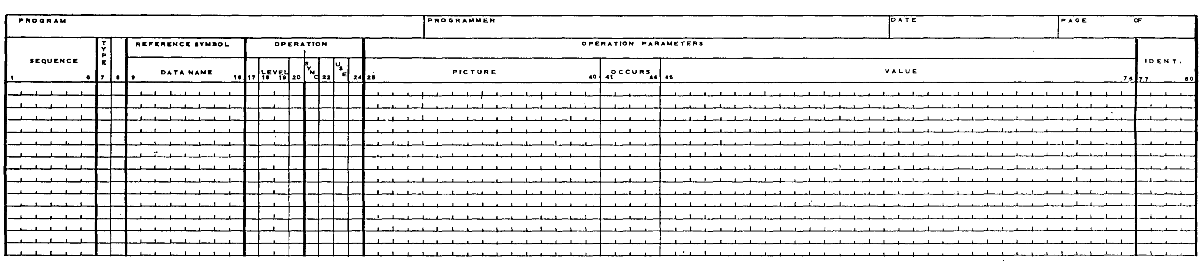
Code	Description
SGMT:	indicates name and address of segment.
DIG:	indicates symbolic global reference in the segment.
DXG:	indicates symbolic external global symbols in a segment. segment.
DGRX:	helps to reduce number of global symbols by "chaining".
DGRE:	ends definition of global symbols defined by DGRX.
DGR:	indicates beginning of common storage in a segment.

.82 Pseudos (Contd.)

Code	Description
EQUG:	equates a local symbol to an external global symbol.
CALL:	indicates that segments are needed which are on a library tape.
INCL:	indicates that segments are needed and must be supplied at assembly time.
INCS:	indicates that segments are needed and must be supplied and listed at assembly time.
BSSL, BPSL, LSBL, ARPL:	allows allocation of storage that is occupied by the loader.
BSS:	reserves a block of consecutive memory locations and defines a tag as the first location.
BPS:	reserves a block of memory and defines a tag as the location which immediately precedes the block.
LSB:	reserves a block of consecutive locations and assigns a tag to the last location.
ARP:	insures that those symbols used as accumulator references are defined as locations which are evenly divisible by 4.
FDEC:	defines a floating point decimal constant.
SBIN:	defines a signed binary constant.
RMT:	causes subsequent instructions to be assembled out of the normal sequence.
NRMT:	terminates the remote function initiated by RMT.
RMTL:	causes previously unprocessed blocks of instructions defined by an RMT to be assembled immediately. The TLI, TLD, and END pseudo-instructions also have this function.
ACUM:	establishes a working accumulator and assigns a tag.
FILL:	specifies the contents of Fill words produced by the assembler during processing of ARP or ACUM.
DECS, DECD, DECT, DECQ:	defines decimal constants.
AN:	defines an alphanumeric constant.
LSAN:	defines an alphanumeric constant with tag assigned to the last location.
OCTS, OCTD, OCTT, OCTQ:	defines an octal constant.
TTL:	specifies the heading line printed at the top of each subsequent page in the listing.
EJT:	causes the assembler to skip to the top of the next page.
IDEN:	specifies the identification, in columns 77-80, on the binary output cards.
FULL:	causes assembler to produce cards in full binary mode (40 instructions per card).
LORG:	specifies the beginning of a literal table in the object program.
ORG:	sets the location counter to a specific value.
ORGO:	sets the location counter to a specific octal number.
EQU:	equates a symbol to a value.
EQUO:	equates a symbol to an octal number.
PRFX:	specifies a unique prefix for a region of a segment.
TLI:	permits interruption in loading process to execute some instructions and then return control.
TLD:	terminates the assembly of a segment and prepares a TLD transfer card for the loader.
END:	terminates assembly of segment and prepares a transfer card for the loader.

GE 400 SERIES PROGRAMMING FORM

GENERAL ELECTRIC



MACHINE ORIENTED LANGUAGE: MACRO ASSEMBLY PROGRAM

.1 GENERAL

.11 Identity: . . . . GE-400 Series Macro Assembly Program Language. MAP Language.

.12 Origin: . . . . GE Computer Dept. Phoenix, Arizona.

.13 Reference: . . . . GE-400 Series Reference Manual CPB-351.

.14 Description

The Macro Assembly Program Language is an extension of the Basic Assembly Language (Section 330:171) and is the recommended language for machine oriented programming of GE-400 series systems. Input is divided into four divisions closely resembling those of COBOL: Identification, Environment, Data, and Procedure. In the Procedure Division, both Basic Assembly Language instructions and pseudo-instructions and Macro Assembly Program language statements can be used. The Macro Assembly Program (Section 330:181) converts source programs written in the Macro Assembly Language into machine language object programs.

The MAP system is an unusual compromise between the generalized, process oriented approach of compiler systems (such as COBOL) and the straightforward but time-consuming approach of simple symbolic assembly systems (such as the Basic Assembly Language). The objective is to minimize the detail work associated with assembly-level coding while retaining its characteristically high object program efficiencies.

The Macro Assembly Program Language was designed primarily to simplify the coding of these types of operations:

- Input-output.
- Arithmetic.
- Data movement.
- Procedure control.

The four divisions in a MAP language program have the following functions:

- The Identification Division identifies the source program, labels the output from the assembly, and specifies an absolute or relocatable assembly.
- The Environment Division indicates the characteristics of the object computer, specifies the major control routines required by the Extended Input-Output System or the Basic Input-Output Supervisor for execution of the object program, and specifies the method for including a subroutine.
- The Data Division, which consists of a File Section and a Working Storage Section, describes the input and output files to be processed and allocates memory for input-output buffers, intermediate work areas, file parameter tables, indexes, switches, and constants. Information such as data name, level number, picture, value, synchronization, redefinition, usage, and occurs must be supplied by the programmer. Special columns on the coding form are provided for this purpose.
- The Procedure Division contains macro-instructions or Basic Assembly Language symbolic instructions and pseudo-operations which define the functions to be performed.

The Macro Assembly Language is designed to operate with the Extended Input/Output System and the Basic Input-Output Supervisor (see Paragraph 330:191.12).

.15 Publication Date: . . . . December, 1963.

.2 LANGUAGE FORMAT

.21 Diagram: . . . . refer to coding form, Page 330:171.820.

.22 Legend

Data Division

Sequence: . . . . provides a sequence number check for cards in the source deck.

Type: . . . . describes the use of the line.

Data name: . . . . indicates name assigned to an entry.

Level: . . . . defines the various levels of a logical record and indicates related and unrelated items in working storage.

Sync (Synchronization): . . . . specifies the positioning of elementary items within a computer word or words.

Use: . . . . specifies how a data item is to be used in memory.

Picture: . . . . describes the mode, size, decimal point location, and editing characteristics of the named entry.

Occurs: . . . . indicates the number of times an item is to be repeated.

.22 Legend (Contd.)

Value: . . . . specifies an initial value for a data item in the Working Storage Section.
Ident (Identification): . . associates the individual card with a source program deck.

Procedure Division

Sequence: . . . . same use as in Data Division.
Type: . . . . indicates a comment or continuation line.
Reference Symbol: . . . assigns symbols to the instructions and pseudo instructions in the Procedure Division.
Operation: . . . . a mnemonic code: a macro instruction, machine instruction, or pseudo operation.
Operation Parameters: supply information needed to complete the operation function.
Ident (Identification): . . same use as in Data Division.

.23 Corrections: . . . . no special provisions.

.24 Special Conventions

.241 Compound addresses: reference symbol parameters ± decimal integer.
.242 Multi-addresses: . . . . standard in many macro instructions.
.243 Literals: . . . . non-numeric literals are enclosed in quotation marks.
.244 Special coded addresses: . . . . * refers to "this address."
.245 Other—
Operation parameters: . . . . consist of operands, choices, options, key words.

.3 LABELS

.31 General

.311 Maximum number of labels: . . . . 1,200 for 8K memory.
.312 Common label formation rule: . . . . . . yes.
.313 Reserved labels: . . . . names of standard library routines (begin with B%).
.314 Other restrictions: . . . at least one character must be alphabetic. Imbedded blanks are not allowed.
.316 Synonyms permitted: yes; EQU, EQUO, and EQUG pseudos in BAL.

.32 Universal (Global) Labels

.321 Labels for procedures—
Existence: . . . . mandatory if referenced in another segment (internal) or if defined in another segment and referenced by current segment (external).
Formation rule —
First character: . . alphanumeric (A-Z, 0-9).
Others: . . . . same.
Number of characters: . . . . . 1 to 8 characters; at least one must be alphabetic. Imbedded blanks are not allowed.
.322 Labels for library routines: . . . . same as procedures.
.323 Labels for constants: same as procedures.
.324 Labels for files: . . . . same as procedures.
.325 Labels for records: . . same as procedures.
.326 Labels for variables: same as procedures.
.327 Labels for Basic I/O Supervisor routines —
Existence: . . . . . . supplied when referenced by Extended I/O System or main program.
Formation rule —
First two characters: B%.
Others: . . . . alphanumeric (A-Z, 0-9).
Number of characters: . . . . 1 to 8.

.33 Local Labels

.331 Region: . . . . local to segments in which they are defined.
.332 Labels for procedures —
Existence: . . . . mandatory if referenced within the segment.
Formation rule—
First character: . . alphanumeric: A-Z, 0-9.
Others: . . . . same as first character.
Number of characters: . . . . 1 to 8 characters; at least one must be alphabetic. Imbedded blanks are not permitted.
.333 Labels for library routines: . . . . library routine labels are universal.
.334 Labels for constants: same as procedures.
.335 Labels for files: . . . . same as procedures.
.336 Labels for records: . . same as procedures.
.337 Labels for variables: . same as procedures.

.4 DATA

.41 Constants

.411 Maximum size constants —
Integer:
Decimal: . . . . 16 digits plus sign.
Octal: . . . . 32 octal digits.
Fixed numeric:
Decimal: . . . . 16 digits plus sign.
Floating numeric: . . 8 decimal digits for fraction, 3 for exponent; exponent must be less than 128.
Alphabetic: . . . . no restriction.
Alphameric: . . . . . . no restriction.
.412 Maximum size literals —
Integer:
Decimal: . . . . 16 digits plus optional sign.
Fixed numeric:
Decimal: . . . . 16 digits plus sign and/or decimal point.

(Contd.)

.412 Maximum size literals (Contd.)
Floating numeric: . . 8 decimal digits for fraction, 3 for exponent; exponent must be less than 128.
Alphameric: . . . . . . 40 characters, enclosed in quotes.

.42 Working Areas

.421 Data layout: . . . . specified in program.
.422 Data type:. . . . . tabulated in program.
.423 Redefinition: . . . . yes.

.43 Input-Output Areas

.431 Data layout: . . . . explicit layout.
.432 Data type:. . . . . specified in program.
.433 Copy layout: . . . . yes.

.5 PROCEDURES

.51 Direct Operation Codes:. . . . . all facilities of the Basic Assembly Language are usable (see Paragraph 330:171.51).

.52 Macro-Codes

.521 Number available—
Input-output: . . . . . . 12.
Arithmetic:. . . . . . . 8.
Math functions: . . . . 0.
Error control:. . . . . 1.
Restarts: . . . . 1.
Data movement:. . . . 3.
Procedure control:. . 7.
.522 Examples—
Simple: . . . . MOVE A; B.
Elaborate: . . . . IF A EQ B GOTO PLACE.
.523 New Macros:. . . . . . . no special provision.

.53 Interludes: . . . . none.

.54 Translator Control: . . see Basic Assembly Language (Paragraph 330:171.54).

.6 SPECIAL ROUTINES AVAILABLE

.61 Special Arithmetic

.611 Facilities: . . . . multiply and divide.
.612 Method of call: . . . . . CALL, INCS, or INCL pseudo instructions.

.62 Special Functions: . . . none to date.

.63 Overlay Control: . . . . provided by Loader.

.64 Data Editing

.641 Radix conversion: . . . BCD-to-binary and binary-to-BCD.
.642 Code translation:. . . . none to date (ASA standard character codes are used).
.643 Format control—
Zero suppression: . . implemented by hardware.
Size control:. . . . . . implemented by hardware.
Sign control:. . . . . . implemented by hardware.
Special characters: implemented by hardware.

.65 Input-Output Control

.651 File labels:. . . . . Extended I/O System.
.652 Reel labels: . . . . Extended I/O System.
.653 Blocking: . . . . Extended I/O System.
.654 Error control:. . . . . . Basic I/O and Extended I/O Systems.
.655 Method of call: . . . . . Basic I/O: Automatic & macros.
Extended I/O: macros and file parameter tables.

.66 Sorting

.661 Facilities: . . . . GE-400 Series Sort and Merge Generators (see Section 330:151).

.67 Diagnostics

.671 Dumps: . . . . post-mortem memory dump and various tape dumps.
.672 Tracers: . . . . selective trace.
.673 Snapshots: . . . . selective memory dump.

.7 LIBRARY FACILITIES

.71 Identity: . . . . Service Routines library on System Tape or separate Library Tape.

.72 Kinds of Libraries: . . expandable master.

.73 Storage Form:. . . . . . magnetic tape.

.74 Varieties of Contents: routines, subroutines, and macro generators.

.75 Mechanism

.751 Insertion of new item: Librarian routine.
.752 Language of new item: machine or assembly language.
.753 Method of call: . . . . . CALL, INCL, or INCS pseudo instructions.

.76 Insertion in Program

.761 Open routines exist: . . yes.
.762 Closed routines exist: yes.
.763 Open-closed is optional:. . . . . no.
.764 Closed routines appear once:. . . . . yes.

.8 MACRO AND PSEUDO TABLES

.81 Macros

Code	Description
MOVE:	transfers data from one item to another conforming to the description of the receiving item.
LOAD:	transfers data to the standard accumulator.
UNLOAD:	transfers contents of standard accumulator to a data area.

.81 Macros (Contd.)

Code	Description
COMPARE:	compares the contents of two data areas and transfers control to one of three symbols based on the result of that comparison (>, =, <).
IF:	branches to a symbol or continues in-line coding based upon the existence of a specified condition (>,<, =, not >, not <, ≠, +, -, zero, not zero, ON, OFF).
SETSW:	sets a programmer-specified switch to an on or off condition.
GOTO:	transfers control to a specified reference symbol.
GOTO . . . DEPENDING ON:	transfers control to one of n specified reference symbols based upon the value of a specified data name.
HALT:	halts the object program after ensuring that all critical computer operations have terminated.
EOJ:	terminates processing by the object program.
ABORT:	terminates processing by the object program under error conditions and causes a memory dump.
ADDR:	adds two numeric items and places the rounded result in the second item (or a third item, if specified).
ADDT:	same as above except that result is truncated.
SUBR:	subtract and round.
SUBT:	subtract and truncate.
MPYR:	multiply and round.
MPYT:	multiply and truncate.
DIVR:	divide and round.
DIVT:	divide and truncate.

Extended Input-Output System Macros

Code	Description
READ:	obtains the next logical record from an input file.
WRITE:	releases a record to an output file.
WRITEX:	releases a record without internal movement of the data record.
OPEN:	prepares input or output files for processing by input-output macro instructions.
CLOSE:	terminates the processing of input-output files.
TYPE:	performs requested typewriter input-output operations in alphanumeric or octal.
FSTM:	forward-space to tape mark.
BSTM:	back-space to tape mark.
BSNBLK:	back-space N blocks.
REWIND:	rewinds tape.
WRITETM:	writes tape mark.
CKPT:	writes checkpoint dump.
FORCE:	forces immediate end-of-reel processing.
RELEASE:	causes next READ or WRITE macro to reference start of new block.

.82 Pseudos: . . . . see Basic Assembly Language (Paragraph 330:171.82).

PROGRAM TRANSLATOR: MACRO ASSEMBLY PROGRAM

.1 GENERAL

.11 Identity: . . . . Macro Assembly Program. MAP.

.12 Description

The Macro Assembly Program (MAP) is used to convert programs written in the Basic Assembly Language, the Macro Assembly Language, or (most commonly) a combination of the two into GE-400 Series machine language. Minimum requirements for MAP are 8,192 words of memory, 4 magnetic tape handlers, printer, card reader, and punch. Additional tape units permit tape to be used in place of the card equipment and the printer.

MAP is a three-phase translator. The second phase is bypassed when the program being assembled contains only the Basic Assembly Language. The Translator phase reads and processes the source program. The Selector phase links macro calls with required generators. The final phase, the Assembler, assembles the generated and source Basic Assembly Language instructions and produces an object program deck and listing.

.13 Originator: . . . . . . GE Computer Department.

.14 Maintainer: . . . . . GE Computer Department.

.15 Availability: . . . . . June, 1964.

.2 INPUT

.21 Language

.211 Name: . . . . Macro Assembly Program Language and Basic Assembly Language.
.212 Exemptions: . . . . . none.

.22 Form

.221 Input Media: . . . . . punched cards or magnetic tape.
.222 Obligatory ordering: . Control and Option Cards.
Identification Division.
Environment Division (optional).
Data Division (optional).
Procedure Division.
End of Transfer Card.
.223 Obligatory grouping: list of subroutines required, data description, procedures.

.23 Size Limitations

.231 Maximum number of source statements: no limit.
.232 Maximum size source statements: . . . . . 1 card (Basic statements). no limit (Macro procedure statements).
.233 Maximum number of data items: . . . . . approximately 1,200 with 8K core memory.

.3 OUTPUT

.31 Object Program

.311 Language name: . . . GE-400 Series relocatable binary.
.312 Language style: . . . machine.
.313 Output media: . . . . punched cards or magnetic tape.

.32 Conventions

.321 Standard inclusions: . Extended I/O System.

.322 Compatible with: . . . Basic I/O Supervisor, Program Monitor, Loader, Sort Generator, Merge Generator, and Report Program Generator.

.33 Documentation

Subject	Provision
Source Program: . .	listing.
Object Program: . .	listing.
Storage map:	none.
Restart point list: .	none.
Language errors: . .	listing.
Symbol analysis: . .	listing (optional).

.4 TRANSLATING PROCEDURE

.41 Phases and Passes

Translator phase: . . reads and processes the source program; produces a tape with macro-calls and Basic Assembly Language

Selector phase: . . . links macro-calls with their required generators and produces a tape of generated and input Basic Assembly Language instructions.

Assembler phase: . . assembles the Basic Assembly Language instructions and produces the assembly listing and object deck.

Note: When source deck contains only Basic Assembly Language instructions, phase 2 is bypassed.

.42 Optional Mode

.421 Translate: . . . . . . yes
.422 Translate and run: . . yes, under control of Program Monitor (Section 330:191).
.423 Check only: . . . . . yes.
.424 Patching: . . . . no special provisions.
.425 Up-dating: . . . . . . no special provisions.

.43 Special Features

.431 Alter to check only: . yes.
.432 Fast unoptimized translate: . . . . . . no.
.433 Short translate on restricted program: phase 2 is by-passed when no macros are used.

.44 Bulk Translating: . . . yes, under control of Program Monitor.

.45 Program Diagnostics

.451 Tracers: . . . . Selective Trace subroutine.
.452 Snapshots: . . . . . . Selective Memory Dump subroutine.
.453 Dumps: . . . . ABORT macro, post-mortem memory dump, and tape dump subroutines.

.46 Translator Library

.461 Identity: . . . . Systems Tape (and Library Tape).
.462 User restriction: none.
.463 Form —
Storage medium: . . magnetic tape.
Organization: . . . . software packages and subroutine library, with Program Monitor between each program.
.464 Contents —
Routines: . . . . . . open and closed utility routines, diagnostics, generators.
Data descriptions: . none.
Macro generators: . yes.
.465 Librarianship —
Insertion: . . . . . . yes.
Amendment: . . . . yes.
Call procedure:
CALL: . . . . . . loaded at execution time.
INCS and INCL: . . included at assembly time.

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed overhead

Name	Space	Comment
Program Monitor:	none	read in when needed.
Basic I/O Supervisor:	1,280 words.	
Extended I/O System:	variable	may specify the subroutines needed.
Loader:	none	special area definition pseudos allow overlay of the loader area.

.512 Space required for each input-output file: . . . . alternate input-output areas are optional.
.513 Approximate expansion of procedures —
Basic Assembly Language: . . . . . 1 to 1.
Maco Assembly Language: . . . . . 7 to 1 (average, estimated by GE).

.52 Translation Time: . . no data available to date.

.53 Optimizing Data: . . . data fields can be unpacked during input, and packed during output.

.54 Object Program Performance: . . . . unaffected for Basic Assembly Language coding (i.e., same as hand coding); somewhat less efficient with respect to both space and time when macros are used extensively.

.6 COMPUTER CONFIGURATIONS

.61 Translating Computer

.611 Minimum configuration: . . . . GE-400 Series central processor with 8,192 core storage locations.
4 magnetic tape handlers (1 tape control unit).
1 printer.
1 card reader.
1 card punch.
.612 Larger configuration advantages: . . . . . 16K and 32K core storage provides faster translations and handles more data item names.

.62 Target Computer

.621 Minimum configuration: . . . . any GE-400 Series system.
.622 Usable extra facilities: . . . . . . all.

.7 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Missing entries:	check	flagged in listing.
Unsequenced entries:	optional check	flagged in listing.
Duplicate names:	check	flagged in listing.
Improper format:	check	flagged in listing.
Incomplete entries:	check	flagged in listing.
Target computer overflow:	check	flagged in listing.

.8 ALTERNATIVE TRANSLATORS: . . . . none.

PROGRAM TRANSLATOR: COBOL

.1 GENERAL

.11 Identity: . . . . GE-400 Series COBOL Compiler.

.12 Description

The GE-400 Series COBOL Compiler accepts COBOL/400 source programs (see Section 330:161) from punched cards or magnetic tape and converts the source statements into equivalent BAP symbolic coding. The standard MAP translator (see Section 330:181) is used to generate relocatable binary object coding on either punched cards or magnetic tape. Translation is continuous from the loading of the source program through the production of the object program and listing.

The translating GE-400 Series computer must have a minimum of 8,192 words of core storage, 4 magnetic tape handlers, one printer, one card reader, and one card punch. An additional tape handler allows an object program to be executed immediately after compilation (i.e., "compile and run" operation). Any GE-400 Series system can compile programs to be run on a different GE-400 system.

All COBOL source programs are compiled under control of the Tape Operating System (see Section 330:191). COBOL object programs require the Tape or Card Operating System to provide I/O control and run-to-run supervision.

Extensive checking is performed on both the source coding and the generated symbolic coding for syntax errors and for consistency. A listing of the source coding, the generated coding, and the errors can be printed on-line or written on magnetic tape for subsequent transcription by a media conversion routine.

.13 Originator: . . . . Computer Division, General Electric Company.

.14 Maintainer: . . . . as above.

.15 Availability: . . . . . . May, 1965.

.2 INPUT

.21 Language

.211 Name: . . . . GE-400 Series COBOL, (COBOL/400; see Section 330:161).
.212 Exemptions: . . . . see "Deficiencies with Respect to Required COBOL-61" in Paragraph 330:161.142.

.22 Form

.221 Input media: . . . . . . punched cards or magnetic tape.
.222 Obligatory ordering: . . Identification Division.
Environment Division.
Data Division.
Procedure Division.
.223 Obligatory grouping: . . by division, section, and paragraph.

.23 Size Limitations

.231 Maximum number of source statements: . . no practical limit.
.232 Maximum size source statements: . . . . 96 syntactical entries or 288 operands per statement.
.233 Maximum number of labeled data items: . . ?
.234 Maximum number of files: . . . . 15.

.3 OUTPUT

.31 Object Program

.311 Language name: . . . . . Basic Assembly Program (BAP).
.312 Language style: . . . . . 1-to-1 symbolic language.
.313 Output media: . . . . . . punched cards or magnetic tape.

.32 Conventions

.321 Standard inclusions: . . Basic Input/Output Supervisor, Extended Input/Output System, and Standard subroutines.
.322 Compatible with: . . . . Tape or Card Operating Systems (see Section 330:191).

.33 Documentation

Subject	Provision
Source program:	optional listing on printer or magnetic tape.
Object program:	optional listing.
Storage map:	listing at load time.
Restart point list: . . .	none.
Language errors:	listing.

.4 TRANSLATING PROCEDURE

.41 Phases and Passes

Phase 1: . . . . reads the source program from cards or magnetic tape; checks source statements for validity and

.41 Phases and Passes (Contd.)

consistency; creates DCW lists for each file; analyzes syntax and creates table of generator calls; creates symbol table; lists diagnostic messages.

Phase 2: . . . . generates Basic Assembly Language (BAP) symbolic instructions based on generator call table created in Phase I.

Phase 3: . . . . translates BAP coding into machine-language object coding using MAP translator (see Section 330:181).

.42 Optional Mode

.421 Translate: . . . . yes.
.422 Translate and run: . . . yes.
.423 Check only: . . . . no.
.424 Patching: . . . . no.
.425 Updating: . . . . no.

.43 Special Features

.431 Alter to check only: . . no.
.432 Fast unoptimized translate: . . . . no.
.433 Short translate on restricted program: . . . . no.

.44 Bulk Translating: . . . yes.

.45 Program Diagnostics

.451 Tracers: . . . . no provisions.
.452 Snapshots: . . . . can be incorporated using options of the NOTE clause; deletion requires recompilation.
.453 Dumps: . . . . provided by standard operating systems.

.46 Translator Library: . . The only library available is the standard relocatable library, which contains all subroutines.

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed overhead (for supervisor, etc) —

Name	Space
Basic I/O Supervisor:	1,280 words.
Extended I/O System:	2,400 words.

.512 Space required for each input-output file: . . . . ?
.513 Approximate expansion of procedures: . . . . averages between 4.5 and 7 to 1 (GE estimate).

.52 Translation Time: . . . no data available to date.

.53 Optimizing Data: . . . . none.

.54 Object Program Performance: . . . . . no data available to date.

.6 COMPUTER CONFIGURATIONS

.61 Translating Computer

.611 Minimum configuration: . . . . . 8,192 words of core storage.
1 printer.
1 card reader.
1 card punch.
4 magnetic tape handlers.

.612 Larger configuration advantages: . . . . . . additional memory permits larger internal tables.
additional tape unit allows "compile and run" operation.

.62 Target Computer

.621 Minimum configuration: . . . . . 8,192 words of core storage.
1 magnetic tape handler or card reader for loading program.

.622 Usable extra facilities: . . . . all additional memory and conventional peripheral devices.

.7 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Missing entries:	check	print error message.*
Unsequenced entries:	check	print error message.*
Duplicate names:	check	print error message.*
Improper format:	check	print error message.*
Incomplete entries:	check	print error message.*
Target computer overflow:	none.	
Inconsistent program:	check	print error message.*

*Error messages can be printed on the printer or written on magnetic tape. The normal action is to delete the erroneous entry and continue the translation.

.8 ALTERNATIVE TRANSLATORS: . . . none.

PROGRAM TRANSLATOR: BASIC FORTRAN IV

.1 GENERAL

.11 Identity: . . . . GE-400 Series Basic FORTRAN IV Translator.

.12 Description

The GE-400 Series Basic FORTRAN IV Translator is used to translate programs written in the Basic FORTRAN IV language into Basic Assembly Language (BAL; see Section 330:171). The BAL coding is then translated into GE-400 Series machine language by the Macro Assembly Program (MAP; see section 330:181). Translation is continuous from the loading of the source program through the production of the object program and listing, and is under control of the Tape Operating System (Section 330:191). The generated object program requires the use of the Tape or Card Operating System in the target computer to furnish I/O control and run-to-run supervision.

Minimum requirements for use of the Basic FORTRAN IV Translator are 8,192 words of core storage, 4 magnetic tape handlers, a card reader, a printer, and a card punch. Any GE-400 Series computer system can generate an object program for any other member of the series that has the required memory and peripheral complement.

.13 Originator: . . . . GE Computer Department, Phoenix, Arizona.

.14 Maintainer: . . . . same as above.

.15 Availability: . . . . . . June, 1965.

.2 INPUT

.21 Language

.212 Name: . . . . GE-400 Series Basic FORTRAN IV; see Section 330:162.
.213 Exemptions: . . . . none.

.22 Form

.221 Input media: . . . . punched card or magnetic tape.
.222 Obligatory ordering: . . yes; e.g., a DIMENSION statement for an array must precede the first appearance of an array name in an executable statement.
.223 Obligatory grouping: . . none.

.23 Size Limitations

.231 Maximum number of source statements: . . no practical limit.
.232 Maximum size source statements: . . . . no practical limit.
.233 Maximum number of data items: . . . . . . approximately 300 data items and statement numbers with an 8K memory.

.3 OUTPUT

.31 Object Program

.311 Language name: . . . . Basic Assembly Language.
.312 Language style: . . . . . 1-to-1 symbolic assembly language.
.313 Output media: . . . . . . punched card or magnetic tape, and/or printer.

.32 Conventions

.321 Standard inclusions: . . Basic I/O Supervisor, and desired subroutines and built-in functions.
.322 Compatible with: . . . . Tape Operating System.

.33 Documentation

Subject	Provision
Source program:	listing.
Object program:	optional listing in Basic Assembly Language.
Storage map:	provided by Basic Assembly Program and Loader.
Restart point list: . . .	none.
Language errors: . . .	printer listing.

.4 TRANSLATING PROCEDURE

.41 Phases and Passes

Phase 1: . . . . read source statements and generate assembly-language coding.
Phase 2: . . . . process above into object coding using Macro Assembly Program.

.42 Optional Mode

.421 Translate: . . . . yes.
.422 Translate and run: . . . yes.
.423 Check only: . . . . no.
.424 Patching: . . . . no special provisions.
.425 Updating: . . . . handled by GE-400 Series Librarian.

.43 Special Features

.431 Alter to check only: . . no.
.432 Fast unoptimized translate: . . . . no.

.433 Short translate on restricted program: . . . . no.

.44 Bulk Translating: . . . yes.

.45 Program Diagnostics

.451 Tracers: . . . . standard subroutine.
.452 Snapshots:. . . . . standard subroutine.
.453 Dumps: . . . . two subroutines, DUMP and PDUMP, enable selected segments of core storage to be dumped in octal floating point, integer, or octal with mnemonic format. The DUMP routine causes the program to be terminated and control transferred to the Program Monitor after dumping. With the PDUMP routine, the program is continued after dumping.

.46 Translator Library

.461 Identity: . . . . GE-400 Relocatable Library.
.462 User restriction: . . . . none.
.463 Form —
Storage medium: . . . magnetic tape.
Organization: . . . . . relocatable binary.
.464 Contents —
Routines: . . . . open.
Functions: . . . . yes; standard and user-coded.
Data Descriptions: . . no.
.465 Librarianship: . . . . . . handled by GE-400 Librarian.

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed overhead (for supervisor, etc.) —

Name	Approximate Space
Basic Input/Output Supervisor:	1,300 words.
Input/Output areas:. .	1,000 words.
Floating-point subroutines:	300 words.

.512 Space required for each input-output file: . . . . contained in I/O areas.

.513 Approximate expansion of procedures: . . . . ?

.52 Translation Time: . . . no data available to date.

.53 Optimizing Data: . . . . none.

.54 Object Program Performance: . . . . . no data available to date.

.6 COMPUTER CONFIGURATIONS

.61 Translating Computer

.611 Minimum configuration: . . . . . 4 magnetic tape handlers.
Card reader.
Card punch.
Printer.
8,192 words of core storage.
.612 Larger configuration advantages: . . . . . . additional core storage permits more symbols.

.62 Target Computer

.621 Minimum configuration: . . . . any GE-400 Series computer system with at least 8,192 words of core storage, an input device, and an output device.
.622 Usable extra facilities: . . . . additional memory and I/O devices.
Floating Point Option.

.7 ERRORS, CHECKS AND ACTION

Error	Check	Action
Missing entries:	yes	print error message on printer.
Unsequenced entries	no	print error message on printer.
Duplicate names:	yes	print error message on printer.
Improper format:	yes	print error message on printer.
Incomplete entries:	yes	print error message on printer.
Target computer overflow:	no	print error message on printer.
Inconsistent program:	limited checking	print error message on printer.

.8 ALTERNATIVE TRANSLATORS: . . . none.

OPERATING ENVIRONMENT: TAPE OPERATING SYSTEM

.1 GENERAL

.11 Identity: . . . . GE-400 Series Tape Operating System.

GE-400 Series Card Operating System

.12 Description

The Tape Operating System is a group of related routines for controlling the execution of programs and for handling run-to-run control. There are three major routines:

Loader
Basic Input-Output Supervisor.
Program Monitor.

The Loader is described in Paragraph 330:151.17, Problem Oriented Facilities.

The Basic Input-Output Supervisor resides in core storage at all times and performs the following functions:

- Execution of all basic input-output commands.
- Input-output error analysis.
- Standard procedures for equipment error correction or recovery.
- Input-output simultaneity control.
- Typewriter input-output control.
- Control of processor channel interrupts due to:
  - Arithmetic overflow.
  - Invalid operation.
  - Invalid address.
  - Operator interrupt.
- Standard job termination routine.
- Link to post-mortem memory dump routine.
- Translation of logical to actual input-output channel and device numbers.
- Core image loading routine.
- Control of magnetic tape dual channel usage.
- Monitor linkage.

Additional I/O facilities can be incorporated in programs at assembly or compile time through the use of the Extended Input-Output System. Communication with the system is performed by macro-instructions and file parameters; the appropriate coding is generated and becomes an integral part of a program. Facilities provided by the Extended I/O System include:

- Fixed- and variable-length logical record processing.
- Blocking and unblocking of logical data records.
- Input-output buffer alternation.
- Extended error recovery procedures.
- Input-output buffer scheduling, based upon Automatic Program Interrupt logic design.
- Tape label checking.
- End-of-reel tape alternation.
- Block count and block serial number checking.
- Checkpoints and restarts.
- Modular design for maximum flexibility and core utilization.

The Program Monitor assists in the handling of assembly, debugging, and production runs by providing run-to-run control and reducing setup time between runs.

In the assembly and debugging stage, the Program Monitor uses the System Tape as the operating tape. The Monitor can load the appropriate translator, read in symbolic programs, assemble them, and execute them. The System Tape contains all the major software packages: the Program Monitor itself, the Loader, the Librarian, the Sort and Merge Generators, the Report Program Generator, the Macro Assembly Program, the COBOL Compiler, the FORTRAN compiler, and a library of standard subroutines.

The operating tape for the production function of the monitor is a Master Instruction Tape containing production programs and the Program Monitor itself. These programs are usually in the high-speed (non-relocatable) core load format, although a relocatable format can also be used. The Librarian routine is used to create and maintain the System and Master Instruction Tapes.

The Program Monitor is automatically called into core storage from tape at the end of each run. It receives "next job" or "next run" information from "control records," which can be entered via the card reader, console typewriter, or magnetic tape. The monitor then locates and loads the next program to be run. The monitor need not be present in core storage during the run, so there is no reduction in available storage space. All system functions are performed in the sequence specified by the control records. The sequence can be altered at run time by the operator or by the programs themselves.

The Tape Operating System described above is available now. In its present form it does not provide any multiprogramming facilities. Also currently available is a Card Operating System that includes all the facilities of the present Tape Operating System except the capability for handling language translations. Use of the Card Operating System makes one additional magnetic tape handler available to the program.

A new version of the Operating System is being developed to enable several programs to be run concurrently in a multiprogramming mode. This version is scheduled to become available in the second quarter of 1966. The multiprogramming version will require the Direct Access

.12 Description (Contd.)

Option (see Paragraph 330:051.12). Versions using disc storage units for system storage will be available with the delivery of the new disc storage units.

.13 Availability

Tape Operating System —
- No multiprogramming capabilities: currently in use.
- Multiprogramming version: . . . . . . second quarter, 1966.
- Card Operating System: . . . . . . currently available.

.14 Originator: . . . . GE Computer Dept.

.15 Maintainer: . . . . GE Computer Dept.

.2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . . from system tape, library tape, or previously prepared master instruction tape, directed by control records entered via cards, magnetic tape or keyboard.
.212 Independent programs: from punched cards or magnetic tape, directed by control records.
.213 Data: . . . . as incorporated in user's program.
.214 Master routines: . . . from System Tape or Master Instruction Tape.

.22 Library Subroutines: from System Tape or separate Library Tape.

.23 Loading Sequence: . . as specified by control records; sequence can be established while collecting programs to form Master Instruction Tape or Input Stack Tapes (independent programs), and can be altered at execution time when necessary.

.3 HARDWARE ALLOCATION: . . . as incorporated in user's program.

.31 Storage

.311 Sequencing of program for movement between levels: . . . . incorporated in program if in high-speed core format; otherwise in relocatable form and assigned by loader.
.312 Occupation of working storage: . . . . programs and overlay segments can be in either absolute or relocatable form.

.32 Input-Output Units

.321 Initial assignment: . . standard assignment.
.322 Alternation: . . . . . . control records.
.323 Reassignment: . . . . control records.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: as incorporated in user's program.

.42 Multiprogramming: . present versions lack multiprogramming capabilities; a multiprogramming version is being developed.

.43 Multi-sequencing: . . no provisions.

.44 Errors, Checks, and Action

Error	Check or Interlock	Action
Loading input error:	check	operator alert.
Allocation impossible:	check	operator alert.
In-out error — single:	check	automatic recovery.
In-out error — persistent:	check	operator alert.
Storage overflow:	check	operator alert.
Invalid instructions:	check	alert and optional recovery.
Program conflicts:	none.	
Arithmetic overflow:	check	alert and optional recovery.
Underflow:	none.	
Invalid operation:	check	alert and optional recovery.
Invalid address:	check	alert and optional recovery.
Reference to forbidden area:	none.	

Note: "Alert" means that operator's attention is required.

.45 Restarts

.451 Establishing restart points: . . . . handled by Extended I/O System.
.452 Restarting process: via control records.

.5 PROGRAM DIAGNOSTICS

.51 Dynamic

.511 Tracing: . . . . via control records.
.512 Snapshots: . . . . via control records.

(Contd.)

.52 Post Mortem: . . . . . operator or program can transfer to ABORT routine, which writes a core dump on magnetic tape and then returns control to the monitor.

.6 OPERATOR CONTROL

.61 Signals to Operator

.611 Decision required by operator: . . . . console typewriter.
.612 Action required by operator: . . . . console typewriter.
.613 Reporting progress of run: . . . . all control records are typed as they are executed; typing of "last run", "next run", and time of day is optional.

.62 Operator's Decisions: via console typewriter.

.63 Operator's Signals

.631 Inquiry: . . . . via console typewriter.
.632 Change of normal progress: . . . . console typewriter permits operator to assume control and type in control records to direct monitor functions.

.7 LOGGING

.71 Operator Signals: . . . console typewriter.

.72 Operator Decisions: . console typewriter.

.73 Run Progress: . . . . . console typewriter.

.74 Errors: . . . . console typewriter.

.75 Running Times: . . . . optional typeouts.

.8 PERFORMANCE

.81 System Requirements

.811 Minimum configuration: . . . . 8,192 core storage locations.
1 card reader.
5 magnetic tape handlers.
1 console typewriter.

Note: The card reader replaces one magnetic tape handler when the Card Operating System is used. An additional magnetic tape handler permits program execution immediately after translation ("compile and run").

.812 Usable extra facilities: . . . . all Library Tapes, 2 scratch tapes, Input Stack tape (control data).
.813 Reserved equipment: 1,280 locations are reserved for fixed words and the Basic I/O Supervisor; monitor uses core storage and equipment only between runs.

.82 System Overhead

.821 Loading time: . . . . insignificant; loaded from tape.
.822 Reloading frequency: monitor is reloaded automatically upon termination of each job.

.83 Program Space Available: . . . . . . all except 1,280 words mentioned in .813.

.84 Program Loading Time: . . . . limited by speed of input device.

.85 Program Performance: no running overhead other than normal I/O control; the Program Monitor only handles run-to-run linkages. No performance information is available to date for the multiprogramming version.

SYSTEM PERFORMANCE

The overall performance of a GE-400 Series computer system varies with the speed of the core storage unit and the peripheral equipment incorporated. The performance of each of the current members of the GE-400 Series on the AUERBACH Standard EDP Reports benchmark measures of system performance has been analyzed separately. For performance curves, summary worksheets, and analyses of the results, turn to the System Performance sections of the individual subreports, as listed below:

PHYSICAL CHARACTERISTICS

Unit	Width, inches	Depth, inches	Height, inches	Weight, pounds	Power, KVA	BTU per hr.
415 and 425 Central Processors (includes core storage)	64	69	76	1,500	3.85	7,800
435 Central Processor (includes core storage)	78	78	76	1,900	4.2	9,800
Console	78	26	41	309	0.11	380
CR-21 Card Reader	42	33	47	600	3.2	9,850
CP-11 Card Punch	47	33	49	700	1.5	2,540
CP-20 Card Punch	28	63	60	1,300	2.3	6,450
TS-20 Paper Tape Reader/Punch	61	26	68	770	1.63	5,400
PR-21 Printer	76	34	58	1,470	5.4	11,000
ML-20 Multiple Tape Lister	52	38	57	1,500	2.1	5,360
MT-24, MT-26 Magnetic Tape Unit	29	32.5	72	750	2.0	5,500
MT-17, MT-19, MT-21, MT-23 Magnetic Tape Unit	24	32.5	72	540	1.5	4,400
Magnetic Tape Controller (single-channel)	56	32.5	72	785	1.56	4,600
Magnetic Tape Controller (dual-channel)	56	32.5	72	890	1.9	5,600
MR-20 MICR Reader-Sorter	176	28	45	2,000	9.95	25,000
DS-15 Removable Disc Storage Unit (includes space for two disc drives)	50	24	61	?	?	?
DS-15 Disc Cartridge	19.1	16.5	1.4	?	0	0
DS-15 Controller	41	29	72	?	?	?
DS-20 Disc File Unit	71	38	63	2,500	3.95	7,560
DS-20 Controller	61	26	68	870	1.9	6,180
DS-20 File Electronics	40	32	76	390	1.9	2,220
DS-25 Disc Storage Unit	71	38	76.5	4,000	?	?
DS-25 Controller	91	34	72	?	?	?
DS-25 File Electronics	91	34	72	?	?	?
MS-40 Mass Storage Unit	68.5	50.5	60	1,950	8.7	19,500
MS-20 Controller	41	29	72	?	?	?
DATANET-20, DATANET-21, DATANET-25	Located in Central Processor Cabinet.					
DATANET-30	117	32	76	2,200	9.6	2,200
DATANET-70	44	34	70.4	?	2.0	?
Manual Peripheral Switch Console (includes space for 16 switching units)	39	25	67	400	0.7	1,965

General Requirements

Temperature: .... 65 to 85°F.
Relative Humidity: .... 40 to 60%.
Power: .... 208/120 volt, 3-phase, 4-wire, 60-cycle source.

PRICE DATA

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance† $	Purchase* $
CENTRAL PROCESSOR		Central Processor, Console, I/O Typewriter, eight I/O Channels (excluding High Speed Channels) and Core Storage:			
		GE-415			
	415-04	4,096 words of core storage	1,750	155	108,192
	415-08	8,192 " " " "	2,050	166	120,528
	415-16	16,384 " " " "	3,250	230	186,295
	415-32	32,768 " " " "	4,450	338	244,608
		GE-425			
	425-08	8,192 words of core storage	3,000	178	154,560
	425-16	16,384 " " " "	4,100	238	195,400
	425-32	32,768 " " " "	5,500	345	257,510
		GE-435			
	435-08	8,192 words of core storage	5,500	?	221,130
	435-16	16,384 " " " "	7,000	305	280,800
	435-32	32,768 " " " "	8,800	455	354,240
		Optional Features			
	CM6050	IBM 1401 Compatibility	300	30	12,000
	TC6011	Time of Day Clock	110	5	4,900
	PS6010	Programmed Peripheral Switch	500	55	24,000
		Floating Point Option:			
	OPT140	For GE-415	350	30	16,800
	OPT141	For GE-425	450	30	21,600
	OPT142	For GE-435	550	30	26,400
	DAP930	Direct Access option, including: Memory Protect, Second-Level Interrupt, Interval Timer, Non-Stop Mode, Symbol Controlled Mode, and Channel Expansion (four additional I/O channels, excluding High Speed Channels)	300	—	14,500
	OPT504	Channel Expansion	125	—	6,000
	OPT072	Symbol-Controlled Move	65	—	3,120
	OPT506	High Speed Channel (400 KC)	250	8	12,000
INTERNAL STORAGE	DS-15	Removable Disc Storage Unit (7.8 million characters)	450	45	21,600
	DPC600	Controller for DS-15 (includes High Speed I/O Channel)	700	50	33,600
	OPT137	Second Channel Option	175	10	8,400
	OPT136	Block Count/File Protect	50	—	2,400
	OPT135	Disc Cartridge	15	—	400
	DS-20	Disc Storage Unit with 4 Discs (5.9 million char)	1,125	350	53,000
	DSC200	Controller for DS-20	1,475	45	86,400

* Purchase price includes installation.

† Maintenance rates shown here are for 0-36 months; maintenance rates for older equipment are slightly higher.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance† $	Purchase* $
INTERNAL STORAGE (Contd.)	OPT201	4 Additional Discs (5.9 million char)	200	—	8,000
	OPT202	8 Additional Discs (11.8 million char)	400	—	16,000
	OPT203	12 Additional Discs (1.7 million char)	600	—	23,000
	OPT204	Fast Access I (4 Discs)	300	—	15,000
	OPT205	Fast Access II (8 Discs)	400	—	20,000
		Note: Maximum of 16 discs per DS-20 unit; maximum of 8 Fast Access discs per unit.			
	DS-25	Disc Storage Unit with 16 discs (100 million char)	4,700	300	225,000
	DSC-250	Controller for DS-25 (single channel)	1,250	67	60,000
	DSC-251	Controller for DS-25 (dual channel)	1,900	100	91,000
	OPT601	3 Additional Discs (50 million char)	1,100	52	50,000
	OPT602	16 Additional Discs (100 million char)	2,200	102	100,000
	OPT604	Additional Data Channel (maximum of 3; only 1 per GE-400 Series Processor)	300	—	14,500
	MS-40	Data Cell Drive (533 million char)	2,800	475	136,500
	DCA609	Controller for MS-40	1,100	58	52,800
	OPT130	Second Channel Option	175	10	8,400
	OPT620	Data Cell Cartridge	—	—	350
INPUT-OUTPUT	PC6011	Peripheral Switch Console with 1 Switch Unit (contains space for a total of 16 Switch Units)	125	15	6,000
	PS6011	Switch Unit	40	4	1,920
	PC6011	Plotter Interface Unit	275	50	6,750
		Punched Card Units and Printer			
	CR-21	Card Reader (900 cpm)	650	69	30,000
	OPT150	51-Column Card Option	35	5	1,680
	CP-10	Card Punch (100 cpm)	500	69	22,500
	CP-20	Card Punch (300 cpm)	825	115	41,150
	PR-21	Printer (1200 lpm)	1,400	247	64,800
		Custom Print Segments	90	—	3,000
		Code Wheel Change	80	5	3,200
		Extra Code Wheel	—	—	150
	ML-20	Multiple Tape Lister (6 lists; 2,000 lpm)	1,700	285	81,600
		Punched Tape Units			
	TR-20	Punched Tape Reader (500 cps)	500	75	22,500
	TP-20	Punched Tape Punch (150 cps)	560	75	25,200
	TS-20	Punched Tape Reader and Punch	950	78	45,600
		MICR Equipment			
	MR-20	MICR Reader/Sorter (1,200 dpm)	2,000	300	90.000

* Purchase price includes installation.

† Maintenance rates shown here are for 0-36 months; maintenance rates for older equipment are slightly higher.

(Contd.)

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Monthly Maintenance† $	Purchase* $
INPUT-OUTPUT (Contd.)	OPT11	Endorser Option	100	—	450
		Magnetic Tape			
		7-Track Magnetic Tape Units:			
	MT-17	20,900 char/sec max.	290	80	13,920
	MT-19	30,000 char/sec max.	400	100	19,200
	MT-21	42,000 char/sec max.	485	150	23,280
	MT-23	60,000 char/sec max.	590	180	28,320
	MT-24	83,000 char/sec max.	700	200	31,500
	MT-26	120,000 char/sec max.	900	200	40,500
		9-Track Magnetic Tape Units:			
	MT-17	28,000 char/sec max.	385	85	18,500
	MT-19	40,000 char/sec max.	430	110	20,640
	MT-21	56,000 char/sec max.	575	160	27,600
	MR-23	80,000 char/sec max.	635	165	30,408
	MT-24	11,000 char/sec max.	850	210	38,250
	MT-26	160,000 char/sec max.	990	225	44,550
		7-Track Magnetic Tape Controllers:			
	MTC-71	Single-Channel; up to 8 tape units, any combination	900	30	43,200
	MTC-72	Dual Channel; up to 16 tape units, any combination	1,380	50	66,240
		9-Track Magnetic Tape Controllers:			
	MTC-91	Single-Channel; up to 8 tape units, any combination	970	40	46,560
	MTC-92	Dual-Channel; up to 16 tape units, any combination	1,485	60	71,280
		Communications Equipment			
	OPT033	DATANET-20 (asynchronous single-line controller)	200	30	9,600
	OPT034	DATANET-21 (synchronous single-line controller)	200	30	9,600
	SC6011	DATANET-25 (multi-processor adaptor)	290	15	11,600
	MLC200	DATANET-70	720	60	34,600
	OPT120	Teletype Buffer	10	2	480
	OPT121	Voice Line Buffer (Asynchronous)	60	6	2,880
	OPT122	Voice Line Buffer (Synchronous)	50	5	2,400
	OPT123	Automatic Calling Unit Adaptor	20	3	960
	OPT124	Telpak A Buffer	175	17	8,400

* Purchase price includes installation.

† Maintenance rates shown here are for 0-36 months; maintenance rates for older equipment are slightly higher.

GE 415

General Electric Company

AUERBACH

STANDARD EDP REPORTS

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INTRODUCTION

The GE-415 is characterized by the cycle time of its core storage unit — 5.8 microseconds for each access of one 24-bit word.

This report concentrates upon the performance of the GE-415 in particular. All general characteristics of the GE-400 Series hardware and software are described in Computer System Report 330: GE-400 Series — General.

The System Configuration section which follows shows the GE-415 in the following standard configurations:

I: Typical Card System
II: 4-Tape Business System
III: 6-Tape Business System
IV: 12-Tape Business System
V: 6-Tape Auxiliary Storage System
VIIA: 10-Tape General System (Integrated).

These configurations were selected to illustrate the versatility of the GE-415 computer system. Note that while configuration VIIA is very similar to Configuration IV, it incorporates the optional floating-point hardware. The system configurations are arranged according to the rules in the Users' Guide, page 4:030.120, and any significant deviations from the standard specifications are listed.

Section 332:051 presents detailed central processor timing data for the GE-415. See Section 330:051 for the other characteristics of the GE-400 Series Central Processors.

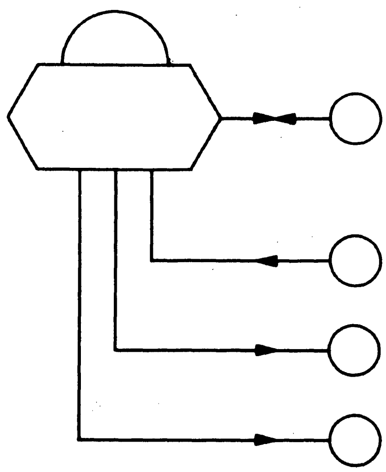
The software provided for all GE-400 Series systems is described in Sections 330:151 through 330:191 of the general report.

A detailed analysis of the overall System Performance of the GE-415 on our standard benchmark problems is presented in Section 332:201.

SYSTEM CONFIGURATION

.1 TYPICAL CARD SYSTEM; CONFIGURATION I

Deviations from Standard Configurations: . . . . core storage is 100% larger.
card punch is 50% faster.
5 more index registers and console I/O typewriter are included.

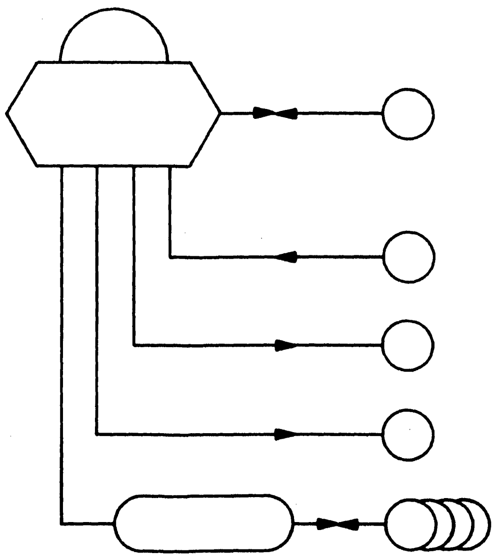


Equipment	Rental
Core Storage: 4,096 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 1,750
CR-21 Card Reader: 900 cards/min.	650
CP-20 Card Punch: 300 cards/min.	825
PR-21 Printer: 1,200 lines/min.	1,400
TOTAL RENTAL:	$ 4,625

For overall configuration rules for GE-400 Series systems, please refer to Section 330:031.

.2 4-TAPE BUSINESS SYSTEM; CONFIGURATION II

Deviations from Standard Configuration: . . . . core storage is 100% larger.
magnetic tape units are 39% faster.
printer is at least 80% faster.
card reader is 80% faster.
6 index registers, console I/O typewriter, and multiply-divide are standard.
any or all I/O operations can be performed simultaneously with internal processing.



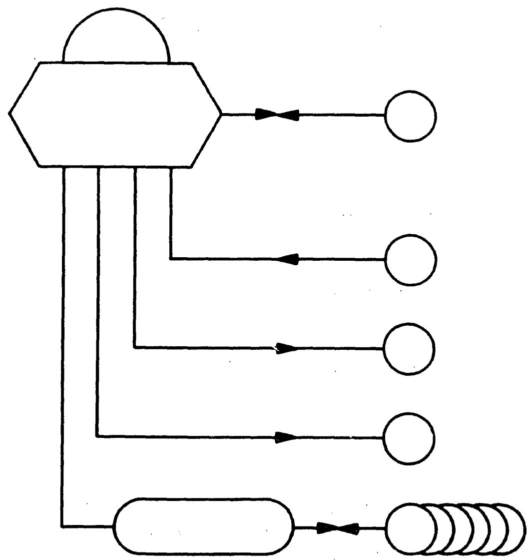
Equipment	Rental
Core Storage: 4,096 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 1,750
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-17 Magnetic Tape Handlers (4) and Controller: 20,900 characters/sec.	2,060
TOTAL RENTAL:	$ 6,360

Note: GE states that tape configurations will normally contain at least 8,192 words of core storage because most of the tape-oriented software requires 8K; this would increase the system rental by $300 per month.

(Contd.)

.3 6-TAPE BUSINESS SYSTEM; CONFIGURATION III

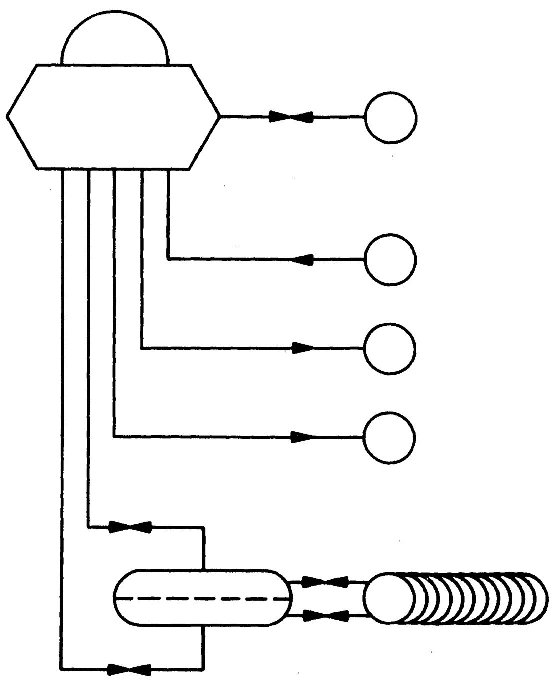
Deviations from Standard Configuration: . . . . core storage is 100% larger.
printer is at least 80% faster.
card reader is 80% faster.
3 more index registers and console typewriter input are included.
2 more simultaneous non-tape data transfers are possible.



Equipment	Rental
Core Storage: 8,192 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 2,050
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-19 Magnetic Tape Handlers (6) and Controller: 30,000 characters/sec.	3,300
TOTAL RENTAL:	$ 7,900

.4 12-TAPE BUSINESS SYSTEM; CONFIGURATION IV

Deviations from Standard Configuration: . . . . card punch is 50% faster.
console typewriter input included.
1 more simultaneous non-tape data transfer is possible.

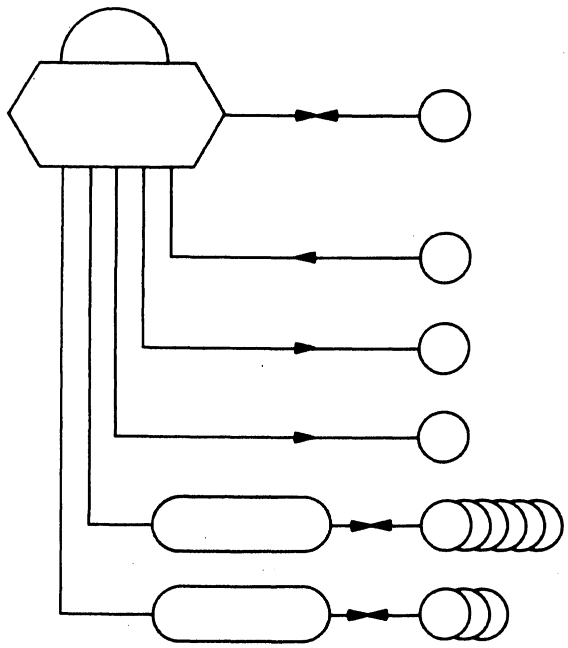


Equipment	Rental
Core Storage: 8,192 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 2,050
CR-21 Card Reader: 900 cards/min.	650
CP-20 Card Punch: 300 cards/min.	825
PR-21 Printer: 1,200 lines/min.	1,400
MT-23 Magnetic Tape Handers (12) and Dual Channel Controller: 60,000 characters/sec.	8,460
TOTAL RENTAL:	$13,385

(Contd.)

.5 6-TAPE AUXILIARY STORAGE SYSTEM; CONFIGURATION V

Deviations from Standard Configuration: . . . . core storage is 100% larger.
printer is at least 80% faster.
card reader is 80% faster.
3 more index registers and console typewriter input are included.
2 more simultaneous non-tape data transfers are possible.

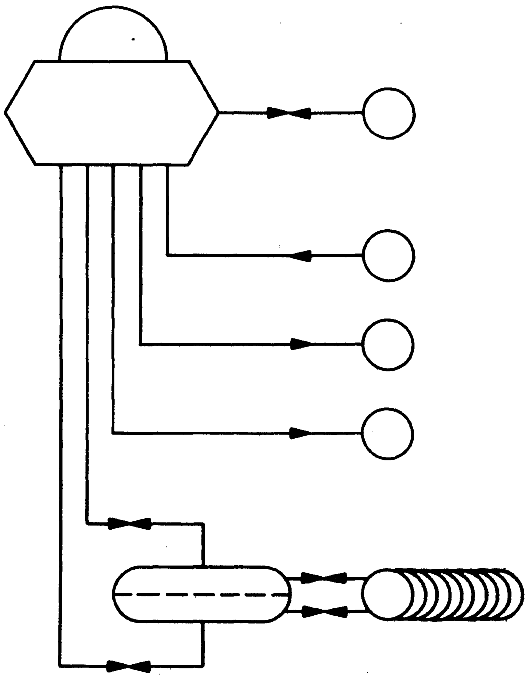


Equipment	Rental
Core Storage: 8,192 words; Central Processor, Console, I/O Typewriter, and I/O Channels (except High Speed Channel)	$ 2,050
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-19 Magnetic Tape Handlers (6) and Controller: 30,000 characters/sec.	3,300
DS-15 Removable Disc Storage Units (3), Controller, and High Speed I/O Channel: 23.4 million characters	2,050*
TOTAL RENTAL:	$ 9,950

* Does not include $15 per month rental for each Disc Cartridge.

.6 10-TAPE GENERAL SYSTEM (INTEGRATED); CONFIGURATION VIIA

Deviations from Standard Configurations: . . . . core storage is 25% larger.
printer is at least 80% faster.
card reader is 80% faster.
1 more simultaneous non-tape transfer is possible.



Equipment	Rental
Core Storage: 32,768 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 4,450
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-23 Magnetic Tape Handlers (10) and Dual Channel Controller: 60,000 characters/sec.	7,280

Optional Features Included: . . . . Floating Point Option 350

TOTAL RENTAL: $14,630

CENTRAL PROCESSOR

.1 GENERAL

.11 Identity: . . . . GE-400 Series Central Processor with GE-415 Core Storage Unit.

.12 Description

See Section 330:051 for a comprehensive presentation of the capabilities of the GE-400 Series Central Processor.

The Instruction Times and Processor Performance Times for the GE-415 system are listed below. This system now has a 5.8-microsecond core storage cycle. See Paragraphs 4:050.41 and 4:050.42 of the Users' Guide for the definitions of these standard measures of central processor performance.

.4 PROCESSOR SPEEDS

Note: W = number of 24-bit words in operand.

.41 Instruction Times in Microseconds

.411 Fixed point —
- Add-subtract: . . . . . 5.8 + 11.6W
- Multiply: . . . . 62.2 + 2.1M (M = value of the single multiplier digit).
- Divide: . . . . 131.3 + 2.1Q (Q = value of the single quotient digit).

.412 Floating point* –

These times are based on no address modification in the succeeding instruction. See Paragraph 330:051.4 for a general presentation of the floating-point execution times.

- Add-subtract: 17.4
- Multiply: 21.8
- Divide: 31.7

.413 Additional allowance for —
- Indexing: . . . . 5.8 per sequence step.
- Indirect addressing: . 5.8 per level.
- Recomplementing: . . 7.7W (1.0 when W = 1).

.414 Control —
- Compare: . . . . 5.8 + 11.6W
- Branch: . . . . 5.8 (11.6 for Branch on Minus or Zero).

* With Floating Point Option.

.415 Counter control (step and test) —
- Fixed-word counter: . 13.5
- Any-word counter: . . 19.3

.416 Edit —
- With suppression: . . 6.4 + 44.8W average.
- Without suppression: 5.8 + 27.6W average.

.417 Convert: . . . . none.

.418 Shift —
- Character: . . . . 8.9 to 165.8
- Binary: . . . . 17.6 to 55.5

.42 Processor Performance in Microseconds

D = number of digits in multiplier or quotient.

Note that in some tasks additional time may be required to properly position the product or quotient.

	Fixed point	Floating point*
.421 For random addresses —		
$c = a + b$:	17.4 + 23.2W	70.6
$b = a + b$:	11.6 + 11.6W	70.6
Sum N items:	(5.8 + 11.6W)N	17.4N
$c = ab$:	54.1 + 85.2D	74.0
$c = a/b$:	77.3 + 154.3D	83.9
.422 For arrays of data —		
$c_i = a_i + b_j$:	75.3 + 23.2W	127.5
$b_j = a_i + b_j$:	63.7 + 11.6W	127.5
Sum N items:	(38.6 + 11.6W)N	85.0N
$c = c + a_ib_j$:	133.3 + 91D	143.5

.423 Branch based on comparison (numeric or alphanumeric information): . . . . 72.4 + 11.6W.

.424 Switching —
- Unchecked: 17.4
- Checked: 58.0
- List search: . . . . . . 38.6 + 61.8N (N = number of comparisons).

.425 Format control, per character —
- Unpack: . . . . 0.58.
- Compose: . . . . 12.3.

.426 Table look-up, per comparison —
- For a match: . . . . . . 44.4 + 11.6W
- For least or greatest: 50.2 + 11.6W
- For interpolation point: . . . . 44.4 + 11.6W.

.428 Moving: . . . . 29.4 + 11.6W.

* With Floating Point Option.

SYSTEM PERFORMANCE

GENERALIZED FILE PROCESSING (332:201.100)

These problems involve updating a master file from transaction data in a detail file and producing a printed record of the results of each transaction. This type of run is one of the most common commercial data processing jobs (e.g., in payroll, billing, and inventory control applications). The Standard File Problems are fully described in Section 4:200.1 of the Users' Guide.

In all of the GE-415 Standard Configurations (shown in Section 332:031), the detail file is assigned to the on-line card reader and the report file to the on-line printer. The master file is on punched cards in Configuration I and on magnetic tape in all the other Standard Configurations. Because of the GE-415's powerful scatter-read, gather-write facilities (described in Section 330:111), the master file can be packed very efficiently on magnetic tape and held to a record size of 108 characters — the same tape record size as in character-oriented systems such as the IBM 1400 line.

The file processing performance of Standard Configuration I, which has no magnetic tape units and uses punched cards for the master file, is limited by the 300-cards-per-minute output speed of the CP-20 Card Punch.

Standard Configurations II, III, IV, and VIIA are progressively more powerful and more expensive, but the following general comments apply to the performance of all four configurations of all four of the Standard File Problems. At low activity (i.e., low ratios of transaction records to master records), magnetic tape time for reading the master file and writing the updated master file is the limiting factor, as shown by the horizontal lines at the left side of Graphs 332:201.100 through 332:201.140. At higher activities, the speed of the on-line printer (665 lines per minute at the required 1-inch average line spacing) becomes the limiting factor in all cases. The GE-415 central processor is sufficiently fast so that at no time does internal processing speed become the limiting factor on system performance on these problems.

SORTING (332:201.200)

The standard estimates for sorting 80-character records by straightforward merging on magnetic tape (Graph 332:201.200) were developed from the processing times for Standard File Problem A according to the method explained in the Users' Guide, Paragraph 4:200.213.

MATRIX INVERSION (332:201.300)

The standard estimate for inverting a non-symmetric, non-singular matrix was computed, by the simple method described in Paragraph 4:200.312 of the Users' Guide, for Standard Configuration VIIA, which includes the Floating Point Option. Computation is performed in the floating-point format (11-digit precision).

GENERALIZED MATHEMATICAL PROCESSING (332:201.400)

Standard Mathematical Problem A is an application in which there is one stream of input data, a fixed computation to be performed, and one stream of output results. Two variables are introduced to demonstrate how the time for a job varies with different proportions of input, computation, and output. The factor C shows the effect of variations in the amount of computation per input record. The factor R indicates the ratio of input records to output records. The procedure used to evaluate performance on the Standard Mathematical Problem is fully described in Paragraph 4:200.2 of the Users' Guide.

For the GE-415, this problem was evaluated for Standard Configuration VIIA, which includes the Floating Point Option. Computation is performed in the floating-point format (11-digit precision). As a result of the high cost of performing the radix conversions between the BCD format of the input and output and the internal floating-point binary format, the central processor is the limiting factor for all conditions evaluated.

WORKSHEET DATA TABLE 1 (STANDARD FILE PROBLEM A)											
	ITEM		CONFIGURATION I		II		III		IV & VIIA		REFERENCE
1 Input-Output Times	Char/block	(File 1)	8.0		1,080		1,080		1,080		4:200.112
	Records/block	K (File 1)	0.5		10		10		10		
	msec/block	File 1 = File 2	66.7/200		72.5		56.9		29.0		
		File 3	66.7		66.7		66.7		66.7		
		File 4	90.2		90.2		90.2		90.2		
	msec/switch	File 1 = File 2	0		0		0		0		
		File 3	0		0		0		0		
		File 4	0		0		0		0		
	msec penalty	File 1 = File 2	0.70		3.17		3.17		3.17		
		File 3	1.13		1.13		1.13		1.13		
		File 4	1.61		1.61		1.61		1.61		
2 Central Processor Times	msec/block	a_1	0.29		0.29		0.29		0.29		4:200.1132
	msec/record	a_2	0.28		0.28		0.28		0.28		
	msec/detail	b6	0.18		0.18		0.18		0.18		
	msec/work	b5 + b9	2.75		2.75		2.75		2.75		
	msec/report	b7 + b8	1.67		1.67		1.67		1.67		
3 Standard File Problem A F = 1.0	msec/block for C.P. and dominant column.		C.P.	Punch	C.P.	Printer	C.P.	Printer	C.P.	Printer	4:200.114
		a_1	0.29		0.29		0.29		0.29		
		a_2 K	0.14		2.80		2.80		2.80		
		a_3 K	2.30		45.90		45.90		45.90		
		File 1: Master In	0.70		3.17		3.17		3.17		
		File 2: Master Out	0.70	200	3.17		3.17		3.17		
		File 3: Details	0.56		11.30		11.30		11.30		
		File 4: Reports	0.80		16.10	902	16.10	902	16.10	902	
		Total	5.49	200	82.73	902	82.73	902	82.73	902	
4 Standard File Problem A Space	Unit of measure	(word*)									4:200.1151
		Std. routines	952		952		952		952		
		Fixed	72		72		72		72		
		3 (Blocks 1 to 23)	120		120		120		120		
		6 (Blocks 24 to 48)	732		732		732		732		
		Files	884		1,796		1,796		1,796		
		Working	125		125		125		125		
		Total	2,885		3,922		3,922		3,922		

* 1 word = 4 characters.

WORKSHEET DATA TABLE 2 (STANDARD MATHEMATICAL PROBLEM A)				
	ITEM		CONFIGURATION VIIA	REFERENCE
5 Standard Mathematical Problem A	Fixed/floating point		Floating point	4:200.413
	Unit name	input	CR-21 Card Reader	
		output	PR-21 Printer	
	Size of record	input	80 char	
		output	130 char	
	msec/block	input T_1	66.7	
		output T_2	90.2	
	msec penalty	input T_3	1.1	
		output T_4	1.5	
	msec/record	T_5	100.00	
	msec/5 loops	T_6	17.58	
	msec/report	T_7	1.01	

(Contd.)

.1 GENERALIZED FILE PROCESSING

.11 Standard File Problem A

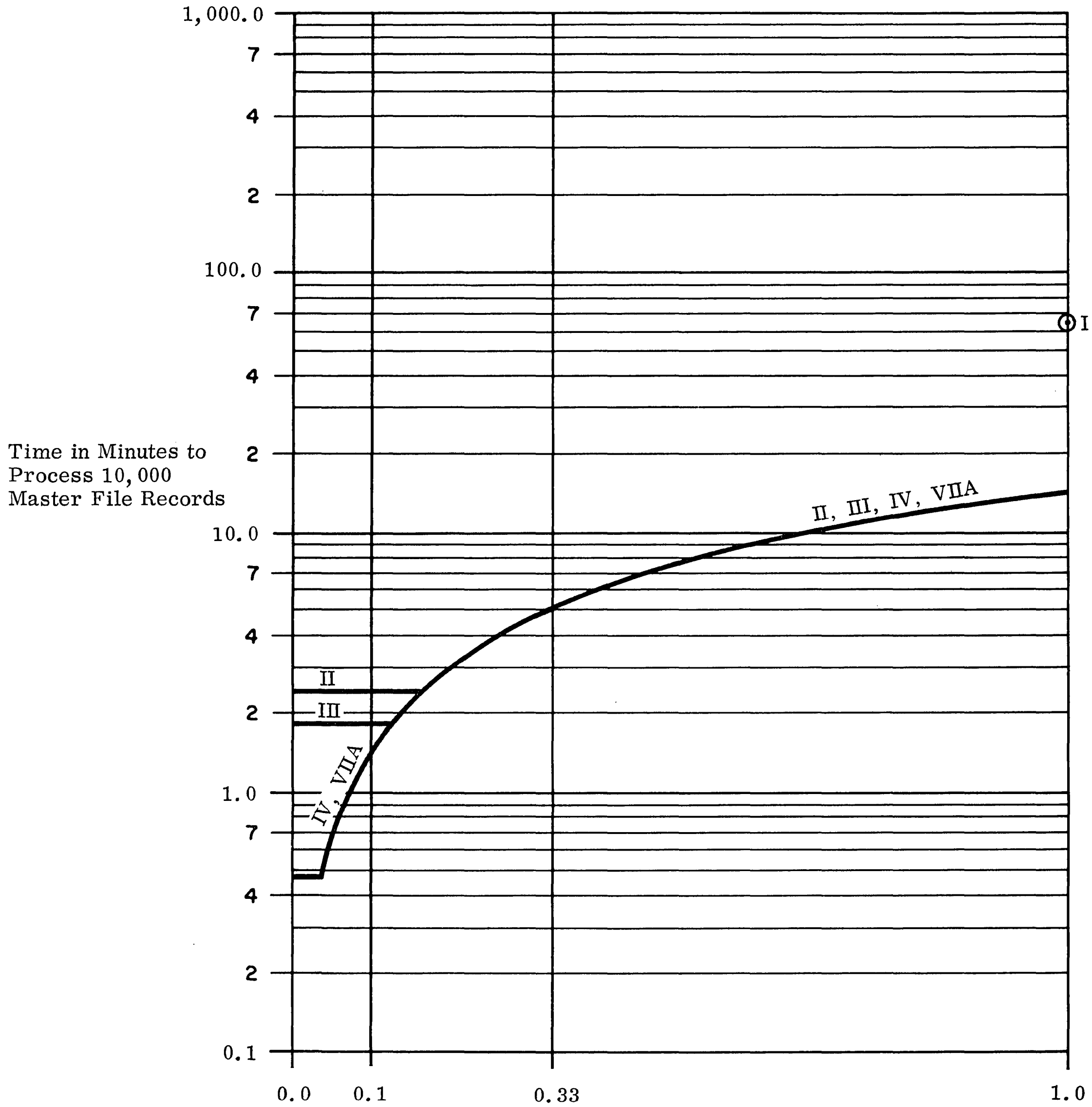
.111 Record sizes —
Master file: . . . . . . 108 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.112 Computation:. . . . . . . standard.

.113 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.113.

.114 Graph: . . . . see graph below.

.115 Storage space required —
Configuration I: . . . . 2,885 words.
Configuration II: . . . 3,922 words.
Configuration III: . . . 3,922 words.
Configuration IV: . . . 3,922 words.
Configuration VIIA: . 3,922 words.



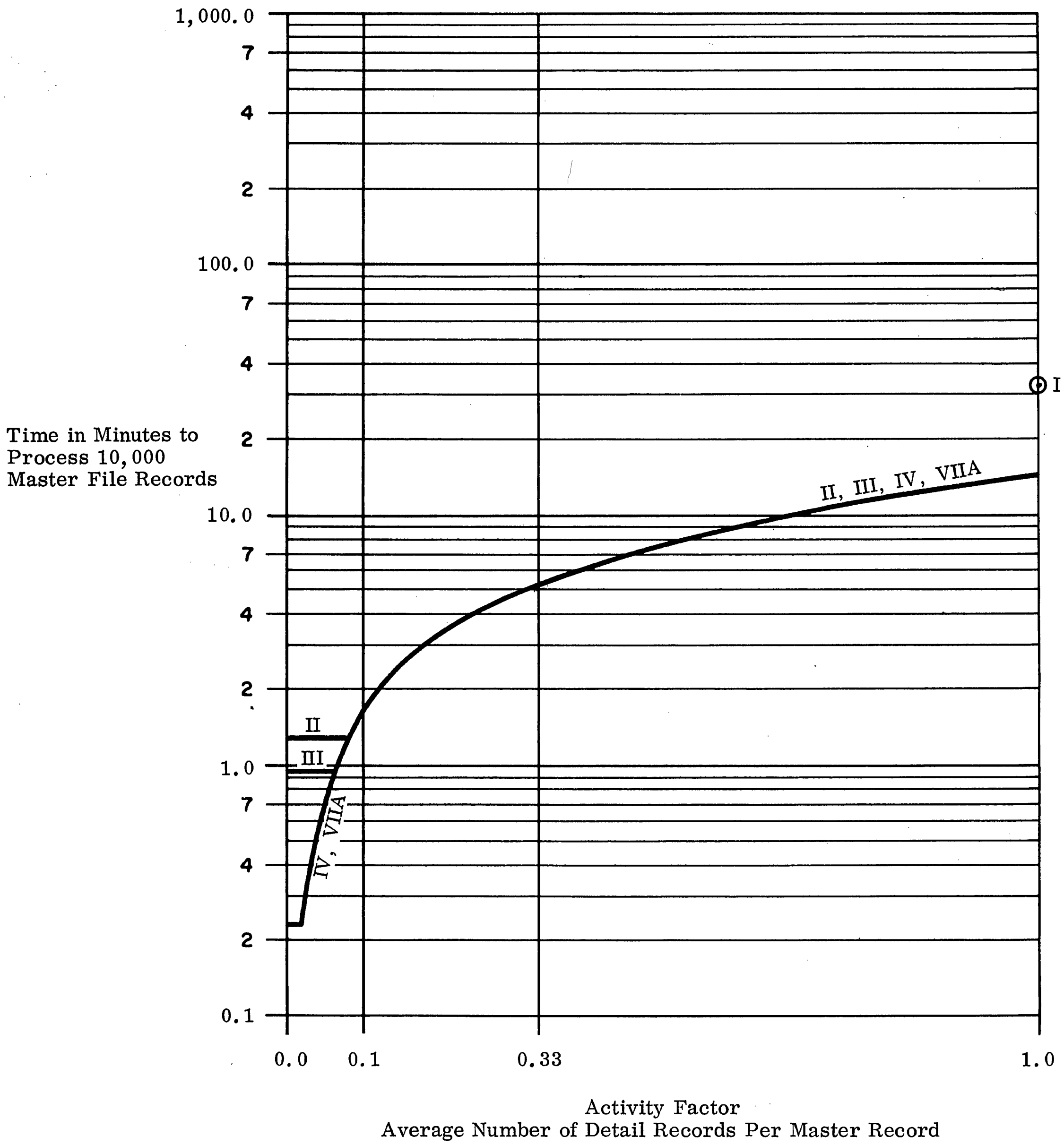
Activity Factor
Average Number of Detail Records Per Master Record

(Roman numerals denote standard System Configurations.)

.12 Standard File Problem B

.121 Record sizes —
Master file: . . . . . . 54 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.122 Computation:. . . . . . . standard.
.123 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.12.
.124 Graph: . . . . see graph below.



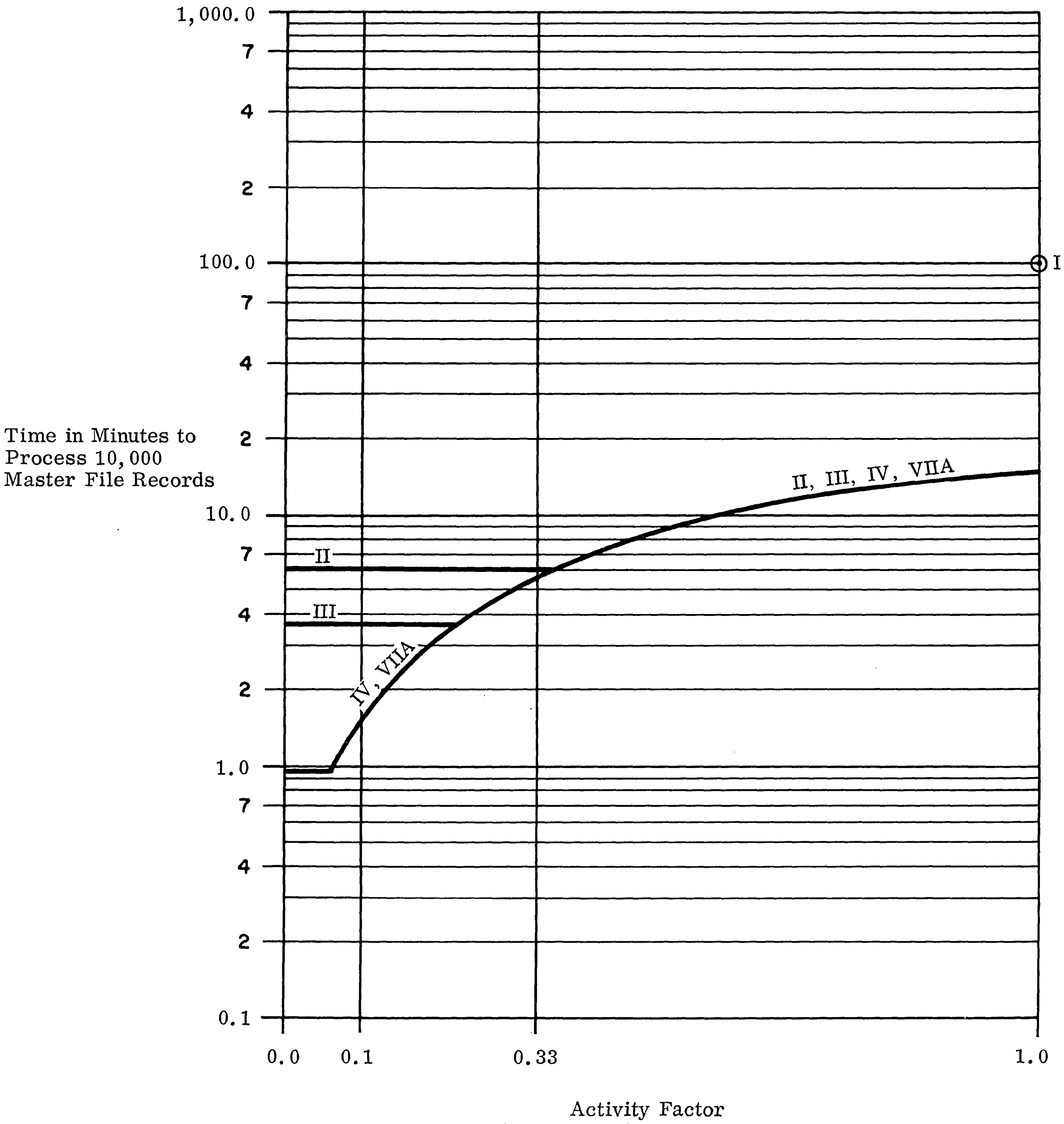
(Roman numerals denote standard System Configurations.)

(Contd.)

.13 Standard File Problem C

.131 Record sizes —
Master file: . . . . . . 216 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.132 Computation:. . . . . . . standard.
.133 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.13.
.134 Graph:. . . . . see graph below.

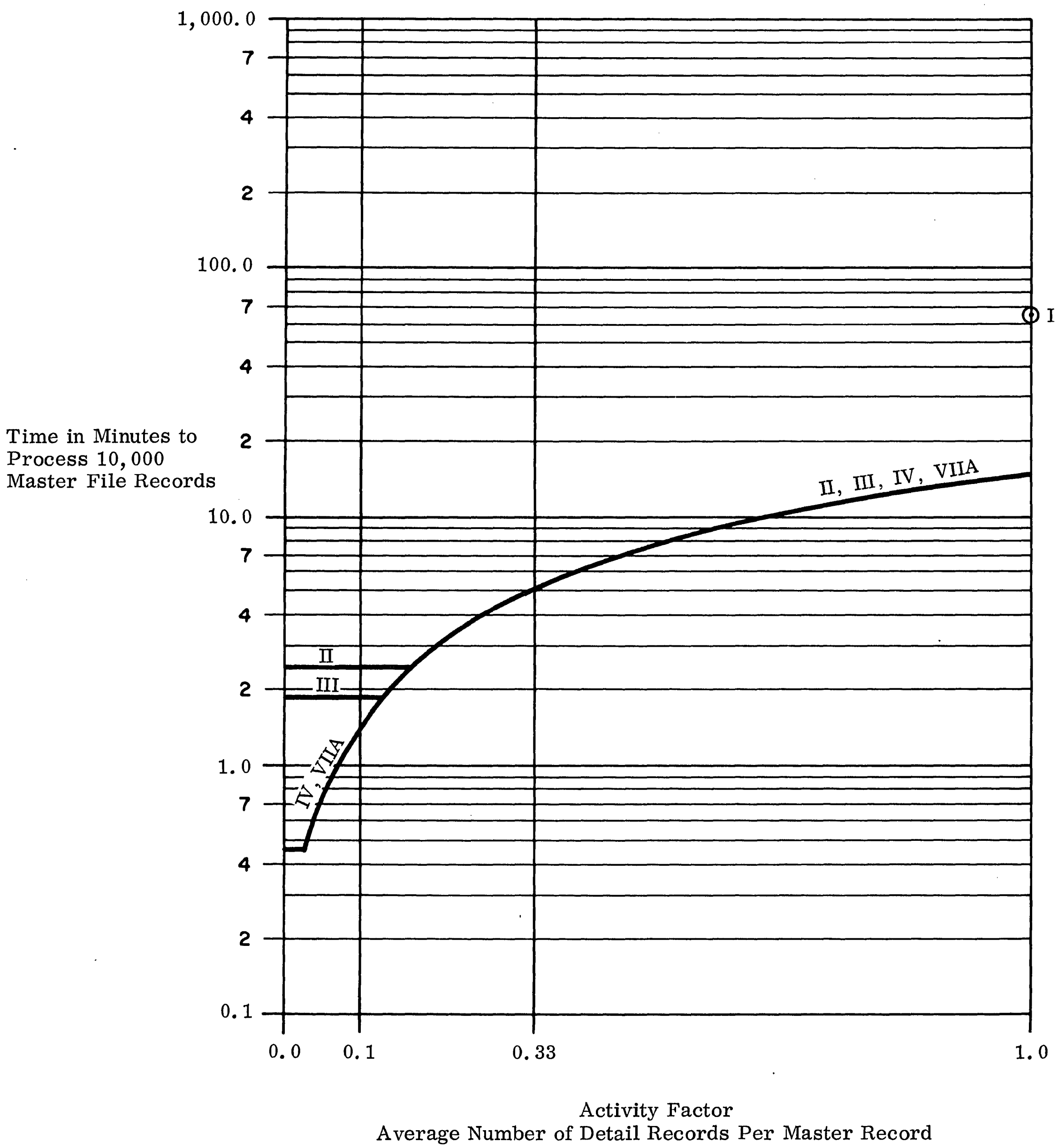


(Roman numerals denote standard System Configurations.)

.14 Standard File Problem D

.141 Record sizes —
Master file: . . . . . . 108 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.142 Computation:. . . . . . . trebled.
.143 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.14.
.144 Graph:. . . . . see graph below.



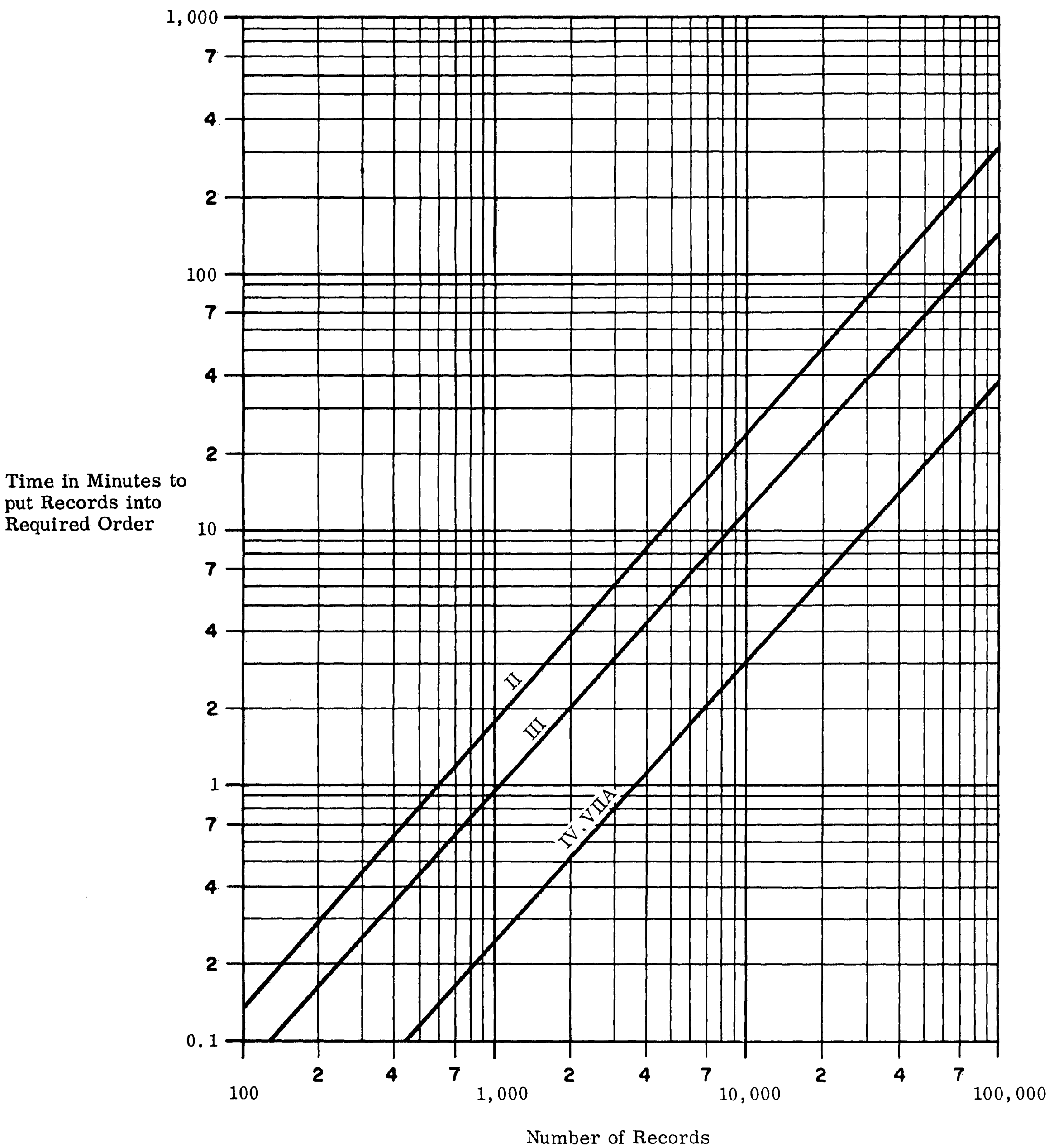
(Roman numerals denote standard System Configurations.)

(Contd.)

.2 SORTING

.21 Standard Problem Estimates

.211 Record size: . . . . 80 characters.
.212 Key size: . . . . 8 characters.
.213 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.213.
Two-way merge is used in Standard Configuration II, and three-way merge in Configurations III, IV, and VIIA.
.214 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

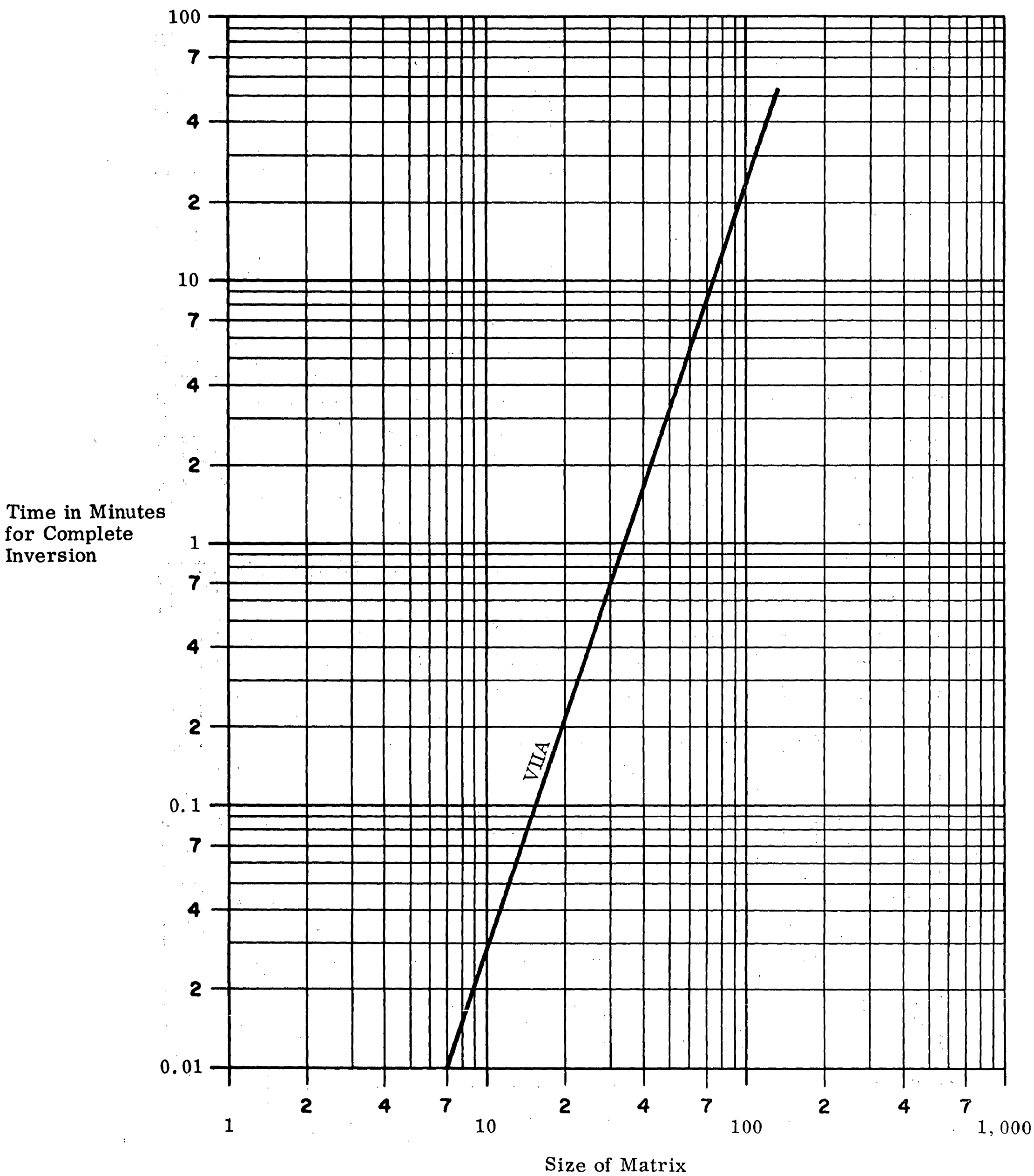
.3 MATRIX INVERSION

.31 Standard Problem Estimates

.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.312 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.312, and Floating Point Option.

.313 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

(Contd.)

.4 GENERALIZED MATHEMATICAL PROCESSING

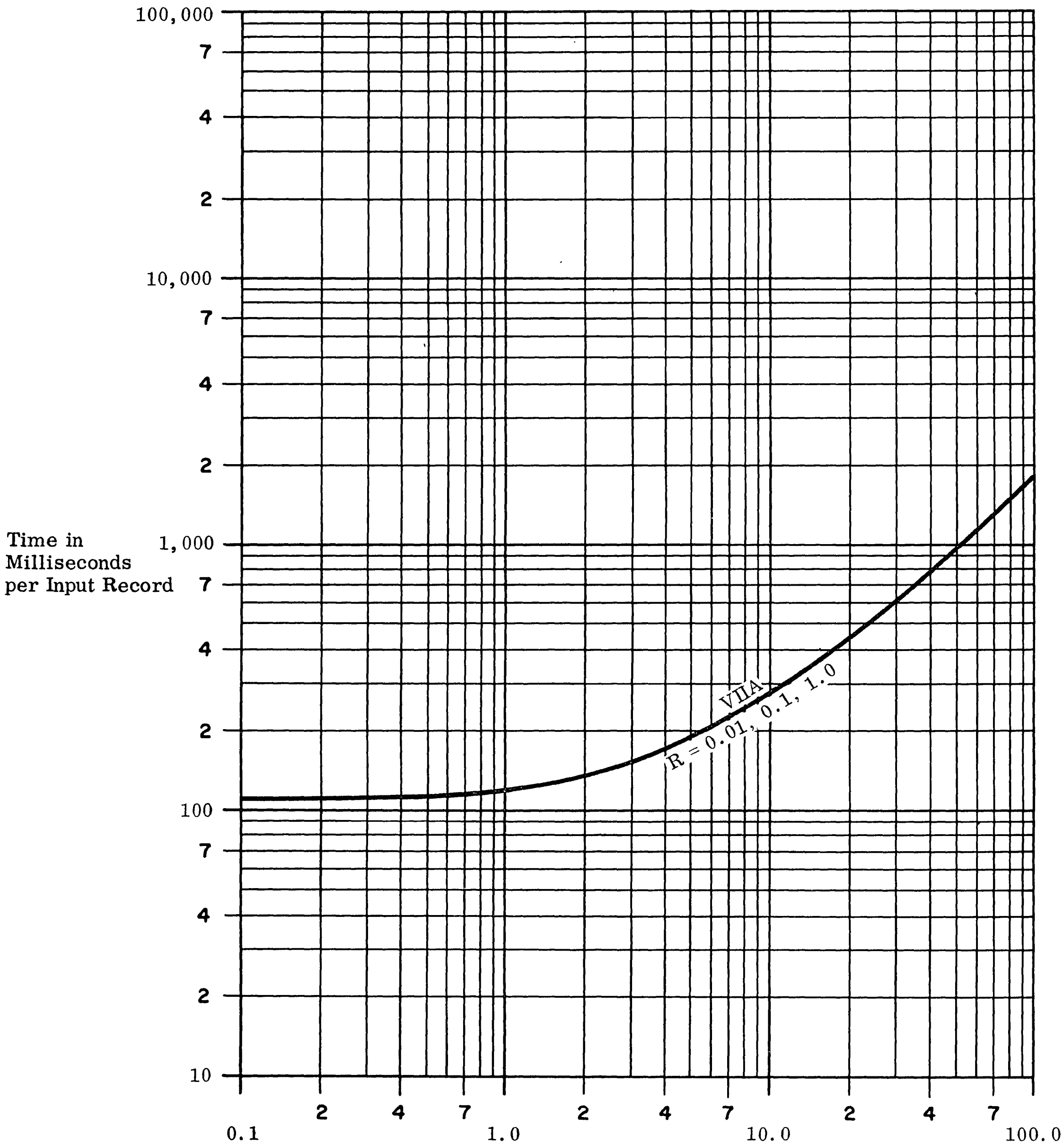
.41 Standard Mathematical Problem A Estimates

.411 Record sizes: . . . . . . 10 signed numbers; avg. size 5 digits, max. size 8 digits.

.412 Computation: . . . . 5 fifth-order polynomials, 5 divisions, and 1 square root; computation is in floating-point mode (11-digit precision).

.413 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.413.

.414 Graph: . . . . see graph below.



C, Number of Computations per Input Record

(Roman numeral denotes standard System Configuration.
R = Number of output records per input record.)

GE 425

General Electric Company

STANDARD
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INTRODUCTION

The GE-425 is characterized by the cycle time of its core storage unit — 3.9 microseconds for each access of one 24-bit word.

This report concentrates upon the performance of the GE-425 in particular. All general characteristics of the GE-400 Series hardware and software are described in Computer System Report 330: GE-400 Series — General.

The System Configuration section which follows shows the GE-425 in the following standard configurations:

I: Typical Card System
II: 4-Tape Business System
III: 6-Tape Business System
IV: 12-Tape Business System
V: 6-Tape Auxiliary Storage System
VIIA: 10-Tape General System (Integrated).

These configurations were selected to illustrate the versatility of the GE-425 computer system. Note that while Configuration VIIA is very similar to Configuration IV, it incorporates the optional floating-point hardware. The system configurations are arranged according to the rules in the Users' Guide, page 4:030.120, and any significant deviations from the standard specifications are listed.

Section 333:051 presents detailed central processor timing data for the GE-425. See Section 330:051 for the other characteristics of the GE-400 Series Central Processors.

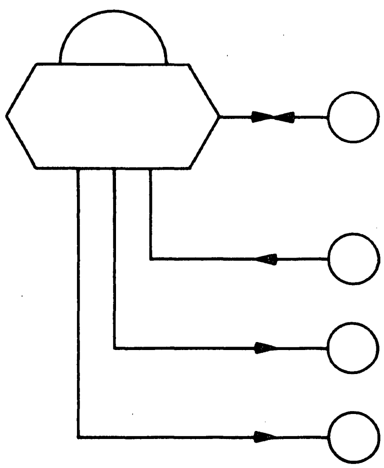
The software provided for all GE-400 Series systems is described in Sections 330:151 through 330:191 of the general report.

A detailed analysis of the overall System Performance of the GE-425 on our standard benchmark problems is presented in Section 333:201.

SYSTEM CONFIGURATION

.1 TYPICAL CARD SYSTEM; CONFIGURATION I

Deviations from Standard Configurations: . . . . core storage is 300% larger.
card punch is 50% faster.
5 more index registers and console I/O typewriter are included.

