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IBM Systems Reference Library

IBM 1448 Transmission Control Unit

This reference publication includes a description of the IBM 1448 Transmission Control Unit as a link between an IBM 1440 or 1460 Data Processing System and a network of as many as 40 half-duplex communication lines. Each line can have a number of terminals. The description of this IBM Tele-processing system includes appearance, operation, functions, programming aspects, and special features. Also discussed are communication codes, communication terminology, and line control.

This publication is for those familiar with the programming and operation of the data processing system to which the 1448 is connected.

Because the 1448 serves the processor, many functions of both are interdependent. Included here are the scan operation, the interrupt routine, and related programming operations.

For a list of associated publications, see IBM *Tele-Processing Bibliography,* Form A24-3089.

Major Revision (March 1965)

This edition, A24-3010-3, obsoletes A24-3010-2 and Technical Newsletter N24-0182. Additional information on disk, tape, and direct-data-channel timings has been added.

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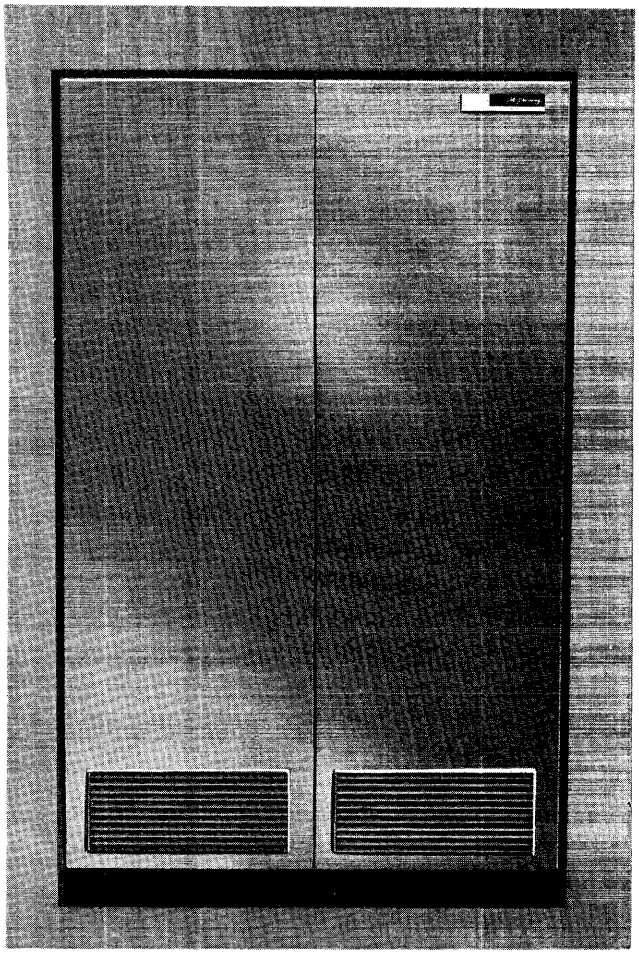

Figure 1. IBM 1448 Transmission Control Unit

IBM Tele-Processing Systems

Data processing without fast and accurate communication is limited by the numerous delays between the source of data and the processing unit. A data processing system serving as a central control for many remote locations requires the best techniques of data communication. The ideal method is a combination of communication and processing operations in an effective single system.

IBM Tele-processing systems are serving business and industry by combining computer operations and data transmission facilities into integrated data processing systems. Here are the speed, convenience, and efficiency of centralized data processing for the business, large or small, that is physically decentralized. Here is the control center for the business that requires, at a central point, variable or fixed information from many locations. Special features such as automatic-calling and automatic-answering increase the versatility of the system even more.

Transmission Control

Each line added to a communication network increases the possibility of delay and error. Speed and dependability of a communication system depend on the control equipment, which blends the array of transmission lines into an efficient network. Transmission control is the nucleus of any communication system made up of many lines, each with a number of terminals, leading to a central point.

The three basic purposes for transmission control in an integrated data processing system are:

1. To establish a connection between the processing unit and the terminals on the communication circuit.
2. To prevent indeterminate situations on the line such as distorted transmission or garbled or lost signals.
3. To allow for the requirements of the data processing equipment.

The IBM 1448 Transmission Control Unit (Figure 1) is an economical means of entering numeric, alphabetic, and special-character data directly into an IBM data processing system from as many as 40 half-duplex multipoint communication lines (Figure 2). (See the section: *Communication Terminology.)* Information can be transmitted on half-duplex lines in either direction, but in only one direction at a time. This IBM Teleprocessing system component directs and regulates the flow of data and provides compatibility among terminals and processing and exchange devices.

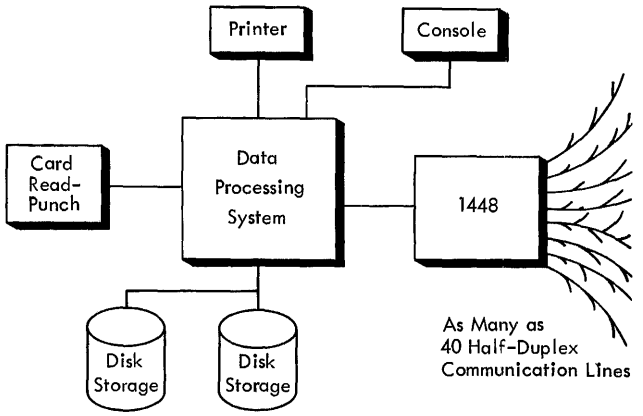

Figure 2. The Processing Unit and IBM 1448 Control as many as 40 Half-Duplex Channels

The 1448 links its associated data processing system with any or all of these systems (publication form numbers appear in parentheses):

IBM 1030 Data Collection System (A24-3018)

IBM 1050 Data Communications System (A24-3020)

IBM 1060 Data Communications System (A24-3034)

The 1448 functions similarly with all these systems except where so stated in this publication.

The 1448 with its associated processing unit handles such applications as inquiry and file updating. The 1448 and processing unit combination controls transmission of information, and processes this information in-line.

The 1448 and the data processing system provide on-line peripheral service to other IBM data processing systems (Figure 3). In this role, the 1448 processing unit combination functions as a stored-program transmission control system that controls and monitors the lines and assembles messages.

Transmission data is transferred from communication lines to processing unit core storage. The processing unit stores the message data on disks, and transfers

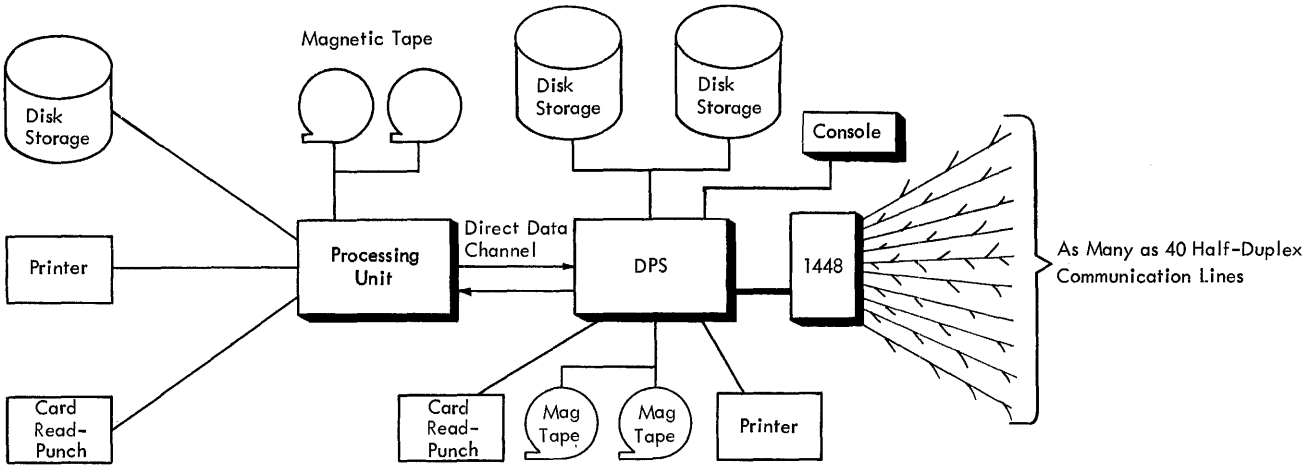

Figure 3. IBM 1448 and Processing Unit Serving a Central Data Processing System

the data to another processing unit on a scheduled or demand basis. The disks can also be transferred manually to other systems having IBM 1311 Disk Storage Drives. With the direct-data-channel special feature, data is transferred directly to and from another IBM data processing system having direct-data-channel capabilities. (See the Systems Reference Library publications: *Special Features of* IBM *1401 and 1460,* Form A24-3071, and *System Operation Reference Manual,* IBM *1440 Data Processing System,* Form A24-3116.

This expanded system covers a list of other operations, such as: format checking of incoming messages, editing and scheduling outgoing messages from the data of the second processing unit, message accounting, and message switching. The second processing unit takes over a share of the total required systems functions, and uses the first processing unit with its disk-storage capabilities as a backup.

Effectiveness and efficiency of large systems increase substantially with the IBM 1401 Data Processing System as a peripheral data converter (card-to-tape, tape-to-card, and tape-to-printer). A 1448-1440 system (for transmission, data conversion, and editing) magnifies even more the economy and efficiency of the system.

With the 1448 a decentralized system becomes, in effect, centralized. The program of the processing unit controls the whole network, and uses the transmission control unit as an instrument of that control.

General Description

IBM 1448 Transmission Control Unit circuitry is enclosed in a module 60 inches high, 45 inches wide, and

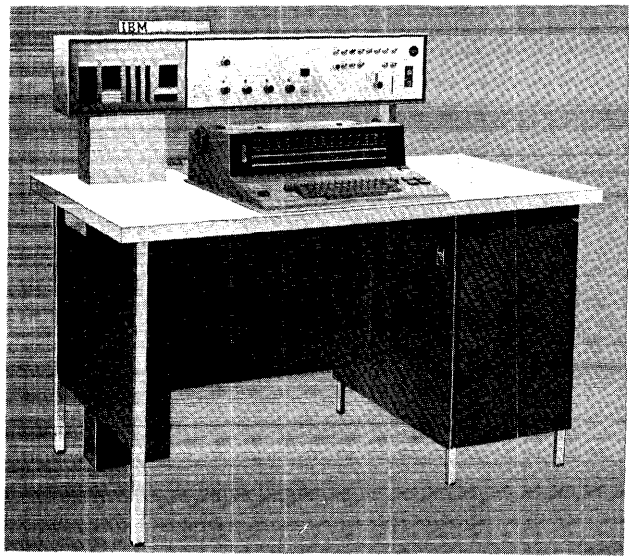

Figure 4. IBM 1447 Console, Model 4

30½ inches deep. For operator convenience, the operating keys, lights, and switches for the 1448 are combined with those of the processing unit on the IBM 1447 Console (Figure 4). (See the section on *Console.)*

The data processing system to which the 1448 is connected must have:

1. Indexing and Store Address Register Feature
2. Transmission Control Unit (1448) Attachment
3. 1447 Console Model 4.

CHARACTERS	ODD PARITY BCD CODE						
	8	4	2	1	B	A	C
1				1			
2			2				
3			2	1			C
4		4					
5		4		1			C
6		4	2				C
7		4	2	1			
8	8						
9	8			1			C
0	8		2				C
A				1	B	A	
B			2		B	A	
C			2	1	B	A	C
D		4			B	A	
E		4		1	B	A	C
F		4	2		B	A	C
G		4	2	1	B	A	
H	8				B	A	
I	8			1	B	A	C
J				1	B		C
K			2		B		C
L			2	1	B		
M		4			B		C
N		4		1	B		
O		4	2		B		
P		4	2	1	B		C
Q	8				B		C
R	8			1	B		
S			2			A	C
T			2	1		A	
U		4				A	C
V		4		1		A	
W		4	2			A	
X		4	2	1		A	C
Y	8					A	C
Z	8			1		A	
.	8		2	1	B	A	
$	8		2	1	B		C
,	8		2	1		A	C
/ (slash)				1		A	C
# (pound sign)	8		2	1			
- (hyphen)					B		
@ (at sign) *	8	4					C
& (and) *					B	A	C
+ (plus) **					B	A	C
★ (star) **	8	4					C

*1030, 1050 and 1070 only
**1060 only

Figure 5. Processing Unit Code Chart

Codes

The 1448 accepts all characters transmitted by remote terminals. However, idle and delete characters are deleted, and information is forwarded to the processing unit. Figure 5 shows the processing unit code.

Only when receiving from the 1030, the 1448 translates the line code A-bit (@) to processing unit code 8-2-C (zero).

The 1448 translates the following codes from line code to processing unit code when receiving; when transmitting, the 1448 converts the code in reverse:

Line Code	*Processing Unit Code*
8-4-2-A-C (EOB)	8-2-A (Record Mark)
A(b)	8-4-C (@)

Communications Terminology

To clarify the explanation of the IBM 1448 Transmission Control Unit, some communication terms are defined.

Centralized Half-Duplex. This network of half-duplex communication lines is centrally controlled, and all transmissions pass through the controlling unit.

Contention. This condition occurs on a multipoint line when two or more locations try to transmit at the same time.

Data Set Equipment. This modulator-demodulator device accepts binary-valued electrical signals from the transmitter, and converts them into signals for transmission. The data set equipment also accepts the signals from the communication lines, and converts them to signals acceptable to the receiving unit.

Half-Duplex. Information can be transmitted in either direction on a half-duplex communication line, but in only one direction at a time.

Multipoint Channel. This communication line interconnects several locations.

Off-Line. An off-line system requires human operations between the original recording functions and the ultimate data processing function.

On-Line. An on-line system puts the input/output units under direct control of the processing unit.

Poll. This centrally controlled method permits stations on a multipoint line to transmit without contending for the line.

Start-Stop Transmission. In this method of transmission, the data bits are preceded by a start bit, and are followed by one or more stop bits. The total number of stop bits is not necessarily an integer. This method allows the receiving unit to stay in synchronization with the transmitting unit. The start and stop bits are the synchronizing information, so that the receiver is resynchronized by each character.

Switching Network. This system provides transfer of incoming data from one line to another outgoing line or lines.

Communication-Company Equipment

The communication lines over which data is transmitted to and from the 1448 are switched-telephone, 150 bps teletypewriter exchange (TWX), toll voice-grade, leased voice-grade, or leased low-speed (as many as 600 bits per second) common-carrier lines. The 1448 can also operate over privately owned lines.

The IBM 1448 Transmission Control Unit is a multiple-low-speed-communication-line scanning device. An IBM 1448 can serve as many as 40 half-duplex lines, which can be point-to-point (one terminal) or multipoint channels. Nominal speed is 14.8 characters per second (cps) for the IBM 1050 and 1060 Data Communications Systems.

An IBM 1448 can serve terminals of various speeds. The number of lines it can serve decreases as the speeds of the lines increase over 200 bits per second. Nominal speed for the IBM 1030 is 60 characters per second (cps). The 1448 can serve as many as 20 1030 lines.

The cable connection makes the 1448 an integral part of the associated processing unit, and for many functions they become interdependent.

Information from the lines enters the 1448 serial-by-bit, serial-by-character. The 1448 assembles the bits into characters and, when necessary, translates them into binary coded decimal (BCD) odd-parity interchange code. A minimum of two characters of incoming information is accepted by 1448 core storage for each line.

The exchange of information between the 1448 and the processing unit is under control of the program in the processing unit. The 1448 is in synchronism with the processing unit when exchanging data or status information with the processing unit.

All transmission is centralized through the 1448 (Figure 6).

Data Control

The 1448 provides the core storage described in this section for *each* transmission line.

The *assembly character* consists of 11 bits where characters are serialized and deserialized.

Buffers for characters to be transmitted to the line or transferred to the processing unit are: two character positions for the IBM 1050 and 1060 Data Communications Systems and six character positions for the IBM 1030 Data Collection System.

The *block-check position* holds the longitudinal redundancy check (LRC) character as required by the

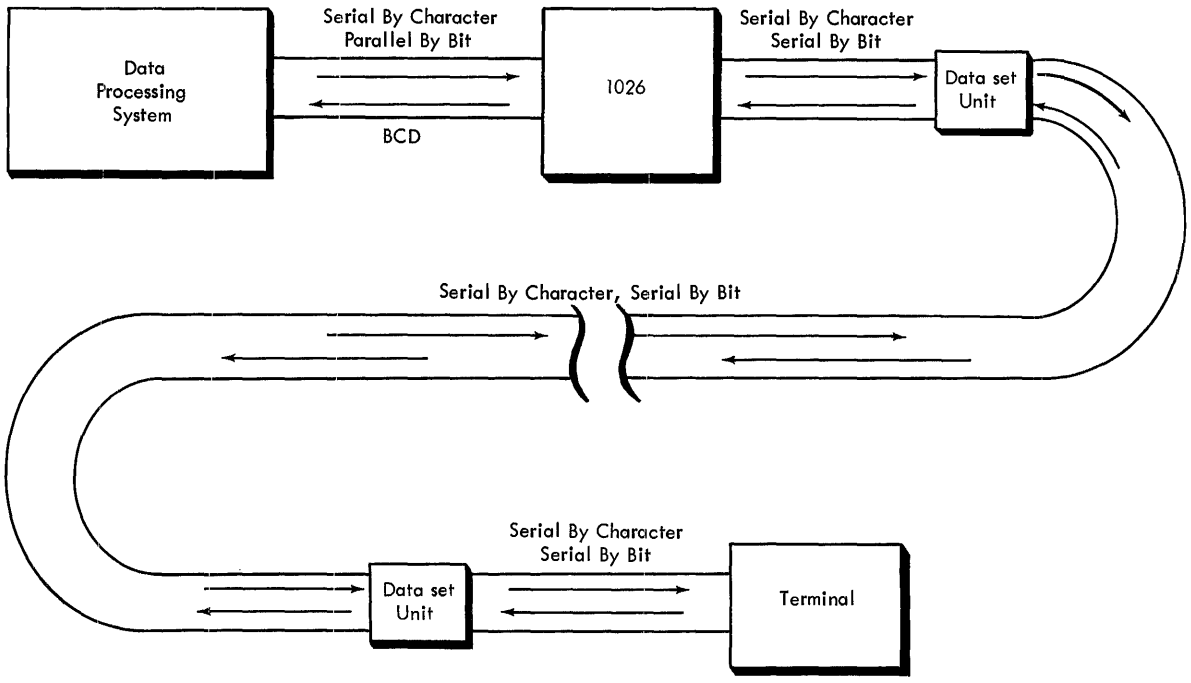

Figure 6. Data Flow Between Processing Unit and Terminals

1050 and 1060. LRC serves as an additional transmission check. The 1030 does not use LRC. It uses a format check provided by the programmer.

The *control character* for each line holds control data for that line. The control character is read whenever the assembly character, buffer characters, or the block-check character is addressed. The bits that make up the control character are:

1. Phase bits (3 bits) determine the rate at which the 1448 is to sample a communication line to detect bits or to place bits on the line.
2. Status bits (8 bits) store the condition of the communication line. The processor also has eight status bits.
3. 1448 storage status bits (2 bits for the 1050 and 1060, and 6 bits for the 1030) store the number of characters to be transmitted on the line, or those to be transferred to the processing unit.
4. Sequence-control bits (2 bits) control the sequence of transmission checking and *answerback,* polling character transmission, and responses. These bits break down a status into substatuses when it is necessary for the 1448 to switch from transmit to receive.

Programming Aspects

IOCS

The IBM Input/Output Control System (IOCS) eliminates the need for detailed programming of the IBM 1448 and processing unit combination. IOCS routines are tailored to satisfy the particular requirements of each job.

IOCS for the 1448 and processing unit provides:

1. Initialized polling on any or all lines
2. Initialized transmit on any or all lines
3. Output message scheduling
4. End-of-message detection on any line
5. Error detection
6. Interrupt subroutine
7. Expanded serial I/O adapter control
8. Direct-data-channel control
9. On-line test
10. Automatic calling of terminals.

IOCS for the IBM 1448 Transmission Control Unit and processing units is described in the Systems Reference Library publications:

Input/Output Control System for IBM *1440-1448: Specifications,* Form C24-3024

Input/Output Control System for IBM *1460-1448: Specifications,* Form C24-3047

IOCS for the direct-data-channel for 1401, 1440, and 1460 is described in the Systems Reference Library publication:

IBM *1401, 1440, and 1460 Direct Data Channel Input/Output Control System: Specifications,* Form C24-3025.

1448 Scan Operation

The exchange of information between the 1448 and processing unit is initiated by a *scan operation code* associated with a *priority interrupt.* An *interrupt* is a temporary interruption of the processing unit's main routine by an external signal, in this case, from the 1448. The main routine continues in sequence after the interrupt routine, including the scan operation, is completed.

The scan operation itself causes the automatic transfer of as many as two characters per receiving line for the terminal from the 1448 to the message-assembly areas in the processing unit. It also effects the automatic transfer of two characters per transmitting line from the message-distribution areas of the processing unit to the 1448 for subsequent transmission. For the 1030, the scan operation transfers as many as six characters per receiving line from the 1448 to the message-assembly areas in the processing unit, but only two characters from the message-distribution areas to the 1448.

The stored program assigns the message-assembly and distribution areas, which are variable in both length and location. The scan operation automatically performs indirect address generation and address modification. During a scan operation, line-status characters are read out either to alter the status character because of line-status change, or to alter the line status as a result of a change by the stored program.

Another function of the scan operation is the extraction of polling addresses from the list in the processing unit when polling.

The program must execute a scan operation to initialize line conditions and to start outgoing messages, when there is no line activity.

The scan operation must be given in order to discover the cause of interrupt.

Instruction Format

Op Code	*I-address*
O	xxx

The scan instruction, in actual machine-language, is made up of an alphabetic O as the operation code, and a 3-character address representing the high-order position of the scan-control field. The line under the Op code denotes a word mark. The scan proceeds through the control field in a left-to-right scan.

The scan instruction is restricted to basic single-address format and must be followed by a word mark in the next location. An attempt to force a 2-address format causes an improper address in the B-address register at the beginning of instruction execution time, and the instruction affects storage locations other than the intended control field.

The instruction address is used during the execution of the instruction to automatically obtain from the control field the addresses of the:

1. Line-status characters
2. Line running addresses
3. Polling-list addresses.

The *line-status character* indicates the status of the transmission line with which the 1448 is associated. The status represented is the status of the line after the last 1448 line bit scan before execution of the processing unit's scan operation.

The line *running address* is the location where the next character from a receiving line is to be stored, and where the next character to be transmitted on a transmitting line is stored.

The *polling-list address* is the location of the next terminal-and-component-polling address to be transmitted when a line is polling. It functions simply as a pointer, automatically moving through the polling list and keeping track of the terminal to be polled next.

The scan operation address (high-order position of the control field) is the location of the status character for the first line. The 1448 scans the lines, accepting and transferring status and data information in a fixed sequence.

Each scan operation reads out for updating *every* line-status character whether or not data is transferred.

Control Field

The control field consists of ten character positions per transmission line, in contiguous locations in processing unit storage. The scan routine operates on the control field, transferring characters between the 1448 and the processing unit.

The control field can start in any storage location, but the field must not cross a 4,000-character boundary in processor storage (that is, addresses 3999, 7999, and 11999).

The control field should always correspond to the number of lines attached to the 1448, although the program may not use all of them.

Control-Field Format. Figure 7 is a diagram of the control-field format.

The status character of line one should be stored in the high-order position of the control word. It is read out to the 1448, compared to the 1448 status character (for possible updating of either status character), and restored in one cycle.

The next three positions of storage, in ascending order, contain the hundreds, tens, and units positions respectively of the running address for the message-assembly or distribution area. The stored program sets this address initially. If the line is in RECEIVE or TRANSMIT status, and data transfer is required to or from the 1448, the scan operation reads out and modifies the running address. At the end of block (end-of-message) on RECEIVE the running address denotes the location of the end-of-block character *plus one*. On TRANSMIT it denotes the location of the end-of-block character *plus one* or *two*, depending on whether the number of characters is even or odd.

The next three positions of the control word (initializing address) are for the programmer's convenience.

FIRST TRANSMISSION LINE										SECOND TRANSMISSION LINE				LAST TRANSMISSION LINE			
Status Char.	Running Address			Initializing Address			Polling-list Address			Status Char.	Running Address			Polling-list Address			Scan Ends
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	±

Figure 7. Schematic of First and Last Few Positions of Processing Unit Storage Containing the Control Field

He can use this area for any purpose. He may store the initial running address here as a reference to the beginning of the message block.

The next three positions of the control word contain the *polling-list address*, which indicates the terminal-and-component address to be sent out on the next polling cycle. The stored program initially sets the polling-list address to the high-order position of the *polling list* for the particular line. A polling list is a sequence of addresses for terminals on a multipoint channel.

The scan operation causes this address to be read and updated, if the line is in the polling status (RECEIVE—CONTROL status), and if a polling cycle is requested by the 1448. When the status for that line becomes end-of-polling-list (RECEIVE—CONTROL—END-OF-BLOCK) status the program must reset the polling-list address to the beginning of the polling list.

The next position of the control word (following the polling-list address) is the status character for the next transmission line. The control word continues in this sequence through the last transmission line.

A group-mark with a word-mark in the status-character position that follows the last line in the control word designates the end of a scan operation. For example, if 20 transmission lines are on the system, this group-mark with a word-mark is in the position of the 21st status character. When more lines are added to the system, the program is changed to add the control fields and move the terminating status character.

Execution of Scan on Control Field

As a result of the scan instruction, the IBM 1447 Transmission Control Unit, in synchronism with the processing unit, sequentially scans its line-status characters and its buffers, beginning with the first status character, while the processing unit progresses sequentially through the control field.

The scan operation can take one of *three* different sequences on each transmission line, depending on the status of the line. The flowchart in Figure 8 shows the scan operation sequences.

1. The *status sequence* of scan occurs on the control field for a line, when no data is to be transferred between the processing unit and 1448, and when the line is not to be polled.

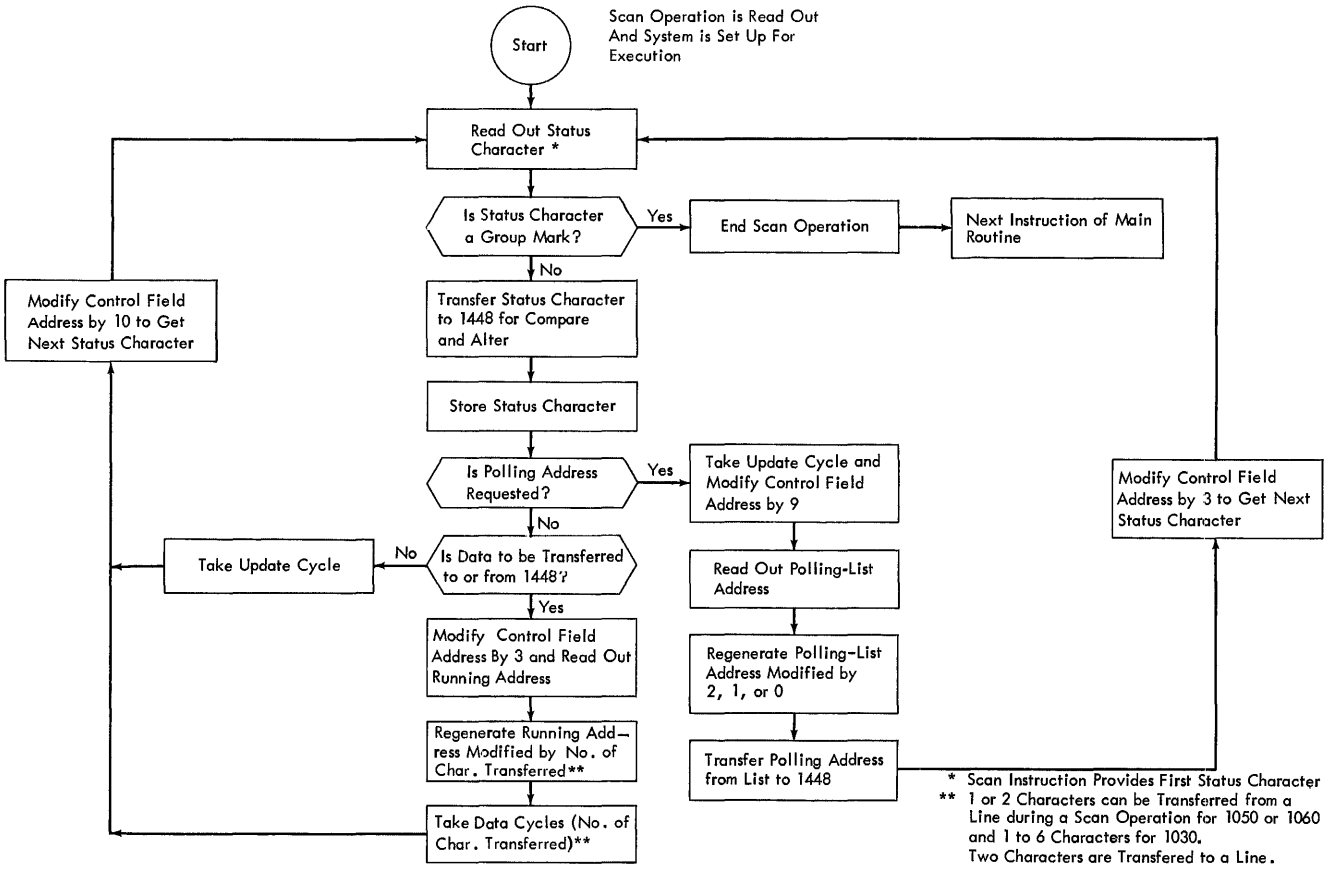

Figure 8. Flow Chart of Scan Operation

The status sequence is composed of two cycles: a *status cycle* when the processing unit status character is transferred to the 1448 for comparison, and an *update* cycle when the scan jumps to the status character for the next line.

2. The *data sequence* of scan occurs on the control field for a line, when the line is in either RECEIVE or TRANSMIT status and data is to be transferred between the 1448 and the processing unit's message-assembly or distribution area.

   The data sequence is composed of at least five cycles, the first of which is the status cycle. The next three cycles take in the reading of the running address (to be used in data transfer). A modified running address is regenerated into the control field. The modifier (from the 1448) depends on the number of characters to be transferred during the subsequent data cycles which complete the data sequence. The number of these remaining cycles depends on the transmission speed.

3. *Polling sequence* of scan occurs on the control field for a line, when the line is in poll (RECEIVE—CONTROL) status, and the 1448 requires a polling address from the polling list to send out on the line.

   The polling sequence takes six or seven cycles, depending on the polling address. The first cycle is the status cycle.

   The second is an *update* cycle when the scan jumps to the polling-list address. The next three cycles take in the reading of the polling-list address. A modified polling-list address is regenerated into the control field. The remaining cycles take in the reading and transfer of the polling address to the 1448.

The three sequences can occur in random combinations in a scan operation. Figure 9 shows a possible combination.

Message-Assembly and Distribution Areas

The processing unit controls its message-assembly and distribution areas, which are variable in length and location. The running addresses in the control field specify the location of these areas. Data is transferred between the 1448 and these areas of the processing unit in high-order to low-order position sequence (left-to-right scan).

The message-assembly and distribution areas can start in any storage location, but must not cross a 4,000-character boundary in processing unit storage.

Assembly-Area Format. The initial running address defines the high-order position of the area, while the program ends the area with a group-mark with a word-mark. The input data must not extend beyond this area.

The processing unit accepts characters in the assembly area until it receives an end-of-block signal (record mark) from the 1448, or until it senses a group-mark with a word-mark in processing unit storage.

If a group-mark with a word-mark is sensed first, it causes an END-OF-STORAGE-AREA status in the 1448 status character for that line. The 1448 continues to accept characters from the line until it receives the END-OF-BLOCK. These characters (following the group-mark with a word-mark) are not transferred to the processing unit. At the END-OF-BLOCK, the processing unit's status character for that line will be RECEIVE—END-OF-BLOCK—END-OF-STORAGE-AREA indicating the long-length record.

Figure 10 shows an example of the assembly area and control field.

Distribution-Area Format. The initial running address defines the high-order position of the area, and the program ends the area with a group-mark with a word-mark. Output data should always be terminated by a record mark.

Characters are transferred from the processing unit to the 1448 for transmission until a record mark or a group-mark with a word-mark is detected in the distribution area.

If a group-mark with a word-mark in the distribution area is sensed, the processing unit status is set to TRANSMIT—END-OF-BLOCK—END-OF-STORAGE-AREA status, and no more data is transferred from that distribution area until the status is changed by the program.