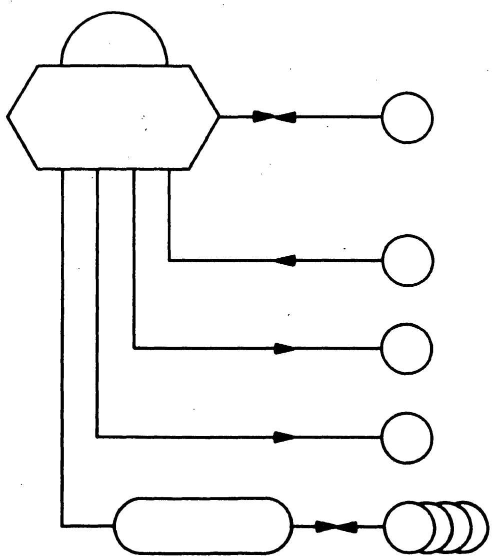


Equipment	Rental
Core Storage: 8,192 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 3,000
CR-21 Card Reader: 900 cards/min.	650
CP-20 Card Punch: 300 cards/min.	825
PR-21 Printer: 1,200 lines/min.	1,400
TOTAL RENTAL:	$ 5,875

For overall configuration rules for GE-400 Series systems, please refer to Section 330:031.

.2 4-TAPE BUSINESS SYSTEM; CONFIGURATION II

Deviations from Standard Configuration: . . . . core storage is 100% larger.
magnetic tape units are 39% faster.
printer is at least 80% faster.
card reader is 80% faster.
6 index registers, console I/O typewriter, and multiply-divide are standard.
any or all I/O operations can be performed simultaneously with internal processing.

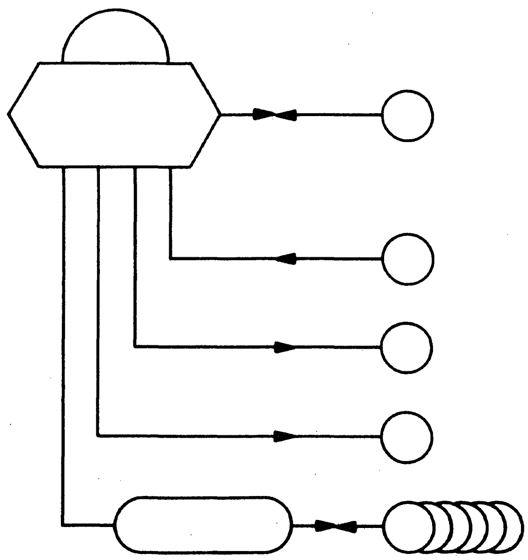


Equipment	Rental
Core Storage: 8,192 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 3,000
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-17 Magnetic Tape Handlers (4) and Controller: 20,900 characters/sec.	2,060
TOTAL RENTAL:	$ 7,610

(Contd.)

.3 6-TAPE BUSINESS SYSTEM; CONFIGURATION III

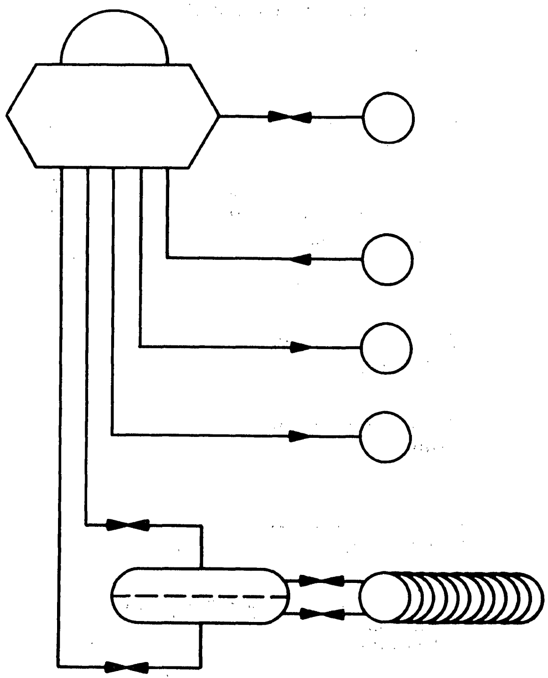
Deviations from Standard Configuration: . . . . core storage is 100% larger.
printer is at least 80% faster.
card reader is 80% faster.
magnetic tape is 39% faster.
3 more index registers and console typewriter input are included.
2 more simultaneous non-tape data transfers are possible.



Equipment	Rental
Core Storage: 8,192 words Central Processor, Console, I/O Typewriter, and I/O Channels	$ 3,000
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-19 Magnetic Tape Handlers (6) and Controller: 30,000 characters/sec.	3,300
TOTAL RENTAL:	$ 8,850

.4 12-TAPE BUSINESS SYSTEM; CONFIGURATION IV

Deviations from Standard Configuration: . . . . card reader is 10% slower.
card punch is 50% faster.
console typewriter input included.
1 more simultaneous non-tape data transfer is possible.

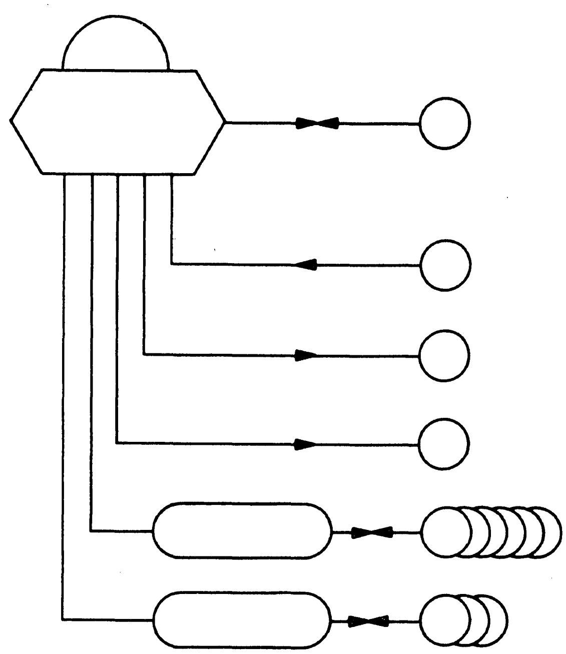


Equipment	Rental
Core Storage: 8,192 words Central Processor, Console, I/O Typewriter, and I/O Channels	$ 3,000
CR-21 Card Reader: 900 cards/min.	650
CP-20 Card Punch: 300 cards/min.	825
PR-21 Printer: 1,200 lines/min.	1,400
MT-23 Magnetic Tape Handlers (12) and Dual Channel Controller: 60,000 characters/sec.	8,460
TOTAL RENTAL:	$14,335

(Contd.)

.5 6-TAPE AUXILIARY STORAGE SYSTEM; CONFIGURATION V

Deviations from Standard Configuration: . . . . core storage is 100% larger.
printer is at least 80% faster.
card reader is 80% faster.
3 more index registers and console typewriter input are included.
2 more simultaneous non-tape data transfers are possible.

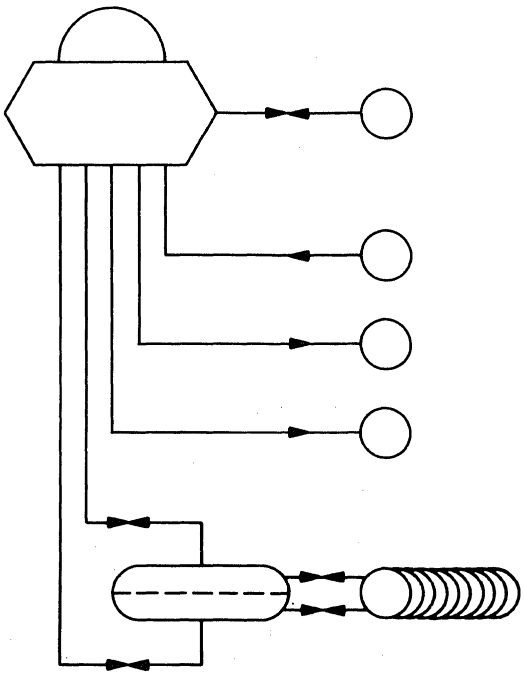


Equipment	Rental
Core Storage: 8,192 words; Central Processor, Console, I/O Typewriter, and I/O Channels (except High Speed Channel)	$ 3,000
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-19 Magnetic Tape Handlers (6) and Controller: 30,000 characters/sec.	3,300
DS-15 Removable Disc Storage Units (3), Controller, and High Speed Data Channel: 23.4 million characters	2,050*
TOTAL RENTAL:	$10,900

* Does not include $15 per month rental for each Disc Cartridge.

.6 10-TAPE GENERAL SYSTEM (INTEGRATED); CONFIGURATION VIIA

Deviations from Standard Configurations: . . . . core storage is 25% larger.
printer is at least 80% faster.
card reader is 80% faster.
1 more simultaneous non-tape transfer is possible.



Equipment	Rental
Core Storage: 32,768 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 5,500
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-23 Magnetic Tape Handlers (10) and Dual Channel Tape Controller: 60,000 characters/sec.	7,280

Optional Features Included: . . . . Floating Point Option 450

TOTAL RENTAL: $15,780

CENTRAL PROCESSOR

.1 GENERAL

.11 Identity: . . . . GE-400 Series Central Processor with GE-425 Core Storage Unit.

.12 Description

See Section 330:051 for a comprehensive presentation of the capabilities of the GE-400 Series Central Processor.

The Instruction Times and Processor Performance Times for the GE-425 system are listed below. This system uses a 3.9-microsecond core storage unit. See Paragraphs 4:050.41 and 4:050.42 of the Users' Guide for the definitions of these standard measures of central processor performance.

.4 PROCESSOR SPEEDS

Note: W = number of words in operand.

.41 Instruction Times in Microseconds

.411 Fixed point —
- Add-Subtract: . . . . . 3.9 + 7.8W
- Multiply: . . . . 48.0 + 2.1M (M = value of the single multiplier digit).
- Divide: . . . . 100.8 + 2.1Q (Q = value of the single quotient digit).

.412 Floating point* —

These times are based on no address modification in succeeding instruction. See Paragraph 330:051.4 for a general presentation of the floating-point execution times.
- Add-Subtract: 11.8
- Multiply: 18.0
- Divide: 27.9

.413 Additional allowance for —
- Indexing: . . . . 3.9 per sequence step.
- Indirect addressing: . 3.9 per level.
- Recomplementing: . . 5.8W (1.9 when W = 1).

.414 Control —
- Compare: . . . . 3.9 + 7.8W
- Branch: . . . . 3.9 (7.8 for Branch on Minus or Zero).

* With Floating Point Option.

.415 Counter control (step and test) —
- Fixed-word counter: . 9.7
- Any-word counter: . . 13.6

.416 Edit —
- With suppression: . . 39.7W - 2.7 average.
- Without suppression: 19.9W + 3.9 average.

.417 Convert: . . . . none.

.418 Shift —
- Character: . . . . 12.9 to 92.1
- Binary: . . . . 12.9 to 43.8

.42 Processor Performance in Microseconds

D = number of digits in multiplier or quotient.

Note that in some tasks additional time may be required to properly position the product or quotient.

	Fixed point	Floating point*
.421 For random addresses —		
c = a + b:	11.7 + 15.6W	47.2
b = a + b:	7.8 + 7.8W	47.2
Sum N items:	(3.9 + 7.8W)N	11.8N
c = ab:	36.5 + 68.2D	53.4
c = a/b:	52.1 + 121.0D	63.3
.422 For arrays of data —		
$c_i = a_i + b_j$:	52.5 + 15.6W	88.0
$b_j = a_i + b_j$:	43.7 + 7.8W	88.0
Sum N items:	(27.2 + 7.8W)N	58.7N
$c = c + a_ib_j$:	91.5 + 72.1D	98.2

.423 Branch based on comparison (numeric or alphanumeric information): . . . . 50 + 7.8W

.424 Switching —
- Unchecked: 11.7
- Checked: 39.0
- List search: . . . . . . 27.2 + 42.8N (N = number of comparisons).

.425 Format control, per character —
- Unpack: 0.39
- Compose: 9.9

.426 Table look-up, per comparison —
- For a match: . . . . . . 31.1 + 7.8W
- For least or greatest: . . . . 33.0 + 7.8W
- For interpolation point: . . . . 31.1 + 7.8W

.428 Moving: . . . . 21.8 + 7.8W

* With Floating Point Option.

SYSTEM PERFORMANCE

GENERALIZED FILE PROCESSING (333:201.100)

These problems involve updating a master file from transaction data in a detail file and producing a printed record of the results of each transaction. This type of run is one of the most common commercial data processing jobs (e.g., in payroll, billing, and inventory control applications). The Standard File Problems are fully described in Section 4:200.1 of the Users' Guide.

In all of the GE-425 Standard Configurations (shown in Section 333:031), the detail file is assigned to the on-line card reader and the report file to the on-line printer. The master file is on punched cards in Configuration I and on magnetic tape in all the other Standard Configurations. Because of the GE-425's powerful scatter-read, gather-write facilities (described in Section 330:111), the master file can be packed very efficiently on magnetic tape and held to a record size of 108 characters — the same tape record size as in character-oriented systems such as the IBM 1400 line.

The file processing performance of Standard Configuration I, which has no magnetic tape units and uses punched cards for the master file, is limited by the 300-cards-per-minute output speed of the card punch.

Standard Configurations II, III, IV, and VIIA are progressively more powerful and more expensive, but the following general comments apply to the performance of all four configurations on all four of the Standard File Problems. At low activities (i.e., low ratios of transaction records to master records), magnetic tape time for reading the master file and writing the updated master file is the limiting factor, as shown by the horizontal lines at the left side of Graphs 333:201.100 through 333:201.140. At higher activities, the speed of the on-line printer (665 lines per minute at the required 1-inch average line spacing) becomes the limiting factor in all cases. The GE-425 central processor is sufficiently fast so that at no time does internal processing speed become the limiting factor on system performance on these problems.

SORTING (333:201.200)

The standard estimates for sorting 80-character records by straightforward merging on magnetic tape (Graph 333:201.200) were developed from the processing times for Standard File Problem A according to the method explained in the Users' Guide, Paragraph 4:200.213.

MATRIX INVERSION (333:201.300)

The standard estimate for inverting a non-symmetric, non-singular matrix was computed, by the simple method described in Paragraph 4:200.312 of the Users' Guide, for Standard Configuration VIIA, which includes the Floating Point Option. Computation is performed in the floating-point format (11-digit precision).

GENERALIZED MATHEMATICAL PROCESSING (333:201.400)

Standard Mathematical Problem A is an application in which there is one stream of input data, a fixed computation to be performed, and one stream of output results. Two variables are introduced to demonstrate how the time for a job varies with different proportions of input, computation, and output. The factor C shows the effect of variations in the amount of computation per input record. The factor R indicates the ratio of input records to output records. The procedure used to evaluate performance on the Standard Mathematical Problem is fully described in Paragraph 4:200.2 of the Users' Guide.

For the GE-425, this problem was evaluated for Standard Configuration VIIA, which includes the Floating Point Option. Computation is performed in the floating-point format (11-digit precision). As a result of the high cost of performing the radix conversions between the BCD format of the input and output and the internal floating-point, binary format, the central processor is the limiting factor for all conditions evaluated except at low computational loads (C less than 0.8) when R = 1. Under these conditions, the printer is the limiting factor.

WORKSHEET DATA TABLE 1 (STANDARD FILE PROBLEM A)											
	ITEM		CONFIGURATION								REFERENCE
			I		II		III		IV & VIIA		
1 Input-Output Times	Char/block	(File 1)	54		1.080		1,080		1.080		4:200.112
	Records/block	K (File 1)	0.5		10		10		10		
	msec/block	File 1 = File 2	66.7/200		72.5		56.9		29.0		
		File 3	66.7		66.7		66.7		66.7		
		File 4	90.2		90.2		90.2		90.2		
	msec/switch	File 1 = File 2	0		0		0		0		
		File 3	0		0		0		0		
		File 4	0		0		0		0		
	msec penalty	File 1 = File 2	0.51		2.29		2.29		2.29		
		File 3	0.83		0.83		0.83		0.83		
		File 4	1.16		1.16		1.16		1.16		
2 Central Processor Times	msec/block	a_1	0.20		0.20		0.20		0.20		4:200.1132
	msec/record	a_2	0.19		0.19		0.19		0.19		
	msec/detail	b6	0.12		0.12		0.12		0.12		
	msec/work	b5 + b9	2.05		2.05		2.05		2.05		
	msec/report	b7 + b8	1.22		1.22		1.22		1.22		
3 Standard File Problem A F = 1.0			C.P.	Punch	C.P.	Printer	C.P.	Printer	C.P.	Printer	4:200.114
	msec/block for C.P. and dominant column.	a_1	0.20		0.20		0.20		0.20		
		a_2 K	0.10		1.90		1.90		1.90		
		a_3 K	1.70		33.90		33.90		33.90		
		File 1: Master In	.51		2.29		2.29		2.29		
		File 2: Master Out	.51	200	2.29		2.29		2.29		
		File 3: Details	.42		8.30		8.30		8.30		
		File 4: Reports	.58		11.60	902	11.60	902	11.60	902	
		Total	4.02	200	60.48	902	60.48	902	60.48	902	
4 Standard File Problem A Space	Unit of measure	(word*)									4:200.1151
		Std. routines	952		952		952		952		
		Fixed	72		72		72		72		
		3 (Blocks 1 to 23)	120		120		120		120		
		6 (Blocks 24 to 48)	732		732		732		732		
		Files	884		1,796		1,796		1,796		
		Working	125		250		250		250		
		Total	2.885		3,922		3,922		3,922		

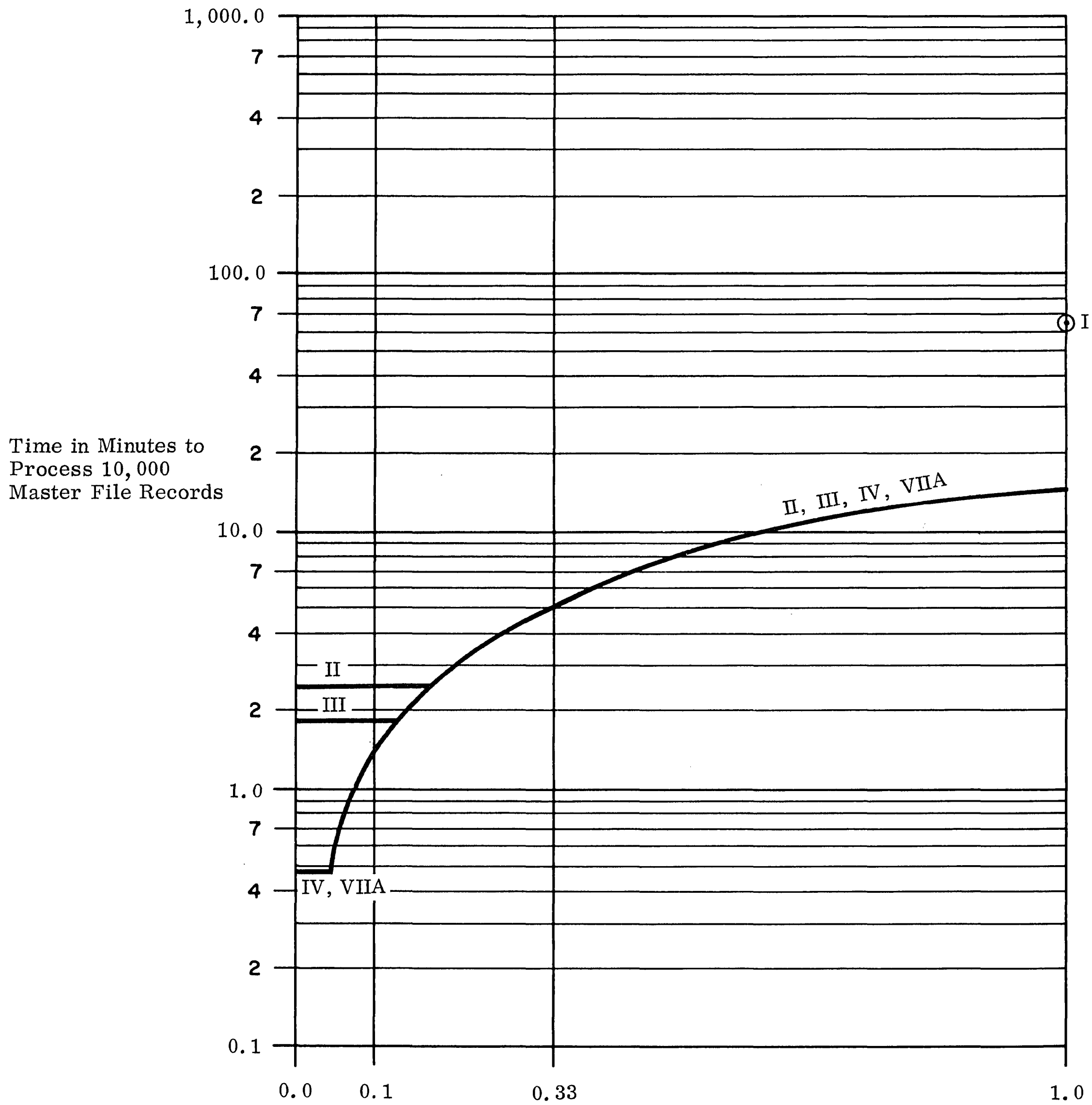
WORKSHEET DATA TABLE 2 (STANDARD MATHEMATICAL PROBLEM A)				
	ITEM		CONFIGURATION VIIA	REFERENCE
5 Standard Mathematical Problem A	Fixed/floating point		Floating point	4:200.413
	Unit name	input	CR-21 Card Reader	
		output	PR-21 Printer	
	Size of record	input	80 char	
		output	130 char	
	msec/block	input T_1	66.7	
		output T_2	90.2	
	msec penalty	input T_3	0.83	
		output T_4	1.07	
	msec/record	T_5	80.0	
	msec/5 loops	T_6	14.4	
	msec/report	T_7	0.83	

(Contd.)

.1 GENERALIZED FILE PROCESSING

.11 Standard File Problem A

.111 Record sizes—
Master file: . . . . . . 108 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.
.112 Computation:. . . . . . . standard.
.113 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.113.
.114 Graph: . . . . see graph below.
.115 Storage space required—
Configuration I: . . . . 2,885 words.
Configuration II: . . . 3,922 words.
Configuration III: . . . 3,922 words.
Configuration IV: . . . 3,922 words.
Configuration VIIA: . 3,922 words.



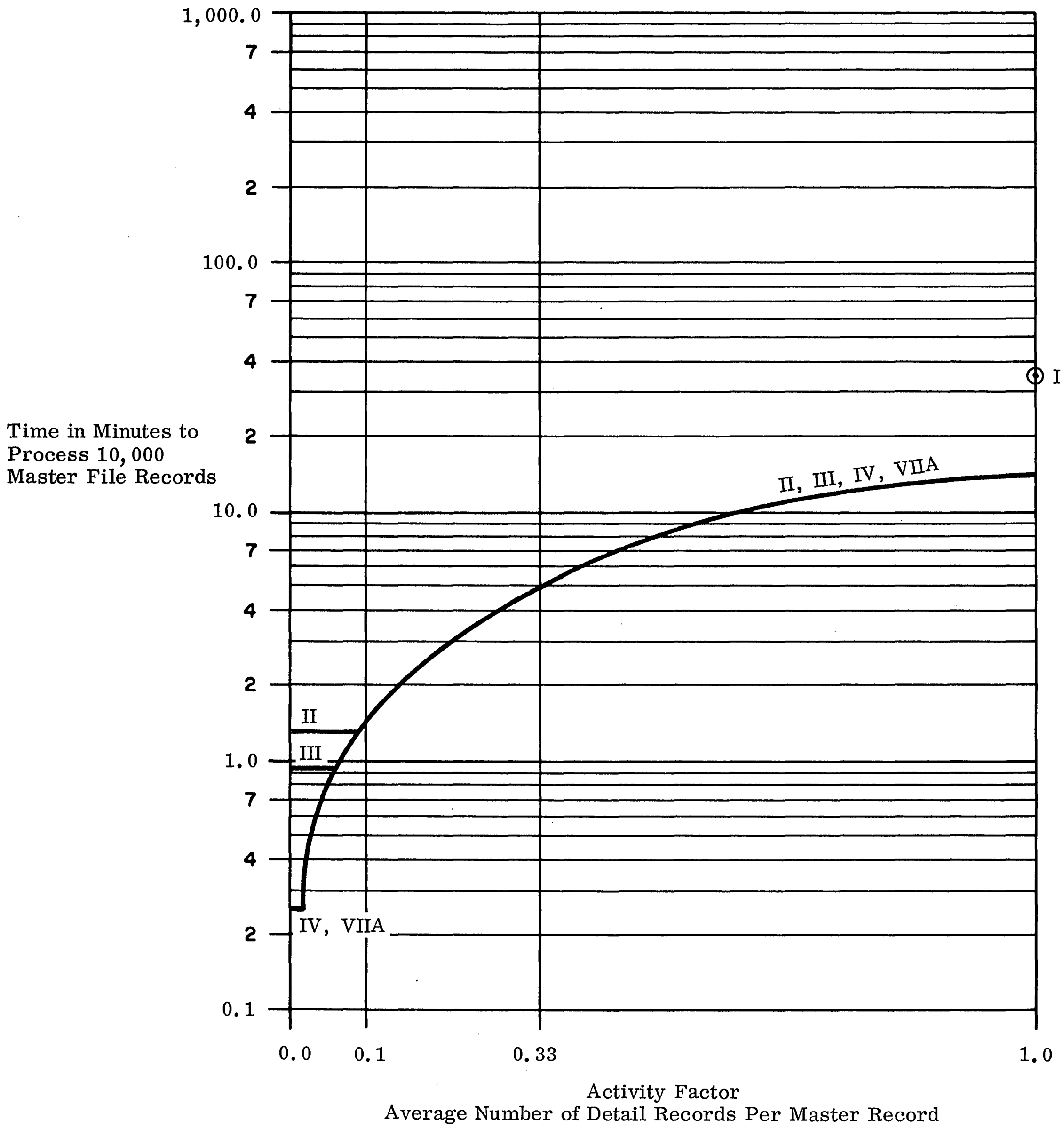
Activity Factor
Average Number of Detail Records Per Master Record

(Roman numerals denote standard System Configurations.)

.12 Standard File Problem B

.121 Record sizes —
Master file: . . . . . . 54 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.122 Computation:. . . . . . . standard.
.123 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.12.
.124 Graph: . . . . see graph below.



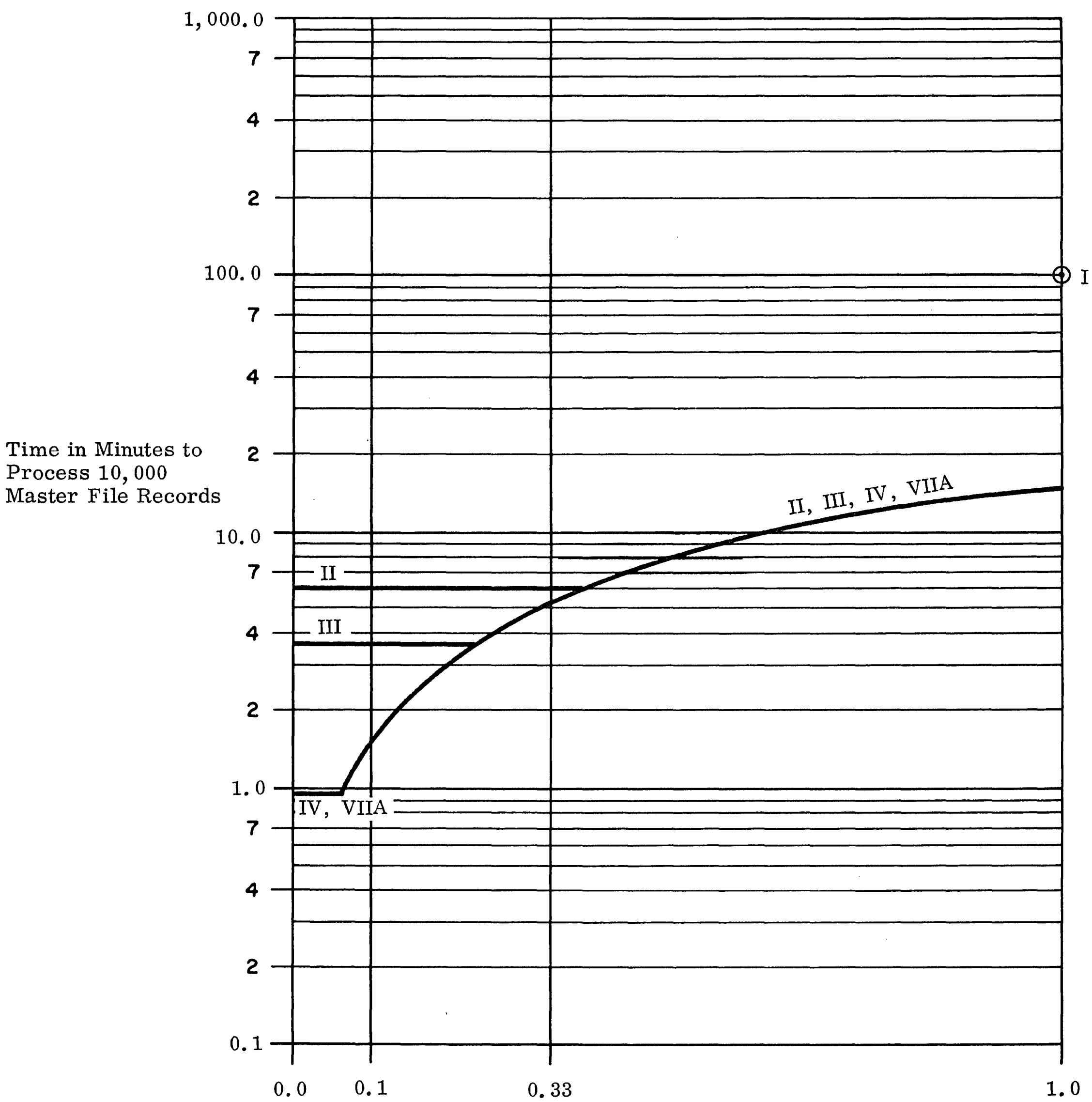
(Roman numerals denote standard System Configurations.)

(Contd.)

.13 Standard File Problem C

.131 Record sizes —
Master file: . . . . . . 216 characters.
Detail file: . . . . 1 card.
Report file: . . . . . . 1 line.

.132 Computation: . . . . standard.
.133 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.13.
.134 Graph: . . . . see graph below.



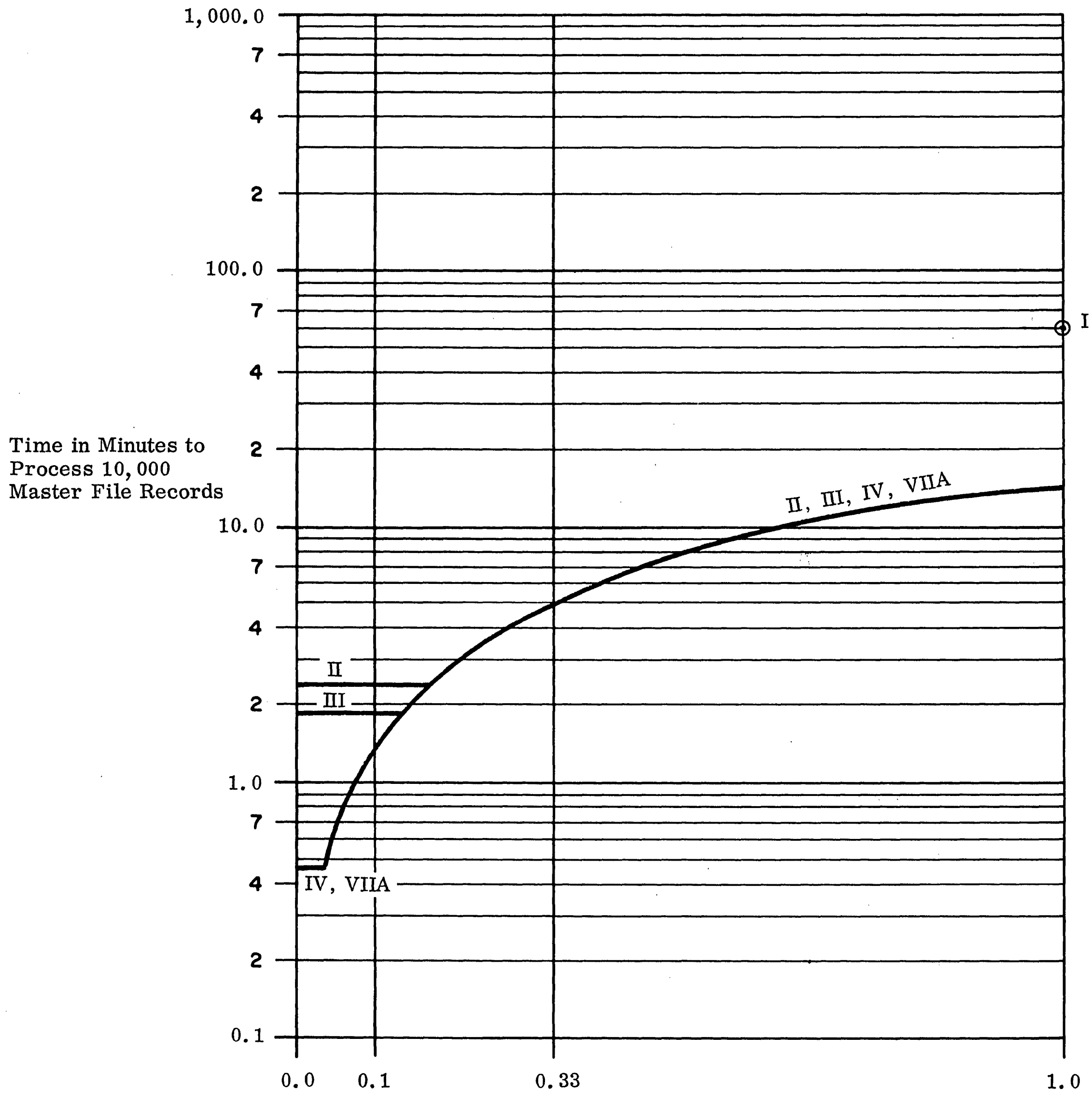
Activity Factor
Average Number of Detail Records Per Master Record

(Roman numerals denote standard System Configurations.)

.14 Standard File Problem D

.141 Record sizes —
Master file: . . . . . . 108 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.142 Computation: . . . . trebled.
.143 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.14.
.144 Graph: . . . . see graph below.



Activity Factor
Average Number of Detail Records Per Master Record

(Roman numerals denote standard System Configurations.)

(Contd.)

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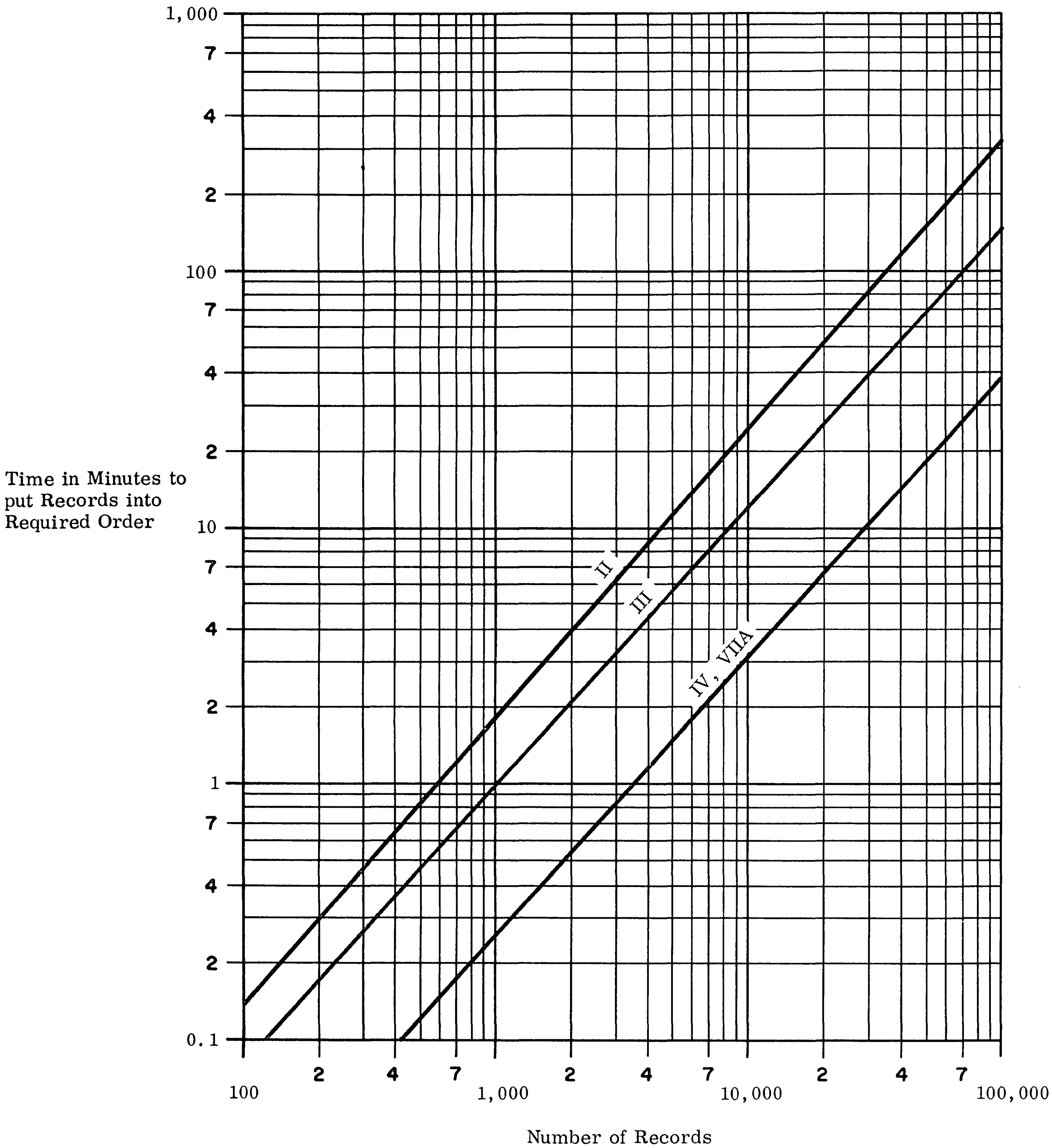
.2 SORTING

.21 Standard Problem Estimates

.211 Record size: . . . . 80 characters.
.212 Key size: . . . . 8 characters.
.213 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.213.
Two-way merge is used in Standard Configuration II, and three-way merge in Configurations III, IV, and VIIA.
.214 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

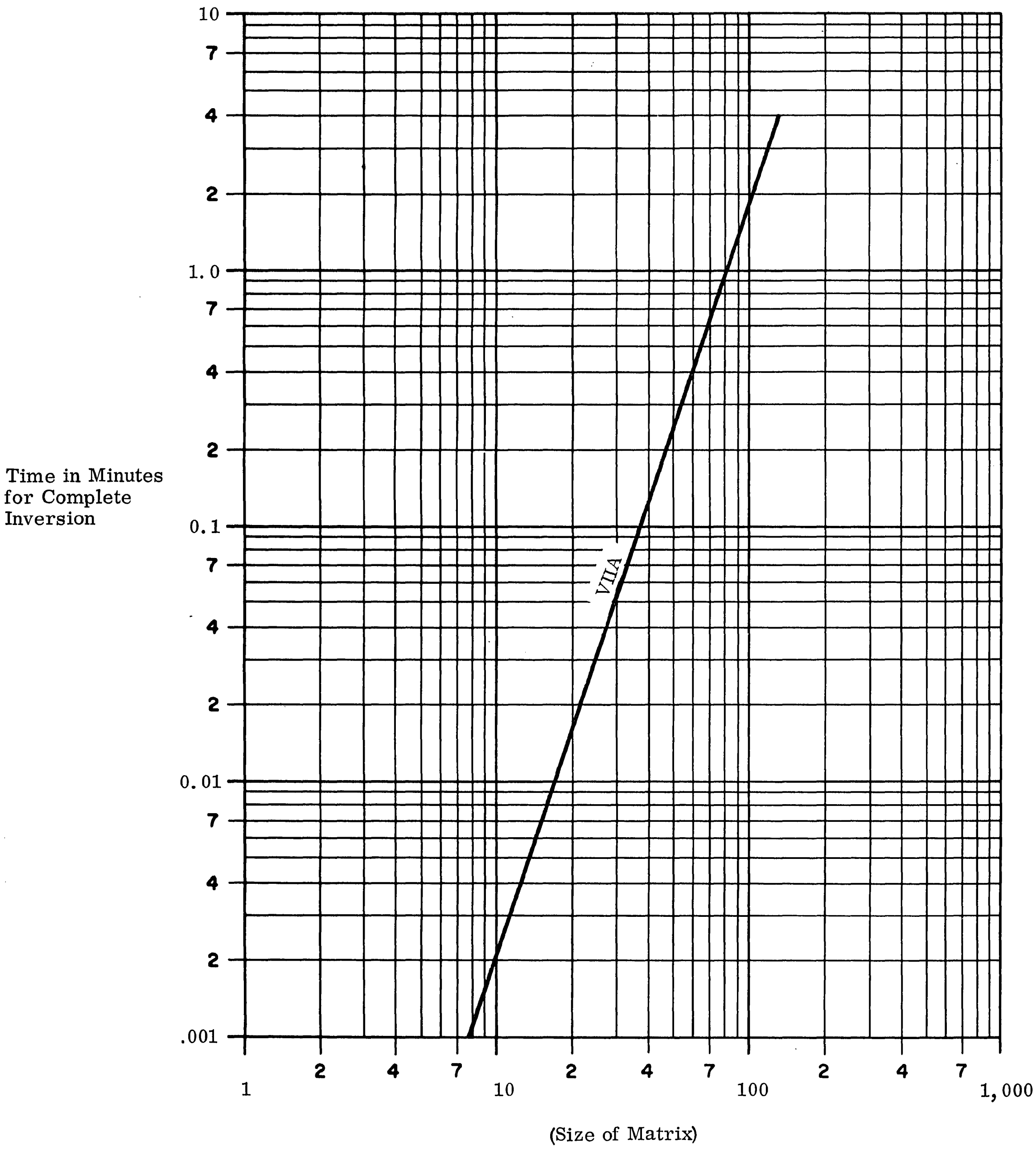
.3 MATRIX INVERSION

.31 Standard Problem Estimates

.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.312 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.312, and Floating Point Option.

.313 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

(Contd.)

.4 GENERALIZED MATHEMATICAL PROCESSING

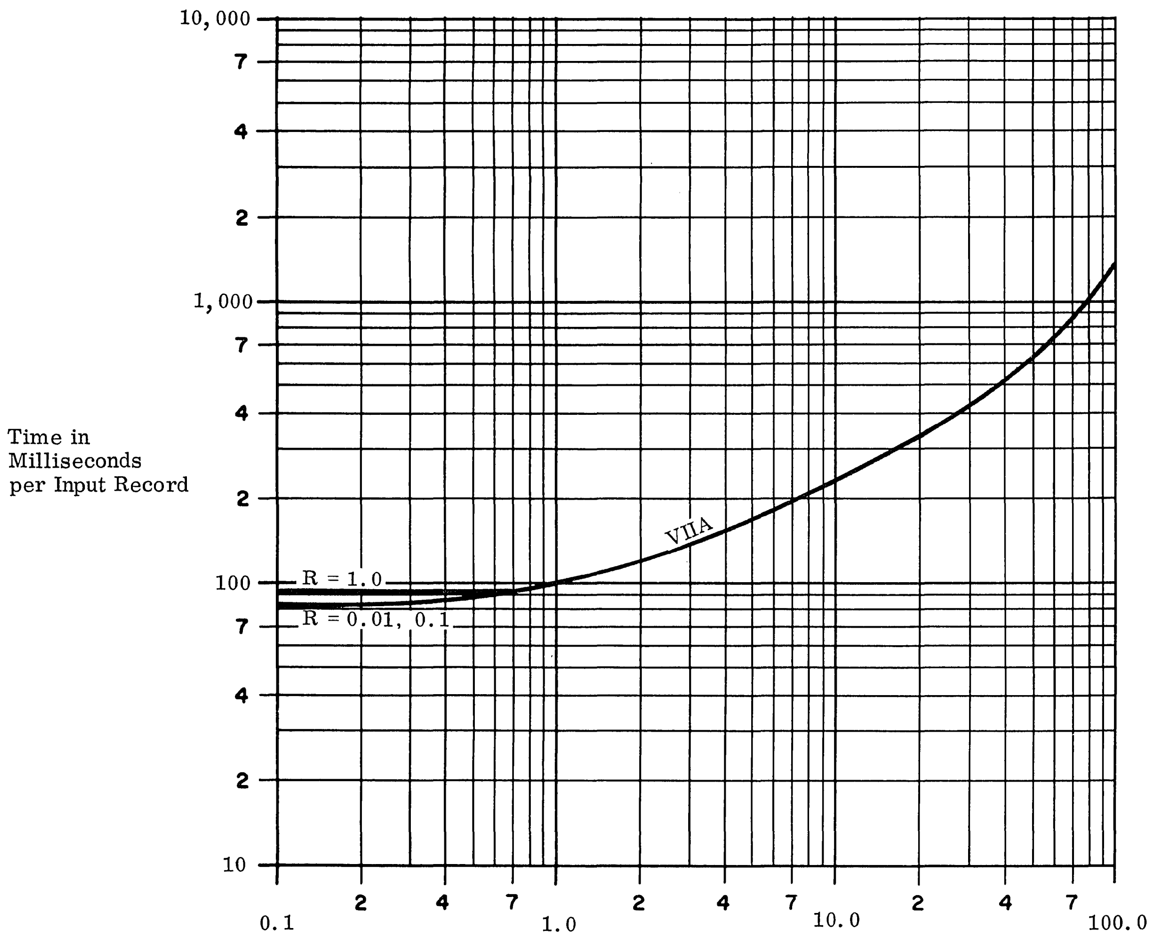
.41 Standard Mathematical Problem A Estimates

.411 Record sizes: . . . . . . 10 signed numbers; avg. size 5 digits, max. size 8 digits.

.412 Computation:. . . . . . . 5 fifth-order polynomials, 5 divisions, and 1 square root; computation is in floating-point mode (11-digit precision).

.413 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.413.

.414 Graph: . . . . see graph below.



C, Number of Computations per Input Record)

(Roman numeral denotes standard System Configuration.
R = Number of output records per input record.)

GE 435

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INTRODUCTION

The GE-435 is characterized by the cycle time of its core storage unit — 2.7 microseconds for each access of one 24-bit word.

This report concentrates upon the performance of the GE-435 in particular. All general characteristics of the GE-400 Series hardware and software are described in Computer System Report 330: GE-400 Series — General.

The System Configuration section which follows shows the GE-435 in the following standard configurations:

III: 6-Tape Business System
IV: 12-Tape Business System
V: 6-Tape Auxiliary Storage System
VIIA: 1 -Tape General System (Integrated).

These configurations were selected to illustrate the versatility of the GE-435 computer system. Note that while configuration VIIA is very similar to Configuration IV, it incorporates the optional floating-point hardware. The system configurations are arranged according to the rules in the Users' Guide, page 4:030.120, and any significant deviations from the standard specifications are listed.

Section 334:051 presents detailed central processor timing data for the GE-435. See Section 330:051 for the other characteristics of the GE-400 Series Central Processors.

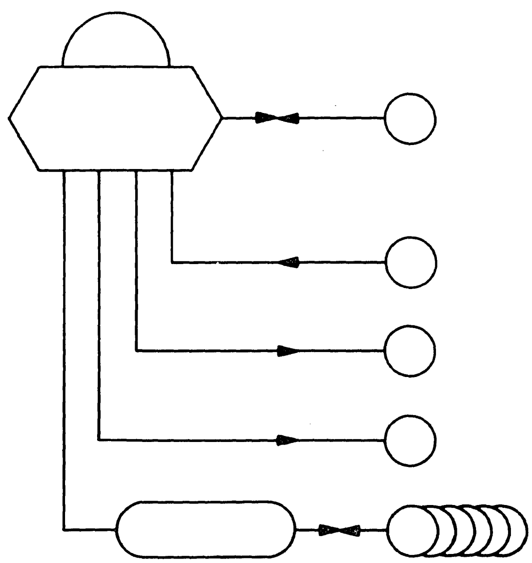
The software provided for all GE-400 Series systems is described in Sections 330:151 through 330:191 of the general report.

A detailed analysis of the overall System Performance of the GE-435 on our standard benchmark problems is presented in Section 334:201.

SYSTEM CONFIGURATION

.1 6-TAPE BUSINESS SYSTEM; CONFIGURATION III

Deviations from Standard Configuration: . . . . core storage is 100% larger.
printer is at least 80% faster.
card reader is 80% faster.
3 more index registers and console typewriter input are included.
2 more simultaneous non-tape data transfers are possible.

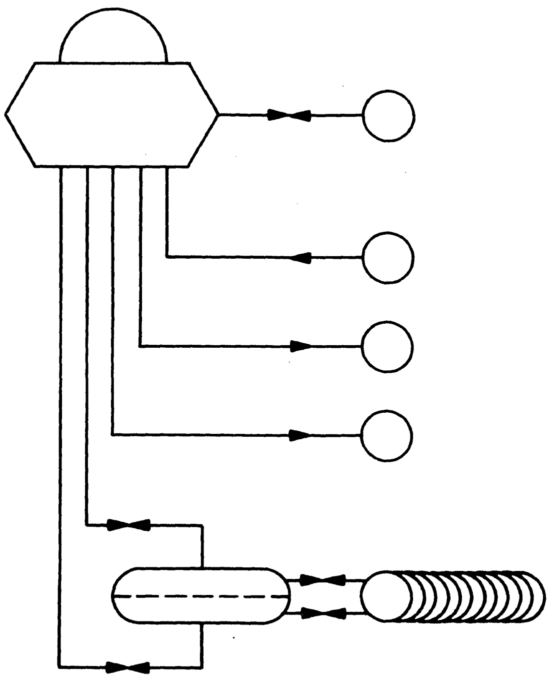


Equipment	Rental
Core Storage: 8, 192 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$ 5,500
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-19 Magnetic Tape Handlers (6) and Controller: 30,000 characters/sec.	3,300
TOTAL RENTAL:	$11,350

For overall configuration rules for GE-400 Series systems, please refer to Section 330:031.

.2 12-TAPE BUSINESS SYSTEM; CONFIGURATION IV

Deviations from Standard Configuration: . . . . card reader is 10% slower.
card punch is 50% faster.
console typewriter input included.
1 more simultaneous non-tape data transfer is possible.

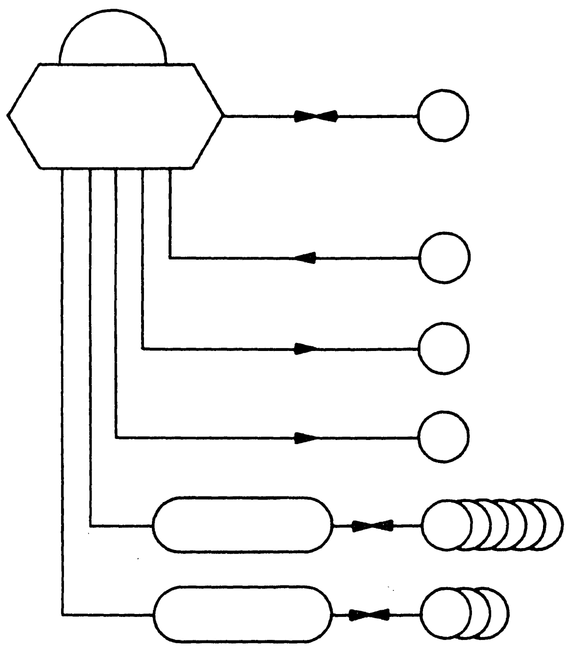


Equipment	Rental
Core Storage: 8,192 words; Central Processor, Console, I/O Typewriter, and I/O Channels	$5,500
CR-21 Card Reader: 900 cards/min.	650
CP-20 Card Punch: 300 cards/min.	825
PR-21 Printer: 1,200 lines/min.	1,400
MT-23 Magnetic Tape Handlers (12) and Dual Channel Controller: 60,000 char/sec.	8,460
TOTAL RENTAL:	$16,835

(Contd.)

.3 6-TAPE AUXILIARY STORAGE SYSTEM; CONFIGURATION V

Deviations from Standard Configuration: . . . . core storage is 100% larger.
printer is at least 80% faster.
card reader is 80% faster.
3 more index registers and console typewriter input are included.
2 more simultaneous non-tape data transfers are possible.

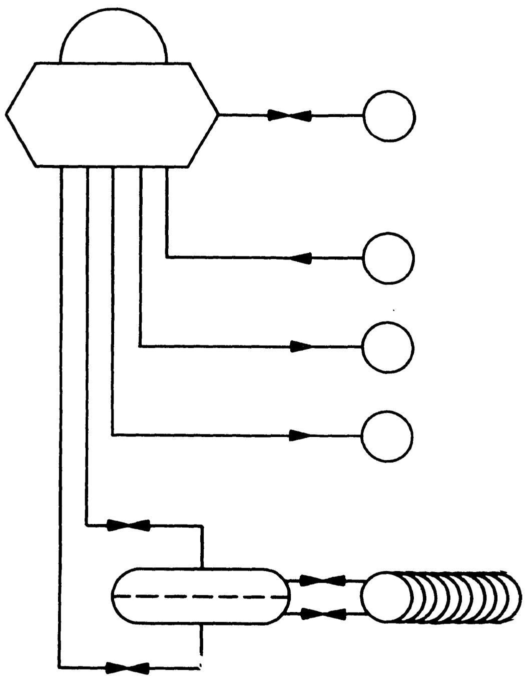


Equipment	Rental
Core Storage: 8,192 words Central Processor, Console, I/O Typewriter, and I/O Channels (except High Speed Channel)	$ 5,500
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-19 Magnetic Tape Handlers (6) and Controller: 30,000 characters/sec.	3,300
DS-15 Removable Disc Storage Units (3), Controller, and High Speed Data Channel: 23.4 million characters	2,050*
TOTAL RENTAL:	$13,400

* Does not include $15 per month rental for each Disc Cartridge.

.4 10-TAPE GENERAL SYSTEM (INTEGRATED); CONFIGURATION VIIA

Deviations from Standard Configuration: . . . . core storage is 25% larger.
printer is at least 80% faster.
card reader is 80% faster.
1 more simultaneous non-tape transfer is possible.



Equipment	Rental
Core Storage: 32,768 words Central Processor, Console, I/O Typewriter, and I/O Channels	$ 8,800
CR-21 Card Reader: 900 cards/min.	650
CP-10 Card Punch: 100 cards/min.	500
PR-21 Printer: 1,200 lines/min.	1,400
MT-23 Magnetic Tape Handlers (10) and Dual Channel Controller: 60,000 characters/sec	7,280

Optional Features Included: . . . . Floating Point Option 550

TOTAL RENTAL: $19,180

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CENTRAL PROCESSOR

.1 GENERAL

.11 Identity: . . . . GE-400 Series Central Processor with GE-435 Core Storage Unit.

.12 Description

See Section 330:051 for a comprehensive presentation of the capabilities of the GE-400 Series Central Processor.

The Instruction Times and Processor Performance Times for the GE-435 system are listed below. This system has a 2.7-microsecond core storage cycle. See Paragraphs 4:051.41 and 4:050.42 of the Users' Guide for the definitions of these standard measures of central processor performance.

.4 PROCESSOR SPEEDS

Note: W = number of 24-bit words in operand.

.41 Instruction Times in Microseconds

.411 Fixed point —
- Add-subtract: . . . . . 2.8 + 5.7W
- Multiply: . . . . 38.9 + 2.1M (M = value of the single multiplier digit).
- Divide: . . . . 79.3 + 2.1Q (Q = value of the single quotient digit).

.412 Floating point* —

These times are based on no address modification in the succeeding instruction. See Paragraph 330:051.4 for a general presentation of the floating-point execution times.
- Add-subtract: 8.5
- Multiply: 15.5
- Divide: 25.5

.413 Additional allowance for —
- Indexing: . . . . 2.7 per sequence step.
- Indirect addressing: . 2.7 per level.
- Recomplementing: . . 4.4W (1.4 when W = 1).

.414 Control —
- Compare: . . . . 2.8 + 5.7W
- Branch: . . . . 2.7 (5.4 for Branch on Zero or Minus).

* With Floating Point Option.

.415 Counter control (step and test) —
- Fixed-word counter: . 7.5
- Any-word counter: . . 10.6

.416 Edit —
- With suppression: . . 3.4 + 33.8W average.
- Without suppression: 2.6 + 19.9W average.

.417 Convert: . . . . none.

.418 Shift —
- Character: . . . . 10.0 to 101.2
- Binary: . . . . 10.0 to 32.6

.42 Processor Performance in Microseconds

D = number of digits in multiplier or quotient.

Note that in some tasks additional time may be required to properly position the product or quotient.

		Fixed point	Floating point*
.421	For random addresses —		
	c = a + b:	8.3 + 10.8W	32.8
	b = a + b:	5.5 + 5.7W	32.8
	Sum N items:	(2.8 + 5.7W)N	8.5N
	c = ab:	25.6 + 56.9D	39.8
	c = a/b:	35.9 + 97.3D	49.8
.422	For arrays of data —		
	$c_i = a_i + b_j$:	38.3 + 10.8W	62.4
	$b_j = a_i + b_j$:	32.8 + 5.7W	62.4
	Sum N items:	(20.2 + 5.7W)N	42.1N
	$c = c + a_i b_j$:	66.0 + 59.6D	75.6

.423 Branch based on comparison (numeric or alphanumeric information): . . . . 36.8 + 5.7W

.424 Switching —
- Unchecked: 8.1
- Checked: 27.4
- List search: . . . . . . 19.8 + 31.3N (N = number of comparisons).

.425 Format control, per character —
- Unpack: 0.27
- Compose: 7.9

.426 Table look-up, per comparison —
- For a match: . . . . . . 22.9 + 5.7W
- For least or greatest: . . . . 26.6 + 5.7W
- For interpolation point: . . . . 22.9 + 5.7W

.428 Moving: . . . . 16.8 + 5.2W

* With Floating Point Option.

SYSTEM PERFORMANCE

GENERALIZED FILE PROCESSING (334:201.100)

These problems involve updating a master file from transaction data in a detail file and producing a printed record of the results of each transaction. This type of run is one of the most common commercial data processing jobs (e.g., in payroll, billing, and inventory control applications). The Standard File Problems are fully described in Section 4:200.1 of the Users' Guide.

In all of the GE-435 Standard Configurations (shown in Section 334:031), the detail file is assigned to the on-line card reader and the report file to the on-line printer. The master file is on punched cards in Configuration I and on magnetic tape in all the other Standard Configurations. Because of the GE-435's powerful scatter-read, gather-write facilities (described in Section 330:111), the master file can be packed very efficiently on magnetic tape and held to a record size of 108 characters — the same tape record size as in character-oriented systems such as the IBM 1400 line.

Standard Configurations III, IV, and VIIA are progressively more powerful and more expensive, but the following general comments apply to the performance of all three configurations on all four of the Standard File Problems. At low activities (i.e., low ratios of transaction records to master records), magnetic tape time for reading the master file and writing the updated master file is the limiting factor, as shown by the horizontal lines at the left side of Graphs 334:201.100 through 334:201.140. At higher activities, the speed of the on-line printer (665 lines per minute at the required 1-inch average line spacing) becomes the limiting factor in all cases. The GE-435 central processor is sufficiently fast so that at no time does internal processing speed become the limiting factor on system performance on these problems.

SORTING (334:201.200)

The standard estimates for sorting 80-character records by straightforward merging on magnetic tape (Graph 334:201.200) were developed from the processing times for Standard File Problem A according to the method explained in the Users' Guide, Paragraph 4:200.213.

MATRIX INVERSION (334:201.300)

The standard estimate for inverting a non-symmetric, non-singular matrix was computed, by the simple method described in Paragraph 4:200.312 of the Users' Guide, for Standard Configuration VIIA, which includes the Floating Point Option. Computation is performed in the floating-point format (11-digit precision).

GENERALIZED MATHEMATICAL PROCESSING (334:201.400)

Standard Mathematical Problem A is an application in which there is one stream of input data, a fixed computation to be performed, and one stream of output results. Two variables are introduced to demonstrate how the time for a job varies with different proportions of input, computation, and output. The factor C shows the effect of variations in the amount of computation per input record. The factor R indicates the ratio of input records to output records. The procedure used to evaluate performance on the Standard Mathematical Problem is fully described in Paragraph 4:200.2 of the Users' Guide.

For the GE-435 this problem was evaluated for Standard Configuration VIIA, which includes the Floating Point Option. Computation is performed in the floating-point format (11-digit precision). At low computational loads, there is sufficient time, even with the necessary radix conversions, for the GE-435 to complete the required processing and keep the peripheral units running at their peak effective speeds. For R = 1.0, the printer is the limiting factor for computational loads less than about 2.4 times the standard amount (C = 2.4). When less frequent printed output is required (R = 0.01 or 0.1), the card reader is the limiting factor for computational loads less than about 0.45 times the standard amount. The central processor is the limiting factor for all other conditions evaluated.

WORKSHEET DATA TABLE 1 (STANDARD FILE PROBLEM A)							
	ITEM		CONFIGURATION				REFERENCE
			III		IV & VIIA		
1 Input-Output Times	Char/block	(File 1)	1,080		1,080		4:200.112
	Records/block	K (File 1)	10		10		
	msec/block	File 1 = File 2	56.9		29.0		
		File 3	66.7		66.7		
		File 4	90.2		90.2		
	msec/switch	File 1 = File 2	0		0		
		File 3	0		0		
		File 4	0		0		
	msec penalty	File 1 = File 2	1.80		1.80		
		File 3	0.68		0.68		
		File 4	0.96		0.96		
2 Central Processor Times	msec/block	a_1	0.15		0.15		4:200.1132
	msec/record	a_2	0.14		0.14		
	msec/detail	b6	0.09		0.09		
	msec/work	b5 + b9	1.62		1.62		
	msec/report	b7 + b8	1.01		1.01		
3 Standard File Problem A F = 1.0	msec/block for C.P. and dominant column.		C.P.	Printer	C.P.	Printer	4:200.114
		a_1	0.15		0.15		
		a_2 K	1.40		1.40		
		a_3 K	27.20		27.20		
		File 1: Master In	1.80		1.80		
		File 2: Master Out	1.80		1.80		
		File 3: Details	6.80		6.80		
		File 4: Reports	9.60	902	9.60	902	
		Total	48.75	902	48.75	902	
4 Standard File Problem A Space	Unit of measure	(word*)					4: 200:1151
		Std. routines	952		952		
		Fixed	72		72		
		3 (Blocks 1 to 23)	120		120		
		6 (Blocks 24 to 48)	732		732		
		Files	1,796		1,796		
		Working	125		125		
		Total	3,922		3,922		

* 1 word = 4 characters.

WORKSHEET DATA TABLE 2 (STANDARD MATHEMATICAL PROBLEM A				
	ITEM		CONFIGURATION VIIA	REFERENCE
5 Standard Mathematical Problem A	Fixed/floating point		Floating point	4:200.413
	Unit name	input	CR-21 Card Reader	
		output	PR-21 Printer	
	Size of record	input	80 char	
		output	120 char	
	msec/block	input T_1	66.7	
		output T_2	90.2	
	msec penalty	input T_3	0.67	
		output T_4	0.96	
	msec/record	T_5	60.00	
	msec/5 loops	T_6	12.76	
	msec/report	T_7	0.69	

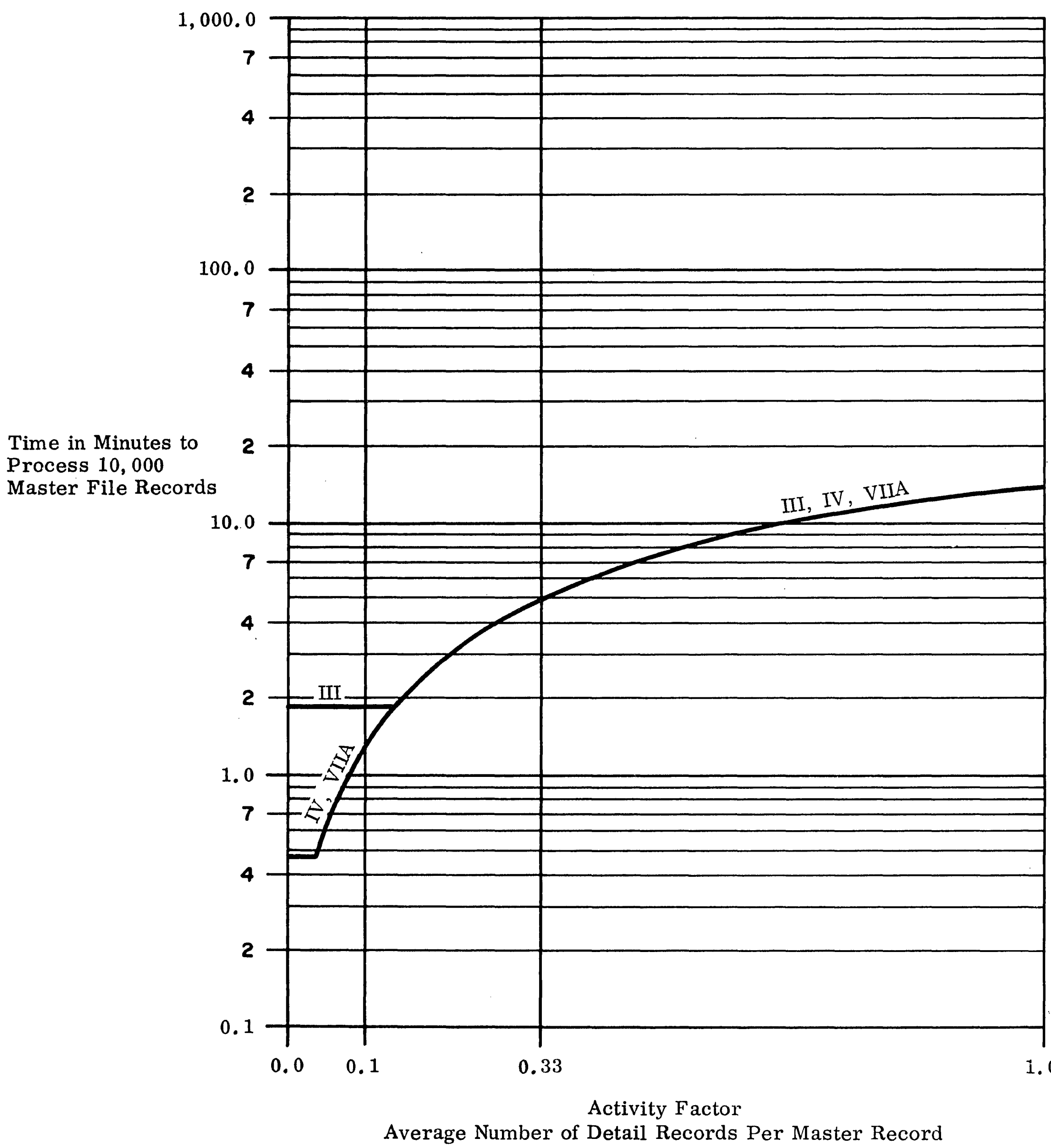
(Contd.)

.1 GENERALIZED FILE PROCESSING

.11 Standard File Problem A

.111 Record sizes —
Master file: . . . . . . 108 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.112 Computation:. . . . . . . standard.
.113 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.113.
.114 Graph:. . . . . see graph below.
.115 Storage space required —
Configuration III: . . . 3,922 words.
Configuration IV: . . . 3,922 words.
Configuration VIIA: . 3,922 words.



(Roman numerals denote standard System Configurations.)

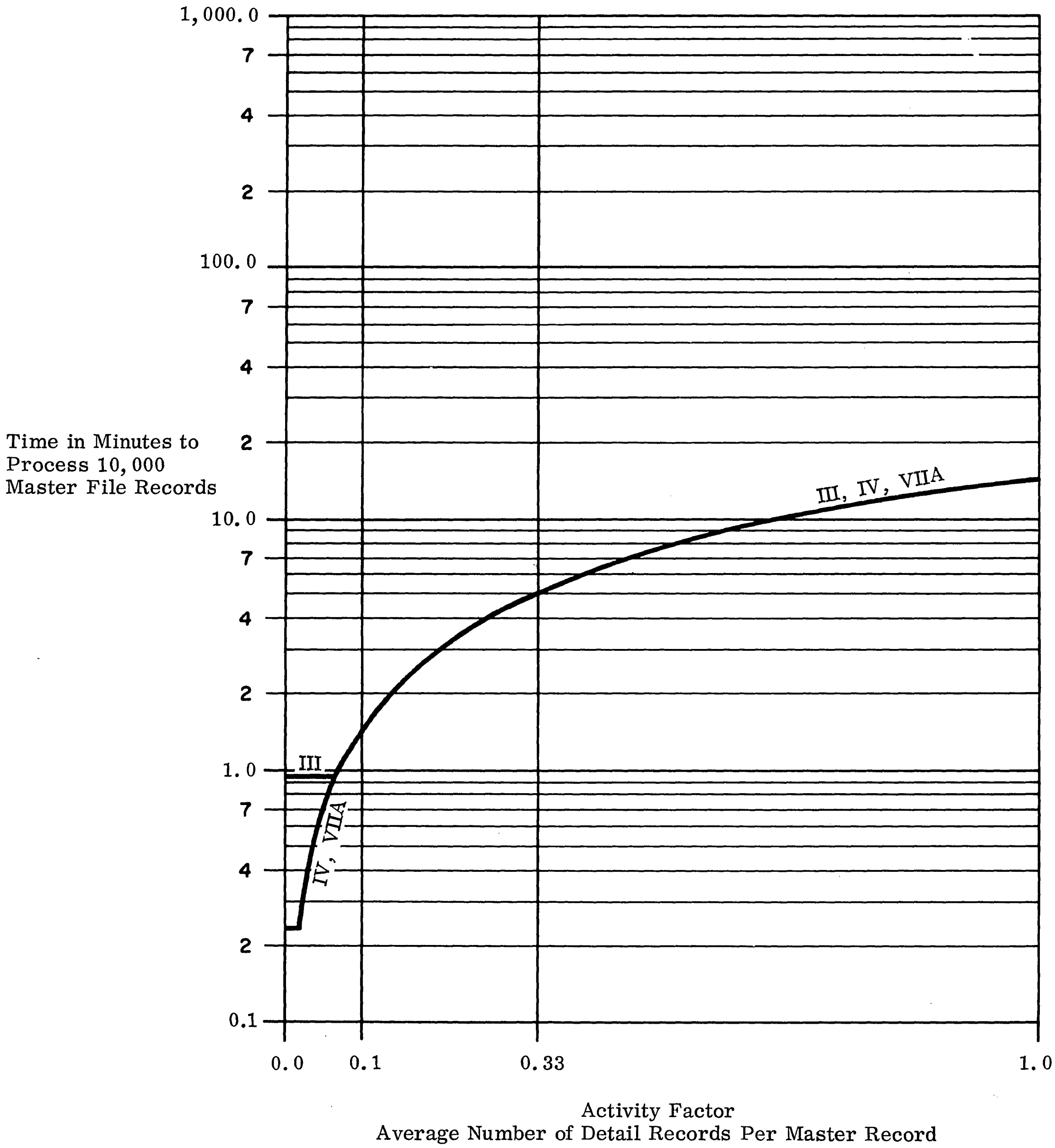
.12 Standard File Problem B

.121 Record sizes—
Master file: . . . . . . 54 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.122 Computation:. . . . . . . standard.

.123 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.12.

.124 Graph:. . . . . see graph below.



(Roman numerals denote standard System Configurations.)

(Contd.)

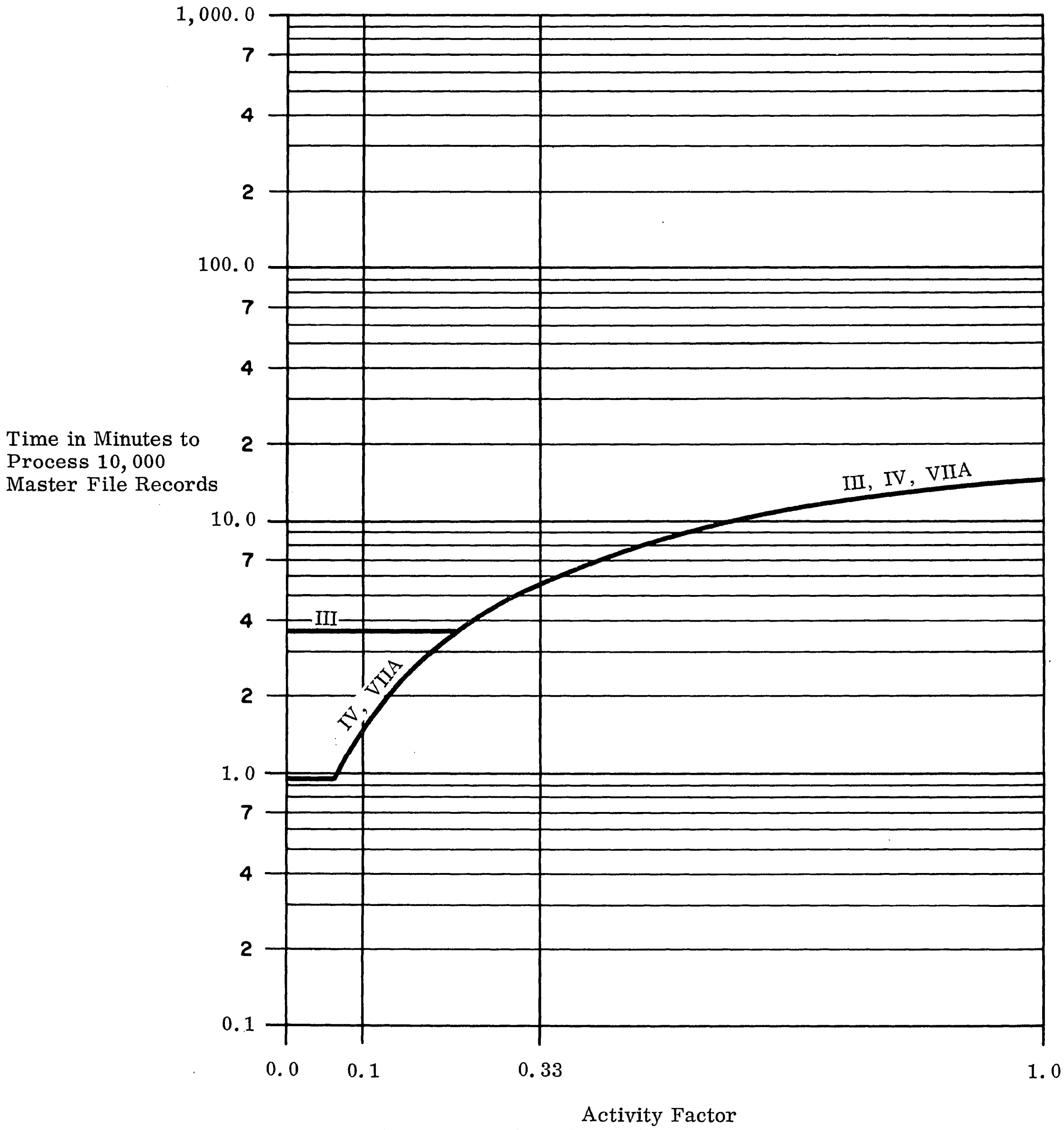
.13 Standard File Problem C

.131 Record sizes —
Master file: . . . . . . 216 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.132 Computation:. . . . . . . standard.

.133 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.13.

.134 Graph:. . . . . see graph below.

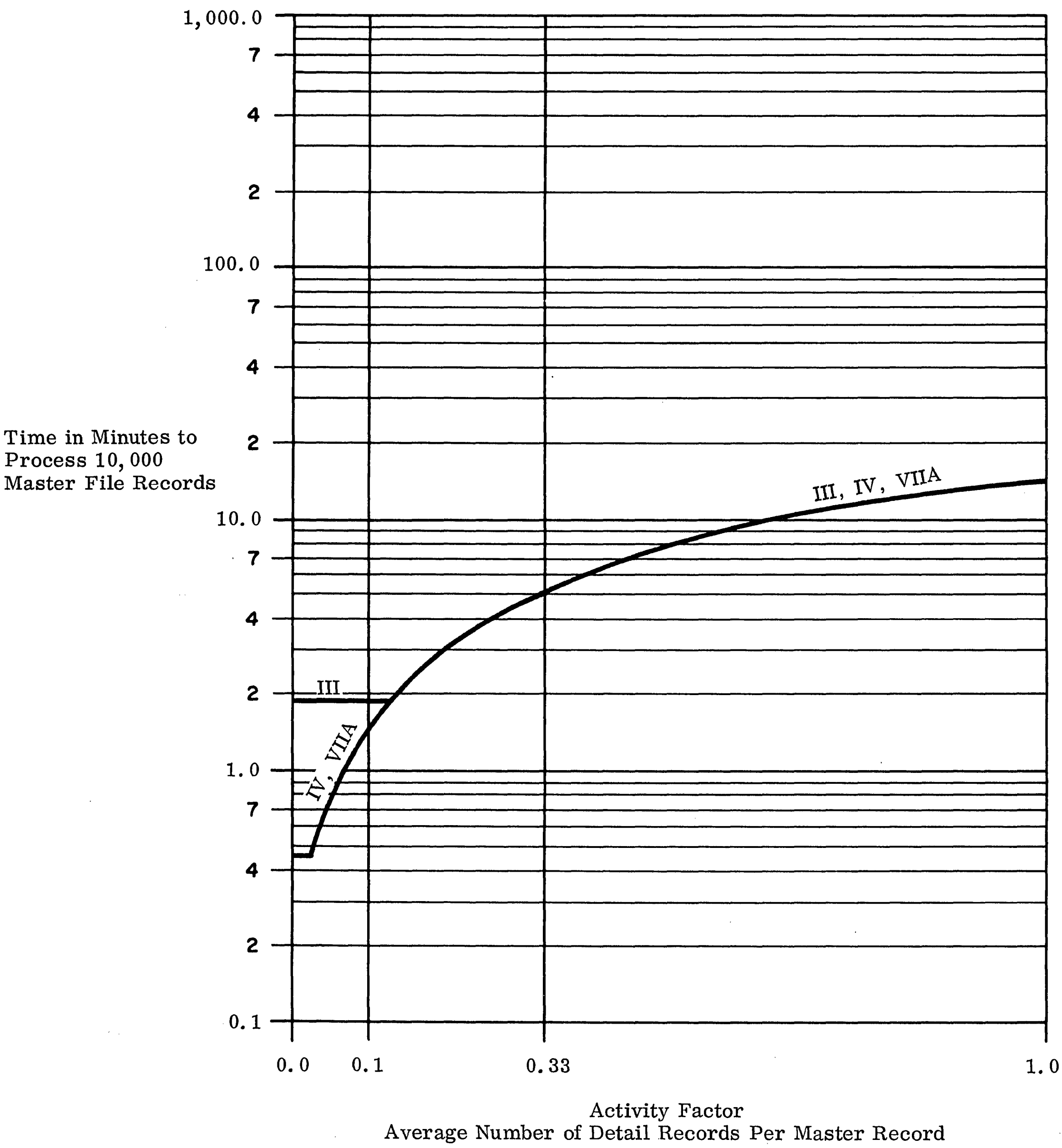


(Roman numerals denote standard System Configurations.)

.14 Standard File Problem D

.141 Record sizes —
Master file: . . . . . . 108 characters.
Detail file: . . . . 1 card.
Report file:. . . . . . . 1 line.

.142 Computation:. . . . . . . trebled.
.143 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.14.
.144 Graph: . . . . see graph below.



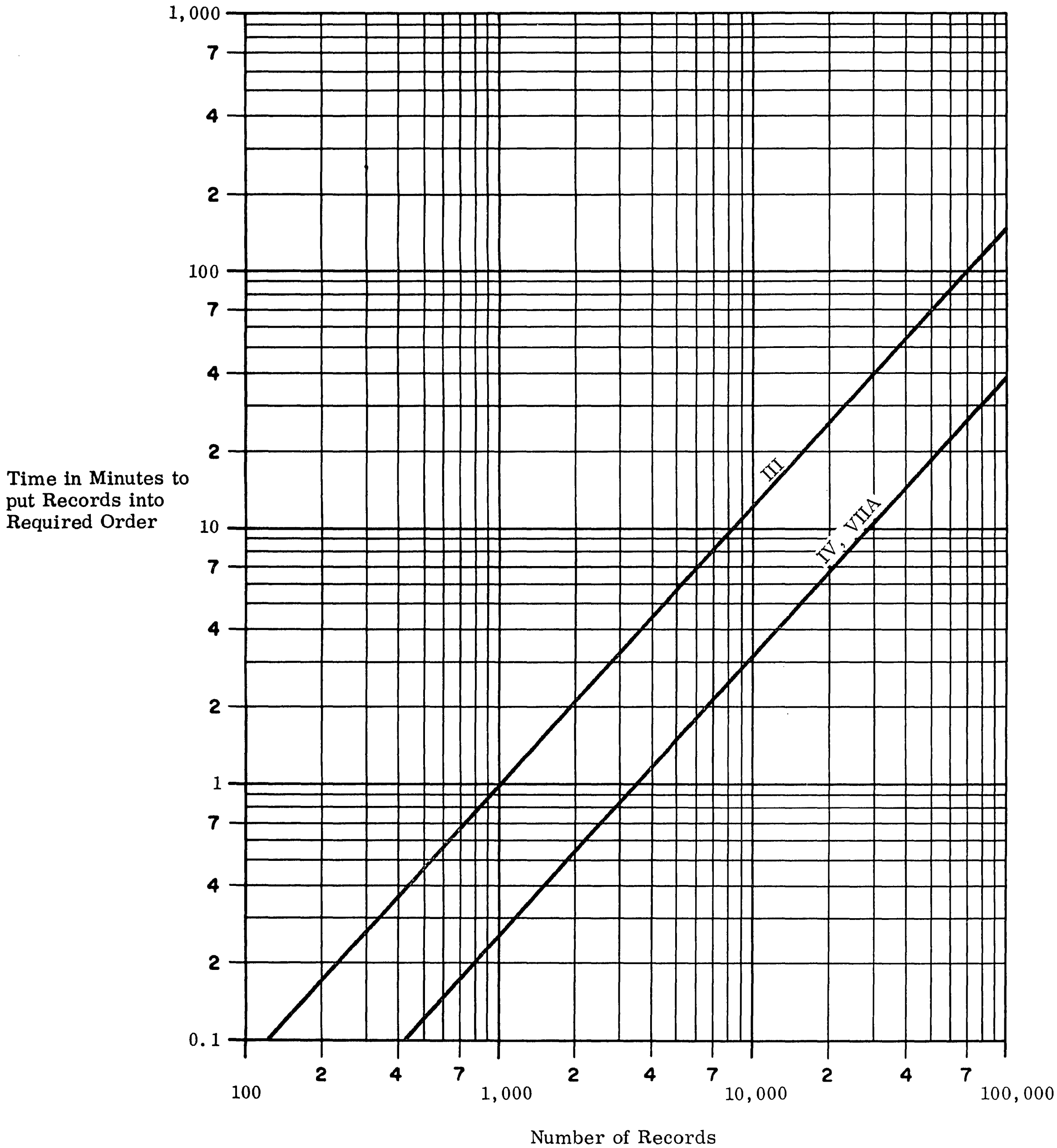
(Roman numerals denote standard System Configurations.)

(Contd.)

.2 SORTING

.21 Standard Problem Estimates

.211 Record size: . . . . 80 characters.
.212 Key size: . . . . 8 characters.
.213 Timing basis: . . . . . . using estimating procedure, outlined in Users' Guide, 4:200.213.
Three-way merge is used in Configuration III, IV. and VIIA.
.214 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

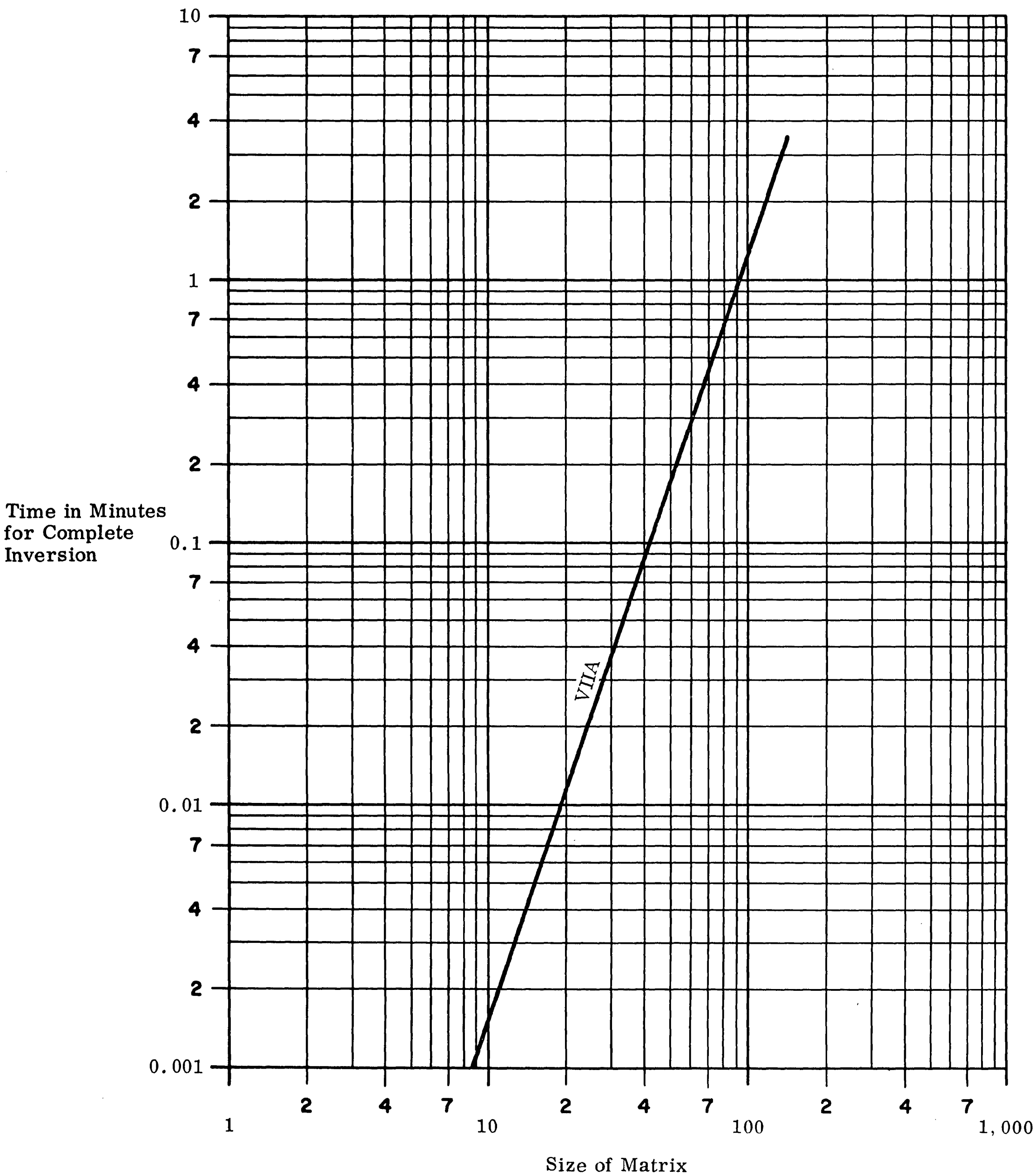
.3 MATRIX INVERSION

.31 Standard Problem Estimates

.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.312 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.312, and Floating Point Option.

.313 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

(Contd.)

AUERBACH

.4 GENERALIZED MATHEMATICAL PROCESSING

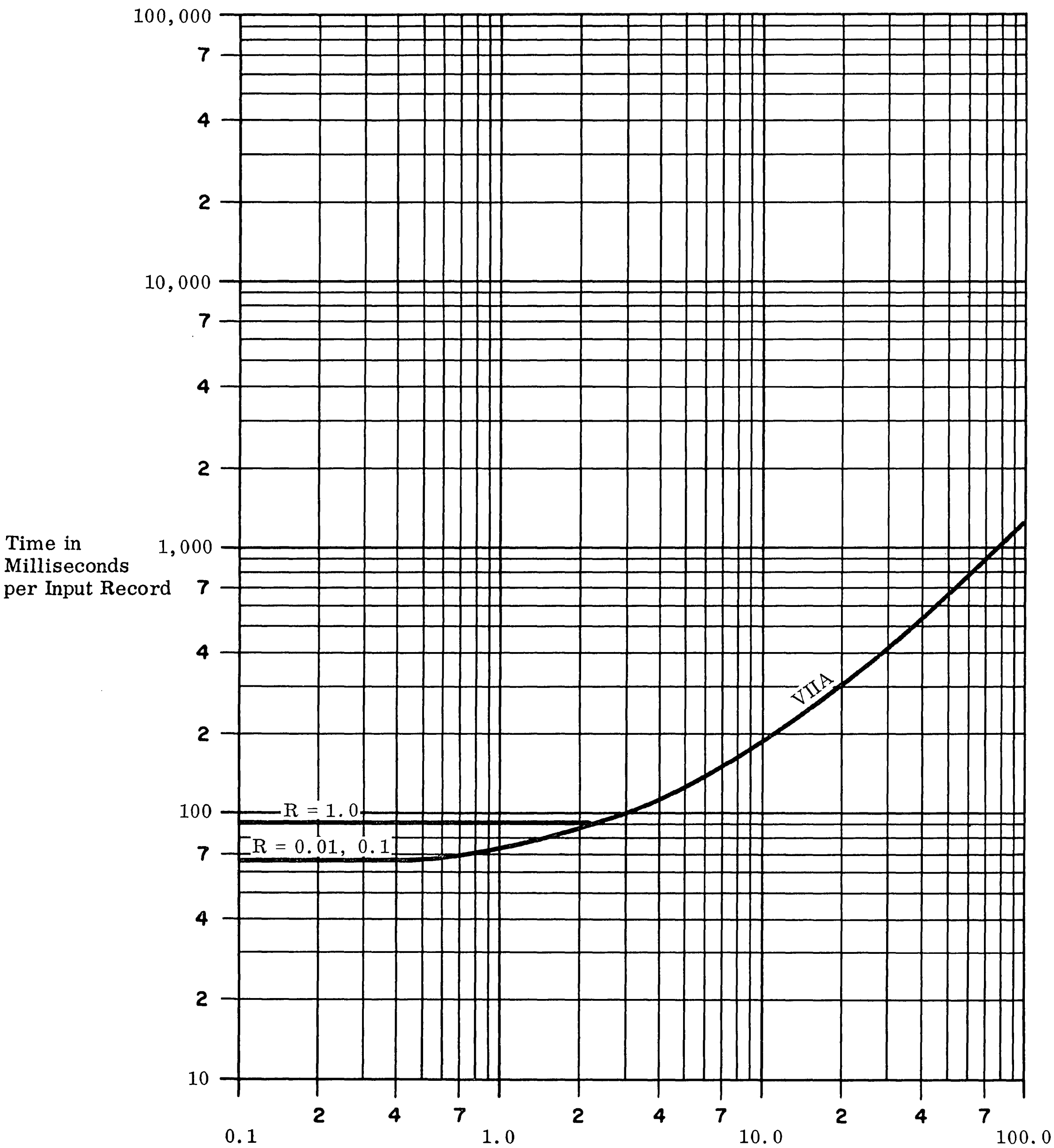
.41 Standard Mathematical Problem A Estimates

.411 Record sizes: . . . . . . 10 signed numbers; avg. size 5 digits, max. size 8 digits.

.412 Computation: . . . . . 5 fifth-order polynomials, 5 divisions, and 1 square root; computation is in floating-point mode (11-digit precision).

.413 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.413.

.414 Graph: . . . . see graph below.



C, Number of Computations per Input Record

(Roman numeral denotes standard System Configuration.
R = Number of output records per input record.)

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CONTENTS

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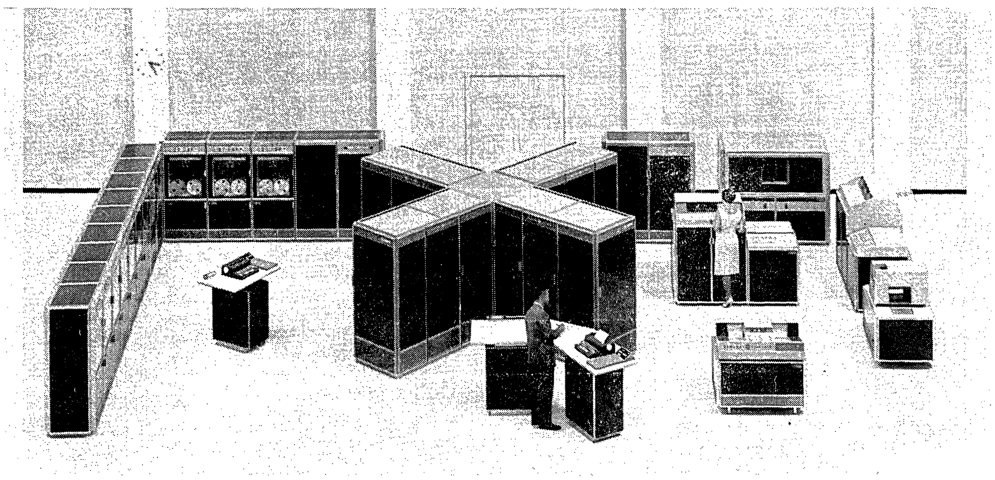


GE-625 COMPUTER SYSTEM
(Photo courtesy of General Electric Computer Department)

INTRODUCTION

The GE-600 Series represents the General Electric Computer Department's first entry into the large-scale computer field. Emphasis in the design of the GE-600 Series has been to incorporate the better features of existing computer systems rather than to blaze new trails in hardware development. The series was developed primarily to supersede the many IBM 7090/7094 installations within the General Electric organization. It appears to be a well-engineered and well-coordinated, although cautious, entry into the large-scale computer market.

Two members of the series, the GE-625 and GE-635, were announced for commercial sale in May 1964, with rumors of more to come. Already announced is a corresponding line of computers for military procurement. This line includes, along with the above systems: the militarized M-625; the M-605, which is similar to the M-625 but lacks floating-point and double-precision hardware; and the A-605, which is a miniaturized version for aerospace applications. The GE-625 and GE-635 share all components except core storage, and their performance is quite similar. First delivery of a commercial GE-600 Series computer system is scheduled for the first quarter of 1965. Typical rentals for a single-processor GE-635 system range from approximately \$40,000 to \$65,000 per month. GE-625 systems with 32K words of core storage will rent for \$3,000 less than the corresponding GE-635 systems.

There is no direct program compatibility between the GE-600 Series and other GE computer systems (the GE-400 Series and the GE-200 Series), although the 600 and 400 Series do share the same peripheral devices. More important is the question of compatibility between the GE-600 Series and the IBM 7090 and 7094 systems. Present compatibility is limited to the following:

- Software — The GE-600 Series FORTRAN IV compiler will accept and compile source programs written in FORTRAN IV for an IBM 7090/94. The General Internal FORTRAN Translator (GIFT) will accept source programs written in FORTRAN II for an IBM 7090/94 and translate them to FORTRAN IV language. The restrictions for GIFT are the same as for SIFT, the Share Internal FORTRAN Translator.

- Hardware — The GE-600 Series Magnetic Tape Handlers are code-compatible (except for a few special characters) with IBM 729 Magnetic Tape Units in both the binary and BCD modes.

The compatibility outlook for the future is more promising. General Electric is developing a combination hardware-software system that will enable an IBM 7090/94 object program to be run on a GE-600 Series computer system with few, if any, changes. The hardware for this purpose will be a "black box" containing the same number and size of accumulators and registers as in the simulated computer, and some control logic. The software will consist of extensions to the operating system (GECOS) to provide the necessary interrupt actions and I/O interface; i.e., the 7090/94 input-output operations will be simulated. GE indicates that the object programs run on a GE-600 Series computer system will duplicate the results (precision, truncation, etc.) obtained on the simulated computer, and that it will be possible to run a 7090/94 program in a multiprogramming mode with other GE-600 Series programs. Typical scientific program run times are expected to be at least as fast as on the IBM systems. The 7090/94 simulator facilities are scheduled for release about the third quarter of 1965.

In order to emphasize the similarities of the current members of the GE-600 Series and to prepare for future additions to the line, the AUERBACH Standard EDP Reports analysis of the GE-600 Series is organized in a manner similar to the IBM System/360 report. The main body of general description and analysis is presented in this Computer System Report (340:), with subreports (343: for the GE-625 and 344: for the GE-635) providing detailed information about the performance of the individual systems. In the general report (340:), where differences exist, the specifications are presented for both systems. Otherwise, all remarks apply to both the GE-625 and GE-635.

The GE-600 Series Computer systems can be characterized by three major topics: the modularity of the hardware, the comprehensive line of software, and the emphasis upon multiprogrammed operation. Each of these topics is discussed in the paragraphs that follow.

HARDWARE

A GE-600 Series computer system includes four major types of components:

- Memory Modules
- Processor Modules
- Input/Output Controller Modules
- Peripheral devices.

Memory Module

The two currently-announced members of the GE-600 Series, the GE-625 and the GE-635, differ only in the speed of their core storage units. The GE-625 uses a core memory with a cycle time of 2 microseconds; the GE-635 uses a unit with a 1-microsecond cycle time. Each access, in both systems, is for a word-pair (two 36-bit-plus-parity words).

Up to 262,144 36-bit words of core storage can be incorporated in a single-processor GE-600 Series system, in modules of 32,768 words. One 40,960-word module can be substituted for a 32K module in systems containing less than the maximum capacity.

The Memory Module is the heart of every GE-600 Series system. Each Memory Module is composed of a System Controller and one or two 32K modules of core storage (or possibly one 32K and one 40K module), and is an independent unit capable of being accessed simultaneously with other Memory Modules.

The System Controller performs many of the priority and control functions in a GE-600 Series system. Among these functions are:

- Control of communication between memory and the central processor and between memory and the I/O Controller.
- Control of input-output interrupts for multiprocessor jobs, system programs, and peripheral devices.
- Switching of control signals, addresses, and data to and from the Memory Module.

Each System Controller has eight "memory ports" (channels) for connection to Processor Modules, I/O Controller Modules, or non-standard peripheral devices.

Processor Module

The GE-600 Series Processor Module uses a single-address instruction format and has a wide range of address modification capabilities, including various combinations of indexing and indirect addressing. There are two basic modes of processor operation: master mode and slave mode. Control programs will normally be executed in the master mode, and the user's object programs in the slave mode. Programs running in the master mode have access to the entire core memory, can initiate peripheral and internal control functions, and do not have base address relocation applied. Programs running in the slave mode have access to a limited portion of the memory (as specified by the Base Address Register), cannot initiate peripheral control instructions, and have the contents of the Base Address Register added to all relative memory addresses of the object program. The processor is automatically put into the master mode of operation when the Master Mode Indicator is set or when any interrupt is recognized. In a system having multiple Processor Modules, one is designated the control processor. Only the control processor, operating in the master mode, can initiate input-output operations.

Instructions are fetched in pairs — an even word and the successive odd word. Address modification, operand fetching, instruction execution, and fetching of the next pair of instructions are overlapped to increase processor performance wherever possible. Indexing does not increase the instruction execution times, but indirect addressing does.

Processor registers include a timer register, eight index registers, an indicator register, an instruction counter, a 72-bit accumulator (which can also be used as two independent accumulators or four independent index registers), an exponent register for floating point operations, and the Base Address Register mentioned above.

A total of 170 basic instructions are available, most of which will be familiar to programmers of other large-scale binary computers. The instruction repertoire includes comparisons (logical, algebraic, magnitude, masked, and between limits), loading, storing, Boolean operations, branching, and shifting instructions. Provision is made for the use of half-word, single-word, or double-word operands in many operations.

Floating-point operations include single or double precision loading, storing, comparison, addition, subtraction, multiplication, and division. Floating-point numbers are represented by a mantissa of 28 bits (single precision) or 64 bits (double precision) and a binary exponent of 8 bits. Both the exponent and mantissa are represented in two's complement notation. Single precision is equivalent to about 8 decimal digits, and double precision to 19 decimal digits.

Several special instructions can reduce programming effort and increase efficiency by facilitating the processing of lists of data and the coding of routines that require multi-word precision. There are, however, no editing instructions, no code translation instructions other than Gray to binary, and no radix conversion instructions other than a one-digit-at-a-time binary to BCD instruction.

A powerful, nine-level interrupt system is incorporated into the GE-600 Series processors. The interrupt levels fall into two broad classifications:

- Fault interrupts — five level of interrupts caused by detection of faults or special conditions within the Processor Module.
- Program interrupts — four levels of interrupts, all dealing with input-output conditions.

Handling of the interrupts and error conditions is normally a function of GECOS, the standard supervisory routine, but the programmer can specify the use of his own routines for many conditions.

Input/Output Controller Module

The I/O Controller is a small processor containing the necessary logic circuits for independent handling of all I/O operations once a connection to a Memory Module has been established. The I/O Controller uses information from the supervisory area of core memory to indicate the input or output area of memory. It also performs an address check to prevent an I/O operation from either reading or writing in an area outside the proper program area. An I/O Controller can have up to 16 input-output channels: 10 standard-speed (up to 25,000 characters per second) and 6-high-speed (up to 400,000 characters per second). Each I/O Controller can access up to four Memory Modules, and each Memory Module can be connected to up to four I/O Controllers, providing the capability for connecting a large number of peripherals on-line to a GE-600 Series computer system.

Peripheral Devices

A limited number of conventional peripheral devices have been announced to date; they are listed in Table I, along with the number of high-speed (type HS) or standard-speed (type SC) input-output channels required for each subsystem.

System Configuration

Configuration rules for the GE-600 Series components can be summarized as follows:

- Each Processor Module can be connected to 1 to 4 Memory Modules.
- Each Memory Module can be connected to a total of up to 8 Processor Modules, I/O Controller Modules, and non-standard input-output devices. Up to 262,144 words of core storage can be incorporated in a single-processor system.
- Each I/O Controller Module can be connected to 1 to 4 Memory Modules and can have from 3 to 6 high-speed input-output channels and from 5 to 10 standard-speed input-output channels.

Software

General Electric is providing a well-integrated line of software for the 600 Series that includes:

- General Comprehensive Operating Supervisor (GECOS) — This is a master control routine, and all activities of a GE-600 Series computer system are normally carried out under its control. GECOS has provisions for receiving job programs from a card reader or from a program library, scheduling, allocation of peripherals and memory, and communication with the operator. It can control the execution of up to eight programs concurrently in a multiprogramming mode. Scheduling is based on priority and peripheral availability. Communication with GECOS is handled through control cards or the console typewriter. A version of GECOS that will handle multi-sequencing (multiple Processor Modules) is scheduled for mid-1965.

- General File Record Control (GEFRC) — This is the control routine that will usually be used by programmers specifying input-output operations. It permits all input-output data to be regarded by the programmer in terms of files, and frees the programmer from tedious coding of input-output operations. File Specifications in the user's programs specify record sizes, blocking, and other information. (They are produced automatically by the COBOL and FORTRAN compilers.) The device assigned to each file at execution time depends upon the content of the File Control Card submitted at load time, providing a degree of freedom from the need for specific types of peripheral devices.

- General Loader — The functions of the General Loader include: (1) loading programs from the magnetic drum (or disc) into core storage when they have been scheduled to run; (2) relocating subprograms into a contiguous area of memory and setting the required linkages; and (3) loading overlay segments and setting up the required linkages. The General Loader can also cause debugging facilities to be incorporated at load time.

- General Remote Terminal Supervisor (GERTS) — GERTS is the control program for handling jobs from remote terminals. It accepts jobs, stores them on the magnetic drum (or disc), and submits them to GECOS for execution based on a priority transmitted with the job.

- Macro Assembler (GEM) — GEM is the symbolic assembly language for the GE-600 Series. The prime feature of GEM is its extensive macro capabilities.

- COBOL — GE-600 Series COBOL incorporates all of Required COBOL-61, most of Elective COBOL-61, and the SORT and Report Writer facilities of Extended COBOL-61. The implemented features of Elective COBOL-61 include the CORRESPONDING option of the MOVE verb and the COMPUTE, ENTER, and USE verbs.

- FORTRAN — This is a standard implementation of the IBM 7090/94 FORTRAN IV language, with a few extensions. Capabilities for debugging and variable-field input and output are featured.

- SORT/MERGE — The GE-600 Series Sort/Merge routine accepts input from magnetic drum, disc, or tape and will produce output to any of the same devices. Sorts can be performed on numeric or alphanumeric keys, with the individual fields of a key in either ascending or descending order.

- Bulk Media Conversion — The Bulk Media Conversion routine is contained in the system library and can be called by control cards. Conversion capabilities include punched card to magnetic tape or magnetic disc; perforated tape to magnetic disc; magnetic tape to printer, punched card, or remote terminal; and magnetic disc to punched card, remote terminal, or magnetic tape.

- Mathematical Routines — An extensive library of mathematical routines includes trigometric, exponential, and logrithmic function evaluation, matrix manipulation, curve fitting, and polynomial root determination.

- Service Routines — An integrated set of service routines is provided for file maintenance, software maintenance (updating of system or user's compilers or programs), and diagnostics.

- Integrated Data Store (I-D-S) — This routine provides the capability for organizing files on a disc storage unit in a non-sequential manner. Individual detail records are linked together to form chains. A record can belong to more than one chain, effectively eliminating the need to store duplicate information. Macro operations are provided for obtaining a record to be processed, for storing and linking a processed record, and for deleting a record. I-D-S can be used to provide mass storage facilities for COBOL or assembly-language programs for any GE-600 Series computer system that includes a disc storage unit.

Use of GECOS, the standard supervisory control routine, requires 8,192 words of core storage and the following complement of peripheral equipment: one magnetic drum or disc file, three magnetic tape units, card reader, card punch, and printer. In addition, the system compilers, such as COBOL and FORTRAN, require three additional files which can be held on three more tape units or one drum or disc file.

The success of the GE-600 Series will be largely dependent upon the quality of the software provided. Most of the GE-600 Series software was developed by individual GE departments that are experienced users of large-scale computers, and GE is emphasizing the benefits of this "user-developed" software.

MULTIPROGRAMMING

The general considerations for successful multiprogramming are examined at length in the IBM System/360 report, Paragraph 420:011.52. In the GE-600 Series systems, scheduling of programs to be run is a function of GECOS, based on availability of peripherals and user-defined priorities. Precautions have been taken to prevent a program from being locked out due to a large requirement for peripherals and to prevent a compute-bound program from "hogging" the processor. Switching from one program to another program is normally a result of the initiation of an I/O operation that would delay the program from actively using the processor. Control is given to another program selected on the basis of priority and ability to use the processor immediately (i.e., no I/O operation in process). There appears to be little a user can do to influence the mix of programs being run at any given time in any way other than through judicious assignment of priorities. The operator can alter priorities to permit the inclusion of a "crash" program.

It is impossible, without modification of the standard control routines, for one program to access any area outside the program limits set at load time. This applies to input-output operations as well as internal processing, and should provide adequate protection against interference between concurrently running programs.

Because multi-programming will probably be the normal mode of operation for GE-600 Series computer systems, their performance on the Standard File Processing Problems and the Standard Mathematical Processing Problem has been evaluated with this in mind. Input and output files are considered to be on tape for the main processing runs, and the times for the input and output data transcription runs are shown separately.

TABLE I: GE-600 SERIES PERIPHERAL SUBSYSTEMS

I/O Channels		Subsystem	Reference
No.	Type		
1	SC	CR-20 Card Reader — 900 cpm	340:071
1	SC	CP-10 Card Punch — 100 cpm	340:072
1	SC	CP-20 Card Punch — 300 cpm	340:072
1	SC	PR-20 Printer — 1200 lpm	340:081
1	SC	TP-20 Perforated Tape Punch — 110 char/sec	340:073
1	SC	TR-20 Perforated Tape Reader — 500 char/sec	340:073
1	SC	TS-20 Perforated Tape Reader/Punch	340:073
1	HS	Single-Channel Magnetic Tape Subsystem — 1 to 16 7-track or 9-track magnetic tape units, from 7,500 to 160,000 char/sec	340:091, 340:092
2	HS	Dual-Channel Magnetic Tape Subsystem — 1 to 16 7-track or 9-track magnetic tape units, from 7,500 to 160,000 char/sec	340:091, 340:092
1	HS	MDS 200 Magnetic Drum Unit — 786,432 words, 17 msec average access time	340:044
1	HS	DS-20 Disc Storage Unit — 4 to 16 discs, 245,760 words per disc, 225 msec average access time	340:042
1	SC	DATANET-30 Data Communications Processor	340:101
1	SC	Console with Typewriter	340:061

DATA STRUCTURE

.1 STORAGE LOCATIONS

Name of Location	Size	Purpose or Use
Word:	36 bits + parity bit	basic addressable storage unit; holds 6 characters or one single-precision fixed-point or floating-point binary operand.
Word pair (Double-word):	2 words	basic unit transferred from core storage in each access; holds one double-precision fixed-point or floating-point binary operand.
Row (magnetic tape):	6 or 8 data bits + parity bit	holds 1 character.
Sector (Disc Storage):	40 words	Disc Storage record location.
Track (Disc Storage):	8 or 16 sectors	Disc Storage.
Band (Magnetic Drum):	6,144 words	Magnetic Drum.

.2 INFORMATION FORMATS

Type of Information	Representation
Alphanumeric character:	6-bit portion of a word.
Fixed-point binary operand (short):	1 word.
Fixed-point binary operand (long):	2 words.
Floating-point binary operand (short):	1 word; 28-bit fraction and 8-bit binary exponent.
Floating-point binary operand (long):	2 words; 64-bit fraction and 8-bit binary exponent.
Instruction:	1 word.

SYSTEM CONFIGURATION

A GE-600 Series computer system is a highly flexible system capable of almost unlimited expansion. Each GE-600 system consists of:

- Processor Module(s).
- Main Memory Module(s) and associated System Controller(s).
- Input-Output Controller Module(s).
- Various peripheral subsystems.
- Magnetic drum or magnetic disc unit(s).

Processor Module

Only one Processor Module, Model CP 8030, has been announced to date for GE-600 Series computer systems. Each processor in a system can have up to four Processor Ports, each connected to a different System Controller. Each processor can thus directly address up to 262,144 words of core storage.

Main Memory

The core storage modules offered with the GE-625 system are:

- Model MM 8031 - System Controller and 32,768 words.
- Model MM 8032 - System Controller and 40,960 words.
- Model OPT 804 - 32,768 words.

The GE-625 core storage units are characterized by a cycle time of 2 microseconds per access of two 36-bit words.

The core storage modules offered with the GE-635 system are:

- Model MM 8030 - System Controller and 32,768 words.
- Model MM 8033 - System Controller and 40,960 words.
- Model OPT 801 - 32,768 words.

The GE-635 core storage units are characterized by a cycle time of 1 microsecond per access of two 36-bit words.

The rules for combining core storage modules are the same for both systems. A Memory Module is composed of a System Controller and 32K, 40K, 64K, or 72K words of memory; however, only one 40K or 72K unit is allowed per system. The maximum core storage for a "single computer system" is 262,144 words. (Such a system can actually have more than one Processor Module — one processor acts as control processor with the others acting as slave processors.) The maximum core storage for a "multi-computer system" (independent processors sharing one or more core storage units) depends upon the number of processors incorporated in the system. Each System Controller can have up to eight Memory Ports, each connected to a Processor Module, an Input-Output Controller Module, or a non-standard input-output device.

Input-Output Controller Module

Each Input-Output Controller can have from 3 to 6 high-performance (400,000 characters per second) and from 5 to 10 standard-performance (25,000 characters per second) input-output channels. The maximum data transfer rate between an I/O Controller and a System Controller is 1.6 million characters per second. Each I/O Controller can have up to four IOC Ports, each connected to a different System Controller.

Peripheral Subsystems

The number and type of channels required for each GE-600 Series peripheral subsystem are shown in Table I. HS refers to a high-speed input-output channel, SC to a standard-speed channel. The Reference column defines the report section where additional information can be found concerning each subsystem.

TABLE I: GE-600 SERIES PERIPHERAL SUBSYSTEMS

I/O Channels		Subsystem	Reference
No.	Type		
1	SC	CR-20 Card Reader - 900 cpm	340:071
1	SC	CP-10 Card Punch - 100 cpm	340:072
1	SC	CP-20 Card Punch - 300 cpm	340:072
1	SC	PR-20 Printer - 1200 lpm	340:081
1	SC	TP-20 Perforated Tape Punch - 110 char/sec	340:073
1	SC	TR-20 Perforated Tape Reader - 500 char/sec	340:073
1	SC	TS-20 Perforated Tape Reader/Punch	340:073
1	HS	Single-channel Magnetic Tape Subsystem - 1 to 16 magnetic tape units, 7,500 to 160,000 char/sec	340:091, 340:092
2	HS	Dual-channel Magnetic Tape Subsystem - 1 to 16 magnetic tape units, 7,500 to 160,000 char/sec	340:091, 340:092
1	HS	MDS 200 Magnetic Drum Unit - 786,432 words, 17 msec average access time	340:044
1	HS	DS-20 Disc Storage Unit - 4 to 16 discs, 245,760 words per disc, 225 msec average access time	340:042
1	SC	DATANET-30 Data Communications Processor	340:101
1	SC	Console with Typewriter	340:061

Summary of General Configuration Rules

- Each Processor Module can be connected to 1 to 4 Memory Modules.
- Each Memory Module can be connected to a total of 8 Processor Modules, I/O Controller Modules, and non-standard input-output devices. Up to 262,144 words of core storage can be incorporated in a single-computer system.
- Each I/O Controller Module can be connected to 1 to 4 Memory Modules and can have from 3 to 6 high-speed input-output channels and from 5 to 10 standard-speed input-output channels.

Minimum Configuration

Use of the standard supervisory program, GECOS, requires the following peripherals:

- Magnetic drum unit or disc storage unit;
- 3 magnetic tape units;
- Card reader;
- Card punch;
- Printer.

In addition, the system compilers, such as COBOL or FORTRAN, require three files for compilation. These files can be implemented with three magnetic tape units or a single magnetic drum or disc storage unit (in addition to the magnetic tape units, magnetic drum, or disc file for GECOS).

Standard Configurations

Representative standard configurations (as defined in Section 4:030, System Configuration, of the Users' Guide) are shown in the individual system sub-reports:

GE-625: . . . . Section 343:031.
GE-635: . . . . Section 344:031.

INTERNAL STORAGE: CORE STORAGE

.1 GENERAL

.11 Identity: . . . . MM 8031 2-μsec Memory Module (includes 32,768 words and System Controller).
MM 8032 2-μsec Memory Module (includes 40,960 words and System Controller).
OPT 804 2-μsec additional module (32,768 words).

MM 8030 1-μsec Memory Module (includes 32,768 words and System Controller).
MM 8033 1-μsec Memory Module (includes 40,960 words and System Controller).
OPT 801 1-μsec additional module (32,768 words).

.12 Basic Use: . . . . . working storage.

.13 Description

The two currently-announced members of the GE-600 Series, the GE-625 and the GE-635, differ only in the speed of their core storage units. The GE-625 uses a core storage unit with a cycle time of 2 microseconds; the GE-635, a unit with a 1-microsecond cycle time. Each access, in both systems, is for a word-pair (two 36-bit-plus-parity words). Where differences exist, such as in data transfer rates, entries are given for each unit; otherwise, all remarks in this section apply to both GE-625 and GE-635 core storage units.

Up to 262,144 36-bit words of core storage can be incorporated in a single-processor system, in modules of 32,768 words. One 40,960-word module can be substituted for a 32K module in systems containing less than the maximum capacity.

Each Memory Module is composed of a System Controller and one or two 32K modules (or possibly one 32K and one 40K module) and is an independent unit capable of being accessed simultaneously with other Memory Modules.

The System Controller performs many of the priority and control functions in a GE-600 Series system. Among these functions are:

- Control of communication between memory and the Processor Module and between memory and the I/O Controller.

- Control of program (I/O) interrupts for multiprocessor jobs, system programs, and peripheral devices.

- Switching of control signals, addresses, and data to and from the Memory Module.

Contained in the System Controller are four registers which aid in controlling the movement of data within a GE-600 Series system:

- Execute Interrupt Register - a 32-bit register that specifies, on a priority basis, which of 8 ports and which of 4 conditions caused a program (I/O) interrupt (see Paragraphs 340:951.125 and 340:051.33).

- Execute Interrupt Mask Register - a 32-bit register that can be set to prevent the corresponding positions of the Execute Interrupt Register from causing an interrupt.

- Memory Port Lockout Mask - an 8-bit register that can be set to prevent access to the devices connected to one or more of the eight ports of a System Controller.

- Control-Processor-Designation Register - indicates (in a multiprocessor system) which processor can alter the contents of the above special registers or can initiate an I/O operation.

The first three of the above special registers are program-accessible by the processor designated as control processor when it is operating in the master mode. Any attempt to access these registers under other conditions results in a fault interrupt. The last register, the Control-Processor-Designation Register, is set by external switches on the Core Storage Unit Cabinet. Other switches permit the assignment of Memory Modules to continuous segments of memory.

Each System Controller has eight memory ports (channels) for connection to Processor Modules, I/O Controller Modules, or non-standard I/O devices. These ports are assigned priorities to facilitate the servicing of demands on memory in an orderly manner.

.14 Availability: . . . . ?

.15 First Delivery: . . . . 1st quarter, 1965.

.16 Reserved Storage: . . 8,192 words of core storage are normally reserved for the operating system (GECOS). This includes areas for I/O control, multiprogramming control, etc.

.2 PHYSICAL FORM

.21 Storage Medium: . . . magnetic core.

.23 Storage Phenomenon: . direction of magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . yes.
.242 Data regenerated constantly: . . . . . no.
.243 Data volatile: . . . . . no.
.244 Data permanent: . . . no.
.245 Storage changeable:. . no.

.28 Access Techniques

.281 Recording method: . . coincident current.
.283 Type of access:. . . . uniform.

.29 Potential Transfer Rates

.292 Peak data rates —

	GE-625	GE-635
Unit of data (words/access)	2	2
Cycling rates (cycles/second)	500,000	1,000,000
Conversion factor (bits/word)	36	36
Data rate (words/sec)	1,000,000*	2,000,000*

* Effective cycle can be somewhat faster through overlapped accessing of two Memory Modules.

.3 DATA CAPACITY

.31 Module and System Sizes
(See table below.)

.32 Rules for Combining Modules

A Memory Module is composed of a System Controller and one or two 32K modules. (One 40K module can be incorporated in a system except when the total storage connected to a processor would be greater than 262K.)

A maximum of 262,144 words, or eight 32K modules, of core storage can be addressed by any one Processor Module.

.4 CONTROLLER

.41 Identity: . . . . System Controller.

.42 Connection to System: 1 to 4 System Controllers can be connected to any one Processor Module. A total of 8 processors and/or I/O Controllers can be connected to any one System Controller.

.43 Connection to Device: each System Controller controls one 32K, 40K, 64K, or 72K core storage unit.

.5 ACCESS TIMING

.52 Simultaneous Operations: . . . . . all Memory Modules can be accessed simultaneously.

.53 Access Time Parameters and Variations

.531 For uniform access —

	GE-625	GE-635
Access time (microseconds)	?	?
Cycle time (microseconds)	2.0	1.0
Unit of data (words/access)	2	2

.7 PERFORMANCE

.72 Transfer Load Size

With self: . . . . . . 1 or 2 words (up to 1024 words can be transferred by one Repeat Double loop).

.73 Effective Transfer Rate (with self, using Repeat Double loop)

GE-625: . . . . 400,000 words/second (2,400,000 char/second).
GE-635: . . . . 556,000 words/second (3,330,000 char/second).

.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	interrupt.
Invalid code:	all codes valid.	
Receipt of data:	parity check	interrupt.
Recording of data:	record parity bit.	
Recovery of data:	parity check	interrupt.
Dispatch of data:	send parity bit.	
Reference to protected* area:	check	interrupt.

*Area outside of program limits.

.31 Module and System Sizes

	Minimum Storage				Maximum Storage**
Identity:	32K Memory Module	40K Memory Module	64K Memory Module	72K Memory Module	
Words:	32,768	40,960	65,536	73,728	262,144
Characters:	196,608	245,760	393,216	442,368	1,572,864
Instructions:	32,768	40,960	65,536	73,728	262,144
Modules:	1	1	2	2	8

** Maximum storage addressable by any one Processor Module.

INTERNAL STORAGE: DISC STORAGE UNIT

.1 GENERAL

.11 Identity: . . . . DS-20 Disc Storage Unit.
DSC-20 Disc Storage Controller.

.12 Basic Use: . . . . . auxiliary storage.

.13 Description

The DS-20 Disc Storage Unit consists of up to 16 data discs (32 recording surfaces) capable of storing up to 23.5 million characters. From 1 to 4 of these units can be connected to the DSC-20 Disc Storage Controller to provide a total random access storage capacity of 94 million characters per controller. The combination DS-20 and DSC-20 is referred to by the manufacturer as the Disc Storage Subsystem and requires one high-speed input-output channel of an Input-Output Controller Module. There is no practical limit upon the total number of Disc Storage Units that can be connected on-line to a GE-600 Series system (see Section 340:031, System Configuration).

Each disc surface is divided into two 128-track parts called the outer and inner zones. Each circumferential track is, in turn, divided into a number of addressable sectors; 16 sectors per outer-zone track and 8 per inner-zone track. This arrangement yields a total of 3,072 fixed addressable sector positions on each disc surface at which the reading or writing of data can begin. A sector has a fixed capacity of 240 six-bit characters plus a six-bit modulo-64 check character.

Each disc is served by an individual positioning arm containing 8 read-write heads (4 per surface) so that only 64 arm positions are required to cover all the tracks on a disc. Arm positioning time ranges from 70 to 305 milliseconds, and the total average waiting time for random accessing is 225 milliseconds. Up to 368,000 characters per Disc Storage Unit can be transferred with no movement of the access arms. Peak data transfer rate is 41,700 (inner zone) or 83,400 (outer zone) characters per second. An effective bulk transfer rate of 69,500 characters per second can be obtained with optimum data placement.

The DSC-20 Controller contains a 1,024-character addressable buffer which facilitates the serial-to-parallel conversion process between the Disc Storage Unit and core storage. The buffer arrangement also permits the simultaneous transfer of data between core storage and one section of the buffer, and between another section of the buffer and any one Disc Storage Unit. Under program control, information written onto the discs can be read back and a character-by-character comparison made with the data image as it appears in the controller buffer. Thus a verification check can be made to insure that data was recorded correctly.

The 1,024-character addressable core buffer can hold up to four 240-character disc records (sectors) at a time. This feature, coupled with the system's scatter-read, gather-write capabilities, lets the user transfer only the fields he needs for updating into and out of core memory, without moving the whole record. This can result in faster file updating operations and reduced core memory space requirements.

The ability to search up to 32 consecutive disc sectors with one instruction makes it possible to locate the desired sector on the basis of its content rather than its specific address. This capability can save processing time by reducing or eliminating the need to pre-sort input records that would normally require separate disc look-up operations.

A parity check is made on each word transferred to or from the controller buffer. In addition, each 240-character sector has an associated check character to help increase reading and writing accuracy. The detection of a parity error results in the termination of the disc operation. The address of each sector is permanently recorded in a "header" word and used for sector identification and track address confirmation.

The following disc file instructions are used by current GE-600 Series systems:

- Seek File.
- Read File Continuous and Release Seek.
- Write File Continuous and Release Seek.
- Write File Continuous, Verify, and Release Seek.

The Disc Storage Unit will be available with 4, 8, 12, or 16 discs. A Fast Access option provides high-speed (26 milliseconds average) access to high-priority data for program overlay routines, address dictionaries, subroutines, tables, and key data for fast record updating. It is estimated that use of Fast Access storage for tables and subroutines can reduce unit-record update-cycle times by 50% or more.

The high-speed access is provided by locking the read-write arms on 4 or 8 discs, eliminating positioning and track verification time. Access time is thus only the disc latency time (an average of 26 milliseconds). Storage capacity of each fast Access disc is 96 sectors (23,040 characters). The total number of discs (standard plus Fast Access) in a DS-20 Disc Storage Unit cannot exceed 16.

Data can be simultaneously transferred between the central processor and the disc file buffer, and between the buffer and any one Disc Storage Unit. The number of Disc Storage Subsystems that can operate simultaneously depends on the number of

.13 Description (Contd.)

other operating peripherals connected to the same I/O Controller Module (see Section 340:111, Simultaneous Operations).

Special conditions (such as successful completion of an operation, invalid command, etc.) cause the setting of the appropriate bit in the execute-interrupt register of the System Controller. Subsequent action by a supervisor program (normally GECOS) can determine the particular condition by interpreting a requested Status Return.

Normally a GE-600 Series programmer does not program input-output operations in detail; this is usually handled by the operating system (GECOS) on a file-specification basis. A detailed description of the input-output process is presented in Section 430:111, Simultaneous Operations. Accessing of the Disc Storage Unit can be overlapped with other input-output operations and with processing. Detailed considerations for simultaneity, including time demands on the system, are also presented in the Simultaneous Operations section.

.15 First Delivery: . . . April, 1964 (with GE-400 Series systems).

.16 Reserved Storage: . . none.

.2 PHYSICAL FORM

.21 Storage Medium: . . . multiple discs.

.22 Physical Dimensions

.222 Disc —
Diameter: . . . . . 31 inches.
Thickness or length: 0.158 inch.
Number on shaft: . . 16.

.23 Storage Phenomenon: direction of magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . yes.
.242 Data regenerated constantly: . . . . . no.
.243 Data volatile: . . . . no.
.244 Data permanent: . . . no.
.245 Storage changeable: . no.

.25 Data Volume per Band of 1 track

	Inner Zone	Outer Zone
Words:	320	640.
Characters:	1,920	3,840.
Digits:	1,920	3,840.
Instructions:	480	960.
Sectors:	8	16.

.26 Tracks per Physical Unit: . . . . 512 (256 per disc surface).

.27 Interleaving Levels: . 1.

.28 Access Techniques

.281 Recording method: . . moving heads.

.283 Type of access —

Description of Stage	Possible Starting Stage
Move head to selected track:	if new track is selected.
Wait for start of selected sector: . .	if same track was previously selected.
Transfer data: . . .	no.

.29 Potential Transfer Rates

.291 Peak bit rates —
Cycling rate: . . . . 1,170 rpm.
Bit rate per track: . 250,000 or 500,000 bits/sec/track.

.292 Peak data rates —
Unit of data: . . . . character.
Conversion factor: . 6 bits/char.
Data rate: . . . . . 41,700 (inner zone) or 83,400 (outer zone) char/sec.

.3 DATA CAPACITY

.31 Module and System Sizes

	Minimum Storage	Maximum Storage
Identity:	DS-20	DS-20
Storage Units:	1 module	4 units.
Discs:	4	64.
Words:	983,000	15,700,000.
Characters:	5,898,000	94,000,000.
Instructions:	1,466,000	23,500,000.
Sectors:	24,576	393,216.

.4 CONTROLLER

.41 Identity: . . . . DSC-20 Disc Storage Controller.

.42 Connection to System

.421 On-line: . . . . up to 6 controllers per I/O Controller Module.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: . . . . up to 4 Disc Storage Units.
.432 Restrictions: . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . 1 to 32 sectors of 240 characters each.
.442 Input-output area: . . core storage, via addressable 1,024-character buffer.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Synchronization: . . . automatic.
.447 Table control: . . . . yes; scatter-read and gather-write are available at programmer's option.

.448 Testable conditions: device-controller ready; device busy; error condition.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of Stacks —
Stacks per system: 128 to 512 per controller.
Stacks per unit: 128.
Stacks per yoke: 8.
Yokes per unit: 16 (one for each disc).
.512 Stack movement: horizontal only.
.513 Stacks that can access any particular location: 1.
.514 Accessible locations
By single stack —
With no movement: 8 or 16 sectors.
With all movement: 512 or 1,024 sectors.
By all stacks —
With no movement: 1,536 sectors per unit. 6,144 sectors per controller.
.515 Relationship between stacks and locations: least significant 7 bits of disc address specify stack and sector.

.52 Simultaneous Operations: data can be simultaneously transferred between the I/O Controller and disc file buffer, and between the buffer and any one Disc Storage Unit.

.53 Access Time Parameters and Variations

.532 Variation in access time —

Stage	Variation (msec)	Average (msec)
Move head to selected track:	0 or 70 to 305	199.
Wait for selected sector:	0 to 52	26.
Transfer 1 sector:	3.2 or 6.4	3.2
Total:	3.2 to 363.4	228.2

.6 CHANGEABLE STORAGE: none.

.7 AUXILIARY STORAGE PERFORMANCE

.72 Transfer Load Size

With core storage: 1 to 32 sectors; maximum of 240 characters per sectors.

.73 Effective Transfer Rate

With core storage: 69,500 characters/sec or 17,375 words/sec.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	check	interrupt.
Invalid code:	check	interrupt.
Receipt of data:	parity check	interrupt.
Recording of data:	generate check character.	
Recovery of data:	character and sector parity check	interrupt.
Dispatch of data:	send parity bit.	
Timing conflicts:	check	interrupt.
Wrong record selected:	address comparison	interrupt.

STANDARD EDP REPORTS

INTERNAL STORAGE: MAGNETIC DRUM

.1 GENERAL

.12 Identity: . . . . MDS 200 Magnetic Drum and Controller (UNIVAC FH-880 Drum).

.13 Basic Use: . . . . auxiliary storage.

.14 Description

Use of the GE-600 Series supervisory program, GECOS, requires either a magnetic drum or disc storage unit. Initial deliveries of systems using a magnetic drum will incorporate the UNIVAC FH-880 Drum, designated the MDS 200 by GE. This unit is described in detail in the Computer System Report on the UNIVAC 1107, page 784:043.100. A summary of the characteristics of the FH-880 Drum and special considerations for its use in GE-600 Series systems are presented below.

- One drum and one drum controller comprise a Magnetic Drum Subsystem.
- Each drum controller is attached to one high-speed input-output channel of a GE-600 Series I/O Controller Module; there are six high-speed channels available on each I/O Controller.
- The storage capacity of each drum is 786,432 words (36 bits each).
- The maximum potential storage capacity is 786,432 words per subsystem and 4,718,592 words per I/O Controller.
- Average access time is 17 milliseconds.
- Up to 262,144 words can be transferred by means of a single command.
- Peak data transfer rate is approximately 62,000 words (372,000 characters) per second.
- Each character transferred is checked for parity.
- Only one data transfer operation (read or write) can take place at a time per Magnetic Drum Subsystem.

Normally a GE-600 Series programmer does not program input-output operations in detail; this is usually handled by the operating system (GECOS) on a file-specification basis. A detailed description of the input-output process is presented in Section 430:111, Simultaneous Operations. Transfer of data to or from a Magnetic Drum Subsystem can be overlapped with other input-output operations and with processing. Detailed considerations for simultaneity, including time demands on the system, are also presented in the Simultaneous Operations section.

CENTRAL PROCESSOR

.1 GENERAL

.11 Identity: . . . . Model CP 8030 Processor Module.

.12 Description

.121 Basic Design

GE-625 and GE-635 systems use the same central processor, the Model CP 8030 Processor Module, which insures program compatibility between the two systems. Differences in their processor performance are a result of using core storage units with different cycle times: the GE-625 uses a 2-microsecond memory, and the GE-635 uses a 1-microsecond memory. (See Section 340:041, Core Storage, for a discussion of the different core storage units.)

The Processor Module uses a single-address instruction format with a wide range of address modification capabilities (see Paragraph .123, Addressing). There are two basic modes of processor operation: master mode and slave mode. Control programs will normally be executed in the master mode, and object programs in the slave mode. Programs running in the master mode have access to the entire core memory, can initiate peripheral and internal control functions, and do not have base-address relocation applied. Programs running in the slave mode have access to only a limited portion of core memory (as specified by the Base Address Register), cannot initiate peripheral control instructions, and have the contents of the Base Address Register added to all relative memory addresses of the object program. The processor is automatically switched into the master mode of operation when the Master Mode Indicator is set or when any interrupt is recognized.

All input-output operations are initiated by a single instruction, Connect, which can be executed only in the master mode. This instruction establishes a connection between core memory and the appropriate I/O Controller and then sends the necessary information to the controller to initiate the input or output operation. After execution of the Connect instruction, the input or output operation is under control of the I/O Controller, and the central processor is not involved again until a program (I/O) interrupt occurs. Section 340:111, Simultaneous Operations, presents a detailed description of the input-output process.

A scatter-gather facility allows blocks of up to 4, 096 words of data to be read into non-contiguous segments of core storage. This facility can reduce the time required to move data from place to place in memory.

A 24-bit Timer Register is available (accessible only in the master mode), which is decremented by one every 15.625 microseconds. The timer is used by the standard executive routine, GECOS, for automatic job termination, to prevent a job from monopolizing a processor, and to provide accounting information by monitoring processing and input-output elapsed time.

Instructions are fetched in pairs (an even word and the successive odd word). Address modification, operand fetching, instruction execution, and the fetching of the next pair of instructions are overlapped to increase processor performance wherever possible. Certain operations, such as indirect addressing, transferring control from an even location, or transferring control to an odd location, cannot take full advantage of this overlapping capability.

.122 Registers

The Base Address Register (BAR) is an 18-bit register located in the Processor Module. The first nine bits of the BAR (the ninth bit is permanently set to zero) are used as the base address and are added to the first nine bits of a program address to form an actual address. Each reference to core storage made by a program running in the slave mode is indexed by the contents of the BAR prior to any other specified address modifications.

The last nine bits of the BAR (again the ninth bit is permanently set to zero) are used as the program limit to check an actual address prior to accessing core storage but after performing all address modification. The first nine bits of the actual address are subtracted from the program limit, with a fault interrupt resulting if the result is zero or negative. This address translation and checking occurs only when the processor is in the slave mode. Allocation of memory to a program is in blocks of 1024 words. The Base Address Register can be loaded only in the master mode, but its contents can be stored in either mode.

The other registers provided include a timer register, eight index registers, an indicator register, an instruction counter, a 72-bit accumulator (which can also be used as two independent accumulators or four independent index registers), and an exponent register for floating point operations. These registers are described in Paragraph .241.

.123 Addressing

A wide range of address modification capabilities is provided. All addresses in the slave mode are

.123 Addressing (Contd.)

indexed by the contents of the BAR (as described above) prior to other address modification. The general format of the instructions is shown below.

Name:	Address	(See Paragraph	Tag field	
Symbol:	y	.232)	t_m	t_d
Bits	18	12	2	4

Initial modification is specified by the tag field of the instruction. The field t_m specifies one of four types of address modification:

R - indexing.
RI - indexing, then indirect.
IR - indirect, then indexing.
IT - indirect, then tally.

For types R, RI, and IR, the field t_d specifies the register to be used for indexing (see Paragraph .2375 for a listing of the possible registers that can be used), or that no indexing is to take place. In addition, for type R only, the field t_d can specify that the 18-bit address field specified in the instruction is to be used as the upper or lower half of a literal operand, the remaining bits being treated as zeros.

For "indirect, then tally" (IT) address modifications, the field t_d specifies the type of tally operation. The format of the indirect word is shown below.

Name	Address	Tally field	Tag field
Bits:	18	12	6

There are nine possible tally designators that specify how the indirect word to be fetched is modified or used, as listed in Table I.

Address modifications can be chained, with the chain generally ending when a type R or IT modification is encountered. Register modification (type R) is straight indexing. For type RI modifications the address specified in the instruction (or indirect word), modified according to the register specified in the tag field, is used to fetch an indirect word. The tag field of the indirect word is analyzed, and further modifications can be of any type.

For type IR modifications an indirect word is fetched first from the location specified by the address in the instruction (or another indirect word). Further modification is based on an analysis of the tag field of the indirect word and can only be of type R, RI, or IR. The register specified by the last IR modification encountered is used to index the developed address after all other modifications have taken place. The various possibilities for type IT modifications are shown in Table I.

Indexing takes no extra execution time due to the overlapping of functions in the processor. Indirect addressing does require extra time:

	GE-625	GE-635
Time per indirect cycle which does not modify the indirect word:	2.0 μsec	1.7 μsec
Time per indirect cycle which modifies the indirect word:	3.5 μsec	2.5 μsec

The SC and CI variations of the "indirect, then tally" (IT) type of address modification can be used with single-precision load, store, add, subtract, Boolean, divide, and compare instructions, permitting extensive operations to be performed on individual characters of a BCD field. The SC variation permits stepping, character-by-character, through a whole field. This capability is important because no automatic code translation (except Gray to binary) or decimal arithmetic facilities are provided, and only a one-digit-at-a-time radix conversion facility (binary to BCD only) is provided.

.124 Instruction Repertoire

A total of 170 basic instructions are available in the CP 8030 Processor, and most of them will be familiar to programmers of other large-scale binary computers. The instruction repertoire is shown in the Instruction List (page 340:121.100) and includes instructions which perform comparisons (logical, algebraic, magnitude, masked, and between limits), loading, storing, Boolean operations, branching, and shifting. Provision is made for the use of half-word, single-word, or double-word operands in many operations.

All shifts, regardless of length, take essentially the same length of time (2.0 microseconds in the GE-625 and 1.8 microseconds in the GE-635). This is worthy of notice because many applications of large-scale binary computers require a large number of shifts, particularly where automatic editing facilities are not provided.

The format for fixed-point binary numbers is two's complement notation. Fixed point addition or subtraction can be performed with either single-word (36-bit) or double-word (72-bit) operands, and the result can appear in either the accumulator (A, Q, or AQ) or in core storage. Fixed-point multiplication and division are provided for single-word operands in both fractional (result left-justified) or integer (result right-justified) form.

Floating-point numbers are represented by a mantissa of 28 bits (single precision) or 64 bits (double precision) and a binary exponent of 8 bits. Both the exponent and mantissa are represented in the two's-complement notation. Single precision is equivalent to 8 decimal digits, and double precision to 19 decimal digits.

Floating-point operations include single or double precision loading, storing, comparison, addition, subtraction, multiplication, and division. The AQ register holds the mantissa and the exponent register holds the exponent for all floating-point operations. Floating-point multiplication, addition, and subtraction can be either normalized or unnormalized.

There is one important consideration for all double-word operations. Core storage is organized in 72-bit word-pairs (although there is a parity bit for each word). The first word of each pair is in an even location and the second is in the following odd location (e.g., locations 1102 and 1103). Each request by the processor results in the System Controller in the appropriate Memory Module sending a word-pair to the processor,

TABLE I: EFFECTS OF THE TALLY DESIGNATORS IN TYPE IT MODIFICATION

Tally designator, t_d (symbolic)	Next item fetched and address	Indirect word modification*
I	Operand is fetched from the address specified by the indirect word.	No modification takes place.
DI	Operand is fetched from the address specified by the indirect word after modification.	Address field is decremented by one; tally field is incremented by one.
ID	Operand is fetched from the address specified by the indirect word before modification.	Address field is incremented by one; tally field is decremented by one.
DIC	Depends on the tag field of the indirect word. All references use the address specified in the indirect word after modification.	Address field is decremented by one; tally field is incremented by one.
IDC	Depends on the tag field of the indirect word. All references use the address specified in the indirect word before modification.	Address field is incremented by one; tally field is decremented by one.
AD	Operand is fetched from the address specified in the indirect word before modification.	Address field is incremented by the contents of the tag field in the indirect word; tally field is decremented by one.
CI	A six-bit segment specified by the tag field of the indirect word is fetched from the location specified by the address in the indirect word.	No modification takes place.
SC	Same as for CI (using the address specified in the indirect word before modification).	Tag field is incremented by one; if the result is greater than six, the address field is incremented by one and the tag field is reset to zero; tally field is decremented by one.
F	None.	A fault interrupt occurs when this tag is recognized.

* When the tally field reaches zero during modification, the tally run-out indicator is set to one; no interrupt is generated.

.124 Instruction Repertoire (Contd.)

regardless of whether the even word or the odd word was addressed. For single-word operations, internal circuitry selects the proper word of the word-pair. For double-word operations, the complete word-pair is used, thus requiring the first word of every double-word operand to be in an even location. This consideration is taken into account in the standard software, but it could cause problems in debugging and patching of machine-language programs.

Program-testable indicators provide information about the result of an operation and permit program control through the use of branch-on-condition instructions. The negative and zero indicators are affected each time the contents of a register or adder are altered (e.g., through operations such as load, add, add to store, multiply, compare, shifts, etc.). In addition, a carry indicator is set when a carry is generated out of the left-most bit position during left shift, addition, subtraction, and compare operations. Two tests, involving the negative, zero, and carry indicators, are required to distinguish between equal, greater than, and less than conditions. A single test can distinguish between the condition "equal to or greater than" and the condition "equal to or less than."

Overflow indicators are included for indicating arithmetic overflow, exponent overflow, and exponent underflow. Normally an overflow also generates a fault interrupt, but an overflow mask bit can be set that prevents the interrupt, but does not affect the setting, testing, or storing of the

.124 Instruction Repertoire (Contd.)

three overflow indicators. The parity error indicator is set when a parity error is detected during a reference to a core storage unit. As with the overflow indicators, setting of this indicator normally causes a fault interrupt, but the interrupt can be masked out without affecting the setting, testing, or storing of the indicator. The tally-run-out indicator is set when the tally field associated with an indirect-then-tally (IT) address modification, or with a Repeat, Repeat Double, or Repeat Link instruction, reaches zero.

There are several noticeable omissions from the GE-600 Series instruction repertoire:

- No editing instructions.
- No code translation instructions other than Gray to binary.
- No radix conversion instructions other than a one-digit-at-a-time binary to BCD instruction.

Estimates by the editorial staff indicate that formation of a typical 120-character line of print (including radix conversions), such as that for the Standard File Processing Problem (see page 4:200.1112 of the Users' Guide), takes approximately 2.2 milliseconds for the GE-625 and 1.7 milliseconds for the GE-635.

Several useful instructions are provided that can reduce programming effort and increase program efficiency. Three repeat instructions, Repeat (RPT), Repeat Double (RPD), and Repeat Link (RPL), are useful for processing lists of data. The RPT and RPD instructions permit the execution of the next one or two instructions a specified number of times (up to 256) with or without indexing. Index registers can be automatically stepped by an increment specified in the RPT or RPD instruction. The loop may be terminated when the specified number of executions has been performed or when one or more specified indicators are ON or OFF. The address of the operand causing the termination, if any, as well as the indicator specifying the condition, are available for program use.

The most frequent use of the RPT instruction will probably be with comparison instructions for list searching. The RPD instruction (with the Load Double and Store Double instructions) is the most efficient method for mass movement of data within core storage. Using this loop, the GE-625 can transfer data within core storage at an effective rate of 400,000 words per second (2,400,000 characters per second), and the GE-635 at 556,000 words per second (3,333,000 characters per second).

The RPL instruction is similar to the other repeat instructions except that each word in the list contains an 18-bit operand and an 18-bit address of the next word in the list; no indexing is allowed except to specify the first word in the list.

Special addition and subtraction instructions are provided that are useful for programming in multiword precision. These instructions automatically add or subtract one from the least significant position of the accumulator if the carry indicator is ON at the beginning of the instruction.

.125 Interrupt System

A powerful, nine-level interrupt system is incorporated in the GE-600 Series processor. The interrupt levels fall into two broad classifications:

- Fault interrupt — five levels of interrupts for faults or special conditions within the Processor Module.
- Program interrupt — four levels of interrupts, all dealing with input-output conditions.

Detailed information about the interrupt system is presented in Paragraph .33 of this report section. In general, each fault interrupt causes a transfer to one of 16 locations (one for each type of fault interrupt) in the area allocated to the executive routine. Program interrupts cause a specific bit in the Execute-Interrupt Request Register in the appropriate core storage System Controller to be set. This register has 32 bit positions, 16 of which are not used at present. There is one bit for each of four conditions for each of four I/O controllers. At the same time that the request interrupt bit is being set, a status word containing information about the channel, device, and particular condition is stored in a queue in the executive area. The Execute-Interrupt Register is scanned between instruction fetches unless the scan is inhibited by an inhibit specification in the instruction or by a branch instruction. The highest priority interrupt active at the time of the scan is serviced. Additional information about program interrupts with respect to the Input/Output Controller is presented in Section 340.111, Simultaneous Operations.

Handling of the interrupts and error conditions is normally under the direction of the executive routine, but the programmer can specify his own routines for many conditions. Information about how the interrupt system is incorporated in the software is included in the section on the standard executive routine, GECOS (page 340:191.100).

.126 Multiprogramming Facilities

The capability to run more than one program at a time requires effective solutions to two major hardware problems. These are the sequencing problem (i.e., providing automatic switching between programs) and the safety problem (i.e., safeguarding each program from interference by all the others). In the GE-600 Series computer systems, the necessary functions are performed by an executive routine in conjunction with the interrupt system and several special registers.

An interrupt, or the execution of one of two special instructions (Master Mode Entry, MME, or Detail, DRL), causes a transfer to the executive routine area and causes the processor to enter the master mode. While in the master mode, the contents of the Base Address Register, the Timer Register, the Memory Controller Mask Register, and the Memory Controller Interrupt Register can be altered and I/O operations can be initiated.

The usual mode of multiprogramming permits switching from program to program based upon I/O demands; i.e., if the processor would be

.126 Multiprogramming Facilities (Contd.)

delayed to await the completion of an I/O operation in one program, control will be switched to another program. Provision has been made in the executive routine to limit a program to no more than 16 milliseconds of processor time without recognizing a program (I/O) interrupt. This effectively prevents a processor-bound program from "hogging" the processor.

A special mode of multiprogramming, Courtesy Call, is primarily for use by data transcription programs. In this mode, control is returned to a program for a short length of time (400 microseconds for the GE-625, 200 microseconds for the GE-635) as soon as the I/O operation requested by that program is completed. Exceeding this time causes the program to be aborted. Normally, once a program has relinquished control, it does not resume control until the program following it and all higher-priority programs have been serviced.

Program protection is accomplished through checking of each address prior to referencing memory, both by the processor when fetching operands and instructions, and by the I/O Controller when reading data in or out. Although it is possible for a program to destroy one of its own files, it cannot read or write in the area assigned to another program.

It is difficult to estimate the amount of time used by the executive routine in controlling multiprogrammed operation, since this will vary with the particular types of programs being run together. The time occupied in switching from one program to another must include the time required for safe-storing all registers used by the present program and for loading the registers for the next program. Currently this must be done one register at a time because there is no instruction for storing multiple registers in a single operation.

.2 PROCESSING FACILITIES

.21 Operations and Operands

	Operation and Variation	Provision	Radix	Size
.211	Fixed point*			
	Add-subtract:	automatic	binary	half-word, full-word, or double-word.
	Multiply.	automatic	binary	full word (70-bit product + sign).
	Divide:			
	No remainder:	none.		
	Remainder:	automatic	binary	full word (full-word quotient and full-word remainder).

* Both fractional and integer.

	Operation and Variation	Provision	Radix	Size
.212	Floating point —			
	Add-subtract:**	automatic	binary	27 & 7 bits (short). 63 & 7 bits (long).
	Multiply:**	automatic	binary	27 & 7 bits (short). 63 & 7 bits (long).
	Divide:	automatic	binary	27 & 7 bits (short). 63 & 7 bits (long).

** Both normalized and un-normalized.

	Operation and Variation	Provision	Radix	Size
.213	Boolean —			
	AND:	automatic	binary	half-word, full-word, or double-word.
	Inclusive OR:	automatic	binary	half-word, full-word, or double-word.
	Exclusive OR:	automatic	binary	half-word, full-word, or double-word.
.214	Comparison —			
	Numbers:	automatic	binary	half-word, full-word, or double-word.
	Absolute:	automatic	binary	half-word, full-word, or double-word.
	Letters (in binary form only):	automatic		1, 3, 6, or 12 characters.

Collating sequence: . . . numbers, then letters, with special characters interspersed (see Data Code Table, Page 340.141.100).

		Provision	From	To	Size
.215	Code translation:	automatic	Gray	binary	1 word.
.216	Radix conversion:	automatic	binary	BCD	1 decimal digit.

.217 Edit format: . . . . no hardware facilities other than the capability of addressing individual 6-bit characters within a word. Editing subroutines will be provided that meet the requirements of COBOL.

.218 Table lookup: . . . . none (but see Repeat instruction, Paragraph .219).

	Provision	Comments
.219 Others -		
Shifts:	automatic	circular, logical, and arithmetic; 1 to 127 bit positions.
Execute and Execute Double:	automatic	causes one or two out-of sequence instructions to be executed.
Repeat and Repeat Double:	automatic	causes one or two sequential instructions to be repeated a specific number of times or until a specified condition occurs. Index registers can be automatically stepped in any increment up to 127.
Repeat Link:	automatic	similar to Repeat, except address of next operand is specified in the upper portion of this operand. Thus, nonordered lists can be processed.

.232 Instruction layout (general) —

Name:	y	Op. Code	z	i	z	t_m	t_d
Size (bits):	18	9	1	1	1	2	4

.233 Instruction parts

Name	Purpose
y:	specifies relative operand address, address of indirect word, or shift count; or holds an 18-bit literal operand.
Op. Code:	specifies operation code.
i:	specifies interrupts (Group V and I/O — see Paragraph .331) to be delayed (see Paragraph .334).
t_m:	specifies type of address modification.
t_d:	specifies the register to be used for indexing or the type of indirect addressing.
z:	must be zero.

.234 Basic address structure: 1 + 0.

.235 Literals —

Arithmetic: . . . . 18 bits.
Comparisons and tests: 18 bits.
Incrementing modifiers: . . . . 18 bits.

.237 Address indexing

.2371 Number of methods: . . . 2.

.2372 Names: . . . . (1) base address register (automatic in the slave mode).
(2) register.

.2373 Indexing rule: . . . . addition; addresses generated beyond program limits (while processor is in slave mode) or beyond limits of existing core storage result in a fault interrupt.

.2374 Index specification: . . . addresses are always indexed by contents of BAR when processor is in the slave mode; further indexing is specified by contents of tag field (bits 30 through 35) of the instruction word.

.2375 Number of potential indexers: . . . . 14; 8 index registers, 4 18-bit sections of AQ register, BAR, and instruction counter.

.2376 Addresses which can be indexed: . . . . all core storage addresses.

.2377 Cumulative indexing: . . none, but see Paragraph .2384.

.2378 Combined index and step: . . . . none, except for Repeat and Repeat Double Instructions (see Paragraph .219).

.238 Indirect addressing

.2381 Recursive: . . . . yes.

.2382 Designation: . . . . tag field (bits 30 through 35) of instruction word.

.2383 Control: . . . . the last indirect word is marked by contents of the tag field (bits 30 through 35) of the indirect word.

.2384 Indexing with indirect addressing: . . . . yes; indexing can take place before starting indirect cycles (RI), after completion of indirect cycles (IR), or before or after each indirect cycle (IT).

.239 Stepping

.2391 Specification of increment: . . . . in the Repeat or Repeat Double instruction.

.2392 Increment sign: . . . . . always positive.

.2393 Size of increment: . . . 0 to 127.

.236 Directly addressed operands —

Internal storage type	Minimum size	Maximum size	Volume accessible
Core storage:	6 bits	double-word	262,144 words.
Registers:	8 bits	double-word	1 8-bit register (exponent register), 8 18-bit registers (index registers and instruction counter) and 1 72-bit register (can be used as 72-bit accumulator, 2 independent 36-bit accumulators, or 4 independent 18-bit index registers).

.2394 End value: . . . . when the tally count (number of repeats yet to be performed) reaches zero or when a specified condition (the status of one or more indicators) is met.

.2395 Combined step and test: . . . . yes.

.24 Special Processor Storage

.241

Category of storage	Number of locations	Size in bits	Program usage
Accumulator register	1	72	serves as mantissa register for floating-point operations, as operand register for double-precision fixed-point operations (each half can be used independently for single-precision fixed-point operations), or as four independent 18-bit index registers.
Index register:	8	18	serves as index register or as operand register for half-precision fixed-point operands.
Exponent register:	1	8	hold exponent for all floating-point operations.
Base Address register:	1	18	stores the base address and memory allocation for an object program.
Indicator register:	1	18	stores the status of the various indicators.
Timer register:	1	24	decremented by 1 each 15.625 μsec; causes a fault interrupt when its contents reach zero (can be program-set only in the master mode).
Instruction Counter register:	1	18	contains the address of the next instruction to be executed.

.3 SEQUENCE CONTROL FEATURES

.31 Instruction Sequencing: sequential.

.311 Number of sequence control facilities: . . . 1 - instruction counter.
.312 Arrangement: . . . . . . in central processor.
.314 Special sub-sequence counters: . . . . index register XO holds tally field for Repeat instructions.
.315 Sequence control step size: . . . . 1 word.
.316 Accessibility to routines: . . . . instruction counter can be stored at any location in core storage.

.32 Look-Ahead: . . . . instructions are fetched in pairs while the previous operation is being executed. Address indexing and operation fetching are also overlapped. Time savings are lost if a transfer instruction, or the location transferred to, is the second word of an instruction pair.

.33 Interruption

.331 Possible causes —

FAULT INTERRUPTS

Classification (in descending priority)	Interrupt Number (octal)	Cause
I	17	activation of Execute switch on maintenance panel.
	14	power applied to the system.
II	13	address outside the limits of existing core storage; an operation was not completed by processor or system Controller.
	7	an interrupt inhibit has existed for more than 64 msec.
III	16	divide check.
	15	fixed-point overflow or floating-point overflow or underflow.

.331 Possible causes (Contd.)

FAULT INTERRUPTS (Contd.)

Classification (in descending priority)	Interrupt Number (octal)	Cause
IV	12	attempted execution of an invalid operation code (all zeros).
	11	parity error in core storage acess.
	6	execution of a Derail instruction.
	5	attempt to issue in the slave mode an instruction reserved for master mode, or attempt to use a memory channel that has been masked off.
	3	recognition of a Fault Tag in an indirect word.
	2	execution of a Master Mode Entry instruction.
	1	program referenced an address that was outside physical memory or outside program boundaries.
V	10	execution of a Connect instruction.
	4	Timer register reached zero.
	0	power removed from system.

PROGRAM (I/O) INTERRUPTS

Classification (in descending priority)	Interrupt cell no. (octal)	Cause
C	04	failure to access Data Control Word and duplicate without parity errors.
S	14	occurrence of special conditions (completion of magnetic tape rewind, device ready, etc.).
I	24	failure to initiate an I/O operation.
T	34	termination of a channel busy status.

Note: The interrupt cell numbers shown are for the first I/O Controller Module. The numbers for the next module would be 05, 15, 25, 35, etc. Priority is by interrupt cell number, with the lowest cell number having the highest priority.

.332 Control by routine —

Individual control: . . . I/O interrupts from each I/O Controller can be generated or inhibited by classification (see Paragraph .331).
parity and overflow interrupts can be inhibited.
I/O and group V interrupts can be delayed (see Paragraph .334); all other interrupts are granted, automatically, based on priority.

Method: . . . . setting of specific bit in appropriate register or instruction word.

.333 Operator control: . . . . . operator can only request interrupt via the console typewriter and the I/O Interrupt Register in the System Controller.

.334 Interruption conditions —

General: . . . . only one interrupt within a priority group (except I/O interrupts) can be active at any one time.

Group I and II: . . . . . . interrupt will be processed immediately without completing present operation.

Group III and IV: . . . . interrupt will be processed following completion of present operation.

Group V and I/O interrupts: . . . . interrupt procedure will be carried out as soon as an instruction from an odd memory location has been executed that: (1) did not have bit position 28 set to a 1, (2) did not cause an actual transfer of control, and (3) was not an Execute or Execute Double instruction (the second instruction in an Execute Double instruction will be executed prior to allowing the interrupt in any case).

.335 Interruption process —

Interruption action: . . . forced transfer to a location within the supervisor area determined by the classification of the interrupt.

Registers saved: . . . . none of the registers is stored automatically; however, the operating system (see GECOS, page 340:191.100) normally stores the contents of the Instruction Counter and Indicator register prior to executing an interrupt routine, and will

.335 Interruption process —
Registers saved (Contd.)
save the contents of all registers if a transfer to another program is made.

.335 Control methods —
Determine cause:
Group I through V: . fixed-point overflow and floating-point overflow and underflow can be distinguished by an analysis of the Indicator register; each of the 16 conditions mentioned in Paragraph .331 causes a transfer to a unique location; except for overflow conditions, no further analysis is possible.
I/O interrupts: . . . analysis of the device status word, which is stored in an interrupt queue in memory at the same time the execute request register is set. Each status word specifies the device, channel, and condition causing an interrupt.
Enable interruption: . automatically enabled once the condition is serviced, or enabled by resetting the masks.

.34 Multiprogramming

(Multiprogramming is the process of intermingling instructions from several different independent programs.)

.341 Method of control: . . . handled by the operating system, GECOS (see page 340:191.100).
.342 Maximum number of programs:. . . . . 8.
.343 Precedence rules: . . . priority list.
.344 Program protection —
Storage: . . . . program base address and program boundaries are stored in the Base Address Register (BAR). Any attempt by a program in the slave mode to reference an address outside the boundaries causes the program to be aborted.
In-out units: . . . . . . the I/O controller performs an address check on all input or output areas. If the areas are outside the program boundaries, the program is aborted.

.35 Multi-sequencing: . . . handled by software (due to be available in mid-1965).

.4 PROCESSOR SPEEDS

The processor speeds for each GE-600 Series system are presented in the following individual sub-reports:
GE-625: . . . . page 343:051.100
GE-635: . . . . page 344:051.100

.5 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Overflow (fixed or floating-point):	check	*
Underflow (floating-point):	check	*
Zero divisor:	check	*
Unavailable operation:	check	instruction acts as No Operation or forced transfer to a fixed location, depending on the instruction.
Invalid operation:	check	*
Operation not completed:	check	*
Invalid address:	check	*
Receipt of data:	parity check by System Controller	*
Dispatch of data:	none.	
Lock-up (continuous inhibition of interrupts for more than 64 msec):	check	*

* Forced transfer to a fixed location in core storage.

INPUT-OUTPUT: CARD PUNCHES

.1 GENERAL

.11 Identity: . . . . CP-10 Card Punch (100 cards per minute).
CP-20 Card Punch (300 cards per minute).

.12 Description

CP-10

The CP-10 Card Punch is the same unit offered with the GE-400 Series computer systems. The peak punching speed of the CP-10 is 100 cards per minute. A new punch instruction must be received within 43 milliseconds after the completion of the previous cycle to maintain the maximum rate of punching. The rate of punching drops 7 cards per minute for each 43-millisecond period (or fraction thereof) of delay after the initial one.

CP-20

The CP-20 Card Punch is a new unit, developed by GE. Its peak punching speed is 300 cards per minute. A new punch command must be received within 10 milliseconds after the completion of the previous cycle to maintain the maximum rate of punching. If the 10-millisecond period is exceeded, the rate of punching drops to 150 cards per minute.

Characteristics

There is virtually no limit to the number of card punches that can be connected on-line (see Section 340:031, System Configuration). Models can be intermixed in the same GE-600 system. The number of card punches that can operate simultaneously depends on the number of other operating peripherals connected to the same I/O controller module (see Section 340:111, Simultaneous Operations).

Some important characteristics of the card punches are:

- An 80-bit buffer (CP-10) or a full-card-image buffer (CP-20) internal to the card punch.
- 800-card input hopper and output stacker capacity in the CP-10; 3500-card hopper and 3000-card stacker in the CP-20.
- Only one output stacker.
- Punches 80-column cards row-by-row.
- Loading and unloading can be done during operation.
- Accepts either square- or round-cornered cards (can be intermixed).
- Column binary punching capability.
- Post-punch row parity check.
- Parity check on data received for punching.

Special conditions (such as successful completion of an operation, full output stacker, card jam, invalid command, etc.) cause the setting of a bit for the appropriate channel in the execute-interrupt register of the System Controller in the Memory Module. Subsequent action by a supervisor program (normally GECOS) can determine the particular condition by interpreting a requested Status Return.

Normally a programmer does not program input-output operations in detail; this is usually handled by the operating system (GECOS) on a file-specification basis. A detailed description of the input-output process is presented in Section 430:111, Simultaneous Operations. Card punching can be overlapped with other input-output operations and with processing. Detailed considerations for simultaneity, including time demands on the system, are also presented in the section on Simultaneous Operations.

INPUT-OUTPUT: PUNCHED TAPE EQUIPMENT

.1 GENERAL

.11 Identity: . . . . TS-20 Perforated Tape Reader/Punch.

.12 Description

The TS-20 Tape Reader/Punch, a free-standing unit housing a reader, punch, and control circuitry for punched tape input and output, is the same unit offered for the GE-400 Series computer systems. The reader and punch are mechanically independent, and the user may order the reader and its spooler mechanisms only (Model TR-20) or the punch and its spooler only (Model TP-20). Punched tape with standard or special 5-, 6-, 7-, 8-level character code configurations can be read or punched. The Tape Reader/Punch can also be used off-line for duplicating or verifying tapes.

Reader

The reader operates at a peak speed of 500 characters per second, using standard paper or plastic tape with fully-punched holes. Reading is by means of photoelectric diodes. There is only one reader command, which causes continuous feeding and reading of tape in a channel mode established by the removable plugboard. The plugboard has provisions for recognizing stop or end-of-file characters. The bit configuration of these characters is determined by plugboard wiring and can be either single characters or groups. The plugboard also controls parity checking (odd, even, or none) and deletion of plugboard-specified characters. In addition, a plugboard identification configuration (6 bits) can be wired and is part of the normal Subsystem Ready Status Return. The plugboard must be in place prior to initiating a punched tape read instruction.

Characters can be transmitted to storage either in their tape format or in a format rearranged by plugboard wiring. Each 36-bit word in storage can hold up to six characters of a 5- or 6-level tape code or three characters of a 7- or 8-level tape code. Conversion to the internal BCD character code, when necessary, must be accomplished by programming through the use of a translating routine and suitable translation tables.

Punch

The punch has a peak speed of 150 characters per second, and the on-line operating modes are under program control at all times. The following instructions are available:

- Punch — feed and punch 7-channel tape with odd parity punched in channel 5. Each word in storage produces 6 tape characters.
- Punch Edited — same as Punch, except delete any Ignore characters in the output data.
- Punch Single — feed and punch 5- or 6-channel tape with no parity bit punched. Each word in storage produces 6 tape characters.
- Punch Double — feed and punch 7- or 8-channel tape with no parity bit punched. Each word in storage produces 3 tape characters.

Accuracy control consists of a parity check on each character received from core memory and a transfer timing check which detects an error if a data character is not received within 10 milliseconds of the time for activating the punch pins. Either of these errors results in terminating the current operation and in transmitting a "data alert" signal to the I/O Controller.

Configuration and Simultaneity

There is virtually no limit to the number of punched tape subsystems that can be connected on-line (see Section 340:031, System Configuration). The number that can operate simultaneously depends on the number of other operating peripherals connected to the same I/O controller module (see Section 340:111, Simultaneous Operations). Punched tape reading and punching cannot occur simultaneously in the same unit, but either reading or punching can be overlapped with other input-output operations and with processing.

Special conditions (such as successful completion of an operation, out-of-tape, invalid command, etc.) cause the setting of a bit for the appropriate channel in the execute-interrupt register of the System Controller in the Memory Module. Subsequent action by a supervisor program (normally GECOS) can determine the particular condition by interpreting a requested Status Return.

Normally a programmer does not program input-output operations in detail; this is usually handled by the operating system (GECOS) on a file-specification basis. A detailed description of the input-output process is presented in Section 430:111, Simultaneous Operations. Detailed considerations for simultaneity, including time demands on the system, are also presented in the section on Simultaneous Operations.

INPUT-OUTPUT: PRINTER

.1 GENERAL

.11 Identity: . . . . PR-20 Printer.

.12 Description

The PR-20 Printer is the same unit offered for GE-400 series computer systems, but with a slightly different selection of special characters (see Table 2 of this section and page 324:141.100, Data Code Table for the GE-425). The maximum rate of printing single-spaced lines is 1,200 lines per minute using any contiguous 46-character set and 949 lines per minute using the full 64-character set. The 46 "most common" characters are arranged in a contiguous set. (Table 2 shows the arrangement of the characters on the print drum.)

Effective printing rates for multiline spacings are shown in Table 1, for both a 46-character set and the full 64-character set.

There is virtually no limit to the number of printers that can be connected on-line (see Section 340:031, System Configuration). The number of printers that can be operated simultaneously depends on the number of other operating peripheral units connected to the same I/O controller module (see Section 340:111, Simultaneous Operations).

Some important characteristics of the PR-20 Printer are as follows:

- The printer is fully buffered.
- Printing is done by pressing the ribbon and paper against the rotating drum by an on-the-fly hammer stroke.
- 64 printable characters (excluding space).
- 136 print positions.
- Up to 6 copies plus original can be made.
- Paper stock can be from 3 to 19 inches in width.
- Vertical spacing can be 6 or 8 lines per inch at the option of the operator.
- Special controls, in conjunction with a standard subroutine, enable the operator to reprint, space forward or backspace by line or page, and perform some operations on the input devices to the printer (magnetic tape or disc/drum).

Continuous skipping is at the rate of 27.5 inches per second after the first two lines, which take 14 milliseconds and 6 milliseconds, respectively. Automatic skipping can be initiated and stopped by appropriate punches in the Vertical Format Control (VFU) tape. Single spacing, double spacing, or skipping to the top of a page can be initiated by programmed commands. Alternatively, a skip of up to 15 lines following the printing of a line can be specified by the inclusion of special "slew characters" in the formation of the print line. Other editing characters can cause deletion of a character, printing of an editing character, skipping to a particular point on the vertical format control (VFU) tape, skipping to the top of a page, insertion of one blank in the print line, or insertion of up to 120 blanks (in multiples of 8) in the print line.

Two modes of printing are available. In the edit mode, the special editing characters cause the actions described above, but, in general, are not printed. In the nonedit mode, the print line is printed just as it is received by the printer buffer; the special characters are printed according to their bit configuration but do not cause any special actions to take place.

Special conditions (such as successful completion of an operation, out-of-paper condition, parity error, invalid command, top-of-page signal, etc.) cause the setting of a bit for the appropriate channel in the execute-interrupt register of the System Controller

TABLE I: EFFECTIVE SPEED OF PR-20 PRINTER

Lines Advanced per Line Printed (6 lines per inch)	Printed Lines per Minute Using 46-Character Set	Printed Lines per Minute Using 64-Character Set
1	1200	949
2	900	864
3	800	800
4	800	746
5	720	700
6 (1 inch)	665	655
12 (2 inches)	485	485
18 (3 inches)	400	380
24 (4 inches)	320	315
30 (5 inches)	275	270

12 Description (Contd.)

in the Memory Module. Subsequent action by a supervisor program (normally GECOS) can determine the particular condition by interrogating the printer controller.

Normally a programmer does not program input-output operations in detail; this usually is handled by the operating system (GECOS) on a file-specification basis. A detailed description of the input-output process is presented in Section 430:111, Simultaneous Operations. Printing can be overlapped with other input-output operations and with processing. Detailed considerations for simultaneity, including time demands on the system, are given in the section on Simultaneous Operations.

TABLE II: CHARACTER SET OF PR-20 PRINTER

Relative Position on Print Drum	Character	Relative Position on Print Drum	Character
1	+	33	M
2	/	34	N
3	&	35	O
4	0	36	P
5	1	37	Q
6	2	38	R
7	3	39	S
8	4	40	T
9	5	41	U
10	6	42	V
11	7	43	W
12	8	44	X
13	9	45	Y
14	[	46	Z
15	.	47	←
16	,	48	]
17	%	49	(
18	-	50	<
19	$	51	\
20	*	52	↑
21	A	53	)
22	B	54	;
23	C	55	'
24	D	56	=
25	E	57	"
26	F	58	!
27	G	59	>
28	H	60	?
29	I	61	b̸
30	J	62	#
31	K	63	@
32	L	64	:

INPUT-OUTPUT: 7-TRACK MAGNETIC TAPE HANDLERS

.1 GENERAL

.11 Identity: . . . . 7-Track Magnetic Tape Handlers:
MT-17 (20.9 KC)
MT-19 (30 KC)
MT-21 (42 KC)
MT-23 (60 KC)
MT-24 (83 KC)
MT-26 (120 KC).
7-Track Magnetic Tape Controllers:
MTC-71 (Single Channel)
MTC-72 (Dual Channel).

.12 Description

General Electric currently offers three families of magnetic tape units (12 models in all) for its computer systems. All of these models are available for the GE-600 Series systems. Each family is based on one tape handler; the differences are in recording densities and the number of data tracks. Both 7-track and 9-track models are available in each family. The characteristics and performance of each 7-track tape handler are presented in this section. For information about the 9-track handlers, see Section 340:092.

All 7-track tape handlers described in this section are compatible with the tape units used in previous GE systems and with the IBM 729 and 7330 Magnetic Tape Units.

.121 MT-17 and MT-19

The MT-17 and MT-19 Magnetic Tape Handlers are improved versions of the GE-developed economy-model magnetic tape handlers first introduced as the MTH-200 and MTH-300, respectively. Forward tape speed has been increased to 37.5 inches per second (36 inches per second previously), and rewind speed has been increased to 300 inches per second (110 inches per second previously).

The most significant difference between the MT-17 and MT-19 is that the MT-19 can read and write at a density of 800 characters per inch in addition to the 200 and 556 characters-per-inch densities available in the MT-17. Peak data transfer rate for the MT-17 is 20,900 characters per second; peak data transfer rate for the MT-19 is 30,000 characters per second.

.122 MT-21 and MT-23

The MT-21 and MT-23 are two versions of a new GE-developed magnetic tape handler designed to supplant the Ampex units (MTH-201 and MTH-301) formerly used as the medium-speed magnetic tape units in the GE line. Mechanical design is similar to that of the MT-17 and MT-19 mentioned above. Forward tape speed is 75 inches per second and rewind speed is 300 inches per second.

The most significant difference between the two models is that the MT-23 can read and write at a density of 800 characters per inch in addition to the 200 and 556 characters per inch densities available in the MT-21. Peak data transfer rate is 42,000 characters per second for the MT-21 and 60,000 characters per second for the MT-23.

.123 MT-24 and MT-26

The MT-24 Magnetic Tape Handler was first introduced as the MTH-202, with recording densities of 200 and 556 characters per inch. The MT-26 is the same basic unit with an additional recording density of 800 characters per inch. These two magnetic tape units feature:

- Photoelectrically controlled tape bins (approximately 30 feet of tape) instead of the usual vacuum columns;
- 150 inches per second forward tape speed;
- 300 inches per second rewind speed;
- Tape drive by means of four vacuum capstans.
- Permanent, quick-connect tape leader

Peak data transfer rate is 83,000 characters per second for the MT-24 and 120,000 characters per second for the MT-26.

.124 Controllers

Two controllers are available for the magnetic tape units: a single-channel model and a dual-channel model. Either can control up to 16 tape units. Each single-channel controller fully occupies one high-speed channel of the I/O Controller module; each dual-channel controller fully occupies two. There is no practical limit upon the total number of magnetic tape units that can be connected on-line (see Section 340:031, System Configuration).

A dual-channel controller can permit simultaneous read-read, read-write, or write-write operations by any two magnetic tape units connected to the same controller, or it can permit either of two computer systems access to all tape units connected to that controller. Simultaneous operations can also be performed utilizing two tape units connected to different single-channel controllers. Any combination of the tape units described in this section can be connected to the same controller.

.125 Programming Characteristics

All of the magnetic tape units described in this section are functionally identical; i.e., it makes no difference to the programmer which model tape unit is being used (except for the 800-characters per-inch feature of the MT-19, MT-21, and MT-26). Instructions are available for reading or writing one block (forward only) in either BCD or binary mode, spacing backward or forward over either 1 to 63 logical records or one file, selecting high or low density, rewinding, writing an end-of-file character, and erasing 8.5 inches forward.

The contents of each 36-bit word are written as six tape rows in both the BCD and binary modes. In the binary mode, the data is written on tape exactly as it appears in storage; in the BCD mode, an automatic code translation is performed between GE-600 internal code and the IBM BCD tape code as used in IBM 7090/7094 systems.

A dual-gap head provides read-after-write checking; both lateral (row) and longitudinal (block) parity are checked. A check is also made for loss of data due to timing errors.

Normally, a GE-600 Series programmer does not program input-output operations in detail; this is usually handled by the operating system (GECOS) on a file-specification basis. A detailed description of the input-output process is presented in Section 430:111, Simultaneous Operations. Magnetic tape operations can be overlapped with other input-output operations and with processing. Detailed considerations for simultaneity, including time demands on the system, are also presented in the Simultaneous Operations Section.

.14 First Delivery: . . . . . March, 1965.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . vacuum capstan (MT-24 and MT-26 use 4 vacuum capstans).
.212 Reservoirs —
Number: . . . . 2.
Form: . . . . vacuum columns (MT-24 and MT-26 use photo-electrically controlled tape bins).
Capacity: . . . . about 10 inches (MT-24 and MT-26: about 30 feet).
.213 Feed drive: . . . . proportional servo motor.
.214 Take-up drive: . . . . . . proportional servo motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . magnetic head.
.222 Sensing system: . . . . . magnetic head.
.223 Common system: . . . . two-gap head provides read-after-write parity check.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . . recording.
Stacks: . . . . 1.
Heads/stack: . . . . 7.
Method of use: . . . . . . 1 row at a time.

Use of station: . . . . . . reading.
Distance: . . . . 0.3 inch.
Stacks: . . . . 1.
Heads/stack: . . . . 7.
Method of use: . . . . . . 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . plastic tape with magnetic-able surface.
.312 Phenomenon: . . . . magnetization.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 200, 556, or (in some models) 800 rows/inch; N is limited only by available core storage.
.322 Parallel by: . . . . 7 tracks.
.324 Track use —
Data: . . . . 6.
Redundancy check: . . . 1.
Timing: . . . . 0.
Control signals: . . . . . 0.
Unused: . . . . 0.
Total: . . . . 7.

.325 Row use —
Data: . . . . 1 to N.
Redundancy check: . . . 1 per block.
Timing: . . . . 0.
Control signals: . . . . . 0.
Unused: . . . . 4.
Gap: . . . . 0.75 inch inter-block; 3.78 inches end-of-file.

.33 Coding: . . . . 1 tape row per character, or 6 tape rows per GE-600 word. Automatic translation between IBM BCD tape code and GE-600 internal code in BCD mode; no translation in binary mode.

.34 Format Compatibility

Other device or system	Code translation
IBM 729 and 7330 tape units:	not required, except for a few special characters.
GE-200 or 400 Series systems using 7-track tape units: . . .	not required.

.35 Physical Dimensions

.351 Overall width: . . . . . . 0.50 inch.
.352 Length: . . . . 2,400 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . MTC-71 (single channel). MTC-72 (dual channel).

.42 Connection to System

.421 On-line: . . . . maximum of 6 single-channel controllers or 3 dual-channel controllers per I/O Control Module. (See Section 340:031, System Configuration.)
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1 to 16.
.432 Restrictions: . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . 1 to N words.
.442 Input-output areas: . . . core storage.
.443 Input-output area access: . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . . yes; scatter-read and gather-write are available at programmer's option, as described in Section 340:111, Simultaneous Operations.
.446 Synchronization: . . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . 1 to N words.
.512 Block demarcation —
Input: . . . . gap on tape or exhausted Data Control List.
Output: . . . . Data Control List specifies number, length, and core locations of data fields comprising a tape block (see Section 340:111).

.52 Input-Output Operations

.521 Input: . . . . read 1 block forward.
.522 Output: . . . . write 1 block forward. write end-of-file record. erase 8.5 inches forward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . forward or backward space: one file or 1 to 63 logical records.
.525 Marking: . . . . inter-block gap. end-of-file character and gap. 1 to 62 multi-purpose block delimiters.
.526 Searching: . . . . none.

.53 Code Translation: . . . . automatic in BCD mode. no translation in binary mode.

.54 Format Control: . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . yes.
Select density: . . . . . . yes.
Select code: . . . . yes.
Rewind: . . . . yes.
Unload: . . . . yes.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . yes.
Output lock: . . . . yes.
Nearly exhausted: . . . . yes (1200 inches from physical end).
Busy controller: . . . . . yes.
End-of-file marks: . . . yes.
End-of-medium marks: . . . . yes.

.6 PERFORMANCE

.62 Speeds

.621 Nominal or peak speed: . . . . see Table I.
.622 Important parameters: see Table I.
.623 Overhead: . . . . see Interblock Gap Lengths, Table I.
.624 Effective speeds: . . . . see Table I and graphs.

.63 Demands on System: . . see Section 340:111, Simultaneous Operations.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment: . . . . recording density.
Method: . . . . switch.

.72 Other Controls

Function	Form	Comment
Address selection:	rotary switch	assign logical address (0 through 15).
Rewind:	push button.	
File protection:	ring on reel	absence of ring inhibits writing.

.73 Loading and Unloading

.731 Volumes handled —
Capacity per 2,400-foot reel (for 1000-character blocks): . . . . 5 million characters at 200 rows/inch.
11.3 million characters at 556 rows/inch.
14.4 million characters at 800 rows/inch.
.732 Replenishment time: . . 0.5 to 1.0 minute (approximately 0.3 minute for MT-24 and MT-26); tape unit needs to be stopped.
.734 Optimum reloading period: . . . . 3.2 to 12.8 minutes to read or write a full reel at peak speed, depending upon model.

.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Recording:	read-after-write parity check	*
Reading:	lateral and longitudinal parity check	*
Input area overflow:	check	*
Output block size:	preset.	
Invalid code:	all codes valid.	
Exhausted medium:	reflective marker on tape	*
Imperfect medium:	none, but read and write parity checks will pick up many imperfections.	

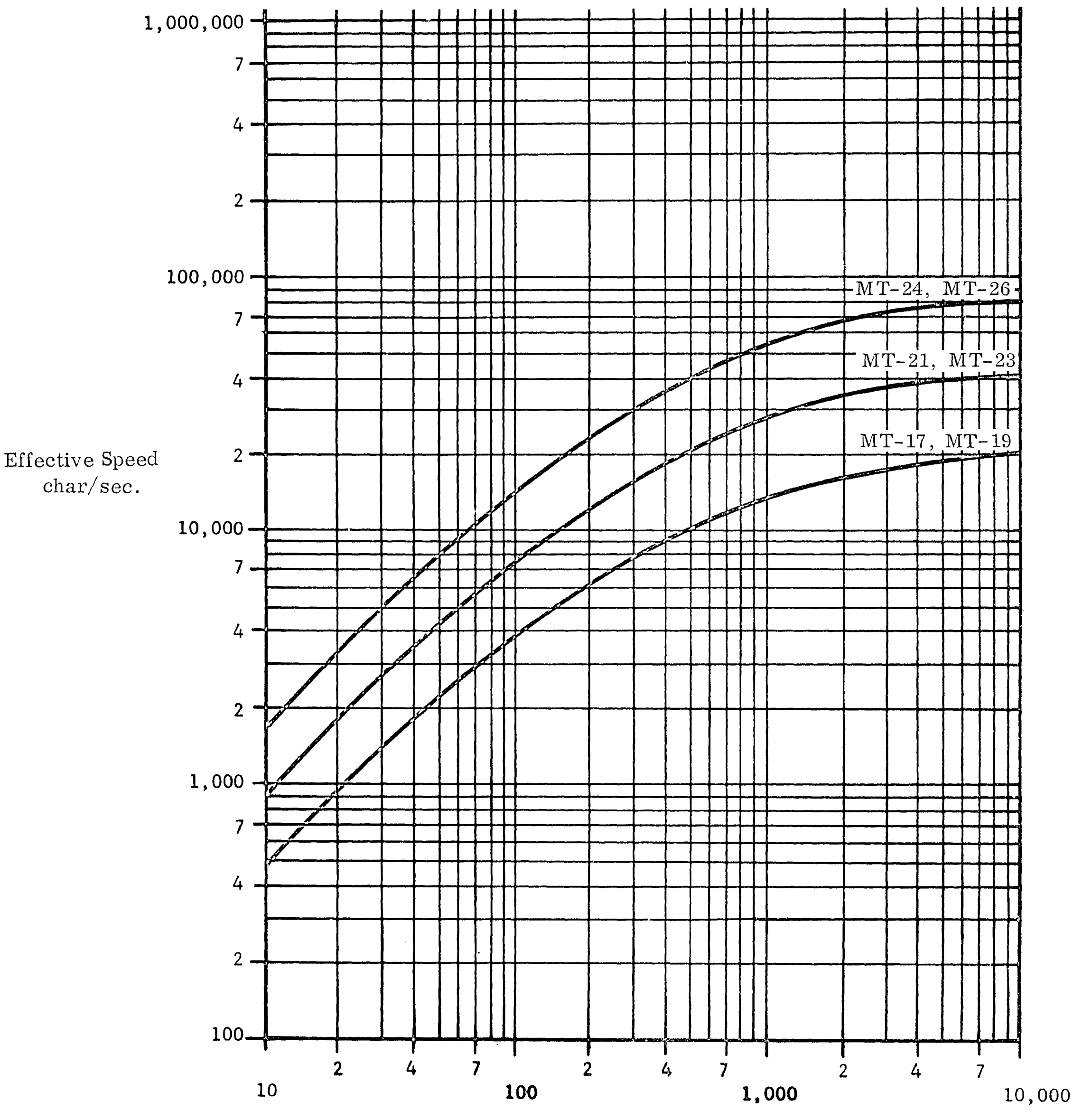
* Occurrence of these and other abnormal conditions causes an interrupt and a branch to a specified location in the supervisor (GECOS) area. Information as to the channel, device, and particular condition is contained in a status word which is stored in a specified location in memory and is available to GECOS for examination.

TABLE I: CHARACTERISTICS OF 7-TRACK MAGNETIC TAPE HANDLERS

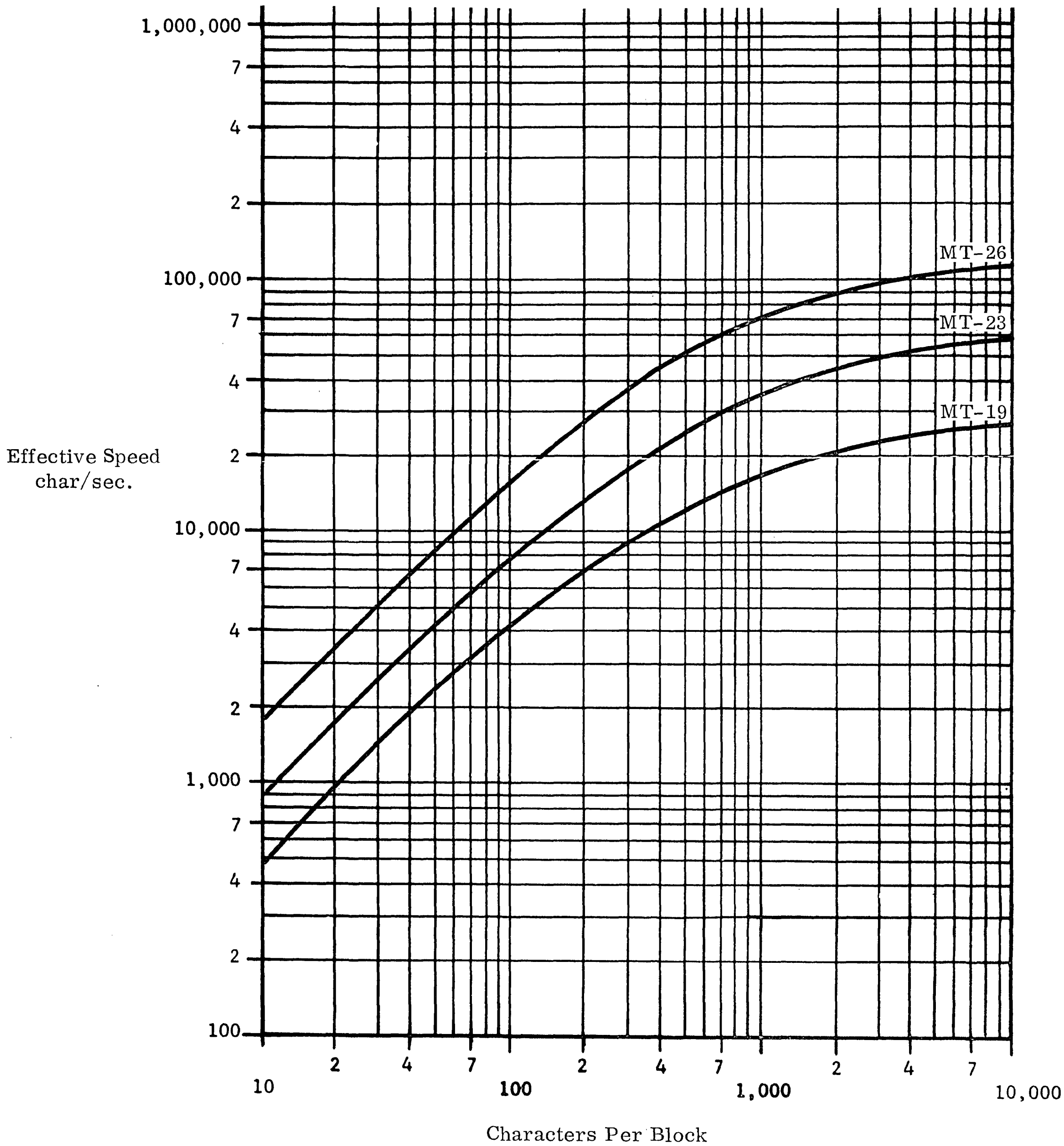
Model No.	Tape Speed, inches per sec	Recording Density, bits per inch	Peak Speed, char per sec	Interblock Gap Lengths: inches	Interblock Gap Lengths: msec (1)	Interblock Gap Lengths: chars (2)	Efficiency, % (3): 100-char blocks	Efficiency, % (3): 1,000-char blocks	Rewind Speed, inches per sec	Rated Start + Stop Time, msec
MT-17	37.5	200 556	7,500 20,900	0.75 0.75	21 21	157 437	38.9 18.6	86.4 69.6	300	<10
MT-19	37.5	800(4)	20,000	0.75	21	629	13.7	61.4	300	<10
MT-21	75	200 556	15,000 42,000	0.75 0.75	11 11	165 459	37.8 17.9	85.8 68.5	300	<10
MT-23	75	800(5)	60,000	0.75	11	660	13.2	60.2	300	<10
MT-24	150	200 556	30,000 83,000	0.75 0.75	5.3 5.3	159 441	38.6 18.5	86.2 69.4	300	3
MT-26	150	800(6)	120,000	0.75	5.3	636	13.6	61.2	300	3

(1) Time in milliseconds to traverse each interblock gap when reading or writing consecutive blocks.
(2) Number of character positions occupied by each interblock gap.
(3) Effective speed at the indicated block size, expressed as a percentage of peak speed.
(4) Performance of the MT-19 at 200 and 556 bits per inch density is the same as that of the MT-17.
(5) Performance of the MT-23 at 200 and 556 bits per inch density is the same as that of the MT-21.
(6) Performance of the MT-26 at 200 and 556 bits per inch density is the same as that of the MT-24.

EFFECTIVE SPEED:
7-TRACK MAGNETIC TAPE HANDLERS
(556 bits per inch)



EFFECTIVE SPEED:
7-TRACK MAGNETIC TAPE HANDLERS
(800 bits per inch)



INPUT-OUTPUT: 9-TRACK MAGNETIC TAPE HANDLERS

.1 GENERAL

.11 Identity: . . . . 9-Track Magnetic Tape Handlers:
MT-17A (28 KC)
MT-19A (40 KC)
MT-21A (56 KC)
MT-23A (80 KC)
MT-24A (111 KC)
MT-26A (160 KC).
9-Track Magnetic Tape Controllers:
MTC-91 (Single Channel)
MTC-92 (Dual Channel).

.12 Description

General Electric offers a 9-track version of each 7-track magnetic tape handler described in Section 340:091 (including the models having a maximum recording density of 556 bits per inch). The basic characteristics of corresponding models are similar. Some of the more significant differences between the 7-track and 9-track magnetic tape units are:

- In the 9-track units, two 36-bit words are recorded on nine rows of tape exactly as they appear in core storage.
- Interblock and end-of-file gaps are both reduced to 0.6 inch.
- A cyclic parity check is made by the 9-track controller in addition to lateral and longitudinal parity checks, permitting the automatic correction of single-track errors.

The 9-track tape units are compatible with the IBM 2400 Series units. Any combination of 9-track and/or 7-track GE-600 Series tape handlers can be connected to a single 9-track controller. (Nine-track tape units, however, cannot be connected to a 7-track controller.)

.14 First Delivery: . . . . . September, 1965.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . vacuum capstan (MT-24A and MT-26A use 4 vacuum capstans).
.212 Reservoirs —
Number: . . . . 2.
Form: . . . . vacuum columns (MT-24A and MT-26A use photo-electrically controlled bins).
Capacity: . . . . about 10 inches (MT-24A and MT-26A: about 30 feet).
.213 Feed drive: . . . . proportional servo motor.
.214 Take-up drive: . . . . . . proportional servo motor.

.22 Sensing and Recording Systems

.221 Recording system: . . . magnetic head.
.222 Sensing system: . . . . . magnetic head.
.223 Common system: . . . . two-gap head provides read-after-write parity check.

.23 Multiple Copies: . . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . . recording.
Stacks: . . . . 1.
Heads/stack: . . . . 9.
Method of use: . . . . . . 1 row at a time.

Use of station: . . . . . . reading.
Distance: . . . . 0.15 inch.
Stacks: . . . . 1.
Heads/stack: . . . . 9.
Method of use: . . . . . . 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . plastic tape with magnetizable surface.
.312 Phenomenon: . . . . magnetization.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 200, 556, or (in some models) 800 rows/inch; N is limited only by available core storage.
.322 Parallel by: . . . . 9 tracks.
.324 Track use —
Data: . . . . 8.
Redundancy check: . . . 1.
Timing: . . . . 0.
Control signals: . . . . . 0.
Unused: . . . . 0.
Total: . . . . 9.
.325 Row use —
Data: . . . . 1 to N.
Redundancy check: . . . 2 per block.
Timing: . . . . 0.
Control signals: . . . . . 0.
Unused: . . . . 6.
Gap: . . . . 0.6 inch inter-block; 0.6 inch end-of-file.

.33 Coding: . . . . 9 tape rows per two 36-bit words.

.34 Format Compatibility

Other device or system	Code translation
IBM 2400 Series tape units:	not required.
GE-200 or 400 Series systems using 9-track tape units:	not required.

.35 Physical Dimensions

.351 Overall width: . . . . . . 0.50 inch.
.352 Length:. . . . . 2,400 feet per reel.

.4 CONTROLLER

.41 Identity: . . . . MTC-91 (single channel) MTC-92 (dual channel).

.42 Connection to System

.421 On-line: . . . . maximum of 6 single-channel controllers or 3 dual-channel controllers per I/O Control Module. (See Section 340:031, System Configuration.)
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller:. . . . . 1 to 16.
.432 Restrictions:. . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . 1 to N words.
.442 Input-output areas: . . . core storage.
.443 Input-output area access:. . . . . each word.
.444 Input-output area lockout: . . . . none.
.445 Table control: . . . . . . yes; scatter-read and gather-write are available at programmer's option, as described in Section 340:111, Simultaneous Operations.
.446 Synchronization:. . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block:. . . . . . . 1 to N words.
.512 Block demarcation —
Input:. . . . . gap on tape or exhausted Data Control List.
Output:. . . . . Data Control List specifies number, length, and core locations of data fields comprising a tape block (see Section 340:111).

.52 Input-Output Operations

.521 Input:. . . . . read 1 block forward.
.522 Output:. . . . . write 1 block forward. write end-of-file record. erase 8.5 inches forward.
.523 Stepping:. . . . . none.
.524 Skipping:. . . . . forward or backward space: one file or 1 to 63 logical records.
.525 Marking:. . . . . inter-block gap. end-of-file character and gap. 1 to 62 multi-purpose block delimiters.
.526 Searching:. . . . . none.

.53 Code Translation: . . . none.

.54 Format Control:. . . . . none.

.55 Control Operations

Disable: . . . . yes.
Request interrupt: . . . yes.
Select density:. . . . . . yes.
Select code:. . . . . yes.
Rewind: . . . . yes.
Unload:. . . . . yes.

.56 Testable Conditions

Disable: . . . . yes.
Busy device: . . . . yes.
Output lock:. . . . . yes.
Nearly exhausted:. . . . yes (1200 inches from physical end).
Busy controller:. . . . . yes.
End-of-file marks: . . . yes.
End-of-medium marks: yes.

.6 PERFORMANCE

.62 Speeds

.621 Nominal or peak speed: . . . . see Table I.
.622 Important parameters: see Table I.
.623 Overhead:. . . . . see Interblock Gap Lengths, Table I.
.624 Effective speeds: . . . . see Table I and graph.

.63 Demands on Systems: . see Section 340:111, Simultaneous Operations.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment:. . . . . recording density.
Method: . . . . switch.

.72 Other Controls

Function	Form	Comment
Address selection:	rotary switch	assign logical address (0 through 15).
Rewind:	push button.	
File protection:	ring on reel	absence of ring inhibits writing.

TABLE I: CHARACTERISTICS OF 9-TRACK MAGNETIC TAPE HANDLERS

Model No.	Tape Speed, inches per sec	Recording Density, bits per inch	Peak Speed, char per sec	Interblock Gap Lengths			Efficiency, % (3)		Rewind Speed, inches per sec	Rated Start + Stop Time, msec
				inch	msec (1)	chars (2)	100-char blocks	1,000-char blocks		
MT-17A	37.5	200 556	10,000 28,000	0.6 0.6	21	210 583	32.3 14.7	82.7 63.1	300	<10
MT-19A	37.5	800(4)	40,000	0.6	21	839	10.7	54.4	300	<10
MT-21A	75	200 556	20,000 56,000	0.6 0.6	11	220 612	31.3 14.0	82.0 62.0	300	<10
MT-23A	75	800(5)	80,000	0.6		880	10.2	53.1	300	<10
MT-24A	150	200 556	40,000 111,000	0.6 0.6	5.3	212 589	32.0 14.5	82.3 62.9	300	3
MT-26A	150	800(6)	160,000	0.6	5.3	848	10.5	54.1	300	3

NOTE: All references in this table refer to 6-bit characters.

(1) Time in milliseconds to traverse each interblock gap when reading or writing consecutive blocks.
(2) Number of character positions occupied by each interblock gap.
(3) Effective speed at the indicated block size, expressed as a percentage of peak speed.
(4) Performance of the MT-19A at 200 and 556 bits per inch density is the same as that of the MT-17A.
(5) Performance of the MT-23A at 200 and 556 bits per inch density is the same as that of the MT-21A.
(6) Performance of the MT-26A at 200 and 556 bits per inch density is the same as that of the MT-24A.

.73 Loading and Unloading

.731 Volumes handled —
Capacity per 2,400-foot reel (for 1000-character blocks):
9-track ASCII: . . . 5 million characters at 200 rows/inch.
11.3 million characters at 556 rows/inch.
14.4 million characters at 800 rows/inch.
9-track non-ASCII: . 6.4 million characters at 200 rows/inch.
13.7 million characters at 556 rows/inch.
17.1 million characters at 800 rows/inch.

.732 Replenishment time: . . 0.5 to 1.0 minute (approximately 0.3 minute for MT-24A and MT-26A); tape unit needs to be stopped.

.734 Optimum reloading period: . . . . 3.2 to 12.8 minutes to read or write a full reel at peak speed, depending upon model.

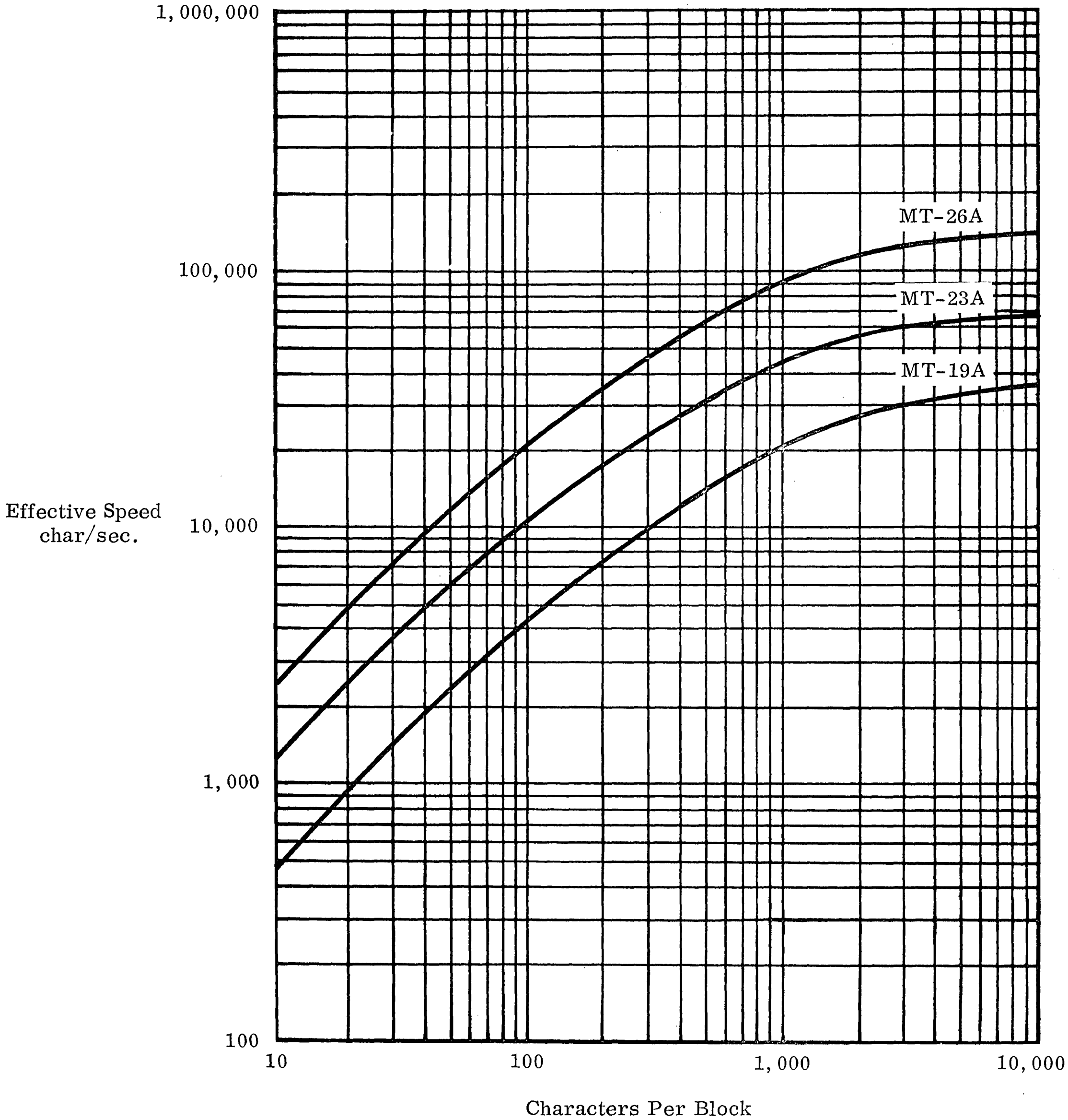
.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Recording:	read-after-write parity check	*
Reading:	lateral, longitudinal, and cyclic parity check†	*
Input area overflow:	check	*
Output block size:	preset.	
Invalid code:	all codes valid.	
Exhausted medium:	reflective marker on tape	*
Imperfect medium:	none, but read and write parity checks will pick up many imperfections.	

* Occurrence of these and other abnormal conditions cause an interrupt and a branch to a specified location in the supervisor (GECOS) area. Information as to the channel, device, and particular condition is contained in a status word which is stored in a specified location in memory and is available to the supervisor for examination.

† The 9-track controllers provide single-track error correction.

EFFECTIVE SPEED:
9-TRACK MAGNETIC TAPE HANDLERS
(800 bits per inch)



NOTE: The effective speed is shown here in terms of 6-bit characters. Performance using 8-bit characters is the same as shown in the graph on page 340:091.901.