Polling

The polling list, stored in the processing unit, is a sequence of addresses for terminals on a multipoint

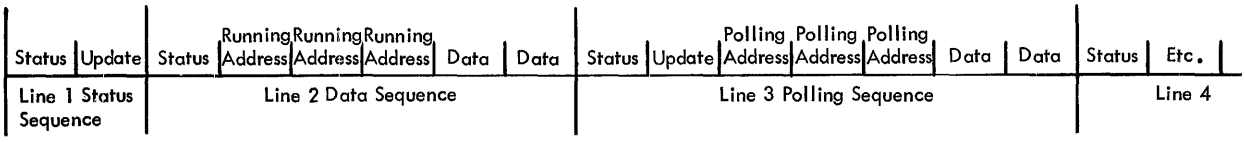

Figure 9. Possible Combinations of Scan Cycles

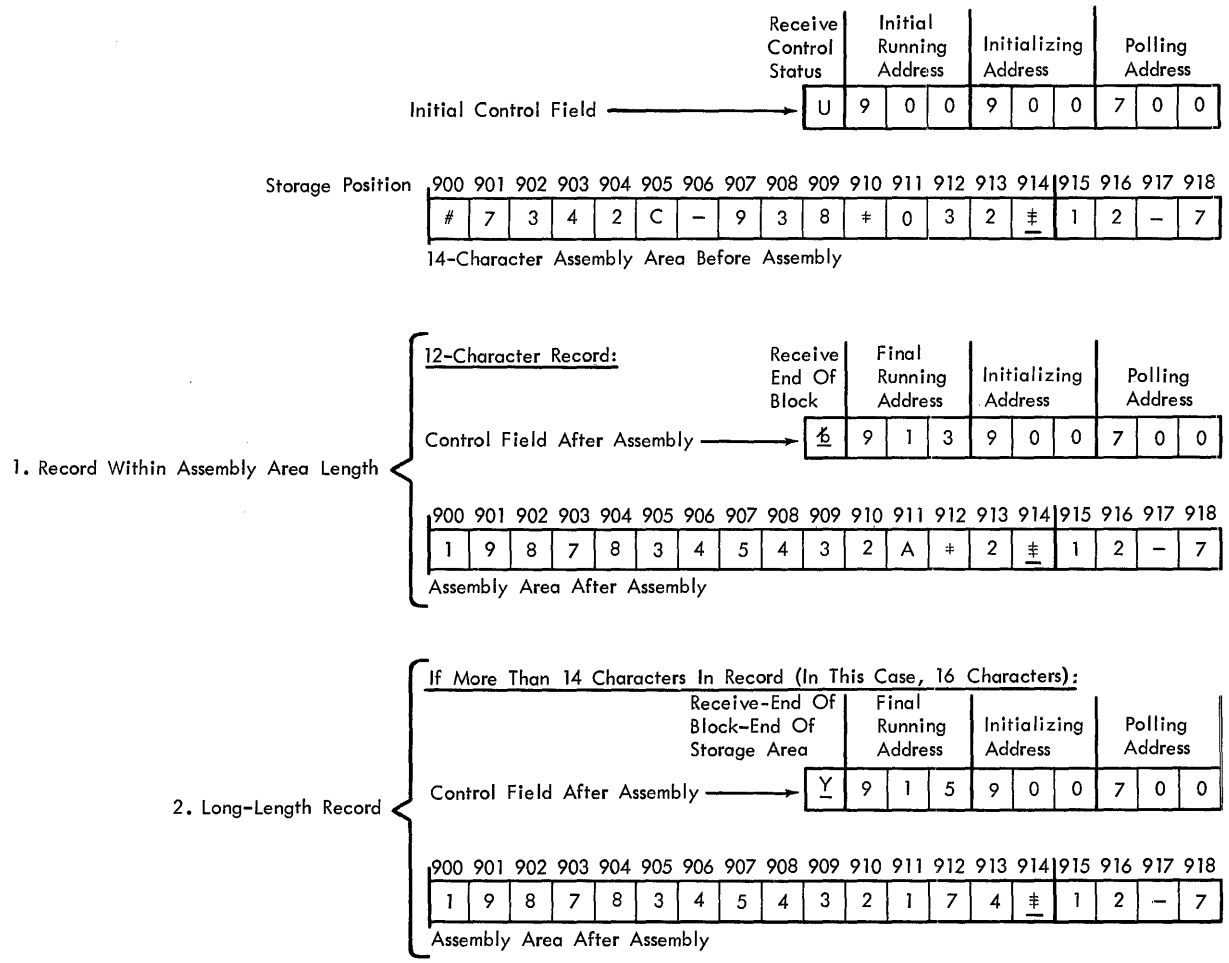

Figure 10. Scan Operation and Control Field During Assembly

channel. The number, location, and length of these lists are variable and under control of the stored program. The polling-list address in the control field designates the high-order position of the next terminal polling address to be transmitted, when that line is in the poll (RECEIVE—CONTROL) status. Polling proceeds in a left-to-right scan. The polling list should not cross a 4,000-character boundary in processing unit storage.

Unlike the message-assembly and distribution areas, the same polling list can be shared by more than one line.

Polling-List Format. Figure 11 shows the effect of the scan operation on the polling list.

The stored program initially sets the polling-list address to the high-order position of the polling list for the particular line. The length of the polling list is defined by a group-mark with a word-mark in the low-order position of the list.

When a communication line is in polling (RECEIVE—CONTROL) status, terminal polling addresses are transferred from the polling list to the 1448 under control of the polling-list address in the control field. A subsequent scan operation continues the polling until it detects a terminal that is trying to transmit, or until it detects a group-mark with a word-mark at the end of the polling list. The group-mark with a word-mark causes the line status to be set at the end-of-polling-list (RECEIVE—CONTROL—END-OF-BLOCK) and polling ends.

The END-OF-BLOCK indicates to the processing unit that the end of the poll list has been reached. The program must reinitialize the polling-list address in the control field and must return the line status to poll (RECEIVE—CONTROL) so that polling can be resumed on that line.

Point-to-Point Channels. When the program puts a point-to-point (one-terminal without component poll-

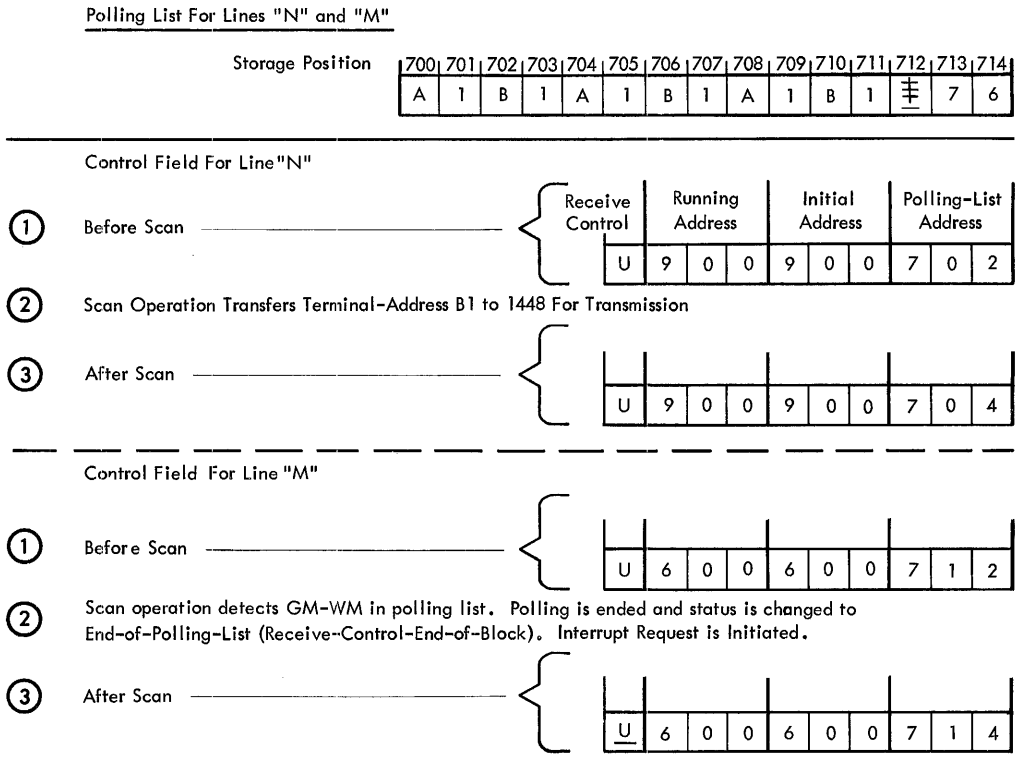

Figure 11. Scan Operation and Control Field During Polling

ing) channel in poll status, the operation differs from the multi-point channel polling in three ways:

1. The polling list consists of only one terminal-and-component address.
2. The polling-list address in the control field is not modified during the scan operation. Therefore, the same address is repeated each polling sequence.
3. Because the polling-list address does not change, the line status does not go to end-of-polling-list (RECEIVE—CONTROL—END-OF-BLOCK). Therefore, the program need not reinitialize the polling-list address or change the line status.

Polling a point-to-point line eliminates the contention problems, which exist even on point-to-point lines.

Polling provides program control of the inputs for each terminal.

Interrupt

Any of these conditions in the 1448 makes the 1448 request an interrupt of the processing unit's main program.

1. Any buffer-full condition on the receiving lines.
2. Any buffer-empty condition on the transmitting lines.
3. Any status condition with an EOB (end-of-block) bit.
4. The 1448 requests the next polling address.
5. An answer (y) or (n) to a received message has been sent.

The interrupt routine contains the necessary preparatory operations and the scan operation. The actual interruption of the main program takes place when an instruction is being read, but before the execution of that instruction (I_4 time). Only unchained operations can be interrupted. Figure 12 is a list of interruptible operations.

The interrupt causes a program skip to address 182 in the processing unit where the first instruction of the interrupt routine is located.

An interlock prevents interrupting while the system is in the interrupt routine. The ENABLE INTERRUPT AND BRANCH instruction resets the interlock at the end of the interrupt subroutine.

The interrupt routine must include:

1. Store B-address register contents. The address in the B-address register must be decreased by four to establish the position of the interrupted main-program instruction. This new address is placed in the ENABLE INTERRUPT AND BRANCH instruction.

Description	Interruptible Ops Op Code	Length	Non-Interruptible Ops Op Code	Length
Add	A	7	A	1, 4
Branch	B	5, 8	B	1, 4
Branch if Bit Equal	W	8	W	1, 4
Branch if Word Mark or Zone	V	8	V	1, 4
Compare	C	7	C	1, 4
Control Carriage	F	5	F	2
Control Unit			U	5
Clear	/	7	/	1, 4
Clear Word Mark	¤	7	¤	1, 4
Divide	%	7	%	4
Edit	E	7	E	4
Expand Compressed Tape	X	7	X	1, 4
Halt	.	5, 7	.	1, 2, 4
I/O Operations			All	All
Load (Excluding I/O)	L	7	L	1, 4
Modify Address	#	7	#	1, 4
Move (Excluding I/O)	M	7	M	1, 4
Move Digit	D	7	D	1, 4
Move Record	P	7, 8	P	1, 4
Move and Suppress Zeros	Z	7	Z	4
Move Zone	Y	7	Y	1, 4
Multiply	@	7	@	4
No Operation	N	5, 7, 8	N	1, 2, 4
Scan			O	4
Select Stacker	K	5	K	2
Set Word Mark	,	7	,	1, 4
Store A-Register	Q	7	Q	1, 4
Store B-Register	H	7	H	1, 4
Subtract	S	7	S	1, 4
Translate	T	7, 8	T	1, 4
Zero and Add	?	7	?	1, 4
Zero and Subtract	!	7	!	1, 4

Figure 12. Interruptible Instructions

2. Saving program conditions (arithmetic overflow, high-low-equal compare and index locations), if they might be lost during the interrupt subroutine. After the interrupt subroutine, the program must restore these conditions.

Enable Interrupt

Op code	*d-Character*
K	>

The ENABLE-INTERRUPT instruction is made up of K for the operation code and a bit configuration of 8-4-2 for the d-character. The interrupt routine interlock is reset, and the program continues with the next sequential instruction.

Enable Interrupt and Branch

Op code	*I-address*	*d-Character*
K	xxx	>

The ENABLE-INTERRUPT-AND-BRANCH instruction, which is used to re-enter the main program, is made up of K as the operation code, a 3-character I-address representing the contents of the B-address register *minus four* at the time of interrupt, and the d-character with the bit configuration 8-4-2. The interrupt routine interlock resets, and the program branches to the instruction address.

Disable Interrupt

Op code	*d-Character*
K	<

The DISABLE-INTERRUPT instruction consists of K for the operation code and a bit configuration of B-A-8-4-2 for the d-character. This instruction, by setting the interrupt interlock, prevents the processing unit from honoring any interrupt requests. The interrupt interlock is reset by the ENABLE-INTERRUPT instructions.

Disable Interrupt and Branch

Op code	*I-address*	*d-Character*
K	xxx	<

The DISABLE-INTERRUPT-AND-BRANCH instruction is made up of K as the operation code, a 3-character I-address representing the next instruction, and a bit configuration of B-A-8-4-2 as the d-character. This instruction is the same as DISABLE INTERRUPT except that the next address is specified by the branch address.

Example of Interrupt Subroutine

Assume that the main program is interrupted at address 494.

Instruction Address	*Instruction*			*Remarks*
182	H	370		Store the B-address register
186	B	700		Unconditional branch
700	O	900		Scan 1448
704	#	380	370	Modify address by minus four (380 contains the constant I9F, the 16,000's complement of 4)
711	M	370	721	Move the address to the ENABLE AND BRANCH operation
718	K	490	>	Enable INTERRUPT, and return to the main routine

1448 Interrupt Timing

The interrupt precedes a possible 1448 buffer overflow by at least the number of milliseconds in time A of Figure 13. It follows a scan operation no sooner than time B of Figure 13. The minimum time between a scan operation and a possible 1448 buffer overflow is time C of Figure 13.

The maximum time for noninterruptible operations in the main program, immediately following a scan operation, is 132.5 ms (14.8 cps) *minus* the time taken by the interrupt routine. Assuming that the time from INTERRUPT to the execution of the scan operation is 4.0 ms for 1440 or 2 ms for 1460, the maximum length of a noninterruptible operation in the main program is about 128.5 ms (time D for 14.8 cps) for 1440 or 130.5 ms for 1460.

With a mixed system (more than one type of terminal) the shorter time applies.

Scan Operation Execution Time

The formula for the scan-operation execution time (T) for the 1440-1448 is:

Character Rate of Terminal	Characters Per Second	
	14.8	60
Time A	67.5 ms	26 ms
Time B	59 ms	59 ms
Time C	132.5 ms	90.2 ms
Time D	128.5 ms	86.2 ms

Figure 13. Interrupt Timing

T = (I+2+2N+5M+6P+7R) 11.1 microseconds.
(For 1460-1448, substitute 6 microseconds wherever 11.1 microseconds appears.)
I = The number of characters in instruction (4).
N = The number of idle lines or receiving lines with empty line buffers, and/or the number of transmitting lines with one or more characters in the line buffers at the beginning of the scan operation, and/or the number of polling lines that do not need a new polling address.
M = The number of receiving lines with one character in the line buffers at the beginning of the scan operation.
P = The number of receiving lines with two characters in the line buffers, and/or the number of transmitting lines with empty line buffers at the start of the scan operation.
R = The number of lines in RECEIVE—CONTROL status that are transferring 2-character polling addresses from the processing unit to the 1448.

Minimal execution time:

T = (I+2+2L) 11.1 microseconds.
L = The number of lines.

Maximum execution time:

T = (I+2+7L) 11.1 microseconds.

Branch on End of Block

Op code	*I-address*	*d-Character*
B	xxx	>

The BRANCH-ON-END-OF-BLOCK instruction is made up of B as the operation code, an I-address, and the d-character > with a bit configuration of 8-4-2.

When a processing unit status character contains an end-of-block bit, the end-of-block indicator turns ON. If it is ON when the BRANCH-ON-END-OF-BLOCK instruction is executed, the next instruction is taken from that branch address. If the indicator is OFF, the program continues to the next sequential instruction.

The indicator is reset at the start of each scan operation.

Branch on Early Warning

When the application of the system calls for allocation of data in variable lengths as opposed to message-blocking, use this early-warning technique.

The early-warning indicator comes on when a group mark (without word mark) is detected in the assembly area of processing unit storage during a scan operation data cycle. The group mark indicates penetration into the early-warning zone and, depending on the size of the early-warning field, that the end of the assembly area is about to be reached.

Op code	*I-address*	*d-Character*
B	xxx	<

The BRANCH-ON-EARLY-WARNING instruction is made up of B as the operation code, an I-address, and the d-character < with a bit configuration of B-A-8-4-2.

When the early-warning indicator is on, this instruction turns it off and causes a branch to the I-address (address of the chaining subroutine). There the program may first locate lines that require more assembly area, then provide new assembly blocks and add a link address to the previous blocks. When this type of storage allocation is used, the program issues this branch instruction after every scan operation.

The low-order positions of the storage block should contain at least the number of consecutive group marks that equals the maximum number of characters that can be transferred during a single scan operation for that line. The last group mark of the series can be followed by three positions for the link address provided by the chaining subroutine.

All group marks turn on the early-warning indicator. The first group mark provides the initial warning. Subsequent group marks are also used in one or more of these ways:

1. Locating the assembly block requiring chaining (by testing for absence of group marks).
2. Timing the buffers to allow for the actual delay in locating and chaining to the block in an early-warning condition.
3. Determining the penetration of data into the early-warning area (group-mark area).

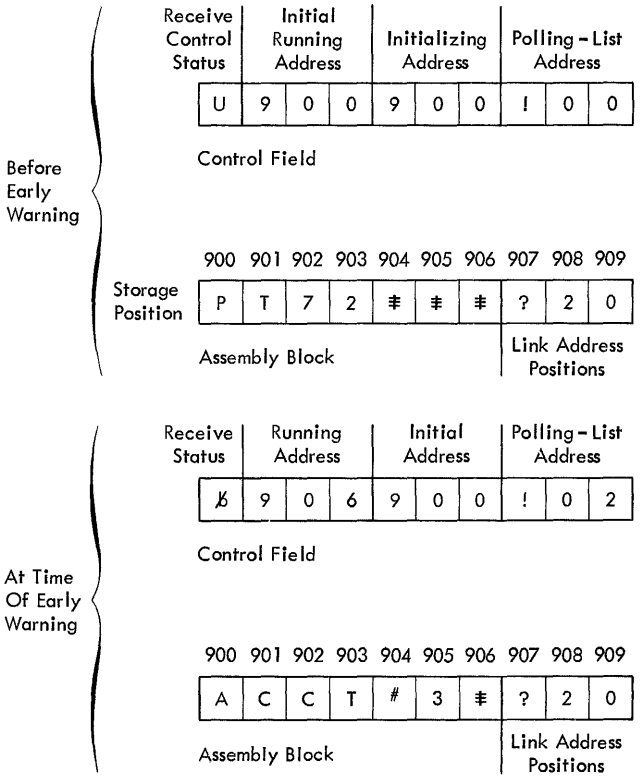

Figure 14. Control Field and Assembly Block During Early-Warning

The example in Figure 14 shows the effect of the early-warning on the assembly area. The message is "Acct #38.....etc." The line status in the control field first shows that the line is in RECEIVE—CONTROL (U) status and polling. The initial-running address and initializing address show that the first assembly block of storage assigned to this line begins in location 900. The line automatically goes to RECEIVE (b) status when a terminal designates that it is ready to transmit. During subsequent scan operations, characters move to the assembly position specified by the running address.