INPUT-OUTPUT: DATANET-30

.1 GENERAL

.11 Identity: . . . . Datanet-30 Data Communications Processor.

.12 Description

The Datanet-30 is a stored program data communications processor that can be used independently or connected on-line to any GE 200, 400 or 600 series computer. It is particularly useful for message switching, data collection and distribution, and integrated information handling systems. The Datanet-30 can scan up to 128 communication lines, receive and temporarily store data, evaluate it for priority, and then send it on to the proper destination. The Datanet-30's principal components and their functions are summarized below.

The Processor

The Datanet-30 processor controls the flow of input and output data and manipulates the data as directed by the stored program. There are over 78 basic instructions, some of which offer many variations. The instructions can be classified into the following groups: load, store, arithmetic, logical, register transfer, branch, special, Buffer Selector (to service the input-output buffers), and Controller Selector (to control computer peripheral devices).

Arithmetic capabilities are limited to nine different binary addition instructions and a "subtract one" instruction. Logical AND, inclusive OR, and exclusive OR instructions are available. The register transfer instructions permit the contents of up to six specified registers to be "ORed" together, manipulated in one of several ways, and transferred to any combination of up to four specific registers.

Each instruction is one 18-bit word in length. Six different modes of addressing are available; three of these modes use direct addresses (contained in the instructions), and the other three use indirect addresses (contained in the memory locations specified in the instructions). All instructions that specify memory addresses use 6 bits for the operation code, 3 bits to specify the addressing mode, and 9 bits to specify the memory address itself. A symbolic assembly program is available to simplify the coding of Datanet-30 programs.

Core Memory

The Datanet-30 can contain 4,096, 8,192, or 16,384 word locations of magnetic core memory. Memory cycle time is 6.94 microseconds for each access of one 18-bit word. Each word location can hold one instruction, three 6-bit alphanumeric characters, or a numeric data word in the form of an 18-bit binary integer. Negative numbers are represented in two's complement form. Eight-level transmission codes can be stored conveniently in memory in the form of 6-bit character codes because special instructions are provided to strip off and check the parity and control bits when a character is received, and to regenerate and insert these two bits when the character is to be transmitted.

Input-Output Buffers

The Datanet-30 can address a total of 128 buffers. Each buffer is connected to a digital subset or teletype line relay which changes signals to or from the form required for the communications facilities being used. Four standard types of buffers are available:

- Bit Buffer Channel — buffers one bit at a time between the Datanet-30 and one full duplex, half duplex, or simplex transmission line. The Bit Buffer Channel is used on low-speed teletype lines at standard transmission speeds of 45 to 150 bits per second. Codes of 5, 6, 7, or 8 levels with stop-start bits can be accommodated. The program must store away each individual bit of received data before the next bit arrives. The maximum number of lines that can operate simultaneously varies with transmission speed, message volume, and a number of other factors.

- Character Buffer Channel — buffers one character of 5, 6, 7, or 8 bits at a time between the Datanet-30 and one half-duplex transmission line. The Character Buffer Channel is required by system timing considerations on lines operating at or above 300 bits per second; it can accommodate speeds up to 2,400 bits per second.

- Word Buffer Channel — buffers one 20-bit Datanet-30 word (18 data bits plus start and stop bits) to permit communication between two Datanet-30's via a half-duplex transmission line. Transmission speeds of 300 to 2,400 bits per second can be accommodated.

- Receive Parallel Unit — provides buffering, in the input direction only, for one character in any code of up to 14 bits, where all bits comprising the character are transmitted in parallel on individual lines. The Receive Parallel Unit is particularly useful for handling the input from a local Datanet-3101 Data Accumulation System. Operation is asynchronous and timed by the transmitting device.

.12 Description (Contd.)

Controller Selector Unit (CSU)

The CSU permits connection of standard GE computer peripheral devices to a Datanet-30. Peripheral units on up to eight channels can operate simultaneously through time-shared accesses to the Datanet-30's core memory. Disc storage units, magnetic tape subsystems, and other peripheral devices can be connected.

Computer Interface Unit (CIU)

The CIU is an 18-bit buffer that provides the connecting link between a GE 600 series computer system and an on-line Datanet-30. The CIU is housed within the Datanet-30, where it is addressed as an input-output buffer, and is connected to a standard capacity input-output channel of the I/O Controller. Data transfer rate is determined by the Datanet-30 program and can be up to 43, 200 characters per second. Both the Datanet-30 and the GE 600 series computer can execute independent programs while data is being transferred between them in either direction.

Data transfers between the Datanet-30 and the CIU are parallel by 18-bit word, with no parity bit. Data transfers between the CIU and the GE 600 series computer are parallel by character, with each character consisting of 6 data bits plus an odd parity bit. The CIU performs the necessary conversions between the word and character modes, adding or deleting parity bits as required. Data received from the 600 series computer is checked for proper parity. Status indicators can be interrogated by either the Datanet-30 or the 600 series computer for the following conditions: ready, intermediate, channel busy, data alert, and command reject.

SIMULTANEOUS OPERATIONS

.1 GENERAL

The Input/Output Controller Module (IOC) is in effect a small processor containing four permanently-wired programs:

- Connect Sequence — initiates the proper I/O operation.
- Data Service Sequence — performs the data transfer between core storage and a peripheral device.
- Terminate Interrupt Sequence — stores the necessary termination information in core storage and sets the appropriate bit in the Interrupt Register of the System Controller.
- Special Interrupt Sequence — handles the occurrence of special conditions, such as completion of magnetic tape rewind and printer becoming ready after operator attention.

The Connect I/O Channel instruction (CIOC) is the only input-output instruction in the GE-600 Series computer system repertoire, and it can be executed only in the master mode. In a multi-processor system, this instruction can be executed only by the module designated as control processor. Execution of the CIOC instruction causes a connection to be made between core storage and an IOC, and the initiation of a Connect Sequence in the IOC. Once the peripheral device has accepted a command, control is transferred to the Data Service Sequence (except for operations that are performed off-line, such as magnetic tape rewind). Control is transferred to the Terminate Interrupt Sequence upon successful completion of data transfer or upon non-completion of a command accepted by the peripheral. If a peripheral device is not successfully started, an initiation interrupt occurs; the Terminate Interrupt Sequence is not entered.

Once the Processor Module has relinquished control to the IOC via the CIOC instruction, the processor is not again involved until the I/O operation is completed or until an error or malfunction is detected, at which time an interrupt signal is generated. There are four types of input-output interrupts (listed in descending priority):

- Counter Parity Interrupt — results if both the queue table counter word and its duplicate cannot be read without parity errors.
- Special Interrupt — results from special conditions arising in a peripheral device (e.g., completion of a magnetic tape rewind).
- Initiation Interrupt — results from: (1) a parity error in reading the Primary Mailbox, (2) the unsuccessful start-up of a peripheral device, (3) a Request status or Reset status of a card punch operation or a multiple-record non-data-transfer operation (e.g., backspace N records on magnetic tape).
- Terminate Interrupt — results when a peripheral device has accepted a data transfer command and the data transfer is completed, either successfully or unsuccessfully, or the data address is invalid.

An IOC can be connected to up to four Memory Modules, providing a direct addressing capability of up to 262,144 words. However, only one of the associated System Controllers can control the IOC. Located in that System Controller is a 16-bit Execute Interrupt Register; one bit for each of the interrupt types for each of four IOC's (A second 16-bit register is optional.) A priority arrangement allows orderly servicing of the needs of the separate IOC's. The occurrence of an interrupt condition results in the setting of the appropriate bit of this register. The register is scanned between instruction fetches (if the scan is not inhibited by an inhibit interrupt specification in the instruction or by a transfer instruction). The highest-priority interrupt active at the time of the scan is serviced.

Associated with each IOC is a 256-word block in the area of core storage allocated to the supervisory program (GECOS). Currently 120 of these locations are used for "mailboxes" (65 words), interrupt queue tables (48 words), queue table counters and duplicates (6 words), and a counter parity interrupt cell (1 word). In addition, a variable number of locations in program storage are used for Data Control Words. The function of each of these entries is explained in the following paragraphs.

.11 Connect Sequence

When the Connect Sequence is initiated, the IOC reads the Primary Mailbox (one word), which contains the specific device command, the device address (for multiple device subsystems such as magnetic tape), the input-output channel to be used, a "lockout" bit, the IOC command, and a record count. The lockout bit is initially set to zero, and it is set to one after the Primary Mailbox has been read by the IOC, permitting a control program to determine whether the previous command has been processed. There are four basic IOC commands:

- Unit Record Transfer — reads or writes one record.
- Single-Character Record — writes a single-character record (specified in word 1 to the secondary mailbox) for file markers.
- Continuous Non-Data-Transfer — used to initiate non-data-transfer operations such as backspacing

or rewinding a magnetic tape unit, or requesting or resetting status.

- Card Punch — initiates a card punch operation (record count must be 12 initially).

In addition, there is a fifth command, initiated from switches on the IOC test panel, that is used to load the control program; it requires no information from the mailboxes in memory. The record count specifies the number of files to be backspaced or forward-spaced.

.12 Data Service Sequence

The Data Service Sequence controls the transfer of data between core storage and the IOC, and between the IOC and peripheral devices. Associated with each of the 16 input-output channels are four words stored in system memory called the Secondary Mailbox, and a variable number of words stored in program memory called Data Control Words (DCW). There is one DCW for each block of data to be transferred by an I/O operation. Each block can contain up to 4,096 words (24,576 characters), and multiple blocks can be transferred by a single I/O command, effectively permitting scatter-read and gather-write operations. A DCW contains the data address (which normally specifies the location of a data word to be transferred), character counter (for Standard-Speed Channels), action code, and the number of words remaining to be transferred. There are four action codes:

- Data Transfer and Stop — instructs the IOC to process the current DCW and then stop.
- Data Transfer and Proceed — instructs the IOC to process the current DCW and then proceed to the next sequential DCW.
- DCW Branch — instructs the IOC to obtain a DCW from the address specified by the data address and proceed.
- No Data Transfer and Proceed — instructs the IOC to send space characters if writing and not to transfer data to memory if reading.

The first word of the four-word Secondary Mailbox for an input-output channel contains the DCW currently being processed. The second word contains the address of the next DCW to be processed and the upper and lower address limits of the program (used to check the address of data areas prior to transfer). The third word is an exact image of the Primary Mailbox. The fourth word contains the address of the first DCW (necessary for card punch operations), IOC status (codes specifying particular error conditions), and a record count residue. The mailboxes must be loaded initially by the program, prior to the issuance of the CIOC instruction. Since the mailboxes are located in the area of memory assigned to the supervisory program and are normally inaccessible to the programmer, the input-output control program, GEIOS, or alternatively the record and file control program, GEFRC, must be used to initiate I/O operations. Paragraphs .122 and .123 of the Operating Environment (Section 340:191) present more information about the services performed by these control routines

The Data Service Sequence automatically handles all data transfers between core storage and a peripheral device and includes the following functions:

- Fetch current DCW. (The DCW is kept in the IOC for a High-Speed Channel and in core storage for a Standard-Speed Channel.)
- Transfer data between core storage (as specified in the DCW) and the buffer unit of the IOC.
- Update DCW (includes incrementing the data address or character counter and decrementing the word count).
- Fetch new DCW or set End Data Transfer bit, depending on the action code of the current DCW.
- Store new or updated DCW.

Data is transferred between core storage and the peripheral device in two steps through the buffer unit of the IOC. Transfers between core storage and the buffer are 36 bits in parallel (one word) for a High-Speed Channel and 6 bits in parallel (one character) for a Standard-Speed Channel. Transfers between the buffer unit and a peripheral device are six bits in parallel (one character). The buffer unit contains two buffers, used alternately, for each input-output channel. For a High-Speed Channel, each buffer consists of 36 data bits, a modulo-6 counter, and an End Data Transfer bit. Each buffer for a Standard-Speed Channel consists of six data bits and an End Data Transfer bit.

.13 Interrupt Queue Table

Associated with each of the three lower-priority interrupts are a 16-word queue table and a queue table counter. The fourth type of interrupt — the Counter Parity Interrupt — has the highest priority and hence does not require a queue list. A single word is reserved to record the occurrence of a counter parity error. The causes for each type of interrupt are presented earlier in this section. An entry in an interrupt queue contains information indicating whether the power to a peripheral subsystem is on or off; one of nine peripheral conditions such as channel/peripheral subsystem ready, device busy, end-of-file, or device data alert; additional information about the status of a subsystem; the channel to which a peripheral subsystem is connected; and a Sync Bit which is set to one when information is stored in a queue table entry.

There is a counter (four bits of a word) associated with each queue table, which specifies the location within the table of the last entry made of each type. The interrupts are serviced on a last-in first-out basis. Each counter has a duplicate; if neither a counter nor its duplicate can be read without parity error, a Counter Parity Interrupt results.

.14 Terminate Interrupt Sequence

Most requests for an I/O operation will normally be terminated by this sequence. After the Terminate Interrupt information is stored in the Secondary Mailbox, and the queue tables and the queue table counter are adjusted, the appropriate bit in the Execute Interrupt Register is set.

.2 DEMANDS ON SYSTEM

The only direct demand on the Processor Module is for the execution of the CIOC instruction and for the servicing of the interrupts. The processor will also be delayed if both the IOC and the processor request access to the same Memory Module simultaneously, since the IOC is given priority. In systems with multiple Memory Modules, this delay can be reduced since different Memory Modules can be accessed simultaneously. The reduction cannot be predicted when the standard software is used, because program and data areas are contiguous and program bounds change during the course of execution due to the termination of other jobs.

Each data transfer I/O operation requires the IOC to execute: (1) a Connect Sequence, (2) a Data Service Sequence for each word transferred to a High-Speed Channel or for each character transferred to a Standard-Speed Channel, and (3) a Terminate Interrupt Sequence. A Connect Sequence requires three core storage accesses. Each Data Service Sequence requires one core storage access for a High-Speed Channel and three accesses for a Standard-Speed Channel. A Terminate Interrupt Sequence requires one core storage access. Some typical demands on the IOC and on core storage during I/O operations using the various peripheral devices are presented in Table I.

.3 SIMULTANEITY

The following considerations govern simultaneity of operations:

- Any I/O operation can be overlapped with central processor operations.
- Multiple accesses to core storage can be made simultaneously if there is more than one System Controller (and its associated Memory Module) incorporated in the system — one access per System Controller.
- The total data transfer rate of all peripheral devices operating simultaneously and connected to the same I/O Controller cannot exceed 1.0 million characters per second.
- As many simultaneous magnetic tape read or write operations can occur as there are channels connected to the tape controllers; e.g., a system having two dual-channel controllers connected to an I/O Controller can have four simultaneous tape operations.
- Reading and punching of paper tape cannot be done simultaneously by one TS-20 Punched Paper Tape unit.

TABLE I: SIMULTANEOUS OPERATIONS

Device	Cycle Time, msec	Type of Channel	Peak Data Rate, char/sec.	Demand on I/O Controller, %		Demand on Core Storage, %	
				GE-625	GE-635	GE-625	GE-635
CR-20 Card Reader[a]	67	SC	—	0.73	0.66	0.72	0.36
CP-10 Card Punch[b]	600	SC	—	0.97	0.88	0.96	0.48
CP-20 Card Punch[b]	200	SC	—	0.24	0.22	0.24	0.12
PR-20 Printer[c] (64 character set)	64 + 6LS	SC	—	1.3	1.2	1.3	0.64
Magnetic Tape:							
7-track —							
MT-26	—	HS	120,000	12.1	11.0	4.0	2.0
MT-24	—	HS	83,300	8.4	7.6	2.8	1.4
MT-23	—	HS	60,000	6.1	5.5	2.0	1.0
MT-21	—	HS	42,000	4.2	3.8	1.4	0.70
MT-19	—	HS	30,000	3.0	2.7	1.0	0.50
MT-17	—	HS	20,900	2.1	1.9	0.7	0.35
9-track —[d]							
MT-26A	—	HS	160,000	16.2	14.7	5.4	2.7
MT-24A	—	HS	111,000	11.2	10.2	3.8	1.9
MT-23A	—	HS	80,000	8.0	7.3	2.6	1.3
MT-21A	—	HS	56,000	5.6	5.1	1.9	0.93
MT-19A	—	HS	40,000	4.1	3.7	1.3	0.67
MT-17A	—	HS	28,000	2.9	2.6	0.94	0.47
TS-20 Punched Tape System:							
Reading	—	SC	500	0.30	0.27	0.30	0.15
Punching	—	SC	110	0.07	0.06	0.07	0.03
Console	—	SC	15	<0.01	<0.01	<0.01	<0.01
DS-20 Disc Storage Unit	—	HS	83,400	8.4	7.6	2.8	1.4
MDS 200 Magnetic Drum	—	HS	372,000	37.5	34.1	12.4	6.2
Datanet-30	—	SC	400	0.24	0.22	0.24	0.12

a Demands based on reading 80 colums per card.
b Demands based on punching 80 columns per card. (CP-10 requires all 80 characters to be transferred for each of the 12 rows; CP-20 has a full card-image buffer.)
c Demands based on printing single-spaced 136-character line.
d 9-track magnetic tape operating in non-ASCII mode.
HS High-Speed Channel.
LS Number of lines skipped between successive printed lines.
SC Standard-Speed Channel.

INSTRUCTION LIST

Mnemonic Code	Description
ARITHMETIC INSTRUCTIONS, FIXED POINT	
ADA	Add to A
ADQ	Add to Q
ADAQ	Add to AQ
ADXn	Add to Xn
ADLA	Add Logic to A
ADLQ	Add Logic to Q
ADLAQ	Add Logic to AQ
ADLXn	Add Logic to Xn
ADL	Add Low to AQ
ASA	Add Stored to A
ASQ	Add Stored to Q
ASXn	Add Stored to Xn
AWCA	Add with Carry to A
AWCQ	Add with Carry to Q
AOS	Add One to Storage
SBA	Subtract from A
SBQ	Subtract from Q
SBAQ	Subtract from AQ
SBXn	Subtract from Xn
SBLA	Subtract Logic from A
SBLQ	Subtract Logic from Q
SBLAQ	Subtract Logic from AQ
SBLXn	Subtract Logic from Xn
SSA	Subtract Stored from A
SSQ	Subtract Stored from Q
SSXn	Subtract Stored from Xn
SWCA	Subtract with Carry from A
SWCQ	Subtract with Carry from Q
NEG	Negate
NEGL	Negate Long
MPY	Multiply Integer
MPF	Multiply Fraction
DIV	Divide Integer
DVF	Divide Fraction
ARITHMETIC INSTRUCTIONS, FLOATING-POINT	
FAD	Floating Add
UFA	Unnormalized Floating Add
DFAD	Double-Precision Floating Add
DUFA	Double-Precision Unnormalized Floating Add
FSB	Floating Subtract
UFS	Unnormalized Floating Subtract
DFSB	Double-Precision Floating Subtract
DUFS	Double-Precision Unnormalized Floating Subtract
FMP	Floating Multiply
UFM	Unnormalized Floating Multiply
DFMP	Double-Precision Floating Multiply
DUFM	Double-Precision Unnormalized Floating Multiply
FDV	Floating Divide
DFDV	Double-Precision Floating Divide
FDI	Floating Divide Inverted

Mnemonic Code	Description
ARITHMETIC INSTRUCTIONS, FLOATING-POINT (Contd.)	
DFDI	Double-Precision Floating Divide Inverted
FNEG	Floating Negate
FNO	Floating Normalize
ADE	Add to Exponent Register
SHIFTING INSTRUCTIONS	
ALS	A Left Shift
ARS	A Right Shift
ARL	A Right Logic
QLS	Q Left Shift
QRL	Q Right Logic
QRS	Q Right Shift
LLS	Long Left Shift
LRL	Long Right Logic
LRS	Long Right Shift
ALR	A Left Rotate
QLR	Q Left Rotate
LLR	Long Left Rotate
LOGIC INSTRUCTIONS	
ANA	AND to A
ANQ	AND to Q
ANAQ	AND to AQ
ANXn	AND to Xn
ANSA	AND to Storage A
ANSQ	AND to Storage Q
ANSXn	AND to Storage Xn
ORA	OR to A
ORQ	OR to Q
ORAQ	OR to AQ
ORXn	OR to Xn
ORSA	OR to Storage A
ORSQ	OR to Storage Q
ORSXn	OR to Storage Xn
ERA	Exclusive OR to A
ERQ	Exclusive OR to Q
ERAQ	Exclusive OR to AQ
ERXn	Exclusive OR to Xn
ERSA	Exclusive OR to Storage A
ERSQ	Exclusive OR to Storage Q
ERSXn	Exclusive OR to Storage Xn
COMPARE INSTRUCTIONS	
CMG	Compare Magnitude
CMPA	Compare with A
CMPQ	Compare with Q
CMPAQ	Compare with AQ
CMPXn	Compare with Xn
CANA	Comparative AND with A
CANQ	Comparative AND with Q
CANAQ	Comparative AND with AQ

Mnemonic Code	Description
COMPARE INSTRUCTIONS (Contd.)	
CANXn	Comparative AND with Xn
CNAA	Comparative Not AND with A
CNAQ	Comparative Not AND with Q
CNAAQ	Comparative Not AND with AQ
CNAXn	Comparative Not AND with Xn
CMK	Compare Masked
CWL	Compare with Limits
COMPARE INSTRUCTIONS, FLOATING-POINT	
FCMP	Floating Compare
DFCMP	Double-Precision Floating Compare
FCMG	Floating Compare Magnitude
DFCMG	Double-Precision Floating Compare Magnitude
FSZN	Floating Set Zero and Negative Compare from Memory
CONTROL INSTRUCTIONS	
EAA	Effective Address A
EAQ	Effective Address Q
EAXn	Effective Address to Xn
RET	Return
TSXn	Transfer and Set Xn
TSS	Transfer and Set Slave Mode
MME	Master Mode Entry
DRL	Derail
TRA	Transfer Unconditionally
TOV	Transfer on Overflow
TQO	Transfer on Quotient Overflow
TZE	Transfer on Zero
TNZ	Transfer on Not-Zero
TMI	Transfer on Minus
TPL	Transfer on Plus
TRC	Transfer on Carry
TNC	Transfer on No Carry
TTF	Transfer on Tally Run-out Indicator OFF
TEO	Transfer on Exponent Overflow
TEU	Transfer on Exponent Underflow
XEC	Execute
XED	Execute Double
NOP	No Operation
DIS	Delay until Interrupt Signal
SZN	Set Zero and Negative Indicator from Memory

Mnemonic Code	Description
SPECIAL INSTRUCTIONS	
BCD	Binary to Binary-Coded-Decimal
GTB	Gray to Binary
RPT	Repeat
RPD	Repeat Double
RPL	Repeat Link
EXTERNAL CONTROL INSTRUCTIONS	
RMCM*	Read Memory Controller Mask Registers
RMFP*	Read Memory File Protect Register
SMCM*	Set Memory Controller Mask Registers
SMFP*	Set Memory File Protect Register
SMIC*	Set Memory Controller Interrupt Cells
CIOC*	Connect I/O Channel
STT	Store Timer Register
LDT**	Load Timer Register
DATA MOVEMENT INSTRUCTIONS	
LDA	Load A
LDQ	Load Q
LDXn	Load Xn
LDAQ	Load AQ
LCA	Load Complement A
LCQ	Load Complement Q
LCAQ	Load Complement AQ
LCXn	Load Complement Xn
LDI	Load Indicator Register
LBAR**	Load Base Address Register
STA	Store A
STQ	Store Q
STXn	Store Xn
STAQ	Store AQ
STC1	Store Instruction Counter Plus 1
STC2	Store Instruction Counter Plus 2
STZ	Store Zero
STI	Store Indicator Register
SBAR	Store Base Address Register
STCA	Store Characters of A
STCQ	Store Characters of Q
DATA MOVEMENT INSTRUCTIONS, FLOATING-POINT	
FLD	Floating Load
DFLD	Double-Precision Floating Load
FST	Floating Store
DFST	Double-Precision Floating Store
LDE	Load Exponent Register
STE	Store Exponent Register

* Causes fault command if executed in slave mode.
** Functions as NOP in slave mode.

DATA CODES

Standard Character Set	GE Internal Machine Code	Octal Code	Hollerith Card Code	Standard Character Set	GE Internal Machine Code	Octal Code	Hollerith Card Code
0	00 0000	00	0	↑	10 0000	40	11-0
1	00 0001	01	1	J	10 0001	41	11-1
2	00 0010	02	2	K	10 0010	42	11-2
3	00 0011	03	3	L	10 0011	43	11-3
4	00 0100	04	4	M	10 0100	44	11-4
5	00 0101	05	5	N	10 0101	45	11-5
6	00 0110	06	6	O	10 0110	46	11-6
7	00 0111	07	7	P	10 0111	47	11-7
8	00 1000	10	8	Q	10 1000	50	11-8
9	00 1001	11	9	R	10 1001	51	11-9
[	00 1010	12	2-8	-	10 1010	52	11
#	00 1011	13	3-8	$	10 1011	53	11-3-8
@	00 1100	14	4-8	*	10 1100	54	11-4-8
:	00 1101	15	5-8	)	10 1101	55	11-5-8
>	00 1110	16	6-8	;	10 1110	56	11-6-8
?	00 1111	17	7-8	'	10 1111	57	11-7-8
b̸	01 0000	20	(blank)	+	11 0000	60	12-0
A	01 0001	21	12-1	/	11 0001	61	0-1
B	01 0010	22	12-2	S	11 0010	62	0-2
C	01 0011	23	12-3	T	11 0011	63	0-3
D	01 0100	24	12-4	U	11 0100	64	0-4
E	01 0101	25	12-5	V	11 0101	65	0-5
F	01 0110	26	12-6	W	11 0110	66	0-6
G	01 0111	27	12-7	X	11 0111	67	0-7
H	01 1000	30	12-8	Y	11 1000	70	0-8
I	01 1001	31	12-9	Z	11 1001	71	0-9
&	01 1010	32	12	←	11 1010	72	0-2-8
.	01 1011	33	12-3-8	,	11 1011	73	0-3-8
]	01 1100	34	12-4-8	%	11 1100	74	0-4-8
(	01 1101	35	12-5-8	=	11 1101	75	0-5-8
<	01 1110	36	12-6-8	"	11 1110	76	0-6-8
\	01 1111	37	12-7-8	!	11 1111	77	0-7-8

Reproduced from GE-635 System Manual, CPB 371A.

Note: The GE Internal Machine Code represents the internal collating sequence and the codes recognized by the printer and written on magnetic tape units operating in the binary mode.

PROBLEM ORIENTED FACILITIES

.1 UTILITY ROUTINES

.11 Simulators of Other Computers: . . . . . . none announced to date.

.12 Simulation by Other Computers: . . . . none.

.13 Data Sorting and Merging

GE-600 Series SORT/MERGE

Reference: . . . . GE publication CPB-1005.
Record size: . . . . 1 to 4,189 words.
Block size: . . . . 1 to 4,192 words.
Key size: . . . . 1 to 99 fields of 1 to 99 bits or 1 to 99 characters each.
File size: . . . . dependent upon number of collation tape units provided.
Number of tapes: . . . . 3 to 16 (for collation files).
Date available:. . . . . . available with first system delivery.
Description:

The SORT/MERGE program is a generalized program that can perform three separate functions:

- Sort a disordered file.
- Sort a disordered file and merge with a well-ordered file.
- Merge 2 to 16 well-ordered files.

The sorting technique is polyphase. When more than five collation tape units are available, a refinement of the polyphase technique which GE calls the "standby" technique is used. SORT/MERGE is accessed through the Macro Assembler (GEM) by a macro call. Own-coding in GEM symbolic language may be incorporated and can be used to pre-process input data, to change the collation sequence, to combine or eliminate duplicate records, and to process output data. A typical tape sort with no own-coding can be described in as few as two GEM statements.

The normal mode of operation is magnetic tape input and output, but own-coding can be used to allow any devices (including magnetic drum or disc) to be used for input or output.

Memory and peripheral allocations are specified by control cards at load time. Ranges can be specified for both, and the SORT/MERGE program will automatically adjust itself to fit the available memory space and peripheral devices at execution time.

.14 Report Writing

The only report writing facility provided is the Report Writer feature of COBOL, described on page 340:161.100.

.15 Data Transcription

General Electric will provide a Bulk Media Conversion Program for conversions between any two peripheral devices. The program will be in the system library and will be called by means of control cards. Details on this program are not available to date.

.16 File Maintenance

Integrated Data Store (I-D-S)

Reference: . . . . Introduction to Integrated Data Store.
Date available:. . . . . . Second quarter, 1965.
Description:

I-D-S is a GE-developed technique for the organization and manipulation of files for disc storage devices. Files are organized into a series of chains of logical records, one chain for each major type of record. Each chain contains one master record and one or more detail records. Each logical record, as stored on the magnetic disc unit, can optionally contain links to the master record or prior detail record, and will always contain a link to the next detail record. The chains are closed loops — the last detail record references the master record as the next record. Any record can be either a detail or master type and can be linked into any number of chains; however, there can be only one master record per chain. Information common to all detail records of a chain can be stored in the master record of that chain. The effect of this organization is to minimize the amount of information that needs to be stored in duplicate.

A set of Data Description entries defines each record. Information specified in these entries includes symbolic names for the record and individual fields, the symbolic name of each chain with which the record is to be linked, the relationship of the record to each chain (master or detail), the prime chain for the record, and various control fields required for record retrieval. All chains are ordered in one of three methods specified in the control fields of the Data Description entries:

- Sorted — The detail records in a sorted chain are arranged in sequence based on one or more keys specified in the Data Description entries. Each key can be treated in either ascending or descending sequence.
- First-In/First-Out (FIFO) — A new record is added to a chain by inserting it at the end of the chain, just prior to the master record.
- Last-In/First-Out (LIFO) — A new record is added to a chain by inserting it immediately after the master, making it the first detail record in the chain.

.16 File Maintenance (Contd.)

Individual records can be members of different chains using different sequencing methods.

The logical records are packed automatically into blocks (based on prime chains) for storage. Data is retrieved by blocks and transferred to buffers in core storage; individual records are then moved to working areas. Only the records in the working area are accessible to a programmer. Multiple blocks of data are maintained in core storage, based upon the amount of core storage available and the frequency of use of the data blocks. Each time a new block of data is called into core storage, the block that had the least previous usage is returned to the disc unit, provided any of the records it contains has been modified. Only record fields that have been modified are rewritten on the disc unit. Working areas for each type of record are maintained, and records become unavailable only when another record of the same type (name) has been called.

Four macro-instructions, in a format similar to COBOL verbs, are provided for manipulation of disc records:

- STORE — Links new records into a chain in accordance with its Data Description.
- RETRIEVE — Retrieves a record and unpacks it into a working area.
- MODIFY — Uses the contents of specified fields in a working storage area to modify (add to or subtract from only) or to replace the corresponding fields of a record.
- DELETE — Causes a record to be deleted from a file and the links to be reformed. In general, when a master record is deleted, all the associated detail records are also deleted. If one of these detail records happens to be a master record for a second chain, the details in the second chain are also eliminated. This process continues until all dependent detail records have been deleted. If desired, the records deleted can be printed out, or the deletion process can be aborted with no resultant deletions if a specified detail record is encountered.

Except for the STORE command, the record involved can be specified to be the current, next, previous, or master record of a chain. Conditional phrases are provided, permitting a transfer to a program step or the performance of a series of program steps out of the normal sequence with return to the step immediately following the branch, based on the record name of the record accessed. Other control phrases permit the processing of alternate records if retrieved, execution of subroutines, and error checking.

I-D-S is intended primarily to provide mass storage facilities for COBOL programs, although it does not follow the format of the ASA COBOL preliminary standard for mass storage facilities as stated in ASA X-3.4 COBOL Information Bulletin #4. I-D-S- can also be used independently for incorporation into assembly-language source programs, and can be used with any GE-600 Series computer system having a disc storage unit.

Other file maintenance routines will be made available; however, details are not available to date.

.17 Other

General Internal FORTRAN Translator (GIFT)

Reference: . . . . GIFT, General Internal FORTRAN Translator.
Date available:. . . . . . available with first system delivery.
Description:

GIFT is the GE Computer Department's version of the SHARE Internal FORTRAN Translator (SIFT). GIFT is a program written in FORTRAN IV and GEM that is designed to translate a FORTRAN II source program into a FORTRAN IV source program by reconciling most of the differences between the two languages. These differences are pointed out in the analysis of IBM 7090/7094 FORTRAN IV, Paragraph 408:162.141. GIFT is oriented primarily toward the translation of programs written in FORTRAN II for the IBM 7000 Series computer systems; it cannot accept the extensions to FORTRAN II that were implemented in GE's FORTRAN compiler for the GE-200 Series computer systems. (See Paragraph 321:162.142 for a list of these extensions.)

Some of the important restrictions and other considerations to be kept in mind when using GIFT are listed below.

- A FORTRAN II subprogram to be translated by GIFT on a GE-600 Series computer system must be capable of being compiled successfully by an IBM 7000 Series computer system. If this condition is not met, an incorrect translation may result, because little diagnostic checking is performed by GIFT.
- Restrictions are placed upon the total number of COMMON, DIMENSION, EQUIVALENCE, double-precision, and complex variables in a single program or subprogram.
- Inconsistencies due to forced assignment (through the EQUIVALENCE statement) of the most significant part of a double-precision variable or the real part of a complex variable to an odd memory location must be resolved manually. When GIFT detects such an occurrence, a diagnostic message is printed.
- Subprograms written in FAP (FORTRAN Assembly Program) are ignored by GIFT.
- CHAIN jobs require manual changes before they can be translated by GIFT.
- Some conflicts between the names of the FORTRAN II programs' subroutines and functions and new FORTRAN IV function names must be resolved manually.

The configuration requirements for the use of GIFT are the same as for the GE-600 Series FORTRAN IV compiler; i.e., 3 files (magnetic tape, drum, or disc) in addition to the GECOS requirements.

PROCESS ORIENTED LANGUAGES: COBOL

.1 GENERAL

.11 Identity: . . . . GE-600 Series COBOL.

.12 Origin: . . . . General Electric Company.

.13 References: . . . . . GE Publication CPB-1007.

.14 Description

COBOL-61 is the most widely implemented pseudo-English common language for business applications. The GE-600 Series COBOL language consists of all of Required COBOL-61, a majority of the features of Elective COBOL-61, and the SORT and Report Writer extensions to COBOL-61.

Probably the most important elective not implemented is the INCLUDE verb, which would permit the use of program libraries. The Segmentation feature, which provides more efficient use of core storage through overlay techniques, has been implemented in a non-standard manner. The concept of section priorities has not been implemented. Segments are compiled (and debugged) as separate programs. Referencing, or calling, of an outside segment is accomplished by using an option of the ENTER verb. Layout of segments is specified by control cards at load time to the General Loader, which forms the necessary linkages for communication between segments for data files, working storage areas, and procedures. Detailed lists of the extensions of the COBOL language and the electives provided in GE-600 Series COBOL are included at the end of this description.

The COMPUTE verb is a valuable elective incorporated into GE-600 Series COBOL. This verb permits arithmetic operations to be expressed in a concise formula notation similar to that of FORTRAN. For example, the COBOL operations:

SUBTRACT B FROM A GIVING T

DIVIDE C INTO T GIVING X

can alternatively be expressed as:

COMPUTE X = (A - B)/C.

GE-600 Series COBOL provides the complete SORT feature of COBOL-61 Extended. This facility can be used to process data prior to sorting, to process it further after sorting, and to sort intermediate files.

The Report Writer is implemented as specified in COBOL-61 Extended, except that RESET and SIGNED clauses are not provided.

Other electives of COBOL-61 that are provided include the ENTER verb (which permits the inclusion of GEM symbolic language in a program and the ability to call subroutines in languages other than COBOL), the SOURCE-COMPUTER and OBJECT-COMPUTER clauses of the Environment Division, and rerun facilities.

GE-600 Series COBOL programs are compiled and run under the control of GECOS, the standard supervisory routine (see Section 340:191). Programs are translated from COBOL source statements to GEM assembly language and then to machine coding. GECOS handles the intermediate translation automatically and needs no attention from the operator. Programs written in COBOL can be run concurrently with other programs in a multiprogramming mode.

.141 Availability

Language (GE-600
Series version): . . . 1964.
Compiler: . . . . ?

.142 Deficiencies with Respect to Required COBOL-61: . . . . . none.

.143 Extensions to COBOL-61

Extensions to COBOL-61 include SORT facilities and Report Writer facilities. Mass storage facilities will be provided but have not been defined to date. Tele-communication facilities have not been announced to date.

.144 COBOL-61 Electives Implemented (see Paragraph 4:161.3 in Users' Guide)

Key No.	Elective	Comments
	Characters and Words	
1	Formula characters	Formulas are allowed.
2	Relationship characters	The symbols < , >, = are allowed.
3	Semicolon	A semicolon is in the character set.
4	Long literals	The maximum size is 132 characters.
5	Figurative constants	HIGH or LOW BOUND(S) are available.
6	Figurative constants	HIGH or LOW VALUES(S) are available.
	File Description	
8	BLOCK CONTAINS	A range of block sizes can be given.
9	FILE CONTAINS	The approximate size of the file can be shown.
	Record Description	
13	Table-length	Lengths of tables and arrays may vary.
15	BITS option	Items can be specified in binary.
16	RANGE IS	Value range of items can be shown.
17	RENAMES	Alternative groupings of elementary items can be specified.
18	SIGN IS	Separate signs are allowed.
19	SIZE clause	Variable-length items can be specified.
20	Conditional ranges	VALUES can be ascribed to conditionals.
21	Label handling	Special label procedures may be used.
	Verbs	
22	COMPUTE	Algebraic formulas may be used.
24	ENTER	Non-COBOL languages can be used in a program.
26	USE	Non-standard auxiliary I/O error-handling or label-handling routines can be inserted.
	Verb Options	
27	LOCK	A rewound tape can be optionally locked.
28	MOVE CORRESPONDING	Commonly-named items in a group can be handled together.
30	ADVANCING	Specific paper advance instructions can be given.
32	Formulas	Algebraic formulas may be used.
33	Operand size	Operands are not restricted to 10 digits.
34	Relationship	IS EQUAL TO, EQUALS, EXCEEDS relationships are allowed.
35	Tests	IF x IS NOT ZERO test is allowed.
36	Conditionals	Implied subjects with implied objects are allowed.
37	Complex conditionals	ANDs and ORs may be intermixed.
38	Complex conditionals	Nested conditionals are permitted.
39	Conditional statements	IF, SIZE ERROR, AT END, ELSE (OTHERWISE) may follow an imperative statement.
	Environment Division	
40	SOURCE-COMPUTER	Computer description can be given.
41	OBJECT-COMPUTER	Computer description can be given.
46	I-O-CONTROL	A full range of rerun techniques is available.
	Identification Division	
47	DATE-COMPILED	The current date is inserted automatically.
	Special Features	
49	Segmentation	Segmentation of programs is allowed, but in a non-standard manner.

.145 COBOL-61 Electives Not Implemented (see Paragraph 4:161.3 in Users' Guide)

Key No.	Elective	Comments
	Characters and Words	
7	Computer-name	No alternative object computers.
	File Description	
10	Label formats	Labels must be standard or omitted.
11	SEQUENCED ON *	No key fields can be used for sequencing.
12	HASHED	Hash totals cannot be created.
	Record Description	
14	Item-length	Variable-length items cannot be specified.
	Verbs	
23	DEFINE	The user cannot define new verbs.
25	INCLUDE	No library routines are available automatically.
	Verb Options	
29	OPEN REVERSED	Tapes cannot be read backward.
31	STOP provisions	No special numeric-coded alphabetic displays.
	Environment Division	
42	SPECIAL-NAMES	Hardware devices, and their status conditions, cannot be given special names by the program.
43	FILE-CONTROL	File naming and description of desired control method cannot be taken from the library.
44	PRIORITY IS	Priorities cannot be given.
45	I-O-CONTROL	Input-output control cannot be taken from the library.
	Special Features	
48	Library	Library facilities for the Procedure Division are not available.

* The compiler will accept, but ignore, this clause.

PROCESS ORIENTED LANGUAGES: FORTRAN IV

.1 GENERAL

.11 Identity: . . . . GE-600 Series FORTRAN IV.

.12 Origin: . . . . GE Computer Department.

.13 Reference: . . . . GE-600 Series FORTRAN IV Reference Manual (CPB-1006).

.14 Description

The GE-600 Series FORTRAN IV Language is virtually identical to IBM 7090/7094 FORTRAN IV (as described in Section 408:162 of the IBM 7090 report) with a few extensions. In general, a program written for an IBM 7090/7094 in FORTRAN IV can be compiled on a GE-600 Series system, with few if any changes necessary. General Electric also intends to make GE-600 Series FORTRAN IV as compatible as possible with IBM System/360 FORTRAN IV. The only exception currently known is that the specification statements (COMMON, EQUIVALENCE, etc.) must come first in a GE-600 Series FORTRAN IV source program.

The principal extensions are the NAMELIST and DEBUG statements. These two statements are described in Paragraph .143, along with other extensions.

The GE-600 series FORTRAN IV compiler works under control of the GECOS operating system and translates the source program written in FORTRAN IV language into assembly language. This is automatically assembled by the GEM assembler, and the resulting machine-language program is ready for immediate execution. Files can be assigned to any device physically present. Assignment is made at load time by means of control cards.

FORTRAN IV is the only version of FORTRAN to be implemented for GE-600 Series computer systems; however, the General Internal FORTRAN Translator (GIFT) will convert source programs in FORTRAN II language into FORTRAN IV language. GIFT operates under control of the GECOS operating system and will accept FORTRAN II programs that can be compiled on an IBM 7090/7094. Paragraph 340:151.17 contains a description of GIFT and a brief listing of its limitations.

The translating computer for both FORTRAN IV and GIFT must have facilities for three files in addition to the requirements for GECOS. These files may be held on magnetic tape, drum, or disc.

Restrictions and extensions of the GE-600 Series FORTRAN IV language relative to IBM 7090/7094 FORTRAN IV (as described in Section 408:162) are summarized below.

.141 Availability

Language specifications: . . . . . September 1964.

Compiler: . . . . available with first system delivery.

.142 Restrictions Relative to IBM 7090/7094 FORTRAN IV

(1) Physical sense switches and sense lights are not provided in GE-600 Series systems. Instead, particular bit positions of a word reflect the settings or conditions of the logical sense switches and lights. Sense switches are set by control cards.

.143 Extensions Relative to IBM 7090/7094 FORTRAN IV

(1) The capability for specifying logical field types (True or False) in the FORMAT statement is provided.

(2) The NAMELIST statement provides facilities for reading, writing, and conversion of data without using a list in the input-output statement or reference to a FORMAT statement. The NAMELIST statement is incorporated in the body of the program and specifies the name of the list and the variables belonging to that list. Input-output statements reference only the logical file number and the name of the list. Variable names and data are specified on the data records. Partial lists and partial arrays may be input or output.

(3) The DEBUG statement (written within the body of the program) permits the output of a list of variables in a fixed format each time (or at specified times) a designated statement is executed. The output can be made conditional upon the value of an algebraic or logical expression.

(4) The COMMON statement can designate two types of common block storage — labeled and blank.

MACHINE ORIENTED LANGUAGE: GEM

.1 GENERAL

.11 Identity: . . . . GE-600 Series Symbolic Macro Assembler Language (GEM).

.12 Origin: . . . . GE Computer Dept., Phoenix, Arizona.

.13 Reference: . . . . GE-600 Series Programming Reference Manual, CPB-1004.

.14 Description

The GE-600 Series Symbolic Macro Assembler Language (GEM) is the language provided for machine-oriented programming of GE-600 Series systems. It is a fairly straightforward symbolic assembly language with facilities for the definition and use of macro instructions.

Some of the principle features of GEM are:

- Provision for the use of algebraic and Boolean expressions (in a format similar to FORTRAN expressions) for addresses.
- Use of symbolic tags to specify address modification, which simplifies the use of the extensive and complex hardware addressing facilities.
- Provision of a large number of pseudo-operations (65) providing many useful features such as: selection of assembly listing print-out options, absolute or relocatable output, multiple instruction counters, storage allocation options, and control of the RPT, RPD, and RPL instructions.
- Facilities for user-defined macro instructions.

All the input-output operations in a symbolic-language program are handled by GECOS, either through GEFRC (see Paragraph 340:191.123) on a subroutine call and file parameter specification basis, or directly through GEIOS (See Paragraph 340:191. 122). Overlay control and diagnostic routines (such as memory dumps and snapshot facilities) are provided by the General Loader. Any number of libraries of user-coded subroutines recorded on any medium can be used.

.15 Publication Date: . . . . July, 1964.

.2 LANGUAGE FORMAT

.21 Diagram: . . . . see Table I.

TABLE I: GE-600 SERIES MACRO ASSEMBLER CODING FORM

GENERAL ELECTRIC SYMBOLIC CODING FORMS

PROBLEM

PROGRAMMER | DATE | PAGE OF

LOCATION 1 2 6	E O 7	OPERATION 8 14	15	ADDRESS, MODIFIER 16	COMMENTS 32 72	IDENTIFICATION 73 80

CE-108 (10-63)

Reprinted from GE-600 Series Programming Reference Manual, CPB-1004.

.22 Legend

Location: . . . . may be blank or may contain a symbolic tag; has special use for some pseudo-operations.

E/O: . . . . specifies whether the instruction will be placed in an odd or even location or in the next available location.

Operation:. . . . . contains a mnemonic instruction code, a pseudo-operation, or a special macro call or operation code.

Address, Modifier (Variable Field):. . . . contains one or more subfields in free form separated by commas. These subfields may be an address and mnemonic modification tag for a machine instruction, substitutable arguments for macro-operations, special entries for pseudo-operations, or literals. The field is terminated by space, except for Hollerith literals.

Comments: . . . . comments follow the terminating space of the Address, Modifier field; they are printed in the output listing but cause no action to be taken by the assembler.

Identification: . . . . . . used for instruction identification and sequencing, and is optional.

.23 Corrections

.231 Insertions: . . . . new source program statements can be inserted though the use of the ALTER control card at load time.

.232 Deletions:. . . . . source program statements can be deleted at load time through the use of the ALTER control card.

.233 Alterations:. . . . . erase and correct.

.24 Special Conventions

.241 Compound addresses: . any valid algebraic expression; these expressions are written and evaluated in a manner similar to integer FORTRAN expressions.

.242 Multi-addresses: . . . . none.

.243 Literals:. . . . . literals are designated by "=" in column 16.

.244 Special coded addresses: . . . . * refers to "this address."

.245 Other —
Address modification: indexing and/or indirect modifications are indicated by a symbolic tag following the absolute, compound, or symbolic address, or by a two-digit octal number.

.3 LABELS

.31 General

.311 Maximum number of labels: . . . . no practical limit.

.312 Common label formation rule: . . . . yes.

.313 Reserved labels: . . . . none.

.314 Other restrictions:. . . at least one non-numeric character must appear in a label; imbedded blanks are allowed.

.316 Synonyms permitted:. . yes; EQU pseudo-operation.

.32 Universal Labels

.321 Labels for procedures —
Existence:. . . . . mandatory if referenced by other instructions.
Formation rule —
First character:. . . numeric, alphabetic, or period.
Other: . . . . same.
Number of characters:. . . . . 1 to 6 characters; at least one must be alphabetic; imbedded blanks are not allowed.

.322 Labels for library routines:. . . . . same as procedures.

.323 Labels for constants: . same as procedures.

.324 Labels for files:. . . . . same as procedures.

.325 Labels for records: . . same as procedures.

.326 Labels for variables: . same as procedures.

.33 Local Labels

Local labels defined for subroutines follow the formation rules for the corresponding universal labels. Labels defined in a subroutine and used externally to the subroutine must be listed in a SYMDEF pseudo-operation. Labels defined externally to a subroutine and used within the subroutine must be listed in a SYMREF pseudo-operation. The CALL pseudo-operation is used to enter a subroutine, and it automatically provides the SYMREF reference for the label assigned to the subroutine.

Local labels can be created automatically for different sections of a program through the use of the HEAD pseudo-operation. These labels (must be 5 or fewer characters) are automatically prefixed with the one-character "heading" for the section in which they appear. Six-character labels are not affected by the HEAD pseudo-operation. Local labels defined by the HEAD operation can be referenced by other sections by prefixing the appropriate heading character and the $ symbol.

.4 DATA

.41 Constants

.411 Maximum size constants —

Machine form	Coding sheet form
Integer —	
Decimal:	none.
Binary:	11 decimal digits or 12 octal digits.
Fixed numeric —	
Decimal:	none.
Binary:	decimal value, decimal exponent, and decimal scale factor (can be either single or double precision).
Floating numeric —	
Decimal:	none.
Binary:	rational decimal value, decimal point, and decimal exponent (either decimal point or decimal exponent can be omitted, but not both).
Alphameric:	54 characters.

.412 Maximum size constants written as literals —

Machine form	Coding sheet form
Integer —	
Decimal:	none.
Binary:	11 decimal digits or 12 octal digits.
Fixed numeric:	same as fixed numeric, paragraph .411.
Floating numeric:	same as floating numeric, paragraph .411.
Alphameric:	53 characters.
Instructions:	any symbolic operation code and associated variable field, preceded by the character M.
Variable field:	any number of fields of up to 36 bits each, packed into words.

.413 Maximum size machine literals —
Binary (first 18 bits of the instruction): . . . the upper or lower portion of a one-word literal can be placed in the address field of the instruction, depending upon the type of literal. This action is designated by a tag following the literal.

.42 Working Areas: . . . . . implied by use.

.43 Input-Output Areas: . . normally handled by General File and Record Control (GEFRC; see Paragraph 340:191.123); otherwise, data layout must be explicitly indicated by proper Data Control Words.

.5 PROCEDURES

.51 Direct Operation Codes

.511 Mnemonic —
Existence: . . . . mandatory.
Number: . . . . 170 plus variations.
Example: . . . . ADA = Add to A.
Comments: . . . . the above number includes many entries to control routines through the MME instruction.

.512 Absolute: . . . . none.

.52 Macro-Codes

There are no explicit macro-codes within GEM, but the user may define any number. The user-defined macro-codes may appear directly in a source program, or they can be put into a library for future use. The definition of a macro-operation can contain any processor instruction, most pseudo-operations, and any macro defined previous to call time. Up to 63 levels of macro-nesting are permitted within a macro. Macro names are formed in the same manner as labels (see Paragraph .32).

A macro is called by coding the macro name in the operation field and from 1 to 63 substitutable arguments, separated by commas, in the variable field. The arguments can be literals, symbols, or expressions. The arguments are substituted sequentially for the argument pointers within the body of the macro definition, which are indicated as #1, #2, etc. The argument pointers can be used for symbols, operation codes, portions of the operation codes, or any other desirable purpose.

The conditional pseudo-operations described in Paragraph .531 can be used to control the incorporation or deletion of sections of coding. An iterative facility, IDRP, will cause a section of coding to be repeated once for each occurrence in the macro call line of the argument specified by the IDRP pseudo-operation. Multiple arguments for the same argument pointers are set off by parentheses or brackets. IDRP is limited to use only within a macro definition and cannot be nested.

.53 Interludes

.531 Possible roles —
Direct translator: . . . four conditional pseudo-operations direct the translator to assemble or to bypass the next N cards, based on the results of a comparison of two specified expressions.

.532 Example: . . . . IFE 4*ALPHA-7, 15, 7 (The next 7 cards are assembled only if (4*ALPHA-7) is equal to 15).

.54 Translator Control

.541 Method of control —
- Allocation counter: . . pseudo-operation.
- Label adjustment: . . . pseudo-operation.
- Annotion: . . . . pseudo-operation, special cards, and notes.

.542 Allocation counter —
- Set to absolute: . . . . ABS
- Set to label: . . . . ORG.
- Step forward: . . . . . . ORG.
- Step backward: . . . . . ORG.
- Reserve area: . . . . . BSS, BFS.
- Define multiple symbolic allocation counters: . . . . USE.
- Set symbolic allocation counter to absolute or label: . . BEGIN.

.543 Label adjustment —
- Set labels equal: . . . . EQU, SET.
- Set absolute value: . . EQU, SET.
- Clear label table: . . . none.

.544 Annotation —
- Comment phrase: . . . REM, special cards or notes after instruction line.
- Title phrase: . . . . . . TTL, TTLS (two levels of titles).

.6 SPECIAL ROUTINES AVAILABLE

General Electric will provide a number of mathematical routines as part of the system library. Facilities will include common function evaluation (e.g., sines, cosines, exponentials, and logarithms), matrix manipulation, curve fitting, and polynomial root determination. These routines can be called by the pseudo-operation CALL in the same manner as user-defined macros.

.63 Overlay Control

Overlay control is accomplished by user coding or by the General Loader at load time, through the use of control cards specifying which segments are to be in core storage at the same time.

.64 Data Editing

General Electric will provide, as routines, the same editing facilities for symbolic-language programmers as are provided in COBOL. Complete definition of these routines is not available to date.

.65 Input-Output Control

I/O control is normally handled by the General File Record Control routine (see Paragraph 340:191.123, GEFRC). Programmers wishing to program their own input-output cannot directly address any input-output devices, but must use the I/O control routines of the GEIOS section of GECOS. Entry to these routines is by a MME GEIOS instruction followed by a sequence of 3 or 5 words (depending upon the peripheral) which contains the I/O command, the peripheral file concerned, and the first of a list of words specifying data locations (scatter/gather list). Input-output control is handled in this manner to insure security in a multiprogramming environment.

.66 Sorting

The SORT/MERGE routine described in Paragraph 340:151.13 can incorporate pre-sort and post-sort sections written in the assembly language.

.67 Diagnostics

There are no separate diagnostic facilities presently incorporated within the GEM language, although the macro-definition capabilities will facilitate their definition and use. See Paragraph 340:191.5 for a description of the diagnostic facilities provided by GECOS for any program.

.7 LIBRARY FACILITIES

A systems library containing the more commonly-used library routines is available to the General Loader. These routines, written in relocatable text in the same format as produced by the Assembler, are blocked and recorded in the file by a system edit program. The file is normally found in system-committed storage (the disc, drum, or magnetic tape units assigned to GECOS). In addition, a user can have any number of private libraries of subroutines recorded on any medium in the same manner as the system library.

The Loader program locates and loads the routines and forms the required linkages. The user's libraries are made known to the Loader by a LIBRARY control card, and they are searched for each subroutine in turn prior to searching the systems libraries. The libraries are searched on the basis of undefined SYMREF symbols (see Paragraph .33). If a subroutine is not found in the available libraries, the run is terminated if the OPTION control card specified GO (execute if no loading errors) or NOGO (do not execute after loading). If the CONGO (execute regardless of errors) option is specified, a MME GEBORT instruction is inserted in place of references to the undefined symbol, aborting the activity when executed.

Programs, data, and/or control cards can be stored on the magnetic disc or drum in standard system format by the disc or drum maintenance program. The programmer can recall this information at a later time by the use of a SELECT control card. Control cards can be changed when recalled, allowing changes in file assignments.

.8 MACRO AND PSEUDO TABLES

.81 Macros

No explicit macro-operations are provided (but see Paragraph .52 for a description of the facilities for user-defined macros).

.82 Pseudos

Functional Group	Number	Principal Uses
Control:	17	Selection of printout options for the assembly listing, direction of punchout of absolute/ relocatable binary program decks, selection of format for the absolute binary deck.
Location counter:	4	Programmer control of single or multiple instruction counters.
Symbol defining:	10	Definition of Assembler source program symbols by means other than appearance in the location field of the coding form.
Data generating:	5	Production of binary data words for the assembly program.
Storage allocation:	4	Provision of programmer control for the use of memory.
Special:	2	Generation of zero operation code instructions, of binary words divided into two 18-bit fields, and of continued subfields for selected pseudo-operations.
Macro:	4	Begin and end macro prototypes; assembler generation of macro argument symbols, and repeated substitution of arguments within macro prototypes.
Conditional:	4	Conditional assembly of variable numbers of input words, based upon the subfield entries of these pseudo-operations.
Program linkage:	4	Macro generation of standard system subroutine calling sequences and return (exit) linkages.
Address, tally:	3	Control of automatic address, tally, and character incrementing/decrementing.
Repeat mode coding formats:	8	Control of the repeat mode of instruction execution (coding of RPT, RPD, and RPL instructions.)

OPERATING ENVIRONMENT: GECOS

.1 GENERAL

.11 Identity: . . . . General Comprehensive Operating Supervisor (GECOS).
General Input/Output Supervisor (GEIOS).
General File Record Control (GEFRC).
General Loader.
General Remote Terminal Supervisor (GERTS).

.12 Description

All activities of a GE-600 Series computer system are normally carried out under control of the General Comprehensive Operating Supervisor (GECOS) and the following related control programs: General Input/Output Supervisor (GEIOS), General File Record Control (GEFRC), General Loader, and General Remote Terminal Supervisor (GERTS). Together these routines form a comprehensive operating environment for the scheduling and running of programs. Up to eight programs can be contained in core storage simultaneously and can be run together in a multiprogramming mode. Scheduling is based primarily on priority and availability of peripherals.

.121 GECOS

GECOS is composed of five sections:

(1) Input Media Conversion — This section reads the job from the on-line card reader, interprets all control cards, generates tables to be used by the allocation section, and records the job on the magnetic drum (or disc). A "job" consists of one or more dependent "activities" (programs). The control cards can specify the use of programs contained in libraries.

(2) Allocation — This section assigns peripherals and a memory area to an activity to be executed, based on the tables set up by the Input Media Conversion section. Each job is assigned an "urgency" (priority) by a control card at load time. The activities of the jobs are considered for scheduling based upon their urgencies and peripheral requirements. The activities of a given job are executed sequentially in the order they are submitted, and two activities of the same job cannot be in core storage at the same time. Whenever an activity is bypassed due to insufficient peripheral availability, the urgency of that activity (but not the urgency of other activities of the same job) is increased.

The eighteen "most urgent" jobs are considered for scheduling at any one time, and up to eight activities can reside in core storage simultaneously. Allocation of peripherals is made several programs in advance, giving the operator an opportunity to mount tape reels or perform other preparatory functions while prior programs are being executed. The operator can change the priority of a job, delete a job from the schedule either before or after allocation, and add a top-priority program which will be allocated and executed before any other program.

(3) Monitor — This section oversees the execution of each activity. Its functions include processing of fault interrupts, control of all other control programs, calling of the least-used system routines from a magnetic drum (or disc) into the overlay area of system memory, loading and control of system compilers (COBOL and FORTRAN), and control of communications to and from the operator via the console typewriter.

(4) Termination — Termination of an individual activity or a complete job, due to completion or to detection of an error by GECOS, is initiated by the Monitor section (described above). The Termination section performs these functions:

- Provides a post-mortem dump for programs terminated because of an error.
- Communicates to the operator (through the Monitor section and console typewriter) the need for removal of files.
- Summarizes the output file information for the Output Media Conversion section (described below).
- Provides an accounting record of the processor and peripheral times on the system output file.
- Closes the system output file.
- "De-allocates" peripherals.
- Removes references to the terminated program from other control routines.
- Compacts areas allocated to other programs into contiguous segments in high-order memory.
- Transfers control to the Allocation section for possible reassignment of released peripherals and memory.

.121 GECOS (Contd.)

(5) Output Media Conversion — Output from programs can be on two types of files. The system output file contains accounting information, error notations, and other information about all programs being run; it can also contain, for low-volume output, multiple interspersed records from one or more programs. Large-volume reports are stored on discrete files.

The Output Media Conversion section processes the system output file for output to a standard peripheral device, such as a printer or card punch, as specified in the file. Bulk media conversion routines are available for transcribing the larger discrete files. Either type of output file can be blocked as specified in the file description. No editing or radix conversions can be performed by the Output Media Conversion section.

.122 GEIOS

The General Input/Output Supervisor is the control program that services input-output requests for all programs. A programmer cannot directly address a peripheral device; he must use GEIOS. Each time a program yields control to GECOS because it is waiting for an input or output operation to be completed, the Dispatcher section of GEIOS controls the switching to another program that can make use of the central processor. Every program is considered (up to seven other programs can be in core storage waiting for service), and control is given to that program which: (1) has the highest urgency (priority), (2) is actively seeking use of the processor, and (3) is not waiting for an input or output operation to be completed. The Dispatcher section considers all GECOS control routines to have a higher priority than any job program.

Between two programs that both meet the above requirements, control is given to the one that was allocated first. Programs are not presently guaranteed a turn at the processor — a succession of high-priority programs can effectively block a low-priority program. However, General Electric is planning to remedy this situation.

There are three methods by which job programs can relinquish control to GEIOS:

- Roadblock — This is the normal entry for most input-output operations. After initiation of the input or output operation, the program relinquishes control if another program can make use of the processor. Control is not normally returned to the "roadblocked" program immediately upon completion of the operation; the Dispatcher section returns control as specified in previous paragraphs.

- Courtesy Call — This entry is used primarily for such programs as bulk media conversion routines. Immediately after completion of each requested input-output operation, control is returned to the conversion routine for a maximum of 200 microseconds in the GE-635 or 400 microseconds in the GE-625. If the routine does not yield control to GECOS within the specified time, that routine is automatically terminated. The Courtesy Call facilitates effective utilization of peripheral devices such as card readers and printers by making it possible to keep them operating at their peak speeds.

- Forced Relinquish — This entry prevents a compute-bound job program or a symbolic or machine-coded program not using the above two entries from retaining control for more than a specified period of time. The time limit can be defined by the installation, but is 62.5 milliseconds originally. The timer is set upon entry to a job program, and control is transferred to the Dispatcher section if the specified time limit is exceeded. Control is not returned to the compute-bound program until another program has had a turn.

When control is transferred from one job program to another job program, the contents of the processor registers are automatically safe-stored, freeing the programmer of this responsibility. GEIOS keeps track of the time used by each program on the central processor and the peripheral devices separately.

The full facilities of GEIOS are available to the symbolic-language programmer. However, he can alternatively make use of the General File Record Control (GEFRC) routine, described below, and regard all input-output data as being composed of records and files.

.123 GEFRC

Use of the General File Record Control (GEFRC) routine will probably be the most common method of accomplishing input-output operations. All compilers (COBOL and FORTRAN) and job programs generated by compilers access the input-output control routines (GEIOS) through GEFRC. Programmers using symbolic language can also use GEFRC.

A "file control block" must be written for each file to be used. This is produced automatically by the compilers, but must be written by the programmer for symbolic-language programs. This file control block contains such information as record length, block length, file name, file code, etc. At load time, control cards referencing the file by file code specify the type of device to which the file is to be assigned. GEFRC will automatically handle blocking or deblocking of records, buffer alternation, label processing, unit swapping, and movement of records between buffers and working areas.

.124 General Loader

The General Loader is used to transfer programs from temporary drum (or disc) storage to core

.124 General Loader (Contd.)

storage when they have been scheduled for execution. It will also perform the following functions:

- Relocate subprograms into one contiguous program and establish the required linkages.
- Store and establish the required linkages for overlay segments.
- Provide debug facilities. Debug statement cards are read at load time, and snapshot printouts of specific locations within a program are made at execution time.

.125 GERTS

The General Remote Terminal Supervisor supervises the reception of job programs from remote terminals, submits them to GECOS for processing, and returns the desired output to the remote terminal submitting the program.

.13 Availability

	Initial	Final
GECOS:	12/64	2/65.
GEIOS:	12/64	2/65.
GEFRC:	-	12/64.
GERTS:	1/65	4/65.
General Loader:	-	12/64.

.14 Originator: . . . . GE Computer Department, Phoenix, Arizona.

.15 Maintainer: . . . . same as above.

.2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . . multiple users' libraries can be assembled in various media, forms, and languages (absolute, relocatable, GEM, COBOL, or FORTRAN). Loading and allocation are directed by control cards.

.212 Independent programs: magnetic drum, disc, or tape; system card reader.

.213 Data: . . . . from any available input device, as specified in the program; or data can be loaded immediately following the program.

.214 Master routines: . . . contained in the 8,192 words of core storage allotted to GECOS, and on magnetic drum or disc.

.22 Library Subroutines:. loaded from system library (on drum or disc) or from users' libraries at load time.

.23 Loading Sequence: . . jobs, consisting of one or more programs, compilations, assemblies, etc. are assigned priorities and are loaded onto the magnetic drum (or disc storage unit) assigned to GECOS. Scheduling of jobs is based on priority and peripheral requirements. The eighteen most urgent jobs are considered for allocation at any time. If a job is bypassed due to insufficient peripheral units being available, its priority is increased, finally reaching the level where no other jobs will be scheduled until the requirements for the delayed job are met and that job is scheduled for execution.

.3 HARDWARE ALLOCATION

.31 Storage

.311 Sequencing of program for movement between levels: . . . . . the program is segmented by the programmer, and individual segments are assembled or compiled individually. Loading and execution are as described in the following paragraph.

.312 Occupation of working storage: . . . . LINK control cards specify the starting location of a segment. At load time the segments are written on a drum (or disc) file and the necessary linkages are set up. Segments are loaded into the area of core storage specified in the control cards by a CALL macro within the calling program.

.32 Input-Output Units

.321 Initial assignment: . . all references to input-output devices must be symbolic; the required facilities are defined by control cards, and actual assignments are made automatically by GECOS when scheduling a job. These assignments are normally made several programs in advance and are communicated to the operator by means of the console typewriter.

.322 Alternation: . . . . . . two tape units can be assigned to the same file, and are automatically swapped upon recognition of end-of-reel condition.

.323 Reassignment: . . . . . same as initial assignment; GECOS can release assigned facilities for use by another program.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: GECOS controls all input-output operations and attempts to maximize utilization of the available peripheral devices.

.42 Multiprogramming: . . up to eight programs can reside in core storage simultaneously. Switching techniques are described in Paragraph .122.

.43 Multi-sequencing: . . no provisions to date. (A multi-processor version of GECOS is to be available in mid-1965.)

.44 Errors, Checks and Action

Error	Check or Interlock	Action
Loading input error or improper format:	check	print message; continue, skipping incorrect card images, or terminate program, depending on loading mode and type of error.
Allocation impossible:	check	increase priority and delay; select another program.
In-out error - single:	check	try again.
In-out error - persistent:	check	print message and offer options.
Time limit violated:	check	wait until processor is in slave mode and terminate program. *
Invalid instructions (in slave mode):	check	print message and terminate program. *
Arithmetic overflow:	check	print message; set flag; continue. *
Floating point overflow:	check	print message; set flag; return largest magnitude; continue. *
Floating point underflow:	check	print message; set flag; return zero; continue. *
Invalid operation:	check	print message and terminate program. *
Invalid address:	check	print message and terminate program. *
Reference to forbidden area:	check	print message and terminate program. *

* The action specified is that normally taken by GECOS. The programmer has the option of specifying his own error routine for individual conditions. The message is normally written on the system tape for later print-out. Normal action that causes a program to be terminated due to an error also includes a post-mortem dump.

.45 Restarts

.451 Establishing restart points: . . . . user can specify any number of restart points on magnetic tape file, but only one on a magnetic drum or disc file, and that one must be the first entry on the file.

.452 Restarting process: . the restart routine call is specified by the user; if the routine is entered at execution time, a message is printed and the operator has the option of restarting or terminating the program.

.5 PROGRAM DIAGNOSTICS

.51 Dynamic

.511 Tracing: . . . . none.

.512 Snapshots: . . . . DEBUG control cards cause printout of specified locations (can be symbolic) at execution time. The printout can be controlled by a count specification and/or a simple conditional.

.52 Post-Mortem: . . . . normally included when standard software response to an error results in terminating a program.

.6 OPERATOR CONTROL

.61 Signals to Operator

.611 Decision required by operator: . . . . console printer messages, under control of GECOS or user's program.

.612 Action required by operator: . . . . same as .611.

.613 Reporting progress of run: . . . . recorded on system tape for later print-out.

.62 Operator's Decisions: keyboard entry or, in some cases, by placing peripheral equipment in ready condition.

.63 Operator's Signals

.631 Inquiry: . . . . ?

.632 Change of normal progress: . . . . ?

.7 LOGGING: . . . . all logging facilities are provided by GECOS and are controlled by program parameters where needed.

.71 Operator Signals: . . on console typewriter.

.72 Operator Decisions: . on console typewriter.

.73 Run Progress: . . . . . on system tape.

.74 Errors: . . . . on console printer or system tape.

.75 Running Times: . . . . on system tape.

.76 Multiprogramming Status: . . . . none.

.8 PERFORMANCE

.81 System Requirements

.811 Minimum configuration: . . . . CP 8030 Processor Module.
32,768 words of core storage.
1 console with typewriter.
3 magnetic tape units.
1 card reader.
1 magnetic drum (786,000 words) or equivalent amount of disc storage.

.812 Usable extra facilities: . . . . all.

.813 Reserved equipment: . . . . 8,192 words of core storage.
console and typewriter.
3 magnetic tape units.
786,000 words of drum or disc storage.

.82 System Overhead

.821 Loading time: . . . . . ?

.822 Reloading frequency: resident portions of GECOS remain in core storage; other portions are called in automatically from drum (or disc) as required.

.83 Program Space Available: . . . . . . all of core storage except the 8,192 words mentioned in Paragraph .813.

.84 Program Loading Time: . . . . ?

.85 Program Performance: . . . . no estimate is available from GE to date.

SYSTEM PERFORMANCE

The overall performance of a GE-600 Series computer system varies with the speed of the Memory Module and the peripheral equipment incorporated. The performance of the currently-announced members of the GE-600 Series on the AUERBACH Standard EDP Reports benchmark measures of system performance has been analyzed separately. For performance curves, summary worksheets, and analyses of the results, turn to the System Performance sections of the individual subreports, as listed below:

GE-625: . . . . Section 343:201
GE-635: . . . . Section 344:201

PHYSICAL CHARACTERISTICS

Unit	Width inches	Depth, inches	Height, inches	Weight, pounds	Power, KVA	BTU per hr.
CP 8030 Central Processor	38.9	78.3	77.5	2,200	2.6	7,400
Memory Module - A-11 (includes one or two core storage modules and System Controller)	38.9	78.3	77.5	1,800	3.7	12,300
Input/Output Controller Module	38.9	78.3	77.5	2,200	3.7	12,700
Console	40	36	48	360	0.6	1,700
CR-20 Card Reader	47	33	40	475	4.08	11,900
CP-10 Card Punch	47	33	48	700	3.0	4,400
CP-20 Card Punch	28	60	60	1,300	2.2	4,400
PR-20 Printer	76	34	58	1,460	5.4	11,000
MT-24, MT-26 Magnetic Tape Unit	29	26	67	400	3.0	2,500
MT-17, MT-19, MT-21, MT-23 Magnetic Tape Unit	56	26	67	400	1.69	4,100
Magnetic Tape Controller (single-channel)	56	26	67	840	1.56	4,600
Magnetic Tape Controller (dual-channel)	56	26	67	840	1.9	5,560
TS-20 Paper Tape Reader/Punch	61	26	68	700	1.63	5,400
DS-20 Disc File Unit	71	38	63	2,390	5.94	9,700
DSC-20 Disc File Controller	61	26	68	870	3.3	9,560
MDS 200 Magnetic Drum	53.9	36.5	78.6	1,580	1.5	5,500
Magnetic Drum Controller	61.0	26.0	67.0	800	2.0	3,600
MG 8030 Motor-Generator Set (31.3 KVA)	26.6	64.1	37.8	1,830	31.3	30,000
MT 8031 Motor-Generator Set (62.5 KVA)	32.5	71.8	42.1	2,700	62.5	46,000

General Requirements

Temperature: . . . . 65 to 85° F.
Relative Humidity: . . . . 40 to 60%.
Power: . . . . 208/120 volt, 3-phase, 4-wire, 60-cycle source.

STANDARD EDP REPORTS

PRICE DATA

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental * $	Monthly Maintenance† $	Purchase $
CENTRAL PROCESSOR	CP 8030	Central Processor Module (includes 1 CPU port)	16,000	1,140	624,000
		Additional Processor Module (includes 1 CPU port)	8,900	620	256,000
	OPT 809	CPU Port (maximum of four per Processor Module)	70	5	3,080
CORE STORAGE	MM 8031	GE-625 32K Core Storage Module and System Controller (includes 2 Memory Ports)	6,500	489	279,500
	MM 8032	GE-625 40K Core Storage Module and System Controller (includes 2 Memory Ports)	7,500	591	337,500
	OPT 804	GE-625 32K Core Storage Module (includes 2 Memory Ports)	4,300	301	193,000
	MM 8030	GE-635 32K Core Storage Module and System Controller (includes 2 Memory Ports)	9,500	715	408,500
	MM 8033	GE-635 40K Core Storage Module and System Controller (includes 2 Memory Ports)	10,600	835	477,000
	OPT 801	GE-635 32K Core Storage Module	6,700	469	301,500
	OPT 802	Memory Port (maximum of 8 per System Controller)	80	6	3,520
RANDOM ACCESS STORAGE		Disc Storage			
	DS-20	Disc Storage Unit (includes 4 discs)	1,125	350	53,000
	OPT 201	4 Additional Discs	200	-	8,000
	OPT 202	8 Additional Discs	400	-	16,000
	OPT 203	12 Additional Discs	600	-	23,000
	OPT 204	Fast Access I (4 Discs)	300	-	15,000
	OPT 205	Fast Access II (8 Discs)	400	-	20,000
		Note: Maximum of 16 discs total per unit; maximum of 8 fast access discs per unit.			
	DSU-20	DSU Controller	1,475	45	86,400
		Magnetic Drum Unit			
	MDS 200	Magnetic Drum and Controller (786K words)	3,300	433	148,500

* Rentals shown are for unlimited usage.
† Maintenance rates shown apply only for the first 36 months after installation, and are somewhat higher thereafter.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental * $	Monthly Maintenance† $	Purchase $
INPUT-OUTPUT	DC 8030	Input/Output Controller (includes one IOC Port, three 400KC Channels, and five 25KC Channels)	5,400	288	190,000
	OPT 808	IOC Port (maximum of 4 per I/O Controller	80	6	3,520
	OPT 807	400KC Channel (maximum of 6 per I/O Controller)	100	8	4,400
	OPT 806	25KC Channel (maximum of 10 per I/O Controller)	50	4	2,250
	CO 8030	Console (includes typewriter)	400	32	18,400
	CO 8031	Auxiliary Console (includes typewriter)	375	32	18,300
		Punched Card and Printer			
	CR-20	Card Reader (900 cpm)	650	69	30,000
	CP-10	Card Punch (100 cpm)	500	69	22,500
	CP-20	Card Punch (300 cpm)	825	115	41,150
	PR-20	Printer (1200 lpm)	1,400	247	64,800
		Punched Tape			
	TR-20	Perforated Tape Reader	500	75	22,500
	TP-20	Perforated Tape Punch	560	75	25,200
	TS-20	Perforated Tape Subsystem (includes reader and punch)	950	78	45,600
		Magnetic Tape			
		7-channel Magnetic Tape Units:			
	MT-17	20,900 char/sec max.	290	80	13,920
	MT-19	30,000 char/sec max.	400	100	19,200
	MT-21	42,000 char/sec max.	485	150	23,280
	MT-23	60,000 char/sec max.	590	180	28,320
	MT-24	83,000 char/sec max.	700	200	31,500
	MT-26	120,000 char/sec max.	900	200	40,500
		7-channel Magnetic Tape Controllers:			
	MTC-71	Single-channel, 16 units	900	30	43,200
	MTC-72	Dual-channel, 16 units	1,380	50	66,240
		9-channel Magnetic Tape Units:			
	MT-17A	28,000 char/sec max.	385	85	18,500
	MT-19A	40,000 char/sec max.	430	110	20,640
	MT-21A	56,000 char/sec max.	575	160	27,600
	MT-23A	80,000 char/sec max.	635	165	30,408
	MT-24A	111,000 char/sec max.	850	210	38,250
	MT-26A	160,000 char/sec max.	990	225	44,550
		9-channel Magnetic Tape Controllers:			
	MTC-91	Single-channel, 16 units	970	40	46,560
	MTC-92	Dual-channel, 16 units	1,485	60	71,280
OTHER	MG 8030	Motor-Generator Set - 31.3 KVA with SEQ.	270	19	11,000
	MG 8031	Motor-Generator Set - 62.6 KVA with SEQ.	320	23	13,000

* Rentals shown are for unlimited usage.
† Maintenance rates shown apply only for the first 36 months after installation, and are somewhat higher thereafter.

GE 625

General Electric Company

STANDARD EDP REPORTS

AUERBACH INFO, INC.

PRINTED IN U. S. A.

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INTRODUCTION

The GE-625 is characterized by the cycle time of its core storage unit — two microseconds for each access of two 36-bit words.

This report concentrates upon the performance of the GE-625 in particular. All general characteristics of the GE-600 Series hardware and software are described in Computer System Report 340: GE-600 Series — General.

The System Configuration section which follows shows the GE-625 in the following standard configurations:

VIIA: 10-Tape General System (Integrated)

VIIIA: 20-Tape General System (Integrated)

These configurations were selected because multiprogramming is a featured capability of the GE-625. The main processing runs and the input and output data transcription runs are assumed to be running in parallel on the main-frame, so no off-line data transcription facilities are required.

The system configurations are arranged according to the rules in the Users' Guide, page 4:030.120, and any significant deviations from the standard specifications are listed. The main deviation is the inclusion of random access storage; this is necessary to permit use of the standard supervisory routine, GECOS.

Section 343:051 provides detailed central processor timing data for the GE-625. See Section 340:051 for all the other characteristics of the program-compatible GE-600 Series processors.

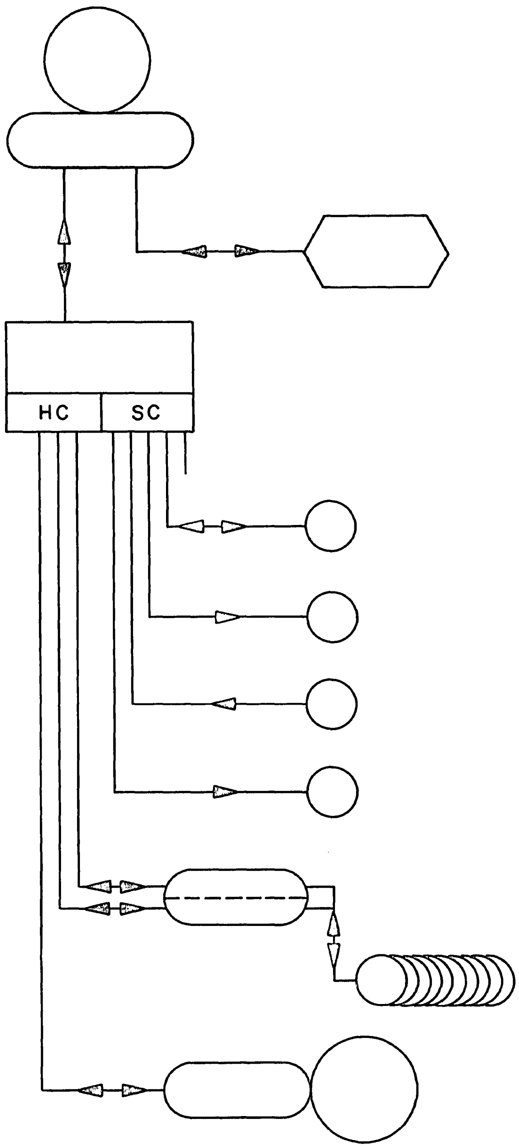
The software that is provided for all GE-600 Series systems is described in Sections 340:151 through 340:191.

A detailed analysis of the GE-625's overall System Performance is provided in Section 343:201.

SYSTEM CONFIGURATION

.1 10-TAPE GENERAL SYSTEM (INTEGRATED): CONFIGURATION VIIA

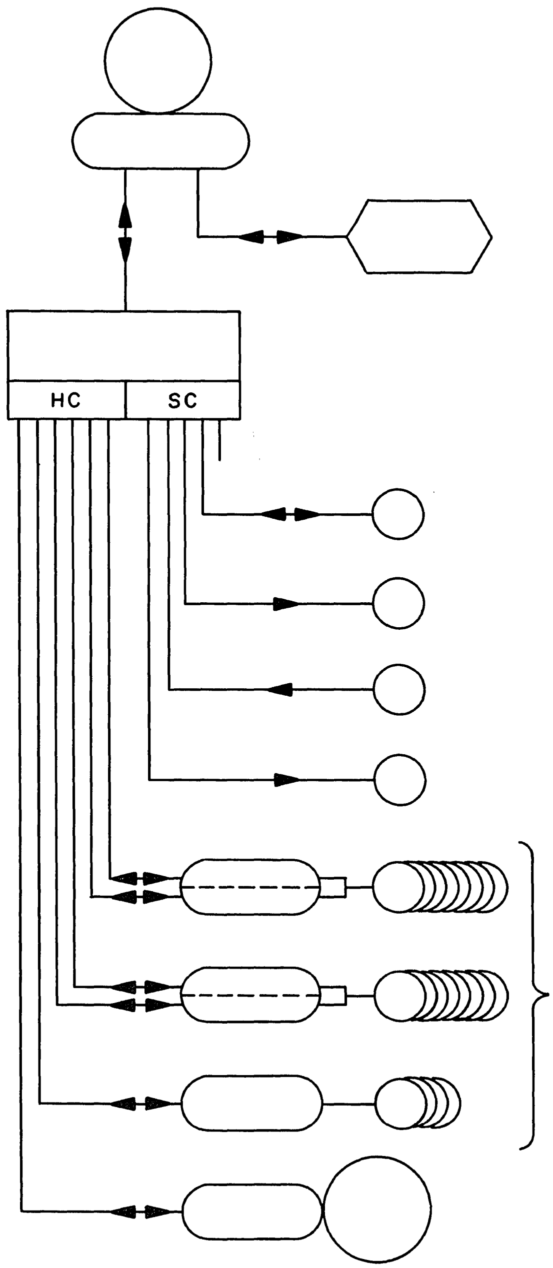
Deviations from Standard Configuration: . . Magnetic drum is required for GECOS.
Core storage is 60% larger.
Printer is up to 140% faster.
Card reader is 40% faster.



Equipment	Rental
MM 8031 - 32K Memory Module and System Controller (includes 32K words of storage and 2 memory ports)	$ 6,500
CP 8030 Central Processor (includes 1 processor port)	16,000
I/O Controller Module (includes 5 standard and 3 high-performance channels and 1 IOC port)	5,400
Console and Typewriter:	400
PR-20 Printer: prints 1200 lines per minute	1,400
CR-20 Card Reader: reads 900 cards per minute	650
CP-10 Card Punch: punches 100 cards per minute	500
Dual Channel Tape Controller	1,380
10 MT-23 Magnetic Tape Units: up to 60,000 characters per second	5,900
MDS 200 Magnetic Drum and Control (786,000 words)	3,300
Motor-Generator Set	270
TOTAL:	$41,700

.2 20-TAPE GENERAL SYSTEM (INTEGRATED): CONFIGURATION VIIIA

Deviations from Standard Configuration: . . Magnetic Drum is required for GECOS. Card punch is 50% faster.



Equipment	Rental
MM 8032 - 40K Memory Module and System Controller (includes 40K words of storage and 2 memory ports)	$ 7,500
CP 8030 Central Processor (includes 1 processor port)	16,000
I/O Controller Module (includes 5 standard and 6 high-performance channels and 1 IOC port)	5,700
Console and Typewriter:	400
PR-20 Printer: prints 1200 lines per minute	1,400
CR-20 Card Reader: reads 900 cards per minute	650
CP-20 Card Punch: punches 300 cards per minute	825
2 Dual Channel Tape Controllers	2,760
1 Single Channel Tape Controller	900
20 MT-26 Magnetic Tape Units: up to 120,000 characters per second	18,000
MDS 200 Magnetic Drum and Control (786,000 words)	3,300
Motor-Generator Set	270
TOTAL:	$57,705

CENTRAL PROCESSOR

.1 GENERAL

.11 Identity: . . . . CP 8030 Processor Module.

.12 Description

See Section 340:051 for a comprehensive description of the Model CP 8030 Processor Module.

The Instruction Times and Processor Performance times for the GE-625 system are listed below. See Paragraphs 4:050.41 and 4:050.42 of the Users' Guide for the definitions of these standard measures of central processor performance.

.4 PROCESSOR SPEEDS

.41 Instruction Times in Microseconds

		Short (1 word)	Long (2 words)
.411	Fixed point -		
	Add-subtract:		
	To accumulator:	3.0	3.0
	To storage:	4.0	-
	Multiply:	7.0	-
	Divide:	14.5	-
.412	Floating point -		
	Add-subtract:	3.0	3.0
	Multiply:	6.0	12.0
	Divide:	14.5	23.5
.413	Additional allowance for -		
	Indexing:	0.	
	Indirect addressing:	2.0 (3.5 if indirect word is modified)	
	Re-complementing:	0.	
.414	Compare -		
	Fixed point (short or long):	3.0	
	Floating point (short or long):	3.0	
	With limits:	3.0	
	Masked:	3.0	
	Branch:	2.0	
.415	Counter control (indirect addressing) -		
	Step:	3.5	
	Step and test:	3.5	
.416	Edit:	no direct hardware facilities.	
.417	Convert:	4.0 (basic 1-digit conversion).	
.418	Shift:	2.0	

.42 Processor Performance in Microseconds

		Fixed point	Floating point
.421	For random addresses -		
	$c = a + b$:	9.5 (long) 9.5 (short)	10.0 (long) 9.5 (short)
.421	For random addresses (Contd.)		
	$b = a + b$:	9.5 (long) 7.0 (short)	10.0 (long) 9.5 (short)
	Sum N items (long or short):	3.0N	3.0N
	$c = ab$:	13.5 (short)	19.0 (long) 12.5 (short)
	$c = a/b$:	21.0 (short)	30.5 (long) 21.0 (short)
.422	For arrays of data -		
	$c_i = a_i + b_j$:	18.0 (long) 18.0 (short)	18.5 (long) 18.0 (short)
	$b_j = a_i + b_j$:	18.0 (long) 16.0 (short)	18.5 (long) 18.0 (short)
	Sum N items:	12.0N (long or short)*	12.0N (long or short)*
	$c = c + a_ib_j$:	22.5 (long)	30.5 (long) 24.0 (short)

.423 Branch based on comparison -
Numeric data: 14.5N
Alphabetic data: . . . 14.5N

.424 Switching -
Unchecked: 7.0
Checked: 13.0
List search: . . . . . 8.5 + 16.5N*

.425 Format control, per character -
Unpack:
Without radix conversion: 1.33
With radix conversion: 59.7
Compose: 18.6

.426 Table lookup, per comparison -
For a match: 16.5*
For least or greatest: . . . . 15 to 18.
For interpolation point: 16.5*

.428 Moving: . . . . 2.5 per word (using Repeat Double loop).

*These times could possibly be improved with loops using the Repeat instructions, but the timing information is not available to date.

SYSTEM PERFORMANCE

GENERALIZED FILE PROCESSING (343:201.100)

These problems involve updating a master file from information in a detail file and producing a printed record of each transaction. This application is one of the most common commercial data processing jobs and is fully described in Section 4:200.1 of the Users' Guide. Standard File Problems A, B, and C show the effects of varying record sizes in the master file. Standard Problem D increases the amount of computation performed upon each transaction. Each problem is estimated for activity factors (ratios of number of detail records to number of master records) of zero to unity. In all cases a uniform distribution of activity is assumed.

Because multiprogramming is a featured capability of the GE-625, the central processor time requirements are shown on all of the graphs in addition to the usual curves of elapsed time (i.e., total processing time). The difference between the curves of elapsed time and central processor time represents the amount of central processor time that is potentially available for concurrent processing of other programs.

In designing the master file layout for the GE-600 Series, alignment of data items in core storage was carefully considered. Double-word boundaries were observed throughout in order to make use of the various double-word instructions to improve performance efficiency. Penalties due to placement of transfer instructions in even locations and transfers to instructions in odd locations were taken into account; i.e., half were placed in favorable locations and half in unfavorable locations. As there is only one Memory Module in both of our Standard Configurations, no advantage could be taken of simultaneous accesses to core storage. The scatter-gather method of tape reading and writing was not used extensively; instead, individual records were moved by means of the high-speed Repeat Double, Load Double, Store Double loop transfer method.

In the multiprogramming mode of operation, we assume that two programs are run simultaneously. One program, the Processing Run, performs all of the processing prescribed for the Generalized File Processing Problem with the master, detail, and report files all assigned to magnetic tape. The second program is a data Transcription routine that converts magnetic tape records to printed records (the report file) and simultaneously converts records on punched cards (the detail file) to magnetic tape records.

Detailed information is not available to date about the standard Bulk Media Conversion Routines. Consequently, the detail file and report file records on magnetic tape are assumed to be unblocked; i.e., only one record per block. Also, the Central Processor times for the data transcription routine do not include the time for I/O control, because the timing data was not available.

The controlling factor at all activities in all problems for Configuration VIIA is a combination of one master file tape and the report file tape. An average of 80% of the central processor's time is available to process other programs.

Additional tape channels and faster tape units reduce the overall elapsed times for Configuration VIIIA, while the Central Processor times remain the same as for Configuration VIIA. The controlling factor at moderate and high activities is the report file tape; at low activities, it is one master file tape. In Configuration VIIIA, an average of 50% of the central processor's time is available to process other problems.

In both configurations a large portion of the central processor's time is occupied with editing and radix conversions since there are no automatic hardware provisions for these operations.

Elapsed times for the data transcription routine are controlled by the printer at all activities. The amount of central processor time required for this routine is quite small.

SORTING (343:201.200)

The standard estimate for sorting 80-character records by straightforward merging on magnetic tape was developed from the time for Standard File Problem A by the method explained in Paragraph 4:200.213 of the Users' Guide. A three-way merge is used in all system configurations for the GE-625. The results are shown in Graph 343:201.200.

MATRIX INVERSION (343:201.300)

The standard estimate for inverting a non-symmetric, non-singular matrix was computed by the simple method described in Paragraph 4:200.312 of the Users' Guide. Computation is performed in single-precision floating-point format (8-digit precision).

GENERALIZED MATHEMATICAL PROCESSING (343:201.400)

The Standard Mathematical Problem A is an application in which there is one stream of input data, a fixed computation to be performed, and one stream of output results. Two variables are introduced to demonstrate how the time for a job varies with different proportions of input, computation, and output. The factor C is used to vary the amount of computation per input record. The factor R is used to vary the ratio of input records to output records. The procedure used for the Standard Mathematical Problem is fully described in Section 4:200.2 of the Users' Guide.

Computations are performed in single-precision floating-point arithmetic, which provides the minimum 8-digit precision prescribed in the Users' Guide.

Again, because multiprogramming is featured in the GE-625, the curves show the central processor time as well as total elapsed time. The performance for both Configurations VIIA and VIIIA is assessed for the multiprogramming mode of operation. The graphs show the time for the main Processing run, in which the input and output are on magnetic tape and in which all of the prescribed internal processing is performed (including editing and radix conversions). The table beneath the chart shows the times for the corresponding data Transcription run, in which the card-to-tape (input) and tape-to-printer (output) transcriptions are assumed to run simultaneously.

Graph 343:201.400 shows the results for Configuration VIIA with two curves. The curve marked R = 1.0 is for the case in which one output record is written for each input record. The other curve is for the case in which one output record is written for every tenth (R = 0.1) and every hundredth (R = 0.01) input record. (There is no effective difference between the two cases, R = 0.1 and R = 0.01.) For R = 1.0, the output tape is the controlling factor for amounts of computation up to about 4 times the standard (i.e., C = 4). The input tape is the controlling factor for up to about 6 times the standard amount of computation (i.e., C = 6) for R = 0.1 and R = 0.01.

The results for Configuration VIIIA are shown in a similar manner on graph 343:201.415. Because of the faster tapes, the output tape is the controlling factor for only up to about 1.5 times the standard computation (C = 1.5) for R = 1.0, and the input tape is the controlling factor for only up to about 2.5 times the standard computation for R = 0.1 and R = 0.01.

WORKSHEET DATA TABLE 1 (STANDARD FILE PROBLEM A)							
	ITEM		CONFIGURATION				REFERENCE
			VIIA		VIIIA		
1	Char/block	(File 1)	960		960		
	Records/block	K (File 1)	10		10		
	msec/block	File 1 = File 2	28.0		15.3		
		File 3	13.3*		8.0*		
Input-Output Times		File 4	14.0*		8.3*		
	msec/switch	File 1 = File 2	0		0		4:200.112
		File 3	0		0		
		File 4	0		0		
	msec penalty	File 1 = File 2	0.33		0.33		
		File 3	0.03		0.03		
		File 4	0.05		0.05		
2	msec/block	a_1	0.14		0.14		
Central Processor Times	msec/record	a_2	0.15		0.15		
	msec/detail	b_6	1.04		1.04		4:200.1132
	msec/work	$b_5 + b_9$	0.23		0.23		
	msec/report	$b_7 + b_8$	2.30		2.30		
3	msec/block		C.P.	Tapes	C.P.	Tapes	
System Performance at	for C.P. and	a_1	0.14		0.14		
	dominant	a_2 K	1.50		1.50		4:200.114
	column.	a_3 K	35.71		35.71		
F = 1.0		File 1 Master In	0.33	28.0	0.33		
		File 2 Master Out	0.33		0.33		
		File 3 Details	0.34		0.34		
		File 4 Reports	0.48	140.0	0.48	83.2	
		Total	38.83	168.0	38.83	83.2	
4	Unit of measure:	words					
		Std. routines	†		†		
Storage Space Required		Fixed	32		32		
		3(Blocks 1 to 23)	213		213		
		6(Blocks 24 to 48)	1,422		1,422		4:200.1151
		Files	710		710		
		Working	50		50		
		Total	2,427 †		2,427 †		

* Files 3 and 4 are on magnetic tape for the main Processing run.

† Does not include 8,192 words required for standard supervisory routine. GECOS.

WORKSHEET DATA TABLE 2 (STANDARD MATHEMATICAL PROBLEM A)					
	ITEM		CONFIGURATION		REFERENCE
			VIIA	VIIIA	
5	Fixed/Floating point		Floating point	Floating point	
	Unit name	input	Model MT-23 Tape	Model MT-26 Tape	
Standard Mathematical Problem A		output	Model MT-23 Tape	Model MT-26 Tape	
	Size of record	input	80 char.	80 char.	
		output	130 char.	130 char.	
	msec/block	input T_1	13.3	8.0	
		output T_2	14.2	8.4	4:200.413
	msec penalty	input T_3	0.03	0.03	
		output T_4	0.05	0.05	
	msec/record	T_5	3.23	3.23	
	msec/5 loops	T_6	1.45	1.45	
	msec/report	T_7	2.78	2.78	

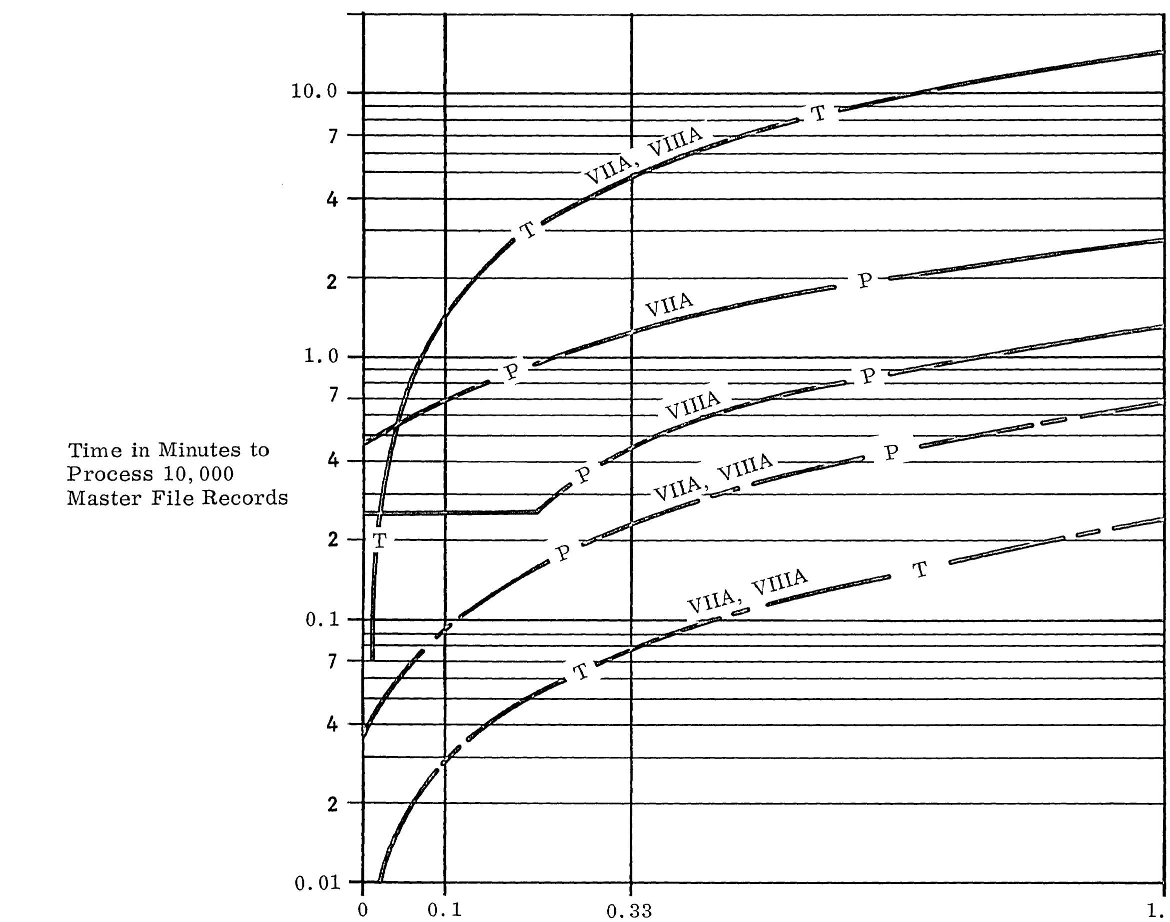
SYSTEM PERFORMANCE

.1 GENERALIZED FILE PROCESSING

.11 Standard File Problem A

.111 Record sizes —
Master file: . . . . 108 data characters (16 words).
Detail file: . . . . 1 card.
Report file: . . . . 1 line.
.112 Computation: . . . . standard.
.113 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.113; see also the explanation on page 343:201.001.
.114 Graph: . . . . see graph below.
.115 Storage space required —
Configuration VIIA and VIIIA: . . . . 2,427 words.*

* Does not include 8,192 words required for the standard supervisory routine, GECOS. All I/O control routines, editing routines, radix conversion routines, etc., are within GECOS.



LEGEND

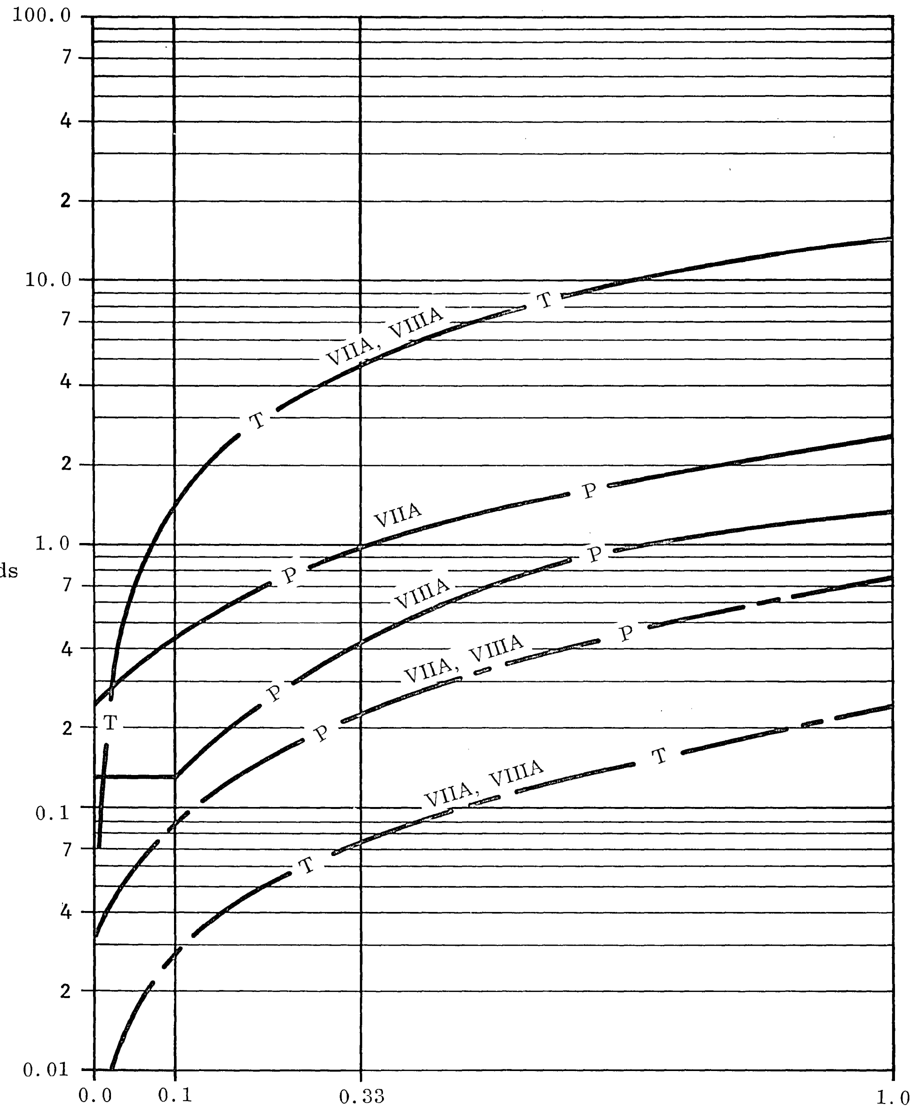
P	Elapsed time for main Processing run.
T	Elapsed time for data Transcription runs.
P (dashed)	Central Processor time for main Processing run.
T (dashed)	Central Processor time for data Transcription runs.

(Roman numerals denote standard System Configurations.)

.12 Standard File Problem B

.121 Record sizes —
Master file: . . . . 54 data characters (8 words).
Detail file: . . . . 1 card.
Report file: . . . . 1 line.

.122 Computation: . . . . standard.
.123 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide 4:200.12; see also the explanation on page 343:201.001.
.124 Graph: . . . . see graph below.



Activity Factor
Average Number of Detail Records Per Master Record

LEGEND

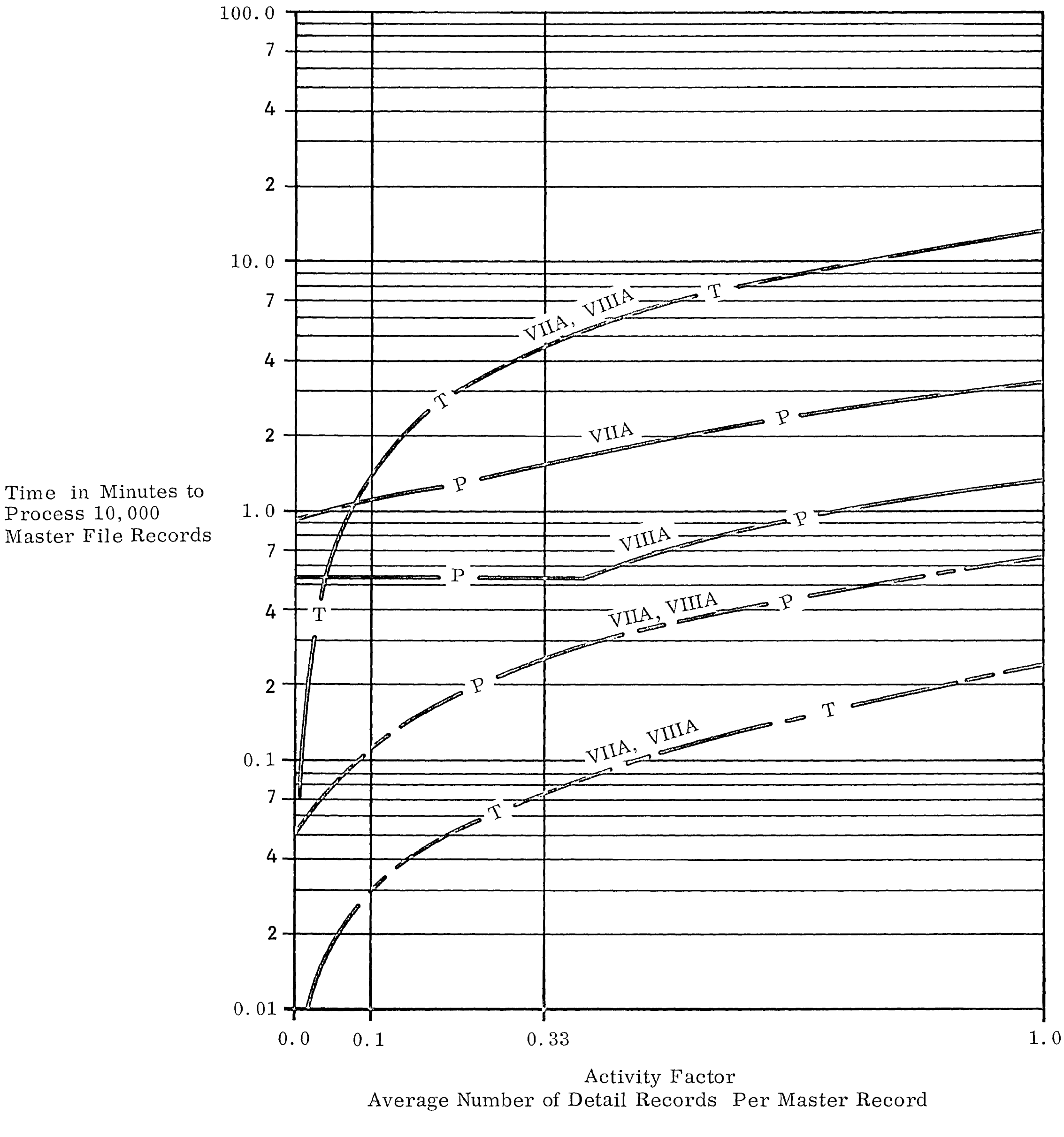
P	Elapsed time for main Processing run.
T	Elapsed time for data Transcription runs.
P	Central Processor time for main Processing run.
T	Central Processor time for data Transcription runs.

(Roman numerals denote standard System Configurations.)

.13 Standard File Problem C

.131 Record sizes —
Master file: . . . . . . 216 data characters (32 words).
Detail file: . . . . 1 card.
Report file: . . . . 1 line.

.132 Computation: . . . . standard.
.133 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.13.
.134 Graph: . . . . see graph below.



LEGEND

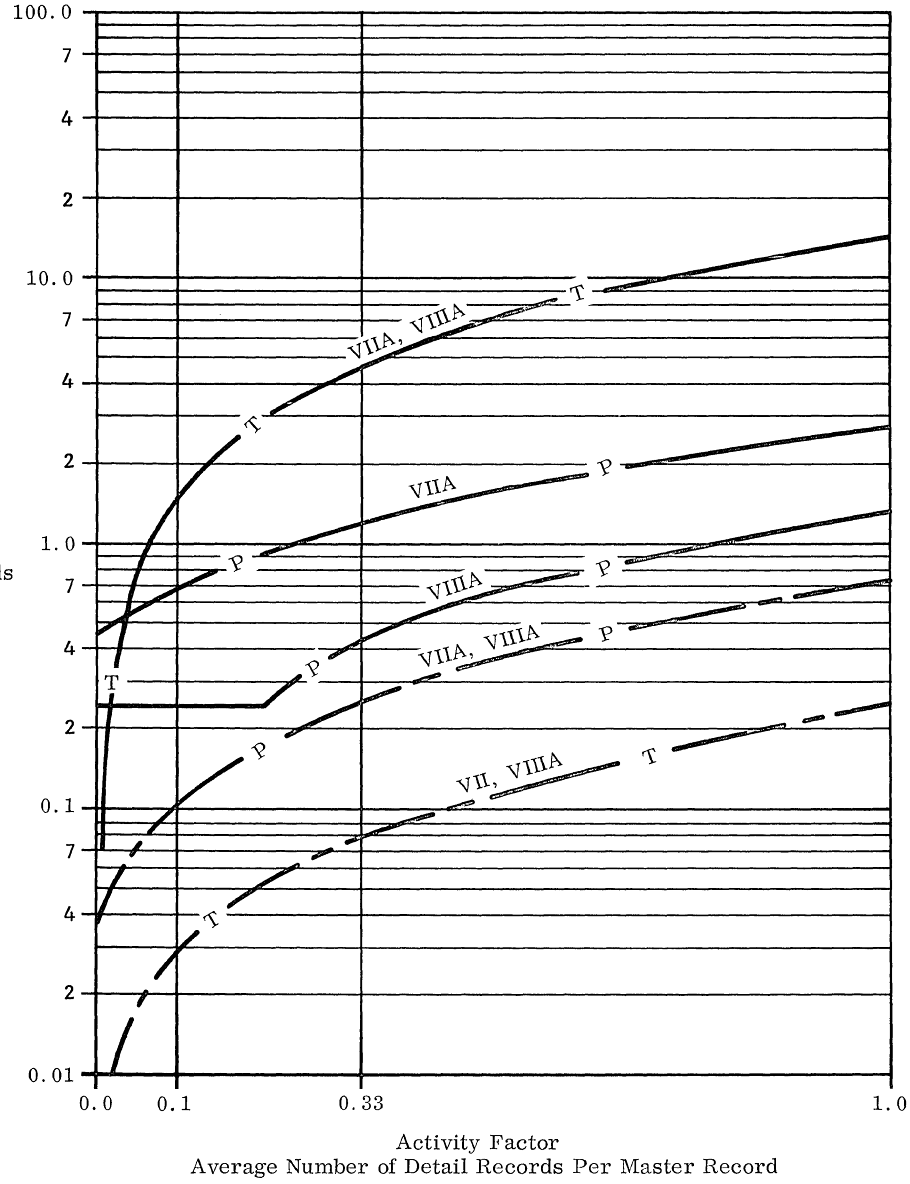
P Elapsed time for main Processing run.
T Elapsed time for data Transcription runs.
P Central Processor time for main Processing run.
T Central Processor time for data Transcription runs.

(Roman numerals denote standard System Configurations.)

.14 Standard File Problem D

.141 Record sizes —
Master file: . . . . 108 data characters (16 words).
Detail file: . . . . 1 card.
Report file: . . . . 1 line.

.142 Computation: . . . . trebled.
.143 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.14.
.144 Graph: . . . . see graph below.



LEGEND

P Elapsed time for main Processing run.
T Elapsed time for data Transcription runs.
P Central Processor time for main Processing run.
T Central Processor time for data Transcription runs.

(Roman numerals denote standard System Configurations.)

.2 SORTING

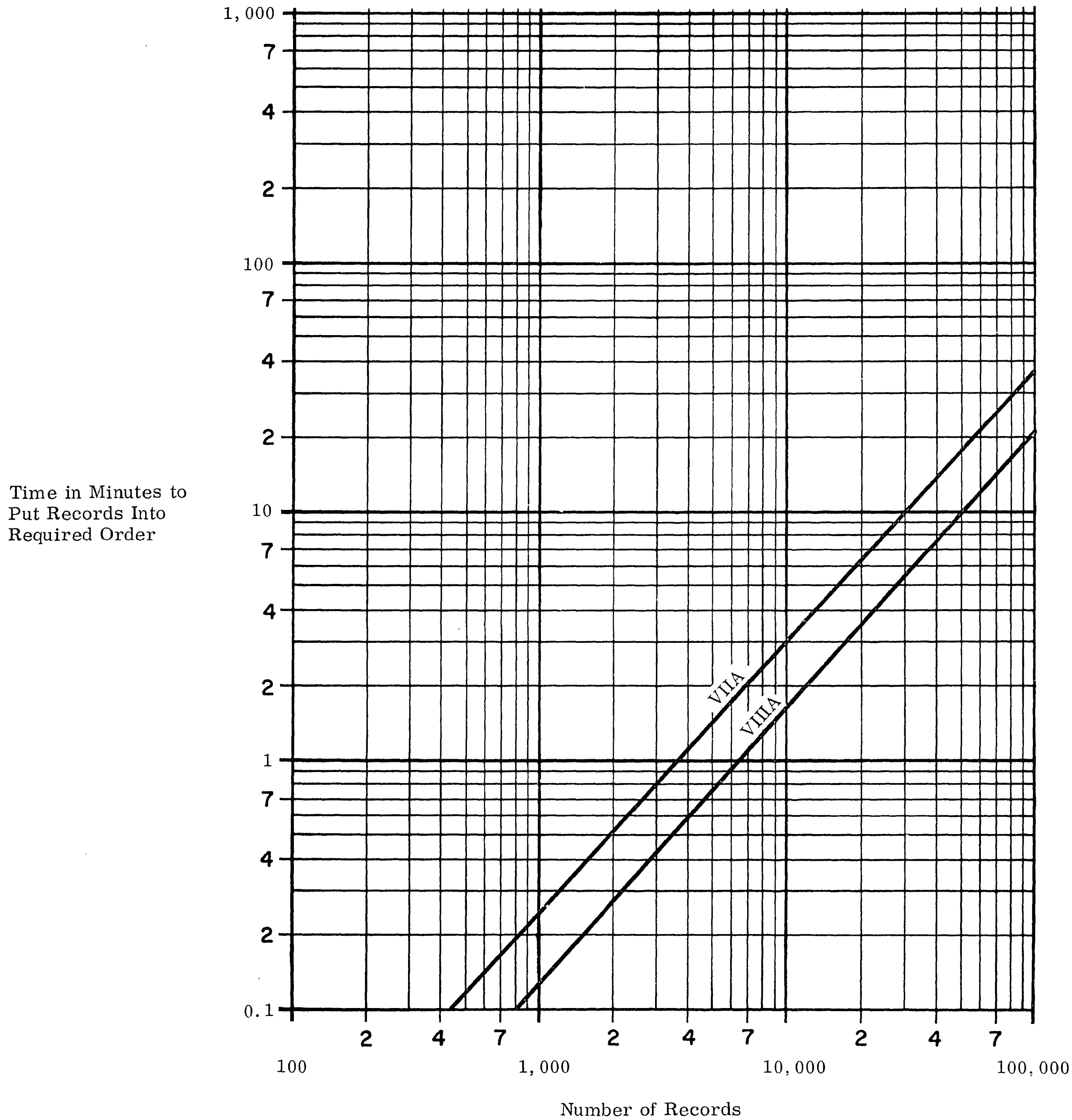
.21 Standard Problem Estimates

.211 Record size: . . . . 80 characters.

.212 Key size: . . . . 8 characters.

.213 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.213.

.214 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

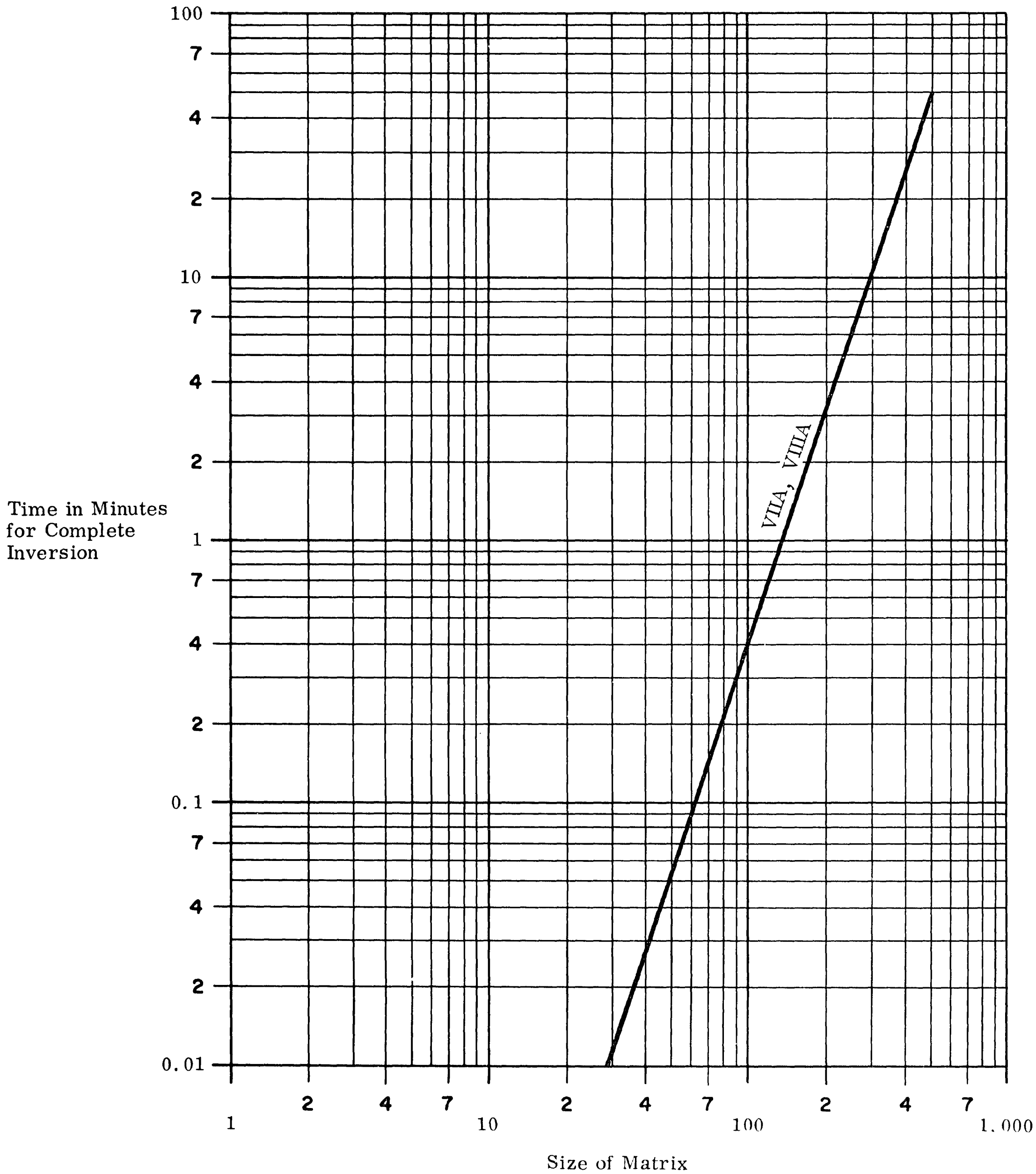
.3 MATRIX INVERSION

.31 Standard Problem Estimates

.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits (single-precision).

.312 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.312.

.313 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

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.4 GENERALIZED MATHEMATICAL PROCESSING

.41 Standard Mathematical Problem A Estimates

.411 Record sizes: . . . . . . 10 signed numbers, avg. size 5 digits, max. size 8 digits.

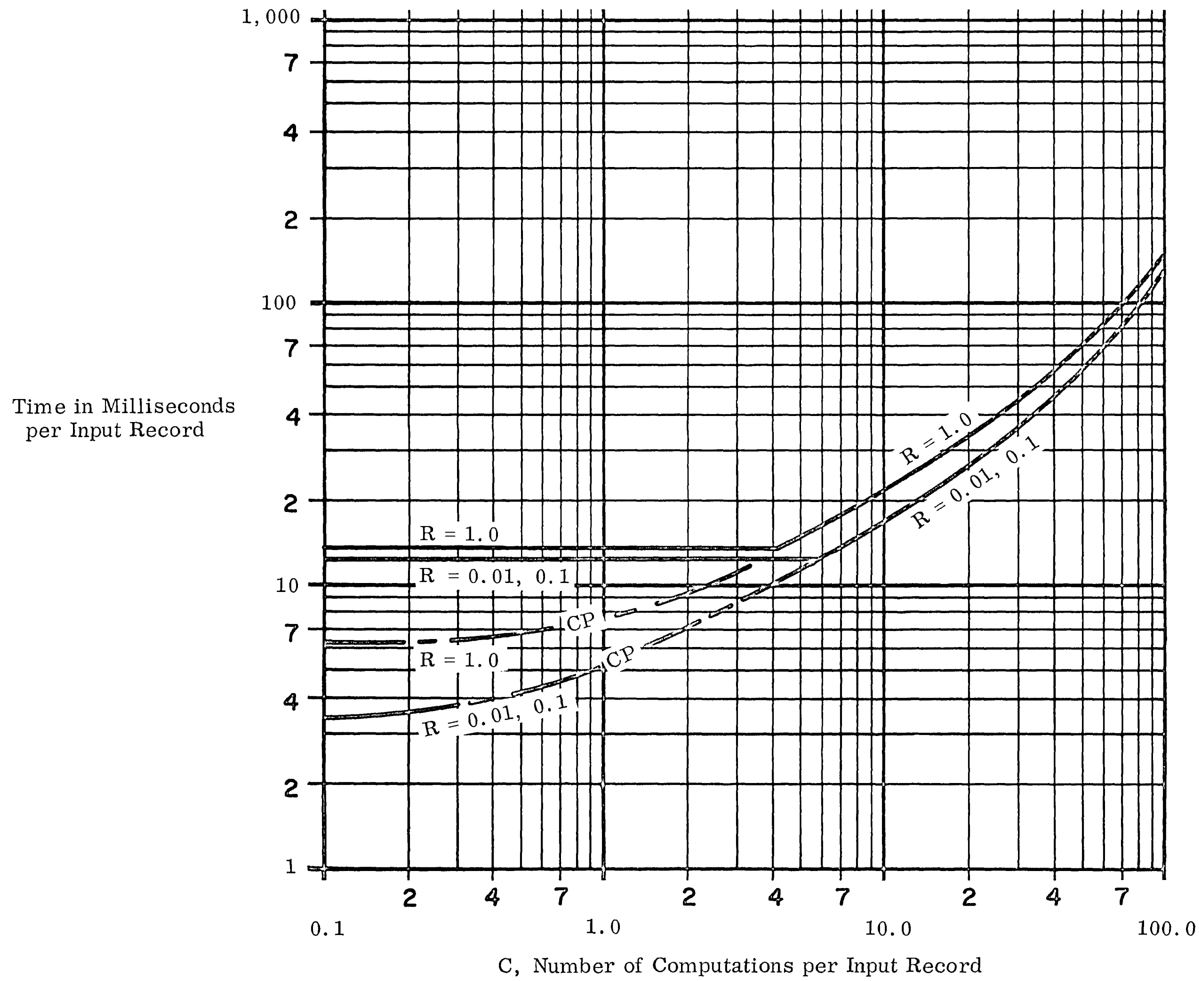
.412 Computation: . . . . 5 fifth-order polynomials, 5 divisions, and 1 square root; computation is in single-precision floating-point mode (8-digit precision).

.413 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.413.

.414 Graph, Configuration VIIA: . . . . see graph below.

.415 Graph, Configuration VIIIA: . . . . see next page.

MAIN PROCESSING RUN, CONFIGURATION VIIA



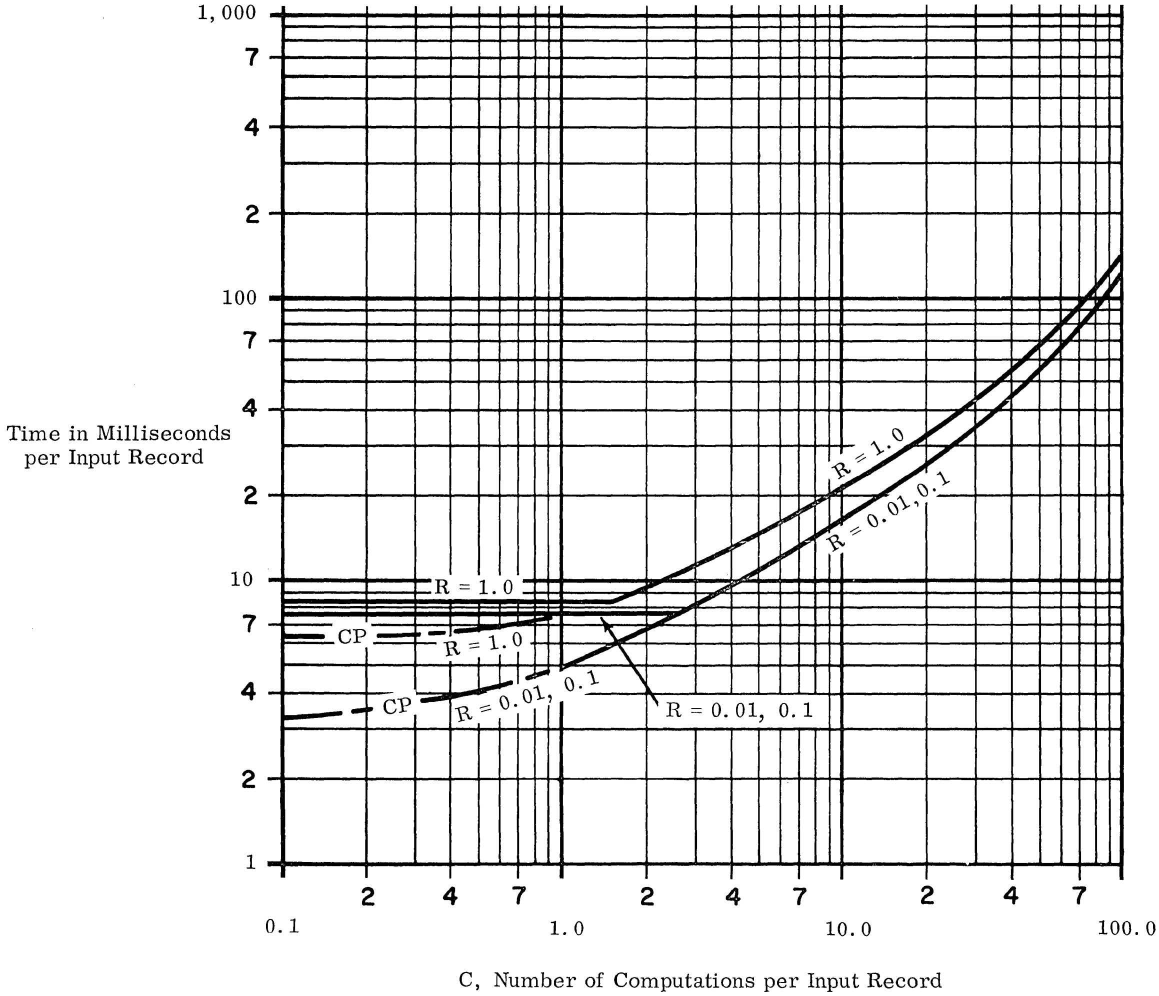
DATA TRANSCRIPTION RUN, CONFIGURATION VIIA

	Milliseconds per Input Record		
	R = 0.01	R = 0.1	R = 1.0
Elapsed time —			
Input (card to tape)	67	67	67
Output (tape to printer)	0.90	9	90
Central Processor time —			
Input*	0.55	0.55	0.55
Output*	0.01	0.09	0.89

*Does not include the time for the I/O control routines.

(Roman numerals denote standard System Configurations.
R = Number of output records per input record.)

MAIN PROCESSING RUN, CONFIGURATION VIIIA



DATA TRANSCRIPTION RUN, CONFIGURATION VIIIA

	Milliseconds per Input Record R = 0.01	R = 0.1	R = 1.0
Elaspsed time —			
Input (card to tape)	67	67	67
Output (tape to printer)	0.90	9	90
Central Processor time —			
Input*	0.55	0.55	0.55
Output*	0.01	0.09	0.89

*Does not include the time for the I/O control routines.

(Roman numerals denote standard System Configurations.
R = Number of output records per input record.)

GE 635

General Electric Company

STANDARD EDP REPORTS

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INTRODUCTION

The GE-635 is characterized by the cycle time of its core storage unit - one microsecond for each access of two 36-bit words.

This report concentrates upon the performance of the GE-635 in particular. All general characteristics of the GE-600 Series hardware and software are described in Computer System Report 340: GE-600 Series - General.

The System Configuration section which follows shows the GE-635 in the following standard configurations:

VIIA: 10-Tape General System (Integrated)

VIIIA: 20-Tape General System (Integrated)

These configurations were selected because multiprogramming is a featured capability of the GE-635. The main processing runs and the input and output data transcription runs are assumed to be running in parallel on the main-frame, so no off-line data transcription facilities are required.

The system configurations are arranged according to the rules in the Users' Guide, page 4:030.120, and any significant deviations from the standard specifications are listed. The main deviation is the inclusion of random access storage; this is necessary to permit use of the standard supervisory routine, GECOS.

Section 344:051 provides detailed central processor timing data for the GE-635. See Section 340:051 for all the other characteristics of the program-compatible GE-600 Series processors.

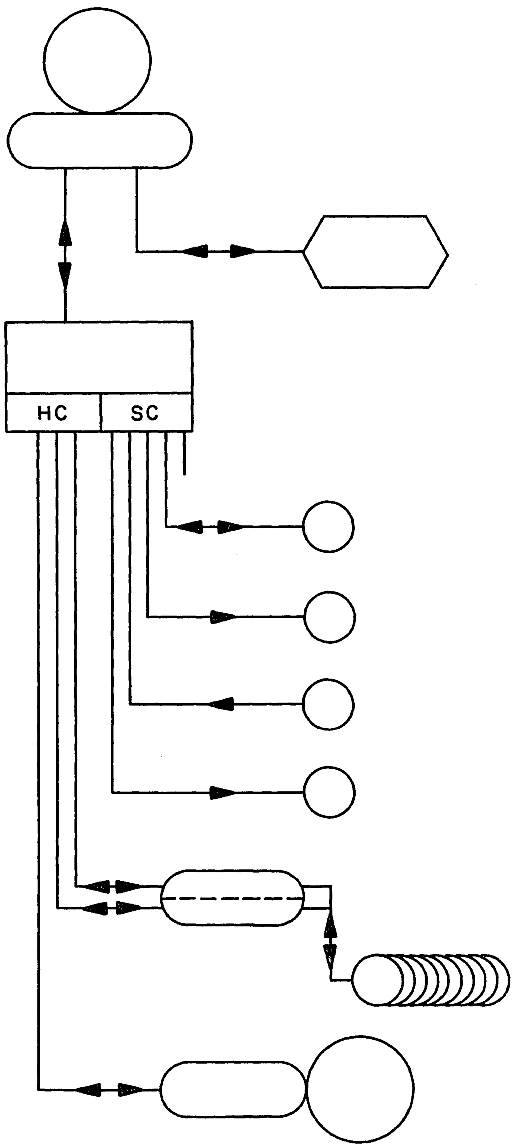
The software that is provided for all GE-600 Series systems is described in Sections 340:151 through 340:191.

A detailed analysis of the GE-635's overall System Performance is provided in Section 344:201.

SYSTEM CONFIGURATION

.1 10-TAPE GENERAL SYSTEM (INTEGRATED); CONFIGURATION VIIA

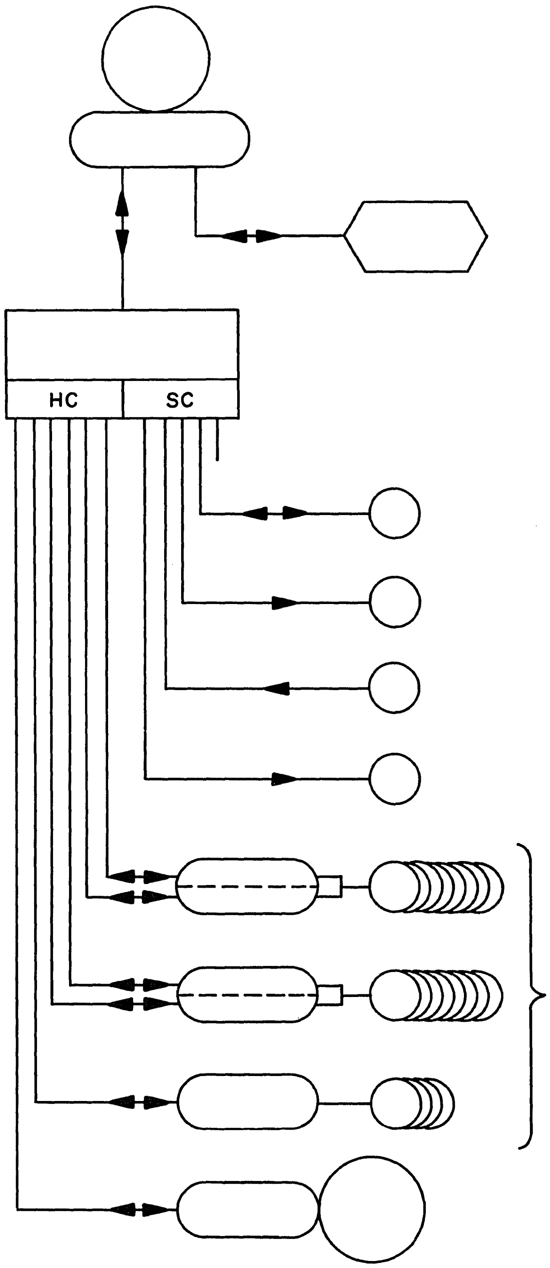
Deviations from Standard Configuration: . . Magnetic drum is required for GECOS.
Core storage is 60% larger.
Printer is up to 140% faster.
Card reader is 40% faster.



Equipment	Rental
MM 8030 - 32K Memory Module and System Controller (includes 32K words of storage and 2 memory ports)	$ 9,500
CP 8030 Central Processor (includes 1 processor port)	16,000
I/O Controller Module (includes 5 standard and 3 high-performance channels and 1 IOC port)	5,400
Console and Typewriter:	400
PR-20 Printer: prints 1200 lines per minute	1,400
CR-20 Card Reader: reads 900 cards per minute	650
CP-10 Card Punch: punches 100 cards per minute	500
Dual Channel Tape Controller	1,380
10 MT-23 Magnetic Tape Units: up to 60,000 characters per second	5,900
MDS 200 Magnetic Drum and Control (786,000 words)	3,300
Motor-Generator Set	270
TOTAL:	$44,700

.2 20-TAPE GENERAL SYSTEM (INTEGRATED): CONFIGURATION VIIIA

Deviations from Standard Configuration: . . Magnetic Drum is required for GECOS. Card punch is 50% faster.



Equipment	Rental
MM 8033 - 40K Memory Module and System Controller (includes 40K words of storage and 2 memory ports)	$10,600
CP 8030 Central Processor (includes 1 processor port)	16,000
I/O Controller Module (includes 5 standard and 6 high-performance channels and 1 IOC port)	5,700
Console and Typewriter:	400
PR-20 Printer: prints 1200 lines per minute	1,400
CR-20 Card Reader: reads 900 cards per minute	650
CP-20 Card Punch: punches 300 cards per minute	825
2 Dual Channel Tape Controllers	3,000
1 Single Channel Tape Controller	900
20 MT-26 Magnetic Tape Units: up to 120,000 characters per second	18,000
MDS 200 Magnetic Drum and Control (786,000 words)	3,300
Motor-Generator Set	270
TOTAL:	$61,045

CENTRAL PROCESSOR

.1 GENERAL

.11 Identity: . . . . CP 8030 Processor Module.

.12 Description

See Section 340:051 for a comprehensive description of the Model CP 8030 Processor Module.

The Instruction Times and Processor Performance times for the GE-635 system are listed below. See Paragraphs 4:050.41 and 4:050.42 of the Users' Guide for the definitions of these standard measures of central processor performance.

.4 PROCESSOR SPEEDS

.41 Instruction Times in Microseconds

		Short (1 word)	Long (2 words)
.411	Fixed point -		
	Add-subtract:		
	To accumulator: .	1.8	1.9
	To storage:. . . .	2.8	-
	Multiply:	7.0	-
	Divide:	14.2	-
.412	Floating point -		
	Add-subtract:		
	Normalized: . . .	2.7	2.7
	Un-normalized: .	2.5	2.5
	Multiply:		
	Normalized: . . .	5.9	11.7
	Un-normalized: .	5.7	11.5
	Divide:	14.2	23.2

.413 Additional allowance for —
Indexing: . . . . . . 0.
Indirect addressing: 1.7 (2.5 if indirect word is modified).
Re-complementing: 0.

.414 Compare -
Fixed point (short): 1.8
Fixed point (long): . 1.9
Floating point (short or long): 2.1
With limits: 2.2
Masked: 2.2

.415 Counter control (indirect addressing) —
Step: 2.5
Step and test: . . . 2.5

.416 Edit: . . . . no direct hardware facilities.

.417 Convert to decimal: . 3.4 (basic 1-digit conversion).

.418 Shift: 1.8

.42 Processor Performance in Microseconds

		Fixed point	Floating point
.421	For random addresses -		
	$c = a + b$:	6.8 (long) 6.1 (short)	7.6 (long) 7.0 (short)
	$b = a + b$:	6.8 (long) 4.6 (short)	7.6 (long) 7.0 (short)
	Sum N items:	1.9N (long) 1.8N (short)	2.7N (long) 2.7N (short)
	$c = ab$:	11.3 (short)	16.6 (long) 10.2 (short)
	$c = a/b$:	18.5 (short)	28.1 (long) 18.5 (short)
.422	For arrays of data -		
	$c_i = a_i + b_j$:	12.8 (long) 12.1 (short)	13.6 (long) 13.0 (short)
	$b_j = a_i + b_j$:	12.8 (long) 11.1 (short)	13.6 (long) 13.0 (short)
	Sum N items: . . .	8.2N (long)* 8.1N (short)*	9.0N (long or short)*
	$c = c + a_ib_j$:	17.6 (short)	25.3 (long) 18.9 (short)
.423	Branch based on comparison -		
	Numeric data: . . .	10.3N	
	Alphabetic data: . .	10.3N	
.424	Switching -		
	Unchecked:	5.2	
	Checked:	9.3	
	List search:	5.8 + 12.6N*	
.425	Format control, per character -		
	Unpack:		
	Without radix conversion: . . .	1.04	
	With radix conversion: . . .	43.2	
	Compose:	14.1	
.426	Table lookup, per comparison -		
	For a match: . . .	12.6*	
	For least or greatest:	9 to 12.	
	For interpolation point:	12.6*	
.428	Moving:	1.8 per word (using Repeat Double loop).	

* These times could possibly be improved with loops using the Repeat instructions, but the timing information is not available to date.

SYSTEM PERFORMANCE

GENERALIZED FILE PROCESSING (343:201.100)

These problems involve updating a master file from information in a detail file and producing a printed record of each transaction. This application is one of the most common commercial data processing jobs and is fully described in Section 4:200.1 of the Users' Guide. Standard File Problems A, B, and C show the effects of varying record sizes in the master file. Standard Problem D increases the amount of computation performed upon each transaction. Each problem is estimated for activity factors (ratios of number of detail records to number of master records) of zero to unity. In all cases a uniform distribution of activity is assumed.

Because multiprogramming is a featured capability of the GE-635, the central processor time requirements are shown on all of the graphs in addition to the usual curves of elapsed time (i.e., total processing time). The difference between the curves of elapsed time and central processor time represents the amount of central processor time that is potentially available for concurrent processing of other programs.

In designing the master file layout for the GE-600 Series, alignment of data items in core storage was carefully considered. Double-word boundaries were observed throughout in order to make use of the various double-word instructions to improve performance efficiency. Penalties due to placement of transfer instructions in even locations and transfers to instructions in odd locations were taken into account; i.e., half were placed in favorable locations and half in unfavorable locations. As there is only one Memory Module in both of our Standard Configurations, no advantage could be taken of simultaneous accesses to core storage. The scatter-gather method of tape reading and writing was not used extensively; instead, individual records were moved by means of the high-speed Repeat Double, Load Double, Store Double loop transfer method.

In the multiprogramming mode of operation, we assume that two programs are run simultaneously. One program, the Processing Run, performs all of the processing prescribed for the Generalized File Processing Problem with the master, detail, and report files all assigned to magnetic tape. The second program is a data Transcription routine that converts magnetic tape records to printed records (the report file) and simultaneously converts records on punched cards (the detail file) to magnetic tape records.

Detailed information is not available to date about the standard Bulk Media Conversion Routines. Consequently, the detail file and report file records on magnetic tape are assumed to be unblocked; i.e., only one record per block. Also, the Central Processor times for the data transcription routine do not include the time for I/O control, because the timing data was not available.

The controlling factor at all activities in all problems for Configuration VIIA is a combination of one master file tape and the report file tape. An average of 85% of the central processor's time is available to process other programs.

Additional tape channels and faster tape units reduce the overall elapsed times for Configuration VIIIA, while the Central Processor times remain the same as for Configuration VIIA. The controlling factor at moderate and high activities is the report file tape; at low activities, it is one master file tape. In Configuration VIIIA, an average of 65% of the central processor's time is available to process other problems.

In both configurations a large portion of the central processor's time is occupied with editing and radix conversions since there are no automatic hardware provisions for these operations.

Elapsed times for the data transcription routine are controlled by the printer at all activities. The amount of central processor time required for this routine is quite small.

SORTING (344:201.200)

The standard estimate for sorting 80-character records by straightforward merging on magnetic tape was developed from the time for Standard File Problem A by the method explained in Paragraph 4:200.213 of the Users' Guide. A three-way merge is used in all system configurations for the GE-635. The results are shown in Graph 344:201.200.

MATRIX INVERSION (344:201.300

The standard extimate for inverting a non-symmetric, non-singular matrix was computed by the simple method described in Paragraph 4:200.312 of the Users' Guide. Computation is performed in single-precision floating-point format (8-digit precision).

GENERALIZED MATHEMATICAL PROCESSING (344:201.400)

The Standard Mathematical Problem A is an application in which there is one stream of input data, a fixed computation to be performed, and one stream of output results. Two variables are introduced to demonstrate how the time for a job varies with different proportions of input, computation, and output. The factor C is used to vary the amount of computation per input record. The factor R is used to vary the ratio of input records to output records. The procedure used for the Standard Mathematical Problem is fully described in Section 4:200.2 of the Users' Guide.

Computations are performed in single-precision floating-point arithmetic, which provides the minimum 8-digit precision prescribed in the Users' Guide.

Again, because multiprogramming is featured in the GE-635, the curves show the central processor time as well as total elapsed time. The performance for both Configurations VIIA and VIIIA is assessed for the multiprogramming mode of operation. The graphs show the time for the main processing run in which the input and output are on magnetic tape and in which all of the prescribed internal processing is performed (including editing and radix conversions). The table beneath the chart shows the times for the corresponding data Transcription run, in which the card-to-tape (input) and tape-to-printer (output) transcriptions are assumed to run simultaneously.

Graph 344:201.400 shows the results for Configuration VIIA with two curves. The curve marked R = 1.0 is for the case in which one output record is written for each input record. The other curve is for the case in which one output record is written for every tenth (R = 0.1) and every hundredth (R = 0.01) input record. (There is no effective difference between the two cases, R = 0.1 and R = 0.01.) For R = 1.0, the output tape is the controlling factor for amounts of computation up to about 8.5 times the standard (i.e., C = 8.5). The input tape is the controlling factor for up to about 9 times the standard amount of computation (i.e., C = 9) for R = 0.1 and R = 0.01.

The results for Configuration VIIIA are shown in a similar manner on graph 344:201.415. Because of the faster tapes, the output tape is the controlling factor for only up to about 3.5 times the standard computation (C = 3.5) for R = 1.0, and the input tape is the controlling factor for only up to about 5 times the standard computation for R = 0.1 and R = 0.01.

WORSHEET DATA TABLE 1 (STANDARD FILE PROBLEM A)							
	ITEM		CONFIGURATION				REFERENCE
			VIIA		VIIIA		
1 Input-Output Times	Char/block	(File 1)	960		960		4:200.112
	Records/block	K (File 1)	10		10		
	msec/block	File 1 = File 2	28.0		15.3		
		File 3	13.3*		8.0*		
		File 4	14.0*		8.3*		
	msec/switch	File 1 = File 2	0		0		
		File 3	0		0		
		File 4	0		0		
	msec penalty	File 1 = File 2	0.16		0.16		
		File 3	0.02		0.02		
		File 4	0.02		0.02		
2 Central Processor Times	msec/block	a_1	0.09		0.09		4:200.1132
	msec/record	a_2	0.10		0.10		
	msec/detail	b_6	1.75		1.75		
	msec/work	$b_5 + b_9$	0.17		0.17		
	msec/report	$b_7 + b_8$	1.73		1.73		
3 System Performance at F = 1.0	msec/block for C.P. and dominant column.		C.P.	Tapes	C.P.	Tape	4:200.114
		a_1	0.09		0.09		
		a_2 K	1.03		1.03		
		a_3 K	26.51		26.51		
		File 1 Master In	0.16	28.0	0.16		
		File 2 Master Out	0.16		0.16		
		File 3 Details	0.17		0.17		
		File 4 Reports	0.24	140.0	0.24	83.2	
		Total	28.36	168.0	28.36	83.2	
4 Storage Space Required	Unit of measure:	words					4:200.1151
		Std. routines	†		†		
		Fixed	32		32		
		3(Blocks 1 to 23)	213		213		
		6(Blocks 24 to 48)	1,422		1 422		
		Files	710		710		
		Working	50		50		
		Total	2,427†		2,427†		

* Files 3 and 4 are on magnetic tape for the main Processing run.
† Does not include 8,192 words required for standard supervisory routine, GECOS.

WORKSHEET DATA TABLE 2 (STANDARD MATHEMATICAL PROBLEM A)					
	ITEM		CONFIGURATION		REFERENCE
			VIIA	VIIIA	
5 Standard Mathematical Problem A	Fixed/Floating point		Floating point	Floating point	4:200.413
	Unit name	input	Model MT-23 Tape	Model MT-26 Tape	
		output	Model MT-23 Tape	Model MT-26 Tape	
	Size of record	input	80 char.	80 char.	
		output	130 char.	130 char.	
	msec/block	input T_1	13.3	8.0	
		output T_2	14.2	8.4	
	msec penalty	input T_3	0.02	0.02	
		output T_4	0.03	0.03	
	msec/record	T_5	2.33	2.33	
	msec/5 loops	T_6	1.10	1.10	
	msec/report	T_7	2.01	2.01	

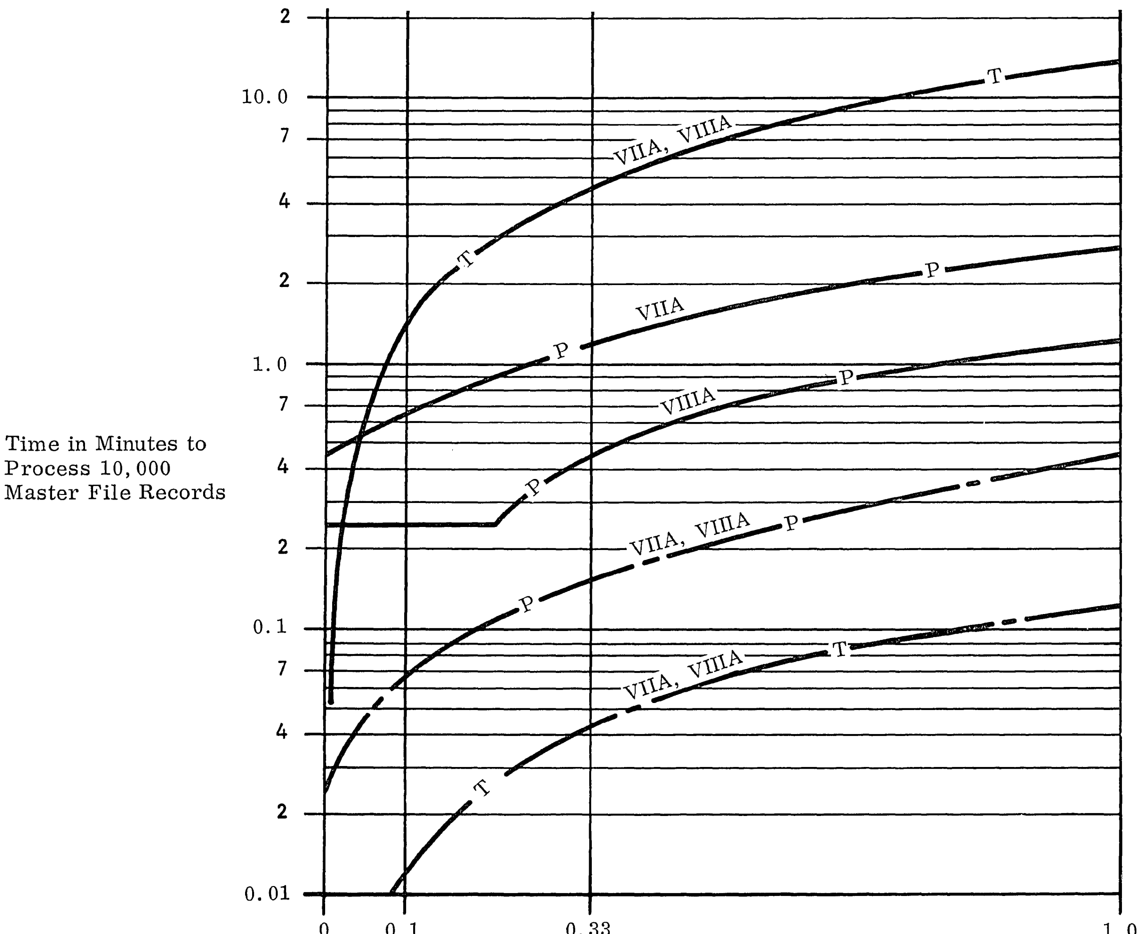
SYSTEM PERFORMANCE

.1 GENERALIZED FILE PROCESSING

.11 Standard File Problem A

.111 Record sizes –
Master file: . . . . 108 data characters (16 words)
Detail file: . . . . 1 card.
Report file: . . . . 1 line.
.112 Computation: . . . . standard.
.113 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.113; see also the explanation on page 344:201.001.
.114 Graph: . . . . see graph below.
.115 Storage space required –
Configuration VIIA and VIIIA . . . . 2,427 words.*

* Does not include 8,192 words required for the standard supervisory routine, GECOS. All I/O control routines, editing routines, radix conversion routines, etc., are within GECOS.



LEGEND

P — Elapsed time for main Processing run.
T — Elapsed time for data Transcription runs.
P — Central Processor time for main Processing run.
T — Central Processor time for data Transcription runs.

(Roman numerals denote standard System Configurations.)

.12 Standard File Problem B

.121 Record sizes —

Master file: . . . . 54 data characters (8 words).

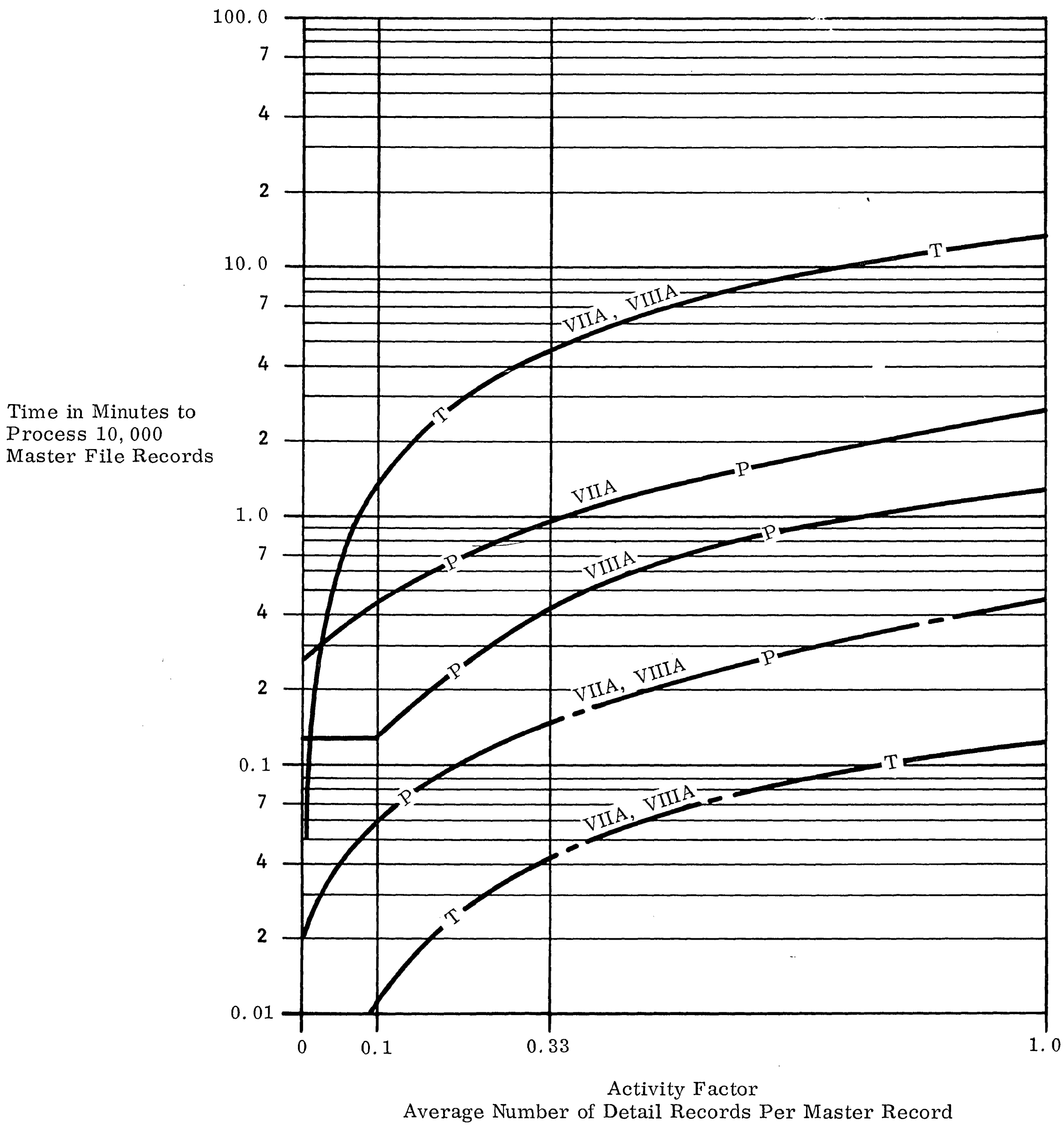
Detail file: . . . . 1 card.

Report file: . . . . 1 line.

.122 Computation: . . . . standard.

.123 Timing Basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.12; see also the explanation on page 344:201.001.

.124 Graph: . . . . see graph below.



LEGEND

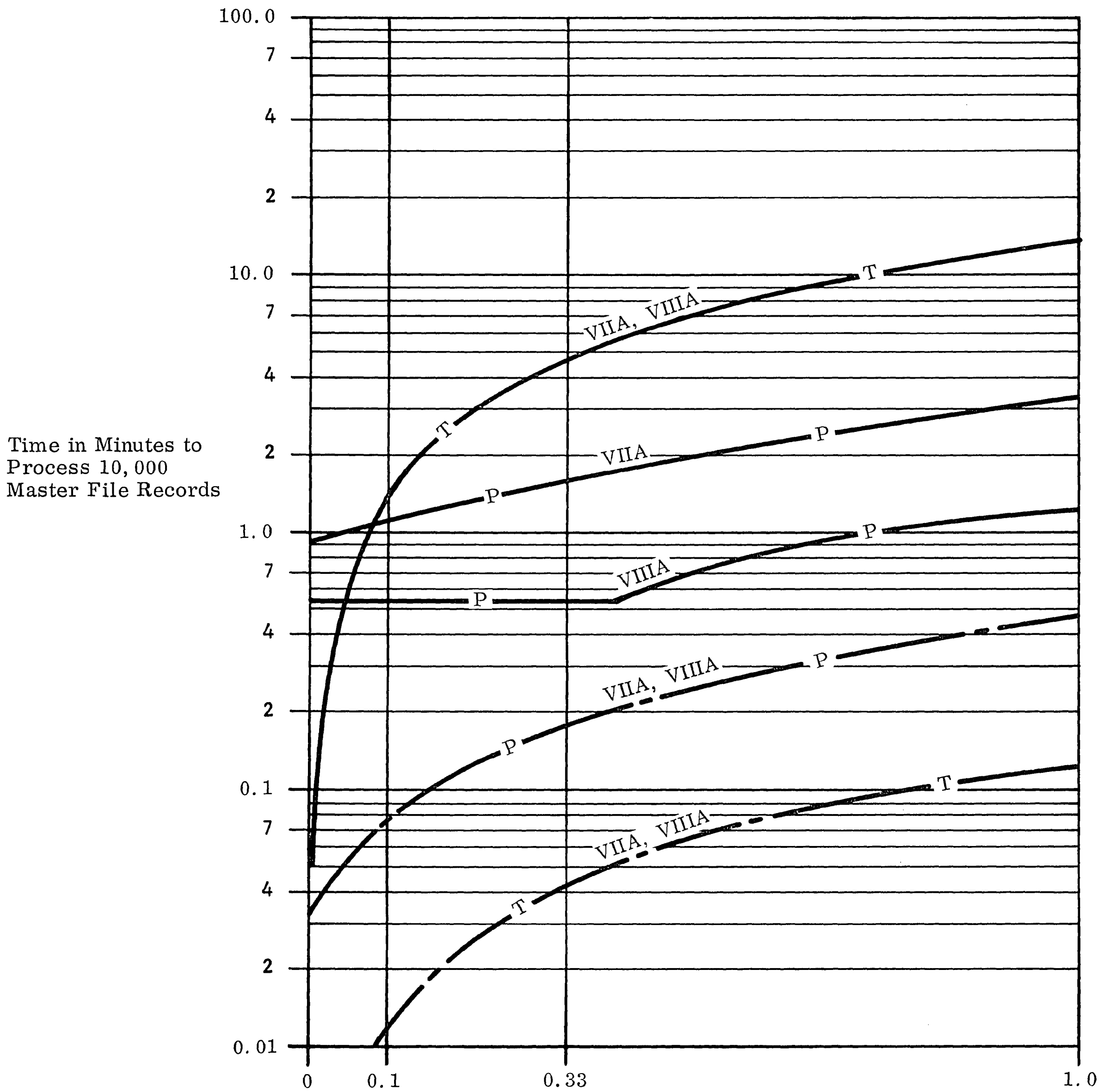
P —— Elapsed time for main Processing run.
T —— Elapsed time for data Transcription runs.
P — - — Central Processor time for main Processing run.
T — - — Central Processor time for data Transcription runs.

(Roman numerals denote standard System Configurations.)

.13 Standard File Problem C

.131 Record sizes –
Master file: . . . . 216 data characters (32 words).
Detail file: . . . . 1 card.
Report file: . . . . 1 line.

.132 Computation: . . . . standard.
.133 Timing basis: . . . . . . using estimating procedure outlines in Users' Guide, 4:200.13.
.134 Graph: . . . . see graph below.



Activity Factor
Average Number of Detail Records Per Master Record

LEGEND

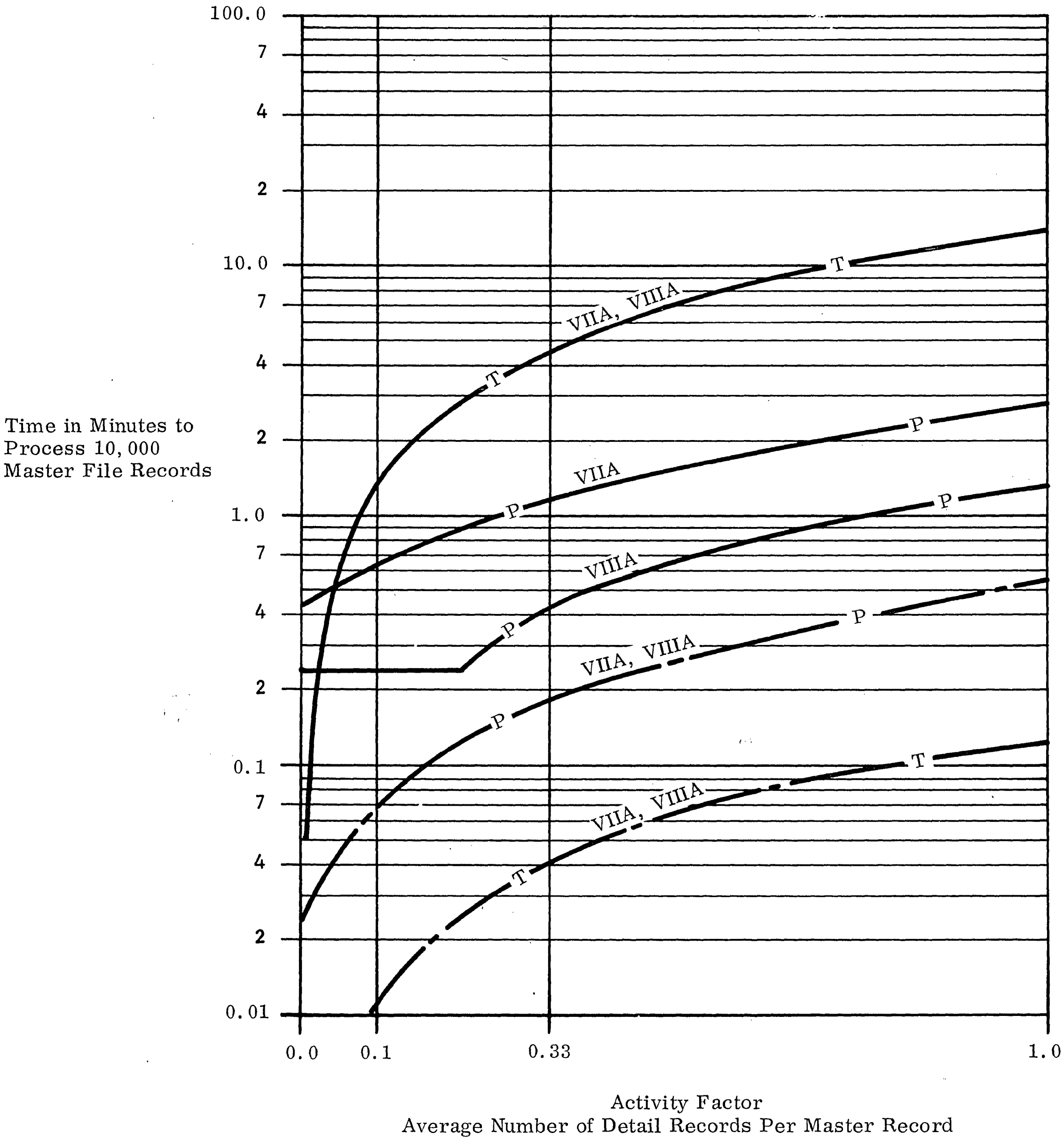
P Elapsed time for main Processing run.
T Elapsed time for data Transcription runs.
P Central Processor time for main Processing
T Central Processor time for data Transcriptio

(Roman numerals denote standard System Configurations.)

.14 Standard File Problem D

.141 Record sizes —
Master file: . . . . 108 data characters (16 words).
Detail file: . . . . 1 card.
Report file: . . . . 1 line.

.142 Computation: . . . . trebled.
.143 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide. 4:200.14.
.144 Graph: . . . . see graph below.



LEGEND

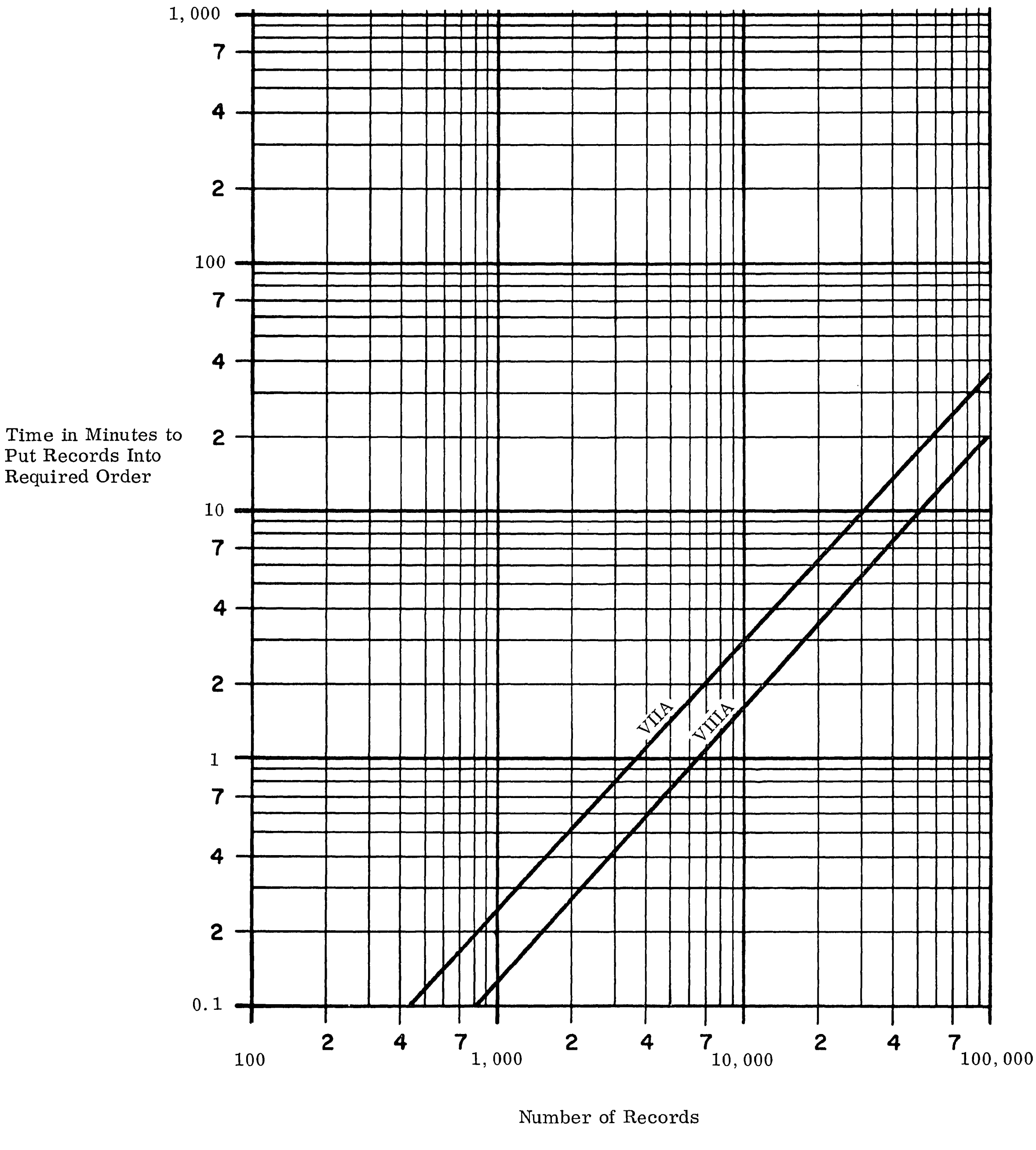
P Elapsed time for main Processing run.
T Elapsed time for data Transcription runs.
P Central Processor time for main Processing run.
T Central Processor time for data Transcription runs.

(Roman numerals denote standard System Configurations.)

.2 SORTING

.21 Standard Problem Estimates

.211 Record size: . . . . 80 characters.
.212 Key size: . . . . 8 characters.
.213 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.213.
.214 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

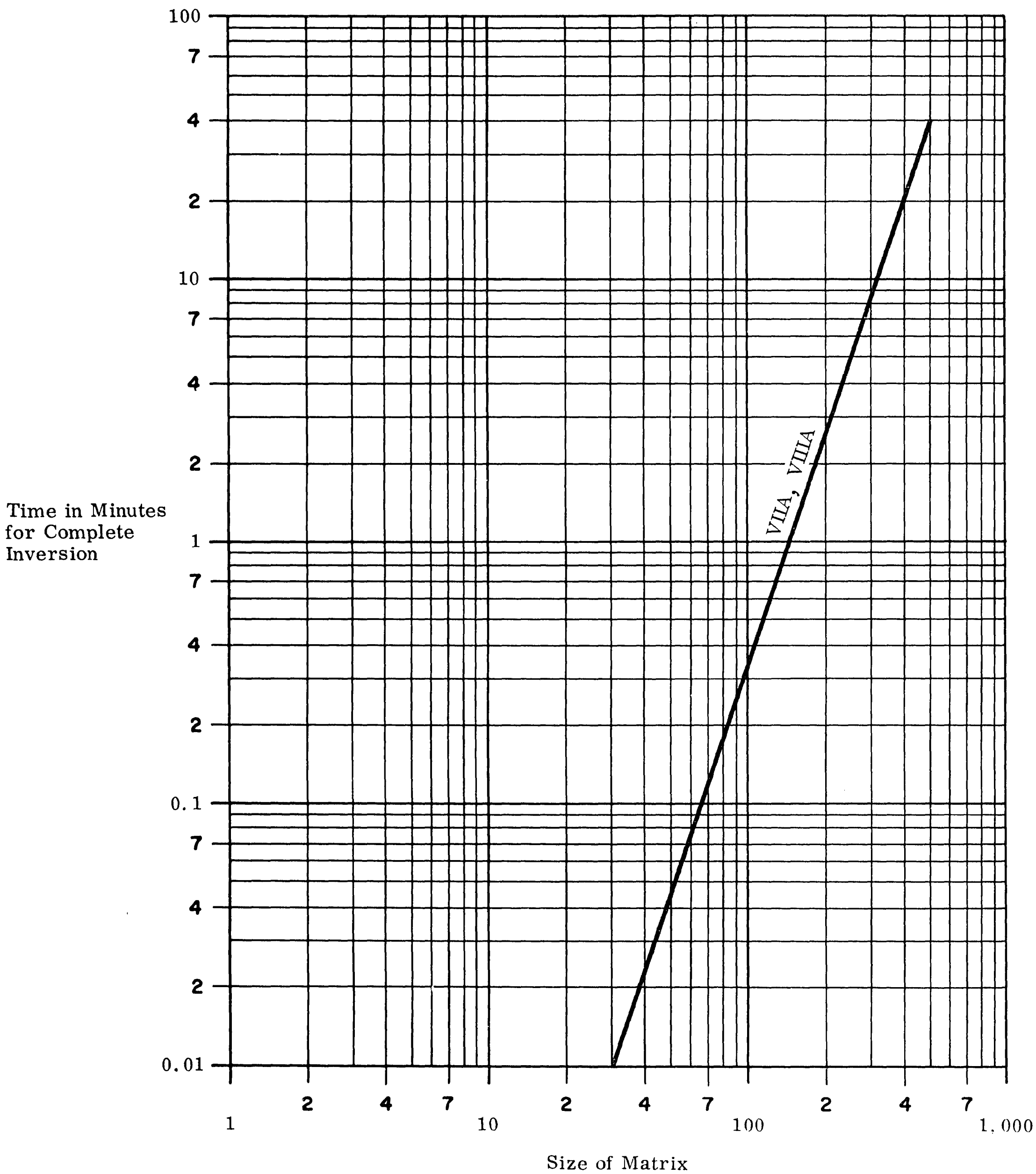
.3 MATRIX INVERSION

.31 Standard Problem Estimates

.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits (single-precision).

.312 Timing basis. . . . . . . using estimating procedure outlined in Users' Guide, 4:200.312.

.313 Graph: . . . . see graph below.



(Roman numerals denote standard System Configurations.)

.4 GENERALIZED MATHEMATICAL PROCESSING

.41 Standard Mathematical Problem A Estimates

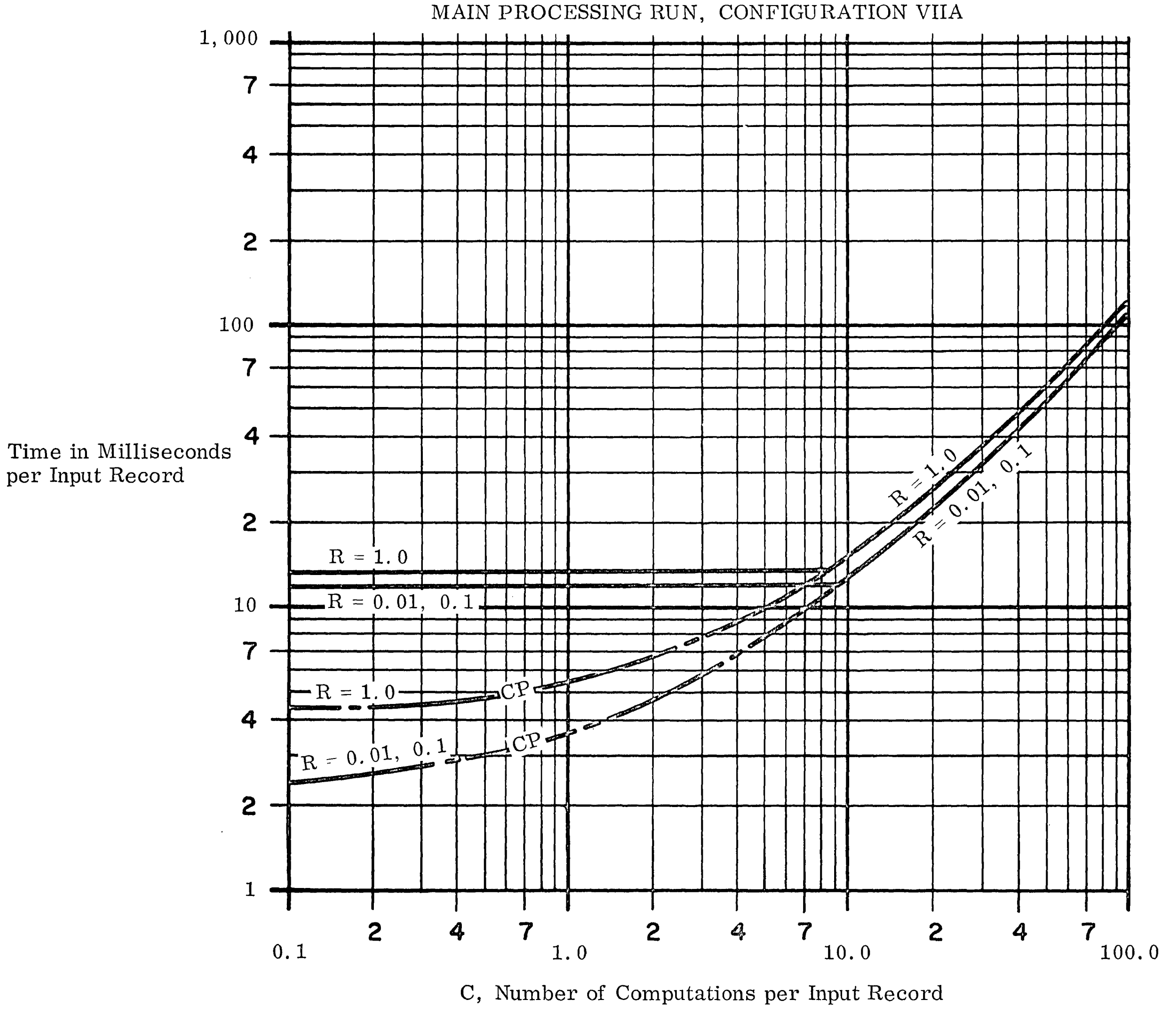
.411 Record sizes: . . . . . . 10 signed numbers, avg. size 5 digits, max. size 8 digits.

.412 Computation: . . . . 5 fifth-order polynomials, 5 divisions, and 1 square root; computation is in single-precision floating-point mode (8-digit precision).

.413 Timing basis: . . . . . . using estimating procedure outlined in Users' Guide, 4:200.413.

.414 Graph, Configuration VIIA: . . . . see graph below.

MAIN PROCESSING RUN, CONFIGURATION VIIA



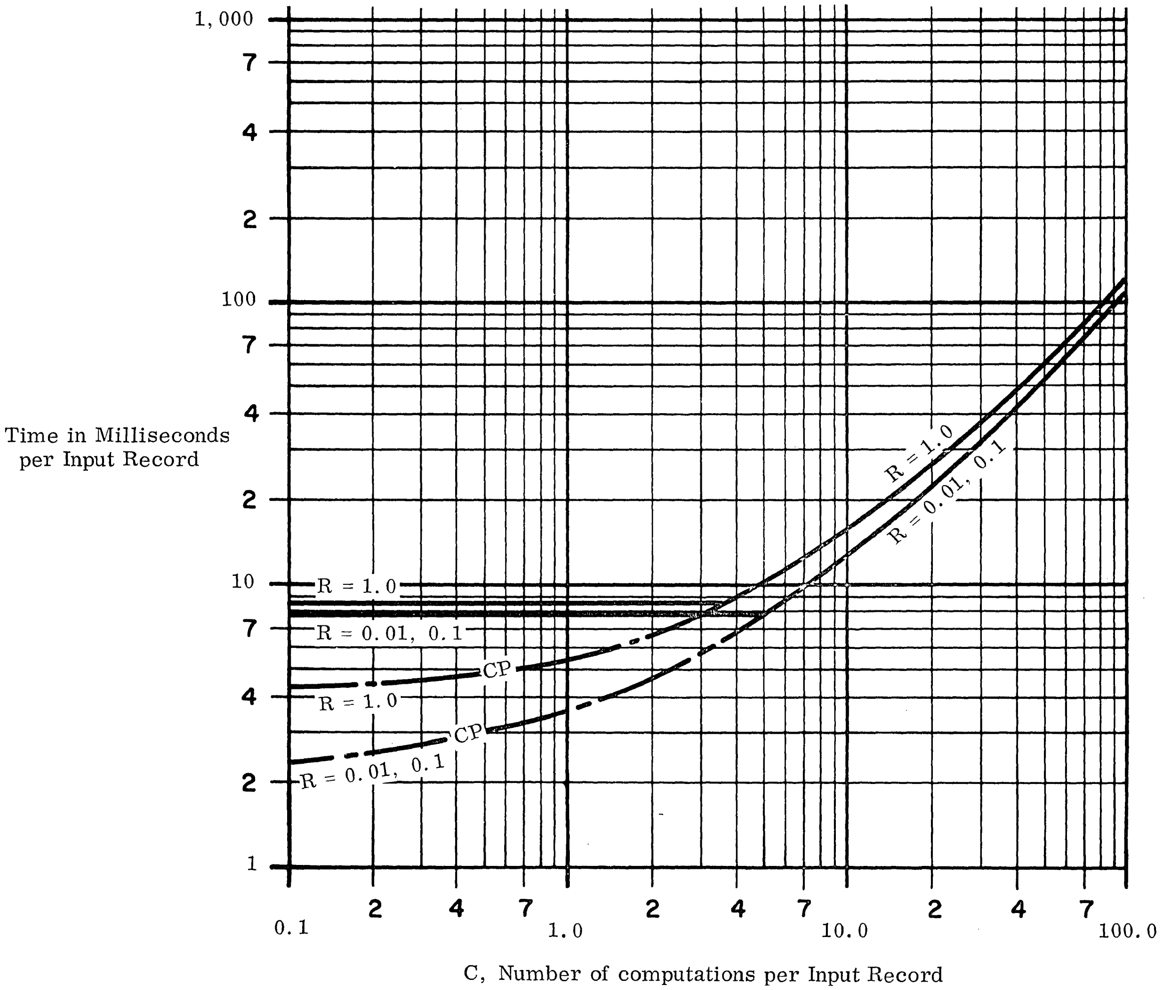
DATA TRANSCRIPTION RUN, CONFIGURATION VIIA

	Milliseconds per Input Record		
	R=0.01	R=0.1	R=1.0
Elapsed time —			
Input (card to tape)	67	67	67
Output (tape to printer)	0.90	9.0	90
Central Processor time —			
Input*	0.55	0.55	0.55
Output*	0.01	0.09	0.89

* Does not include the time for the I/O control routines.

(Roman numerals denote standard System Configurations; R = Number of output records per input record.)

.415 Graph, Configuration VIIIA:. . . . . see graph below.



DATA TRANSCRIPTION RUN, CONFIGURATION VIIIA

	Milliseconds per Input Record		
	R=0.0.	R=0.1	R=1.0
Elapsed time —			
Input (card to tape)	67	67	67
Output (tape to printer)	0.90	9.0	90
Central Processor time —			
Input*	0.55	0.55	0.55
Output*	0.01	0.09	0.89

*Does not include the time for the I/O control routines.

(Roman numerals denote standard System Configurations; R = Number of output records per input record.)

RPC 4000

General Precision, Inc.

STANDARD EDP REPORTS
AUERBACH

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CONTENTS

INTRODUCTION

The RPC-4000 is a desk size data processing system suitable for a wide range of complex but relatively low-volume engineering and scientific problems, and for certain business applications where high input-output speeds are not essential. It is an expanded and improved version of the earlier LGP-30 of the same manufacturer, providing solid state circuits, doubled storage, and one-plus-one instruction addressing.

The standard configuration is the 4010 Computer and the 4500 Tape Typewriter System, which consists of a reader/punch unit for paper tape, and a typewriter used for input with hard copy and for output. Optional units available are additional Tape Typewriter Systems, a 500 character per second paper tape reader, and a 300 character per second tape punch. If input-output radix conversion is required, the speeds of these fast devices are reduced sharply from their peak speeds.

Each word location can hold either a one-plus-one address instruction, a data word 31 bits long (equivalent to 9 decimal digits), five alphanumeric characters in six-bit form, or eight hexadecimal characters. Access time to a location varies from 0.26 to 16.7 milliseconds.

Words are stored in bit serial form on 125 main bands and on one fast-access band of the drum storage, for a total of 8,008 words. Each main band stores 64 words and has a cycle time of 16.7 milliseconds. Two of the main storage bands provide access at two points to the stored data, reducing access time.

A set of 32 instructions and one index register are provided for arithmetic, logic, and input-output operations. When instructions and operands are in optimum locations, instructions may be executed at an approximate rate of 1,000 per second. Multiply and divide operations are carried out at an approximate rate of 60 per second. The repertoire includes a Repeat instruction which provides an execution phase at consecutive word times. This function has value in block transfers (maximum of eight words), table comparisons (64 usable comparisons), and summing of values (64 locations).

Output instructions punch or type one character per instruction, and overlap punching and typing with computation. Single character mode input operations overlap paper advance with computation. However, input and output are generally performed by subroutines which handle a number of digits and perform radix conversion and editing. Parity checking is provided when reading from paper tape, but there is no parity check on words in storage.

Programming may be done in machine language or in the symbolic ROAR language. The ROAR translator produces reasonably optimized machine language programs.

Floating point operations may be performed by routines assembled by ROAR or by COMPACT, or by using the PINT interpretive system developed by Purdue University. COMPACT is an algebraic compiler which accepts FORTRAN II language and additional COMPACT statements.

Problem-oriented facilities are oriented toward floating point arithmetic operations and trigonometric functions. There are a few diagnostic routines such as trace, dump, and program checkout.

Utility routines provide for the interpretive execution of LGP-30 machine code tapes and interpretive language tapes. These provide access to the more than 200 subroutines and utility routines available from the manufacturer and from POOL, the LGP-30 and RPC-4000 Users' Organization. POOL has established an unusually effective system for review and evaluation of submitted routines, and only those routines which meet all of its standards are distributed.

DATA STRUCTURE

§ 021.

.1 STORAGE LOCATIONS

Name of Location	Size	Purpose or Use
Sector:	32 bits	working storage.
Register:	1 or 8 sectors	computer registers.
Branch Control:	1 bit	overflow indicator.

.2 DATA FORMATS

Type of Data	Representation
Numeral:	6 bits + parity bit on paper tape row.
Hexadecimal Character:	4 bits + parity bit on paper tape row.
Letter or Symbol:	6 bits + parity bit on paper tape row.
Word:	32 bits in processor.
Number:	word of 31 bits + sign.
Instruction:	word of 32 bits.

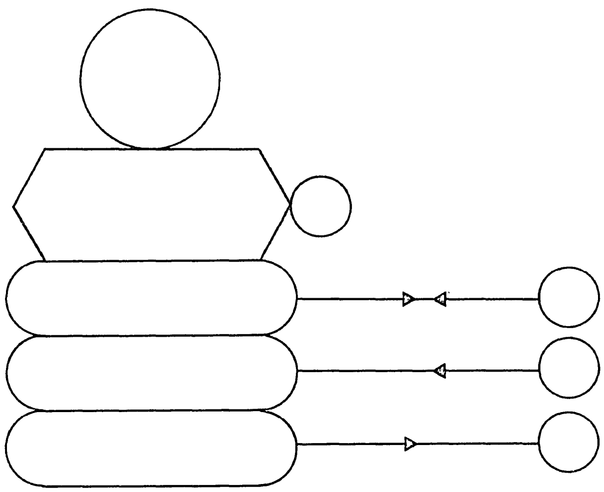
SYSTEM CONFIGURATION

§ 031.

IX. DESK SIZE SCIENTIFIC

Deviations from Standard Configuration: . . . . reader is 50 char/sec faster.
punch is 30 char/sec faster.

Rentals: . . . . $1,750 per month.



Drum Storage: 8,008 words.

Processor and Console.

Typewriter and Controller.

Paper Tape Reader and Controller.

Paper Tape Punch and Controller.

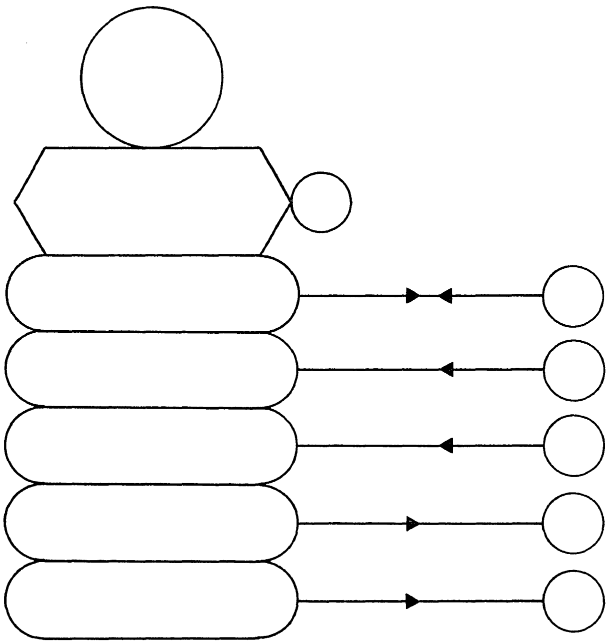
Optional Features Included: . . . . 1 index register.

§ 031.

X. PUNCHED TAPE SCIENTIFIC

Deviations: . . . . no floating point hardware.
only 1 input/output channel.

Rental: . . . . $2,450 per month.



Drum Storage: 8,008 words.

Processor and Console.

Typewriter and Controller.

Paper Tape Reader (60 char/sec.) * and Controller.

Paper Tape Reader (500 char/sec.) and Controller.

Paper Tape Punch (30 char/sec.) * and Controller.

Paper Tape Punch (300 char/sec.) and Controller.

* These are supplied as standard equipment.

INTERNAL STORAGE: MAGNETIC DRUM

§ 041.

.1 GENERAL

.11 Identity: . . . . magnetic drum.

.12 Basic Use: . . . . working storage.

.13 Description:

The Magnetic Drum provides the working storage for, and is a part of, the 4010 Computer. The drum contains storage locations for 8,008 words; each location is individually addressable and has 32 bit positions. The word may be interpreted as a 31-bit word (binary equivalent of 9 decimal digits) with a sign bit, or a 32-bit instruction. There is no parity bit in the word. In addition to the working storage, the drum provides storage space for the four computer registers.

Rotation speed of the drum is 3,600 revolutions per minute, providing a maximum waiting time for a word of 16.667 milliseconds. Basic storage consists of 123 bands of 64 words or sectors each, with word transfer time of 0.260 milliseconds. Two additional bands are dual-access bands, with two read/record heads on each band. On one of the dual-access bands the heads are separated by 16 word times, and on the other, by 24 word times. Each head is separately addressed in an instruction. Thus the general access to a word in a dual access band is unaffected, but a second access to the same word can be made in one-quarter or three-eighths of a revolution. A third additional band stores only eight words, allowing reading of a given word every eight word times, or a maximum of 2.08 milliseconds waiting time. Each of the eight words has eight sector addresses around a band, and the proper sector address must be given to obtain the desired word in minimum time. The drum includes a timing track used for sector identification and for general timing purposes.

The drum includes a timing track used for sector identification and for general timing purposes.

All data transfers to or from drum storage are made via the computer registers.

Data on the drum may be protected from being erased. Toggle switches are provided to prevent recording on groups of bands, 16 bands to a group. All bands may be so protected, permitting reading, but not recording.

.14 Availability: . . . . 60 days.

.15 First Delivery: . . . . . October, 1960.

.16 Reserved Storage: . . . none.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . magnetic drum.

.222 Drum
- Diameter: . . . . . . ?
- Thickness or length: . ?
- Number on shaft: . . 1.

.23 Storage Phenomenon: . . magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . yes.
.242 Data regenerated constantly: . . . . no.
.243 Data volatile: . . . . . . no.
.244 Data permanent: . . . . no.
.245 Storage changeable: . . . no.

.25 Data Volume Per Band of 1 Track

- Words: . . . . 64.
- Bits: . . . . 2,048.
- Digits: . . . . 576 equivalent decimal digits in binary form.
- Instructions: . . . . . . 64.

.26 Bands Per Physical Unit: 126, plus 4 additional bands for central processor registers, plus one clock track.

.27 Interleaving Levels: . . 1.

.28 Access Techniques

.281 Recording method: . . . fixed heads.
.283 Type of access

Description of stage	Possible starting stage
Wait for start of addressed word . .	yes.
Transfer data:	no.

.29 Potential Transfer Rates

.291 Peak bit rates
- Cycling rates . . . . . 3,600 rpm.
- Track/head speed: . . . ? inches/sec.
- Bits/inch/track: . . . . ?
- Bit rate per track: . . . 123,000 bits/sec/track.

.292 Peak data rates
- Cycling rate: . . . . . . 60 cycles/sec.
- Unit of data: . . . . . . word.
- Conversion factor: . . . 32 bits/word.
- Gain factor: . . . . . . 1.
- Loss factor: . . . . . . 1.
- Data rate: . . . . 3,840 words/sec.

§ 041.

.3 DATA CAPACITY

.31 Module and System Sizes

Drums: . . . . 1.
Words: . . . . 8,008.
Instructions: . . . . . . 8,008.
Decimal digits
(in binary equivalent): 72,072.
Modules: . . . . 1.

.4 CONTROLLER: . . . . . none.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of Stacks

Stacks per system: . . 128.
Stacks per module: . . 128.
Stacks per yoke: . . . . 1, on 124 tracks; 2, on 2 tracks.

.512 Stack movement: . . . . none.

.513 Stacks that can access any particular location . . . . 1 on 124 tracks; 2 on 2 tracks.

.514 Accessible locations
By single stack: . . . . 64 words on 125 tracks; 8 words on 1 track.
By all stacks: . . . . . 8,008 words.

.515 Relationship between stacks and locations. . 3 most significant digits of 5-digit decimal address.

.52 Simultaneous Operations: . . . . none.

.53 Access Time Parameters and Variations

.532 For variable access

Stage	Time, μ sec.	Example, μ sec.
Wait for start of addressed word		
Main storage:	0 to 16,667	8,333.
Dual access track, 1st access:	0 to 16,667	8,333.
Dual access track, 2nd access:	4,160 to 6,240, depending on track used.	
High speed access track:	0 to 2,080	1,040.
Transfer data:	260	260.

.6 CHANGEABLE STORAGE: none.

.7 PERFORMANCE

.71 Data Transfer

Pair of storage units possibilities
With self: . . . . yes, programmed via computer control registers.

.72 Transfer Load Size: . . 1 word normally; can be 1 to 8 words in Repeat Mode.

.73 Effective Transfer Rate

With self: . . . . approx. 4 words/drum revolution; 240 words/second; in words of 32 bits.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	none.	
Invalid code:	none.	
Receipt of data:	none.	
Recording of data:	programmed re-read only.	
Recovery of data:	none.	
Dispatch of data:	none.	
Timing conflicts:	interlock	wait.
Reference to locked area:	none.	

CENTRAL PROCESSOR

§ 051.

.1 GENERAL

.11 Identity: . . . . Computer.
Model 4010.

.12 Description

The RPC-4000 Central Processor is a serial binary unit, operating on signed 31-bit words (2's complement). The word size is equivalent to nine decimal digits. A one-plus-one address instruction is used. Fully-optimized programming can be performed at the rate of 1,000 instructions per second. Operand addresses can be indexed, using the single index register.

The processor has four one-word serial registers; upper, lower, index, and instruction, each with a cycle time of 260 microseconds.

The processor contains a useful set of instructions, including the shift, normalize, and logic (Boolean) operations. Multiply and divide instructions are part of the standard instruction repertoire. Convert and floating point operations, however, are performed by subroutines. The processor has two additional facilities: Repeat Mode, and Lengthened Accumulator Mode.

Repeat Mode causes the instruction being repeated to perform its execution phase on successive words of storage. The program specifies the number of repeats to occur, up to a maximum of 127 times. The words used as operands are from one track only, therefore, if the repeat specified is greater than 63 (first operation followed by 63 repeats) some words will be accessed two times. The instruction is useful in the operations of table look-up, comparison, and block transfer (a maximum of eight words to or from the lengthened lower accumulator).

In the Lengthened Accumulator Mode, the lower accumulator is extended to a length of eight words. The extended length is useful in block transfers and in receiving input data. In this mode input data can be 64 hexadecimal characters or 72 six-bit characters in length.

The instructions provide for operating on one-word length operands. The result of a multiplication is two words in length, and the dividend for a divide operation may also be two words in length. An overflow condition results in the setting of a testable indicator, and the processor continues with the next instruction. Six manually-set sense switches are available to the program.

The 8-word fast-access band is useful in reducing access time to certain instructions or operands. Each of the 8 words in the fast access band is repeated 8 times around the drum and therefore has 8 separate sector addresses. To obtain a particular fast-access word in the minimum time, the proper address of its 8 sector addresses must be specified. This requirement may reduce the effectiveness of the fast-access band in some applications.

Input commands can read in one of two modes; either a character, or a block of characters terminated by a stop code. The input mode is set by a manual switch. The output command transfers one six-bit character while input characters may be four or six bits in size, selected by the program.

Multiple-character input and output transfer subroutines are available. Generally input, output and computation are performed sequentially.

Programs may be optimized by programmers when hand-coded, or by the ROAR Assembler, when coded in assembly language.

.13 Availability: . . . . . . 60 days.

.14 First Delivery: . . . . October, 1960.

.2 PROCESSING FACILITIES

.21 Operations and Operands

	Operation and Variation	Provision	Radix	Size
.211	Fixed point			
	Add-subtract	automatic	binary	31 bits (1 word).
	Multiply			
	Short:	none.		
	Long:	automatic	binary	31 bits (1 word).
	Divide			
	No remainder:	none.		
	Remainder			
	1-word dividend:	automatic	binary	31 bits.
	2-word dividend:	automatic	binary	31 bits.
.212	Floating point			
	Add-subtract:	subroutine	binary	9 & 2; 2 words.
	Multiply:	subroutine	binary	9 & 2; 2 words.
	Divide:	subroutine	binary	9 & 2; 2 words.
.213	Boolean			
	AND:	automatic	binary	31 bits (1 word).
	Inclusive OR:	none.		
	Masked Merge: $L = (U \wedge M) \vee (\bar{U} \wedge M)$*	automatic	binary	31 bits (1 word).

* See MML on Instruction List.

.214	Comparison			
	Numbers:	automatic		1 to 31 bits.
	Absolute:	none.		
	Letters:	treated as binary word		1 to 31 bits.
	Mixed:	treated as binary word		1 to 31 bits.
	Collating sequence:	0 to 9, A to Z, specials.		

§ 051.

.215 Code translation
Provision: . . . . none.

.216 Radix conversion

Provision	From	To	Size
subroutine*	BCD fixed or floating point	binary floating point	9 BCD digits.
subroutine*	binary fl. pt.	BCD fl. pt.	8 or 9 dec. digits.

* during input-output operations only.

.217 Edit format
Provision: . . . . none.

.218 Table look-up

	Provision	Size
Equality:	automatic*	1 to 64 words.
Greater than or equal:	automatic*	1 to 64 words.
Greatest:	none.	
Least:	none.	

* When using Repeat Mode.

.219 Others

	Provision	Comment
Normalize:	automatic	double length accumulator.
Shift:	automatic	double length accumulator.
Branch on sign:	automatic.	
Repeat:	automatic	execute 1 instr. up to 128 times.

.22 Special Cases of Operands

.221 Negative numbers: . . . 2's complement form.
.222 Zero: . . . . positive zero.

.23 Instruction Formats

.231 Instruction structure:. . 1 word.
.232 Instruction layout:

Part	Command	Data Track	Data Sector	Next Track	Next Sector	Index Tag
Size (bits)	5	7	6	7	6	1

.233 Instructions parts

Name	Purpose
Command:	operation code.
Data track:	track address of operand.
Data sector:	sector address of operand.
Next track:	track address of next instruction.
Next sector:	sector address of next instruction.
Index tag:	indicate whether operand address is to be incremented.

.234 Basic address structure: . . . . . . 1 + 1.
.235 Literals
Arithmetic: . . . . . none.
Comparisons and tests: . . . . 13 bits, index register only.
Load index register: 13 bits.
Incrementing modifiers: . . . . . 13 bits, by indexing load index command.
Shift specification: . 31 bit positions.
Repeat count: . . . . 7 bits.
Char for printing: . . 1 char.

.236 Directly addressed operands
.2361 Internal storage
Type: . . . . working storage.
Size: . . . . 8,008 words.
Volume accessible: all.
.2362 Increased address capacity: . . . . . . none.
.237 Address indexing
.2371 Number of methods: 1.
.2372 Name: . . . . index modification.
.2373 Indexing rule: . . . . add operand address and contents of index register. Carry lost if overflow.
.2374 Index specification: . within instruction.
.2375 Number of potential indexers: . . . . . 1.
.2376 Addresses which can be indexed: . . . . all operand addresses.
.2377 Cumulative indexing: none.
.2378 Combined index and step: . . . . none.
.238 Indirect addressing: . none.
.239 Stepping: . . . . no automatic stepping of index register contents. Program must change contents or add to contents.

.24 Special Processor Storage

.241

Category of storage	Number of locations	Size	Program usage
computer register:	1	1 word	Upper Accumulator (U).
computer register:	1	1 word or 8 words	Lower Accumulator (L).
computer register:	1	1 word	Index Register (X).
computer register:	1	1 word	Command Register (C).
computer register:	1	1 bit	Branch Control Toggle (BC).

.242

Category of storage	Total number locations	Physical form	Cycle time μ sec
U	1	recirculating word	260.
L	1 or 8	recirculating word	260, or 2,080.
X	1	recirculating word	260.
C	1	recirculating word	260.
BC	1	toggle.	

.3 SEQUENCE CONTROL FEATURES

.31 Instruction Sequencing: 1 + 1 addressing.

.32 Look-Ahead: . . . . . . none.

.33 Interruption: . . . . . . none.

.34 Multi-running: . . . . . none.

.35 Multi-sequencing: . . . none.

§ 051.

.4 PROCESSOR SPEEDS

.41 Instruction Times in μ secs

.411 Fixed point

Conditions

I:	random data location.	
II:	fully optimized data and instruction locations.	
	I	II
Add-subtract:	4,700	1,040.
Multiply:	22,000	18,000.
Divide:	22,000	18,000.

.412 Floating point

Add-subtract:	93,000 av.
Multiply:	72,000 av.
Divide:	80,000 av.

.413 Additional allowance for

Indexing:	no extra time required.
Re-complementing:	no extra time required.

.414 Control

Compare:	4,750.
Branch:	4,750.

.415 Counter control

Step:	1,080.
Step and test:	none.
Test:	1,080 (no transfer).

.416 Edit: no edit facility.

.417 Convert: 500,000 dec to bin (1 word). 200,000 bin to dec (1 word).

.418 Shift: 260 (7 + B). B = no. bit positions shifted.

.42 Processor Performance in μ secs

.421 For random addresses

	Fixed point	Floating point
c = a + b:	16,700	165,000.
b = a + b:	26,000	165,000.
Sum N items:	4,680	93,000.
c = ab:	23,400	145,000.
c = a/b:	23,400	152,000.

.422 For arrays of data

	Fixed point	Floating point
$c_i = a_i + b_j$:	66,700	165,000.
$b_j = a_i + b_j$:	66,700	165,000.
Sum N items:	522	93,000.
$c = c + a_i b_j$:	100,000	255,000.

.423 Branch based on comparison

Numeric data:	33,300.
Alphabetic data:	33,300.

.424 Switching

.4241	Unchecked:	17,700.
.4242	Checked:	31,200.
.4243	List search:	17,700 + 25,000T. T = no. of 64-word tracks in table.

.425 Format control per character

	Fixed point	Floating point
Unpack (by subroutine):	57,000	92,000.
Compose (by subroutine):	20,000*	183,000.

* Performed during output of previous char. Output limited by typewriter speed at 10 char/second.

.426 Table look-up per comparison

For a match:	390.
For least or greatest:	33,300.
For interpolation point:	390.