When a character moves to the first group-mark position (location 904) the group mark is detected and the early-warning indicator comes on. The character replaces the group mark. After the execution of the scan operation the BRANCH-ON-EARLY-WARNING instruction is issued (as after every scan operation). Because the indicator is on, the program branches to the chaining subroutine. This occurs for any scan operation during which a group mark without a word mark is detected in the assembly area or the distribution area.

When the line is in TRANSMIT status, the same early warning occurs. The group mark is sent to the 1448 and is replaced in the processor by a C-bit only (blank). The 1448 converts the group mark to an idle character, which is sent on line to the terminal.

Direct Data Channel Interrupt

Direct-data-channel interrupt is standard with the transmission-control-unit (1448) attachment. It is *not* available on the direct-data-channel *without* the attachment.

With the direct-data-channel interrupt, an interrupt request in computer A (1440 with 1448) is made when computer B (host computer) indicates that it is requesting to read from computer A, or indicates that it is requesting to move data to computer A.

The main program is interrupted when an instruction is being read, but before the actual execution of that instruction. Only unchained instructions can be interrupted.

An interrupt request by the direct-data-channel causes the 1440 to start checking the instruction readouts for an interruptible point. This is accomplished by interrogating the fifth instruction (actually I_4) readout cycle for no B-register word mark.

The actual interrupt causes a program skip to address 182 where the first instruction of the interrupt routine should start. The 1448 interrupt routine should contain a test for direct-data-channel interrupt.

The direct-data-channel interrupt request is reset when it actually causes the interrupt. If the 1448 interrupt request causes an interrupt first, the direct-data-channel interrupt request is not reset, and a subsequent interrupt will occur after the enable interrupt or enable interrupt and branch in the 1448 interrupt routine.

The following listing indicates the maximum number of characters that can safely be transferred over the direct-data-channel after a successful connection has been established:

Machines Connected	*Nominal Transfer Rate*	*Maximum Characters*
1441-1441	80KC	80,000
1441-1461	90KC	90,000
1461-1461	148KC	148,000

Line Control

Line Modes

Time on the communication line is divided into two modes, LINE CONTROL mode and TEXT mode. The coded characters have a different meaning in each of the two modes.

Line-Control Mode

In the LINE-CONTROL mode, the characters are interpreted as line-control signals, polling signals, and addressing signals. In this mode, signals control the transmission line, and are not read by the data processing components. Figure 15 is a list of processing unit line-control characters.

When a terminal receives an EOT (end-of-transaction) signal from the 1448, the terminal goes to, or remains in, the LINE-CONTROL mode. If the terminal is in selected status, it goes to a nonselected status.

Description	Symbol	Processor Bit Configuration	Processor Character
End of Transaction (EOT)	Ⓒ	C-8-4-2-1	¬ (tape mark)
Address Select (Control)	Ⓢ	C-A-8-2-1	, (comma)
End of Address (EOA)	Ⓓ	8-2-1	# (pound sign)
Negative Response (Control)	Ⓝ	B	- (hyphen)
Positive Response (Control)	Ⓨ	B-A-8-2-1	. (period)
Negative Response (Text)	ⓝ	B	- (hyphen)
Positive Response (Text)	ⓨ	B-A-8-2-1	. (period)
Positive Response (Inquiry)	ⓓ	8-2-1	# (pound sign)
End of Block (EOB)	Ⓑ	A-8-2	‡ (record mark)

Figure 15. Processing Unit Line-Control Characters

Text Mode

In the TEXT mode, the characters are interpreted the same as those that make up messages in the interchange between the 1448 and the terminal components. They consist of graphic characters, interstation control characters (such as upper-case and line-feed) and checking characters.

Transmission Procedure

The transmission procedure varies, depending on the terminal.

IBM 1060 to IBM 1448, Half-Duplex, Multipoint

This section illustrates a general, centralized, multipoint, half-duplex transmission from the IBM 1060 Data Communication System to the 1448.

Initially the 1448 and the 1060 are in the TEXT mode.

The program of the processing unit:

1. Initializes the control-field running address to an assembly area.
2. Initializes the polling-list address to the beginning of the appropriate polling list.
3. Sets the line status to RECEIVE—CONTROL.
4. Executes a scan operation.

The 1448:

1. Changes its status to RECEIVE—CONTROL.
2. Receives a polling-address from the processing unit via a scan operation.
3. Automatically generates an EOT character (C) onto the line when it is changed to the CONTROL mode from the TEXT mode. This puts all receiving terminals into the CONTROL mode.
4. Transmits the first polling address. This might be A5.
5. Waits for an answerback from the polled terminal.

When the 1448 receives a negative response (N), it obtains the next polling address from the processing unit during the next scan operation, and resumes polling. If the 1448 receives no response within a limited time (time out) of 540 ms, it generates an EOT character (C) to the line. It obtains the next polling address from the processing unit during the next scan operation and resumes polling.

Any response other than negative (N) or affirmative (D) causes the 1448 to change to RECEIVE—CHECK status and to end polling. The processing unit status changes to RECEIVE and does not get the check condition until an EOB condition occurs. The line goes to CONTROL-CHECK EOB status on normal text time-out if no text characters are received. The affirmative (D) response is the EOA (end-of-address) character, which changes 1448 status to RECEIVE. The EOA character (D) results if an execute key at the terminal is pressed before the terminal is polled. The EOA puts the terminal into the TEXT mode. Text characters follow the EOA.

Figure 16 shows that the first terminal and component polled responds with (N), or that it is not ready to send. The 1448 requests an interrupt. After the interrupt and scan operation, it continues to poll, using the next terminal-and-component address, B5, provided by the processing unit's polling list. Terminal B responds with a (D) to indicate that it is ready to transmit.

The 1448 goes to RECEIVE status, it stops polling, and receives transmission from terminal B.

During the next scan operation, the 1448 changes the processing unit status to RECEIVE. During subsequent scan operations, data is transferred to the processing unit assembly area specified by the running address in the control field. The terminal eventually sends an EOB (B) character to indicate the end of a unit or block of data, but not necessarily the end of the complete transmission. The terminal then sends an LRC (longitudinal redundancy check) character to be compared with the 1448 LRC character. At this point the terminal is locked out until verification of its last transmission.

After the LRC comparison, the 1448 changes its status and the processing unit's status during the next scan operation to RECEIVE—EOB. Or, if a VRC (vertical redundancy check) parity error or LRC error is detected, it changes its status and the processing unit's status to RECEIVE—CHECK—EOB. In either status, the EOB indicator is set in the processing unit and the 1448 makes an interrupt request. The processing unit's program, upon detecting the RECEIVE—EOB or the RECEIVE—CHECK—EOB, releases the answerback to the terminal by changing line status to either RECEIVE—IDLE or RECEIVE—IDLE—CHECK.

The program can either release the answerback immediately on the basis of the VRC or LRC check, or it can wait and include the results of a programmed format or field check.

If the program change line status to RECEIVE—IDLE, the 1448 generates a positive (y) answerback to the terminal. This indicates that the previous block was correct, and the program changes the status to RECEIVE—CONTROL, or CONTROL, and a (C) is sent by the 1448. If the program changes the status to TRANSMIT, the program sends the (C).

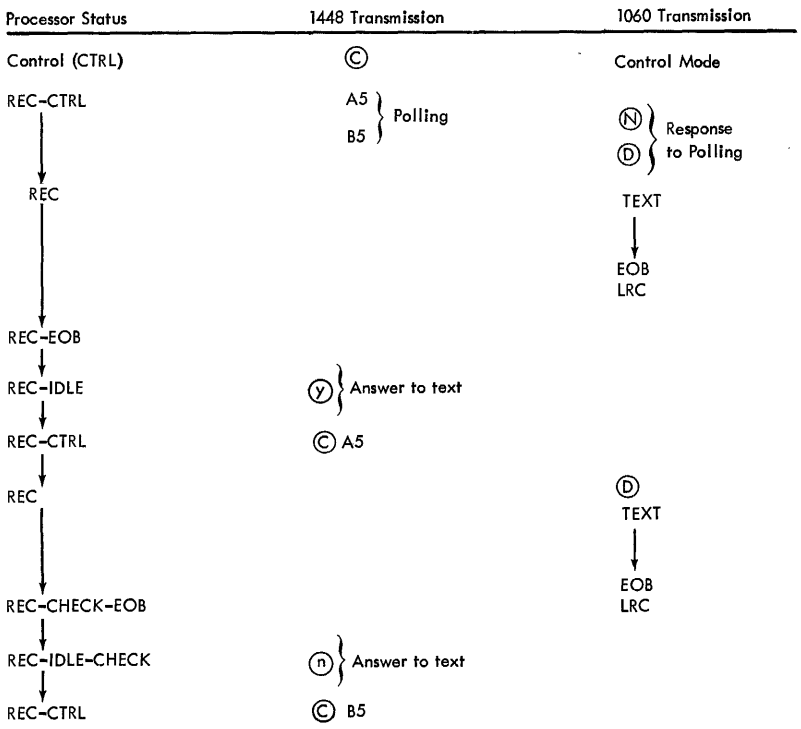

Figure 16. General Multipoint, Half-Duplex Operation (1060 to Processing Unit—1448)

If the program changes line status to RECEIVE—IDLE—CHECK, the 1448 generates a negative n answerback to the terminal. This indicates the previous block was incorrect, and requests a retransmission. The program changes the status to RECEIVE—CONTROL, or CONTROL, and a (C) is sent by the 1448. If the program changes the status to TRANSMIT, the program sends the (C).

IBM 1050 to IBM 1448, Half-Duplex, Multipoint

This procedure is the same as that described under IBM *1060 to* IBM *1448, Half-Duplex, Multipoint, with* these three exceptions:

1. The (D) response to polling is automatic when the transmitting component at the 1050 is ready (cards in card reader, tape in tape reader, and the component switch in an assigned position).
2. The processing unit does *not* go to CONTROL, RECEIVE—CONTROL, or TRANSMIT from RECEIVE—IDLE or RECEIVE—IDLE—CHECK. It waits for either the next block of data or (C) from the terminal. The next block of data, which can omit the initial (D), changes the 1448 to RECEIVE status. The (C) changes the 1448 to CONTROL—EOB. The line can go to CONTROL, RECEIVE—CONTROL, or TRANSMIT from any EOB status or CONTROL status.
3. The terminal sends the EOT (C) character after receipt of its last block of data has been confirmed by the 1448. The 1448, upon recognition of the (C), changes the processing unit status to CONTROL—EOB. The program then returns the line to polling (RECEIVE—CONTROL) or leaves the line locked out (CONTROL) or in TRANSMIT status.

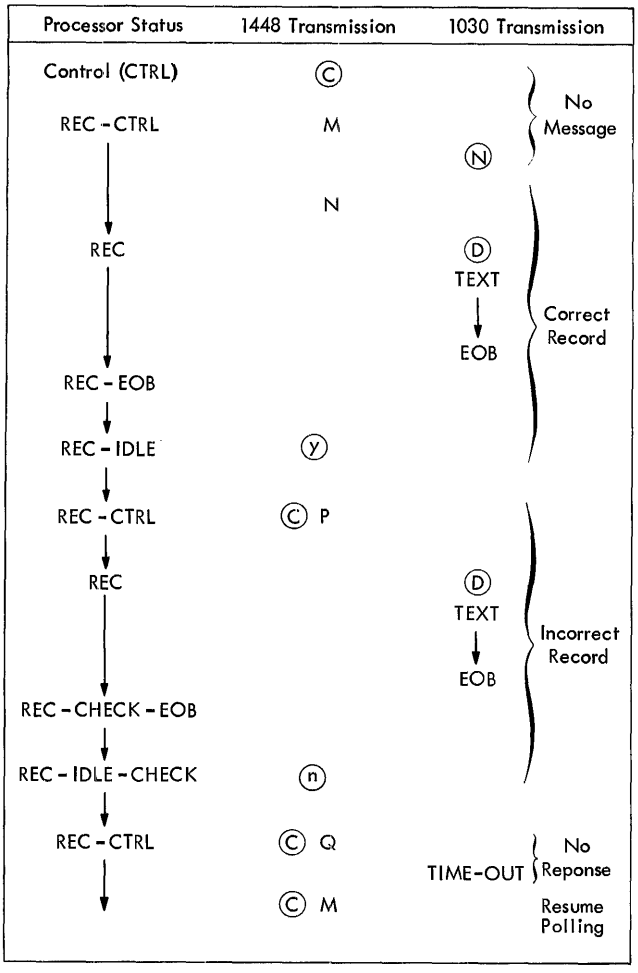

Figure 17. General Multipoint, Half-Duplex Operation (1030 to Processing Unit—1448)

IBM 1030 to IBM 1448, Half-Duplex, Multipoint

This procedure is the same as that described under IBM *1060 to* IBM *1448, Half-Duplex, Multipoint,* except that the polling address is a single alphabetic character, excluding A and J.

Figure 17 illustrates this procedure with the 1030. As shown, if the 1448 transmits a negative answer (n) to the terminal, the 1448 goes to the next termial address (Q) and does not allow terminal P to retransmit until addressed again. The (C) resets lines to the control mode and initiates polling.

IBM 1448 to IBM 1060, Half-Duplex, Multipoint

Figure 18 illustrates the transmission sequence where the processing unit makes a successful bid for the transmission, and the processing unit-1448 combination addresses and transmits to an IBM 1060. The 1448 and the processing unit are initially in the RECEIVE—CONTROL status for the particular line, and the 1448 is polling the terminals on the line. If the program calls for the processing unit to send a transmission, it must first make a bid for the line to avoid contention with a terminal that may be transmitting. The program therefore changes its line status to RECEIVE—CONTROL—IDLE, and executes a scan operation that indicates to the 1448 that it is trying to secure the line from polling.

If the 1448 receives no response it goes to CONTROL—EOB—CHECK and requests an interrupt. If it receives a negative (N) response from the terminal being polled, it stops polling and changes its line status to CONTROL—EOB and requests an interrupt. During the susbsequent interrupt and scan operation, the 1448 changes the processing unit status character to CONTROL—EOB or CONTROL—EOB—CHECK and sets the processing unit EOB indicator. This indicates to the program that its bid for the line was successful.

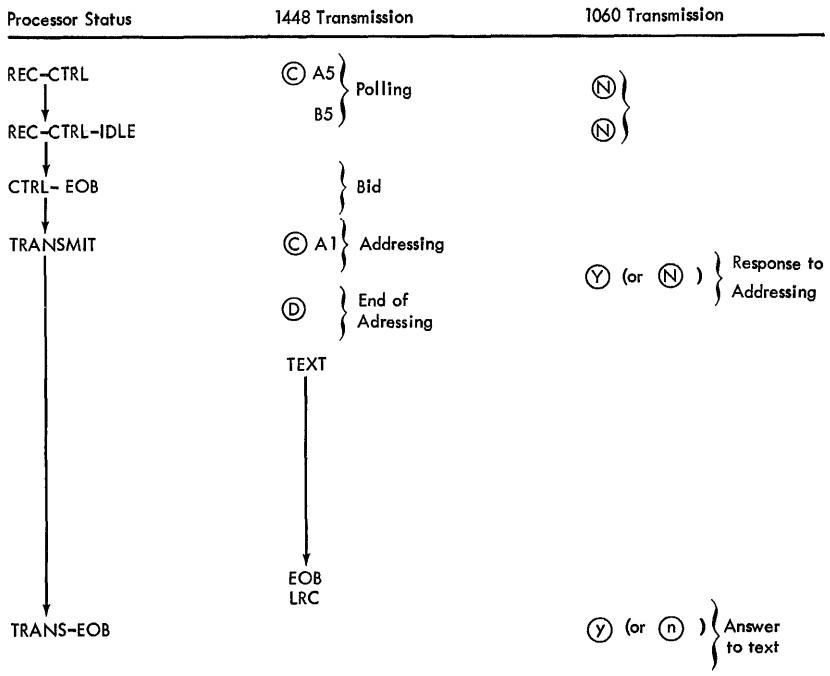

Figure 18. General Multipoint, Half-Duplex Operation (Processing Unit—1448 to 1060)

If the 1448 receives a positive (D) response from the terminal being polled, it changes its line status to RECEIVE, thus denying the program's bid for the line. If the 1448 receives a response other than (D) or (N), it changes its line status to RECEIVE—CHECK, thus denying the program's bid for the line. The program waits for any EOB status so it can take the line directly to TRANSMIT status.

In Figure 18, the processing unit's bid for the line is successful and the 1448 changes its own status and the processing unit's status to CONTROL—EOB. The processing unit's program then initializes the control-field running address to the beginning of the message to be transmitted, and changes the line status to TRANSMIT. The processing unit's program must include in each block of data transmitted, the correct terminal address and control characters.

The first character (C) (inserted by the programmer) ensures that all listening terminals are in the CONTROL mode. In Figure 18, station A is addressed. After transmitting the address (A1), the 1448 waits for a response from the terminal.

Any response to addressing other than positive (Y) causes the 1448 to go to TRANSMIT—CONTROL—EOB, and to set the processing unit EOB indicator. The processing unit detects that the terminal is not ready. Failure of the terminal to respond after a 2.1 seconds time-out by the 1448 also causes the line status to go to CONTROL—EOB—CHECK and terminates transmission.