.427 Bit indicators

Set bit in pattern:	1,040.
Test bit in pattern:	1,040.
Test AND for B bits:	1,040.
Test OR for B bits:	3,120.

.428 Moving

1 word:	1,560 + 260S. S = no. sectors word moved.
N words:	4,180N.

.5 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Overflow:	check on addition, subtraction, division	BC toggle set.
Underflow:	check	value taken as zero.
Zero divisor:	see overflow.	
Invalid data:	all data valid.	
Invalid operation:	none.	
Arithmetic error:	none.	
Invalid address:	all addresses valid.	
Receipt of data:	none.	
Dispatch of data:	none.	

CONSOLE

§ 061.

.1 GENERAL

.11 Identity: . . . . part of 4010 Computer cabinet.

.12 Associated Units: . . none.

.13 Description

The Console is a small, simple unit which provides switches for operator control of the computer, and an oscilloscope for displaying the contents of the four computer registers. The Console does not contain facilities for manual entry of data, but data may be entered readily on the typewriter or paper tape reader adjacent to the computer. Switches on the 4430 Reader/Punch are used to set up connections to devices. A Start Compute button is located on the Console and also on the 4430 Reader/Punch control panel.

.2 CONTROLS

.21 Power

Name	Form	Comment
Power On:	indicating push-button	controls power to 4010 Computer.
Power Off:	indicating push-button	controls power to 4010 Computer.

.22 Connections: . . . . . . see controls on 4430 Reader/Punch.

.23 Stops and Restarts

Name	Form	Comment
One Operation:	indicating 2-position switch	depressing switch stops computer after instruction is executed and next command is obtained.
Start Compute:	momentary switch	computer starts, using instruction in Command Register.

.24 Stepping

Name	Form	Comment
One Operation:	indicating 2-position switch	places computer in One Operation mode. Each depression of Start Compute switch executes one instruction and obtains next one.

.25 Resets

Name	Form	Comment
Set Input:	momentary switch	computer must be in One Operation mode. Set Input causes Lower Accumulator to be cleared and the setting up of an input command. The command is executed when Start Compute is depressed.
Branch Control:	momentary indicating switch	turns off Branch Control (BC) toggle. Lit when BC is on.

.26 Loading

Name	Form	Comment
One operation:		see above.
Set Input:		see above.
Execute Lower Accumulator:	indicating 2-position switch	transfers word in Lower Accumulator to Command Register when Start Compute is depressed.

.27 Special

Name	Form	Comment
Sense switches:	indicating 2 position switches	six switches used in conjunction with sense instruction.

.3 DISPLAY

.31 Alarms: . . . . none; see individual units of Tape Typewriter system.

.32 Conditions

Name	Form	Condition Indicated
Stop:	static lamp	on when computer is halted.
Compute:	static lamp	on when instructions are being executed.

§ 061.

.33 Control Registers

Name	Form	Comment
Oscillo-scope:	cathode ray tube face	displays binary contents of U, L, X, and C registers.
L-Display:	selector switch	selects 1 of 8 words of L when in 8-word condition.

.34 Storage: . . . . none.

.4 ENTRY OF DATA

.41 Into Control Registers

Method	Quantity of Data
Use of One Operation, Set Input, and Execute Lower Accumulator switch:	1 word, into L and then C via input device.

.42 Into Storage: . . . . only by programmed transfer from L to storage.

.5 CONVENIENCES

.51 Communication: . . . none.

.52 Clock: . . . . none.

.53 Desk Space: . . . . . approx. 32"x27" next to 4480 Typewriter; approx. 46"x6" on 4010 Computer; at height of 30".

.54 View: . . . . operator sits convenient to 4500 Tape Typewriter System and 4010 Computer.

.6 INPUT-OUTPUT UNIT

Model 4480 Typewriter, of the Tape Typewriter System, is used for manual input. The typewriter is not directly part of 4010 Computer console, and is described in section .081.

INPUT-OUTPUT: PAPER TAPE READER/PUNCH

§ 071.

.1 GENERAL

.11 Identity: . . . . Paper Tape Reader/Punch. Models 4430, 4431.

.12 Description

Models 4430 Reader/Punch and 4431 Auxiliary Reader/Punch are almost identical units which are used for reading and punching paper tape. Each model contains separate and independent reader and punch units. For both models, the reading speed is 60 characters per second and punching speed is 30 characters per second. Characters are recorded on tape as six data bits and an even parity bit; packing density is ten rows per inch.

Both models of the Reader/Punch are used to form a Tape Typewriter System. Model 4430 is combined with a Model 4480 Typewriter to form a Model 4500 Tape Typewriter System, and Model 4431 is combined with a 4480 Typewriter to form a Model 4600 Auxiliary Tape Typewriter System.

Both Reader/Punch models contain identical control panels, called Tape Typewriter Control, for control of the reader, punch and typewriter. Model 4430, however, contains a system control panel called Master Input-Output Control. The description of this panel is contained in section .074, Tape Typewriter System.

The Tape Typewriter Control panel has the facility to connect the reader and the punch to the system for use under program control (on-line), or to disconnect them for off-line use. In this manner a tape could be duplicated off-line, and then the reader or the punch, or both, can be reconnected to the system.

The Reader/Punch has the ability to read tape, and simultaneously punch a copy of the tape. The devices are interlocked so that they operate at the rate of the slower one. Parity checking can be performed during on-line read operations; this operation may be over-ridden by a switch. In off-line reading parity is not checked. During punch operations, a parity bit is punched on tape, but no check on recording is made.

Reading may be performed in two different modes: "block"; or Single Character, under operator control. In the block mode, characters are accepted until the reader senses a stop code, and then a "start" signal is sent to the computer. In Single Character Mode, a "start" signal is sent to the computer after each character is read. Thus, the computer executes its next instruction in sequence after reading a character, and must later give a new input command to receive a new character.

.12 Description (cont'd)

In off-line reading and punching, reading may be stopped, under switch selection, by either a stop code or by a stop-read button.

On-line punching is accomplished by a computer instruction which punches a single character. This instruction must be followed by an instruction routine which sets up the next character to be punched. Other computation may be performed, ending in a punch instruction. Approximately 85 percent of the time required to punch a group of characters is available for other computation, when punching hexadecimal tapes.

When data is transferred in hexadecimal form (4-bit codes), the reader and punch operate at or near rated speeds. When using standard input-output subroutines, speeds will be 10 to 50 percent of rated speeds. If individual input-output routines are written, speeds will be a function of the routine, and may approach rated speeds.

.13 Availability: . . . . . . .60 days.

.14 First Delivery: . . . . .April 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . die punches.
.222 Sensing system: . . . . brush.
.223 Common system: . . . no.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . sensing.
Stacks: . . . . 1.
Heads/stack: . . . . . 7.
Method of use: . . . . 1 row at a time.

Use of station: . . . . . punching.
Stacks: . . . . 1.
Heads/stack: . . . . . . 7.
Method of use: . . . . . 1 row at a time

.3 EXTERNAL STORAGE

31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . . fully punched holes (chad tape); in-line sprocket.

§ 071.

.32 Positional Arrangement

.321 Serial by: . . . . row, at 10 rows/inch.
.322 Parallel by: . . . . . . 7 tracks at standard spacing.
.324 Track use

Data:	6.
Redundancy check:	1.
Timing:	0.
Control signals:	0.
Unused:	0.
Total:	7 plus sprocket.

.325 Row use: . . . . all for data.

.33 Coding: . . . . as in Data Code Table 1.

.34 Format Compatibility

Other device or system	Code translation
All devices using standard 7-level paper tape:	programmed.

.35 Physical Dimensions

.351 Overall width: . . . . 1.000 ± 0.003 inch.
.352 Length:
Reel: . . . . 1,000 feet on 8 inch diam. reel.
Strips: . . . . ? feet.

.4 CONTROLLER

.41 Identity: . . . . no separate controller; Reader/Punch can operate either directly with 4010 Computer or with Tape Typewriter System.

.42 Connection to System

.421 On-line: . . . . 22 input and 23 output devices may be connected to system; no restrictions on number of Reader/Punch units up to max. Each Reader/Punch counts as one input and one output device.

.422 Off-line
Use: Associated equipment
Duplicating tapes: . . Reader/Punch only.

.44 Data Transfer Control

		Reader	Punch
.441	Size of load:	1 to 64 hex char, or 1 to 42 6-bit char.	1 char.
.442	Input-output areas:	computer registers; Lower, or Upper and Lower accumulators.	computer register.
.443	Input-output area access:	1 word.	1 word.
.444	Input-output area lockout:	yes, except in Single Char Mode.	none.
.445	Table control:	no.	no.
.446	Synchronization:	automatic.	automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

		Reader	Punch
.511	Size of block:	1 to 64 hex char, or 1 to 42 6-bit char.	depends on program.
.512	Block demarcation:	stop code, or program control.	depends on program.

.52 Input-Output Operations

.521 Input: . . . . input forward until stop code sensed.
input forward until program determines end-of-block.
.522 Output . . . . output 1 char/instruction.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . no.
.526 Searching: . . . . . . no.

.53 Code Translation: . . . matched codes.

.54 Format Control

	Reader	Punch
Control:	program	none
Format alternatives:	2; either 4 or 6 bits of each char on tape is read into computer register.	

.55 Control Operations

Disable:	no.
Request interrupt:	no.
Select format:	reader only; 4 or 6-bit input.
Select code:	no.
Rewind:	no.
Unload:	no.

.56 Testable Conditions

Disabled:	can test for condition of "no input device selected."
Busy device:	yes.
Output lock:	no.
Nearly exhausted:	no.
End of medium marks:	no.
Exhausted:	no.

.6 PERFORMANCE

.61 Conditions

I:	reading, "block" mode.
II:	reading, single char mode.
III:	punching.

§ 071.

.62 Speeds

.621 Nominal or peak speed: . . . . Reader (I); 60 char/sec.
Reader (II); 60 char/sec.
Punch; 30 char/sec.

.622 Important parameters

	Reader	Punch
Char density:	10/inch	10/inch.
Tape speed:	6 in/sec.	3 in/sec.

.624 Effective speeds: Reader (I) - 60 N/(N + 2) char/sec.
Reader (II) - depends on program.
Punch - depends on program.
N is No. char transferred.

.63 Demands on System

Component	Condition	m.sec per char	or	Percentage
Computer:	Reader (I)	16.7	or	100.
Computer:	Reader (II)	depends on program.		
Computer:	Punch	4.5*	or	13.5*.

*Allows time for shifting of bits in computer register to form next character, punching hex tape.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . none.

.72 Other Controls

Function	Form	Comment
Place reader on-line:	momentary switch	connects reader to computer; switch lights when reader addressed by computer.
Place punch on-line:	momentary switch	connects punch to computer; switch lights when reader addressed by computer.
Reader conditional stop when operating off-line:	two-position switch	stops reader only when stop code sensed.
Feeds tape:	spring return switch	feeds tape, punching sprocket holes.
Place reader off-line:	two-position switch	removes reader connection to computer.
Place punch off-line:	two-position switch	removes punch connection to computer.

.72 Other Controls (Contd.)

Function	Form	Comment
Start reading, off-line:	momentary switch	starts reader.
Stop reading, off-line:	momentary switch	stops reader.
Single char mode selection, off-line:	two position switch	causes reader to stop after each char read.
Master Reset to all devices:	momentary switch	de-selects all devices; on Model 4430 only.
Character display	7 lamps	display bit configuration of character under reader brushes.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Reel:	1,000 feet.
Box of strip tape: . .	? feet.

.732 Replenishment time: . . . . 2 to 3 mins; unit needs to be stopped.

.733 Adjustment time: . . . . none.

.734 Optimum reloading period: . . . . 2 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Reading:	parity check if desired, can be used only on-line	system halts; alarm.
Input area overflow:	none.	
Output block size:	none (one char normal size).	
Invalid code:	none.	
Exhausted medium:	interlock	system halts; alarm.
Imperfect medium:	none.	
Timing conflicts	interlock	wait.
Reader or punch paper tape jam:	interlock	system halts; alarm.
Device off-line when addressed by computer:	interlock	alarm; computer halts on next input or print instruction.

INPUT-OUTPUT: PHOTO READER

§ 072.

.1 GENERAL

.11 Identity: . . . . Photo Reader. Model 4410.

.12 Description:

The Model 4410 Photoelectric Reader is a high speed input device for the 4010 Computer. It is capable of reading fully-punched paper tape at a peak speed of 500 characters per second. This reader, packaged in its own cabinet, supplements the 4430 Reader/Punch, which has a maximum reading speed of 60 characters per second. The Photo Reader is manufactured by Digitronics Corporation.

The most effective use of the Photo Reader is in transferring four- or six-bit data from paper tape to storage, without radix conversion. Use of standard input subroutines, which include radix conversion, greatly reduces the peak speed of the reader. The effective speed when reading hexadecimal data is approximately 300 characters per second.

Tape may be sensed in the forward or reverse direction under program control. The reader is capable of searching for a specified character, independent of computer operations.

Seven-track paper tape is used; six for data and one for even parity. Under program control, either four or six of the data bits are selected for reading into the computer, where they are placed in the Lower, or Upper and Lower accumulators without translation. Parity is checked by the reader, and failure of the parity check halts the system.

Input may occur in Single Character mode, or in block mode. In block mode, an input command may read a maximum of 16 hexadecimal characters.

Reels of 1,000 feet of tape can be handled by the reader.

.13 Availability: . . . . . . 60 days.

.14 First Delivery: . . . . March 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs: . . . . . . none.
.221 Recording system: . . . none.
.222 Sensing system: . . . . photoelectric.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . sensing.
Stacks: . . . . 1.
Heads/stack: . . . . . 7 + sprocket.
Method of use: . . . . . 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . . fully punched holes (chad tape); in-line sprocket.

.32 Positional Arrangement

.321 Serial by: . . . . row, at 10/inch.
.322 Parallel by: . . . . . . 7 tracks at standard spacing.

.324 Track use
Data: . . . . 6.
Redundancy check: . . 1.
Timing: . . . . 0.
Control signals: . . . 0.
Unused: . . . . 0.
Total: . . . . 7 + sprocket track.
.325 Row use: . . . . all for data.

.33 Coding: . . . . as in Data Code Table 1.

.34 Format Compatibility. . . . . any device using standard punched paper tape.

.35 Physical Dimensions

.351 Overall width: . . . . . 1.000 ± 0.003 inch.
.352 Length: . . . . 1,000 feet stored on 8-inch reel.

.4 CONTROLLER

.41 Identity: . . . . 4010 Computer.

.43 Connection to Device

.431 Devices per controller . . . . . . 22 max; one selected for input at a time.
.432 Restrictions: . . . . . 22 max input devices to the system; including all types.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 to 64 hex char, or 1 to 42 6-bit char.
.442 Input-output areas: . . . computer registers; Lower, or Upper and Lower accumulator.

§ 072.

.443 Input-output area access: . . . . word.
.444 Input-output area lockout: . . . . in block mode.
.445 Table control: . . . . . . none.
.446 Synchronization: . . . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . . up to 16 hex char or 10 6-bit char, in block mode; any length in Single Character mode.

.512 Block demarcation Input: . . . . stop code (asterisk) on tape, or 1 char at a time.

.52 Input-Output Operations

.521 Input: . . . . input 1 block forward or backward.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . moves tape forward or backward stopping at a predetermined code.

.53 Code Translation: . . . . matched codes.

.54 Format Control

Control: . . . . program.
Format alternatives: . . . 2; either 4 or 6 bits of each row on tape is read into computer register.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . . no.
Select format: . . . . . . yes, 4- or 6-bit input.
Select code: . . . . no.
Rewind: . . . . using search mode.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . can test for condition of "no input device selected".
Busy device: . . . . yes.
Nearly exhausted: . . . . no.
End of medium marks . no.
Exhausted: . . . . no.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: . . . . 500 char/sec.
.622 Important parameters
Char density: . . . . . . 10/inch.
Tape speed: . . . . . . 50 inch/sec.
Start time: . . . . 3 m. sec.
Stop time: . . . . 2 m. sec.
.623 Overhead: . . . . overhead is the sum of the following factors.
pass gap: . . . . 20 m. sec/inch of blank tape.
start-stop time: . . . 5 m. sec.
.624 Effective speeds: . . . . approx. 300 char/sec in either mode, without radix conversion.

.63 Demands on System

Component	m. sec per char	or	Percentage
Computer:	3.3*	or	100.*

*allows time for shifting of bits in accumulator to store hex character.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls

Function	Form	Comment
Standby:	2-pos. switch	for loading tape.
Power:	2-pos. switch.	
Select-Reset	momentary switch.	
Forward-Reverse:	momentary switch.	

.73 Loading and Unloading

.731 Volumes handled: . . . . 1,000 feet on 8-inch reel.

.732 Replenishment time: . . . . 0.5 min., unit needs to be stopped.
.734 Optimum reloading period: . . . . 4 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	parity check by reader	reader and computer halt; alarm at reader. Stop lamp at computer.
Input area overflow:	none.	
Invalid code:	all valid.	
Exhausted medium:	interlock	halt computer, alarm.
Imperfect medium:	none.	
Timing conflict:	interlock	wait.

INPUT-OUTPUT: HIGH SPEED PUNCH

§ 073.

.1 GENERAL

.11 Identity: . . . . High Speed Punch. Model 4440.

.12 Description:

The Model 4440 High Speed Punch is an optional output device that is capable of punching fully punched paper tape at 300 characters per second. This punch, used as an on-line device under control of the computer, supplements the 4430 Reader/Punch which has a maximum punching speed of 30 characters per second. The High Speed Punch is manufactured by Soroban Engineering, Inc.

The most effective use of the High Speed Punch is in transferring hexadecimal data from storage to paper tape for intermediate storage or for later hexadecimal listing. Otherwise, standard output routines greatly reduce the peak speed of the punch. Hand coded routines will prove of value for specific cases if radix conversion is required.

Seven-track paper tape is punched while moving in the forward direction; six for data and one for even parity. The parity channel is generated and added to the six-bit data character transferred from the computer. The instruction can specify four or six bits to be taken from the accumulator.

Initiation of a punch command inhibits execution of a second punch command until the first is finished. Reels of 1,000 feet of tape are handled by the punch.

.13 Availability: . . . . . 90 days.

.14 First Delivery: . . . . September, 1961.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive.
.212 Reservoirs: . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . die punches.
.222 Sensing system: . . . none.

.23 Multiple Copies: . . . none.

.24 Arrangement of Heads

Use of station: . . . . punching.
Stacks: . . . . 1.
Heads/stack: . . . . . 7.
Method of use: . . . . 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper tape.
.312 Phenomenon: . . . . . fully punched holes (chad tape); in-line sprocket.

.32 Positional Arrangement

.321 Serial by: . . . . . . row, at 10/inch.
.322 Parallel by: . . . . . 7 tracks at standard spacing.
.324 Track use
Data: . . . . 6.
Redundancy check: . . 1.
Timing: . . . . . . 0.
Control signals: . . . 0.
Unused: . . . . . . 0.
Total: . . . . 7 plus sprocket.
.325 Row use: . . . . all for data.

.33 Coding: . . . . as in Data Code Table 2.

.34 Format Compatibility

Other device or system: all devices using standard 7-track paper tape.
Code translation: . . . programmed.

.35 Physical Dimensions

.351 Overall width: . . . . 1.000 ± 0.003 inch.
.352 Length: . . . . 1,000 feet stored on 8-inch reel.

.4 CONTROLLER

.41 Identity: . . . . 4010 Computer.

.43 Connection to Device

.431 Devices per controller: 23 max.
.432 Restrictions: . . . . . 23 max. output devices in system, counting all types.

§ 073.

.44 Data Transfer Control

.441 Size of load: . . . . . 1 char.
.442 Input-output areas: . . computer register.
.443 Input-output area access: . . . . . . 1 word.
.444 Input-output area lockout: . . . . . . none.
.445 Table control: . . . . no.
.446 Synchronization: . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block:. . . . . depends on program.
.512 Block demarcation Output: . . . . depends on program.

.52 Input-Output Operations

.522 Output: . . . . output 1 char/instruction.
.523 Stepping: . . . . . . none.
.524 Skipping: . . . . . . none.
.525 Marking: . . . . . . no.
.526 Searching: . . . . . . no.

.53 Code Translation:. . . matched codes.

.54 Format Control: . . . none.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . no.
Select format: . . . . no.
Select code: . . . . . no.
Rewind: . . . . no.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . . . no.
Busy device: . . . . . yes.
Output lock: . . . . . no.
Nearly exhausted:. . . no.
End of medium marks: no.
Exhausted: . . . . . . no.

.6 PERFORMANCE

.61 Conditions:. . . . . . none.

.62 Speeds

.621 Nominal or peak speed: 300 rows/sec.
.622 Important parameters
Char density: . . . . 10/inch.
Tape speed: . . . . 30 in/sec.
.623 Overhead: . . . . . . 0.26 m.sec to transmit char to punch.
.624 Effective speeds: . . . 300 char/sec if not more than 3.33 m.sec elapse between char supplied to unit by program.

.63 Demands on System

Component	m.sec per char	or	Percentage
Computer:	3.3*	or	100.*

*allows time for shifting of bits in accumulator to form next hex character.

.7 EXTERNAL FACILITIES

.71 Adjustments:. . . . . none.

.72 Other Controls

Function	Form	Comment
Feed tape manually:	button	advance tape, punching any preset code.
Select	button	connects punch to computer.

.73 Loading and Unloading

.731 Volumes handled
Storage — Capacity
Reel: . . . . 1,000 feet, or up to 120,000 char.
.732 Replenishment time: . 0.5 minute. unit needs to be stopped.
.734 Optimum reloading period: . . . . 6.7 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	1 char/instruction.	
Invalid code:	all codes valid.	
Exhausted medium:	interlock	stop computer, alarm.
Imperfect medium:	none.	
Timing conflicts	interlock	wait.
Broken tape:	interlock	stop computer, alarm.
Tape nearly exhausted:	interlock	stop computer, alarm.

INPUT-OUTPUT: TAPE TYPEWRITER SYSTEM

§ 074.

.1 GENERAL

.11 Identity: . . . . Tape Typewriter System. Model 4500.

Auxiliary Tape Typewriter System. Model 4600.

.12 Description

The basic input-output unit of the RPC-4000 is the Model 4500 Tape Typewriter System. This unit, combined with the Model 4010 Computer, forms a basic RPC-4000 system. Several Tape Typewriter Systems may be used in which each additional system is a Model 4600. This model differs from Model 4500 in that it does not contain the Master Input-Output Control panel which the Model 4500 contains.

A Model 4500 Tape Typewriter System contains a Model 4430 Reader/Punch for reading and perforating 7-level punched paper tape and a Model 4480 Typewriter. The Model 4600 Auxiliary Tape Typewriter System contains a Model 4431 Reader/Punch and a Model 4480 Typewriter. Each system may have an Auxiliary Typewriter, also Model 4480, for on-line use when the main typewriter is being used off-line.

Each Tape Typewriter System has a manual facility for connecting any or all of its devices to the 4010 Computer. The computer may, under program control, select and de-select any of the devices for input and output of data. Only one input device may be in the selected state at any one time; however, any or all of the output devices may be in the selected state at one time. An output command will result in punching and/or printing (typing) on all output devices presently selected. This is called multiple output.

The Tape Typewriter System can disconnect any or all devices from the 4010 Computer. All devices off line on each Tape Typewriter System are automatically interconnected. A Master Reset button on Model 4500 will de-select all system devices simultaneously, including the Photo Reader and High Speed Punch, which may be connected to the Computer. Units may also be simultaneously de-selected under program control.

Input data may be punched or typed on all selected output devices while being read. This is called the Copy Mode and is accomplished under program control or operator control using the Input Duplication switch on Model 4500 console. The operator may start internal computation from the Model 4500 console.

Input devices may operate in a Single Character Mode, selected by the operator, in which each character read or typed produces a start signal to the computer. Otherwise, input proceeds until a stop code is sensed.

Basic speed of the punch unit is 30 characters per second. The reader, which is a completely independent unit, can read 60 characters per second. Typewriter speed is 10 characters per second.

.13 Availability: . . . . . . 60 days.

.14 First Delivery: . . . . April, 1961.

.2 PHYSICAL FORM: . . . Model 4480 or 4481 Typewriter placed on desk next to Model 4430 or 4431 Reader/Punch cabinet.

.4 CONTROLLER

.41 Identity: . . . . no separate controller.

.42 Connection to System

.421 On-line
Several Tape Typewriter Systems may be connected to the 4010 Computer, subject to the restrictions of 22 input and 23 output devices, maximum. Each Tape Typewriter System constitutes two input and two output devices. Specific implementation of connections and addressing structure must be made by manufacturer.

One Tape Typewriter System must be Model 4500, and the others must be Model 4600, Auxiliary Tape Typewriter System.

.422 Off-line

Use	Associated equipment
Perforate tape (and type):	Tape Typewriter System alone.
Typewrite:	Tape Typewriter System alone.
Typewrite from tape:	Tape Typewriter System alone.
Duplicate tape: . . .	Tape Typewriter System alone.

.43 Connection to Device

Each Tape Typewriter System is an independent group of devices when operating off-line. When devices are on-line, all devices may be considered as operating directly with the 4010 Computer, subject to certain manual switch settings on the Master Input-Output Control panel of Model 4500, and on the Tape Typewriter Control panels of all Tape Typewriter Systems (Model 4500 and all Models 4600).

§ 074.

.43 Connection to Device (Contd.)

Of all input devices connected to the system, only one may be selected (addressed) by the computer at any one time. All output devices remain selected once they have been selected, unless specifically reset. Thus, an output load is reproduced on all output devices selected at any one time. This is known as multiple output.

The master reset switch located on the Model 4500 Master Input-Output Control panel resets or deselects all devices in the system, including those in Model 4600 systems, and all devices connected directly to the 4010 Computer.

.7 EXTERNAL FACILITIES

.72 Other Controls

On Master Input-Output Control panel of Model 4500

Function	Form	Comment
Single Char Mode selection	2-pos. switch	this mode causes start signal to be sent to computer after each char read or typed.
Inhibit parity check on reader	2-pos. indicating switch	disables parity checking when on line.
Reset parity error toggle	momentary switch with indicator	lights when parity error occurs.
Master reset	momentary switch	de-selects all input-output devices in system.

.72 Other Controls (Contd.)

Function	Form	Comment
Turn on Input Duplication (Copy) Mode	momentary switch	causes all input data to be copied on all selected output devices.
Reset Input Duplication (Copy) Mode	momentary switch.	
Stop reading tape	momentary switch	stops the reader.
Start reading tape	momentary switch	re-starts the reader.
Start computing	momentary switch	starts computer operation.

On Tape Typewriter Control panel of Models 4500 and 4600
(See paragraph .72 on Model 4430/4431 Reader/Punch, and Model 4480 Typewriter.)

.8 ERRORS, CHECKS AND ACTION (see also sections on Reader/Punch and Typewriter)

Error	Check or Interlock	Action
Reading:	reader parity check if desired, on-line only	halt computer, alarm.
Device selected on-line while switched off-line:	interlock	halt computer, alarm.
Reader or punch paper exhausted:	interlock	halt computer, alarm.
Reader or punch paper tape jam:	interlock	halt computer, alarm.

INPUT-OUTPUT: 4480 TYPEWRITER

§ 081.

.1 GENERAL

.11 Identity: . . . . Typewriter.
Model 4480.

.12 Description

The RPC-4480 Typewriter may be used as an on-line or off-line input/output device, or as a conventional typewriter. It functions as a part of the 4500 or 4600 Tape Typewriter System, along with Models 4430 and 4431 Reader/Punch, respectively. The Reader/Punch and the Tape Typewriter System are described in sections .071 and .074. One or two typewriters are used with the Tape Typewriter System, as main and auxiliary typewriters. The auxiliary unit may be used only on-line; its purpose is to provide on-line input if the main typewriter is being used off-line. Type style is double case Manifold Pica Gothic.

A Model 4480 Typewriter may be used to type data into the computer or print computer output. As an input device it may operate in the Single Character Mode or in a normal block mode.

The Single Character Mode causes the computer to accept a character and start processing; the next character may be typed when a subsequent input command is reached by the program. This is indicated to the operator when the RPC emblem on the typewriter lights.

In the block mode, all characters are transmitted to the computer registers until a "stop" code is typed; processing is then automatically initiated. If the capacity of the registers is exceeded, the earliest data received is lost. Block input may transfer a useful load of two or eight computer words. The larger amount is equivalent to 64 4-bit characters or 42 6-bit characters. The selection of 4 or 6 bits of each 6-bit character is governed by the program. Selection of the mode is controlled by the operator.

When the typewriter is used as an output device, each output instruction transfers one character. Processing time is available between successive characters.

The typewriter can be used for off-line production of paper tape, or for typing from paper tape, using the reader section of the Reader/Punch. When preparing paper tape, the typewriter has the facility for back-spacing the carriage and the tape together, and punching a delete code while typing an X over the character in error.

.13 Availability: . . . . . 60 days.

.14 First Delivery: . . . . October 1960.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . friction drive.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . engraved hammers.
.222 Sensing system: . . . . typewriter keyboard for manual input.
.223 Common system: . . . no.

.23 Multiple Copies

.231 Maximum number
Interleaved carbon: . . depends on stationery.
.233 Types of master
Multilith: . . . . yes.
Zerox: . . . . yes.
Spirit: . . . . yes.

.24 Arrangement of Heads

Use of station: . . . . printing.
Stacks: . . . . 1.
Heads/stack: . . . . . 1.
Method of use: . . . . 1 char at a time.

Use of station: . . . keyboard input.
Stacks: . . . . 1.
Heads/stack: . . . . 44.
Method of use: . . . . 1 key at a time.

.25 Range of Symbols

Numerals:	10	0-9.
Letters:	26	A-Z.
Special:	20*	as in Data Code Table 1.
Alternatives:		none.
FORTRAN set:		yes.
Basic COBOL set: . .		yes.
Total:	56.	

*A number of these are only in the form of electrical codes for control operations to be punched on paper tape.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . continuous fanfold stationery.
.312 Phenomenon: . . . . . key impression.

.32 Positional Arrangement

.321 Serial by: . . . . . . character and line of characters.

§ 081.

.324 Track use
Data: . . . . 10 char/inch up to width of paper.
.325 Row use: . . . . all for data.

.33 Coding: . . . . as in Data Code Table 1.

.34 Format Compatibility: . . none.

.35 Physical Dimensions

.351 Overall width: . . . . 14, 16, or 20 inch carriage.
.352 Length: . . . . no limitations.
.353 Maximum margins: . . no limitations.

.4 CONTROLLER

.41 Identity: . . . . no separate controller, although switching is controlled by Tape Typewriter System described in section .074.

.42 Connection to System

.421 On-line: . . . . 1 or 2 typewriters with each Tape Typewriter System.
.422 Off-line
Use — Associated equipment
Print from paper tape: . . . . Model 4430 or 4431 Reader/Punch.
Punch paper tape and print (optionally): . . . Model 4430 or 4431 Reader/Punch.

.44 Data Transfer Control

.441 Size of load: . . . . . block of characters or single char.
.442 Input-output areas: . . . computer registers.
.443 Input-output area access: . . . . 1 word.
.444 Input-output area lockout: . . . . in block mode.
.445 Table control: . . . . none.
.446 Synchronization: . . . automatic.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . 1 char, or up to 64 4-bit char. (max. useable no. of char in a single input operation.)
.512 Block demarcation
Input: . . . . stop code if reading block.
Output: . . . . 1 char only.

.52 Input-Output Operations

.521 Input: . . . . 1 char or block of char, under operator control; each char 4 or 6 bits, selected by program.
.522 Output: . . . . 1 char of 6 bits.
.523 Stepping: . . . . single line feed.
.524 Skipping: . . . . none.
.525 Marking: . . . . stop code, end-of-block.
.526 Searching: . . . . . . none.

.53 Code Translation: . . matched codes.

.54 Format Control: . . . none.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . no.
Select format: . . . . yes (4-or 6-bit char input).
Select code: . . . . . no.

.56 Testable Conditions

Disabled: . . . . yes.
Busy device: . . . . . yes.
Output lock: . . . . . no.
Nearly exhausted: . . no.
End of medium marks: no.

.6 PERFORMANCE

.61 Conditions

I: . . . . computer-to-typewriter.
II: . . . . typewriter-to-computer, Single Char Mode.
III: . . . . typewriter-to-computer, block mode.

.62 Speeds

.621 Nominal or peak speed: . . . . 10 char/sec.

.63 Demands on System

Component	Condition	m. sec per char	or Percentage
Computer:	I	?	depends on rate of print instructions.
Computer:	II	? + operator response time	depends on operator and rate of instructions.
Computer:	III	depends on operator	100.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method	Comment
Line spacing:	lever	skip 1 or 2 lines.
Margin set:	key.	
Tab setting:	key.	

§ 081.

.72 Other Controls (on Reader/Punch control panels)

Function	Form	Comment
Single Char Mode select	2-position switch	selects normal or Single Char Mode, for on-line operation.
Master reset	momentary switch	deselects all previously selected units.
Typewriter to Computer	momentary switch	connects typewriter to computer.
Aux. Typewriter to Computer	momentary switch	connects auxiliary typewriter to computer.
Computer to Typewriter	momentary switch	connects computer to typewriter.
Computer to Aux. Typewriter	momentary switch	connects computer to auxiliary typewriter.
Typewriter select	2-position switch	places typewriter off-line.
Single Char Mode select	2-position switch	selects normal or Single Char Mode, for off-line use.

.72 Other Controls (Contd.)

Function	Form	Comment
Delete code	typewriter Special bar	with Special bar held down, the back-space key back-spaces tape and carriage. Striking the X key then punches a delete char on tape.

.73 Loading and Unloading

.731 Volumes handled: . . . depends on feed facilities.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	interlock on addressed type bar	computer keeps trying same char.
Reading:	none.	
Input area overflow:	none.	
Output block size:	1 char only.	
Invalid code:	none.	
Exhausted medium:	none.	
Imperfect medium:	none.	
Timing conflicts:	interlock	wait.
Computer selection of off-line unit:	interlock	alarm, system halts.

OFF-LINE TAPE TYPEWRITER

§101.

.1 GENERAL

.11 Identity: . . . . Tape Typewriter. Model 4700.

.12 Description:

The Model 4700 Tape Typewriter is an off-line device, having the general characteristics of a Flexowriter, which operates in the RPC-4000 system code. It is designed to prepare hard copy from manual typing or from punched paper tape, and to prepare chad (fully-punched) paper tape for input to the RPC-4000 system. Type style is Pica Gothic.

Its reader, punch, and typewriter units each operate at 10 characters per second. It is capable of printing 43 characters, and of punching three function codes.

.13 Availability: . . . . 30 days.

.14 First Delivery: . . . . . May, 1961.

SIMULTANEOUS OPERATIONS

§ 111.

.1 SPECIAL UNITS

.11 Identity: . . . . no special units for simultaneous operations.

.12 Description

The central processor is used to initiate and control input-output operations. The only simultaneity that can be obtained must be programmed by the interlacing of appropriate instructions.

Input-output operations are usually controlled by standard routines, in which case no simultaneity is available.

There are two modes of input-output: block and single character. A block mode transfer, only available on input, reads a series of characters into the combined Upper and Lower Accumulators or the eight-word Lower Accumulator until a stop code is read. Use of the block mode means that no simultaneity is possible. A single character mode transfer either inputs one character to the combined

.12 Description (Contd.)

accumulators or the eight-word Lower Accumulator or outputs one character from the Upper Accumula tor or from the instruction itself.

Any input-output instruction waits until a transfer can occur, after which the Processor is free to move on to the next instruction. Careful timing is required to make maximum use of overlapping operations. The most convenient interlacing possible is some computation with either output or input in single character mode.

Although a number of input devices may be connected on line to the computer, only one may be addressed at a given time. When output is performed, all output devices which have been selected by the computer print or punch the output character. This is called multiple device operation. After selection an output device remains selected until a master reset occurs.

In the case of Input Duplication (Copy Mode), selected by the operator, output devices copy the information being entered into the computer.

INSTRUCTION LIST

§ 121.

INSTRUCTION				OPERATION
Mnemonic op-code	D	N	I	
				Arithmetic
RAU	D	N	Yes	(D) ⟶ U.
RAL	D	N	Yes	(D) ⟶ L.
DVU	D	N	Yes	(U) ÷ (D). Quotient ⟶ U. Remainder ⟶ L.
DIV	D	N	Yes	(U+L) ÷ (D). Quotient ⟶ U. Remainder ⟶ L.
MPY	D	N	Yes	(D) X (U) ⟶ (U+L).
MPT	value	N	Yes	(U) X decimal 10, 8, 2, or 0 ⟶ U depending on value in D field. (L) X decimal 10, 8, 2, or 0 ⟶ L depending on value in D field.
ADU	D	N	Yes	(D) + (U) ⟶ U.
ADL	D	N	Yes	(D) + (L) ⟶ L.
SBU	D	N	Yes	(U) - (D) ⟶ U.
SBL	D	N	Yes	(L) - (D) ⟶ L.
				Logic
HLT	000	N	Yes	Computer halts.
SNS	value	N	Yes	Turns on Branch Control Toggle if sense switch(es) depressed, or if selected I/O device not ready, or if no input device is selected.
CXE	value	N	Yes	Compares value in instruction with (I). Turns on Branch Control Toggle if equal.
EXC	value	N	Yes	Performs functions listed below under control of bits 6-11 in instruction: bit 6 = 1; L set to 1-word length. bit 7 = 1; L set to 8-word length. bits 6 and 7 = 1; L length changed from present state. bit 8 = 1; (I) ⟶ U. bit 9 = 1; (U) ⟶ I. bit 10 = 1; (L) ⟶ U. bit 11 = 1; (U) ⟶ L. bit 8 and 10 = 1; (I) LOGICAL OR (L) ⟶ U.
EXT	D	N	Yes	Logical product of (U) and (D) ⟶ U.
MML	D	N	Yes	Where (U)=O, (L) ⟶ L. Where (U)=1, (D) ⟶ L.
CME	D	N	Yes	Compares (D) with (U) where (L)=1. If all selected bits match, Branch Control indicator turned on. In Repeat Mode, address of successful comparison ⟶ I.
CMG	D	N	Yes	Compares (D) with (U) where (L)=i. If selected (D) ⩾ selected (U), Branch Control indicator turned on. In Repeat Mode, address of first successful comparison ⟶ I.
TMI	D	N	Yes	Jump to D Address if (U) negative. Otherwise, go to N address.
TBC	D	N	Yes	Jump to D address if Branch Control indicator is on and turn Branch Control off. Otherwise, go to N address.
				Data Transfer
SAU	D	N	Yes	Moves address portion, bits 5-17, of U to storage.
MST	D	N	Yes	Bits in D replaced by corresponding bits in L wherever mask bits in U = 1.
LDC	D	N	No	Moves bits 18-24 of D into bits 18-24 of I. Next instruction is repeated, controlled by value of these bits.
LDX	value	N	Yes	Move bits 5-17 of instruction into I. Bits 5-17 added to I if instruction is indexed.
SRL	value	N	Yes	(U+L) shifted right controlled by bits 12-17 of instruction, if D track is 000. Low order bits are lost. (U+L) shifted left controlled by bits 12-17 of instruction, if D track is 001. High order bits are lost.

§ 121. **INSTRUCTION LIST–Contd.**

INSTRUCTION				OPERATION
Mnemonic op-code	D	N	I	
				Data Transfer (Cont'd.)
SLC	____	N	Yes	(U+L) shifted to left until bit position 1 contains a 1, or until D sector value plus number of shifts = 64. D sector value plus number of shifts ⟶ L, in bit positions 12-17. Indexing may be used to create initial D sector value.
STU	D	N	Yes	(U) ⟶ D.
STL	D	N	Yes	(L) ⟶ D.
CLU	D	N	Yes	(U) ⟶ D. Zero ⟶ U.
CLL	D	N	Yes	(L) ⟶ D. Zero ⟶ L.
				Input-Output
INP	value	N	Yes	Reads 4-bit chars into accumulator(s) if D track = 000. Reads 6-bit chars into accumulator(s) if D track = 064. If L set at 1 word length, chars go into combined U and L. If L set at 8 word length, chars go into L only. If D track value indexed, result should be 000 or 064, otherwise data becomes garbled.
PRD	value	N	Yes	Prints one char from D track field of Instruction Word, or, depending on value, selects input and/or output devices or modes as shown in list.

Value of D-track field of Instruction Word	Model	Input/Output Selection Codes
064	4500	Reader input.
065	4500	Reader input, Punch output.
066	4500	Reader input, Typewriter output.
067	4500	Reader input, Punch and Typewriter output.
068	4500	Typewriter input.
069	4500	Typewriter input, Punch output.
070	4500	Typewriter input, Typewriter output.
071	4500	Typewriter input, Typewriter and Punch output.
072	4410	Photo-reader, Forward and Search.
073	4410	Photo-reader, Reverse and Search.
074	4410	Photo-reader, Forward.
075	4410	Photo-reader, Reverse.
076-094		available for additional units.
095		master reset (disconnects all units).
096		available for additional unit.
097	4500	Punch output.
098	4500	Typewriter output.
099	4500	Punch and Typewriter output.
100		available for additional unit.
101	4500	Punch output.
102	4500	Typewriter output.
103	4500	Punch and Typewriter output.
104, 105		Search Mode.
106	4440	High Speed Punch.
107-124		available for additional units.

§ 121. INSTRUCTION LIST–Contd.

INSTRUCTION				OPERATION
Mnemonic op-Code	D	N	I	
				<u>Input-Output (Cont'd.)</u> Value of D-track field of Instruction Word — Model — Input/Output Selection Codes 125 — Copy Mode on. 126 — Copy Mode off. 127 — reset output units. Notes 1. Selection of new input device resets previous input device selection. Only one input device selected in system at a time. Master Reset deselects input device also. 2. Any combination of output devices may be in system at one time. May be reset by output reset command, or by Master Reset command.
PRU	value	N	Yes	Prints 1 char from U, or U and instruction word bits, depending on value in D-track.

CODING SPECIMEN: ASSEMBLY LANGUAGE

§ 131.

.1 CODING SPECIMEN

EXAMPLE 1 – LINEAR INTERPOLATION

LOCATION	ORDER	DATA ADDRESS	NEXT ADDRESS	COMMENTS
INTER	LDX	X00001		X_0 ADDRESS → INDEX REGISTER.
	RAL	MASK	CHECK	MASK FOR COMPARISON.
CHECK	LDC	COUNT		SET UP REPEAT COUNT.
	XCMG	0		TABLE LOOK UP ON GREATER OR EQUAL.
	TBC	GOT		→ FOUND X.
	XLDX	100		NOT FOUND, TRY NEXT TRACK.
	CXE	X00321		HAVE WE EXCEEDED THE TABLE ?
	TBC	ERROR	CHECK	→ TABLE EXCEEDED.
MASK	X31	12763	12763	ALL 1's.
COUNT	0	0	6300	COUNT OF 63.
ERROR	HLT	0		STOP WITH X IN ACCUMULATOR.
	CLU	DUMP	FOUND	EXIT WITH 0 UPPER.
GOT	EXC	998		X → U, U → L.
	SDA	HOLD		STORE FOUND TRACK.
	SRL	113		MOVE SECTOR +1 TO D OF U.
	SBU	DSEC1		
	EXT	RIGHT		KEEP D SECTOR OF U, SHIFTED X VALUE.
	ADU	HOLD		
	SAU	XL		ADDRESS OF X_L.
	SBU	DSEC1		
	SAU	XS1		ADDRESS OF X_S.
	SAU	XS2		

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DATA CODE TABLE NO. 1

§ 141.

.1 USE OF CODE: . . . . paper tape, typewriter.

.2 STRUCTURE OF CODE

.21 Character Size: . . . . 7 bits; 6 data, 1 even parity.

.22 Character Structure

.221 More significant pattern: . . . . 2 zone bits; 32, 16.

.222 Less significant pattern 4 numeric bits; 8, 4, 2, 1.

.23 Character Codes

LESS SIGNIFICANT PATTERN	MORE SIGNIFICANT PATTERN			
	0	16	32	48
0	Tape feed	0)	g G	w W
1	Carr. ret	1 °	h H	x X
2	Tab	2 "	i I	y Y
3	Back-space	3 #	j J	z Z
4		4	k K	, $
5	Upper case	5 Δ	l L	= :
6	Lower case	6 @	m M	[;
7	Line feed	7 &	n N	] %
8	*Stop code	8 '	o O	
9		9 (	p P	
10		a A	q Q	+ ?
11	Photo reader	b B	r R	- _
12		c C	s S	. .
13	End of block	d D	t T	space
14		e E	u U	/ ÷
15		f F	v V	Delete code

Note: 1. Both upper and lower case symbols shown in each box.

DATA CODE TABLE NO. 2

§ 142.

.1 USE OF CODE: . . . . . internal.

.2 STRUCTURE OF CODE

.21 Character Size: . . . . . 4 least significant bits of paper tape code (hexadecimal) or 6 significant bits of paper tape code; selected by program.

.22 Character Structure

.221 More significant pattern: . . . . 2 zone bits; 32, 16.

.222 Less significant pattern: . . . . 4 bits; 8, 4, 2, 1.

.23 Character Codes

.231 4-bit hexadecimal.

Numeric pattern	Symbol
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	binary 10
11	binary 11
12	binary 12
13	binary 13
14	binary 14
15	binary 15

.232 6-bit.

LESS SIGNIFICANT PATTERN	MORE SIGNIFICANT PATTERN		
	16	32	48
0	0)	g G	w W
1	1 °	h H	x X
2	2 "	i I	y Y
3	3 #	j J	z Z
4	4	k K	, $
5	5 Δ	l L	= :
6	6 @	m M	[;
7	7 &	n N	] %
8	8 '	o O	
9	9 (	p P	
10	a A	q Q	+ ?
11	b B	r R	- _
12	c C	s S	. .
13	d D	t T	space
14	e E	u U	/ ÷
15	f F	v V	

Note: 1. Both upper and lower case of special symbol codes shown in each box.

PROBLEM ORIENTED FACILITIES

§ 151.

.1 UTILITY ROUTINES

.11 Simulators of Other Computers

LGP-30 (machine language)
Reference: . . . . . LGP-30 to RPC-4000 Interpreter 2, Program H1-01.0.
Date available: . . . ?
Description:
With this routine, the RPC-4000 reads LGP-30 machine language program tapes and executes the LGP-30 routines interpretively. Execution time on the RPC-4000 is 3 to 8 times as long as on the LGP-30.

LGP-30 (24.0 interpretive language)
Reference: . . . . . Flirt 1, Program H1-24.0.
Date available: . . . ?
Description:
Flirt 1 reads and executes routines coded in the LGP-30 24.0 Floating Point Interpretive language Execution time on the RPC-4000 is 20 to 50 percent.of the time required for the same routines on the LGP-30.

.12 Simulation by Other Computers: . . . . none.

.13 Data Sorting and Merging: . . . . . magnetic tape cannot be used; no sorting routines are available.

.14 Report Writing: . . . none.

.15 Data Transcription: . . none; punched tape is the only important input-output medium.

.16 File Maintenance: . . none.

.17 Other

Listed below are the major categories of problem oriented facilities and the number of routines currently available in each.

.171 All LGP-30 Floating Point Interpretive routines, which may be used by the RPC-4000 Flirt 1, described in paragraph .11.

.172 Input-Output: . . . . . 12.
Arithmetic: . . . . . 12.
Mathematical functions: . . . . 10.
Interpretive routines: . . . . 2.
Assembly routines: . . 1.
Compilers: . . . . 1.
Diagnostics: . . . . . 6.
Demonstration routines: . . . . . . 3.

.2 PROBLEM ORIENTED LANGUAGES: . . . . . none.

PROCESS ORIENTED LANGUAGE: COMPACT

§ 161.

.1 GENERAL

.11 Identity: . . . . COMPACT (Compatible Algebraic Compiler and Translator for the RPC-4000). Program H3-01.0.

.12 Origin: . . . . Commercial Computer Division, General Precision, Inc.

.13 Reference: . . . . Compact Operating Procedure, Preliminary Description.

.14 Description

COMPACT is based upon and is largely compatible with the FORTRAN II language as implemented for the IBM 7090. Certain restrictions must be observed, primarily because of RPC-4000 hardware limitations. On the other hand, many useful extensions to the FORTRAN II language have been included. The significant limitations and extensions of the COMPACT language relative to IBM 7090 FORTRAN II are summarized below. If the user has any intention of recompiling and running his COMPACT programs on a different system for which a FORTRAN compiler exists, he should avoid the language extensions and restrict himself to proper FORTRAN coding. Complete specifications of the COMPACT language have not been published to date although the compiler is already in use.

Restrictions

(1) Names may contain a maximum of five characters.

(2) A name may appear only once in an EQUIVALENCE statement.

(3) IF ACCUMULATOR OVERFLOW, IF QUOTIENT OVERFLOW, and IF DIVIDE CHECK all interrogate the single Branch Control indicator. These statements should appear immediately after the arithmetic statement to be tested, since the Branch Control is turned off when a computed GO TO or a DO loop test is executed.

(4) All COMMON, DIMENSION, and EQUIVALENCE statements must appear before the first executable statement in a program.

(5) The following FORTRAN II statements are not permitted: READ TAPE, READ DRUM, WRITE TAPE, WRITE DRUM, END FILE, REWIND, BACKSPACE.

.14 Restrictions (Contd.)

(6) FREQUENCY statements are ignored by the COMPACT translator.

(7) Boolean operations, complex operations, double precision floating point arithmetic, and use of symbolic language entries in the source program are not permitted.

Extensions:

(1) Statement names may be alphameric as well as numeric.

(2) Arrays may have up to 32 dimensions (FORTRAN allows only three).

(3) Any expression that does not contain a function call may be used as a subscript. A subscript may itself contain subscripted variables, with a nesting limit of 16.

(4) DO loop parameters may be any expression in either fixed or floating mode.

(5) The transfer index of a computed GO TO may be any expression in either fixed or floating mode.

(6) Each parameter in a subroutine CALL may be any expression in either fixed or floating mode.

(7) Mixed mode arithmetic expressions can be written. They will be performed in the floating mode, and fixed point items will be floated prior to execution.

(8) More than one "=" operator can be used in an arithmetic statement. The "=" operator can also appear in IF, DO, and computed GO TO statements.

(9) Array names without subscripts can be used as arguments in a FUNCTION statement.

(10) Many of the syntax requirements of the FORTRAN language have been relaxed; the use of commas and parentheses has been made optional wherever possible.

(11) The READ INPUT TAPE and WRITE OUTPUT TAPE statements may specify the use of any available input-output device.

.15 Publication Date: . . . .1961; no formal language specification has been published to date.

§ 161.

.2 PROGRAM STRUCTURE

.21 Divisions

Procedure Statements: . algebraic formulae.
comparisons and jumps.
input and output.

Data Statements: . . . . FORMAT: describes the layout, size, scaling and code of input-output data.
EQUIVALENCE: used to cause two variables to have a common location or to specify synonyms.
COMMON: used to cause a name to be common to more than one segment rather than local to each.
DIMENSION: describes the elements in each dimension of an array or set of arrays.

.22 Procedure Entities

Program: . . . . . . statements.
subroutines.
functions.
Subroutine: . . . . . statements.
Function: . . . . . . statements.
Statement: . . . . . . characters.

.23 Data Entities

Arrays: . . . . variables.
Items: . . . . floating point variables or constants.
integer variables or constants.
Hollerith items.
alphameric items.

.24 Names

.241 Simple name formation
Alphabet: . . . . . . A to Z, 0 to 9.
Size: . . . . 1 to 5 char.
Avoid key words: . . no.
Formation rule: . . . first char must be a letter.

.242 Designators
Procedures
Statement: . . . . unsigned integer or alphameric name.
Function: . . . . . same as variable being defined; name ends in F and is 4 or 5 chars long.
Data
Integer variables: . initial I, J, K, L, M or N.
Real variables: . . any other initial letter.
Equipment
Typewriter output: . implied by verb PRINT.
Paper tape reader: . implied by verb READ.
Paper tape punch: . implied by verb PUNCH.

Note: READ INPUT TAPE and WRITE OUTPUT TAPE allow specification of input or output via any available device.

.242 Designators (Contd.)
Comments: . . . . . any non-zero character in left-most field of input form.
Translator Control: . key words EQUIVALENCE, COMMON, DIMENSION.

.25 Structure of Data Names

.251 Qualified names: . . . none.
.252 Subscripts
Number per item: . . 32.
Applicable to: . . . . all variables.
Class may be
Any variable: . . . yes.
Literal: . . . . . yes.
Expression: . . . . yes; any expression that does not contain a function name; result is truncated.
.253 Synonyms
Preset: . . . . EQUIVALENCE statement.
Dynamically set: . . yes.

.26 Number of Names: . . limited to 2,048 named entities by symbol table in ROAR translator.

.27 Region of Meaning of Names: . . . . all names are considered local to the program, subroutine, or function in which they are defined unless specified in a COMMON statement.

.3 DATA DESCRIPTION FACILITIES

.31 Methods of Direct Data Description

.311 Concise item picture: . yes; FORMAT statement.
.312 List by kind: . . . . . no.
.313 Qualify by adjective: . no.
.314 Qualify by phrase: . . no.
.315 Qualify by code: . . . yes; initial letter designates floating or integer mode.
.316 Hierarchy by list: . . no.
.317 Level by indenting: . . no.
.318 Level by coding: . . . no.
.319 Others (examples)
Array size: . . . . . DIMENSION ARRAY (5, 4, 3, 2).
Four-digit integer: . FORMAT (I4).
Four-digit integers, 5: . . . . FORMAT (5I4).
Floating point items: . . . . . . FORMAT (F8.3, E10.4) for +999.999 and +.9999E+99.

.32 Files and Reels: . . . own coding.

.33 Records and Blocks

.331 Variable record size: . dynamic.
.332 Variable block size: . dynamic.
.333 Record size range: . . no limit.
.334 Block size range: . . . no limit.

§ 161.

.335 Choice of record size: . . . . READ, WRITE, and FORMAT statements.
.336 Choice of block size: . as above.
.337 Sequence control: . . . own coding.

.34 Data Items

.341 Designation of class: . initial letter of name.
.342 Possible classes
- Integer: . . . . . . yes.
- Fixed point: . . . . no.
- Floating point: . . . yes.
- Alphabetic: . . . . yes.
- Alphameric: . . . . yes.

.343 Choice of external radix: . . . . FORMAT statement.
.344 Possible external radices
- Decimal: . . . . . . yes.
- Octal: . . . . yes.

.345 Internal justification: . . . . alpha automatic left justified. integers automatic right justified.
.346 Choice of external code: . . . . FORMAT and READ, WRITE statements.
.347 Possible external codes
- Decimal: . . . . . . yes.
- Octal: . . . . yes.
- Alphameric: . . . . yes.

.348 Internal item size: . . fixed; 1 word per numeric item.
.349 Sign provision: . . . . optional.

.35 Data Values

.351 Constants
- Possible sizes
  - Integer: . . . . . . 0 to 2^{31}
  - Fixed point: . . . none.
  - Floating point: . . 10^{-38} to 10^{+38}.
  - Alphameric: . . . . no limit.
- Subscriptable: . . . yes.
- Sign provision: . . . optional.

.352 Literals
- Possible sizes
  - Integer: . . . . . 0 to 2^{31}.
  - Fixed point: . . . . none.
  - Floating point: . . . 10^{-38} to 10^{+38}.
  - Alphameric: . . . none.
- Designation: . . . . implied for numerics.
- Sign provision: . . . optional.

.353 Figuratives: . . . . . own coding; e.g., ZERO = 10.
.354 Conditional variables: . yes; computed GO TO.

.36 Special Description Facilities

.361 Duplicate format: . . . by multiple references to a single FORMAT statement.
.362 Redefinition: . . . . . COMMON and EQUIVALENCE statements.
.363 Table description
- Subscription: . . . . yes.
- Multi-subscripts: . . yes; up to 32.
- Level of item: . . . variable.

.364 Other subscriptable entities: . . . . . . none.

.4 OPERATION REPERTOIRE

.41 Formulae

.411 Operator list

+ :	addition; also unary.
- :	subtraction; also unary.
* :	multiplication.
/ :	division.
**:	exponentiation.
= :	is set equal to.
ABSF ( ):	absolute value.
XABSF ( ):	absolute value.
INTF ( ):	entire value.
XINTF ( ):	entire value.
MODF (A, B):	remainder A ÷ B.
XMODF (A, B): . . .	remainder A ÷ B.
MAX (A, ...):	max. value.
XMAX (A, ...): . . .	max. value.
MIN (A, ...):	min. value.
XMIN (A, ...):	min. value.
DIMF (A, B):	diminish A by B.
XDIMF (A, B):	diminish A by B.
LOGF ( ):	natural log.
SINF ( )	sine.
COSF ( ):	cosine.
EXPF ( ):	exponential.
SQRTF ( ):	square root.
ATANF ( ):	arctangent.
TANHF ( ):	hyperbolic tangent.
FLOTF ( );	float.
XFIXF ( ):	fix.

Note: Initial X denotes fixed point function.

.412 Operands allowed
- Classes: . . . . all numeric.
- Mixed scaling: . . . . yes.
- Mixed classes: . . . . yes; mixed expressions are evaluated in floating mode.
- Mixed radices: . . . . no.
- Literals: . . . . yes.

.413 Statement structure
- Parentheses
  - a - b - c means: . . (a - b) - c.
  - a + b x c means: . . a + (b x c).
  - a / b / c means: . . (a ÷ b) ÷ c.
  - a^{b^c} means: . . . . . illegal; parentheses must be used.
- Size limit: . . . . . 300 entities (names plus operators).
- Multi-results: . . . . yes.

.414 Rounding of results: . . truncation of integers at each step in expression.
.415 Special cases

	Fixed	Floating
x = -x:	K = -K	X = -X
x = x + 1: . . .	K = K+1	X = X+1.0
x = 4.7 y: . . .	K = 47*I./10	X = 4.7*Y
$x = 5 \times 10^7 + y^2$	K = 50000000 +L**2	X = 5.E7+Y**2

.416 Typical examples: . . . X = (-B+SQRTF(B*B-4.0*A *C))/ (2.0*A).

§ 161.

.42 Operations on Arrays

.421 Matrix operations: . . . none.
.422 Logical operations: . . none.
.423 Scanning: . . . . none.

.43 Other Computation: . . none.

.44 Data Movement and Format

.441 Data copy example: . . Y = X.
.442 Levels possible: . . . items (unsubscripted array name on left side causes value on right side to be copied into every element of the array).
.443 Multiple results: . . . yes; e.g., Y = Z = X.
.444 Missing operands: . . not possible.
.445 Size of operands
Exact match: . . . . implied, except in alpha or input-output.
Alignment rule
Numbers: . . . . . integers right justified.
Alpha: . . . . . left justified.
Filler rule
Numbers: . . . . . zeros.
Alpha: . . . . . blanks.
.446 Editing possible
Change class: . . . . yes; fix, float.
Change radix: . . . . yes; binary-decimal and binary-octal conversions.
Delete editing symbols: . . . . . automatic.
Insert editing symbols
Actual point: . . . . automatic.
Suppress zeroes: . automatic.
.447 Special moves: . . . . none.
.448 Code translation: . . . automatic.
.449 Character manipulation: . . . . none.

.45 File Manipulation

Open: . . . . not required.
Close: . . . . not required.
Advance to next record: . . . . READ, PUNCH, PRINT.
Step back a record: . . not possible.
Set restart point: . . . none.
Restart: . . . . none.
Start new reel: . . . . none.
Start new block: . . . . automatic.
Search on key: . . . . none.
Rewind: . . . . none.
Unload: . . . . none.

.46 Operating Communications

.461 Log of progress: . . . PRINT uses on-line typewriter.
.462 Messages to operator: . same as log.
.463 Offer options: . . . . . PAUSE and hexadecimal display.
.464 Accept option: . . . . IF SENSE SWITCH n, or test data entered from keyboard.

.47 Object Program Errors

Error	Discovery	Special Actions
Overflow:	IF clauses test Branch Control	own COMPACT coding.
In-out:	hardware parity check.	
Invalid data:	range check	print message & halt.

.5 PROCEDURE SEQUENCE CONTROL

.51 Jumps

.511 Destinations allowed: . . named statement.
.512 Unconditional jump: . . GO TO START.
.513 Switch: . . . . GO TO M, (ALPHA, BETA, 37).
.514 Setting a switch: . . . . ASSIGN ALPHA TO M.
.515 Switch on data: . . . . GO TO (START, 10, 20, END) K+M/4.

.52 Conditional Procedures

.521 Designators
Condition: . . . . . IF.
Procedure: . . . . . implied.
.522 Simple conditions
Expression v Expression: yes.
Expression v Variable: . . yes.
Expression v Literal: . . yes.
Expression v Figurative: . yes.
Expression v Condition: . . no.
Variable v Variable: . . yes.
Variable v Literal: . . yes.
Variable v Figurative: . yes.
Variable v Condition: . no.
Conditional value: . . . . . positive, zero, or negative.
.523 Conditional relations
Equal: . . . . }
Greater than: . . . } tested jointly in each IF statement
Less than: . . . . . }
Greater than or equal: . . . . indirect.
Less than or equal: . indirect.
.524 Variable conditions: . . zero.
.525 Compound conditionals: . . . . no.
.528 Typical examples: . . IF (X**2.0-3.0) START, 20, END means go to statement START, 20, or END depending upon whether X^2-3 is less than, equal to, or greater than zero.

.53 Subroutines

.531 Designation
Single statement: . . . not used.
Set of statements
First: . . . . SUBROUTINE.
Last: . . . . END.
.532 Possible subroutines: . any number of statements.
.533 Use in-line in program: . . . . . no.

§ 161.

.534 Mechanism
Cue with parameters: . . . . CALL XXX (A, L).
Number of parameters: . . . . no limit.
Cue without parameters: . . . . CALL XXX.
Formal return: . . . . RETURN at least once.
Alternative return: . . none.

.535 Names
Parameter call by value: . . . . none.
Parameter call by name: . . . . yes.
Non-local names: . . use COMMON.
Local names: . . . . all.
Preserved local variables: . . . . all.

.536 Nesting limit: . . . . no limit.

.537 Automatic recursion allowed: . . . . . . no.

.54 Function Definition by Procedure

.541 Designation
Single statement: . . not used.
Set of statements
First: . . . . . . FUNCTION.
Last: . . . . END.

.542 Level of procedure: any number of statements.

.543 Mechanism
Cue: . . . . by name in expression.
Formal return: . . . RETURN.

.544 Names
Parameter call by value: . . . . . . none.
Parameter call by name: . . . . . . yes.
Non-local names: . . use COMMON.
Local names: . . . all.
Preserved local variables: . . . . . all.

.55 Operand Definition by Procedure: . . . . . none.

.56 Loop Control

.561 Designation of loop
Single procedure: . . none.
First and last procedures: . . . . current place to named end; e.g.,
DO 173 I = 1, N, 2
DO ALPHA, I = A+K, B*L/2.

.562 Control by count: . . . no.

.563 Control by step
Parameter: . . . . . any variable or expression.
Step: . . . . any variable or expression.
Criteria: . . . . . greater than.
Multiple parameters: . . . . . . no.

.564 Control by condition: . no.

.565 Control by list: . . . . no.

.566 Nesting limit: . . . . no limit.

.567 Jump out allowed: . . . yes.

.568 Control variable exit status: . . . . . . available always.

.6 EXTENSION OF THE LANGUAGE: . . . . can write new library functions and subroutines.

.7 LIBRARY FACILITIES

.71 Identity: . . . . COMPACT library.

.72 Kinds of Libraries

.721 Fixed master: . . . . no.

.722 Expandable master: . . yes.

.723 Private: . . . . yes.

.73 Storage Form: . . . . punched tape.

.74 Varieties of Contents: . . . . subroutines and functions.

.75 Mechanism

.751 Insertion of new item: . file tape in library.

.752 Language of new item: . ROAR or COMPACT.

.753 Method of call: . . . . assemble along with user's program.

.76 Types of Routine

.761 Open routines exist: . no.

.762 Closed routines exist: . . . . yes.

.8 TRANSLATOR CONTROL

.82 Optimizing Information Statements: . . . . none.

.83 Translator Environment: . . . . none.

.84 Target Computer Environment: . . . none.

.85 Program Documentation Control: . . . . none in source language.

.9 TARGET COMPUTER ALLOCATION CONTROL

.91 Choice of Storage Level: . . . . none.

.92 Address Allocation: . . . . none in source language.

.93 Arrangement of Items in Words in Unpacked Form: . . . . standard.

.94 Assignment of Input-Output Devices: . . . specified in input-output statements.

.95 Input-Output Areas: . . . automatic.

MACHINE-ORIENTED LANGUAGE: ROAR

§ 171.

.1 GENERAL

.11 Identity: . . . . RPC-4000 Optimizer and Assembly Routine. ROAR.

.12 Origin: General Precision, Inc.

.13 Reference: ROAR Program Description Manual, program H2-01.0. ROAR II, program H2-01.1.

.14 Description

ROAR is the basic machine oriented language for the RPC-4000. It is a straightforward symbolic assembly system which provides no macros, and uses literals only for controlling the index register, shifting, etc., as in the machine codes, and in the Print a Character pseudo, PRC. The coding sheets are punched on paper tape for entry into the assembler.

Addressing conventions allow control of optimization while still retaining the use of symbolic addresses. The TAG pseudo allows differentiation of otherwise identical labels, but the tag is not printed when the program is listed. Operation codes and address may be in numeric or symbolic form.

Constants may be entered as 6-bit or 4-bit characters; the pseudo DEC allows the entry of a signed number with decimal point and binal "q" (binal point location) specification. There are 18 pseudos in the language, including one to initialize at the start of a translating run, and one to stop the translator, ready for restart. The latter may be used at the end of tape.

.15 Publication Date: . . . ?

.2 LANGUAGE FORMAT

.21 Diagram: . . . . . . refer to RPC-4000 Coding Sheet.

.22 Legend

Location: . . . . . . address of instruction in symbolic or numeric coding.
Order: . . . . mnemonic or decimal code for instruction or pseudo-instruction, and flag for indexing.
Data Address: . . . . numeric or symbolic address of operand; or, value for control of instruction.

.22 Legend (Contd.)

Next Address: . . . . numeric or symbolic address of next instruction in object program.
Comments: . . . . . explanatory comments to be listed but not translated.

.23 Corrections: . . . . . no special provisions; any changes are re-written and paper tape changed accordingly.

.24 Special Conventions

.241 Compound addresses: . an unassigned address may be placed a specified distance past normally assigned optimum address, in Data or Next Address column (SKIP).
.242 Multi-addresses: . . . none.
.243 Literals: . . . . . . in SKIP. Also PRC pseudo for printing 1 char.

.244 Special coded addresses: . . . . . D-Address may be assigned to N-Address column. blank; assigned to convenient or optimum location.
.245 Other
Region: . . . . 1 letter or symbol.
1 specific address within a region: . . region char followed by 5 dec digits, specifying relative position in region.
Start of standard subroutine: . . . .] followed by 4 digits.
8-word band: . . . . RECRC1 to RECRC8.
Dual-access bands: . DB1SYM to DB4SYM (SYM may be any 3 characters).

.3 LABELS

.31 General

.311 Maximum number of labels: 2, 048
.312 Common label formation rule: . . . . . . yes.
.313 Reserved labels: . . . none.
.314 Other restrictions: . . none.
.315 Designators: . . . . . none.
.316 Synonyms permitted: . EQR, EQV pseudos.

§ 171.

.32 Universal Labels

.321 Labels for procedures

Existence:	optional, in Location column.
Formation rule	
First character:	letter, number, or symbol.
Last character:	letter, number, or symbol.
Others:	letter, number, or symbol.
Number of characters:	2 to 5 total, including at least 1 non-numeric char.

.322 Labels for library routines

Existence:	mandatory, used for start of standard subroutines.
Formation rule	
First character:	].
Others:	4 numerics.
Number of characters:	5.

.323 Labels for constants:	same as procedures.
.324 Labels for files:	none.
.325 Labels for records:	none.
.326 Labels for variables:	same as procedures.

.33 Local Labels: none.

.4 DATA

.41 Constants

.411 Maximum size constants

Integer	
Decimal:	none.
Octal:	none.
Hexadecimal:	8 hex digit.
Binary:	9 dec digit and "q" with total accuracy; up to 14 dec digit with sign and point, truncated at 9.
Fixed numeric:	same as integer.
Floating numeric:	none.
Alphabetic:	5 alpha char.
Alphameric:	5 alpha char.

.412 Maximum size literals

Integer:	limited groups of decimal digits for index register control, shift control, etc. See paragraph .235 of Central Processor for details.
Fixed numeric:	none.
Floating numeric:	none.
Alphabetic:	1 char for printing.
Alphameric:	1 char for printing.

.42 Working Areas

.421 Data layout

Implied by use:	no.
Specified in program.	yes.

.422 Data type: always numeric.

.43 Input-Output Areas: computer registers or fast-access band.

.5 PROCEDURES

.51 Direct Operation Codes

.511 Mnemonic

Existence:	optional.
Number:	32.
Example:	ADU; (S) + (U)→U. S = storage, U = Upper Accumulator.

.512 Absolute

Existence:	optional.
Number:	32.
Example:	28; (S) + (U) →U. S = storage, U = Upper Accumulator.

.52 Macro-Codes: none.

.53 Interludes: none.

.54 Translator Control

.541 Method of control

Allocation counter:	by assembler and by pseudo operations.
Label adjustment:	by pseudo operations.
Annotation:	automatic.

.542 Allocation counter

Set to absolute:	see .543.
Set to label:	see .543.
Step forward:	none.
Step backward:	none.
Reserve area:	REG pseudo.

.543 Label adjustment

Set labels equal:	EQR, EQV pseudos.
Set absolute value:	EQR, EQV pseudos.
Clear label table:	CLS pseudo.

.544 Annotation

Comment phrase:	tagged field, ignored by translator, and copied to output.
Title phrase:	no title phrase.

.545 Other

RES:	make locations unavailable.
AVL:	make locations available.
NEW:	initialize for new program.
SKIP:	assign location beyond first optimum.
D-ADDR:	make value of N-Address equal to value of D-Address.
Numeric address, main memory sector specification, for use with 8-word Lower Accumulator	
90 to 97:	assign next sector 0-7 modulo 8.
98:	assign first optimum sector.
99:	assign same sector as in instruction location.

.6 SPECIAL ROUTINES AVAILABLE

.61 Special Arithmetic

.611 Facilities:	2-word floating point add, subtract, multiply, divide, fixed to floating point conversions.
.612 Method of call:	assemble with program.

§ 171.

.62 Special Functions

.621 Facilities: . . . . . . 2-word floating point square root, sine-cosine, arctan, arcsin, log, exponential.

.622 Method of call: . . . . assemble with program.

.63 Overlay Control: . . . none.

.64 Data Editing

Editing is normally performed as a function of the input-output subroutines which accomplish the input and output of data and provide radix conversion. Output may be provided in alphanumeric form on a character-by-character basis from data previously composed and stored in the Upper Accumulator, or in the print instructions.

The Floating Point input routine Data Input 2, truncates input digits past the ninth non-zero digit, converts the number to normalized binary form, and calculates the exponent of the number, taking the location of the actual decimal point into account. The resulting number is stored as two words; fixed part and exponent.

The numeric input routine, Data Input 1, truncates as above. The number is converted to one-word binary form and scaled according to the position of the decimal point, and a specified binal point, "q".

Floating Point output subroutines, Data Output 2, 3, output a number with minus sign or space, decimal point, and 8 or 9 decimal digits; followed by the letter E, a minus sign or space, and a two digit decimal exponent.

A numeric output number is output (Data Output 1) as a minus sign or space followed by its integral value, decimal point, and fractional value, up to 10 digits total. Non-significant leading zeros are output as spaces, and one space follows the last digit. The routine allows specification of the "q" of the binary number, and the number of digits to follow the decimal point.

These routines are entered through calling sequences to specified symbolic addresses.

.66 Sorting: . . . . none.

.67 Diagnostics

.671 Dumps: . . . . memory print.
.672 Tracers: . . . . ?
.673 Snapshots: . . . . . . none.

.7 LIBRARY FACILITIES

The library consists of a number of subroutines written in symbolic language and stored on paper tape. Each subroutine has its entry point, which is the first instruction, specified as a unique symbolic address. Tapes are assembled by ROAR. A calling sequence in the source program specifies the subroutine desired and also specifies an exit location. The types of routines included are: input-output, floating-point input-output, floating-point arithmetic, and trigonometric functions, fixed-to-floating-point conversion and the reverse, miscellaneous interpreters, powers of 10 table, trace and dump routines, program checkout, and demonstration routines.

.8 MACRO AND PSEUDO TABLES

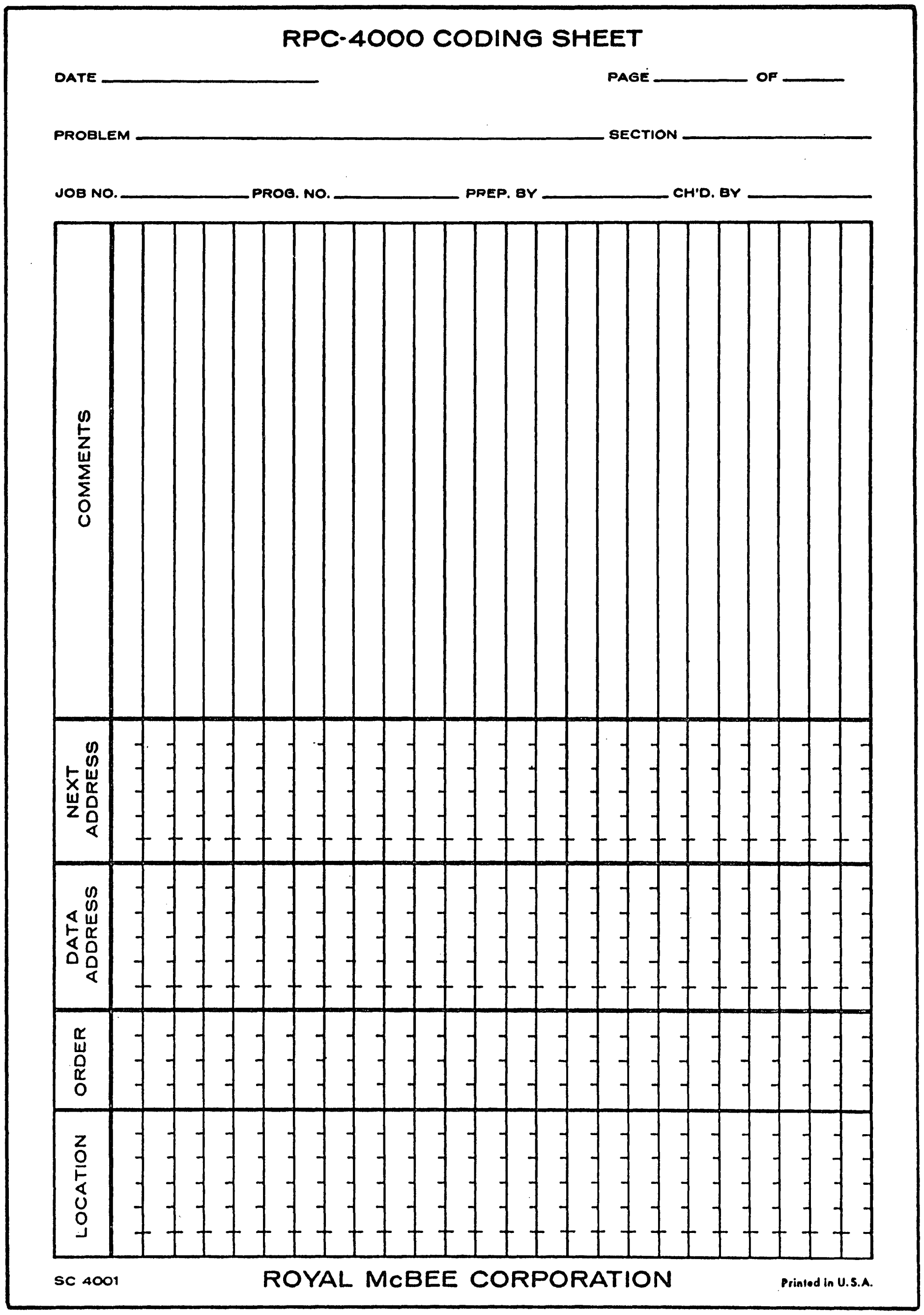
.81 Macros: . . . . none.

.82 Pseudos

Code	Description
REG:	reserve a region.
EQR:	set label to absolute; reserve.
EQV:	set label to absolute; don't reserve.
RES:	make locations unavailable.
AVL:	make locations available.
PAV:	punch availability table in hex code.
PPA:	punch and print availability table; punch hex code, print decimal code.
RAV:	read availability table (automatically punched when PAV, PPA used).
HEX:	input literal in hex (4-bit) codes.
ALF:	input literal in alpha (6-bit) codes.
DEC:	store decimal literal with specified "q", in binary.
TAG:	tag all following symbolic addresses with literal.
PRC:	print char, or control typewriter, as specified in data address field.
NIX:	stop computer during translation; allow restart.
END:	end of program; punch final checksum and set up transfer to specified address.
NEW:	initialize to process a new program.
CLS:	clear label table.
COM:	copy remarks contained in this pseudo on output devices connected to system.

§ 171.

FIGURE 2


RPC-4000 CODING SHEET

DATE ______ PAGE ______ OF ______

PROBLEM ______ SECTION ______

JOB NO. ______ PROG. NO. ______ PREP. BY ______ CH'D. BY ______

COMMENTS

NEXT ADDRESS

DATA ADDRESS

ORDER

LOCATION

SC 4001 ROYAL McBEE CORPORATION Printed in U.S.A.

Reprinted from ROAR programming manual.

MACHINE-ORIENTED LANGUAGE: PINT

§ 172.

.1 GENERAL

.11 Identity: . . . . Purdue Floating Point Interpretive System. Program H1-02.0. PINT.

.12 Origin: . . . . School of Electrical Engineering, Purdue University.

.13 Reference: . . . . . . Publication SC 4059 of General Precision, Inc. Commercial Computer Div.

.14 Description

PINT simulates on an RPC-4000 a slower pseudo computer that has a repertoire of 47 convenient instructions, including floating point arithmetic and the common mathematical functions. The one-address instructions are executed sequentially. Each instruction consists of an optional digit specifying one of the seven index registers, a 3-letter mnemonic operation code, and a 3-digit operand address.

All computations except index register operations are done in the floating point mode. Each data item occupies two locations of RPC-4000 drum storage, with sign and 31 magnitude bits for the fixed point part and sign and 17 bits for the exponent; a wide range of data values can be represented with a precision of about 9.3 decimal digits.

A total of 1,666 PINT storage locations are available to the user, and each pseudo location can hold one instruction or one data item. One thousand locations are addressed by simple 3-digit addresses from 000 through 999; the upper 666 locations require the use of alphabetic characters in their addresses. Independent subroutines can be easily written in the PINT language.

Input and output may be in either fixed or floating point decimal form. The PINT input-output routines handle conversions between the internal floating point binary format and the selected external formats. During data input of floating point items, the fixed point part is considered an integer rather than a normalized fraction as in most systems. Alphameric information can be printed but cannot be processed or entered as data at run time. Insertion of machine coding into a PINT routine is possible but inconvenient.

.2 LANGUAGE FORMAT

.21 Diagram

LOCATION	ORDER	DATA ADDRESS	COMMENTS

.22 Legend

Location: . . . . specifies address (3 decimal digits) of the instruction or constant; not punched on program tape.

Order: . . . . specifies a 3-character mnemonic operation code, a program loading code, or a constant; most operation codes may be preceded by a digit specifying an index register.

Data Address: . . . . . specifies a 3-digit decimal operand address or literal.

Comments: . . . . used for coding sheet documentation only.

.23 Corrections: . . . . . . no special provisions.

.24 Special Conventions

.241 Compound addresses: . none.

.242 Multi-addresses: . . . none.

.243 Literals: . . . . only for loading, incrementing, and testing of index registers.

.244 Special coded addresses: . . . . . . none.

.3 LABELS: . . . . none; all operands are identified by their pseudo addresses in 3-digit decimal form.

.4 DATA

.41 Constants

.411 Maximum size constants

Machine Form	External Form
Integer:	not used.
Fixed numeric: . . .	not used.
Floating numeric Binary:	9 decimal digits for fixed point part and 2 for exponent, or 9 decimal digits with point in proper position and no exponent.
Alphabetic:	4 characters per word, each char represented by a 2-digit code.
Alphameric:	same as Alphabetic.

§ 172.

.412 Maximum size literals
Integer
Binary: . . . . 3 decimal digits; usable only for index register operations.
Fixed numeric: . . . . none.
Floating numeric: . . none.
Alphabetic: . . . . . . none.
Alphameric: . . . . . none.

.42 Working Areas

.421 Data layout: . . . . . . absolute, relocatable addresses are used.
.422 Data type: . . . . always floating numeric.

.43 Input-Output Areas

.431 Data layout: . . . . . . standard formats.
.432 Data type: . . . . always floating numeric, with input and output in decimal form.

.5 PROCEDURES

.51 Direct Operation Codes

.511 Mnemonic
Existence: . . . . . . mandatory.
Number: . . . . 47.
Example: . . . . SUB means "subtract".
Comment: . . . . . . see .83 for complete instruction list.
.512 Absolute
Existence: . . . . . . not used.

.52 Macro Codes: . . . . . none.

.53 Interludes: . . . . none.

.54 Translator Control: . . see section :192.

.6 SPECIAL ROUTINES AVAILABLE: . . . . . none; but floating point arithmetic, common functions, input-output routines, and diagnostics are included in the interpretive system.

.7 LIBRARY FACILITIES

.71 Identity: . . . . private, user-developed subroutine libraries.

.72 Kinds of Libraries

.721 Fixed master: . . . . . no.
.722 Expandable master: . . no.
.723 Private: . . . . yes.

.73 Storage Form: . . . . . punched tape.

.74 Varieties of Contents: . subroutines developed by user.

.75 Mechanism

.751 Insertion of new item: . punch tape and file.
.752 Language of new item: . PINT; relocatable form.
.753 Method of call: . . . . . load into a free area of PINT storage.

.76 Insertion in Program

.761 Open routines exist: . . yes.
.762 Closed routines exist: . yes.
.763 Open-closed is optional: yes.
.764 Closed routines appear once: . . . . yes.

.8 MACRO AND PSEUDO TABLES

.81 Macros: . . . . none.

.82 Pseudos (Program Loading Codes)

Code	Description
BEGIN Y:	transfer to Y and begin executing the stored program.
CLEAR:	set all of PINT storage to "undefined" status to facilitate error detection.
LOAD Y:	load program into consecutive locations beginning at Y.
MOD Y:	add Y to address of all modifiable instructions except those preceded by X.
WAIT:	remain in loading routine and wait for another code word.

.83 Others (See below)

Code	Address	Operation	Time, m.sec.
ADD	Y	(A) + (Y) ⟶ A	68
SUB	Y	(A) - (Y) ⟶ A	68
MUL	Y	(A) x (Y) ⟶ A	68
DIV	Y	(A) ÷ (Y) ⟶ A	68
RDV	Y	(Y) ÷ (A) ⟶ A	68
POS	O	Make (A) positive	34
NEG	O	Make (A) negative	34
CHS	O	Change sign of (A)	34
CCF	Y	(Y) ⟶ A	51
CNF	Y	-(Y) ⟶ A	51
XCH	Y	(Y) ⟶ A and (A) ⟶ Y	68
CCI	Y	(A) ⟶ Y	51
CZI	Y	O ⟶ Y	34
CAI	Y	Round off (A) and store in address portion of Y	119

§ 172.

.83 Others (Contd.)

Code	Address	Operation	Time, m.sec.
SQR	O	$\sqrt{(A)} \rightarrow A$	153
SQA	O	$(A)^2 \rightarrow A$	51
SIN	O	Sine $(A) \rightarrow A$	238
COS	O	Cosine $(A) \rightarrow A$	289
ATN	O	Arctangent $(A) \rightarrow A$	289
PWR	Y	$(A)^{(r)} \rightarrow A$	476
EXP	O	$e^{(A)} \rightarrow A$	187
TEN	O	$10^{(A)} \rightarrow A$	221
LNE	O	$\ln (A) \rightarrow A$	255
LOG	O	$\log (A) \rightarrow A$	255
JMP	Y	Jump unconditionally to Y	34
JIN	Y	Jump to Y if (A) is negative	34
JIP	Y	Jump to Y if (A) is positive	34
JOS	Y	Jump to Y if Sense Switch 2 is down	34
SRA	Y	Set subroutine return address in Y	51
HLT	Y	Halt, then jump to Y if Start button is pressed	34
XIT	Y	Exit from PINT system and transfer control to Y	17
INM	Y	Input data into consecutive locations starting at Y	*
INA	O	Input one data item into A	*
PRM	Y	Print one data item from Y	*
PRA	n	Print (A) in floating point form	*
PFA	n	Print (A) in fixed point form	*
ABC	Y	Print alphameric information from the next Y locations	*
CAR	O	Perform typewriter carriage return	*
TAB	O	Perform typewriter tab	*
jLDC	Y	Load Y into Count portion of j	51
jLDA	Y	Load Y into Address portion of j	34
jLDI	Y	Load Y into Increment portion of j	34
jCIJ	Y	Add Increment of j to its Address portion; decrease Count portion by 1; and jump to Y if Count is greater than zero.	51
jAXA	Y	Add Y to Address portion of j	51
jSXA	Y	Subtract Y from Address portion of j	51
jCXF	Y	Address portion of $(Y) \rightarrow$ Address portion of j	51
jCXI	Y	Address portion of j $\rightarrow$ address portion of Y	51

where
- A is the pseudo accumulator.
- j is an integer from 1 to 7 that specifies an index register.
- n is an integer specifying number of significant digits to be printed.
- Y is a 3-digit address or literal.
- ( ) denotes contents of a register or storage location.
- * indicates that time requirements depend upon the input-output device selected.

Note: Execution time is increased by 17 m.sec for each indexed instruction.

PROGRAM TRANSLATOR: COMPACT

§ 181.

.1 GENERAL

.11 Identity: . . . . COMPACT.
Program H3-01.0.

.12 Description

The COMPACT translator permits utilization of all the facilities of the FORTRAN-like COMPACT language as described in section 351:161. A one-pass compilation transforms the source program into ROAR symbolic statements. These must be translated into the machine language object program by the ROAR translator in a separate run.

Only the basic RPC-4000 Computer and Tape Typewriter System are required for operation of the translator. Documentation can be controlled by Sense Switch settings; suppression of the typed listing significantly increases the translation speed.

The COMPACT Object Program Package occupies 44 tracks of drum storage and must be loaded whenever a COMPACT object program is executed. It contains the FORTRAN II library functions plus the subroutines for floating point arithmetic and input-output operations. Because subroutines must be used for floating point operations, most COMPACT object programs consist largely of subroutine linkages. Errors in the Package subroutines caused serious difficulties with early versions of the COMPACT system. According to the manufacturer, corrected versions are now available.

Data input to the object program is performed in the Single Character Mode. As in FORTRAN, FORMAT statements are executed interpretively at run time. This provides very flexible data formats, but input and output speeds are significantly reduced.

.13 Originator: . . . . Commercial Computer Division, General Precision, Inc.

.14 Maintainer: . . . . . . as above.

.15 Availability: . . . . . . generally issued late in 1961, but not fully documented to date.

.2 INPUT

.21 Language

.211 Name: . . . . COMPACT
.212 Exemptions: . . . . . none; COMPACT is the FORTRAN II language with extensions and restrictions as listed in 351:161.14.

.22 Form

.221 Input media: . . . . . punched tape or typewriter keyboard.
.222 Obligatory ordering: . specification statements, arithmetic function definitions, executable statements.
.223 Obligatory grouping: . none.

.23 Size Limitations

.231 Maximum number of source statements: . limited by target computer storage capacity
.232 Maximum size source statements: . . . . 300 entities (names plus operators).
.233 Maximum number of data items: . . . . 2,048 (limited by ROAR symbol table).

.3 OUTPUT

.31 Object Program

.311 Language name: . . . ROAR.
.312 Language style: . . . symbolic.
.313 Output media: . . . . punched tape.

.32 Conventions

.321 Standard inclusions: . . . . none.
.322 Compatible with: . . . COMPACT Object Program Package, which must be loaded at execution time.

.33 Documentation

Subject	Provision
Source program: . . .	typed listing (optional).
Object program: . . .	typed listing (optional).
Storage map:	none.
Restart point list: . .	none.
Language errors: . .	typed messages.

.4 TRANSLATING PROCEDURE

.41 Phases and Passes: . . . one-pass compiler; but output from this translator must be converted to machine language form by the ROAR translator.

.42 Optional Mode

.421 Translate: . . . . yes.
.422 Translate and run: . . no.
.423 Check only: . . . . . no.
.424 Patching: . . . . no.
.425 Up-dating: . . . . . . no.

§ 181.

.43 Special Features

.431 Alter to check only: . no.
.432 Fast unoptimized translate: . . . . . no.
.433 Short translate on restricted program: . . no.

.44 Bulk Translating: . . . yes.

.45 Program Diagnostics

.451 Tracers: . . . . no.
.452 Snapshots: . . . . no.
.453 Dumps: . . . . no.

.46 Translator Library: . . none; required library routines other than those in the Object Program Package must be assembled along with the output from this translator.

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed overhead: . . . Object Program Package contains all library functions plus routines for input-output and floating point arithmetic; it requires 2,816 storage locations.
.512 Space required for each input-output file: . . single I/O area serves all files.
.513 Approximate expansion of procedures: . . . 8 to 10 (**).

.52 Translation Time

.521 Normal translating: . . generates about 1,300 symbolic instructions per hour (**).

.53 Optimizing Data: . . . none (the ROAR translator assigns optimum drum storage locations whenever possible).

.54 Object Program Performance (***)

Type	Time	Space
Elementary algebra:	unaffected	unaffected.
Complex formulae:	increased	increased.
Deep nesting:	increased	increased.
Heavy branching:	increased	increased.
Complex subscripts:	increased	increased.
Data editing (FORMAT):	greatly increased	increased.
Overlapping operations:	not possible.	

.6 COMPUTER CONFIGURATIONS

.61 Translating Computer

.611 Minimum configuration: . . . . RPC-4000 Computer and Tape Typewriter System.
.612 Larger configuration advantages: . . . Photo Reader and High Speed Punch speed translation.

.62 Target Computer

.621 Minimum configuration: . . . . RPC-4000 Computer and Tape Typewriter System.
.622 Usable extra facilities: . . . . all input-output devices.

.7 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Missing entries:	check	print message & halt.
Unsequenced entries:	check	print message & halt.
Improper format:	check	print message & halt.
Incomplete entries:	check	print message & halt.
Target computer overflow:	ROAR translator check.	
Inconsistent program:	check	print message & halt.
"Inscrutable statement:"	check	print message & halt.

.8 ALTERNATIVE TRANSLATORS: . . . none.

PROGRAM TRANSLATOR: ROAR

§ 182.

.1 GENERAL

.11 Identity: . . . . RPC-4000 Optimizer and Assembly Routine. ROAR.

.12 Description

The ROAR assembly language translator is a one-pass assembler which accepts symbolic or machine code source language and symbolic subroutines on punched paper tape, and produces a relocatable hexadecimal punched paper tape as output. The object program is in RPC-4000 machine language. The output tape consists of: a short bootstrap; an input loading routine; groups of machine language instruction and data words with their locations; and hash total error control words ("checksum words"). The modifier for assignment of relocatable tape addresses is inserted by the operator at object time, prior to initiating the entry of the input routine. Determination of the need for a modifier is done by the bootstrap, using the setting of a sense switch on the 4010 Console. The source and object programs and the comments of the programmer may be listed on the typewriter; instructions are typed in decimal form. Also accepted by the assembler is the output of the algebraic compiler, COMPACT.

The translator reads one symbolic instruction at a time and assigns absolute addresses, allocating them to optimum locations using the RPC-4000 "1 + 1" addressing structure. The instruction generated is punched out as four hexadecimal location characters and eight hexadecimal instruction or constant word characters. Typing is optional as noted above. Input pseudo instructions initiate end of program control, symbol table clearing, and initialization of the translator for accepting another input program. No provision is made for printing the label table.

.13 Originator: . . . . . General Precision, Inc.

.14 Maintainer: . . . . . General Precision, Inc.

.15 Availability: . . . . . released in 1961.

.2 INPUT

.21 Language

.211 Name: . . . . ROAR.
.212 Exemptions: . . . . . none.

.22 Form

.221 Input media: . . . . punched tape; keyboard.
.222 Obligatory ordering: . none.
.223 Obligatory grouping: . none.

.23 Size Limitations

.231 Maximum number of source statements: . no limit; assembly performed 1 symbolic instruction at a time.
.232 Maximum size source statements: . . . . . fixed at 1 symbolic instruction.
.233 Maximum number of data items: . . . . . 2,048 symbolic labels.

.3 OUTPUT

.31 Object Program

.311 Language name: . . . . RPC-4000 machine code with storage address.
.312 Language style: . . . . utilizes complete language.
.313 Output media: . . . . paper tape; typewriter listing normal but not mandatory.

.32 Conventions

.321 Standard inclusions: . . . . checksum words for error control; bootstrap and input program for loading program into object computer.

.33 Documentation

Subject	Provision
Source program: . . .	listing of codes, comments.
Object program: . . .	listing.
Storage map:	none.
Restart point list: . . .	none.
Language errors: . . .	typed messages.
Availability table: . . .	punched and/or printed listing of unassigned storage locations.

.4 TRANSLATING PROCEDURE

.41 Phases and Passes: . . one-pass assembler.

.42 Optional Mode: . . . . no optional modes.

.43 Special Features: . . . none.

.44 Bulk Translating: . . . yes.

§ 182.

.45 Program Diagnostics: . . . . diagnostic routines are either assembled as subroutines for source program, or are called manually. See Operating Environment section for description.

.46 Translator Library: library subroutines can be stored on a single punched tape, which is searched in both directions by the translator to incorporate the subroutines called by the source program.

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed overhead

Name	Space	Comment
Loader:	1 track	space can be used for object program data.

.512 Space required for each input-output file: . . . own coding.

.513 Approximate expansion of procedures: . 1.

.52 Translation Time

.521 Normal translating: . . . 7 to 10 instructions/minute with full on-line listing; 4 times as fast if listing is omitted (**)

.522 Checking only: . . . . not done.

.523 Unoptimized translating: . . . . not done.

.53 Optimizing Data: . . . special addressing conventions; see :171.24.

.54 Object Program Performance: . . . unaffected; i.e., same as carefully optimized hand coded routines except that double access bands and fast access band cannot be utilized as efficiently.

.6 COMPUTER CONFIGURATIONS

.61 Translating Computer

.611 Minimum configuration: . . . . 4010 Central Processor. 4500 Tape Typewriter System.

.612 Larger configuration advantages: . . . fast input of data and faster output when translating speed allows it, if Photo Reader and High Speed Punch are used.

.62 Target Computer

.621 Minimum configuration: . . . . same as Translating Computer.

.622 Usable extra facilities: . . . . 4410 Photo Reader. 4440 High Speed Punch.

.7 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Missing entries:	check	print message & halt.
Unsequenced entries:	none.	
Duplicate names:	?	
Improper format:	check	print message & halt.
Incomplete entries:	check	print message & halt.
Target computer overflow:	check	print message & halt.
Label table full:	check	print message & halt
Invalid operation code:	check	print message & halt.
Inconsistent program:	none.	
Checksum error:	program input routine check	accepted convention is to type out "ERROR" and halt system.
Input parity error:	check	halt computer; alarm.

.8 ALTERNATIVE TRANSLATORS: . . . none.

OPERATING ENVIRONMENT: GENERAL

§ 191.

.1 GENERAL

.11 Identity: . . . . no integrated supervisor available.

.12 Description:

No comprehensive supervisor routine has been announced for the RPC-4000 system. The facilities covered in this section, therefore, must be provided by the incorporation in each program of specific routines, where available, or by individual coding.

The input loading routine may be loaded automatically by a bootstrap incorporated on the ROAR output tape, or may be left in the computer.

.13 Availability: . . . . . all library routines mentioned in this section are currently available.

.14 Originator: . . . . . Commercial Computer Department, General Precision, Inc.

.15 Maintainer: . . . . . as above.

.16 First Use: . . . . . ?

.2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . none.
.212 Independent programs: hexadecimal punched tapes, supplied directly, or assembled by ROAR from symbolic tapes.
.213 Data: . . . . punched tape or keyboard.

.22 Library Subroutines: . . punched tapes, loaded by input routine.

.23 Loading Sequence: . . . manually controlled. Sequence not important.

.3 HARDWARE ALLOCATION

.31 Storage

.311 Sequencing of program for movement between levels: . . . . not possible.
.312 Occupation of working storage: . . . . . . specified manually when entering relocatable tape.

.32 Input-Output Units

.321 Initial assignment: . . . by programmer, or manually by operator.
.323 Reassignment: . . . by operator.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: . . . . not possible.

.42 Multi-running: . . . . . not possible.

.43 Multi-sequencing: . . . not possible.

.44 Errors, Checks and Action

Error	Check or Interlock	Action
Loading input error:	optional checksum	programmed; printout.
Allocation impossible:	?	
In-out error - single:	optional hardware parity check	stop computer, alarm.
In-out error - persistent:	none.	
Storage overflow:	none.	
Invalid instructions:	?	
Arithmetic overflow:	hardware check	BC toggle set.
Underflow:	hardware check	number treated as zero.
Invalid operation:	?	
Improper format:	various input program checks on invalid character or on device	halt, printout.
Invalid address:	all addresses valid.	
Reference to forbidden area:	?	

.45 Restarts: . . . . as incorporated in user's program.

.5 PROGRAM DIAGNOSTICS

.51 Dynamic

.511 Tracing:
TRACE 2; program K1-01.1. Entered manually and traces between defined addresses. Type-out optional. Contents of computer registers, operand, and instruction location may be printed. Time required is about 6.9 seconds per instruction when typing and 1.2 seconds per instruction when not typing.
.512 Snapshots: . . . . . . none.

§ 191.

.52 Post Mortem:

MEMORY PRINT 1; program K2-01.0. Entered manually and types list of instructions in order of execution, listing opcode, data address, and next address. Time required is 1.9 seconds per instruction.

MEMORY PRINT 2; program K2-02.0. Entered manually and types storage contents in sector order. Time required per instruction is 1.2 seconds in hexadecimal format and 2.2 seconds in instruction format.

PROGRAM CHECKOUT 1; program K9-01.0. A debugging routine entered manually, performing functions of MEMORY PRINT 1 and 2, and several additional functions. These include in part, reading a relocatable decimal tape, inserting temporary program stops, searching storage, and clearing storage to a specified bit configuration. Clearing each address to its own address, for example, requires 4.5 seconds.

.6 OPERATOR CONTROL: as incorporated in user's program; also, print-outs controlled by subroutines when operator action required.

.7 LOGGING: . . . . . . as incorporated in user's program, or written by operator.

.8 PERFORMANCE

.81 System Requirements: . . . . . . all routines described here are useable on any RPC-4000 system. Photo reader and high-speed punch can decrease input-output time.

.83 Program Space Available: . . . . (H+D) less than or equal to 8,000 words. (8 words of fast-access band reserved for temporary storage.) I includes all diagnostic and utility programs in storage.

.84 Program Loading Time: function of input routine checking and addresses of instructions being stored. Each instruction read includes a 4-digit location. Estimated speed is 3 instructions per second for 60 char/sec reader, and 12 instructions per second on photo reader. (* * *)

OPERATING ENVIRONMENT: PINT

§ 192.

.1 GENERAL

.11 Identity: . . . . Purdue Floating Point Interpretive System. Program H1-02.0. PINT

.12 Description

This routine interprets and executes programs written in the PINT language. It requires only the basic RPC-4000 Computer and Tape Typewriter System. The PINT system is unusual in that part of the interpretation is done during program loading instead of at run time: each PINT mnemonic operation code is converted to a transfer address to a particular interpretive subroutine, and each PINT operand address is converted and stored as an absolute machine address.

A total of only 1,666 PINT instructions and data items can be stored internally, and only 1,000 of the locations can be addressed decimally; alphameric addresses must be used for the other 666 locations. PINT routines can be coded in relocatable form and loaded into any available section of PINT storage. The PINT master program occupies 2,184 drum storage locations (including the double access and high speed bands), and 3,332 machine locations are reserved for PINT storage. The remaining 2,492 RPC-4000 storage locations are not used by PINT and are available for machine language coding. After the master program has been loaded, the write heads on the first 32 tracks can be manually disabled to protect it from destruction.

The PINT loading routine checks the validity of each operation code, operand address, and numeric constant. If a detectable coding or data range error is encountered during execution of a PINT-coded routine, the computer will halt and print a "post mortem." This consists of all index registers and PINT storage locations that have been altered during execution of the routine. A dump routine prints or punches the contents of specified areas of PINT storage under manual control. Instructions and data values are printed in PINT format. Output from the dump routine can be punched in "compatible" form for direct re-entry into the system.

PINT instructions are executed at the rate of approximately 15 per second (exclusive of input-output operations). Average execution times for the PINT instructions are listed in paragraph :172.83, and standardized performance measures are tabulated in paragraph .85 of this section.

.13 Availability: . . . . . all facilities were made available in 1961.

.14 Originator: . . . . . School of Electrical Engineering, Purdue University.

.15 Maintainer: . . . . . . as above.

.16 First Use: . . . . . . 1961.

.2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . . none.

.212 Independent programs: . . . . punched tape.

.213 Data: . . . . punched tape or keyboard, in decimal form; listing is optional.

.214 Master routines: . . . . punched tape.

.22 Library Subroutines: . . punched tape, in relocatable form.

.23 Loading Sequence: . . . manually controlled.

.24 Interpreter Input

.241 Language
Name: . . . . PINT.
Exemptions: . . . . . none.

.242 Form: . . . . punched tape or keyboard.

.3 HARDWARE ALLOCATION

.31 Storage: . . . . routines can be coded in relocatable form and assigned to any available storage area at loading time.

.32 Input-Output Units: . . . selected by manual switches at run time.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: . . . . none.

.42 Multi-running: . . . . none.

.43 Multi-sequencing: . . . none.

§ 192.

.44 Errors, Checks, and Action

Error	Check or Interlock	Action
Loading input error:	parity check.	
In-out error:	parity check.	
Storage overflow:	?	
Program conflicts:	checks	print post mortem.
Arithmetic overflow:	hardware check	set Branch Control.
Underflow:	none.	
Invalid operation:	check	print message and continue loading.
Improper format:	check	print message and continue loading.
Invalid address:	check	print message and continue loading.
Reference to forbidden area:	manual disabling of write heads	write instructions are ignored.

.45 Restarts: . . . . . . own coding.

.5 PROGRAM DIAGNOSTICS

.51 Dynamic

.511 Tracing: . . . . all PINT-coded routines can be traced by depressing Sense Switch 1; each active jump instruction, its location, and contents of Accumulator are printed.

.512 Snapshots: . . . . . . none.

.52 Post Mortem: . . . . . automatic Post Mortem follows all errors detected by the system during execution; an error message and contents of all altered index registers and storage locations are printed.
DUMP code word causes printout in decimal form of contents of specified storage areas.

.6 OPERATOR CONTROL

.61 Signals to Operator: . . type message.

.62 Operator's Decisions: . . . . keyboard data entry, or setting of Sense Switch 2.

.7 LOGGING: . . . . . . typed record of all input-output operations is optional.

.8 PERFORMANCE

.81 System Requirements

.811 Minimum configuration: . . . . RPC-4000 with Tape Typewriter System.

.812 Usable extra facilities: . . . . Photo Reader, High Speed Punch.

.813 Reserved equipment: . . . . 2,184 drum storage locations (tracks 00 through 31 and 123 through 127) are required for the PINT interpretive routine.

.82 System Overhead

.821 Loading time: . . . . . 12 minutes using 4430 Reader (***).

.822 Reloading frequency: . . can be maintained in working storage, and is protected from destruction by leaving write heads disabled.

.83 Program Space Available: . . . . . . I + D must be less than 1,667 (addresses above 999 require use of alphabetic characters).

.84 Program Loading Time: . . . . 2 instructions/second using 4430 Reader (***).

.85 Program Performance in μ secs

.851 Conditions: . . . . . . none.

.852 For random addresses

c = a + b:	170,000.
b = a + b:	170,000.
Sum N items:	68,000.
c = ab:	170,000.
c = a/b:	170,000.
$b = \sqrt{a}$:	255,000.
b = log a:	357,000.
$b = e^a$	289,000.
b = sin a:	340,000.

.853 For arrays of data

$c_i = a_i + b_j$:	323,000.
$c = c + a_i b_j$:	374,000.

.854 Branch based on comparison: . . . . . 459,000.

.855 Moving, per data item

Using loop:	187,000.
Using straight-line coding:	102,000.

.856 Data input per item: . . . . 0.8 second + character reading time (***).

.857 Data output per item (typed): . . . . 1.8 seconds (***).

NOTES ON SYSTEM PERFORMANCE

§ 201.

.1 GENERALIZED FILE PROCESSING

Because the RPC-4000's output speed is low on punching and typing alphanumeric data, it was considered unsuitable for this type of data processing application at this time. (Where the master file is small enough to be held in internal storage, the RPC-4000 can be quite useful.)

.2 SORTING

Magnetic tape cannot be used with the RPC-4000 system.

.3 MATRIX INVERSION

The standard problem estimate of the Users' Guide was used, which is based on the time for floating point cumulative multiplication. No routines for matrix inversion are available in the manufacturer's program library.

.4 GENERALIZED MATHEMATICAL PROCESSING

Fixed point computations are coded in machine language, with instructions and operands optimized, as would be done by ROAR. Input and output timing is based on the use of subroutines written for the job at hand.

Results are printed on the on-line typewriter for Configuration IX, and punched on the high-speed punch for Configuration X.

.5 GENERALIZED STATISTICAL PROCESSING

Fixed point machine coding is used, optimized as above. Input routines are as in the preceding paragraph. Input is read by the reader of the Tape Typewriter System for Configuration IX, and by the photoelectric reader for Configuration X.

§ 201.

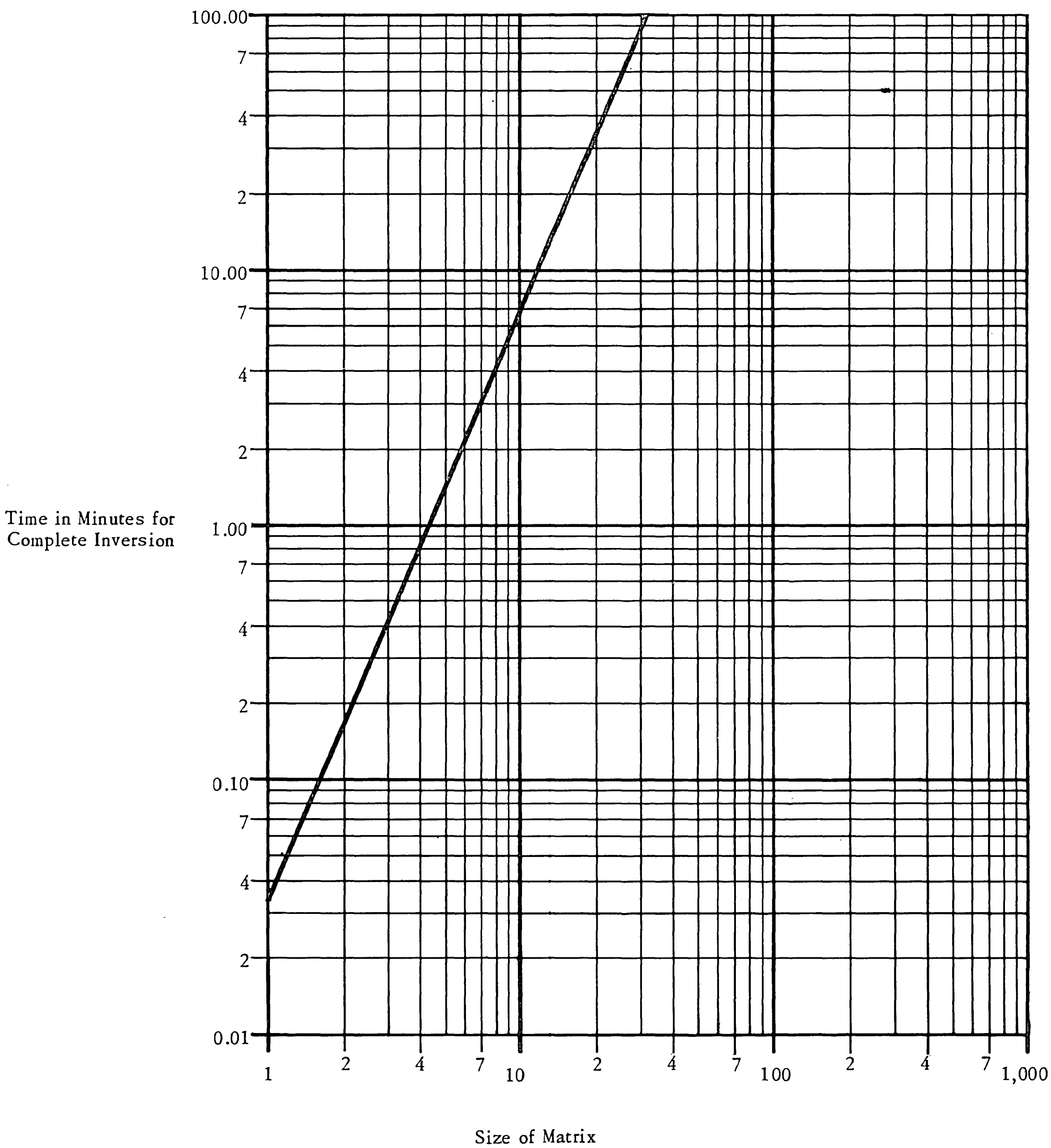
.3 MATRIX INVERSION

.31 Standard Problem Estimates

.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.312 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.312.

.313 Graph: . . . . see graph below.



§ 201.

.4 GENERALIZED MATHEMATICAL PROCESSING

.41 Standard Mathematical Problem A Estimates

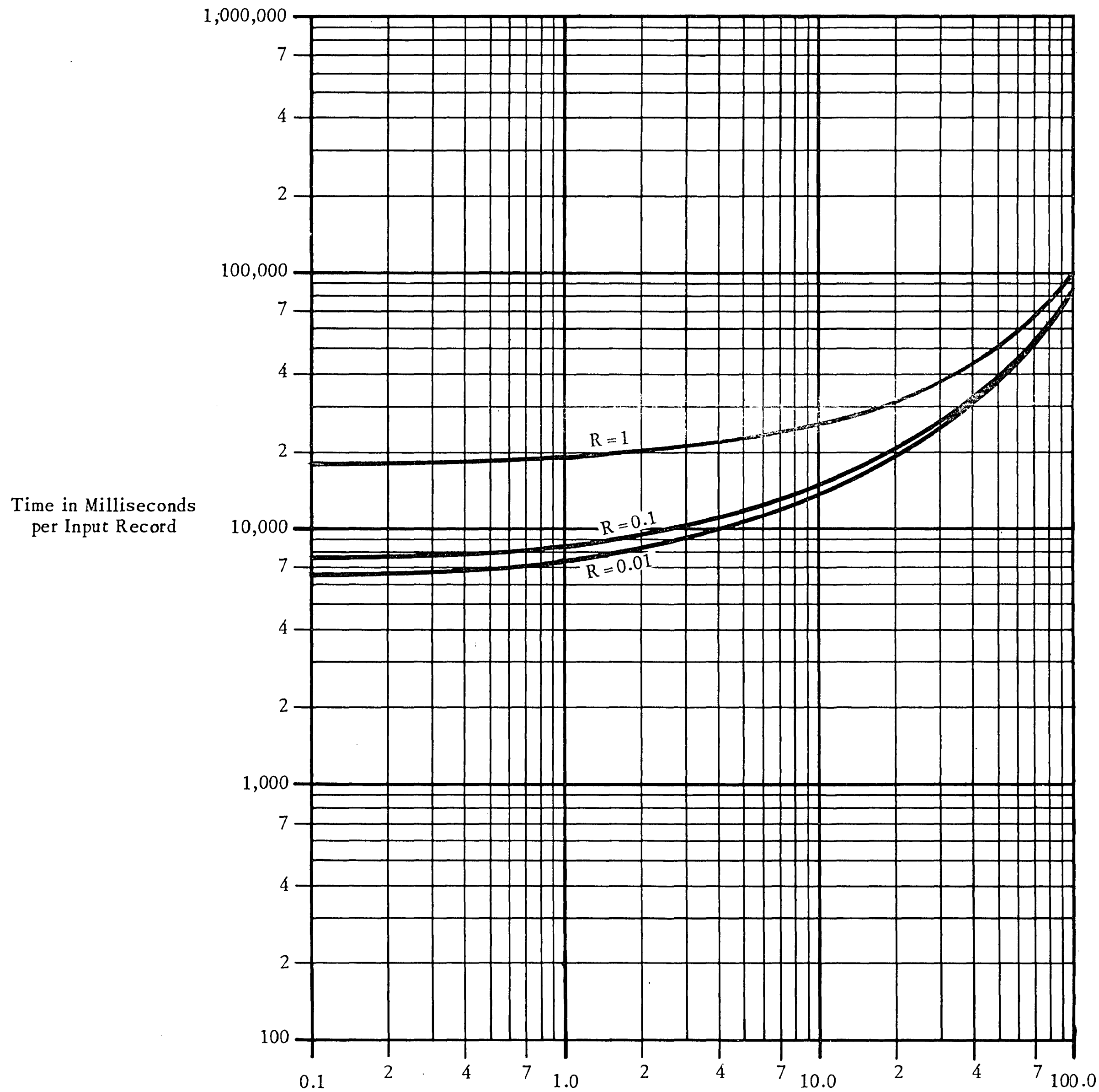
.411 Record sizes: . . 10 signed numbers, avg. size 5 digits, max. size 8 digits.

.412 Computation: . . 5 fifth-order polynomials.
5 divisions.
1 square root.

.413 Timing basis: . . using estimating procedure outlined in Users' Guide, 4:200.413

.414 Graph: . . . . . Configuration IX, Typewriter output, fixed point.

Configuration IX; Single Length (8 digit precision); Fixed Point.
R = Number of Output Records per Input Record

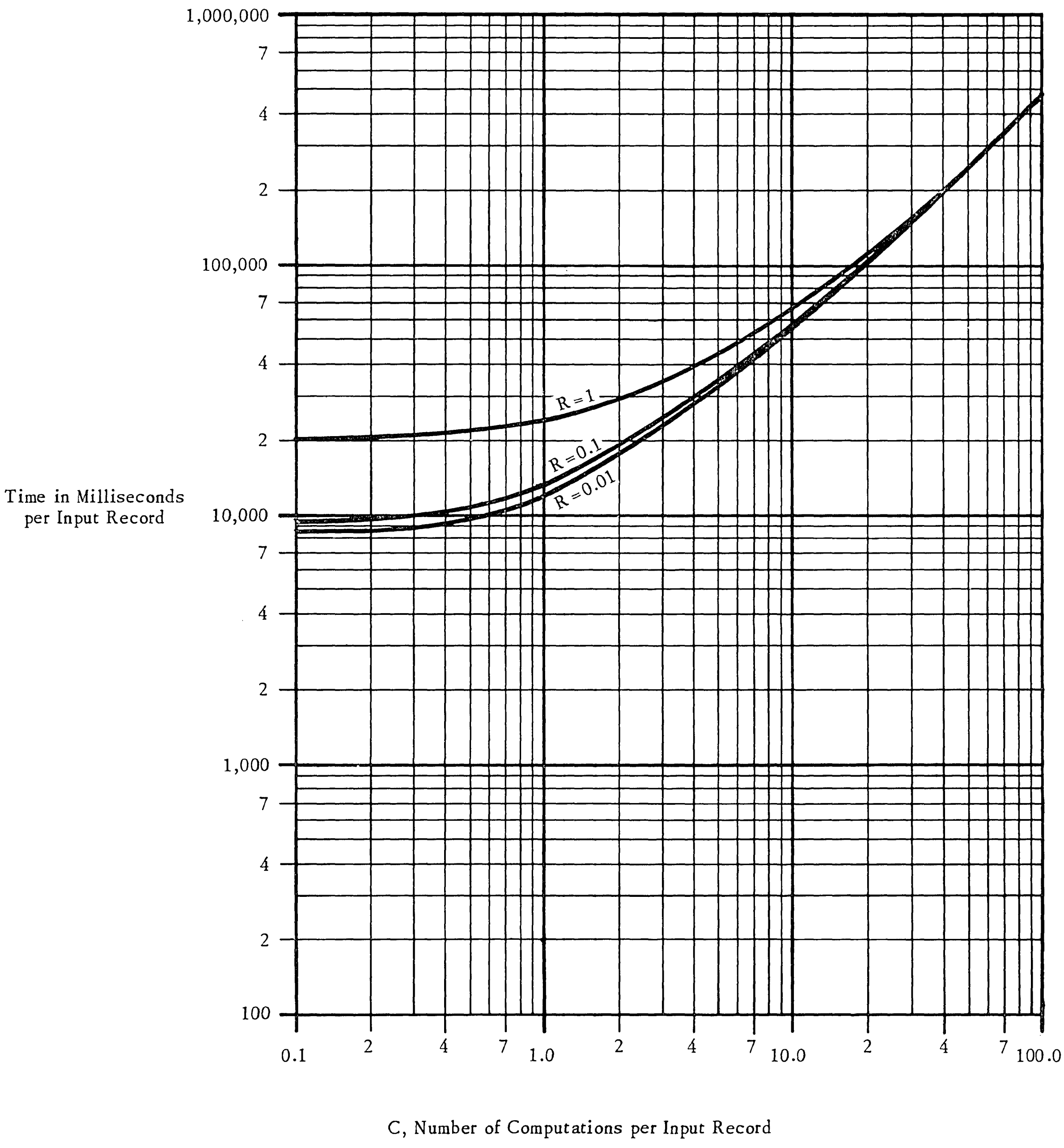


C, Number of Computations per Input Record

§ 201.

.415 Graph: . . . . . Configuration IX, Typewriter output; floating point using subroutines.

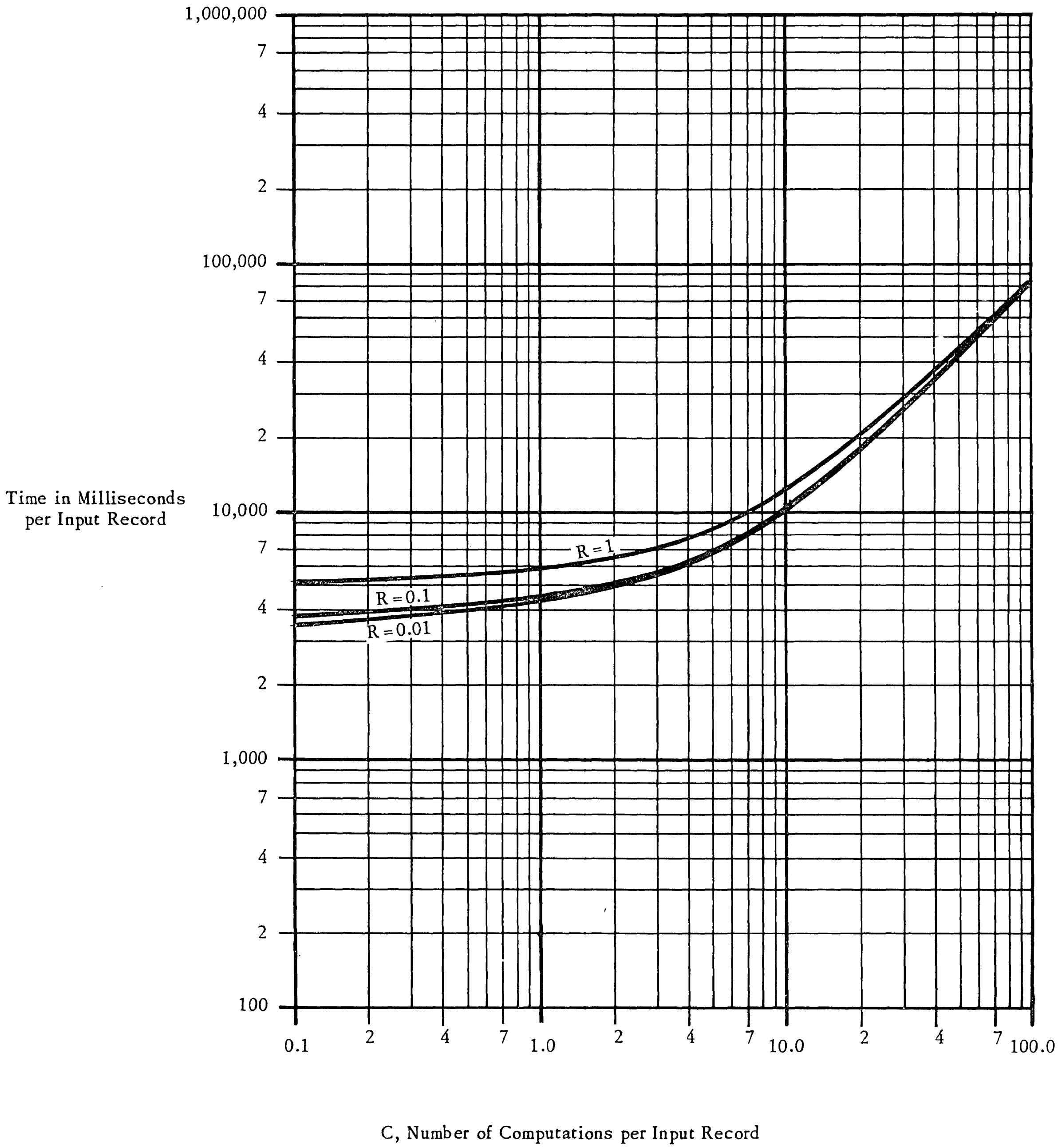
Configuration IX; Single Length (8 digit precision); Floating Point.
R = Number of Output Records per Input Record



§ 201.

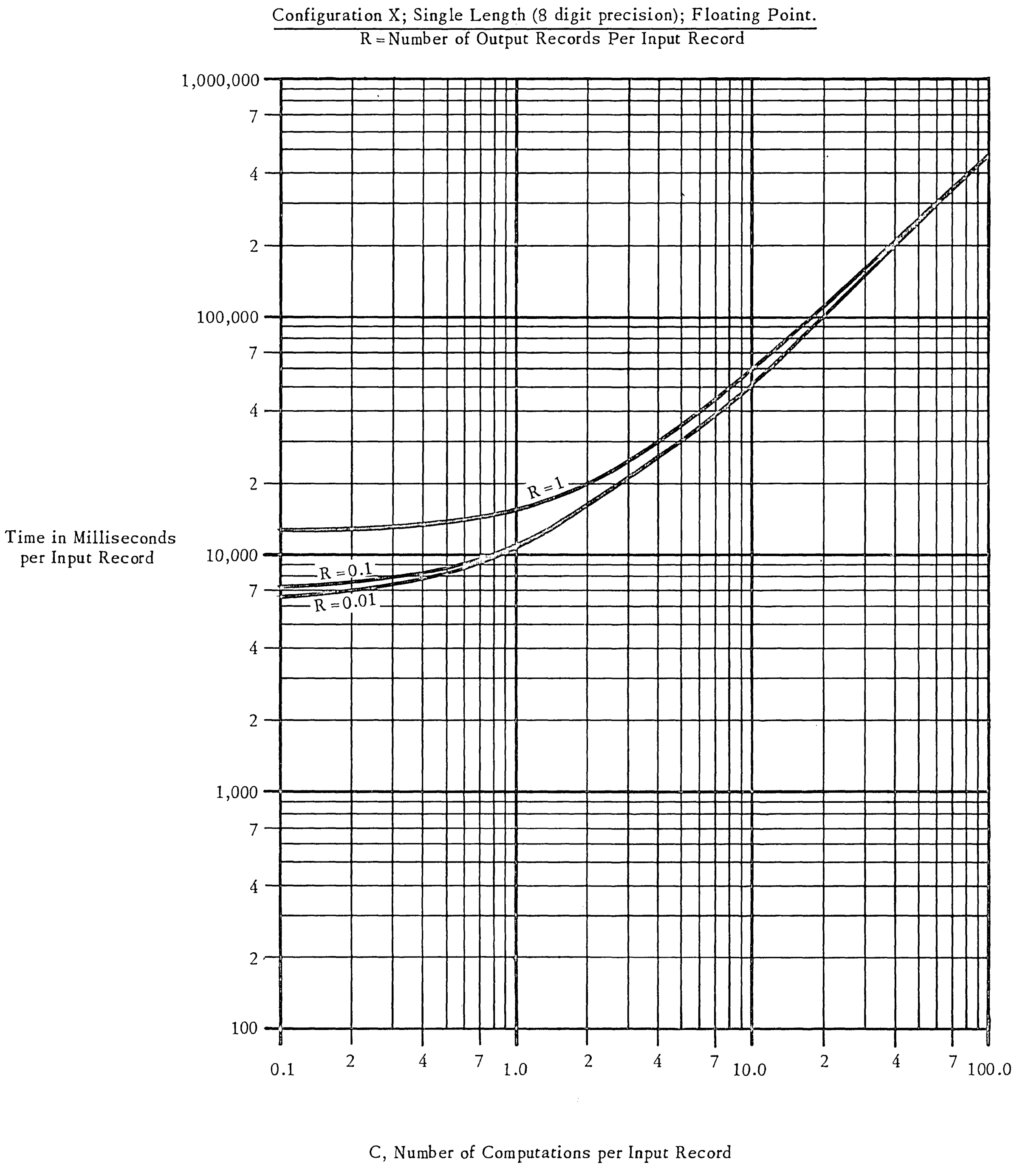
.416 Graph: . . . . . Configuration X, Paper Tape output; fixed point.

Configuration X; Single Length (8 digit precision); Fixed Point.
R = Number of Output Records per Input Record



§ 201.

.417 Graph: . . . . . Configuration X, Paper Tape output; floating point using subroutines.



§ 201.

.5 GENERALIZED STATISTICAL PROCESSING

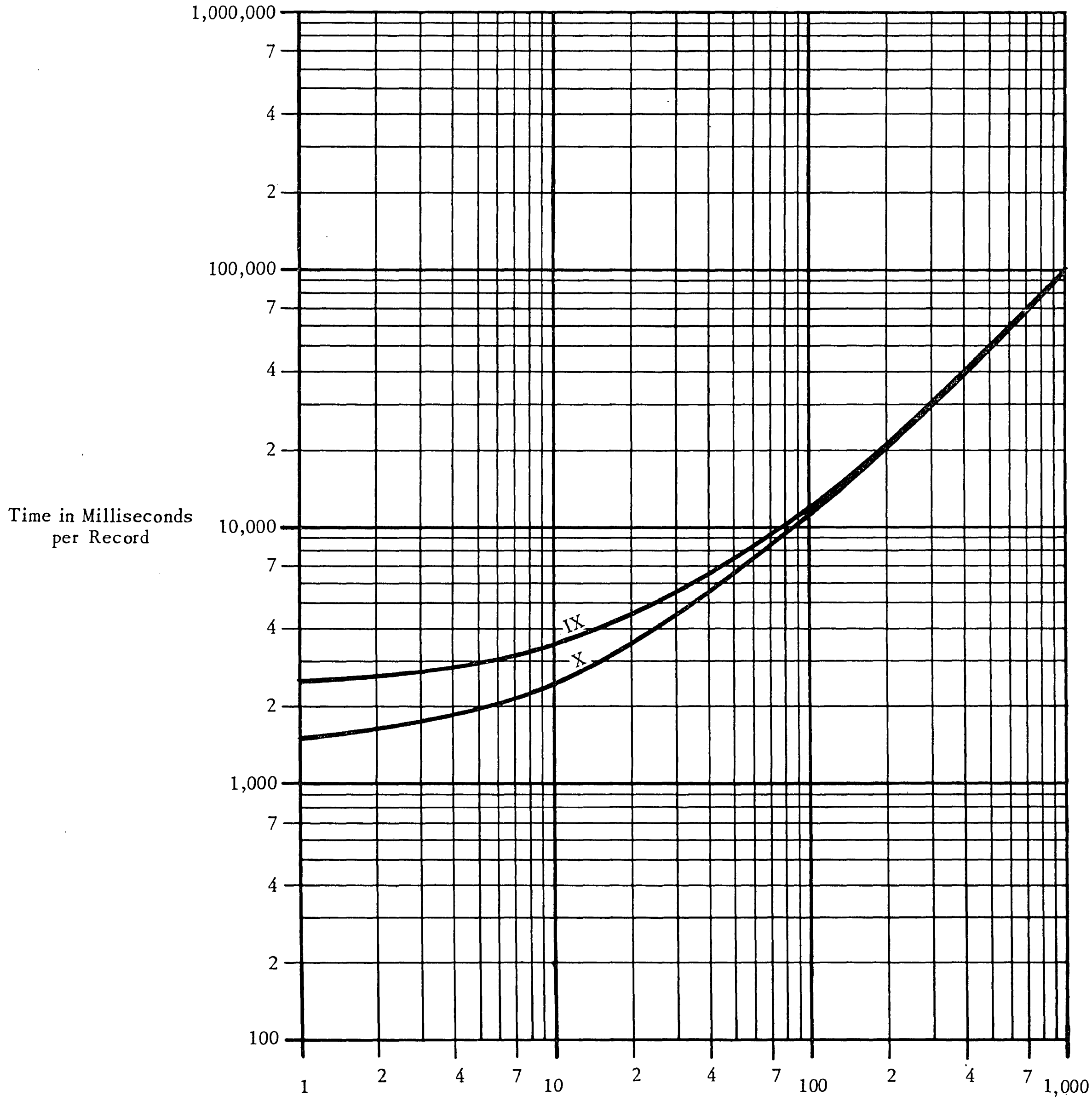
.51 Standard Statistical Problem A Estimates

.511 Record size: . . thirty 2-digit integral numbers.

.512 Computation: . . augment T elements in cross-tabulation tables.

.513 Timing basis: . . using estimating procedure outlined in Users' Guide, 4:200.513.

.514 Graph: . . . . . see below.



T, Number of Augmented Elements.
Roman numerals denote Standard Configurations.

RPC-4000
PHYSICAL CHARACTERISTICS

RPC 4000 PHYSICAL CHARACTERISTICS

			Computer	Reader/ Punch	Tape Typewriter	High Speed Paper Tape Reader	High Speed Paper Tape Punch	Typewriter Desk	Off-Line Tape Typewriter
IDENTITY	Unit Name		Computer	Reader/ Punch	Tape Typewriter	High Speed Paper Tape Reader	High Speed Paper Tape Punch	Typewriter Desk	Off-Line Tape Typewriter
	Model Number		4010	4430; 4431	4480	4410	4440	----	4700
PHYSICAL	Height × Width × Depth, in.		35 × 47 × 27	31 × 23 × 28	11 × 14 × 21	32 × 23 × 28	42 × 23 × 22	30 × 47 × 28	10 × 18 × 20
	Weight, lbs.		498	263	100	244	298	131	115
	Maximum Cable Lengths, feet		----	10 Power 12 Computer	12	10 Power 12 Computer	10 Power 12 Computer	----	10
ATMOSPHERE	Storage Ranges	Temperature, °F.	?	?	?	?	?	----	----
		Humidity, %	Less than dew pt.	Less than dew pt.	?	?	?	----	----
	Working Ranges	Temperature, °F.	85 max.	?	?	?	?	----	----
		Humidity, %	Less than dew pt.	Less than dew pt.	?	?	?	----	----
	Heat Dissipated, BTU/hr.		1,175	785	195	2,350	2,745	----	890
	Air Flow, cfm.		?	?	?	?	?	----	----
	Internal Filters		Yes	Yes	Yes	Yes	Yes	----	No
ELECTRICAL	Voltage	Nominal	115 V. ac	115 V. ac	115 V. ac	115 V. ac	115 V. ac	----	115 V. ac
		Tolerance	±10%	±10%	±10%	±10%	±10%	----	±10%
	Cycles	Nominal	60	60	60	60	60	----	60
		Tolerance	±½	±½	±½	±½	±½	----	±½
	Phases and Lines		1φ 3 wire	1φ 3 wire	1φ 3 wire	1φ 3 wire	1φ 3 wire	----	1φ 3 wire
	Load KVA		345	230	60	690	805	----	265
NOTES									

PRICE DATA

§ 221.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $ 1/	Annual Maintenance $ 2/	Purchase $
Central Processor		RPC-4000 Computer System, including	1,750	4,375	87,500
	4010	Computer with Storage Drum			
	4500	Tape Typewriter System			
Input-Output	4600	Auxiliary Tape Typewriter System	150	375	5,000
	4480	Tape Typewriter *	75	187	2,500
	4430	Reader/Punch **			
	4431	Auxiliary Reader/Punch	75	187	2,500
	4410	High Speed Paper Tape Reader	300	750	15,000
	4440	High Speed Paper Tape Punch	400	1,000	20,000
	4700	Off-Line Tape Typewriter	170	425	4,000

* Used with 4500, or 4600 as Auxiliary Tape Typewriter.
** Part of 4500 Tape Typewriter System.
1/ Includes maintenance.
2/ After first year, on purchased system.

LGP 30

General Precision, Inc.

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CONTENTS

CONTENTS (Contd.)

INTRODUCTION

The LGP-30 is a desk size data processing system that is suitable for a wide range of complex but relatively low-volume engineering and scientific problems, and for certain business applications where high input-output speeds are not essential.

Approximately 500 LGP-30's were built between 1956 and 1961. The system is no longer is production but is still being actively marketed. Internal circuitry is of the vacuum tube and diode type, and power consumption at full load is 1,500 watts. There are no built-in error checks on input, output, or internal operations except for an automatic processor halt when arithmetic overflow occurs.

A magnetic drum provides 4,096 word locations of working storage. Each location can hold a one-address instruction, a binary data word of 30 bits plus sign, or five alphameric characters in six-bit BCD form. Access time varies from 0.26 to 16.7 milliseconds.

Complete arithmetic facilities are provided for single word-length, fixed point binary data. Because there are only 16 basic instructions and no index registers, the number of machine instructions required to solve a given problem is relatively high. On the other hand, machine-language coding is unusually easy to learn. The coder uses a single letter to specify the operation code and a 4-digit decimal address for the drum storage location. These instructions are converted to the required internal binary format during program loading.

Whereas the instruction format of most drum computers includes the address of the next instruction, the one-address LGP-30 executes instructions in sequential fashion. An interlaced pattern of sector numbering around the drum's circumference enables the sophisticated coder to assign "optimum" operand addresses and thereby significantly decrease the rotational delay time in most routines. Program execution speed for typical non-optimized, user-coded routines will be about 50 instructions per second. The standard subroutines, which in most cases are highly optimized, may run several times as fast.

The basic input-output unit for the LGP-30 is a modified Flexowriter that reads and punches six-track punched tape at a peak speed of ten characters per second. A typed record is produced of all data that is read or punched. Data can also be entered directly from the keyboard, and the Flexowriter can be used independently of the computer for tape preparation and listing.

The High Speed Reader/Punch provides, in a single cabinet, a photoelectric punched tape reader rated at 200 characters per second and a mechanical punch rated at 20 characters per second. The photoelectric reader removes the LGP-30 from the "input-bound" class and greatly expands its scope of practical applications. The 20 character-per-second punch is the fastest available output device, so the LGP-30 is not well suited for applications requiring voluminous output.

Because of the simplicity of machine language coding, little attention has been paid to symbolic assembly systems for the LGP-30. None of the existing assembly routines is capable of assigning optimum addresses.

Floating point arithmetic hardware is not available for the LGP-30, so floating point interpretive systems are widely used. Interpretive routines using pseudo-machine languages are available for both one- and two-word data formats. DICATOR is a three-address system that is similar to the Bell Interpretive System for the IBM 650. Use of any of the floating point interpreters results in roughly a ten-fold increase in running time over a non-optimized machine-language routine.

ACT III is an ALGOL-like algebraic compiler that has been designed to facilitate changes to its vocabulary and syntax. Compiling speed is low, but reasonably efficient object programs are produced.

§ 011.

More than 200 subroutines and utility routines are available from the manufacturer and from POOL, the LGP-30 and RPC-4000 Users' Organization. POOL has established an unusually effective system for review and evaluation of submitted routines, and only those routines which meet all of its standards are distributed.

DATA STRUCTURE

§ 021.

.1 STORAGE LOCATIONS

Name of Location	Size	Purpose or Use
Word:	32 bits (1 sign, 30 data, 1 spacer)	basic addressable location.
Row:	6 bits	punched tape.

.2 INFORMATION FORMATS

Type of Information	Representation
Character:	6 bits (internal) or 1 row (tape).
Hexadecimal digit: . . .	4 bits.
Number (fixed point): .	1 word (30 bits + sign).
Number (floating point)	
Single precision: . .	1 word (24 bits + sign for fixed point part; 5 bits + sign for exponent).
Double precision: . .	2 words (1 word for fixed point part; 1 word for exponent).
Instruction:	1 word (only 17 bits are used).

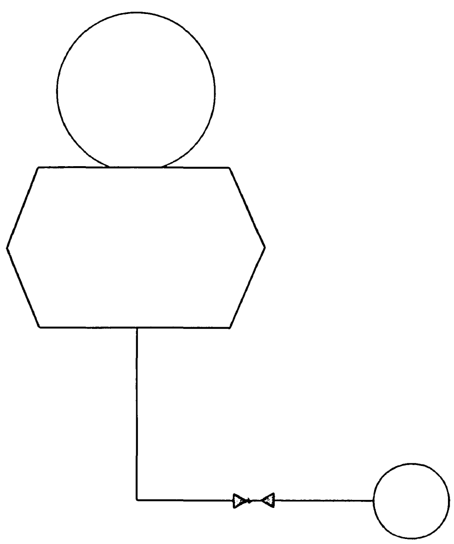
SYSTEM CONFIGURATION

§ 031.

IX. DESK SIZE SCIENTIFIC SYSTEM

Deviations from Standard Configuration: . . . . . . none.

Rental: . . . . $1,100 per month.



Drum Storage: 4,096 words.

Central Processor

Tape Typewriter
Reads: 10 char/sec.
Punches: 10 char/sec.
Prints: 10 char/sec.

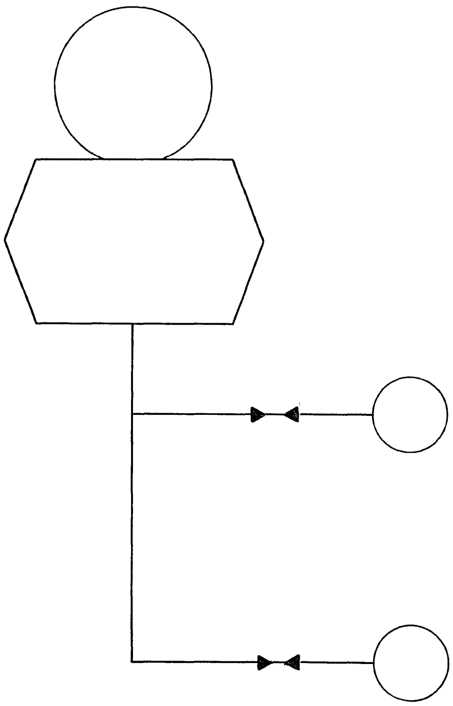
Optional Features Included: . . . . none.

§ 031.

X. PUNCHED TAPE SCIENTIFIC SYSTEM

Deviations from Standard Configuration: . . . . . internal storage is smaller by 3,500 words; tape punch is slower by 80 char/sec; indexing and floating point hardware are not available.

Rental . . . . $1,365 per month.



Drum Storage: 4,096 words.

Central Processor

Tape Typewriter
Reads: 10 char/sec.
Punches: 10 char/sec.
Prints: 10 char/sec.

High Speed Reader/Punch
Reads: 200 char/sec.
Punches: 20 char/sec.

Optional Features Included: . . . . none.

INTERNAL STORAGE: DRUM

§ 041.

.1 GENERAL

.11 Identity: . . . . Drum Storage (part of Model 301 Computer).

.12 Basic Use: . . . . working storage.

.13 Description:

The magnetic drum is an integral part of the LGP-30 Computer. It provides 4,096 word locations of working storage. In addition, the Accumulator, Counter, and Instruction Registers are located on three separate recirculating tracks on the drum. A clocking track is used to synchronize all internal operations with the drum's rotational speed.

Each word location contains 32 bit positions: a sign bit, 30 data bits, and one spacer bit, which separates adjacent words and is always recorded as "O". There are 64 tracks, numbered 00 through 63. Each track is divided into 64 sectors, also numbered 00 through 63, and each sector can hold one 32-bit word. One fixed head serves each track, and recording and reading are done serially. No error checks are provided.

The drum rotates at a nominal speed of 3,600 revolutions per minute. Access time ranges from 260 microseconds (one word time) to 16.7 milliseconds (one revolution time). The 64 sectors in each track are not numbered sequentially around the drum's circumference; instead, an unusual interlace pattern is used to improve the performance of optimized routines. Sector 01 is located approximately one-seventh of a revolution, or nine sectors, beyond sector 00; sector 02 is nine sectors beyond sector 01; etc. The effects of the interlaced address structure on instruction timing and optimized coding are described in section 051.12. The LGP-30's effective internal transfer rates are quite low because of the lack of block transfer facilities, high speed loops, and indexing.

.14 Availability: . . . . . . 1 to 2 months.

.15 First Delivery: . . . . . September, 1956.

.16 Reserved Storage: . . . no addressable locations.

.2 PHYSICAL FORM

.21 Storage Medium: . . . . magnetic drum.

.22 Physical Dimensions

.222 Drum
Diameter: . . . . . . 6.5 inches.
Length: . . . . 7.0 inches.
Number on shaft: . . . 1.

.23 Storage Phenomenon: . . magnetization.

.24 Recording Permanence

.241 Data erasable by instructions: . . . . . yes.
.242 Data regenerated constantly: . . . . . . no.
.243 Data volatile: . . . . . . no.
.244 Data permanent: . . . . no.
.245 Storage changeable: . . no.

.25 Data volume per band of 1 track

Words: . . . . 64.
Characters (in 6-bit mode): . . . . 320.
Digits (decimal equivalent): . . . . . . 576.

.26 Bands per Physical Unit: . . . . 64.

.27 Interleaving Levels: . . 9.

.28 Access Techniques

.281 Recording method: . . . fixed heads.
.282 Type of access

Description of stage	Possible starting stage
Wait for selected sector:	always.
Read or write one word:	no.

.29 Potential Transfer Rates

.291 Peak bit rates
Cycling rates: . . . . . 3,600 rpm.
Track/head speed: . . . 1,230 inches/sec.
Bits/inch/track: . . . . 100.
Bit rate per track: . . . 123,000 bits/sec/track.
.292 Peak data rates
Unit of data: . . . . . . word.
Conversion factor . . . 32 bits/word (including sign and spacer bits).
Gain factor: . . . . . . 1 track/band.
Loss factor: . . . . . . 9 interleaving levels.
Data rate: . . . . . . 427 words/second.

§ 041.

.3 DATA CAPACITY

.31 Module and System Sizes

Identity: . . . . standard.
Drums: . . . . 1.
Words: . . . . 4,096.
Characters: . . . . 20,480.
Digits: 36,864
Instructions: 4,096
Bands: . . . . 64.
Modules: . . . . 1.

.32 Rules for Combining Modules: . . . . 1 drum per system, as above.

.4 CONTROLLER: . . . . . no separate controller.

.5 ACCESS TIMING

.51 Arrangement of Heads

.511 Number of Stacks (for addressable storage)
Stacks per system: . . 64.
Stacks per module: . . 64.
.512 Stack movement: . . . none.
.513 Stacks that can access any particular location: . . . . 1 per band.
.514 Accessible locations
By single stack
With no movement: . . 64.
By all stacks
With no movement: . . 4,096 per module.
4,096 per system.
.515 Relationship between stacks and locations: track address (bits 18-23) designates stack to be used.

.52 Simultaneous Operations: . . . . none.

.53 Access Time Parameters and Variations

.532 Variation in access time

Stage	Variation, m. sec	Example
Wait for selected sector:	260 to 16,700	8,300.
Read or write one word:	260	260.

.6 CHANGEABLE STORAGE: . . . . . none.

.7 AUXILIARY STORAGE PERFORMANCE

.71 Data Transfer

Pairs of storage units possibilities

With self: . . . . . . yes.

.72 Transfer Load Size

With self: . . . . . . 1 word.

.73 Effective Transfer Rate

With self, using loop: . . . . 12 words/sec.
With self, using straight-line coding: . . . . . . 28 words/sec.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Invalid address:	all addresses valid.	
Invalid code:	none.	
Receipt of data:	none.	
Recording of data:	none.	
Recovery of data:	none.	
Dispatch of data:	none.	
Timing conflicts:	none.	

CENTRAL PROCESSOR

§ 051.

.1 GENERAL

.11 Identity: . . . . LGP-30 Computer.
Model No. 301.
CP.

.12 Description

The LGP-30 Computer is a sequential, single-address, fixed word-length, binary processor. All arithmetic and control circuitry, the magnetic drum store, and the console controls are housed in the processor cabinet. The only other component of the basic LGP-30 system is the Tape Typewriter, which sits upon a shelf at the left side of the processor cabinet.

The processor uses 113 vacuum tubes and 1,450 diodes. All of the tubes and their associated components are mounted on 34 etched circuit plug-in cards of 12 different types, and 680 of the diodes are mounted on one plug-in logic board. Power consumption is 1,500 watts at full load. The processor contains a blower and air filters. No special air conditioning is required as long as the ambient temperature does not exceed 85 degrees F.

Only 16 different instructions are provided, but among them are binary addition, subtraction, multiplication, division, and logical AND. The small instruction repertoire is versatile enough to accomplish almost any desired internal operation, though not necessarily in an efficient way. There are no facilities for indexing or indirect addressing. Modification of an operand address can only be accomplished by bringing the instruction into the Accumulator, adding the desired increment to it, and storing it. No automatic facilities are provided for table look-ups, block transfers, data editing, floating point arithmetic, or radix conversions. The only conditional branch instruction is "transfer control if sign of Accumulator is negative", so all tests must be arranged accordingly.

All internal transfers and arithmetic operations are performed serially by bit and are limited to one word of 30 data bits and sign. The Accumulator is a one-word recirculating register on the magnetic drum. It must be loaded with one of the two operands before every arithmetic operation and contains the result upon completion. Either of two different commands may be used for multiplication, depending upon whether the high-order or low-order 30 bits of the product are to be retained in the Accumulator. The Accumulator also serves as the sole input area for the LGP-30, so input load size is limited to one word and internal processing is delayed during input operations. The output instruction initiates the typing or punching of a single character, which can be overlapped with internal processing.

.12 Description (Contd.)

An unusual feature of the LGP-30 is the interlaced pattern of sector numbering on the magnetic drum. Unlike most drum computers, the LGP-30's instruction structure does not include the address of the next instruction to be executed. Instead, instructions are executed in numerical sequence except when branch instructions are encountered. To make possible some reduction in the rotational delays which would otherwise occur, consecutively numbered sectors are spaced approximately one-seventh of the drum's circumference apart; e.g., sector 01 is physically located nine sectors beyond sector 00 on each of the 64 tracks. The sequence of the 64 sectors around each track on the drum is 00, 57, 50, 43, 36, 29, 22, 15, 08, 01, 58, 51, . . . , 14, 07, 00. If an instruction is located in sector 00 and if the operand it specifies is located in sector 50, 43, 36, 29, 22, or 15 of any track, then 13 of the 16 LGP-30 instructions can be executed in time to let the processor pick up the next sequential instruction from sector 01. In this case the full instruction cycle will be completed in one-seventh of a drum revolution (2.34 milliseconds), and the instruction is "optimum". If the operand is located in any one of the 58 "non-optimum" sector positions, a full revolution will be wasted before the next sequential instruction can be read, and the instruction cycle will take 19.0 milliseconds. Multiplication and division instructions require 19.0 milliseconds for "optimum" operand locations and 35.7 milliseconds otherwise.

Since instructions are executed sequentially, only data locations can be optimized. Optimizing an LGP-30 routine by hand is a complex and time-consuming job, and no assembly routine has been published to automate the process. Most LGP-30 users consequently ignore the concept of program optimization. On the other hand, the standard subroutines are highly optimized for maximum performance. Processor speeds for both of these coding modes, as well as for the Floating Point Interpretive mode, are listed in paragraph .4 of this report section.

Optional Features

Memory Track Protection Circuit: Prevents any recording in a group of eight drum storage tracks when a toggle switch is thrown (standard on latest models).

Double Access Track: Adds a second read head to track 62 that permits a second access 13 word times (about one-fifth of a drum revolution) after the first; use of track 63 is lost when this feature is installed.

Memory Power Failure Protection Circuit: Prevents loss of information in drum storage which may otherwise occur during power failures.

§ 051.

.12 Optional Features (Contd.)

Test for Overflow and Break Point Logic: Causes computer to set a testable indicator and continue instead of stopping when an arithmetic overflow occurs, and alters the function of the four Break Point console switches to that of program-testable sense switches.

.13 Availability: . . . . . . 1 to 2 months.

.14 First Delivery: . . . . September, 1956.

.2 PROCESSING FACILITIES

.21 Operations and Operands

	Operation and Variation	Provision	Radix	Size
.211	Fixed Point			
	Add-Subtract:	automatic	binary	1 word.
	Multiply			
	Short:	automatic*	binary	1 word.
	Long:	none*.		
	*M multiply saves most significant half of product (30 bits); N multiply saves least significant half.			
	Divide			
	No remainder:	automatic	binary	1 word.
	Remainder:	none.		
.212	Floating point			
	Add-Subtract: Multiply: Divide:	subroutines or interpretive routines	binary	24 & 5 or 30 & 30 bits.
.213	Boolean			
	AND:	automatic	binary	1 word.
	Inclusive OR:	none.		

	Comparison	Provision	Size
.214	Comparison		
	Numbers:	subtract & test	1 word.
	Absolute:	none.	
	Letters:	none.	
	Mixed:	none.	
	Collating sequence:	irregular (see Data Code Table No. 1).	

		Provision	From	To	Size
.215	Code translation:	none.			
.216	Radix Conversion:	subroutines	decimal	binary	1 word.
		subroutines	binary	decimal	1 word.

Provision

.217 Edit format: . . . . . . none.
.218 Table look-up: . . . . . none.
.219 Others
Store operand address: automatic.
Set return address: . automatic.

.22 Special Cases of Operands

.221 Negative numbers: . . . 2's complement.
.222 Zero: . . . . 1 form, interpreted as plus zero.
.223 Operand size determination: . . . . fixed; 1 word.

.23 Instruction Formats

.231 Instruction structure: . 1 word.
.232 Instruction layout:

Part	Sign	not used	Op.	not used	Addr.	not used
Size (bits)	1	11	4	2	12	2

.233 Instruction parts

Name	Purpose
Sign:	always positive except in -T test instruction.
Op.:	operation code.
Addr.:	track and sector address of operand.

.234 Basic address structure: . . . . . . 1 + 0.
.235 Literals: . . . . none.
.236 Directly addressed operands

.2361	Internal storage type	Minimum size	Maximum size	Volume accessible
	Drum	1 word	1 word	4,096 words.

.2362 Increased address capacity: . . . . . . none.
.237 Address indexing: . . none.
.238 Indirect addressing: . none.
.239 Stepping: . . . . own coding required.

.24 Special Processor Storage

.241	Category of storage	Number of locations	Size in bits	Program usage
	Drum:	1	32	Accumulator.
	Drum:	1	32	Instruction Register.
	Drum:	1	12 used	Counter Register.

.242	Category of storage	Total number locations	Physical form	Access time, μ sec	Cycle time, μ sec
	Drum	3	recirculating tracks	260	260.

.3 SEQUENCE CONTROL FEATURES

.31 Instruction Sequencing

.311 Number of sequence control facilities: . . 1 (Counter Register).
.314 Special sub-sequence counters: . . . . none.
.315 Sequence control step size: . . . . 1 word.
.316 Accessibility to routines: . . . . (contents + 1) can be stored in working storage.
.317 Permanent or optional modifier: . . . . no.

.32 Look-ahead: . . . . . . none.

.33 Interruption: . . . . . . none.

.4 PROCESSOR SPEEDS

Conditions

I: . . . . all data in best possible locations.
II: . . . . all data randomly placed, as in normal coding.
III: . . . . floating point mode, using 24.0 Floating Point Interpretive System.

§ 051.

.41 Instruction Times in μ secs

Condition	I	II	III
.411 Fixed point			
Add-subtract:	2,340	17,450	- .
Multiply:	19,000	34,100	- .
Divide:	19,000	34,100	- .
.412 Floating point			
Add:	-	-	400,000.
Subtract:	-	-	417,000.
Multiply:	-	-	266,000.
Divide:	-	-	283,000.
.413 Additional allowance for			
Indexing:	not possible.		
Indirect addressing:	not possible.		
Re-complementing:	0	0	0.
.414 Control			
Compare and branch:	5,720	43,700	783,000.
.415 Counter control			
Step and test:	27,000	78,600	583,000.
.416 Edit:	none.		
.417 Convert:	none.		
.418 Shift (any length):	19,000	35,700	

.42 Processor Performance in μ secs

Condition	I	II	III
.421 For random addresses			
c = a + b:	7,000	52,000	866,000.
b = a + b:	24,000	52,000	866,000.
Sum N items:	2,340	17,500	400,000.
c = ab:	24,000	69,000	716,000.
c = a/b:	24,000	69,000	749,000.
.422 For arrays of data			
$c_i = a_i + b_j$:	132,000	221,000	2,200,000.
$b_j = a_i + b_j$:	129,000	205,000	2,050,000.
Sum N items:	129,000	205,000	983,000.
$c = c + a_ib_j$:	131,000	217,000	1,820,000.
.423 Branch based on comparison			
Numeric data:	96,000	205,000	2,200,000.
Alphabetic data:	96,000	205,000	
.424 Switching			
Unchecked:	33,000	70,000	
Checked:	47,000	129,000	
List search:	31,000 + 57,000N	57,000 + 136,000N	

.425 Format control per character (* *)
Unpack: . . . . 200,000.
Compose: . . . . 200,000.
Note: These times include input-output on Tape Typewriter and radix conversions, using standard input and output subroutines for numeric data only.

.426 Table look-up per comparison

Condition	I	II	III
For a match:	57,000	128,000	1,900,000.
For least or greatest:	70,000	120,000	1,400,000.
For interpolation point:	55,000	118,000	1,400,000.
.427 Bit indicators			
Set bit in separate location:	4,700	35,000	- .
Set bit in pattern:	26,000	70,000	- .
Test bit in separate location:	6,400	40,000	- .
Test bit in pattern:	8,700	57,000	- .
Test AND for B bits:	11,000	74,000	- .
Test OR for B bits:	49,000	109,000	- .
.428 Moving, per word			
Using loop:	79,000	148,000	1,300,000.
Using straight-line coding:	4,700	35,000	430,000.

.5 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Overflow:	check	halt.
Underflow:	none.	
Zero divisor:	causes overflow	halt.
Invalid data:	none.	
Invalid operation:	all codes valid.	
Arithmetic error:	none.	
Invalid address:	all addresses valid.	
Receipt of data:	none.	
Dispatch of data:	none.	

CONSOLE

§ 061.

.1 GENERAL

.11 Identity: . . . . contained in LGP-30 Computer cabinet.

.12 Associated Units: . . . Tape Typewriter stands on shelf at left side of cabinet.

.13 Description:

The console control panel is mounted at desk-top level on the left side of the LGP-30 Computer cabinet. The Tape Typewriter stands on a shelf to the left of the console panel, and all operating controls are within easy reach of an operator seated in front of the typewriter. All controls that affect system operation are described below; those located on the Tape Typewriter are marked (TT) and those on the optional High Speed Reader/Punch are marked (HSR).

There are no error alarms, but the operating status of the system is clearly indicated by lights under the console control buttons. The contents of the Counter Register, Instruction Register, and Accumulator are displayed in binary form on a small, hard-to-read oscilloscope in the upper right corner of the control panel. No direct display of drum storage contents is provided; it is possible to step through a series of storage locations manually and view their contents in the oscilloscope, but utility routines are usually used to produce a typed record in decimal or hexadecimal form.

.2 CONTROLS

.21 Power

Name	Form
Power On:	button.
Power Off:	button.
Power On-Off (TT):	toggle switch.
Reader Power (HSR):	button.
Punch Power (HSR):	button.

.22 Connections

Name	Form	Comment
Manual Input (TT):	lever	selects keyboard or tape input.
Input (HSR):	2-way switch	selects Tape Typewriter or High Speed Reader for input.
Output (HSR):	2-way switch	selects Tape Typewriter or High Speed Punch for output.
Connect (TT):	2-way switch	permits start signals from Tape Typewriter to reach the computer

.23 Stops and Restarts

Name	Form	Comment
Start	button	initiates execution of the stored program.
Start Compute (TT):	button	same function as Start.
Normal:	button	prepares computer for automatic execution of the stored program.
Break Points:	4 buttons	cause a "stop" instruction to be ignored if the button corresponding to its operand address is depressed.

.24 Stepping

Name	Form	Comment
One Operation:	button	causes execution of one instruction each time Start is depressed.
Manual Input:	button	permits entry of data into Accumulator from keyboard, and display of storage contents without instruction execution.
Execute Instruction:	button	executes the instruction in the Instruction Register.

.25 Resets

Name	Form	Comment
Clear Counter:	button	resets Counter Register to zero.

.26 Loading: . . . . loading of programs is controlled by the Program Input Routine, which is usually stored in the first 192 drum locations and is loaded by a manually-executed "bootstrap" process.

.27 Sense Switches: . . . Transfer Control button serves as a single sense switch in conjunction with the "-T" instruction (see Instruction List).

.28 Special

Name	Form	Comment
Stand By:	button	turns off high voltage during idle periods.
Operate:	button	prepares computer for operation.

§ 061.

.28 Special (Contd.)

Name	Form	Comment
6 Bit Input:	button	causes 6 bits to enter Accumulator for each character read or typed instead of the usual 4 bits.
Fill Instruction:	button	transfers Accumulator contents to Instruction Register.

.3 DISPLAY

.31 Alarms: . . . . none.

.32 Conditions

Name	Form	Condition Indicated
Normal:	lighted button	computer is in the indicated operating mode.
One Operation:	lighted button	
Manual Input:	lighted button	
Stand By:	lighted button	computer is in the indicated state.
Operate:	lighted button	
Stand By to Operate:	light	
Compute:	light panel	computer is executing stored program.
Stop:	light panel	computer has halted.

Note: The Transfer Control, 6 Bit Input, and Break Point buttons are illuminated when depressed.

.33 Control Registers

Name	Form	Comment
Counter Register:	oscilloscope (top line)	binary display of address of next instruction to be executed.
Instruction Register:	oscilloscope (middle line)	binary display of last instruction executed.
Accumulator:	oscilloscope (bottom line)	binary display of contents of Accumulator.

.34 Storage: . . . . no direct display available.

.4 ENTRY OF DATA

.41 Into Control Registers: data can be typed into Accumulator in Manual Input mode, and transferred into Instruction Register by depressing Fill Instruction button.

.42 Into Storage

1. Depress Manual Input button.
2. Type "clear" instruction with desired drum storage location as operand address (in hexadecimal form).
3. Depress Fill Instruction button.
4. Type desired data value (in hexadecimal form).
5. Depress One Operation and Execute Instruction buttons.

Note: Use of the standard input routines facilitates the entry of data and instructions.

.5 CONVENIENCES

.51 Communications: . . . none.

.52 Clock: . . . . none.

.53 Desk Space: . . . . . top of processor cabinet provides free work surface, but lack of knee room makes it inconvenient.

.54 View: . . . . seated operator has clear view of entire system.

INPUT-OUTPUT: TAPE TYPEWRITER (READER)

§ 071.

.1 GENERAL

.11 Identity: . . . . Tape Typewriter.
Model 360.
(Tape reading facilities).
TTR.

.12 Description

This is the Friden Flexowriter, equipped with special control and code translation circuitry. The Flexowriter is an electric typewriter with integrated facilities for reading and punching paper tape. It serves as the basic input-output device for the LGP-30 and is required in all LGP-30 systems, including those that also utilize the High Speed Reader/Punch.

Input may be from the typewriter keyboard or from punched tape at a peak speed of ten characters per second. Either input method produces a typed re cord of all data entered into the system. All output is typed; it may also, at the operator's option, be reproduced on punched tape. In either case the peak output speed is ten characters per second. Effective speeds depend heavily upon the frequency of carriage returns and the efficiency of the routines that process the input and output. Overall speeds of five to eight characters per second can be obtained when the input-output subroutines provided by the manufacturer are used.

The 32-bit Accumulator serves as the sole input area, so input block size is limited to one word composed of up to eight 4-bit characters. If the 6-Bit Input button is depressed, the contents of all six data tracks read from tape enter the Accumulator and the maximum word length is five characters. The character represented by the full 6-bit tape code is typed regardless of whether four or six bits are read into the Accumulator. The end of a word is signalled by sending a start signal to the Computer, either by manual depression of the Start button or by a conditional stop code (') on the tape. Internal processing is inhibited during the input operation. Certain character codes, designated "inhibited characters", do not enter the Accumulator and are used only for control of the typed format; these include the carriage return, backspace, color shift, and case shift codes.

Each output instruction causes the printing (and optional punching) of a single character whose code is contained in the track address portion of the output instruction itself. There is no limit on output block size unless the data is to be re-entered into the system.

No built-in checks are provided on input or output. Therefore, a check sum is commonly generated during an output operation and punched on the end of the tape. When the tape is read, the check sum is re-computed and compared with the check sum read from the tape. This method of error detection, while effective, is useful only for data that is punched under computer control for subsequent re-entry into the system.

In addition to its on-line functions, the Tape Typewriter is useful off-line for preparing and reproducing punched tape and for listing output tapes produced by the High Speed Punch.

Detailed descriptions of the Tape Typewriter's individual facilities are presented in three different report sections:

Tape reading: . . .	this section.
Tape punching: . . .	352:072.
Printing and keyboard input: . . .	352:081.

Optional Features

Special Input Modes: Permits manual selection of any one of four distinct input modes:

1) Standard entry, as described above.

2) Single character entry; reader halts and sends a start signal to the Computer after reading each character.

3) Standard entry, except that all character codes, including the normally inhibited ones, enter the Accumulator.

4) Single character entry, with all codes entering the Accumulator.

Special Models: Three specially modified models of the Tape Typewriter are available:

1) Model 360A has a 20-inch carriage in place of the standard 16-inch carriage.

2) Model 360B is fitted with a reader and punch for verge-punched fanfold cards with prepunched sprocket holes.

3) Model 360C is fitted to accept an Electric Line Finder which can be purchased from the Standard Register Corporation.

.13 Availability: . . . . 1 to 2 months.

.14 First Delivery: . . . . . September, 1956.

§ 071.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive, pull only.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system:. . . see sections :072 and :091.
.222 Sensing system: . . . . sensing pins.
.223 Common system: . . . no.

.23 Multiple Copies: . . . none.

.24 Arrangement of Heads

Use of station: . . . . . . reading punched tape.
Stacks: . . . . 1.
Heads/stack: . . . . . . 6.
Method of use: . . . . . . reads 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper or plastic tape.
.312 Phenomenon: . . . . . punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to 9 rows at 10 rows per inch.
.322 Parallel by: . . . . . . 6 tracks at standard spacing.
.324 Track use
Data: . . . . 6.
Redundancy check: . . 0.
Timing: . . . . 1 (sprocket track).
Control signals: . . . 0.
Unused: . . . . 0.
Total: . . . . 6 plus sprocket track.

NOTE: Unless the 6-Bit Input button is depressed, only 4 of the 6 data bits from each tape row enter the Accumulator.

.325 Row use
Data: . . . . 1 to 8.
Redundancy check: . . . 0.
Timing: . . . . 0.
Control signals: . . . 1 (conditional stop).
Unused: . . . . 0.
Gap: . . . . none required.

.33 Coding: . . . . one character per row, as in Data Code Table No. 1.

.34 Format Compatibility

Other device or system	Code translation
Devices using 6-track punched tape:	programmed, or by various mechanical devices.

.35 Physical Dimensions

.351 Overall width: . . . . . 0.875 inch.
.352 Length: . . . . up to 200 feet per roll.

.4 CONTROLLER

.41 Identity: . . . . built into Computer.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line:

Use	Associated equipment
List and/or punch data from tape: . . .	none required.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . 1 word of up to eight 4-bit or five 6-bit characters.
.442 Input area: . . . . . . Accumulator.
.443 Input area access: . . . fully accessible to program.
.444 Input area lockout: . . . internal processing is inhibited during input.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . automatic; see .444

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . . 1 word.
.512 Block demarcation:
Input: . . . . conditional stop code on tape.

.52 Input-Output Operations

.521 Input: . . . . read 1 word forward into Accumulator, shifting Accumulator contents left 4 or 6 bit positions before each character is entered.
.522 Output: . . . . see sections :072 and :091.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . none.

.53 Code Translation: . . . . matched codes (hexadecimal mode) or subroutines.

.54 Format Control: . . . . none.

NOTE: Format of typed listing of data read from tape can be controlled by "inhibited" tape codes which cause typewriter carriage returns, backspaces, case shifts, or color shifts but which do not enter the Accumulator.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . no.
Select format: . . . . . no.
Select code: . . . . . . no.
Rewind: . . . . no.
Unload: . . . . no.

§ 071.

.56 Testable Conditions

Disabled:	no.
Busy device:	no.
Nearly exhausted:	no.
Busy controller:	no.
End of medium marks:	no.

.6 PERFORMANCE

.61 Conditions: . . . . none.

.62 Speeds

.621 Nominal or peak speed: . . . . 10 char/sec.

.622 Important parameters
Tape speed: . . . . 1.0 inch/sec.
Tape density: . . . . . 10 rows/inch.

.624 Effective speed: . . . . depends upon number of carriage returns and complexity and efficiency of input routines; typical input speeds using standard subroutines are:
(1) 50 words/min. for decimal instructions or data.
(2) 60 words/min. for hexadecimal instructions or data.

.63 Demands on System

Component	m.sec per char.	Percentage
Processor:	100	100

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls

Function	Form	Comment
Start Read:	button.	
Stop Read:	button.	
Manual Input:	lever	selects reader as input device when raised.
Conditional Stop:	lever	causes stop codes (') on tape to be ignored.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Roll:	200 feet, or 24,000 characters.

.732 Replenishment time: . . 0.5 to 1.0 min; reader needs to be stopped.

.734 Optimum reloading period: . . . . 40 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	none.	
Input area overflow:	none. *	
Invalid code:	none	varies.
Exhausted medium:	none	reader continues to operate.
Imperfect medium:	none.	
Timing conflicts:	none.	

* If more than eight (4-bit mode) or five (6-bit mode) characters are read before a stop code is sensed, the first characters read are shifted beyond the left end of the Accumulator and lost.

INPUT-OUTPUT: TAPE TYPEWRITER (PUNCH)

§ 072.

.1 GENERAL

.11 Identity: . . . . Tape Typewriter.
Model 360.
(Tape punching facilities).
TTP.

.12 Description: . . . . . . see 352:071.12.

.13 Availability: . . . . . . 1 to 2 months.

.14 First Delivery: . . . . . September, 1956.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . . sprocket drive, pull only.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . die punches.
.222 Sensing system: . . . . see section :071.
.223 Common system: . . . . no.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . punching tape.
Stacks: . . . . 1.
Heads/stack: . . . . . 6 (plus sprocket punch).
Method of use: . . . . . punches 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of storage

.311 Medium: . . . . paper or plastic tape.
.312 Phenomenon: . . . . . . fully punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 10 rows per inch; N is at most 9 if data is to be re-entered.
.322 Parallel by: . . . . . . 6 tracks at standard spacing (plus sprocket track).
.324 Track use
Data: . . . . 6.
Redundancy check: . . 0.
Timing: . . . . 1 (sprocket track).
Control signals: . . . 0.
Unused: . . . . 0.
Total: . . . . 6 plus sprocket track.

.325 Row use
Data: . . . . 1 to N.
Redundancy check: . . 0.
Timing: . . . . 0.
Control signals: . . . 1 (conditional stop).
Unused: . . . . 0.
Gap: . . . . none required.

.33 Coding: . . . . 1 character per row, as in Data Code Table No. 1.

.34 Format Compatibility

Other device or system	Code translation
Devices using 6-track punched tape:	programmed, or by various mechanical devices.

.35 Physical Dimensions

.351 Overall width: . . . . . 0.875 inch.
.352 Length: . . . . up to 800 feet per roll.

.4 CONTROLLER

.41 Identity: . . . . built into Computer.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line

Use	Associated equipment
Prepare or reproduce punched tape:	none required.

.43 Connection to Device

.431 Devices per controller . 1.
.432 Restrictions: . . . . . none.

.44 Data Transfer Control

.441 Size of load: . . . . . . one 6-bit character.
.442 Output area: . . . . . . none; track address of output instruction defines character to be punched.
.443 Output area access: . . output instructions can be modified by standard coding techniques.
.444 Output area lockout: . . unnecessary.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . delay of at least 100 m. sec. must be programmed between successive output instructions.
.447 Synchronizing aids: . . . stop instruction following output instruction halts internal processing until punching is completed.

§ 072.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 to N characters (1 word if data is to be re-entered).

.512 Block demarcation
Output: . . . . conditional stop code after each word to be re-entered.

.52 Input-Output Operations

.521 Input: . . . . see sections :071 and :091.
.522 Output: . . . . punch one character, defined by track address (bits 18-23) of output instruction.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . special "inhibited" codes cause typewriter carriage returns, backspaces, case shifts, or color shifts but do not enter Accumulator during input.
.526 Searching: . . . . . . none.

.53 Code Translation: . . . matched codes; bit pattern punched on tape is same as bits 18-23 of output instruction.

.54 Format Control: . . . . by program.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . . no.
Select format: . . . . . no.
Select code: . . . . . . no.
Rewind: . . . . no.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . no.
Busy device: . . . . . . no.
Nearly exhausted: . . . no.
Busy controller: . . . . no.
End of medium marks: . no.

.6 PERFORMANCE

.61 Conditions

I: . . . . programmed delays between output instructions.
II: . . . . stop instructions after output instructions (to guard against timing conflicts).

.62 Speeds

.621 Nominal or peak
speed . . . . 10 char/sec.

.622 Important parameters
Tape speed: . . . . . 1.0 inch/sec.
Tape density: . . . . . 10 rows/inch.

.624 Effective speeds: . . . . up to 8 char/sec.; depends upon number of carriage returns and efficiency of output routines; typical output speeds using standard subroutines are:
(1) 64 words/min. for hexadecimal instructions or data.
(2) 60 words/min. for decimal instructions.
(3) 35 words/min. for decimal data.

.63 Demands on System

Component	Condition	m.sec per char	Percentage
Processor:	I	2.4 or 19.1	2.4 or 19.1.
Processor:	II	100	100.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . none.

.72 Other Controls

Function	Form	Comment
Punch On:	lever	causes every character that is typed or read to be reproduced on tape.
Tape Feed:	button	prepares leaders, punching sprocket holes only.
Code Delete:	button	punches all 6 tracks, so code will be ignored.

.73 Loading and Unloading

.731 Volume handled

Storage Capacity

Roll: . . . . 800 feet, or 96,000 characters.

.732 Replenishment time: . . 2.0 to 3.0 mins; punch needs to be stopped.

.734 Optimum reloading
period: . . . . 160 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	not required.	
Invalid code:	none	no punching occurs.
Exhausted medium:	check	stop.
Imperfect medium:	check	stop if tape breaks.
Timing conflicts:	none	characters may be lost or halts may occur.

INPUT-OUTPUT: HIGH SPEED READER

§ 073.

.1 GENERAL

.11 Identity: . . . . High Speed Reader/Punch.
Model 342.
(Tape reading facilities).

High Speed Reader.
Model 341.
HSR.

.12 Description:

The Model 342 High Speed Reader/Punch provides facilities for reading and punching 6-track paper tape at significantly higher speeds than the standard Tape Typewriter. The reader and punch are housed in the same cabinet but are mechanically and functionally independent of one another. The Model 341 High Speed Reader consists of the same reader housed in the same cabinet without the punch unit; it is no longer being sold as a separate unit.

The reader is built by Ferranti and uses photoelectric sensing elements. Its peak speed is 200 characters per second. Because of the necessity to stop the reader and process each word after it has been read into the Accumulator, effective input speeds are generally less than one-fourth as high as the peak speed.

The mechanical punch is built by Friden and rated at 20 characters per second. Since this punch is twice as fast as the Tape Typewriter, there is less processing time between characters, and routines written for Tape Typewriter output may require coding changes.

Programming facilities for the High Speed Reader/Punch are very similar to those for the Tape Typewriter. The same input and output instructions are used for both devices, and selection is by means of separate manual switches for the input and output functions. When the High Speed Reader/Punch is selected, it is not possible to produce a typed copy of the input or output data on-line.

There are no built-in error checks on reading or punching; programmed check sums are commonly used for error detection. Instead of take-up reels, large tape bins are provided for both the reader and punch, and a hand-cranked rewinder is supplied as standard equipment. The system is simple and effective.

Optional Equipment

Six or Eight Channel Punch: Permits selection by a manual switch of standard 6-track punching or of 8-track punching under control of a special routine.

.12 Optional Equipment (Contd.)

Switch Box: Permits a single High Speed Reader or Reader/Punch to serve either of two LGP-30 Computers; selection is by a manual switch.

Single Character Input Mode: Causes reader to stop and send a start signal to the Computer after each character is read from tape. All character codes enter the Accumulator.

.13 Availability: . . . . . 1 to 2 months.

.14 First Delivery: . . . . August, 1957.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . pinch roller friction.
.212 Reservoirs: . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . see section :074.
.222 Sensing system: . . . photo-electric.
.223 Common system: . . . no.

.23 Multiple Copies: . . . none.

.24 Arrangement of Heads

Use of station: . . . . reading punched tape.
Stacks: . . . . 1.
Heads/stack: . . . . . 6 (plus sprocket track).
Method of use: . . . . reads 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper or plastic tape.
.312 Phenomenon: . . . . . punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . . . 1 to 9 rows at 10 rows per inch.
.322 Parallel by: . . . . . 6 tracks at standard spacing.
.324 Track use
Data: . . . . 6.
Redundancy check: . . 0.
Timing: . . . . 1 (sprocket track).
Control signals: . . . 0.
Unused: . . . . 0.
Total: . . . . 6 plus sprocket track.

Note: Unless the 6-Bit Input button is depressed, only 4 of the 6 data bits from each tape row enter the Accumulator.

§ 073.

.325 Row use

Data:	1 to 8.
Redundancy check:	0.
Timing:	0.
Control signals:	1 (conditional stop).
Unused:	0.
Gap:	none required.

.33 Coding: . . . . one character per row, as in Data Code Table No. 1.

.34 Format Compatibility

Other device or system	Code translation
Devices using 6-track punched tape:	programmed, or by various mechanical devices.

.35 Physical Dimensions

.351 Overall width: . . . . 0.875 inch.
.352 Length: . . . . up to 200 feet per roll.

.4 CONTROLLER

.41 Identity: . . . . built into Computer.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . only one device at a time (this unit or Tape Typewriter) can be selected for input; selection is controlled by a manual switch.

.44 Data Transfer Control

.441 Size of load: . . . . . 1 word of up to eight 4-bit or five 6-bit characters.
.442 Input area: . . . . . . Accumulator.
.443 Input area access: . . fully accessible to program.
.444 Input area lockout: . . internal processing is inhibited during input.
.445 Table control: . . . . none.
.446 Synchronization: . . . automatic; see .444.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . 1 word.
.512 Block demarcation
Input: . . . . conditional stop code on tape.

.52 Input-Output Operations

.521 Input: . . . . read 1 word forward into Accumulator, shifting Accumulator contents left 4 or 6 bit positions before each character is entered.
.522 Output: . . . . see section :074.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . none.
.526 Searching: . . . . . . none.

.53 Code Translation: . . matched codes (hexadecimal mode) or subroutines.

.54 Format Control: . . . none.

.55 Control Operations

Disable:	no.
Request interrupt:	no.
Select format:	no.
Select code:	no.
Rewind:	no.
Unload:	no.

.56 Testable Conditions

Disabled:	no.
Busy device:	no.
Nearly exhausted:	no.
Busy controller:	no.
End of medium marks:	no.

.6 PERFORMANCE

.61 Conditions: . . . . . . none.

.62 Speeds

.621 Nominal or peak speed: 200 char/sec.
.622 Important parameters
Tape speed: . . . . 20 inches/sec.
Tape density: . . . . 10 rows/inch.
.624 Effective speed: . . . considerably lower than peak speed because of Computer time required to process and store each input word; typical input speeds using standard subroutines are:
(1) 340 words/min. for decimal instructions.
(2) 440 words/min. for hexadecimal input with check sums.
(3) 120 words/min. for decimal data.

.63 Demands on System

Component	m/sec per char.	Percentage
Processor:	5.0	100.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

§ 073.

.72 Other Controls

Function	Form	Comment
Reader Power:	switch.	
Reader Stop:	button	halts tape transport mechanism.
Input Selection:	switch	selects High Speed Reader or Tape Typewriter.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Feed bin:	200 feet, or 24,000 characters, in form of roll.
Take-up bin:	approx. 200 feet.

.732 Replenishment time: . . . 0.5 to 1.0 mins; reader needs to be stopped.

.734 Optimum reloading period: . . . . 2 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Reading:	none.	
Input area overflow:	none.*	
Invalid code:	none.	
Exhausted medium:	none.	reader continues to operate.
Imperfect medium:	none.	
Timing conflicts:	none.	

* If more than eight (4-bit mode) or five (6-bit mode) characters are read before a stop code is sensed, the first characters read are shifted beyond the left end of the Accumulator and lost.

INPUT-OUTPUT: HIGH SPEED PUNCH

§ 074.

.1 GENERAL

.11 Identity: . . . . High Speed Reader/Punch Model 342. (Tape punching facilities) HSP

.12 Description: . . . . . . see 352:073.12.

.13 Availability: . . . . . . 1 to 2 months.

.14 First Delivery: . . . . August, 1957.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . sprocket drive, pull only.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . die punches.
.222 Sensing sytem: . . . . . see section :073.
.223 Common system: . . . . no.

.23 Multiple Copies: . . . . none.

.24 Arrangement of Heads

Use of station: . . . . . punching tape.
Stacks: . . . . 1.
Heads/stack: . . . . . . 6 (plus sprocket punch).
Method of use: . . . . . punches 1 row at a time.

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . paper or plastic tape.
.312 Phenomenon: . . . . fully punched holes.

.32 Positional Arrangement

.321 Serial by: . . . . 1 to N rows at 10 rows per inch; N is at most 9 if data is to be re-entered.
.322 Parallel by: . . . . . . 6 tracks at standard spacing (plus sprocket track).
.324 Track use
Data: . . . . 6.
Redundancy check: . . 0.
Timing: . . . . 1 (sprocket track).
Control Signals: . . . 0.
Unused: . . . . 0.
Total: . . . . 6 plus sprocket track.

.325 Row use
Data: . . . . 1 to N.
Redundancy check: . . 0.
Timing: . . . . 0.
Control signals: . . . 1 (conditional stop).
Unused: . . . . 0.
Gap: . . . . none required.

.33 Coding: . . . . 1 character per row, as in Data Code Table No. 1.

.34 Format Compatibility

Other device or system	Code translation
Devices using 6-track punched tape:	programmed, or by various mechanical devices.

.35 Physical Dimensions

.351 Overall width: . . . . . . 0.875 inch.
.352 Length: . . . . up to 800 feet per roll.

.4 CONTROLLER

.41 Identity: . . . . built into Computer.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line: . . . . none.

.43 Connection to Device

.431 Devices per controller: . . . . 1.
.432 Restrictions: . . . . . only 1 device at a time (this unit or Tape Typewriter) can be selected for output; selection is controlled by a manual switch.

.44 Data Transfer Control

.441 Size of load: . . . . . . one 6 bit character.
.442 Output area: . . . . . . none; track address of output instruction defines character to be punched.
.443 Output area access: . . output instructions can be modified by standard coding techniques.
.444 Output area lockout: . . unnecessary.
.445 Table control: . . . . . none.
.446 Synchronization: . . . . delay of at least 50 m.sec. must be programmed between successive output instructions.

§ 074.

.447 Synchronizing aids: . . . stop instruction following output instruction halts internal processing until punching is completed.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . . 1 to N characters (1 word if data is to be re-entered).

.512 Block demarcation
Output: . . . . conditional stop code after each word to be re-entered.

.52 Input-Output Operations

.521 Input: . . . . see section :073.
.522 Output: . . . . punch 1 character, defined by track address (bits 18-23) of output instruction.
.523 Stepping: . . . . none.
.524 Skipping: . . . . none.
.525 Marking: . . . . special "inhibited" codes causes typewriter carriage returns, back-spaces, case shifts, or color shifts but do not enter Accumulator during input.
.526 Searching: . . . . none.

.53 Code Translation: . . . . matched codes; bit pattern punched on tape is same as bits 18-23 of output instruction.

.54 Format Control: . . . . . by program.

.55 Control Operations

Disable: . . . . no.
Request interrupt: . . no.
Select format: . . . . . no.
Select code: . . . . . . no.
Rewind: . . . . no.
Unload: . . . . no.

.56 Testable Conditions

Disabled: . . . . no.
Busy device: . . . . . no.
Nearly exhausted: . . no.
Busy controller: . . . no.
End of medium marks: no.

.6 PERFORMANCE

.61 Conditions

I : . . . . programmed delays between output instructions.
II : . . . . stop instructions after output instructions (to guard against timing conflicts).

.62 Speeds

.621 Nominal or peak speed: 20 char/sec.
.622 Important parameters
Tape speed: . . . . . 2.0 inches/sec.
Tape density: . . . . 10 rows/inch.
.624 Effective speeds: . . . depends upon efficiency of output routines; typical output speed using standard subroutine is 140 words/min. for hexadecimal instructions or data.

.63 Demands on System

Component	Condition	m. sec per char.	Percentage
Processor:	I	2.4 or 19.1	5 or 38.
	II	50	100.

.7 EXTERNAL FACILITIES

.71 Adjustments: . . . . . . none.

.72 Other Controls

Function	Form	Comment
Punch Power	switch	
Tape Feed:	button	prepares leaders, punching sprocket holes only.
Output Selection:	switch	selects High Speed Punch or Tape Typewriter.

.73 Loading and Unloading

.731 Volumes handled

Storage	Capacity
Roll:	800 feet, or 96,000 characters.

.732 Replenishment time: . . . . 2.0 to 3.0 mins; punch needs to be stopped.
.734 Optimum reloading period: . . . 80 mins.

.8 ERRORS, CHECKS, AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Output block size:	not required.	
Invalid code:	none.	
Exhausted medium:	check	stop.
Imperfect medium:	check	stop if tape breaks.
Timing conflicts:	none	characters may be lost or halts may occur.

INPUT-OUTPUT: PUNCHED CARD INPUT

§ 075.

.1 GENERAL

.11 Identity: . . . . Punched Card Input Control Unit.
Model 321.
PCI.

.12 Description:

This control unit enables the LGP-30 to accept information from standard 80-column punched cards.

.12 Description (Contd.)

The required input device is an IBM Model 024 or 026 Card Punch, which reads at 20 columns per second and skips at 80 columns per second. The Punched Card Input Control Unit is mounted entirely within the IBM Card Punch and converts the signals into a form acceptable to the LGP-30. Detailed specifications on the control unit are not available, and there are no standard routines that utilize it. Output via punched cards is not possible in the LGP-30 system.

INPUT-OUTPUT: TAPE TYPEWRITER (PRINTER)

§ 081.

.1 GENERAL

.11 Identity: . . . . Tape Typewriter.
Model 360.
(Printing and keyboard input facilities).
TTT.

.12 Description: . . . . . . see 352:071.12.

.13 Availability: . . . . . . 1 to 2 months.

.14 First Delivery: . . . . September, 1956.

.2 PHYSICAL FORM

.21 Drive Mechanism

.211 Drive past the head: . . platen friction.
.212 Reservoirs: . . . . . . none.

.22 Sensing and Recording Systems

.221 Recording system: . . . engraved hammers; see also section :072.
.222 Sensing system: . . . . typewriter keyboard; see also section :071.
.223 Common system: . . . . no.

.23 Multiple Copies

.231 Maximum number: . . . depends on stationery; approximately 6.
.233 Types of master
Multilith: . . . . yes.
Xerox: . . . . yes.
Spirit: . . . . yes.

.24 Arrangement of Heads

Use of station: . . . . . printing.
Stacks: . . . . 1.
Heads/stack: . . . . . 1 print station.
Method of use: . . . . . 1 character at a time.

Use of station: . . . . . keyboard input.
Stacks: . . . . 1.
Heads/stack: . . . . . 48 keys.
Method of use: . . . . . 1 character at a time.

.25 Range of Symbols

Numerals:	10	0-9
Letters:	26	A-Z, upper and lower case.
Special:	28	as in Data Code Table No. 1.
Alternatives: . . .		none.
FORTRAN set: . .		yes.
Basic COBOL set: .		yes.
Total:	64 plus space.	

.3 EXTERNAL STORAGE

.31 Form of Storage

.311 Medium: . . . . continuous fanfold stationery or individual sheets.
.312 Phenomenon:
Input: . . . . key depression.
Output: . . . . printing.

.32 Positional Arrangement

.321 Serial by: . . . . character at 12 per inch.
.324 Track use
Data: . . . . 180 print positions.
.325 Row use: . . . . all for data.

.33 Coding: . . . . engraved character font (internal coding as in Data Code Table No. 1).

.34 Format Compatibility: . . none.

.35 Physical Dimensions

.351 Overall width: . . . . . . continuously variable to maximum of 16 inches for standard carriage, 20 inches for optional carriage.
.352 Length: . . . . no limit.

.4 CONTROLLER

.41 Identity: . . . . built into Computer.

.42 Connection to System

.421 On-line: . . . . 1.
.422 Off-line

Use	Associated equipment
Preparation or listing of punched paper tape; typing of form letters . . .	none required.

.43 Connection to Device

.431 Devices per controller: 1.
.432 Restrictions: . . . . . . none.

.44 Data Transfer Control

.441 Size of load
Input: . . . . one word of up to eight 4-bit or five 6-bit characters.
Output: . . . . one 6-bit character.

§ 081.

.442 Input-output areas
- Input: . . . . Accumulator.
- Output: . . . . none; track address of output instruction defines character to be punched.

.443 Input-output area access: . . . . fully accessible to program.

.444 Input-output area lockout
- Input: . . . . internal processing is inhibited during input.
- Output: . . . . unnecessary.

.445 Table control: . . . . . none.

.446 Synchronization
- Input: . . . . automatic; see .444.
- Output: . . . . delay of at least 100 m. sec. must be programmed between successive output instructions.

.447 Synchronizing aids: . . . stop instruction following output instruction halts internal processing until printing is completed.

.5 PROGRAM FACILITIES AVAILABLE

.51 Blocks

.511 Size of block: . . . . . . 1 word.

.512 Block demarcation
- Input: . . . . depress Start Compute button.
- Output: . . . . punch conditional stop code.

.52 Input-Output Operations

.521 Input: . . . . load 1 manually typed word into accumulator, shifting accumulator contents left 4 or 6 bit positions before each character is entered.

.522 Output: . . . . print 1 character, defined by track address (bits 18-23) of output instruction.

.523 Stepping: . . . . return carriage and step 1, 2, or 3 lines depending upon Line Space lever setting.

.524 Skipping: . . . . "tab" to next manually inserted tab stop.

.525 Marking: . . . . none.

.526 Searching: . . . . none.

.53 Code Translation:

- Input: . . . . matched codes (hexadecimal mode) or subroutines.
- Output: . . . . matched codes.

.54 Format Control

- Input: . . . . manual.
- Output: . . . . by program.

.55 Control Operations

- Disable: . . . . no.
- Request interrupt: . . . no.
- Select format: . . . . . no.
- Select code: . . . . . . no.

.56 Testable Conditions

- Disabled: . . . . no.
- Busy device: . . . . . . no.
- Nearly exhausted: . . . no.
- Busy controller: . . . . no.
- End of medium marks: no.

.6 PERFORMANCE

.61 Conditions

- I : . . . . output; programmed delays between output instructions.
- II: . . . . output; stop instruction after output instructions.
- III: . . . . typed input.

.62 Speeds

.621 Nominal or peak speed
- Input: . . . . manual typing speed.
- Output: . . . . 10 char/sec.

.623 Overhead
- Carriage return: . . . 1,100 m.sec. max.

.624 Effective speeds
- Input: . . . . manual typing speed.
- Output: . . . . up to 8 char/sec.; depends upon number of carriage returns and efficiency of output routines.

.63 Demands on System

Component	Condition	m.sec per char.	Percentage
Processor:	I (output)	2.4 or 19.1	2.4 or 19.1
	II (output)	100	100.
	III (input)	variable	100.

.7 EXTERNAL FACILITIES

.71 Adjustments

Adjustment	Method
Left margin:	sliding stop.
Tab stops:	metal positioners inserted into tab rack.
Line spacing:	lever for single, double, or triple spacing.
Forms alignment:	Paper Release lever frees form.

§ 081.

.72 Other Controls

Function	Form	Comment
Power On-Off	switch	controls Tape Typewriter power.
Connect:	switch	permits start signals to pass to Computer.
Start Compute:	button	sends a start signal to Computer.
Manual Input:	lever	selects keyboard as input device when lowered.

.73 Loading and Unloading

.731 Volumes handled: . . . no special facilities are provided for feeding or stacking forms.

.732 Replenishment time: . . 2.0 to 3.0 mins; typewriter needs to be stopped.

.733 Adjustment time: . . . 3.0 to 4.0 mins.

.8 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Recording:	none.	
Reading:	none.	
Input area overflow:	none	first characters typed are lost.
Output block size:	not required.	
Invalid code:	none.	
Exhausted medium:	none	typing continues.
Imperfect medium:	none	typing continues.
Timing conflicts:	none	characters may be lost or halts may occur.

SIMULTANEOUS OPERATIONS

§ 111.

.1 SPECIAL UNITS: . . . . none.

.12 Description

Simultaneous operations on the LGP-30 are limited to its ability to do internal processing during output operations. Each output instruction causes only a single character to be punched or printed, and all of the overlapped computing time will generally be required to prepare the next character for output. All LGP-30 system functions except output are strictly serial; i.e., no operation can begin until the previous operation has been completed.

.2 CONFIGURATION CONDITIONS: . . . . . none.

.3 CLASSES OF OPERATIONS

A: . . . . Input from Tape Typewriter or High Speed Reader.

B: . . . . Output on Tape Typewriter or High Speed Punch.

C: . . . . Internal Processing.

.4 RULES

a + c = at most 1.
b = at most 1.
ab = 0.

INSTRUCTION LIST

§ 121.

INSTRUCTION		OPERATION
Op.	Addr.	
		Arithmetic
A	Y	(A) + (Y) → A.
S	Y	(A) - (Y) → A.
M	Y	(A) x (Y) → A; retain most significant half of product (30 bits) in A.
N	Y	(A) x (Y) → A; retain least significant half of product (30 bits) in A.
D	Y	(A) ÷ (Y) → A; quotient is rounded to 30 bits.
		Logic
U	Y	Branch unconditionally to Y.
T	Y	Branch to Y if (A) is negative; otherwise, execute next sequential instruction.
-T	Y	Branch to Y if (A) is negative and/or if Transfer Control button is depressed; otherwise, execute next sequential instruction.
Y	Y	(A_{18-29}) → Y_{18-29}; stores address portion only, leaving remainder of (Y) undisturbed.
R	Y	(C) + 1 → Y_{18-29}; sets up return address for sub-routine exit.
Z	ts	Stop unless Break Point switch t is depressed (t = 04, 08, 16, or 32; s affects timing only).
E	Y	AND: Place a 1 bit in A wherever there is a 1 bit in the corresponding positions of both A and Y; otherwise, place a O bit in A.
		Data Transfer
B	Y	(Y) → A.
H	Y	(A) → Y.
C	Y	(A) → Y; 0 → A.
		Input-Output
P	ts	Print or punch character designated by t; s affects timing only.
I	ts	Read data into A, shifting contents of A left 4 or 6 bit positions before each character is entered, until terminated by conditional stop code (') on tape or depression of Start Compute button; ts is normally 0000.

INSTRUCTION LIST NOMENCLATURE

Symbol	Definition
A:	Accumulator.
A_{18-29}:	Bit positions 18 through 29 (address portion) of Accumulator.
Addr.:	Operand address.
C:	Counter Register; contains address of next instruction to be executed.
Op.:	Operation code.
s:	Sector portion (bits 24-29) of operand address.
t:	Track portion (bits 18-23) of operand address.
Y:	A drum storage location.
( ):	Contents of a register or storage location; e.g., (A) means "contents of Accumulator".

§ 131.

.1 CODING SHEET

LGP-30 CODING SHEET

PREPARED FOR:			PAGE OF
MACHINE CODING SPECIMEN			1 / 1
JOB NO.: XX	PROGRAM NO.: YY.Y	PROGRAM PREPARED BY: MEL KAYE	PROGRAM CHECKED BY:
DATE: REV. 6/16/59			
PROBLEM: EVALUATION OF FOURTH DEGREE POLYNOMIAL			TRACK: 10

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION (OPERATION / ADDRESS)	STOP	CONTENTS OF ADDRESS	NOTES
;0001000	'				BEGIN LOADING IN LOC. 1000.	
/0001000	'	☒			SET MODIFIER TO 1000.	
		00	XR0508	'	TRANSFER ROUTINE	TO DATA INPUT NO. 1 TO READ, CONVERT,
		01	XU0500	'	SCALE, AND STORE DATA.	
		02	B0023	'	A0027	INITIALIZE
		03	C0007	'	☒ A0027	"ADD" INSTR.
		04	H0025	'	SET WORKING STORAGE TO 0	
		05	B0025	'	WORKING	STORAGE @ $q = 0$
		06	M0026	'	X @ $q = 0$	
		07	A[ ]	'	☒ A_n @ $q = 0$	ADD nTH COEFF.
		08	H0025	'	WORKING	STORAGE @ $q = 0$
		09	B0007	'	A[0027+N]	
		10	A0022	'	XZ0001	INCREMENT ADDRESS
		11	Y0007	'	☒ A[0027+N+1]	
		12	S0024	'	A0032	FLAG
		13	T0005	'		IF NOT FINISHED, EVALUATE NEXT TERM.
		14	B0025	'	FINAL	RESULT
		15	XR1412	'	☒ TRANSFER	TO DATA OUTPUT
		16	XU1400	'	NO. 1 ROUTINE AND PRINT FINAL	RESULT AT $q = 0$.
		17	XZ0000	'		
		18	XP1600	'		CARRIAGE RETURN
		19	XZ0000	'	☒	PRINT DELAY
		20	XZ0800	'		STOP UNLESS BREAK POINT 8 SW. IS DOWN.
		21	U0000	'		READ MORE DATA
		22	XZ0001	'	1 @ $q=29$	
		23	A0027	'	☒ $A(L_o)$	CONSTANTS AND
		24	A0032	'	$A(L_f+1)$	FLAGS
		25	[ ]	'		WORKING STORAGE
		26		'	X	
		27		'	☒ A_0	
		28		'	A_1	DATA STORAGE
		29		'	A_2	@ $q = 0$
		30		'	A_3	
		31		'	☒ A_4	

FORM LP-10

ROYAL McBEE J13541X

☒ CARRIAGE RETURN

' = CONDITIONAL STOP CODE

Royal McBee Corporation
DATA PROCESSING DIV.
PORT CHESTER, NEW YORK

Reprinted from LGP-30 Subroutine Manual, p. 4.

§ 132. CODING SPECIMEN: 24.0 INTERPRETIVE SYSTEM

.1 CODING SHEET

LGP-30 CODING SHEET

PREPARED FOR:				PAGE OF
24.0 INTERPRETIVE SYSTEM CODING SPECIMEN				1 / 1
JOB NO.	PROGRAM NO.: 24.0	PROGRAM PREPARED BY: G. L. W.	PROGRAM CHECKED BY: M. K.	DATE: REV. 6/26/59
PROBLEM: EVALUATION OF FOURTH DEGREE POLYNOMIAL				TRACK

PROGRAM INPUT CODES	STOP	LOCATION	INSTRUCTION OPERATION	INSTRUCTION ADDRESS	STOP	CONTENTS OF ADDRESS	NOTES
;0001000	'					BEGIN LOADING IN LOC. 1000.	
/0001000	'	☒				SET MODIFIER TO 1000.	
		00	XR	3000	'		ENTER INTERP. ROUTINE.
		01	XU	3000	'		
		02	XI	0000	'		READ DATA
		03	E	0017	'	☒ 0027	INITIALIZE "ADD" INSTR.
		04	Y	0006	'	0027	
		05	B	0013	'	ZERO	
		06	XA	[ ]	'	A_n	ADD nTH COEFF.
		07	XI	0001	'	☒ [0027+n]	INCREMENT ADDRESS ACCUMULATOR BY 1.
		08	Y	0006	'	[0027+n]	STORE INCREMENTED ADDRESS.
		09	Z	0033	'		TEST FOR FINISH
		10	U	0014	'		NOT FINISHED
		11	XP	0000	'	☒	PRINT RESULT
		12	XE	0000	'		EXIT FROM 24.0
		13	XZ	0000	'		STOP
		14	XU	0000	'		INTERCHANGE ACCUM. AND MULT. REGISTER.
		15	M	0026	'	☒	MULTIPLY BY X
		16	U	0006	'		EVALUATE NEXT TERM
		17	Z	0027	'		LOCATION OF A_0
		18			'		
		19			'	☒	
		20			'		
		21			'		
		22			'		
		23			'	☒	
		24			'		
		25			'		
		26			'	X	DATA STORAGE
		27			'	☒ A_0	
		28			'	A_1	
		29			'	A_2	
		30			'	A_3	
		31			'	☒ A_4	

FORM LP-10 ROYAL McBEE J13541X

☒ CARRIAGE RETURN

' = CONDITIONAL STOP CODE

Royal McBee Corporation
DATA PROCESSING DIV.
PORT CHESTER, NEW YORK

Reprinted with modifications from LGP-30 Subroutine Manual, p. 33.

CODING SPECIMEN: ACT III

§ 133.

.1 SOURCE PROGRAM

This program reads an integer "n", then reads n pairs of floating point numbers "a" and "b" and prints them together with their sum, difference, product, and quotient. A test prevents division by zero. A blank word for "n" causes a stop in s10.

```
HJB:  programmer'

          rdxit's10' '
sl'       iread'n' '
          l';'i' '
          if'n'zero'sl' '
s2'       read'a' '
          read'b' '
          cr'1305'print'a' '
          1305'print'b' '
          1305'print'a'+'b' '
          1305'print'a'-'b' '
          1305'print'a'x'b' '
          if'b'zero's3' '
          1305'print'a'/'b' '
s3'       for'i'step'l'until'n'rpeat's2' '
          cr'use'sl' '

s10'      stop' '
          use'sl' ' '
```

Reprinted from ACT III Programmer's Manual, p. 83.

DATA CODE TABLE NO. 1

§ 141.

.1 USE OF CODE: . . . . punched tape and Tape Typewriter input and output.

.2 STRUCTURE OF CODE

.21 Character Size: . . . . 6 bits (see Note 1).

.22 Character Structure

.221 More significant pattern: . . . . 4 bits; values are 8, 4, 2, 1.

.222 Less significant pattern: . . . . 2 bits; values are 2, 1.

.23 Character Codes

LESS SIGNIFICANT PATTERN		MORE SIGNIFICANT PATTERN															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
UPPER CASE	0	SR	LC	UC	CO	CR	BS	TB		CS							
	1	Z	B	Y	R	I	D	N	M	P	E	U	T	H	C	A	S
	2	)	L	*	"	Δ	%	$	π	Σ	(	F	G	J	K	Q	W
	3	SP	_	=	:	?	]	[	V	O	X						DL
LOWER CASE	0	SR	LC	UC	CO	CR	BS	TB		CS							
	1	z	b	y	r	i	d	n	m	p	e	u	t	h	c	a	s
	2	0	1	2	3	4	5	6	7	8	9	f	g	j	k	q	w
	3	SP	-	+	;	/		,	v	o	x						DL

NOTES

1) In the normal input mode, only the more significant pattern (4 bits) enters the Accumulator, so the character codes in each column are internally indistinguishable from one another.