A positive response (Y) from a terminal indicates it is ready to receive, as in Figure 18. The 1448, through the program, sends a (D) (installed by the programmer) to reset the LRC and to put the line into TEXT mode. The 1448 resumes transmitting the first block. When the 1448 recognizes the EOB character from the processing unit, it sends the LRC character to the terminal and waits for a text response from the terminal.

A negative response (n) from the terminal indicates the block was received incorrectly by the terminal, and the terminal will receive a retransmission. The 1448 changes its status to TRANSMIT—CHECK—EOB.

No response within a time-out (21 seconds) indicates the terminal did not receive the last block properly and is not ready for further transmission. The terminal may require operator attention. The 1448 changes it status to CONTROL—EOB—CHECK.

A positive response (y) from the terminal indicates the block was received correctly, and the terminal is ready for the next block if more is to be transmitted. The 1448 changes its status to TRANSMIT—EOB.

The 1448 requests an interrupt and, during the subsequent scan operation, changes the processing unit status to agree with its own, and sets the processing unit EOB indicator.

When the processing unit finishes transmitting, it can either return the line to polling by changing the status to RECEIVE—CONTROL, or leave the line secured by

changing the status to CONTROL, or go to TRANSMIT and transmit to another terminal.

IBM 1448 to IBM 1050, Half-Duplex, Multipoint

This procedure is the same as that described under IBM *1448 to* IBM *1060, Half-Duplex, Multipoint.*

The program must include in the first block of data transmitted from the 1448, the correct terminal and component identification and control characters.

The first character (C) ensures that all listening terminals are in the CONTROL mode. The next characters are the terminal and component characters. After transmitting the address, the 1448 waits for a response from the terminal. More than one terminal can be addressed at a time by group addressing. One terminal is used (through circuitry) as the control unit for that group.

IBM 1448 to IBM 1030, Half-Duplex, Multipoint

This procedure is the same as that described under IBM *1448 to* IBM *1060, Half-Duplex, Multipoint,* with the exception of the address-select character as described here.

The program must include, as shown in Figure 19, in the first block of data transmitted from the 1448, the control characters (C) and (S) and the correct terminal-and-component identification.

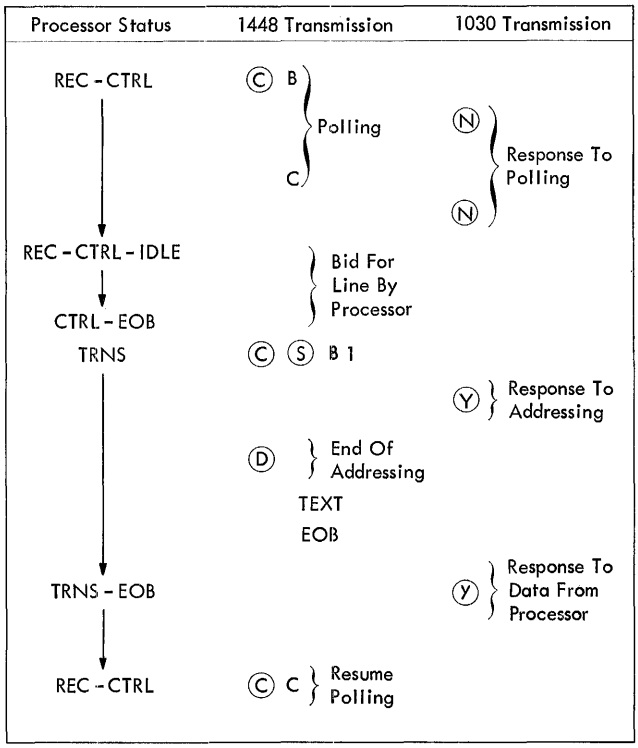

Figure 19. General Multipoint, Half-Duplex Operation (Processing Unit—1448 to 1030)

The first character (C) ensures that all listening terminals are in CONTROL mode. The next character is the address-select character (S) (processing unit BCD code is C-A-8-2-1) which indicates to the terminals that they are being addressed (requested to accept data) rather than polled (allowed to transmit data) and that the next characters are the terminal-and-component identification. The terminal character is alphabetic (excluding A and J) and the component character is the digit 1. After transmitting the address, the 1448 waits for a response from the terminal.

IBM 1060 to IBM 1448, Half-Duplex, Point-to-Point

The difference between general point-to-point half-duplex and multipoint operations lies in the polling function. In point-to-point operation only one terminal is on a line. When the line status is changed to RECEIVE—CONTROL, the single terminal is continuously selected. To prevent contention, the processing unit's program must bid for the line via the RECEIVE—CONTROL—IDLE status as in multipoint operation. See the section *Point-to-Point Channels,* under *Polling.*

IBM 1050 to IBM 1448, Half-Duplex, Point-to-Point

The difference between general point-to-point half-duplex and multipoint operations lies in the polling function. In point-to-point operation only one terminal is on a line. See the section *Point-to-Point Channels,* under *Polling.*

IBM 1030 to IBM 1448, Half-Duplex, Point-to-Point

This procedure is the same as described under IBM *1060 to* IBM *1448, Half-Duplex, Point-to-Point.*

Inquiry Operation (1050)

This operation is used in IBM 1050 inquiry procedures. The terminal originates the transaction by sending one or more blocks of data that require a reply of a block of data from the processing unit and 1448. The 1448 should maintain the connection until the reply is sent and verified rather than allowing the line to resume polling. After sending the reply, the processing unit-1448 ends the transaction and returns the line to polling.

Figure 20 of this publication illustrates the inquiry operation. The procedure is similar to those described previously with certain differences.

The terminal must originate the inquiry operation by transmitting one or more blocks of data. The last block from the terminal must be identified either in the text or by some predetermined systems procedure.

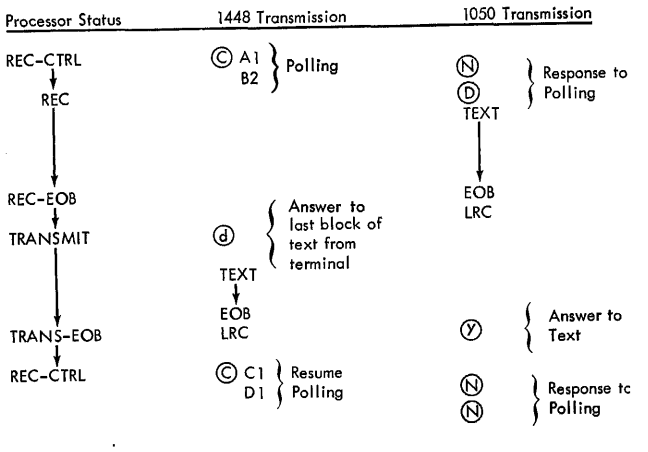

Figure 20. Inquiry Operation

After the last block of data from the terminal, the processing unit's program obtains and formats the required reply. The receiving terminal components should be ready to receive. The program prefixes the first outgoing block of data to the terminal with ⓓ. The processing unit's program changes the line status to TRANSMIT, and executes a scan operation. The ⓓ becomes the answer to the last block of data from the terminal. It indicates to the terminal that its last transmission was received by the processing unit-1448.

After transmitting the last block of data, the program ends the transaction by changing the line status to RECEIVE—CONTROL. This causes an end-of-transaction character Ⓒ to be transmitted and returns the line to polling. If polling is not desired, the program can change the line to TRANSMIT status with a Ⓒ as the first character to be transmitted. Or, the program can change the line to CONTROL, causing the Ⓒ to be transmitted. The line is then set to the desired status.

In an inquiry operation:

1. The terminal originates the transaction by sending one or more blocks of data.
2. Only one exchange of data is allowed.
3. The processing unit-1448 prefixes its first block of data with a ⓓ.
4. The processing unit-1448 terminates the transaction by transmitting a Ⓒ onto the line.

Transmission of Ⓒ

The conditions that cause the 1448 to transmit a Ⓒ are:

1. When modifying the 1448 status to any legal status containing a control bit from a status not containing a control bit.
2. For auto answer lines, when first receiving the clear-to-send signal from the data set when the 1448 is in auto answer mode.
3. When time-out on RECEIVE-CONTROL status occurs.
4. When the 1448 status is modified to CONTROL—EOB as a result of:
   a. a successful program bid for the line, or
   b. receiving a Ⓒ when the 1448 status is RECEIVE—IDLE or RECEIVE—IDLE—CHECK, or
   c. auto-call lines successfully making connection with the communication line at the dialed number.
5. When the 1448 status modifies to CONTROL—CHECK—EOB as a result of a time-out condition.
6. When the 1448 status modifies to TRANSMIT—CONTROL—EOB as a result of a response other than Ⓨ to addressing.

Time-Outs

The 1448 provides various automatic time-outs to prevent system tie-ups due to faulty conditions on a receiving line and to interlock transmission to allow time for certain terminal-control functions.

Text Time-Out

During the reception of text, the 1448 recognizes when the line goes to an inactive condition, and stays there for a predetermined time before the 1448 receives an EOB or EOT character. If at the end of this time, the lines does *not* resume transmission, the 1448 changes the line status to CONTROL—EOB—CHECK.

The duration of text time-outs is 21 seconds.

Text Response Time-Out

After the 1448 sends the EOB character and its LRC character to a terminal, it waits for a specified time for the required response from the terminal. If, at the end of this period, no response is received the 1448 takes the status to CONTROL—EOB—CHECK.

Duration of this time-out is the same as for the text time-out.

Polling Answerback Time-Out

If the 1448 does not receive a reply to a polling address within 540 milliseconds, it transmits a Ⓒ on the line and polls the next terminal.

Addressing Answerback Time-Out

If, after sending an address selection to a terminal, the 1448 does not receive a reply within 2.1 seconds, it changes the line status to CONTROL—EOB—CHECK.

Printer-Control-Function Time-Outs

The 1448 time-out of one second is available for new line, line feed, or horizontal tabulating, or for all three.

If the 1-second time is not suitable, programmed message formatting can take its place. The necessary format for new line is: the new-line character, plus one idle character for each inch (or fraction of an inch) to be skipped, plus one idle character for the line-feed operation.

For horizontal tabulating, the required format is: the tab character plus one character for 4-14 spaces, tab character plus two idle characters for 15-25 spaces. For each additional 11 spaces (or fraction of 11 spaces) another idle character must be added to the message.

For line feed the format is: line-feed character plus one idle character.

Break-In

Because of various internal contention problems for a line in the system, a break-in procedure is necessary to temporarily delay the incoming traffic to transmit some of the outgoing traffic that has accumulated.

To break in while a 1050 terminal is transmitting a message, the 1448 sends a (c) as an answer to the terminal turning on the terminal's resend light. The interrupted message is not accepted by the 1448. The 1448 then addresses a terminal, and upon receiving an affirmative response (y) it transmits its message to the addressed terminal. After the terminal has answered with a (y) the 1448 resumes polling. The interrupted terminal manually sets up the interrupted message for retransmission when it is again polled.

Status Structure

Status characters (for each line) in the processor and in the 1448 provide communication between processing unit and transmission control unit.

The status characters in the processing unit perform six major functions:

1. To provide the program with an updated report on line status and/or message status for each line.
2. To provide the program a means to change line status on each line independently.
3. To provide automatic line lockout on each line until the program performs the required operation.
4. To provide a means by which the lines can be secured systematically for other operations by the processor.
5. To provide a means of releasing an answerback to received text, which reflects format checks as well as VRC and LRC conditions, and which gives a proceed signal to the terminal.
6. To reflect terminal ready and not-ready conditions. The status character is either a single bit or a combination of these bits:

Status	*Bit Assignment*
END-OF-BLOCK	Word mark
RECEIVE	A
TRANSMIT	B
END-OF-STORAGE-AREA	8
CONTROL	4
CHECK	2
IDLE	1

Status Characters

As shown here, the name of each processing-unit status character is followed in parentheses by the bit configuration, then by the processing-unit character that designates the status (the underscore indicates a word mark).

Although the 1448 initiates most status changes, the processing unit initiates these six statuses:

1. RECEIVE—CONTROL (C-A-4) (U) indicates the line is being polled by the 1448.
2. RECEIVE—CONTROL—IDLE (A-4-1) (V) indicates the program is attempting to regain control of the line that it has previously set to a RECEIVE—CONTROL status.
3. CONTROL (4) (4) indicates the line is inactive. No activity can take place on the line until the processing unit program changes the status.
4. RECEIVE—IDLE (C-A-1) (/) indicates, after an EOB from the terminal, that the block just transmitted was received correctly and that the terminal can proceed if it has another block to transmit.
5. RECEIVE—IDLE—CHECK (A-1-2) (T) indicates, after an EOB from the terminal, that the block just transmitted was received incorrectly or failed a program-format check, and that the terminal can retransmit.
6. TRANSMIT (B) (=) indicates the 1448 is transmitting from the distribution area onto the line.

As shown in Figure 21, the processing unit can change the 1448:

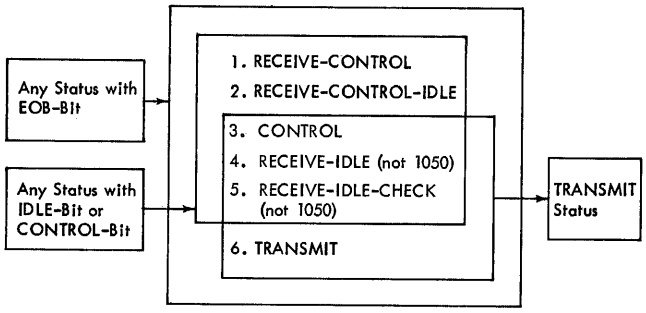

Figure 21. Processing Unit Line-Status Character Transistions

- To any of these six statuses from any status with an EOB bit.
- To any of these statuses *except* TRANSMIT from any status with an IDLE bit or a CONTROL bit.
- To TRANSMIT status from any of these six statuses *except* RECEIVE — CONTROL and RECEIVE — CONTROL — IDLE.

Other processing unit status characters are:

RECEIVE (A) (b) indicates the 1448 recognized a positive response to polling or a start transmission, and is receiving a message on that line.

RECEIVE—END-OF-BLOCK (C-A-WM) (b) indicates that an incoming block of data has been completed and is in the assembly area awaiting a response and further program action.

RECEIVE—END-OF-BLOCK—CHECK (A-2-WM) (S) indicates that an incoming block has been completed and the 1448 has detected a check condition. The terminal is waiting for a response. The check condition results from one or more of these:

1. Character parity-check failure
2. Message LRC failure
3. Buffer overflow in the 1448
4. 1448 parity-check failure as data is transferred through the 1448
5. First character of message was other than (D)
6. The 1448 has detected an EOT (C) before an EOB (B).

RECEIVE—END-OF-BLOCK—END-OF-STORAGE-AREA (A-8-WM) (Y) indicates an incoming block has been completed but exceeds the bounds of the assigned storage area.

RECEIVE — END-OF-BLOCK — END-OF-STORAGE-AREA — CHECK (C-A-8-2-WM) (±) indicates that an incoming block has been completed, but contains a check condition and exceeds the bounds of the assigned storage area.

TRANSMIT—END-OF-BLOCK (C-B-WM) (=) indicates a block has been transmitted successfully.

TRANSMIT—END-OF-BLOCK—CHECK (B-2-WM) (K) indicates that a block has been completed, and that a check condition was detected. The check condition results from one or more of these:

1. A parity-check failure
2. A negative response from the terminal
3. An invalid response from the terminal.

TRANSMIT—END-OF-STORAGE-AREA—END-OF-BLOCK (B-8-WM) (Q) indicates a group-mark with a word-mark was recognized in the processing unit's distribution area before an EOB character. When the group-mark with a word-mark is recognized here, an invalid character is sent onto the line.

TRANSMIT — END-OF-STORAGE-AREA — END-OF-BLOCK — CHECK (C-B-8-2-WM) (!) indicates the same as the previous status character, but a check condition is also detected.

RECEIVE—CONTROL—END-OF-BLOCK (A-4-WM) (U) indicates an end-of-polling list, or that a group-mark with a word-mark (B-A-8-4-2-1-WM) in the polling list was detected by the 1448 while polling.

CONTROL—END-OF-BLOCK (C-4-WM) (4) indicates one or more of these:

1. A terminal has sent an EOT character
2. The line has been secured from polling by the 1448 as a result of a successful bid by the program.

END-OF-BLOCK—CHECK (C-2-WM) (2) indicates that at least one of these situations has been detected:

1. 1448 status parity check
2. Invalid processing unit status
3. Improper status sequence
4. Data set equipment interlock off
5. No data set equipment connection signal during text (automatic calling and automatic answering only).

CONTROL—END-OF-BLOCK—CHECK (4-2-WM) (6) indicates that the 1448 has been delayed beyond the time-out while waiting for one of these:

1. A new data character while in RECEIVE status
2. An address answerback
3. A response to a transmitted block of data
4. A response from the terminal while 1448 is in RECEIVE—IDLE—CHECK or RECEIVE—CONTROL—IDLE status.

TRANSMIT—CONTROL—END-OF-BLOCK (B-4-WM) (M) indicates an answer from the terminal to addressing other than (Y).

Status-Character Operation

Figure 22 is a flowchart of the status-character operation. In the processing unit, the status characters in the control fields can be interrogated any time by the program to determine the status of any line and/or message.

In the transfer portion of the 1448, for every line in sequence, during every processing unit operation (every 135 ms or less with the IBM 1060 or 1050; 90 ms or less with the 1030) the following occurs:

The processing unit and 1448 status characters are read out to the 1448 status-compare-and-modify circuitry. As a result, either, or both, or none of the status characters are modified. The original or the modified status characters are then referred to their respective storage locations.

In the line scan portion of the 1448, the 1448 status character for every line is presented sequentially and automatically to its associated line adapter each 1448 line-scan cycle (about 1 ms). The 1448 status character controls the adapter and may be modified by conditions recognized and presented by the adapter.

Input/Output Operations

On-line input/output while using the 1448 is limited:

1. The I/O device must be programmed so the processing unit is not interlocked longer than the maximum noninterrupt interval. This includes execute time and any *wait* time because the device is busy, or still in a previous cycle time.
2. I/O stop conditions may cause message overflow in the 1448. The 1448 automatically changes status to indicate to the program that a retransmission is required.
3. I/O operations should be preceded by IBM 1448 scan operations to ensure maximum allowable noninterruptible intervals.

When possible, batched I/O operations should be scheduled when the processing unit is not receiving or transmitting.

For more I/O timing information, see the Systems Reference Library publications as listed in the IBM *1440-1240 Bibliography,* Form A24-3005, and IBM *1401/1460 Bibliography,* Form A24-1495.

1442 Card Reading

The read cycle of the IBM 1442 Card Read-Punch, Model 1, is 210 ms. The processing-unit interlock time for a card cycle is calculated:

$T = 32.4 + 1.3\ L_B$ ms

L_B = number of columns read

The read cycle of the IBM 1442, Model 2, is 160 ms. The processing unit-interlock time for a card cycle is calculated:

$T = 26.1 + 1.0\ L_B$ ms

Figure 23 is a graph showing read-interlock time against the number of columns read. It shows the maximum number of columns that can be read in a card cycle during operation of the 1448 and processing unit.

When the 1442 is reading cards during processing unit-1448 operations, time between successive card-read operations must also be considered. The graph shows that all 80 columns of a card can be read by the 1442, Model 2, because interlock time is 106 ms and the maximum allowable noninterruptible interval is assumed to be 128.5 ms. But, if another read operation is given within 17 ms after the previous read operation, the system is interlocked for at least 128 ms, which, with tolerances, may cause an overflow in the 1448.

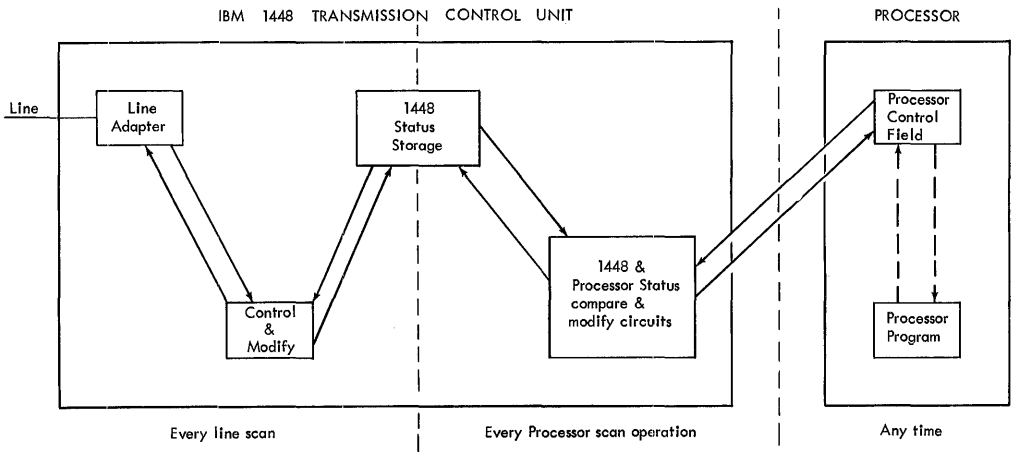

Figure 22. Status-Character Flowchart

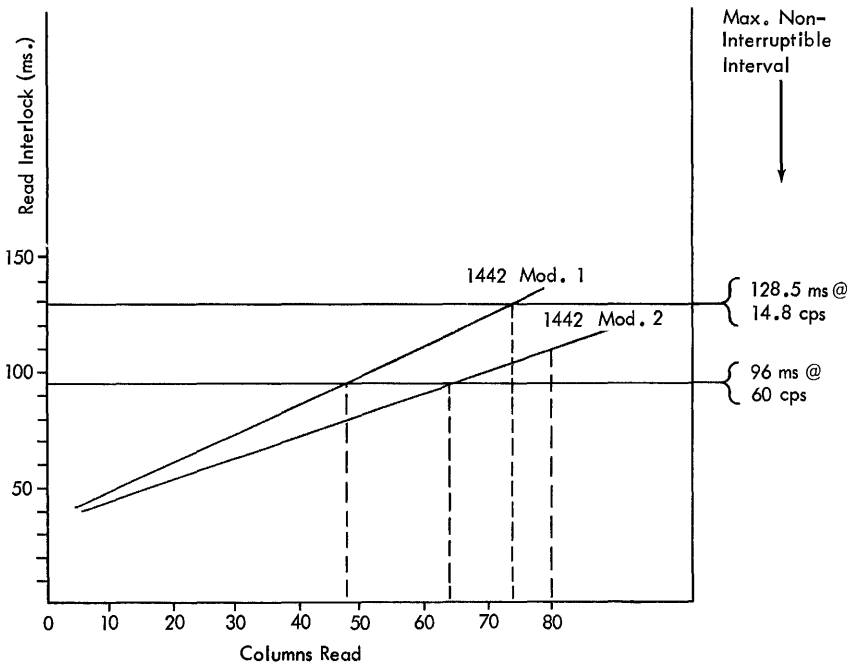

Figure 23. Read Interlock Time vs. Columns Read (1442)

1402 Card Reading

To read cards during 1460-1448 operations in the non-process-overlap mode, the IBM 1402 Card Read-Punch requires the early read feature.

A 1448 scan operation must precede the READ-A-CARD instruction.

With the early card read feature, the maximum non-interruptible interval is about 90 ms. If the read release feature is also used, as many as 21 ms of additional process time are available.

1442 Card Punching

The 1442 has two different punch operations:

1. The *punch* operation allows for multiple punch operations to punch in successive card columns of the same card.
2. The *punch and feed* operation ejects the card after punching.

After a card is registered at the punch station, the punch time is:

Model 1 – $T = .0111\ (L_I + 1) + 12.5L_B + 6.25$ ms

Model 2 – $T = .0111(L_I + 1) + 6.25L_B + 3.125$ ms

L_I = instruction length

L_B = last column punched

The time to advance a card from the read station to the punch station is 210 ms for Model 1 and 160 ms for Model 2.

A read-zero-columns operation can be used to register the first card at the punch station, and thus bypass the additional 210 or 160 ms of interlock on the first punch operation. Punch-and-feed operations register subsequent cards at the punch station.

Figure 24 is a graph showing the maximum number of columns that can be punched in a given punch operation. A punch operation can be given immediately after another punch operation and a 1448 scan operation sequence. A punch operation within 210 or 160 ms of previous punch-card-feed operation can cause a 1448 overflow.

1402 Card Punching

During 1460-1448 operations in the nonprocess-overlap mode, cards cannot be punched by the 1402.

1443 Printing

A buffered IBM 1443 Printer can be used during the 1448-processing unit operation with these considerations:

1. The printer should be tested for a *not-busy* condition before any print or carriage operation.

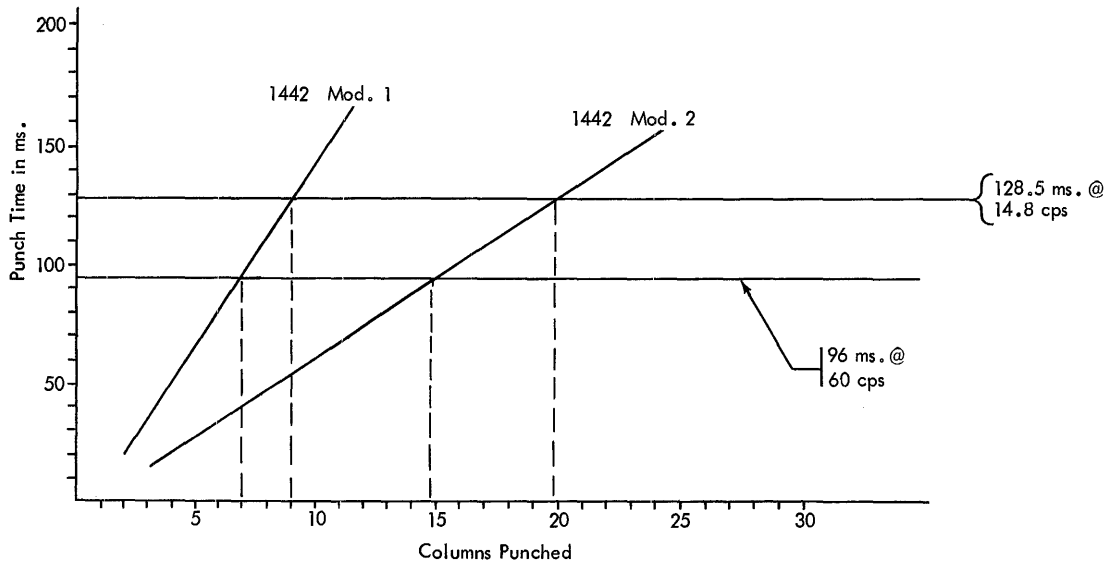

Figure 24. Punch Time vs. Columns Punched (1442)

2. Stop conditions cause a 1448 overflow on receiving lines. Refer to the subsection *Stop Conditions,* in the section, *Checking Procedure.*

Unbuffered 1403 Printing

An unbuffered IBM 1403 Printer can be used during the 1460-1448 operations. The 1460 is interlocked for about 84 ms during a write-a-line operation.

A 1448 scan operation must precede the WRITE-A-LINE instruction.

The BRANCH-ON-CARRIAGE-BUSY instruction should be given before a WRITE-A-LINE instruction. This prevents a system interlock if carriage movement time plus print time exceeds the maximum allowable noninterruptible interval.

Buffered 1403 Printing

A buffered IBM 1403 Printer can be used during 1460-1448 operations without a 1448 scan operation preceding the WRITE-A-LINE instruction.

BRANCH-ON-PRINTER-BUSY or BRANCH-ON-CARRIAGE-BUSY instruction must precede a WRITE-A-LINE instruction. This prevents interlocking due to printer-carriage or printer-busy conditions.

Magnetic Tape

Magnetic-tape operations can be performed in the non-overlap mode during 1460-1448 or 1440-1448 operations, with these important considerations:

1. 1448 scan operations must precede magnetic-tape instructions.
2. Maximum record lengths assure that the system is not interlocked longer than the maximum allowable noninterruptible interval. Figure 25 indicates approximate maximum record lengths. (The interrupt routine is assumed to be 10 ms without skip-and-blank-tape conditions. The maximum nontinterruptible interval is assumed to be 125 ms.)
3. The skip-and-blank-tape function adds to the interlock time of subsequent write operations and future read operations, and thus reduces the maximum allowable record lengths. Each skip-and-blank-tape

Magnetic Tape Unit		Maximum Record Length (in characters)	
		High Density	Low Density
729 II	Read	4700	1700
	Write	4900	1750
729 IV	Read	7400	2700
	Write	7500	2730
7330	Read	2340	840
	Write	2400	860
7335	Read	2340	
	Write	2400	
729 V	Read	6880	
	Write	7050	
729 VI	Read	10600	
	Write	10800	

Figure 25. Maximum Record Lengths

operation results in about 3.5 inches of erased tape. This equals about 46.6 ms on the 729 II and V, 31.1 ms on the 729 IV and VI, and 97.2 ms on the 7330 or 7335.

4. The processing unit is released from read-and-write-tape operations before the tape LRC character is read. If a BRANCH-ON-TAPE-ERROR instruction immediately follows a tape read or write instruction, the processing unit interlocks until the check character is read.
5. The tape adapter unit is interlocked during 7330 or 7335 stop time. For a 7330 or 7335 read operation, the tape adapter unit remains interlocked for 12.8 ms after the processing unit is released. If another tape instruction is given N ms after the processing unit is released, add 12.8 – N ms to the processing unit interlock time of the next tape operation (Figure 26).

   For a 7330 or 7335 write operation, the tape adapter unit remains interlocked for 15.3 ms after the processing unit is released. If another tape instruction is given N ms after the processing unit is released, add 15.3 – N ms to the processing unit interlock time of the next tape operation.

   IBM 729 Magnetic Tape Units remain interlocked, after the processing unit is released, during record-check time only.
6. A tape instruction to a tape unit that is rewinding interlocks the processing unit, and active 1448 receiving buffers may overflow.

   Backspacing interlocks the tape adapter unit. The processing unit does not execute a tape instruction given during backspacing.

   The processing unit interlocks when a write instruction is given on a tape unit with *File Protect* turned on.

During 1460-1448 or 1440-1448 operations, tape operation and programming discipline must be exercised to prevent these conditions from causing 1448 buffer overflows and the resulting requests for retransmission.

Disk Storage

When the IBM 1311 Disk Storage Drive is used in a 1440-1448 or 1460-1448 configuration:

1. Because of the timing considerations involved, it is recommended that the CIOCS for disk files be used. Refer to *Communications IOCS for IBM 1440: Operating Procedures*, Form C24-3111.
2. The maximum time allowed for a file read, write, or write check (on the 1311) is 80 ms. This figure does not include the rotational delay. Therefore, after 8 ms are subtracted for head selection, a maximum of 36 sectors should be written. This allows for a 3,600-character maximum record in the sector mode of operation.
3. If the user does not use CIOCS with files, he must take into account that most mechanical actions of the file take longer than the 1448 can tolerate without losing characters. Therefore, he must use programming techniques similar to those used in CIOCS for files.

Console

Figure 27 shows the keys, lights, and switches for the 1448 as they appear on the console.

Display Lights

These back-lighted indicators provide information about location and bit-configuration of data as it stands in storage.

Magnetic Tape Unit		Record Check Time (ms)		Stop Time (ms)	Tape Adapter Unit Remains Interlocked After Processor is Released (ms)
		556 BPI	200 BPI		
729 II	Read	0.2	0.6	2.1	0.2- 0.6
	Write	4.2	4.6	5.1	4.2- 4.6
729 IV	Read	0,1	0.4	2.1	0.1- 0.4
	Write	2.8	3.0	3.8	2.8- 3.0
7330	Read	0.4	1.0	12.5	12.8-13.5
	Write	8.7	9.3	6.6	15.3-15.9
7335	Read	0.4	—	12.5	12.9
	Write	8.7	—	6.6	15.3

Figure 26. Interlock Time for the Tape Adapter Unit

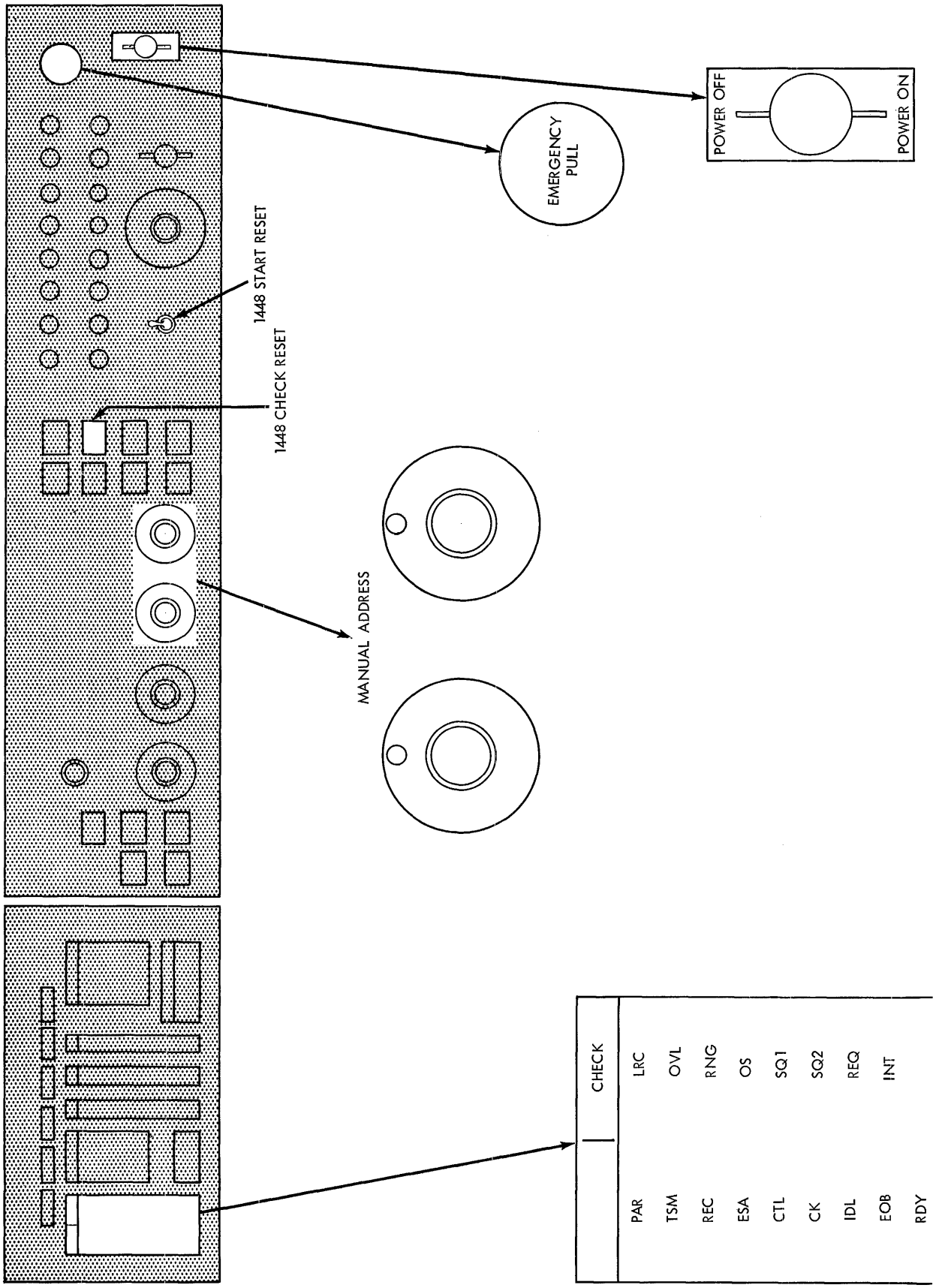

Figure 27. 1448 Keys, Lights, and Switches on the IBM 1447 Console, Model 4

The *status* light comes on to indicate a parity error in status or an invalid processing unit status.