2) The following abbreviations are used for the Tape Typewriter control codes:

BS : . . . . backspace
CO: . . . . color shift
CR: . . . . carriage return
CS: . . . . conditional stop (')
DL: . . . . delete
LC: . . . . lower case
SP : . . . . space
SR: . . . . start reader
TB: . . . . tab
UC: . . . . upper case

3) All of the above control codes except tab and space are "inhibited codes" which do not enter the Accumulator during input operations.

4) The 6-bit codes shown here, when used in the track address portion (bits 18-23) of a "print" instruction, cause punching of the same code and/or printing of the indicated character.

5) Data is recorded on tape in the order 6, 1, 2, 3, 4, 5, from left to right, where 1 is the most significant bit; it enters the Accumulator in the order 1, 2, 3, 4, 5, 6.

PROBLEM ORIENTED FACILITIES

§ 151.

.1 UTILITY ROUTINES

.11 Simulators of Other Computers: . . . . . none.

.12 Simulation by Other Computers

RPC-4000 (machine language)
Reference: . . . . . LGP-30 to RPC-4000 Interpreter 2, Program H1-01.0.
Date available: . . . ?
Description:
With this routine, the RPC-4000 reads LGP-30 machine language program tapes and executes the LGP-30 routines interpretively. Execution time on the RPC-4000 is 3 to 8 times as long as on the LGP-30.

RPC-4000 (24.0 language)
Reference: . . . . . FLIRT 1, Program H1-24.0.
Date available: . . . ?
Description:
FLIRT 1 reads and executes routines coded in the 24.0 Floating Point Interpretive language. Execution time on the RPC-4000 is 20 to 50 percent of the time required for the same routines on the LGP-30.

GE 225
Reference: . . . . . GE Computer Department.
Date available: . . . March, 1962.
Description:
This routine enables a GE 225 with 8,192 core storage locations and punched tape input-output to simulate interpretively each of the 16 LGP-30 instructions. LGP-30 routines of up to about 3,000 words can be accomodated.

.13 Data Sorting and Merging: . . . . . magnetic tape cannot be used; several routines for sorting data records within internal storage are available: Programs L1-45.0, L1-49.0, L1-92.0.

.14 Report Writing: . . . none.

.15 Data Transcription: . none; punched tape is the only important input-output medium.

.16 File Maintenance: . . none.

.17 Other:

Space does not permit complete descriptions of the LGP-30 library routines available from the manufacturer or from POOL, the LGP-30 users' organization. Listed below are the major categories and the number of routines currently available in each. This list should give the prospective LGP-30 user a good idea of the library's value for his own purposes.

Mathematical functions:	46.
Polynomials; roots and evaluation: . . .	6.
Matrix arithmetic:	33.
Curve fitting:	6.
Interpolation:	9.
Statistical calculations:	18.
Integration:	2.
Interpretive routines:	12.
Assembly routines:	2.
Compilers:	3.
PERT:	1.
Linear programming:	2.
Input-output subroutines:	40.
Diagnostics:	18.
Civil engineering calculations:	18.
Electrical engineering calculations: . .	6.
Optical design calculations:	6.
Demonstration routines (miscellaneous): .	16.

.2 PROBLEM ORIENTED LANGUAGES: . . . . none.

PROCESS ORIENTED LANGUAGE: ACT III

§ 161.

.1 GENERAL

.11 Identity: . . . . ACT III.

.12 Origin: . . . . Henry J. Bowlden, Union Carbide Corp., and Roberta R. Smith, presently with Stanford University.

.13 Reference: . . . . . ACT III Programmer's Manual (Operator's Manual and Technical Manual are in preparation).

.14 Description:

The ACT III system consists of an algebraic language and translator developed specifically for the LGP-30. While there are few areas of direct language compatibility between ACT III and either ALGOL or FORTRAN, ACT III coding can be quickly learned by anyone who is familiar with either of the more widely used languages.

The language includes complete facilities for floating point and integer arithmetic and all of the standard mathematical functions. The LGP-30 machine operation codes can also be used without exiting from the ACT III language. A total of 86 operators are implemented in the standard system, and more can be defined and added to the system by the user. Detailed information on the techniques for expanding the system has not been published to date.

One storage location is used to hold each floating point or integer data item. Floating point data representation is sign and 24 bits for the fixed point part and 6 bits for the exponent. Mixed arithmetic within a statement is not permitted; but the translator makes no systematic check, and labels for integer and floating point items are indistinguishable from one another. The burden of avoiding mixed arithmetic therefore falls upon the programmer.

It is possible to execute designated blocks of statements within the user's main program (as in the COBOL "PERFORM") or to define and cue separate closed subroutines called "procedures" (as in ALGOL) with up to 31 parameters. Procedures can be nested to any depth, but recursion is not permitted.

Input-output operations are flexible and convenient. Data may be in integer or floating point form and decimal or hexadecimal radix, and output can be punched in a form suitable for direct re-entry. Alphameric information can be read, stored, and printed or punched in 6-bit form.

.14 Description: (Contd.)

Because input load size on the LGP-30 is limited to five 6-bit characters, it is necessary to punch a conditional stop code (') after each ACT III word of one to five characters. This convention is inconvenient and a frequent source of hard-to-detect errors in the coding and punching of ACT III source programs.

.15 Publication Date: . . . . Preliminary Manual, April, 1961.

.2 PROGRAM STRUCTURE

.21 Divisions: . . . . . . none.

.22 Procedure Entities

Program: . . . . . . statements. procedures.
Procedure: . . . . . . statements. procedures.
Statement: . . . . . . words.
Word: . . . . 1 to 5 characters, followed by conditional stop code.

.23 Data Entities

Arrays: . . . . subscripted floating point or integer variables.
Items: . . . . floating point variables or constants.
integer variables or constants.
alphameric information (for input-output only).

.24 Names

.241 Simple name formation
Alphabet: . . . . . A-Z, 0-9, -;.,/ and space.
Size: . . . . . . 1 to 5 characters.
Avoid key words: . . yes; all operators.
Formation rule: . . 1 to 5 characters plus optional Tape Typewriter control codes, followed by conditional stop code.

.242 Designators
Procedures
Statement labels: . "s" followed by 1 to 4 digits representing an integer from 0 to 190.

Data
Integer constants
First word: . . . . + sign and 1 to 4 digits.
Second word (optional): . . . . 1 to 5 digits.
Example: . . . . . +1234'567'

§ 161.

.242 Designators (Contd.)
Floating point constants
First word: . . . . decimal point and 1 to 4 digits.
Second word: . . . blank or 1 to 5 digits.
Third word: . . . . "e" followed by minus sign if exponent is negative.
Fourth word: . . . 1 or 2 digits for exponent.
Example: . . . . .1234'567'e'10'
Equipment: . . . . . none.
Comments: . . . . . 6 or more characters; sixth from end must be one of the 16 command letters.
Translator control: . none.

.25 Structure of Data Names

.251 Qualified names: . . . none.
.252 Subscripts
Number per item: . . 2.
Applicable to: . . . . variables.
Class may be
Special index variable: . . . . yes.
Any variable: . . . no.
Literal: . . . . . yes.
Expression: . . . . limited; a'j'2' means variable a with subscript j + 2.

Form may be
Integer only: . . . yes.
Signed: . . . . . . no; always positive.
Truncated fraction: . no.
Rounded fraction: . no.
.253 Synonyms: . . . . . none.

.26 Number of Names

.261 All entities: . . . . . see following entries.
.262 Procedures
Statement labels: . . 190.
.263 Data
Items: . . . . 126 named variables.
Data levels: . . . . 2; arrays and items.
Constants: . . . . . 63.
.264 Equipment: . . . . . not named; input-output units are selected by manual switching.

.27 Region of Meaning of Names

.271 Universal names: . . . only those names defined by a non-executable statement preceding the "enter" statement for a procedure.
.272 Local names: . . . . all labels and variables used in a procedure except those designated universal as described above.
.273 Non-local names: . . . not allowed.

.3 DATA DESCRIPTION FACILITIES

.31 Methods of Direct Data Description

.311 Concise item picture: . no.
.312 List by kind: . . . . . no.
.313 Qualify by adjective: . no.
.314 Qualify by phrase: . . no.
.315 Qualify by code: . . . operator prefix "i" denotes data is of integer type; otherwise mode is floating point.
.316 Hierarchy by list: . . no.
.317 Level by indenting: . . no.
.318 Level by coding: . . . no.

.32 Files and Reels: . . . own coding.

.33 Records and Blocks

.331 Variable record size: . . . . preset.
.332 Variable block size: . . dynamic for input; preset for output.
.333 Record size range: . . no limit.
.334 Block size range: . . . 1 item of 1 to 8 characters followed by stop code.
.335 Choice of record size: . . . . procedures.
.336 Choice of block size: . . . . procedures.
.337 Sequence control: . . . none.
.338 In-out error control: . none.
.339 Blocking control: . . . fixed; 1 item per block.

.34 Data Items

.341 Designation of class: . . . . by usage; e.g., integer operator implies integer variables.
.342 Possible classes
Integer: . . . . . . yes.
Fixed point: . . . . no.
Floating point: . . . yes.
Alphameric: . . . . yes.
.343 Choice of external radix: . . . . yes.
.344 Possible radices
Decimal: . . . . . yes.
Hexadecimal: . . . . yes.
.345 Justification: . . . . . automatic right for integers.
.346 Choice of code: . . . . none.
.347 Possible codes: . . . . standard code as in Data Code Table No. 1.
.348 Item size
Variable size: . . . fixed internal size; dynamic for input and preset for output.
Range
Integer numeric: . . 1 word.
Floating point numeric: . . . . . 1 word.
Alphameric: . . . . 1 to 5 char/statement.
.349 Sign provision: . . . . all numeric variables are signed.

.35 Data Values

.351 Constants
Possible sizes
Integer: . . . . . 1 to 536,870,911.
Floating point: . . . 10^{-32} to 10^{+31}.
Alphameric: . . . 1 to 5 char/statement.
Subscriptable: . . . . no.
Sign provision: . . . always positive.
.352 Literals: . . . . . . same as constants.

§ 161.

.353 Figuratives: . . . . . none.
.354 Conditional variables: . none.

.36 Special Description Facilities

.361 Duplicate format: . . no.
.362 Re-definition: . . . . no.
.363 Table description: . . no.
.364 Other subscriptable entities: . . . . . . none.

.4 OPERATION REPETOIRE

.41 Formulae

.411 Operator list

; ' : . . . . substitution.
+ ' : . . . . floating point addition.
- ' : . . . . floating point subtraction.
x ' : . . . . floating point multiplication.
/ ' : . . . . floating point division.
0- ': . . . . floating point sign change (unary).
abs': . . . . floating point absolute value.
pwr': . . . . floating point exponentiation.
ln ': . . . . floating point natural log.
log': . . . . floating point common log.
sqrt' : . . . . floating point square root.
exp ': . . . . floating point exponentiation.
sin ': . . . . floating point sine.
cos ': . . . . floating point cosine.
artan ': . . . . floating point arctangent.
randm ': . . . . floating point random number generator.
i+ ': . . . . integer addition.
i- ': . . . . integer subtraction.
ix ': . . . . integer multiplication with overflow stop.
nx ': . . . . integer multiplication; no overflow stop.
i/ ': . . . . integer division.
iabs ': . . . . integer absolute value.
ipwr ': . . . . integer exponentiation.
flo ': . . . . convert integer to floating point number.
unflo ': . . . . convert to integer with rounding.
fix ': . . . . convert to integer with truncation.

.412 Operands allowed
Classes: . . . . all numeric.
Mixed scaling: . . . . cannot occur.
Mixed classes: . . . . no; each expression must be either all fixed or all floating point.
Mixed radices: . . . . no; binary only.
Literals: . . . . . . yes.

.413 Statement structure
Parentheses
a - b - c means: . . . (a-b)-c.
a + b x c means: . . . a+(b x c).
a / b / c means: . . . (a/b) /c.
a^{bc} means: . . . . . $(ab)^{c}$.
Size limit: . . . . . . ?
Multi-results: . . . . yes.

.414 Rounding of results: . . . automatic, except truncated for integer division.

.415 Special cases
x = -x: . . . . 0- 'ex'; 'ex' '
x = x + 1: . . . . . . ex 'i+'1'; 'ex' '
x = 4.7 y: . . . . . . .47' 'e' 1 'x'y'; 'ex' '
x = 5 x 10^7 = y^2. . . . .5' 'e'8'+ 'y'x'y'; 'ex' '
x = y integer part: . 0'fix'y'; 'ex' '

.416 Typical examples: . . ('0- 'b'+ 'sqrt'('b'b'- '.4' 'e' 1 'x'a'x'c')')'/'(.2' 'e'1 'x' a')'; 'ex' '

.42 Operations on Arrays: . none.

.43 Other Computation: . . none.

.44 Data Movement and Format

.441 Data copy example: . . ex'; 'y' '
.442 Levels possible: . . . data items only.
.443 Multiple results: . . yes; e.g., ex'; 'y'; 'z' '
.444 Missing operands: . . no.
.445 Size of operands
Exact match: . . . . yes; 1 word per item.
.446 Editing possible
Change class: . . . . yes; operators flo, unflo, fix.
Change radix: . . . . automatic, by input-output routines.
Delete editing symbols: . . . . automatic.
Insert editing symbols
Actual point: . . . automatic.
Suppress zeros: . . yes; integers only.
Insert: . . . . "e" before exponent.
Float: . . . . sign for integers.
.447 Special moves: . . . none.
.448 Code translation: . . . automatic, by input-output routines.
.449 Character manipulation: . . . . none.

.45 File Manipulation: . . . own coding.

.46 Operating Communication

.461 Log of progress: . . . daprt or aprt operator types alphameric information.
.462 Messages to operator: . same as log.
.463 Offer options: . . . . . print message or stop with binary register displays.
.464 Accept option: . . . . . accept typed data or test Transfer Control switch setting.

.47 Object Program Errors

Error	Discovery	Special Actions
Overflow:	hardware check	stop.
In-out:	none.	
Invalid data:	automatic	print error code and stop.

.5 PROCEDURE SEQUENCE CONTROL

.51 Jumps

.511 Destinations allowed: . . . . labelled statements.

§ 161.

.512 Unconditional jump: . . . use 'sl' '
.513 Switch: . . . . s20' go to 's0' '
.514 Setting a switch: . . . . set 's20' to 'sl' '
.515 Switch on data: . . . . none.

.52 Conditional Procedures

.521 Designators
Condition: . . . . if'
Procedure: . . . . implied.

.522 Simple conditions

Expression	v	Expression:	no.
Expression	v	Variable: .	no.
Expression	v	Literal: . .	no.
Expression	v	Figurative:	always zero.
Expression	v	Condition: .	no.
Variable	v	Variable: .	no.
Variable	v	Literal: . .	no.
Variable	v	Figurative:	always zero.
Variable	v	Condition: .	no.

Conditional value: . . . . no.

.523 Conditional relations
Equal: . . . .
Greater than: . . . .
Less than: . . . . . } may be compared jointly against zero in each "if" statement.
Greater than or equal: . . . . no.
Less than or equal: . . no.

.524 Variable conditions: . . negative, zero, positive; can test for any or all 3 conditions.

.525 Compound conditionals: . . . . no.

.526 Alternative designator: . . . . alternative is implied if no tested condition is satisfied.

.527 Condition on alternative: . . . . execute next sequential statement.

.528 Typical examples: . . . if 'a'x'b'-'3'neg's29' zero' s37'pos's18' '
if 'n'zero'sl' '

.53 Sub-routines

.531 Designation
Single statement: . . . not used.
Set of statements (procedure)
First: . . . . enter 'name'a'b' ', where a and b are formal parameters.
Last: . . . . end' '

.532 Possible subroutines: . . procedures, composed of a set of statements.

.533 Use in-line in program: . yes; in this case cue is: ret's20'use's15' ', and s20 must be the switch: go to 's0' '

.534 Mechanism
Cue with parameters: . . . . call 'name'arg'a'arg'b' '
Number of parameters: . . . . maximum of 31.
Cue without parameter: . . . . call 'name' '
Formal return: . . . exit' '
Alternative return: . . none.

.535 Names
Parameter call by value: . . . . none.
Parameter call by name: . . . . yes.
Non-local names: . . . specified in non-executable statement preceding "enter"
Local names: . . . . all.
Preserved local variables: . . . . . all.

.536 Nesting limit: . . . . . none.

.537 Automatic recursion allowed: . . . . no; if Procedure A calls Procedure B, then B must be compiled before A.

.54 Function Definition by Procedure: . . . . . . none.

.55 Operand Definition by Procedure: . . . . . none.

.56 Loop Control

.561 Designation of loop
Single procedure: . . none.
First and last procedures: . . . . for 'i'step'j'until 'n'rpeat's 20' ' (branch to s 20 until i exceeds n; then execute next sequential statement).

.562 Control by count: . . . none.

.563 Control by step
Parameter: . . . . . integer variable.
Step: . . . . . . integer.
Criteria: . . . . . . exceeds.
Multiple parameters: . no.

.564 Control by condition
Example: . . . . . . i'+'1'; 'i' until 'm'neg'sl' (branch to sl until m is negative).
Combined with step: . . optional.

.565 Control by list: . . . . no.
.566 Nesting limit: . . . . . ?
.567 Jump out allowed: . . . yes.
.568 Control variable exit status: . . . . available always.

.6 EXTENSION OF THE LANGUAGE: . . . . . vocabulary and syntax can be altered and expanded; documentation on methods for doing so is not yet available.

.7 LIBRARY FACILITIES

.71 Identity: . . . . private procedure libraries.

.72 Kinds of Libraries:

.721 Fixed master: . . . . . no.
.722 Expandable master: . . no.
.723 Private: . . . . yes.

.73 Storage Form: . . . . . punched tape.

§ 161.

.74 Varieties of Contents: . . . . most commonly used procedures for each installation.

.75 Mechanism

.751 Insertion of new item: . . . . punch on tape and file in library.

.752 Language of new item: . . . . ACT III.

.753 Method of call: . . . . compile before source program.

.76 Types of Routine

.761 Open routines exist: . . no.

.762 Closed routines exist: . . . . yes.

.763 Open-closed is variable: . . . . no.

.8 TRANSLATOR CONTROL

.81 Transfer to Another Language . . . . . no, but all LGP-30 machine language operations are available within the ACT III language; e.g., "add" for machine addition.

.83 Translator Environment: . . . . implied.

.84 Target Computer Environment: . . . . implied.

.85 Program Documentation Control: . . . none.

.9 TARGET COMPUTER ALLOCATION CONTROL

.91 Choice of Storage Level: . . . . none.

.92 Address Allocation: . . none.

.93 Arrangement of Items in Words in Unpacked Form: . . . . standard.

.94 Assignment of Input-Output Devices: . . . none.

.95 Input-Output Areas: . . none.

MACHINE ORIENTED LANGUAGE: 24.0

§ 171.

.1 GENERAL

.11 Identity: . . . . Floating Point Interpretive System 1. Program H1-24. 0. "24. 0."

.12 Origin: . . . . Electronic Computer Department, Royal McBee Corporation.

.13 Reference: . . . . LGP-30 Subroutine Manual, pp. 27-33.

.14 Description

The Floating Point Interpretive System, "24. 0", simulates on an LGP-30 a slower pseudo computer that has a repertoire of 33 instructions, including floating point arithmetic and the common mathematical functions. The 24. 0 system was the first floating point interpreter developed for the LGP-30 and is still the most widely used.

All computations except address modification are done in the floating point mode. Each data item occupies one word of drum storage, with sign and 24 bits for the fixed point part and sign and 5 bits for the exponent. Execution of a routine by the 24. 0 system will generally take 10 to 20 times as long as execution of the corresponding machine language routine.

Coding format for the 24. 0 system is identical to LGP-30 machine coding: a single letter designates the operation code and a 4-digit decimal address specifies the operand location. An operand address of zero has a special meaning: when used with any of the 16 command letters it defines one of 16 distinct operations that do not require operand locations. No index registers are provided, but instructions are available to load, increment, test, and store the contents of a pseudo Address Accumulator. Entrances to and exits from the 24. 0 interpretive routine are easily accomplished, and the use of machine coding for address modification and counters will increase program execution speeds with little additional coding effort. The data input routine within the 24. 0 system converts decimal data to floating point binary form. The only output operation causes printing or punching of a single data item in decimal form, followed by a tab. It is necessary to exit from the interpretive routine to perform format control operations or print alphameric information.

.15 Publication Date: . . . . 1957.

.2 LANGUAGE FORMAT

.21 Diagram: . . . . refer to LGP-30 Coding Sheet, 352:132.

.22 Legend

Program Input Codes: . specify the functions to be performed by the Program Input Routine in loading the program.
Location: . . . . specifies the drum storage address of the instruction or constant.
Instruction: . . . . . . specifies operation code letter and 4-digit decimal operand address, or a constant in hexadecimal form.
Contents of Address: } used for program documentation.
Notes: . . . . }

NOTE: Only the contents of the Program Input Code and Instruction columns are punched on the program tape and entered into the computer; the other columns are for coding sheet documentation only.

.23 Corrections: . . . . . . no special provisions; generally handled by "patching" techniques or by substitution.

.24 Special Conventions

.241 Compound addresses: . none.
.242 Multi-addresses: . . . none.
.243 Literals: . . . . only for incrementing and testing the Address Accumulator.
.244 Special coded addresses: . . . . . . addresses of O cause execution of unique operations (see paragraph .83).

.3 LABELS: . . . . none; all operands are identified by their absolute addresses in 4-digit decimal form.

.4 DATA

.41 Constants

.411 Maximum size constants
Integer: . . . . not used.
Fixed numeric: . . . . not used.
Floating numeric
Fixed point part: . . sign and 24 bits.
Exponent: . . . . . . sign and 5 bits.
Alphabetic: . . . . . . none.
Alphameric: . . . . . none.

NOTE: Floating numeric constants must be punched on the program tape in hexadecimal form.

§ 171.

.412 Maximum size literals
Integer
Decimal: . . . . . . 4, 096; usable only for incrementing or testing the Address Accumulator.
Fixed numeric: . . . . none.
Floating numeric: . . none.
Alphabetic: . . . . . . none.
Alphameric: . . . . . none.

.42 Working Areas

.421 Data layout: . . . . . . absolute addresses used.
.422 Data type: . . . . always floating numeric.

.43 Input-Output Areas

.431 Data layout: . . . . . . standard formats.
.432 Data type: . . . . always floating numeric, with input and output in decimal form.

.5 PROCEDURES

.51 Direct Operation Codes

.511 Mnemonic: . . . . not used.

.512 Absolute
Existence: . . . . . . compulsory.
Number: . . . . 33.
Example: . . . . B is "bring contents of addressed storage location into Accumulator".
Comment: . . . . . . see .83 for complete instruction list.

.52 Macro-Codes: . . . . . none.

.53 Interludes: . . . . none.

.54 Translator Control: . . none; execution is interpretive.

.6 SPECIAL ROUTINES AVAILABLE: . . . . . none; but floating point arithmetic, common functions, and special input-output routines are included in the interpretive system.

.7 LIBRARY FACILITIES: none.

.8 MACRO AND PSEUDO TABLES

.81 Macros: . . . . none.

.82 Pseudos: . . . . none.

.83 Others (See below)

Code	Address	Operation	Time, m.sec.
A	Y	(A) + (Y) ⟶ A	400
A	O	Arctangent (A) ⟶ A	450
B	Y	(Y) ⟶ A	233
B	O	Make (A) positive	150
C	Y	(A) ⟶ Y; O ⟶ A	233
C	O	Cosine (A) ⟶ A	517
D	Y	(A) ÷ (Y) ⟶ A	283
D	P	(A) ÷ 2^P ⟶ A	183
E	Y	(Y) ⟶ AA	150
E	O	Exit from interpretive routine	117
H	Y	(A) ⟶ Y	200
H	O	$e^{(A)}$ ⟶ A	450
I	Y	(AA) + Y ⟶ AA	150
I	O	Input floating point data	1, 500 per item
M	Y	(M) x (Y) ⟶ A	266
M	P	(A) x 2^P ⟶ A	150
N	Y	(M) x (Y) + (A) ⟶ A	566
N	O	ln (A) ⟶ A	500
P	Y	(Y) ⟶ M	217
P	O	Print (A)	1, 850
R	Y	Address of this instruction + 2 ⟶ Y	166
R	O	$\sqrt{(A)}$ ⟶ A	500

§ 171.

.83 Others (Contd.)

Code	Address	Operation	Time, m.sec.
S	Y	(A) - (Y) $\rightarrow$ A	417
S	O	Sine (A) $\rightarrow$ A	550
T	Y	Branch to Y if (A) is negative	133
-T	Y	Branch to Y if (A) is negative and/or if Transfer Control switch is depressed	133
T	O	Make (A) negative	150
U	Y	Branch unconditionally to Y	117
U	O	(A) $\rightarrow$ M and (M) $\rightarrow$ A	200
Y	Y	(AA) $\rightarrow$ Y	150
Y	O	Change sign of (A)	150
Z	Y	Skip next instruction if (AA) - Y = 0	133
Z	O	Stop unless Break Point switch 16 is depressed	117

where A is the Floating Point Accumulator (simulated).
AA is the Address Accumulator (simulated).
M is the Multiplier Register (simulated).
P is a literal between 0000 and 0009.
Y is a 4-digit address (entered in decimal form).
( ) denotes contents of a register or storage location.

MACHINE ORIENTED LANGUAGE: 24.2

§ 172.

.1 GENERAL

.11 Identity: . . . . Floating Point Interpretive System 3.
Program H1-24.2.
"24.2".

.12 Origin: . . . . Electronic Computer Department, Royal McBee Corporation.

.13 Reference: . . . . Publication SC 0007 R1.

.14 Description

Like the "24.0" system described in section 171, Floating Point Interpretive System 3 (Program "24.2") simulates on an LGP-30 a slower pseudo computer with floating point arithmetic and all the common mathematical functions. The instruction and address structures of the two systems are very similar, though not directly compatible. The 24.2 system has four major advantages over the earlier 24.0 system:

(1) All data is stored in two-word floating point form; a wide range of data values can be represented with a precision of over nine decimal digits.

(2) Eight index registers are simulated for convenience in coding address modification and loop operations.

(3) The interpretive routine can be protected from destruction by improper instructions in the user's program by manually disabling the write heads on 40 of the 64 tracks.

(4) The 24.2 system includes integrated routines for alphameric output, tracing, and selective storage dumps in decimal or hexadecimal format.

On the other hand:

(1) Execution speeds of routines coded in the 24.2 language are even slower than in the 24.0 system.

(2) The full 24.2 interpretive package requires 42 of the 64 storage tracks, versus 26 tracks for the 24.0 system. Since two locations are used for each data item, the length of the user's program can be severely limited.

The eight simulated index registers are unusual in that each consists of four parts: a "counter", an "address", an "incrementer", and a "decrement" that is always -1. The counter, address, and increment parts must be set by separate instructions before a loop is executed. The address part is added to the operand address of every indexed instruction. When the "loop test" command is given, the increment is added to the address part; the counter is decremented by 1; and, if the counter is still greater than zero, a branch to a specified location is executed. While loop control is straight-forward, other address arithmetic operations are difficult or impossible to accomplish within the 24.2 system.

All input and output is in decimal form, but the fixed point part is an eight-digit integer instead of the more conventional normalized fraction. Conversions to and from the floating binary internal format are accomplished automatically. Output may be punched in a "compatible" format suitable for direct re-entry.

.2 LANGUAGE FORMAT

.21 Diagram: . . . . refer to LGP-30 Coding Sheet, 352:131.

.22 Legend:

Program Input Codes: . specify the functions to be performed by the Program Input Routine in loading the program.
Location: . . . . specifies the drum storage address of the instruction or constant.
Instruction: . . . . . . specifies index register number, operation code letter, and 4-digit decimal operand address; or a constant in hexadecimal form.
Contents of Address: . } used for program documentation.
Notes: . . . . }

NOTE: Only the contents of the Program Input Code and Instruction columns are punched on the program tape and entered into the computer; the other columns are for coding sheet documentation only.

.23 Corrections: . . . . . . no special provisions; generally handled by "patching" techniques or by substitution.

.24 Special Conventions

.241 Compound addresses: . none.
.242 Multi-addresses: . . . none.
.243 Literals: . . . . only for setting index registers.
.244 Special coded addresses: . . . . . . addresses of O cause execution of unique operations (see paragraph .83)

§ 172.

.3 LABELS: . . . . none; all operands are identified by their absolute addresses in 4-digit decimal form.

.4 DATA

.41 Constants

.411 Maximum size constants
- Integer: . . . . not used.
- Fixed numeric: . . . . not used.
- Floating numeric
  - Fixed point part: . . sign and 30 bits (1 word).
  - Exponent: . . . . . . sign and 29 bits (1 word).
- Alphameric: . . . . . 4 characters per word, for output only.
- Alphabetic: . . . . . . same as alphameric.

.412 Maximum size literals
- Integer
  - Decimal: . . . . . . 4, 096; usable only for setting index registers.
- Fixed numeric: . . . . none.
- Floating numeric: . . none.
- Alphabetic: . . . . . . none.
- Alphameric: . . . . . none.

.42 Working Areas

.421 Data layout: . . . . . . absolute addresses used.
.422 Data type: . . . . always floating numeric.

.43 Input-Output Areas

.431 Data layout: . . . . . . standard formats.
.432 Data type: . . . . always floating numeric, with input and output in decimal form.

.5 PROCEDURES

.51 Direct Operation Codes

.511 Mnemonic: . . . . not used.

.512 Absolute
- Existence: . . . . . . compulsory.
- Number: . . . . 40.
- Example: . . . . B is "bring contents of addressed storage location into Accumulator."
- Comment: . . . . . . only 16 different operation code letters are available, so index register and operand address portions are used to help specify exact operation. See .83 for complete instruction list.

.52 Macro-Codes: . . . . . none.

.53 Interludes: . . . . none.

.54 Translator Control: . . none; execution is interpretive.

.6 SPECIAL ROUTINES AVAILABLE: . . . . . none; but floating point arithmetic, common functions, input-output routines, alphameric output, trace, and dump routines are all included in the interpretive system.

.7 LIBRARY FACILITIES: none.

.8 MACRO AND PSEUDO TABLES

.81 Macros: . . . . none.

.82 Pseudos: . . . . none.

.83 Others (See below)

Index	Code	Address	Operation	Time, m.sec.
X	A	Y	(A) + (Y) ⟶ A	525
O	A	O	Arctangent (A) ⟶ A	910
X	B	Y	(Y) ⟶ A	410
O	B	O	Make (A) positive	115
O	C	Y	Convert (Y) to floating point and store in A	1, 300
X	C	Y	Set Counter in X to value Y	395
O	C	O	Cosine (A) ⟶ A	675
X	D	Y	(A) ÷ (Y) ⟶ A	465
O	D	O	Execute typewriter tab	700
O	E	Y	$(A)^{(Y)}$ ⟶ A (exponentiation)	1, 700
X	E	Y	Set Address in X to value Y	240
O	E	O	Exit from interpretive routine	170
X	H	Y	(A) ⟶ Y	310
O	H	O	$e^{(A)}$ ⟶ A	860
O	H	0010	$10^{(A)}$ ⟶ A	860

§ 172.

.83 Others (Contd.)

Index	Code	Address	Operation	Time, m.sec.
O	I	Y	Input floating point data; store beginning at Y	1,500 per item
O	I	O	Input floating point data; store in locations specified on tape	1,500 per item
X	I	Y	Set Incrementer in X to value Y	240
X	M	Y	(A) x (Y) $\longrightarrow$ A	410
O	M	O	Execute typewriter carriage return	800
X	N	Y	-(Y) $\longrightarrow$ A	410
O	N	O	ln (A) $\longrightarrow$ A	890
O	N	0010	log (A) $\longrightarrow$ A	890
X	P	Y	Print (Y)	2,425
O	P	O	Print (A)	2,275
80X	P	Y	Print (Y) in compatible format (for direct re-entry)	2,450
80X	P	O	Print (A) in compatible format	2,300
X	R	Y	(Y) ÷ (A) $\longrightarrow$ A	545
O	R	O	$\sqrt{(A)}$ $\longrightarrow$ A	1,500
X	S	Y	(A) - (Y) $\longrightarrow$ A	525
O	S	O	Sine (A) $\longrightarrow$ A	710
X	T	Y	Branch to Y if (A) is negative	190
O	T	O	Make (A) negative	195
X	U	Y	Branch unconditionally to Y; store location of this instruction in X	195
O	U	O	Interpret contents of following locations as alphameric output codes (N char)	185 + 115N
X	Y	Y	Store (X) in Y	280
O	Y	O	Change sign of (A)	210
O	Z	O	Stop unless Break Point switch 4 is depressed	137
X	Z	Y	Loop test: increase Address in X by Incrementer in X; decrement Counter in X by 1; branch to Y if (Counter) is greater than O.	405
O	Z	Y	Print (Y) as a fixed point number	2,175

where A is the floating point Accumulator (simulated).
X is the number of one of 8 simulated index registers (or X = O for no indexing).
Y is a 4-digit address or literal (entered in decimal form).
() denotes contents of a register or storage location.

NOTE: Indexing adds 50 to 90 milliseconds to execution times shown above.

MACHINE ORIENTED LANGUAGE: DICTATOR

§ 173.

.1 GENERAL

.11 Identity: . . . . DICTATOR. Program H1-124.

.12 Origin: . . . . Charles W. Laudeman, Dodco, Inc., Blawenburg, N. J.

.13 Reference: . . . . DICTATOR; write-up for POOL program H1-124.

.14 Description

The DICTATOR system was developed to parallel the popular Bell Floating-Decimal Interpretive System for the IBM 650 (IBM Publication C28-4024). There is no direct language compatibility with the Bell system because numerous changes were made to take advantage of LGP-30 hardware features, but DICTATOR can be quickly learned by anyone familiar with the Bell system for the 650.

DICTATOR simulates on the LGP-30 a pseudo computer with a three-address instruction format, floating point arithmetic, and the common mathematical functions. Each instruction consists of a numerical operation code followed by one, two, or three 4-digit decimal addresses. The three-address instructions are 13 digits long and must be divided into two words for input to the LGP-30; internally, each instruction is "packed" into a single storage location. There are no index registers, but there is a useful group of instructions that set any one of the three addresses of an instruction to a literal value or increment it by a literal value. Four loop counters are provided, and there are instructions for setting and testing their contents. Useful block transfer and table look-up instructions are included.

DICTATOR makes 1,982 drum storage locations available to the user. Only 998 of these locations may be used for data, and each data item requires two locations. All data is stored in floating point form. The fixed point part and exponent each occupy one word location of sign and 30 bits. Input and output are in decimal form, with 8 digits for the fixed point part and 2 for the exponent. Radix conversions are performed automatically when input-output instructions are interpreted. Alphameric output is limited to one character per DICTATOR instruction.

.15 Publication Date: . . . . October 6, 1959.

.2 LANGUAGE FORMAT

.21 Diagram: . . . . no formal coding sheet; recommended format is three columns, labelled "Location", "Contents", "Notes".

.22 Legend

Location: . . . . decimal address of the instruction or constant; not punched on program tape.

Contents: . . . . 1) an instruction consisting of a 1- or 2-digit operation code and 1, 2, or 3 four-digit decimal addresses; or
2) a floating point constant in decimal form; or
3) an "external command" to the DICTATOR routine (not stored).

Notes: . . . . comments, for coding sheet documentation only.

.23 Corrections: . . . . . . no special provisions.

.24 Special Conventions

.241 Compound addresses: . none.

.242 Multi-addresses: . . . instructions may require 1, 2, or 3 addresses; see .83.

.243 Literals: . . . . only for setting loop counters and incrementing operand addresses.

.244 Special coded addresses: . . . . . . address of O refers to the floating point Accumulator.

.245 Other
Valid instruction addresses: . . . . . 0002 through 1983.
Valid data addresses: even numbers from 0002 through 0998.

.3 LABELS: . . . . none; all operands are identified by their addresses in 4-digit decimal form; paragraph .245 specifies limitations.

§ 173.

.4 DATA

.41 Constants

.411 Maximum size constants
- Integer: . . . . not used.
- Fixed numeric: . . . . not used.
- Floating numeric
  - Binary: . . . . sign and 8 decimal digits for fixed point part; 2 decimal digits for exponent (excess 50 notation).
- Alphabetic: . . . . . . none.
- Alphameric: . . . . . none.

.412 Maximum size literals
- Integer
  - Decimal: . . . . . . 1,983; usable only for address modification and setting loop counters.
- Fixed numeric: . . . . none.
- Floating numeric: . . none.
- Alphabetic: . . . . . . none.
- Alphameric: . . . . . none.

.42 Working Areas

.421 Data layout: . . . . . . absolute addresses used.
.422 Data type: . . . . always floating numeric.

.43 Input-Output Areas

.431 Data layout: . . . . . . standard formats.
.432 Data type: . . . . always floating numeric, with input and output in decimal form.

.5 PROCEDURES

.51 Direct Operation Codes

.511 Mnemonic: . . . . not used.
.512 Absolute
- Existence: . . . . . . compulsory.
- Number: . . . . 32.
- Example: . . . . 1 means "add".
- Comment: . . . . . . see .83 for complete instruction list.

.52 Macro-Codes: . . . . . none.

.53 Interludes: . . . . none.

.6 SPECIAL ROUTINES AVAILABLE: . . . . . none; but floating point arithmetic, common functions, and special input-output routines are included in the interpretive system.

.7 LIBRARY FACILITIES: none.

.8 MACRO AND PSEUDO TABLES

.81 Macros: . . . . none.

.82 Pseudos: . . . . none.

.83 Others (See below)

Code	Address	Operation	Time, m.sec.
1	A'BC'	$(A)+(B) \rightarrow C$	450
2	A'BC'	$(A)-(B) \rightarrow C$	455
3	A'BC'	$(A) \times (B) \rightarrow C$	415
4	A'BC'	$(A) \div (B) \rightarrow C$	415
5	A'BC'	$(A) \times (B) \times (-1) \rightarrow C$	430
6	A'BC'	Move A/2 data items from block starting at B to block starting at C	150 + 85A
7	A'BC'	Perform table look-up for argument at A, independent table starting at B, and dependent table starting at C	1,000
11'	BC'	$e^{(B)} \rightarrow C$	670
12'	BC'	$\ln (B) \rightarrow C$	720
13'	BC'	$\sqrt{(B)} \rightarrow C$	680
14'	BC'	Sine $(B) \rightarrow C$	740
15'	BC'	Cosine $(B) \rightarrow C$	740
16'	BC'	Arctangent $(B) \rightarrow C$	720
17'	BC'	Punch all data between locations B and C with stop codes	2,100 per item
18'	BC'	Print all data between locations B and C with no stop codes	2,100 per item
19'	BC'	Same as code 18, but ignored if Transfer Control switch is depressed	2,100 per item
1'	BC'	Branch unconditionally to C	75
2'	BC'	Test sign of Accumulator; branch to B if positive or to C if negative	135
3'	BC'	If loop counter B (0000 to 0003) is positive, decrement it by 1 and transfer to C; otherwise execute next sequential instruction	175

§ 173.

.83 Others (Contd.)

Code	Address	Operation	Time, m.sec.
4'	BC'	Set C address of instruction at B to C	285
5'	BC'	Set B address of instruction at B to C	205
6'	BC'	Set A address of instruction at B to C	190
7'	BC'	Increment C address of instruction at B by C	285
8'	BC'	Increment B address of instruction at B by C	205
9'	BC'	Increment A address of instruction at B by C	190
8000	C'	Set loop counter 0 to value C	150
8001	C'	Set loop counter 1 to value C	150
8002	C'	Set loop counter 2 to value C	150
8003	C'	Set loop counter 3 to value C	150
8007	C'	Input data into C, C + 2, etc.	2, 100 per item
8008	C'	Stop unless C = 0004, 0008, 0016 or 0032 and corresponding Break Point switch is depressed	105
8009	C'	Print one character defined by last two digits of C.	180

where A, B, and C are 4-digit decimal addresses or literals.
( ) denotes contents of a storage location.
' denotes the stop code punched after each input word.

NOTE: All arithmetic results stored in C are also retained in the Accumulator (address 0000).

PROGRAM TRANSLATOR: ACT III

§ 181.

.1 GENERAL

.11 Identity: . . . . ACT III.

.12 Description:

The ACT III translator can be run on the basic LGP-30 and can use the High Speed Reader/Punch if available. It is a one-pass compiler in the sense that the translator and source program tapes must be read into storage only once. At the end of the translation the object program is contained on the drum. It can be tested immediately and, if correct, a hexadecimal program tape can be punched.

A standard subroutine package must be loaded whenever an ACT III object program is executed. Implementation of all of the language facilities requires 32 tracks of standard subroutines, or half of the LGP-30's 4,096 drum storage locations. Subroutines for unused facilities may be omitted from the package. If total storage requirements for the object program, subroutine package, and data do not exceed 27 tracks, the object program can be executed and subsequent programs compiled without reloading the ACT III translator or the subroutine package. (This is an important feature in basic LGP-30 systems, since program loading via the Tape Typewriter takes about one minute per track.) In any case, the compiled object program cannot occupy more than 27 tracks. Important size limitations on the source program are listed in paragraph .23.

To facilitate testing and debugging, ACT III programs may be "trace-compiled." If the Transfer Control switch is depressed during execution of a trace-compiled routine, then the statement number, the address of the first object instruction, and the computed result will be typed for each source statement. Trace compilation adds two object program instructions per source statement and increases execution time.

.13 Originator: . . . . . . Henry J. Bowlden, Union Carbide Corp., and Roberta R. Smith, presently with Stanford U.

.14 Maintainer: . . . . . . Commercial Computer Division, General Precision, Inc.

.15 Availability: . . . . . . April, 1961.

.2 INPUT

.21 Language

.211 Name: . . . . ACT III

.212 Exemptions: . . . . . . none.

.22 Form

.221 Input media: . . . . . . punched tape or keyboard.
.222 Obligatory ordering: . . statements in coding sheet sequence.
.223 Obligatory grouping: . . none.

.23 Size Limitations

.231 Maximum number of source statements: . . limited by target computer storage availability.
.232 Maximum size source statements: . . . . . ?
.233 Maximum number of data items: . . . . 126 named variables.
.234 Others
Constants: . . . . . . 63.
Labelled statements: . 190.
Bracket nesting limit: . . . . 7.
Object program size: . . . . 1,728 locations.

.3 OUTPUT

.31 Object Program

.311 Language name: . . . . LGP-30 machine language.
.312 Language style: . . . . non-relocatable hexadecimal form with check sum.
.313 Output media: . . . . . punched tape.

.32 Conventions

.321 Standard inclusions: . . none.
.322 Compatible with: . . . . ACT III Subroutine Packages.

.33 Documentation

Subject	Provision
Source program: . . .	typewriter listing.*
Object program: . . .	typewriter listing (hexadecimal).*
Storage map:	typewriter (symbol table).
Restart point list: . .	none.
Language errors: . . .	type error code and stop.
Statement dictionary: .	typewriter.

*Listings are not produced on-line when High Speed Reader/Punch is used for input-output.

.4 TRANSLATING PROCEDURE

.41 Phases and Passes: . . . one-pass compiler; translator and source program are read only once.

§ 181.

.42 Optional Modes

.421 Translate: . . . . yes.
.422 Translate and run: . . . yes.
.423 Check only: . . . . no.
.424 Patching: . . . . no; must re-compile.
.425 Up-dating: . . . . no.

.43 Special Features

.431 Alter to check only: . . no.
.432 Fast unoptimized translate: . . . . no.
.433 Short translate on restricted program: . . . no.

.44 Bulk Translating: . . . yes; operation tables must be reloaded for each translation, but translator and subroutine package can be retained in storage.

.45 Program Diagnostics

.451 Tracers: . . . . programs may be "trace-compiled", in which case depression of Transfer Control switch during execution will cause printing of statement number, machine address of first instruction of statement, and result of statement.
.452 Snapshots: . . . . none.
.453 Dumps: . . . . none.

.46 Translator Library

.461 Identity: . . . . procedure libraries.
.462 User restriction: . . . private; no standard routines available.
.463 Form
Storage medium: . . . punched tape.
Organization: . . . . . . ACT III source language.
.464 Contents
Routines: . . . . closed procedures.
Functions: . . . . no.
Data descriptions: . . no.
.465 Librarianship
Insertion: . . . . punch on tape and file in library.
Amendment: . . . . . . correct the punched tape.
Call procedure: . . . compile before main source program.

.5 TRANSLATOR PERFORMANCE

.51 Object Program Space

.511 Fixed overhead

Name	Space	Comment
Subroutine Package:	1344 locations	basic service routines, floating point arith, input-output, float-unfloat, etc.
Functions:	704 locations	log, exp, sqrt, and trig.
Program Input Routine:	192 locations.	

NOTE: Unused routines may be removed from the package.

.512 Space required for each input-output file: . . . . controlled by coder.
.513 Approximate expansion of procedures: . . . 6 to 8 (* *).

.52 Translation Time

.521 Normal translating: . . . 0.25S minutes, where S is number of elementary source statements (* *).

.53 Optimizing Data: . . . . . none.

.54 Object Program Performance: . . . . . . execution times for ACT III object programs will range from just over times for unoptimized hand coding (if all arithmetic is integer mode) to just under times for the 24.0 Interpretive System (if floating point arithmetic is extensively used). Space requirements will average about 1.5 times those for hand coded programs (**).

.6 COMPUTER CONFIGURATIONS

.61 Translating Computer

.611 Minimum configuration: . . . . LGP-30 with Tape Typewriter.
.612 Larger configuration advantages: . . . . . High Speed Reader/Punch increases overall translation speeds.

.62 Target Computer

.621 Minimum configuration: . . . . LGP-30 with Tape Typewriter.
.622 Usable extra facilities: . . . . High Speed Reader/Punch.

.7 ERRORS, CHECKS AND ACTION

Error	Check or Interlock	Action
Missing entries:	none.	
Unsequenced entries:	none.	
Improper format:	checks	type error code & stop.
Target computer overflow:	check	type error code & stop.
Inconsistent program:	none.	
Symbol table full:	check	type error code & stop.
Statement too large:	check	type error code & stop.
Invalid subscript:	check	type error code & stop.
Invalid bracket count:	check	type error code & stop.

.8 ALTERNATIVE TRANSLATORS: . . . . none.

OPERATING ENVIRONMENT: GENERAL

§ 191.

.1 GENERAL

.11 Identity: . . . . LGP-30 Program Input Routine.
Program J1-10.4.
"PIR."

(Diagnostic routines are identified and described in paragraph .5.)

.12 Description

No integrated operating system is available for the LGP-30. The facilities covered in this section must be provided by individual utility routines, by the user's own coding, or by the operator at run time.

The most important LGP-30 utility routine is the Program Input Routine (PIR) which occupies the first 3 tracks on the drum during all normal system operations. The PIR performs the following functions:

(1) Loads decimal instructions from punched tape or keyboard and converts them into internal binary form.

(2) Loads hexadecimal instructions and data, or hexadecimal constants on a decimal instruction tape.

(3) Modifies decimal instruction addresses to permit routines to be loaded into any available storage area.

(4) Facilitates changes to instructions in storage.

(5) Transfers control to any specified storage location to begin program execution.

Functions of the PIR are controlled by 8-character control words, which may be manually typed or read directly from the input tapes. The PIR cannot handle data words in decimal form, so all constants must be converted to hexadecimal form before the program tape is punched.

.13 Availability: . . . . . . all routines described here are currently available.

.14 Originator: . . . . . . Electronic Computer Department, Royal McBee Corporation (unless otherwise indicated).

.15 Maintainer: . . . . Commercial Computer Division, General Precision, Inc.

.2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . . none.

.212 Independent programs: punched tape in hexadecimal or relocatable decimal form, loaded by Program Input Routine.

.213 Data: . . . . punched tape or keyboard; standard Data Input Subroutines are usually used to handle radix conversions and scaling.

.214 Master routines: . . . . Program Input Routine is loaded into the first 3 tracks by a manually loaded "bootstrap" routine.

.22 Library Subroutines: . . punched tapes, loaded by Program Input Routine.

.23 Loading Sequence: . . . manually controlled.

.3 HARDWARE ALLOCATION

.31 Storage

.311 Sequencing of program for movement between levels: . . . . not possible.

.312 Occupation of working storage: . . . . routines punched in relocatable decimal form can be loaded into any available storage area.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: . not possible.

.42 Multi-running: . . . . . not possible.

.43 Multi-sequencing: . . . not possible.

.44 Errors, Checks and Action

Error	Check or Interlock	Action
Loading input error:	optional check sum on hexadecimal tapes	print message & stop.
In-out error:	none.	
Storage overflow:	none	Program Input Routine will be destroyed.
Invalid instructions:	none	results are unpredictable.
Arithmetic overflow:	hardware check	stop.
Invalid operation:	all codes valid.	
Improper format:	none.	
Invalid address:	all addresses valid.	

§ 191.

.45 Restarts: . . . . as incorporated in user's program.

.5 PROGRAM DIAGNOSTICS

.51 Dynamic

.511 Tracing: . . . . Fixed Point Tracing Subroutine (Program K1-23.1, by J. Wilkinson, Univ. of Michigan) executes a routine and prints, for each instruction within specified address limits, the instruction, its location, and the contents of the instruction address and accumulator. Time required is about 3.8 seconds per instruction when printing and 0.7 seconds when not printing. The routine is a powerful but time-consuming debugging tool.

.512 Snapshots: . . . . none.

.52 Post Mortem: . . . . . Decimal Memory Printout (Program K2-21.0) prints or punches the contents of specified areas of drum storage in decimal form at about 60 words per minute.

Hexadecimal Punch (Program J4-13.2) punches the contents of specified storage areas in hexadecimal form and computes and punches a check sum. Speed is about 64 words per minute on the Tape Typewriter and 140 words per minute on the High Speed Punch. The hexadecimal tape can be read back into storage by the Program Input Routine,

.52 Post Mortem (Contd.)

which recomputes the check sum and stops if the comparison is invalid.

Search for Address (Program K3-26.2) searches drum tracks 00 through 62 and prints the addresses of all locations which contain a specified address in the operand address portion (bits 18-29). Each full search requires 2.75 minutes exclusive of printing.

.6 OPERATOR CONTROL: as incorporated in user's program.

.7. LOGGING: . . . . as incorporated in user's program.

.8 PERFORMANCE

.81 System Requirements: . . . . all routines described here are usable on any LGP-30 system.

.82 System Overhead

.821 Loading time (for Program Input Routine): . . . . 4 minutes using Tape Typewriter.

.822 Reloading frequency: . . Program Input Routine can be maintained in working storage.

.83 Program Space Available: . . . . 3,904 word locations (Program Input Routine occupies the first 192 of the 4,096 locations).

.84 Program Loading Time

Tape Typewriter: . . . I seconds.
High Speed Reader: . . . 0.15I seconds.
where I is number of instructions loaded.

OPERATING ENVIRONMENT: 24.0

§ 192.

.1 GENERAL

.11 Identity: . . . . Floating Point Interpretive System 1.
Program H1-24.0.
"24.0".

.12 Description

This routine interprets and executes programs written in the language of the 24.0 Floating Point Interpretive System. It requires only the basic LGP-30 Computer and Tape Typewriter, and can utilize the High Speed Reader or Reader/Punch if available. When the entire interpretive system is loaded, 2,386 storage locations remain available for the user's instructions and data.

The standard LGP-30 Program Input Routine is used to load the user's instructions and convert their addresses from decimal to binary form. Program tapes can be punched in relocatable decimal form and assigned to any available area of storage at load time.

Instructions in the 24.0 language are executed at the rate of approximately five per second. Average execution times for all of the instructions are listed in paragraph 171.83, and standardized performance measures are tabulated in paragraph .85 of this section.

Most of the standard LGP-30 diagnostic routines can be used under manual control on programs coded in the 24.0 language, but they cannot be directly incorporated into the system.

.13 Availability: . . . . . . all facilities were made available in 1957.

.14 Originator: . . . . . . Electronic Computer Department, Royal McBee Corporation.

.15 Maintainer: . . . . . . Commercial Computer Division, General Precision, Inc.

.16 First Use: . . . . 1957.

.2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . . none.
.212 Independent programs: from punched tape or keyboard, in 24.0 language.
.213 Data: . . . . via keyboard or punched tape in decimal form; listing is obtained unless High Speed Reader is used.
.214 Master routines: . . . . punched tape.

.22 Library Subroutines: . . punched tape.

.23 Loading Sequence: . . . manually controlled.

.24 Interpreter Input

.241 Language
Name: . . . . Floating Point Interpretive System 1, 24.0.
Exemptions: . . . . . none.
.242 Form: . . . . punched tape or keyboard; hexadecimal or relocatable decimal form.

.3 HARDWARE ALLOCATION

.31 Storage

.311 Sequencing of program for movement between levels: . . . . not possible.
.312 Occupation of working storage: . . . . routines punched in relocatable decimal form can be loaded into any available storage area.

.32 Input-Output Units: . . . selected by manual switches; same input-output instructions serve all devices.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: none.

.42 Multi-running: . . . . . none.

.43 Multi-sequencing: . . . none.

.44 Errors, Checks and Action

Error	Check or Interlock	Action
Loading input error:	none.	
In-out error:	none.	
Storage overflow:	none	Program Input Routine will be destroyed.
Invalid instructions:	none	results are unpredictable.
Arithmetic overflow:	hardware check	stop.
Underflow:	check	replaced by zero.
Invalid operation:	all codes valid.	
Improper format:	none.	
Invalid address:	all addresses valid.	
Reference to forbidden area:	none.	interpretive routine may be destroyed.

§ 192.

.45 Restarts: . . . . not possible.

.5 PROGRAM DIAGNOSTICS

.51 Dynamic

.511 Tracing: . . . . Trace and Memory Print 5 (Program K1-23.4) prints instruction, its location, instruction operand, and Accumulator contents after each source language instruction is executed.

.512 Snapshots: . . . . none.

.52 Post Mortem: . . . . . . Decimal Memory Printout (Program K2-21.0) prints the contents of specified areas of drum storage in decimal form.

.6 OPERATOR CONTROL: . . . . none within the 24.0 system; must exit from 24.0 and insert own machine language coding.

.7 LOGGING: . . . . same as .6; typed record of all input and output operations is produced unless High Speed Reader/Punch is used.

.8 PERFORMANCE

.81 System Requirements

.811 Minimum configuration: LGP-30 with Tape Typewriter.

.812 Usable extra facilities: High Speed Reader or Reader/Punch.

.813 Reserved equipment: . . 1,710 drum storage locations for full interpretive routine, Program Input Routine, and temporary storage; facilities not required may be omitted.

.82 System Overhead

.821 Loading time
- Tape Typewriter: . . . 23 minutes.
- High Speed Reader: . . 4 minutes.

.822 Reloading frequency: . . can be maintained in working storage.

.83 Program Space Available: . . . . I + D must be less than 2,387, where I is number of instructions and D is number of data items.

.84 Program Loading Time

- Tape Typewriter: . . . . I + D seconds.
- High Speed Reader: . . . 0.15 (I + D) seconds.

.85 Program Performance in μ secs

.851 Conditions: . . . . none.

.852 For random addresses
- $c = a + b$: . . . . 866,000.
- $b = a + b$: . . . . 866,000.
- Sum N items: . . . . . 400,000N.
- $c = ab$: . . . . 716,000.
- $c = a/b$: . . . . 749,000.
- $b = \sqrt{a}$: . . . . 933,000.
- $b = \log a$: . . . . 933,000.
- $b = e^a$: . . . . 883,000.
- $b = \sin a$: . . . . 983,000.

.853 For arrays of data
- $c_i = a_i + b_j$: . . . . . 2,200,000.
- $c = c + a_i b_j$: 1,820,000.

.854 Branch based on comparison: . . . . 2,200,000.

.855 Moving, per word
- Using loop: . . . . 1,300,000.
- Using straight-line coding: . . . . . 430,000.

.856 Data input, per item
- Tape Typewriter: . . . 1,500,000.
- High Speed Reader: . . 700,000.

.857 Data output, per item
- Tape Typewriter: . . . 1,850,000.
- High Speed Punch: . . . not usable.

OPERATING ENVIRONMENT: 24.2

§ 193.

.1 GENERAL

.11 Identity: . . . . Floating Point Interpretive System 3. Program H1-24.2 "24.2".

.12 Description

This routine interprets and executes programs written in the language of the 24.2 Floating Point Interpretive System. It requires only the basic LGP-30 Computer and Tape Typewriter, and can utilize the High Speed Reader or Reader/Punch if available. When the entire interpretive system is loaded, only 1,408 of the LGP-30's 4,096 drum storage locations remain available for the user's instructions and data.

The standard LGP-30 Program Input Routine loads the user's instructions and converts their addresses from decimal to binary form. Several useful diagnostic routines are included in the 24.2 system, but they cannot be directly incorporated into the user's program; their use is controlled by the operator.

Instructions in the 24.0 language are executed at the rate of approximately three per second. Average execution times for all the instructions are listed in paragraph 172.83, and standardized performance measures are tabulated in paragraph .85 of this section.

.13 Availability: . . . . all facilities were made available in 1959.

.14 Originator: . . . . Electronic Computer Department, Royal McBee Corporation.

.15 Maintainer: . . . . Commercial Computer Division, General Precision, Inc.

.16 First Use: . . . . 1959.

.2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . . . none.
.212 Independent programs: . from punched tape or keyboard, in 24.2 language.
.213 Data: . . . . via keyboard or punched tape, in decimal form; listing is obtained unless High Speed Reader is used.
.214 Master routines: . . . . punched tape.

.22 Library Subroutines: . . punched tape.

.23 Loading Sequence: . . . manually controlled.

.24 Interpreter Input

.241 Language
Name: . . . . Floating Point Interpretive System 3, 24.2.
Exemptions: . . . . . none.
.242 Form: . . . . punched tape or keyboard; hexadecimal or relocatable decimal form.

.3 HARDWARE ALLOCATION

.31 Storage

.311 Sequencing of program for movement between levels: . . . . . not possible.
.312 Occupation of working storage: . . . . . routines punched in relocatable decimal form can be loaded into any available storage area.

.32 Input-Output Units: . . selected by manual switches; same input-output instructions serve all devices.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: . none.

.42 Multi-running: . . . . . none.

.43 Multi-sequencing: . . . none.

.44 Errors, Checks and Actions

Error	Check or Interlock	Action
Loading input error:	none.	
In-out error:	none.	
Storage overflow:	none.	Program Input Routine will be destroyed.
Invalid instructions:	none	results are unpredictable.
Arithmetic overflow:	hardware check	stop.
Underflow:	check	replaced by zero.
Invalid operation:	all codes valid.	
Improper format:	none.	
Reference to forbidden area:	manual disabling of write heads	write instructions are ignored.

.45 Restarts: . . . . not possible.

§ 193.

.5 PROGRAM DIAGNOSTICS: . . . . all routines listed below are an integral part of the 24.2 system but cannot be integrated into the user's program; i.e., their use is controlled by the operator.

.51 Dynamic

.511 Tracing: . . . . Trace and Memory Print 6 (Program K1-23.5) prints instruction, its location, and Accumulator contents after each source language instruction is executed.

.512 Snapshots: . . . . none.

.52 Post Mortem: . . . . . . Decimal Memory Print 2 (Program K2-21.1) prints the contents of specified storage areas in decimal form.
Hexadecimal Output 5 (Program J4-13.4) punches contents of consecutive storage locations and computes and punches a check sum.
Memory Search for Address (Program K3-26.3) searches tracks 40 through 61 and prints each location whose address portion contains a specified address.

.6 OPERATOR CONTROL

.61 Signals to Operator

.611 Decision required by operator: . . . . type message.
.612 Action required by operator: . . . . type message.
.613 Reporting progress of run: . . . . type message.

.62 Operator's Decisions: . Transfer Control switch or keyboard data entry.

.7 LOGGING: . . . . typed record of all input and output operations is produced unless High Speed Reader/Punch is used.

.8 PERFORMANCE

.81 System Requirements

.811 Minimum configuration: . . . . LGP-30 with Tape Typewriter.
.812 Usable extra facilities: . . . . High Speed Reader or Reader/Punch.
.813 Reserved equipment: . . 2,688 drum storage locations for full interpretive routine, Program Input Routine, and temporary storage; facilities not required may be omitted.

.82 System Overhead

.821 Loading time
Tape Typewriter: . . . 36 minutes.
High Speed Reader: . . 6 minutes.
.822 Reloading frequency: . . can be maintained in working storage and protected from destruction by user's programs

.83 Program Space Available: . . . . I + 2D must be less than 1,409, where I is number of instructions and D is number of data items.

.84 Program Loading Time
Tape Typewriter: . . . I + 2D seconds.
High Speed Reader: . . 0.15 (I + 2D) seconds.

.85 Program Performance in μ secs

.851 Conditions: . . . . none
.852 For random addresses
$c = a + b$: . . . . 1,245,000.
$b = a + b$: . . . . 1,245,000.
Sum N items: . . . . . 525,000.
$c = ab$: . . . . 1,130,000.
$c = a/b$: . . . . 1,185,000.
$b = \sqrt{a}$: . . . . 2,220,000.
$b = \log a$: . . . . 1,610,000.
$b = e^a$: . . . . 1,580,000.
$b = \sin a$: . . . . 1,430,000.
.853 For arrays of data
$c_i = a_i + b_j$: . . . . . . 2,210,000.
$c = c + a_i b_j$: . . . . . . 2,570,000.
.854 Branch based on comparison: . . . . . problem as defined is not practical in 24.2 system.
.855 Moving, per data item
Using loop: . . . . . . 1,260,000.
Using straight-line coding: . . . . 720,000.
.856 Data input, per item
Tape Typewriter: . . 2,000,000.
High Speed Reader: . . 1,000,000(* *).
.857 Data output, per item
Tape Typewriter: . . 2,400,000.
High Speed Punch: . . not usable.

OPERATING ENVIRONMENT: DICTATOR

§ 194.

.1 GENERAL

.11 Identity: . . . . DICTATOR.

.12 Description

This routine interprets and executes programs written in the DICTATOR language, which is similar to the Bell Floating Decimal Interpretive System for the IBM 650. Only the basic LGP-30 Computer and Tape Typewriter are required. The interpretive routine leaves 1,982 locations available for the user's instructions and data. If the DICTATOR Instruction Print Routine is used as a diagnostic, the number of available locations is decreased by 284.

Loading of the interpretive routine is initiated by a manual "bootstrap" process. The standard LGP-30 Program Input Routine is not used by the DICTATOR system. Instead, a series of "external commands," entered from the keyboard or punched tape, initiate program loading, data loading, transfers to specified locations, or storage dumps. The "trace transfer" command causes the contents of the pseudo floating point accumulator to be printed after each DICTATOR instruction is interpreted.

Instructions in the DICTATOR language are executed at the rate of approximately three to four per second. Because of the greater power of the multi-address instructions, performance of DICTATOR-coded routines will usually surpass routines coded in the one-address Floating Point Interpretive Systems, 24.0 and 24.2. Average execution times for all the instructions are listed in paragraph 173.83, and standardized performance measures are tabulated in paragraph .85 of this section.

.13 Availability: . . . . . . all facilities were made available in 1959.

.14 Originator: . . . . . . Charles W. Laudeman, Dodco, Inc., Blawenburg, N.J.

.15 Maintainer: . . . . . . .as above.

.16 First Use: . . . . 1959.

2 PROGRAM LOADING

.21 Source of Programs

.211 Programs from on-line libraries: . . . . none.

.212 Independent programs: . from punched tape or keyboard, in DICTATOR language.

.213 Data: . . . . via keyboard or punched tape, in decimal form; listing is obtained unless High Speed Reader is used.

.214 Master routines: . . . . punched tape.

.22 Library Subroutines: . . punched tape.

.23 Loading Sequence: . . . manually controlled.

.24 Interpreter Input

.241 Language
Name: . . . . DICTATOR
Exemptions: . . . . . none.

.242 Form: . . . . punched tape or keyboard.

.3 HARDWARE ALLOCATION

.31 Storage: . . . . allocation is fixed by coder; routines are non-relocatable.

.32 Input-Output Units: . . . selected by manual switches at run time.

.4 RUNNING SUPERVISION

.41 Simultaneous Working: none.

.42 Multi-running: . . . . . . none.

.43 Multi-sequencing: . . . none.

.44 Errors, Checks and Action

Error	Check or Interlock	Action
Loading input error:	none.	
In-out error:	none.	
Storage overflow:	check	stop; print error code
Invalid instructions:	check	stop; print error code.
Arithmetic overflow:	check	stop; print error code.
Underflow:	none.	
Improper data format:	check	stop; print error code.
Invalid address:	check	stop; print error code.
Reference to forbidden area:	check	stop; print error code.

.45 Restarts: . . . . own coding.

.5 PROGRAM DIAGNOSTICS

.51 Dynamic

.511 Tracing: . . . . all DICTATOR-coded routines can be executed in the trace mode, with printout of accumulator contents after each instruction.

.512 Snapshots: . . . . . . none.

§ 194.

.52 Post Mortem: . . . . . DICTATOR Instruction Print Routine (DIP) prints and/or punches contents of specified storage areas in decimal instruction format; it occupies 284 of the 1,982 storage locations normally available for user's programs.

"Data dump" command prints and/or punches contents of consecutive locations in decimal data format.

.6 OPERATOR CONTROL

.61 Signals to Operator: . . . type message (1 character per instruction).

.62 Operator's Decisions: . . . . keyboard data entry.

.7 LOGGING: . . . . typed record of all input-output operations is produced unless High Speed Reader/Punch is used.

.8 PERFORMANCE

.81 System Requirements

.811 Minimum configuration: . . . . LGP-30 with Tape Typewriter.

.812 Usable extra facilities: . . . . High Speed Reader or Reader/Punch.

.813 Reserved equipment: . . 2,114 drum storage locations.

.82 System Overhead

.821 Loading time
Tape Typewriter: . . . 33 minutes.
High Speed Reader: . . 6 minutes.

.822 Reloading frequency: . . can be maintained in working storage and is protected from destruction by user's programs.

.83 Program Space Available: . . . . D must be less than 500, and I + 2D must be less than 1,983, where I is number of instructions and D is number of data items.

.84 Program Loading Time (* *)

Tape Typewriter: . . . I + 2D seconds.
High Speed Reader: . . . 0.15 (I + 2D) seconds.

.85 Program Performance in μsecs

.851 Conditions: . . . . none.

.852 For random addresses
$c = a + b$: . . . . 450,000.
$b = a + b$: . . . . 450,000.
Sum N items: . . . . . 450,000.
$c = ab$: . . . . 415,000.
$c = a/b$: . . . . 415,000.
$b = a$: . . . . 680,000.
$b = \log a$: . . . . 720,000.
$b = e^a$: . . . . 720,000.
$b = \sin a$: . . . . 740,000.

.853 For arrays of data
$c_i = a_i + b_j$: . . . . . . 1,300,000.
$c = c + a_i b_j$: . . . . . . 1,440,000.

.854 Branch based on comparison: . . . . problem as defined is not practical in DICTATOR.

.855 Moving, N data items: . 150,000 + 170,000N.

.856 Data input, per item
Tape Typewriter: . . . 2,100,000.
High Speed Reader: . . 1,000,000 (* *).

.857 Data output, per item
Tape Typewriter: . . . 2,100,000.
High Speed Punch: . . . not usable.

NOTES ON SYSTEM PERFORMANCE

§ 201.

.1 GENERALIZED FILE PROCESSING

Because the LGP-30's output speed cannot exceed 20 characters per second, it was considered unsuitable for this type of data processing application. (Where the master file is small enough to be held in internal storage, the LGP-30 can be quite useful.)

.2 SORTING

Magnetic tape cannot be used with the LGP-30 system.

.3 MATRIX INVERSION

Both the standard problem estimate and the manufacturer's routine times are based on use of the 24.0 Floating Point Interpretive System, which is the most commonly used method of performing floating point arithmetic on the LGP-30. The difference in inversion times is due mainly to the fact that the estimated time is based on use of the interpretive mode exclusively; the manufacturer's routine exits from the interpretive system and uses machine coding for address modification and testing.

The 24.0 system provides a precision of slightly over seven decimal digits, whereas the standard problem specifications call for eight. Greater precision can be obtained by the use of a double-length interpretive system such as 24.2 at the expense of increased execution time and doubled data storage requirements.

.4 GENERALIZED MATHEMATICAL PROCESSING

Fixed point computations are coded in machine language, with operand addresses optimized wherever practical. Standard data input and data output routines are used to handle the radix conversions.

Floating point computations are coded and timed in the 24.0 Floating Point Interpretive System. Use of machine coding with subroutines for the floating point arithmetic operations would reduce execution times, but such routines have not been made available for the LGP-30 except as part of the ACT III compiler system.

Results are printed by the on-line Tape Typewriter in all cases. Data is read by the Tape Typewriter reader in Configuration IX and by the High Speed Reader in Configuration X.

.5 GENERALIZED STATISTICAL PROCESSING

Fixed point machine coding is used, and operands are placed in optimum storage locations wherever practical. The standard Data Input No. 3 Subroutine is used to handle the decimal-to-binary radix conversion. Input is via the Tape Typewriter reader for Configuration IX and the High Speed Reader for Configuration X.

§ 201.

.3 MATRIX INVERSION

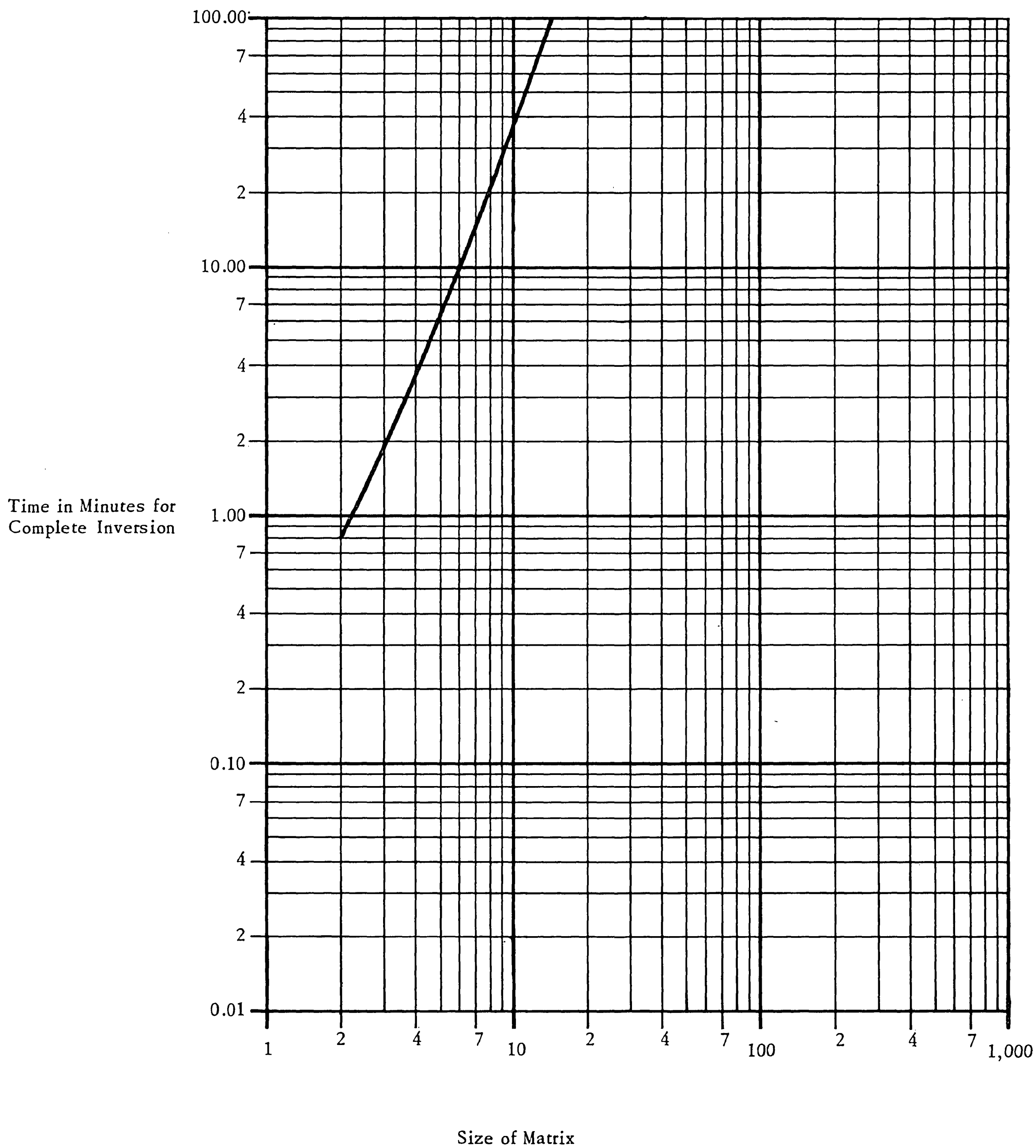
.31 Standard Problem Estimates

.311 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.312 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.312; 24.0 Interpretive System.

.313 Graph: . . . . see graph below.

.314 Maximum matrix size: . 45.



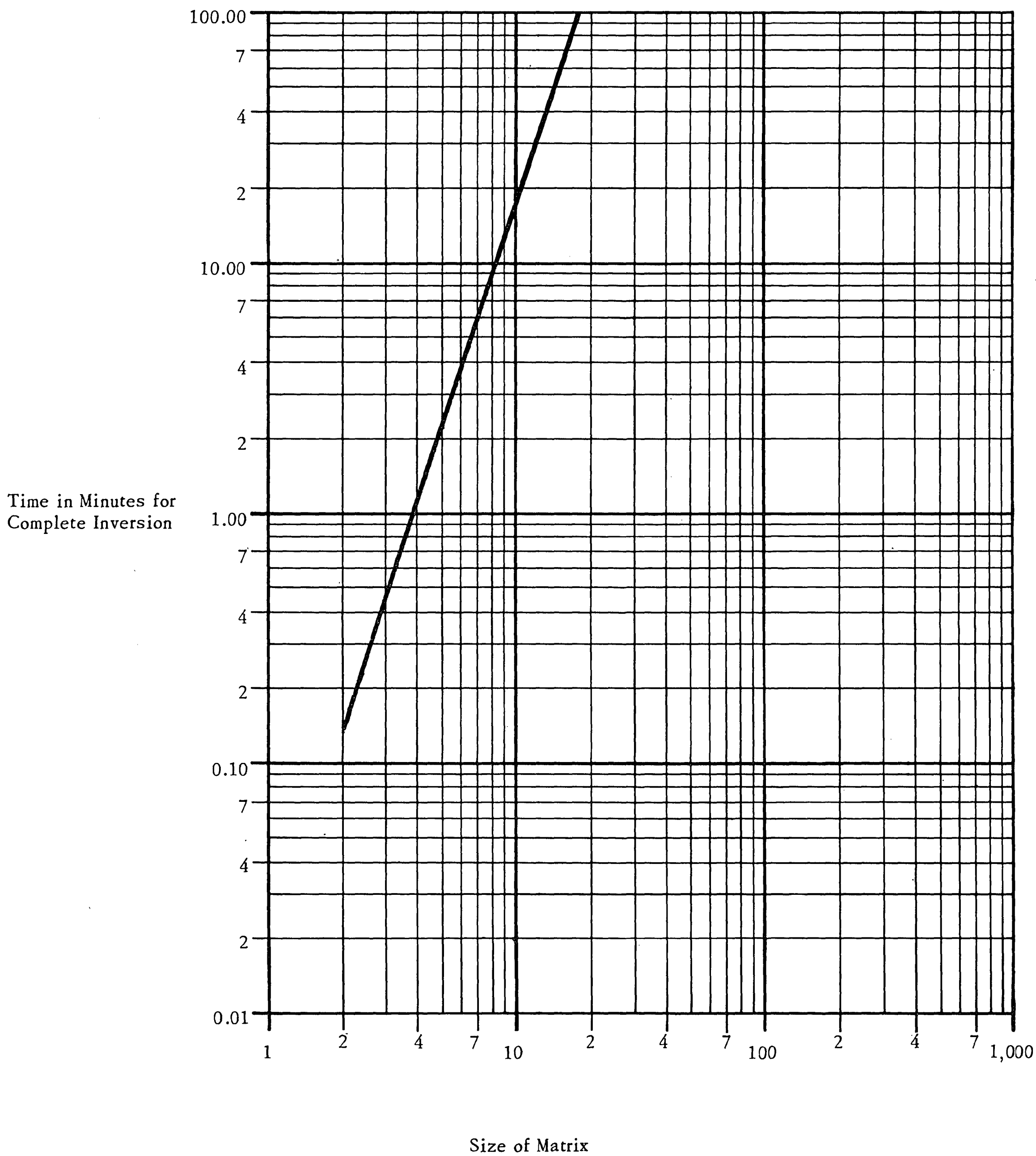
§ 201.

.32 Matrix Inversion 2 Times

.321 Basic parameters: . . . general, non-symmetric matrices, using floating point to at least 8 decimal digits.

.322 Timing basis: . . . . . write-up for Program D1-129.0, Matrix Inversion 2. This routine uses the 24.0 Floating Point Interpretive System.

.323 Graph: . . . . see graph below.



§ 201.

.4 GENERALIZED MATHEMATICAL PROCESSING

.41 Standard Mathematical Problem A Estimates

.411 Record sizes: . . . . . 10 signed numbers, avg. size 5 digits, max. size 8 digits.

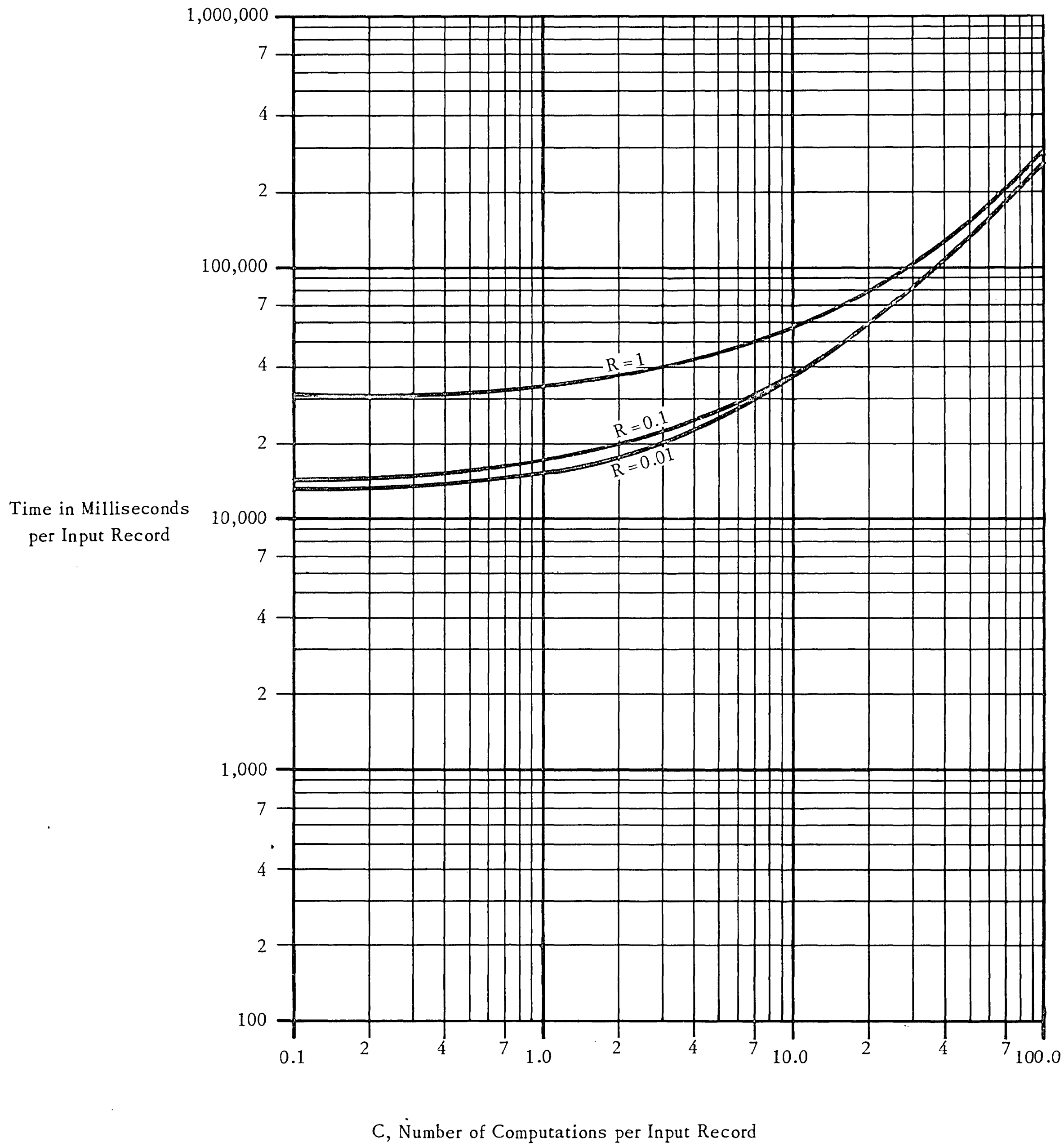
.412 Computation: . . . . . 5 fifth-order polynomials.
5 divisions.
1 square root.

.413 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.413.

.414 Graph: . . . . Configuration IX, typewriter output, fixed point machine coding.

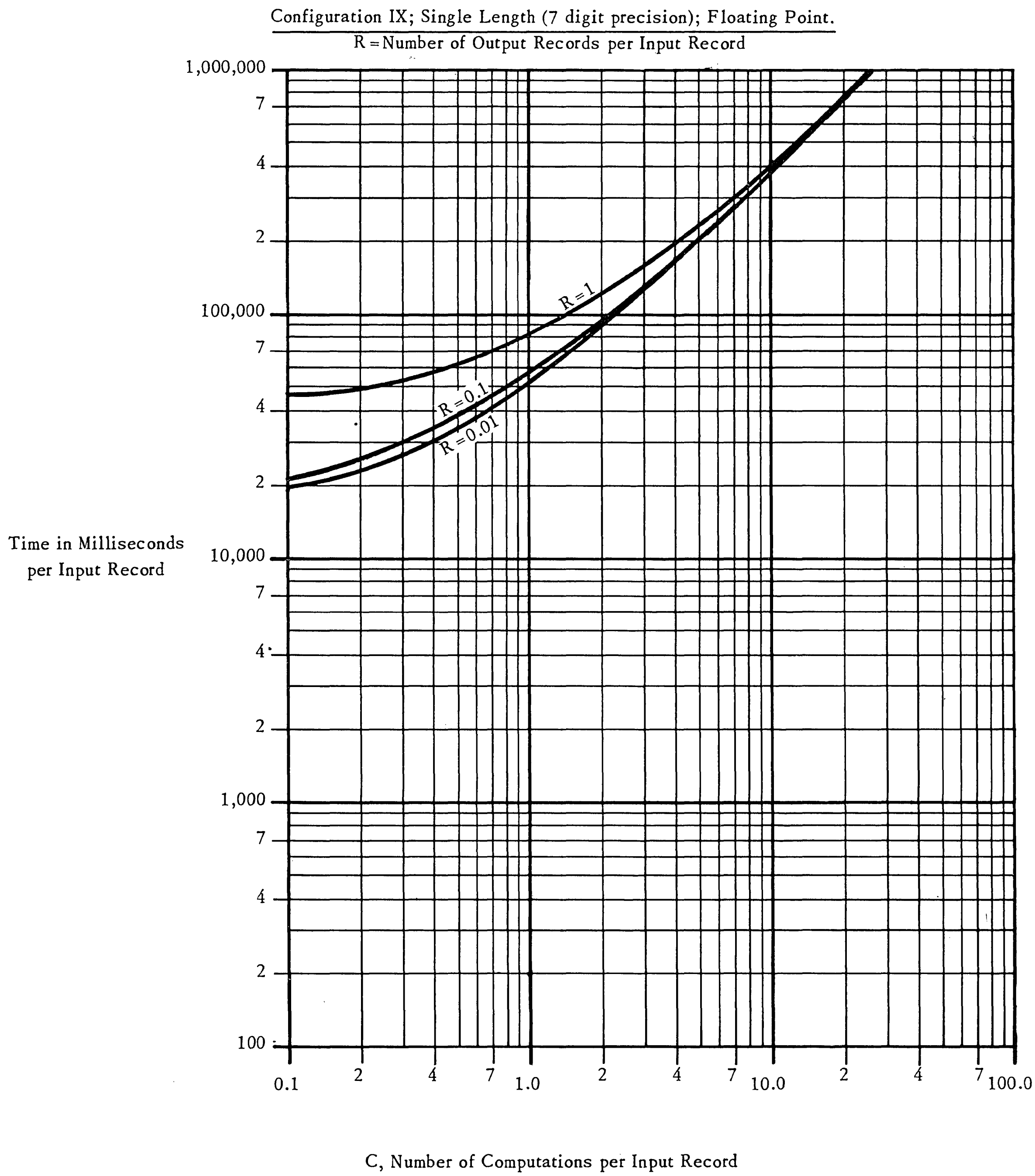
Configuration IX; Single Length (9 digit precision); Fixed Point.

R = Number of Output Records per Input Record



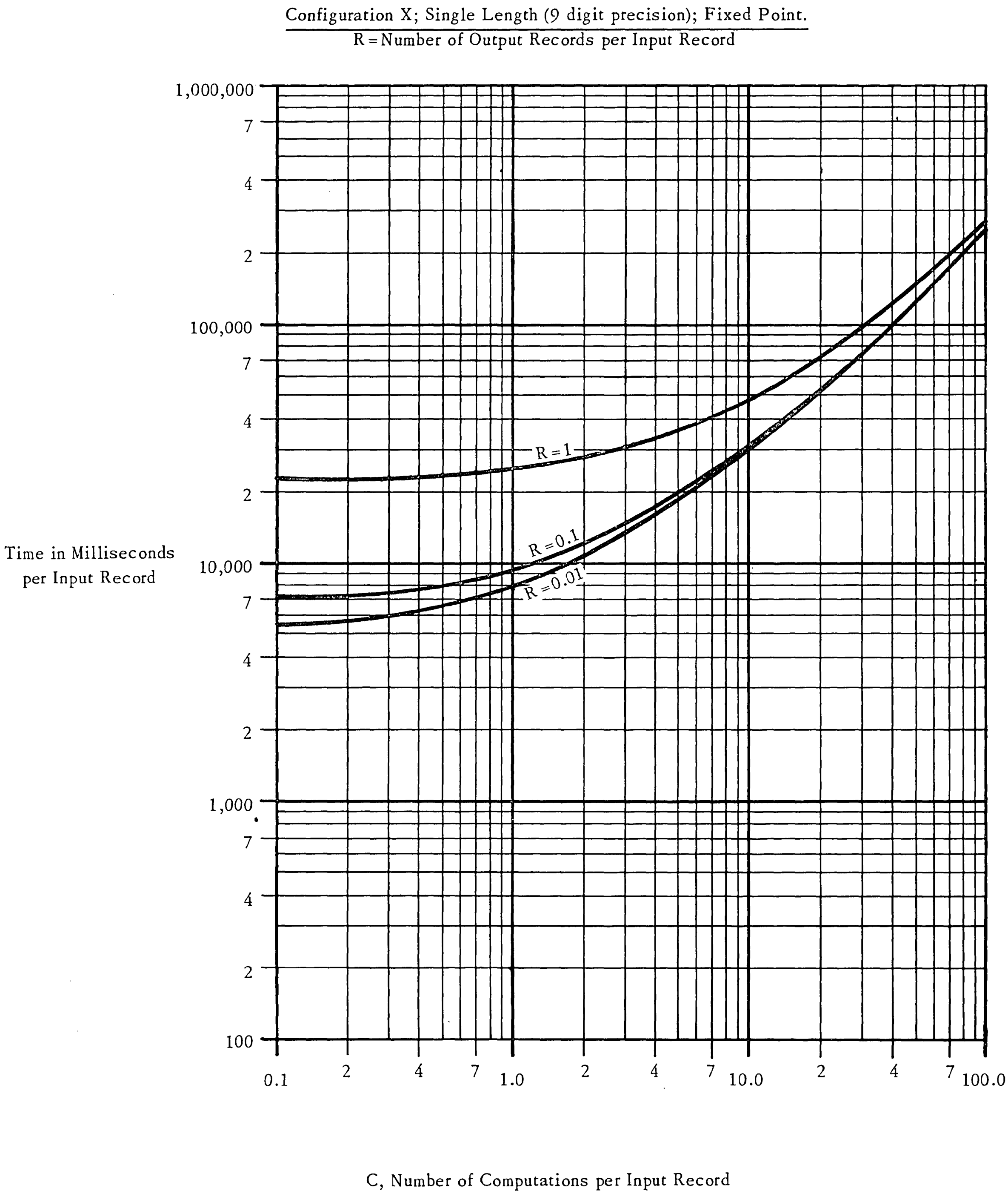
§ 201.

.415 Graph: . . . . Configuration IX, typewriter output, floating point using 24.0 Interpretive System.



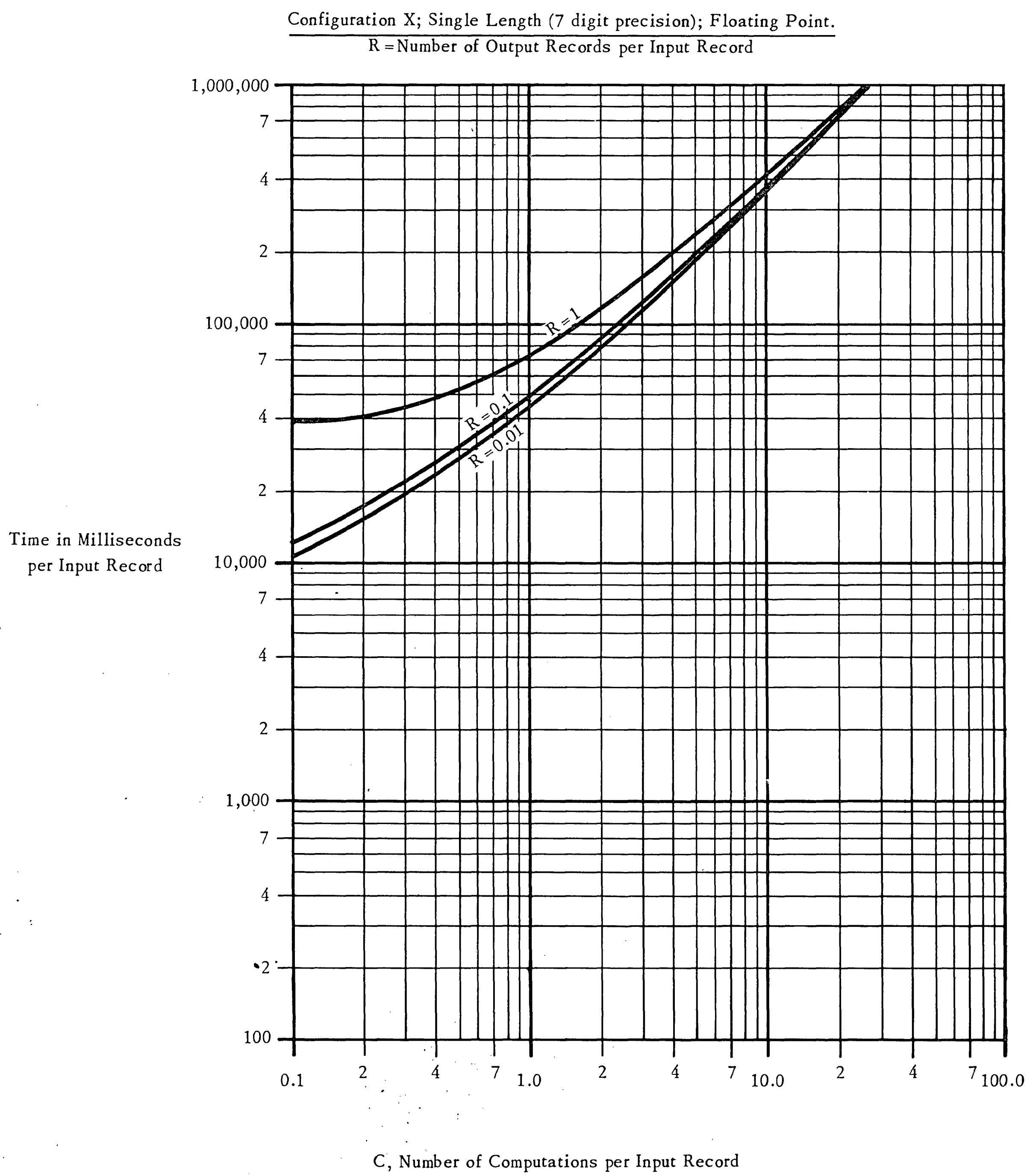
§ 201.

.416 Graph: . . . . Configuration X, typewriter output, fixed point machine coding.



§ 201.

.417 Graph: . . . . Configuration X, typewriter output, floating point using 24.0 Interpretive System.



§ 201.

.5 GENERALIZED STATISTICAL PROCESSING

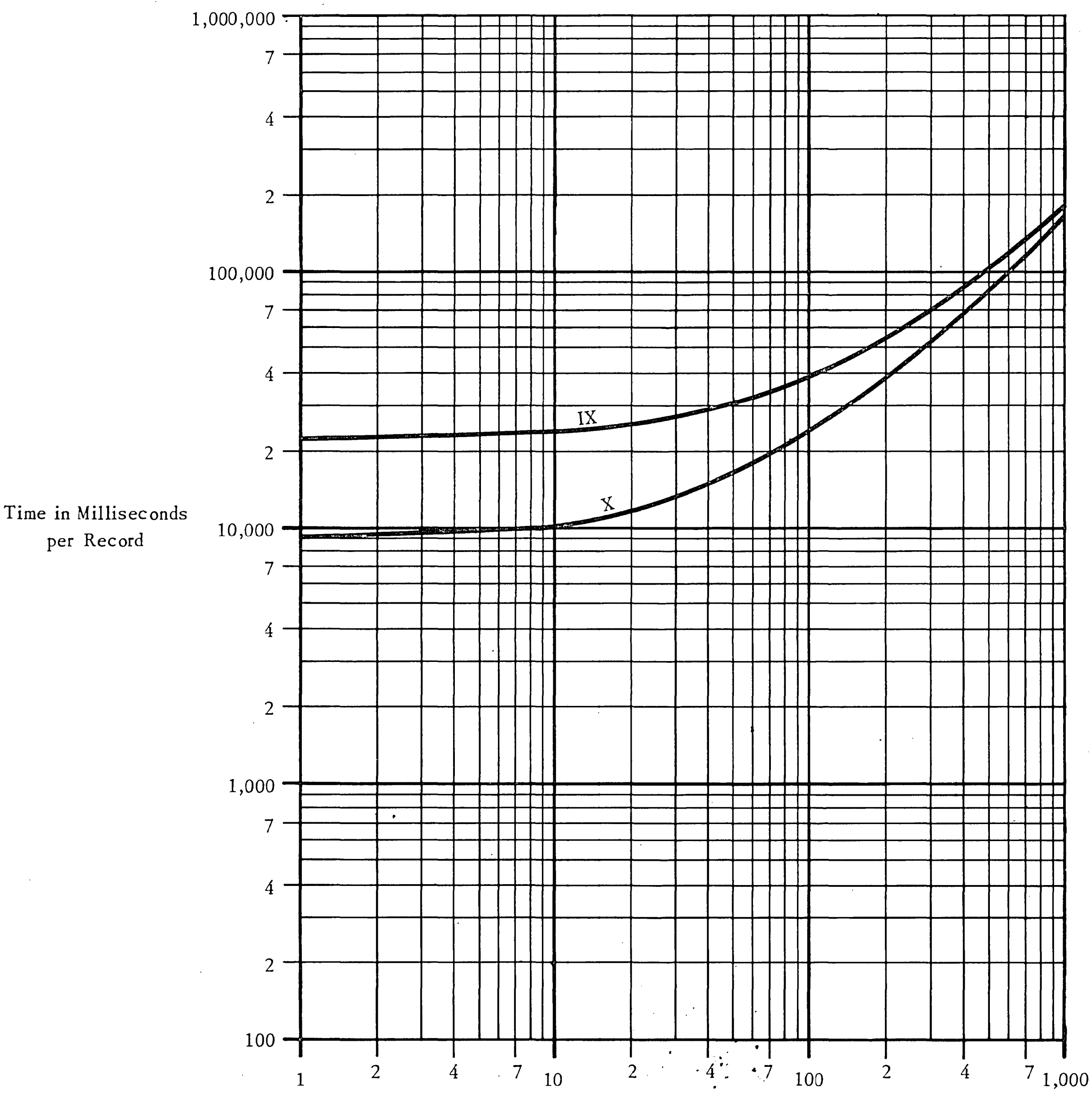
.51 Standard Statistical Problem A Estimates

.511 Record size: . . . . . thirty 2-digit integral numbers.

.512 Computation: . . . . . augment T elements in cross-tabulation tables.

.513 Timing basis: . . . . . using estimating procedure outlined in Users' Guide, 4:200.513.

.514 Graph: . . . . see below.



T, Number of Augmented Elements.
Roman numerals denote Standard Configurations.

LGP-30
PHYSICAL CHARACTERISTICS

LGP-30 PHYSICAL CHARACTERISTICS

IDENTITY	Unit Name		LGP-30 Computer	Tape Typewriter	High Speed Reader	High Speed Reader/Punch
	Model Number		301	360	341	342
PHYSICAL	Height × Width × Depth, in.		33 × 44 × 26	10 × 18 × 21	33 × 28 × 28	33 × 28 × 28
	Weight, lbs.		800	65	?	120
	Maximum Cable Lengths to Designated Units, feet		10 (360) 72 (341 or 342)	10 (301) 36 (341 or 342)	72 (301)	72 (301)
ATMOSPHERE	Storage Ranges	Temperature, °F.	33 - 120	----	----	----
		Humidity, %	Less than dew pt.	----	----	----
	Working Ranges	Temperature, °F.	45 - 85	----	----	----
		Humidity, %	Less than dew pt.	----	----	----
	Heat Dissipated, BTU/hr.		5,000	800	300	700
	Air Flow, cfm.		400	0	10	10
	Internal Filters		Yes	No	Yes	Yes
ELECTRICAL	Voltage	Nominal	115	115	115	115
		Tolerance	90 - 130	90 - 130	90 - 130	90 - 130
	Cycles	Nominal	60	60	60	60
		Tolerance	±5%	±5%	±5%	±5%
	Phases and Lines		1 ϕ, 3-wire	1 ϕ, 3-wire	1 ϕ, 3-wire	1 ϕ, 3-wire
	Load KW		1.5	0.27	0.10	0.25
NOTES			Quoted width does not include Tape Typewriter shelf.			

PRICE DATA

§ 221.

CLASS	IDENTITY OF UNIT		PRICES		
	No.	Name	Monthly Rental $	Annual Maintenance $	Purchase $
Central Processor	301	LGP-30 Computer with Tape Typewriter	1,100	2,750	49,500
		Optional Features			
	301-03	Memory Track Protection Circuit (per 8-track group)	-	-	25
	301-05	Double Access Track	-	-	350
	301-07	Memory Power Failure Protection Circuit	-	-	300
	301-08	Test for Overflow and Break Point Logic	-	-	600
Input-Output	360	Tape Typewriter	150	375	3,500
		Optional Features			
	360A	Special 20-inch Carriage	-	25	25
	360B	Verge-Punched Card Reader and Punch (in place of tape reader and punch)	-	25	175
	360C	Fitted for Electric Line Finder	-	-	75
	360-02	Special Input Modes	-	-	400
	342	High Speed Reader/Punch	265	662	6,360
		Optional Features			
	342-01	Six or Eight-Channel Punch	-	-	300
	342-02	Switch Box	-	-	1,500
	342-03	Single Character Input Mode	-	-	500
	341	High Speed Reader: No longer sold as a separate unit; see Model 342 above.			
	321	Punched Card Input Control (for IBM 024 or 026 unit)	100	250	4,000
	322	Automatic Switching Unit	150	375	6,000
	323	Universal Translator	100		4,000

NOTE: Optional Features are available only on a one-time charge basis. Maintenance charges apply only to purchased equipment and are on an annual basis.