The other display lights in this column refer to the status of the system:

PAR (Parity)
TSM (Transmit)
REC (Receive)
ESA (End-of-Storage-Area)
CTL (Control)
CK (Check)
IDL (Idle)
EOB (End of Block)
RDY (1440 is Ready)

The *check* light comes on to indicate a data parity error. The other display lights in this area include:

LRC comes on to indicate a longitudinal redundancy check at the end of a transmission.

OVL (Overflow) comes on to indicate that a 1448 buffer overflow occurred because the program exceeded the maximum allowable noninterruptible interval, or because of a processing-unit stop condition.

RNG comes on to indicate that during transmission an invalid address occurred for the message storage area.

OS (Out of Step) comes on to indicate that, at the end of the scan operation, the 1448 was not at the last channel address.

SQ1 and SQ2 indicate the sequence of line control operations.

REQ (Request) indicates the request for interrupt is on.

INT (Power Interlock) comes on to indicate that power is not on and that the data set equipment for the addressed line is not ready to operate.

Manual Address Switches

The two manual-address switches (units and tens) address a given data or control character in core buffer. To do this, set the units and tens switches to the line number with which the character is associated (the inner numbers refer to the 1448). The control character for a given line can be addressed by setting the line number in the units and tens switches.

1448 Start Reset Key

This key resets the complete 1448 system.

1448 Check Reset Key

This key resets IBM 1448 error indicators.

Emergency Pull

Only in an emergency, pull this to disconnect all power from the entire system. This switch must be reset manually by an IBM customer engineer before power is restored to the system.

Power On Switch

Operate this switch to turn power on and off in the 1448 and the 1440. It automatically returns to a central position when released.

Use Meter

The 1448 use meter switch is located on the 1448. The use meter operates as follows:

1. The 1448 meter runs whenever the processing unit is running, 1448 power is on, and the 1448 meter switch is on.
2. When the 1448 meter is off, an O-Op cannot be executed.
3. The 1448 meter switch will only change the mode of operation when the processing unit is halted (i.e., if the meter switch is thrown to the OFF position while the processing unit is running, the 1448 meter continues to run until the processing unit is halted).

Check Controls

Buffer Overflow in 1448

A RECEIVE—CHECK that results from buffer overflow is caused by trying to transfer the character from the assembly area into buffer position 2 (6 for 1030) before the processing unit has serviced that line and has accepted two previous characters.

Vertical Redundancy Check (Parity Check)

The 1448 vertical redundancy check (VRC) checks each character it sends or receives. If incorrect (even) parity is detected, the line status goes to RECEIVE—CHECK or TRANSMIT—CHECK. The 1448, under control of the processing unit, generates an answerback or waits for one, depending on whether receiving or transmitting.

Each character is stored in 1448 core storage as it is received (VRC or not) but an asterisk character is sent to the processing unit if a VRC character is detected (assuming CE panel switches are set for normal operation).

Longitudinal Redundancy Check

When receiving, the 1448 compares its own longitudinal redundancy check (LRC) character with the LRC character that follows the EOB of the message from the terminal. If the two do not compare, the 1448 generates a negative answer. If they do compare and no VRC or format error is detected, the 1448 generates a positive answer.

When transmitting, the 1448 transmits the LRC character and waits for the terminal's reply.

Status-Character Validity Check

Status characters in the processing unit and in the 1448 are checked for correct parity. An invalid character changes the line status to END-OF-BLOCK—CHECK.

Checking Procedure

The IBM 1050 or 1060 attached to the processing unit-1448 has both VRC and LRC checking features with answer.

Lights at the terminals indicate when the line connection is established for transmission. Other terminal lights indicate when the processing unit's program through the 1448 has returned a negative answer because of one of these conditions, and is requesting a retransmission:

1. VRC error detected by 1448.
2. LRC error detected by 1448.
3. Overflow of the 1448 buffers because the program exceeds the maximum allowable noninterrupt interval.
4. Overflow of the 1448 buffers due to a processing unit stop condition.
5. Failure to pass a format or some other stored program check.
6. Failure to answer polling with a (D).

Check Condition Sequence

Terminal to processing unit-1448

1. The program initiates the polling of the line by the 1448 by taking the line status to RECEIVE—CONTROL.
2. The terminal, having detected (C) on the line, goes to CONTROL mode and begins to search for its polling identification. Except for the 1030, the condition is indicated by the lights at the terminal, which is in the REQUEST status.
3. When the terminal (except the 1030) recognizes its terminal and component identification, it responds positively (if ready to transmit) by sending a (D) and begins to transmit. When the 1030 recognizes its terminal identification, it sends a (D) and begins to transmit.
4. The processing unit-1448 upon receiving the positive response to the poll, terminates polling and changes its status to RECEIVE.
5. The terminal terminates its block of data with (B), and (except the 1030) automatically generates its LRC character onto the line. The terminal is interlocked awaiting the answer from the processing unit-1448.
6. The 1448 goes to one of these statuses:

   RECEIVE—EOB

   RECEIVE—CHECK—EOB

   RECEIVE—CHECK—ESA—EOB

   RCEIVE—ESA—EOB

   CHECK—EOB (caused by data set failure, invalid status, or sequence check)

   CONTROL—EOB—CHECK (caused by time-out)

   It then requests an interrupt. During the subsequent scan operation, the processing unit status is changed to agree with the 1448 status, and the processing unit EOB indicator is set.
7. If the message has failed any of the checks, the program reinitializes the control-field running address, and changes the status to RECEIVE—IDLE—CHECK and executes a scan operation.

   This status causes the 1448 to generate (n) negative answer which unlocks the terminal.

Any invalid character received from the transmission line is converted by the 1448 to a valid * (B-8-4) before transfer to processing-unit storage. Any invalid character originating in the 1448 is detected at the output of the 1448, and is converted to a valid * before transfer to processing-unit storage.

Note that any validity check failure at the output of the 1448 to the processing unit results in the same sequence as a transmission-line validity check.

Processing unit-1448 to terminal. When the processing unit-1448 is transmitting to the terminal, the check sequence is:

1. After the 1448 transmits the EOB character on the line, it transmits the LRC character and waits for the response from the terminal.
2. If the terminal recognizes a check condition it transmits a negative response (n) to indicate to the processing unit-1448 that it is ready to receive a retransmission.

3. Upon receiving the negative response, (n), the 1448 changes its line status to TRANSMIT—CHECK—EOB and requests an interrupt. During the subsequent scan operation, the processing-unit status is changed to TRANSMIT—CHECK—EOB, and the processing-unit EOB indicator is set.
4. Upon recognizing the TRANSMIT—CHECK—EOB status, the program reinitializes the running address and changes the line status back to TRANSMIT. This initiates the retransmission of the message to the terminal.

Overflow Conditions

These conditions cause the 1448 buffers to overflow:

1. *Long-length message.* If the input message exceeds the assigned storage area (that is, a group-mark with a word-mark is detected in processing-unit storage before EOB from the terminal), the 1448 stops transferring data to the processing unit. The status goes to RECEIVE—END-OF-STORAGE-AREA—END-OF-BLOCK.
2. If the program exceeds the maximum allowable noninterrupt interval (thus preventing the interrupt to the scan operation in time), the 1448 buffers overflow for receiving lines. The status goes to RECEIVE—END-OF-BLOCK—CHECK. This is normally a programming error.

In both cases, the program responds to the terminal, with a negative response, (n), and initiates the same sequence as in a transmission-check condition.

Stop Conditions

These check conditions stop the processing unit, and result in message overflow in the 1448:

1. A-register parity
2. B-register parity
3. Arithmetic validity
4. Inhibit switch parity
5. Op register validity
6. Address validity
7. Wrap-around check.

The processing unit stops if the process-check stop switch is ON, and any of the check conditions occur.

Various I/O stop conditions can occur, if the on-line I/O is used while the 1448 is operating. This results in buffer overflow. Some of these stop conditions can be bypassed by use of BRANCH ON ERROR with the I/O check stop switch off.

The sequence of events at the terminal, on the line, and in the processing unit's status structure is essentially the same as for nonstop overflow conditions. The differences are that the processing unit is stopped, the terminals are locked out for a longer time before receiving text-response retransmission, and a restart procedure is required at the processing unit.

The sequence of events on a given line when the processing unit stops is:

1. The terminal is initially transmitting.
2. The 1448 and processing unit are in the RECEIVE status.
3. When the processing unit stops, its status is frozen at RECEIVE.
4. The 1448 continues to accept characters from active lines.
5. When the 1448 buffers overflow, the 1448 goes to an internal check condition on that line.
6. When the terminal transmits EOB and its LRC character, the 1448 goes to RECEIVE—CHECK—EOB status.
7. The terminal is interlocked and waiting for the text response to signal it when to go ahead, and whether to retransmit or not. Terminal lights indicate the terminal is in use.

Conditions in the 1448 are:

1. All lines that were receiving when the processing unit stopped are at RECEIVE—CHECK—EOB status.
2. All lines that had completed receiving their message before the processing unit stopped, but had not been taken to a text-response release status by the program, are at RECEIVE—EOB status.
3. All lines that were transmitting when the processing unit stopped, stay in TRANSMIT status waiting for scan operations to resume.
4. All lines that had completed transmitting their message before the processing unit stopped, but had not been serviced by the program are at TRANSMIT—EOB status.
5. All lines that were polling, stop polling, wait for scan operations to resume and are in RECEIVE—CONTROL status.
6. All lines that were at an inactive status, such as CONTROL and CONTROL—EOB, remain in this status.
7. Awaiting the restart of the processing unit, the interrupt request is initiated.

Conditions at the terminals are:

1. The terminals that were transmitting are interlocked and awaiting the answer to their text (except the

1030). After 11 seconds the 1030 goes to a nonselected status.
2. The terminal lights indicate when the terminal is in use.

Conditions in the processing unit are:

1. All line status is the same as when the processing unit stopped.

Restart Procedure

The system (processing unit-1448-terminals) is in the condition described in the *Stop Conditions* section. The 1440 is restarted as it would for any stop condition (ignoring the 1448). The interrupt request waiting in the 1448 causes the program (after restarting) to go to the interrupt or scan subroutine. A scan operation is executed, and all of the processing-unit statuses are updated.

The end-of-block indicator is set:

1. For lines at RECEIVE—CHECK—EOB the program, as in the normal process, reinitializes the running address and changes the status to RECEIVE—IDLE—CHECK. This makes the 1448 generate a negative (n) answer to the terminal, initiates any automatic resend functions, and unlocks the terminal.
2. For lines at RECEIVE—EOB status, the program (as in the normal process) reinitializes the running address, and changes the status to RECEIVE—IDLE. This makes the 1448 generate a (y) or positive response, and unlock the terminals.
3. For lines at TRANSMIT—CHECK—EOB, TRANSMIT—EOB, TRANSMIT, or RECEIVE—CONTROL (polling) the normal processing or line function resumes.

Automatic Answering (1050)

With this special feature and the appropriate communications-company equipment on a line, the 1448 can automatically answer when it is called on that line. When in RECEIVE—CONTROL status, the 1448 answers and waits for the frequency connection to be made.

After the connection is made, the conventional point-to-point procedure is followed under control of the program. The processor should terminate the connection (hang up) by changing the 1448 to CONTROL status.

A 1448 line can accommodate either automatic calling or automatic answering, but not both.

Automatic Calling

With this special feature and the appropriate communications-company equipment, the 1448 can automatically call a telephone number to make a connection with a terminal (Figure 28).

The telephone numbers of the terminals are stored either in core storage or on file and are entered, one at a time, in the polling list in the processing unit. The number of digits in the numbers is variable. A record mark indicates the end of each telephone number. The 1448, in RECEIVE—COTROL status moves the digits of the number from the polling list to the communications-company equipment (serial by character, parallel by bit). The 1448 changes to CONTROL—END-OF-BLOCK status to indicate to the processing unit that a connection has been made. Figure 29 shows a breakdown of calling time. The 1448 indicates a data set-equiment failure or line failure by changing to CHECK—EOB status. The 1448 changes to RECEIVE—CONTROL—EOB status if the number called is busy or not ready, or if the number reached is a wrong number.

After the frequency connection is made, the conventional point-to-point procedure is followed, controlled by the program. After connection, the processing unit can either poll or address the terminal. The polling addresses can be in the polling list following the record mark that marks the end of the telephone number. The polling list ends with a group-mark with a word-mark.

As with automatic answering, the processing unit should terminate the connection by changing the 1448 to CONTROL status.

A 1448 line can accommodate either automatic calling *or* automatic answering, but not both.

IBM 1032 Digital Time Unit

The IBM 1032 Digital Time Unit of the IBM 1030 Data Collection System connects directly to the 1448 by a 20-foot cable supplied with the 1032. The 1032 is available with any 1448 system regardless of the type of terminal. One 1032 can supply time data for two 1448's, upon program request, to provide time identification for input records from the terminals. The time is recorded in four digits: tens, units, tenths, and hundredths of hours.

When the processing unit's program changes the 1032 line to RECEIVE--CONTROL, the 1448 polls the 1032 continually using the same polling address. The synchronous motor-driven clock of the 1032, Model 1, advances once each minute. During clock advance, the interlock prevents clock read-out. Time is supplied only when requested (polled). If the 1032 has advanced since the last read-out, the 1032 responds positively (D) to the polling address and sends the 4-digit time message followed by EOB. Upon receiving the EOB the status of the 1448 and the processing unit changes to RECEIVE—EOB (Figure 30). The EOB indicator is set, and the 1448 makes an interrupt request. The processing unit's program, upon detecting the RECEIVE—EOB status, moves the time message to an appropriate working location and then returns the line to RECEIVE—CONTROL.

Because the 1032 neither requires nor responds to a text answer, the program can change the status directly to RECEIVE—CONTROL from RECEIVE—EOB or RECEIVE—EOB—CHECK or CONTROL—EOB—CHECK (caused by time-out).

A VRC (parity) error detected by the 1448 in the 1032 transmission results in RECEIVE—EOB—CHECK status.

If the 1032 being polled has not advanced since the last read-out, it responds to the poll negatively (N). The 1448 continues to poll the 1032 until a positive response is received.

The 1032, Model 2, has an impulse-driven clock, which is self-regulated in accordance with a master time system and advances once every minute. This

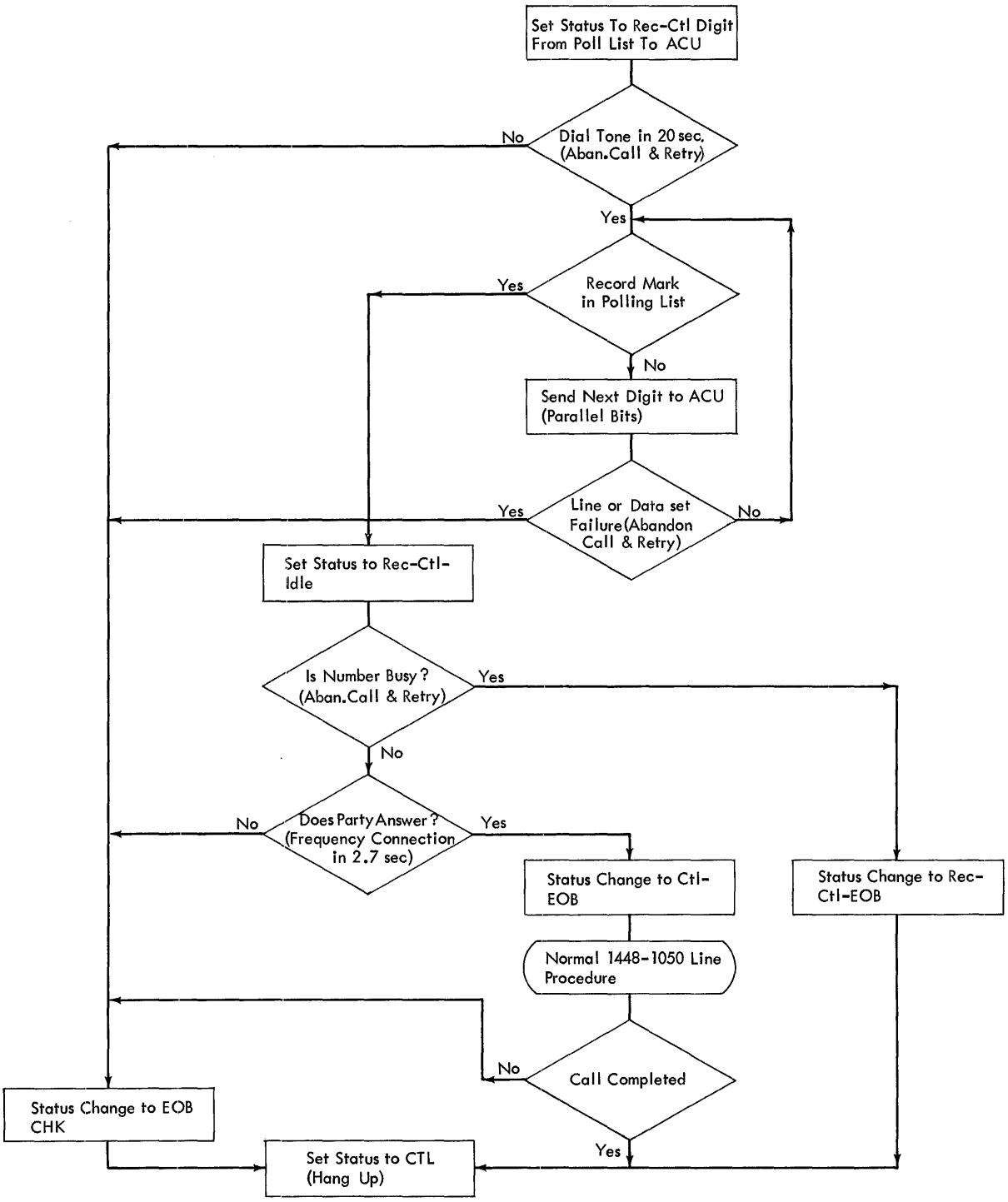

Figure 28. Automatic Calling Procedure

		Seconds	
Dial Tone Delay	—	1.0	
Dial Station Number	—	13.5	
Common-Carrier Central Switching	—	11.0	9.0 for 0-100 miles 11.0 for 101-800 miles 13.0 for 801-3200 miles
Data set Coordinating	—	2.0	
Text	—	x	
Line Release	—	1.5	
Central Switching Office	—	1.3	
	Total	30.3 + x for 101-800 miles	

Figure 29. Timing for Automatic Calling Using Wide-Area Telephone Service (AT&T)

model also provides a synchronous drive unit for clock advance on a standby basis. A standby switch permits manual switching to standby mode when required. A light indicates that the 1032 is in standby mode.

A power switch in the 1032 controls power to the unit. Reset levers are provided to reset the time wheels manually. A light and buzzer indicate either when the 1032 power is interrupted or when the clock fails to receive an impulse within 1½ minutes. A reset switch is provided to turn off the light and buzzer.

Telegraph-Line Attachment

With this special feature, the IBM 1448 accepts not only IBM 1030, 1050, and 1060 lines but also private tele-

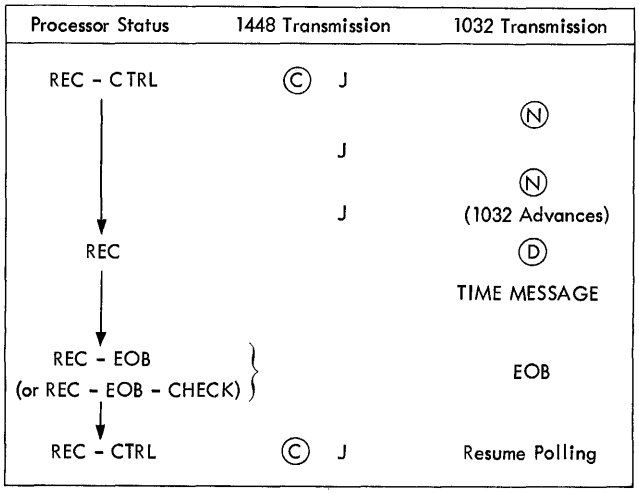

Figure 30. Point-to-Point Operation (1032 to Processing Unit —1448)

graph lines provided by American Telephone and Telegraph Company (83B2 system selective calling terminals) or by Western Union Telegraph Company (115A system outstations). (IOCS for this special feature is described in the SRL publication *IOCS for the 1440-1448, Specifications,* Form C24-3024.)

With telegraph-terminal lines attached, the 1448 assumes the functions of the central station and the interline message-relay stations of the telegraph system. When attached to a 1448, the operation of telegraph lines changes in two ways:

1. All messages go through the 1448. One terminal does not send a message directly to another terminal.
2. Because messages from terminals go to the 1448, no call-directing code is needed for the 1448. Messages are preceded instead by leader characters and the appropriate lockout code.

When communicating with telegraph terminals, the system's EOT character is a sequence of three characters: figures, character, letters. Although the alphabetic character is usually H, the user may choose any alphabetic character for his system. The examples in this publication use the figures-mode H. The system can have a polling time-out that is a nominal 500 ms or a nominal 20 seconds. The shorter time-out allows more message time for KSR's (Keyboard Send-Receive) that may be on the line.

Because the telegraph systems use the Baudot code (5-bit), the processing unit to which the 1448 is attached must have the translate special feature. The 1448 must have recognition circuits to cause the various status transitions.

Similarities in operation between the IBM 1448/Telegraph-Terminal systems and the IBM 1050 Data Communications System are:

1. The line is set to CONTROL mode by an EOT character sequence.
2. The terminal responds to both addressing and polling.
3. An EOA sequence precedes the text from the terminal.

Characteristics of the 1050 that are not in these systems are: VRC and LRC checking of data, message blocking, and answer to text.

Output Message Format

The processing unit's program format of a message to be sent to the selective calling terminal is:

H ↓ AA BB CC CR LF ↓ TEXT RECORD MARK

The disconnect signal is a figures-mode alphabetic character followed by the LETTERS character (↓). AA, BB, and CC represent 2-alphabetic-character addresses of terminals. This example shows a message to three terminals. The CARRIAGE RETURN (CR), LINE FEED (LF), LETTERS (↓) is the EOA sequence (or lockout code). The record mark causes the 1448 to go to TRANSMIT—EOB status. This character must translate to a Baudot blank before going to the 1448.

The processing unit's program format of a message for the outstation terminal is the same as for the selective calling terminal except for the EOA, which is a space character. The message would be sent like this:

H ↓ AA BB CC SPACE TEXT RECORD MARK

Telegraph Terminal to IBM 1448

When the 1448 is ready to receive, the program sets the line to RECEIVE—CONTROL status (Figure 31). If the line is not in CONTROL mode, the 1448 sends the EOT sequence (FIGURES H LETTERS) over the line. The 1448 follows the EOT with the polling address (two alphabetic characters) of the terminal. If the line is already in CONTROL mode, the EOT is omitted. After the polling address is sent, one of these occurs:

1. The 1448 receives no response within a limited time (time-out) of 500 ms or 20 seconds (whichever is used) and sends the next polling address.
2. The 1448 receives a V or M (negative responses to polling for the telegraph system), and it deletes this character and sends the next polling address.
3. The terminal sends the EOA sequence (affirmative) and the 1448 goes to RECEIVE status. (Leader characters that may precede the EOA sequence are deleted.) The EOA sequence is LINE FEED for the American Telephone and Telegraph Company's selective calling terminals. The EOA sequence for Western Union Telegraph Company's outstation terminals is SPACE.
4. Any response other than negative or affirmative causes the 1448 to go to RECEIVE—CHECK status and to end polling.

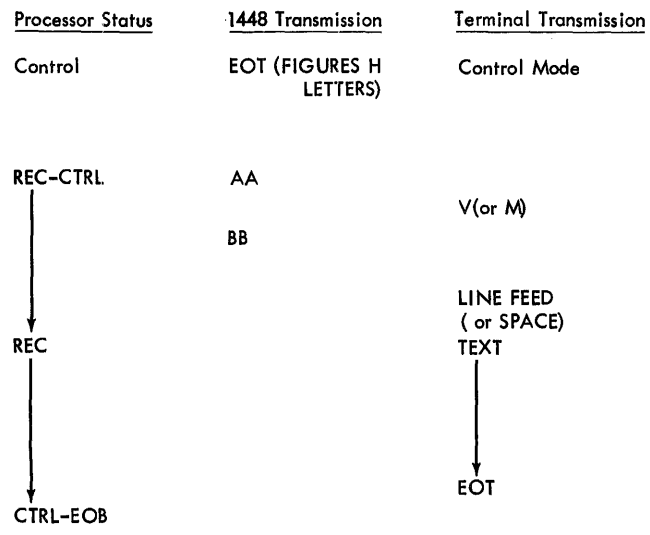

Figure 31. Telegraph Terminal to Processing Unit—1448

The 1448 receives a message in RECEIVE status and remains in this status until it receives an EOT sequence (FIGURES H LETTERS), which changes the status to one of four EOB statuses:

1. If the message is received correctly, the 1448 goes to CONTROL—EOB.
2. If an overflow condition occurred in the 1448 while receiving text, the status changes to RECEIVE—CHECK —EOB.
3. If an end-of-storage-area signal comes from the processing unit while the 1448 is receiving text, the status changes to RECEIVE—ESA—EOB.
4. If an overflow and end-of-storage-area occur on the same message, the status changes to RECEIVE—CHECK —ESA—EOB.

The status does not change to RECEIVE—EOB because the telegraph terminals have no EOB character. Because the telegraph terminal ends its block with the EOT sequence, the 1448 must poll the terminal again to receive another block.

IBM 1448 to Telegraph Terminal

Figure 32 shows the transmission sequence where the processing unit makes a successful bid for the transmission, and the processing unit-1448 combination addresses and transmits to the telegraph terminal.

If the processing unit has a message to transmit, and the 1448 is in RECEIVE—CONTROL status and polling, the processing unit must bid for the line as it does on an IBM 1050 line. The processing unit status goes to RECEIVE—CONTROL—IDLE to bid for the line. When the 1448 receives a V or M answer from the terminal, the 1448 changes status to CONTROL—EOB. A time-out after transmission of a polling address changes the 1448 status to CONTROL—EOB—CHECK. Both these statuses indicate to the processing unit that the line has been secured and can not be modified to TRANSMIT status.

The 1448 in TRANSMIT—CONTROL status transmits the address of the terminal. This address is two alphabetic characters. (On the selective calling terminals only, the 1448 adds a LETTERS character following the second character of each address.)

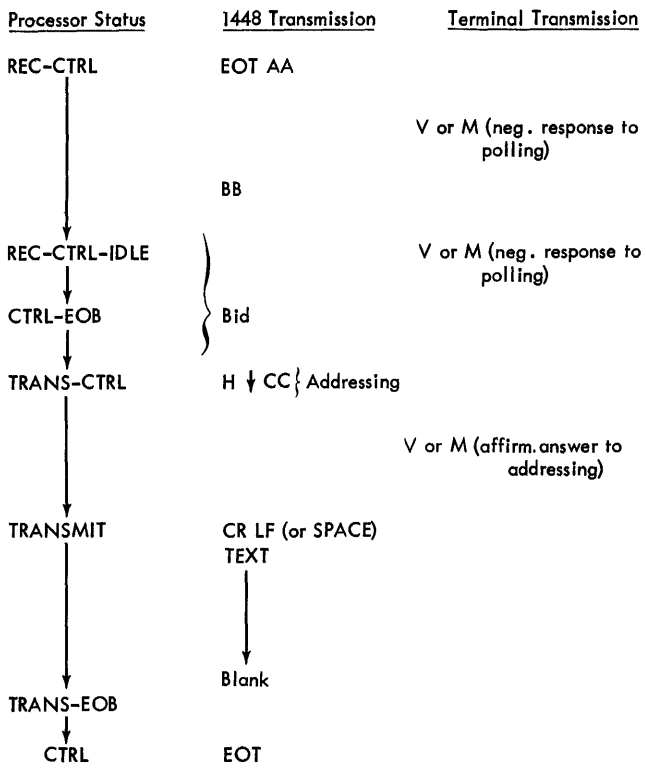

Figure 32. Processing Unit—1448 to Telegraph Terminal

If the 1448 receives no answer within two seconds, it goes to CONTROL—EOB—CHECK status. An answer other than V or M changes the 1448 to TRANSMIT—CONTROL—EOB status. When going to either of these two statuses, the 1448 transmits the sequence of FIGURES H LETTERS. An answer of either V or M (the positive answers to addressing for the telegraph systems) hold the status at TRANSMIT—CONTROL, and the 1448 transmits another address or the EOA sequence.

The EOA for the selective calling terminals is CARRIAGE RETURN LINE FEED LETTERS. The 1448 changes status from TRANSMIT—CONTROL to TRANSMIT when it transmits LINE FEED (SPACE for the outstation terminals). The 1448 remains in TRANSMIT status while it transmits the message. When the 1448 recognizes a Baudot-code blank in its buffer areas, it deletes the blank and goes to one of two EOB statuses. If a parity error has been detected, the status changes to TRANSMIT—CHECK—EOB. If the message is acceptable, the status changes to TRANSMIT—EOB. An end-of-storage-area condition changes the status to TRANSMIT—ESA—EOB, or if a previous parity error is detected, it changes to TRANSMIT—CHECK—ESA—EOB.

If the processing unit has another message to send to the same terminal, it returns the status to TRANSMIT and sends more text. To keep the line secure, the processing unit returns the line to CONTROL status. To resume polling, it goes to RECEIVE—CONTROL status and sends the EOT sequence. To address another terminal, it formats a new message and sends it.

Station-to-Station Operation

With this procedure a terminal can transmit its message to another station at the same time it sends to the 1448. If the message is intended for the other station, the program at the processing unit receives and stores the message but does not process it.

In Figure 33, the 1448 follows the standard polling procedure. When station BB is polled it sends the station address CC onto the line. Station CC answers with a V or M, which is the positive answer to addressing. Station BB then sends LF text which is received by station CC and by the 1448. BB ends the transmission with the EOT sequence (FIGURE H LETTERS).

Open-Line Conditions

When transmitting, the 1448, before each start bit, determines if current is flowing on the line. If no current is detected, the 1448 status goes to EOB—CHECK to indicate the line is open. When the telegraph terminal is transmitting a 20-second time-out is in effect between characters. If the line opens, the time-out causes the 1448 status to change to CONTROL—EOB—CHECK.

Baudot-Code Considerations

Receiving

When receiving, the IBM 1448 Transmission Control Unit detects whether the line is in figures or letters mode. When it receives the FIGURES character, the 1448 deletes it and sets the shift bit into the control word for that line. To each succeeding character, it

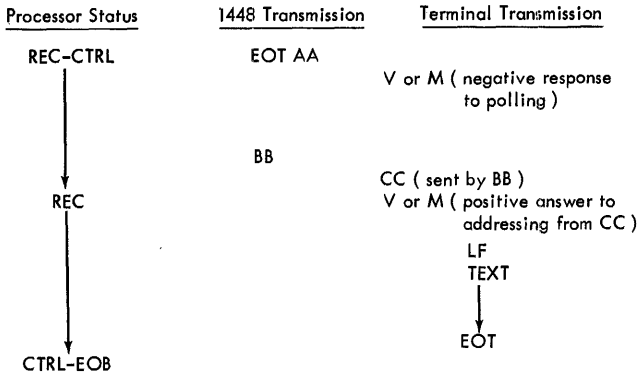

Figure 33. Station to Station

adds a 1-bit to indicate to the processing unit that the character was received in figures mode. When it receives the LETTERS character, the 1448 deletes both the character and the shift bit. Each succeeding character is stored just as it comes off the line. When the characters go to the processing unit, the parity bit is added, when necessary, for correct parity.

When the Baudot bit reaches the processing unit, it is still Baudot code but in BCD (Binary Coded Decimal) Form:

Baudot (line) bits	*BCD (processor) bits*
1	B
2	A
3	8
4	4
5	2
Shift	1

When necessary, the processing unit uses the translate-feature operation code to convert Baudot code to BCD code for processing.

Transmitting

The 1448 receives data from the processing unit in Baudot code, plus a shift bit for characters in the figures mode (for use of the translate feature). When no shift bit is in the control word and the data contains a 1-bit (shift bit), the 1448 inserts a FIGURES character on the line ahead of this character. When the control word contains a shift bit and the data contains no 1-bit, the 1448 inserts a LETTERS character on the line. The insert bit, with the shift bit in the 1448 control word, facilitates these character insertions.

Translate

The translate special feature for IBM 1440 and 1460 Data Processing System is described in the *Special Features* section of the IBM *1440 System Operation Reference Manual,* Form A24-3116, and in *Special Features* — IBM *1401 and 1460 Data Processing Systems,* Form A24-3071.

With this feature, the system translates to and from any code up to and including 7-bit non-shifting codes or 6-bit shifting codes. It translates Baudot code as it enters the system from the 1448. The incoming characters are replaced by BCD characters from a translate table in system storage.

Two translate instructions are available: TRANSLATE-WITH-WORD-MARKS and TRANSLATE-WITHOUT-WORD-MARKS. The translate instructions are interruptible.

The 1448 performs any necessary parity conversion. It also detects shift-bit transitions, generates the required shift character, and removes the shift bit.

Figure 34 shows how the Baudot code is processed through the 1448 into system storage.

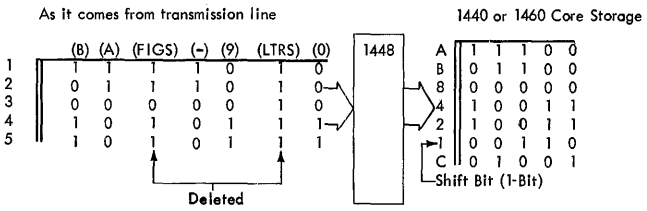

Figure 34. Baudot Code as It is on Line and in Processing Unit Core Storage

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