

NOVEMBER 1964

COMPUTER DESIGN

THE DESIGN AND APPLICATION OF DIGITAL CIRCUITS, EQUIPMENT & SYSTEMS

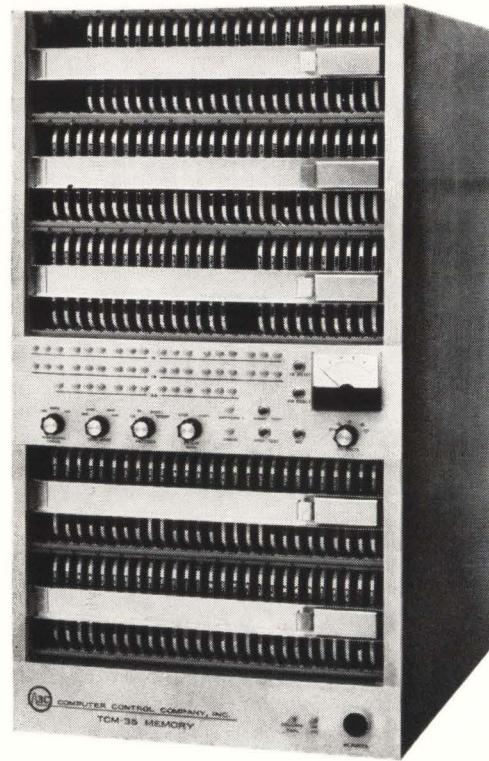
Magnetic Tape
Random Access Storage

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0650

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NEW 1.4-2 μ SEC CORE MEMORY



General Purpose Front Access TCM-35

New TCM-35 family of coincident current core memories offers 1.4 to 2 μ sec full cycle times, 1.2 μ sec maximum half cycle time, and 0.75 μ sec maximum access time. Capacities up to 8,192 words; word lengths to 36 bits. All silicon circuitry. Advanced system design. Extremely compact packaging. Low input power. System height is 24 $\frac{1}{4}$ inches to 35 inches, including self-contained power supply, depending upon storage capacity and options. TCM-35, like the 5 microsecond TCM-32, has pull-out, front-of-rack access. Operating temperature is from 0°C to +50°C with broad margins. 3C quality is built in. Modular design allows custom selection of desired performance and interface characteristics from an extensive list of standard options at volume production prices. Write for TCM-35 brochure (for 5 μ sec memories, ask for TCM-32 brochure).

BASIC TCM-35 FEATURES*

Choice of Input/Output
Logic Levels and Polarity

OPERATING MODES

Clear/Write
Read/Restore
Load
Unload
Read/Modify/Write

CONTROL INPUTS

Address Register Clear
Information Register Clear
Full Cycle/Half Cycle
Hold Address

CONTROL OUTPUTS

Memory Busy
Information Available
End of Cycle

NON-DESTRUCTIVE START-UP/SHUT-DOWN
BUILT-IN MARGINAL TEST

* no extra cost

VOLTAGE FAILURE SENSING
BUILT-IN COOLING SYSTEM

STANDARD OPTIONS**

INFORMATION REGISTER CONTROL
Shift Input
Count
Partition (up to 4 zones)

ADDRESS REGISTER CONTROL
Sequential
Sequential Up/Down
Sequential Interface
Shift Input
Marker Pulses (up to 3)

DATA OUTPUT
Address Register

MEMORY CLEAR
MEMORY TESTER
VOLTMETER
REGISTER DISPLAYS
400 CPS POWER INPUT

** at extra cost



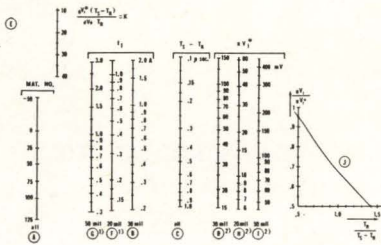
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MD.; DES PLAINES, ILL.; ORLANDO, FLA.; ALBUQUERQUE, N.M.; PALO
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COMPUTER CONTROL COMPANY, INC.
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CIRCLE NO. 1 ON INQUIRY CARD

Not all developments in memory products come from Indiana General

... just the most significant ones



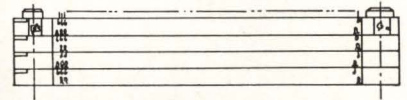
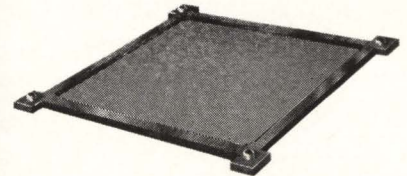
Optimum core selection ...in minutes

Revolutionary new process automates production of memory cores . . . makes possible all magnetic and physical property combinations within nature's boundaries. Sample cores delivered within two weeks. Unique IGC Nomograph lets you select optimum switching speed, drive current and output . . . in minutes. Write for your copy today.



One μ sec stack for the price of a 2 μ sec stack

IGC now offers stacks with 1 μ sec cycle time using 30 mil cores. These new cores are easier to produce, test and string than smaller cores. Result: no cost/speed compromise. You get high speed, low cost plus time-proved IGC reliability. Capacity? Virtually unlimited. Delivery? Faster than ever before.

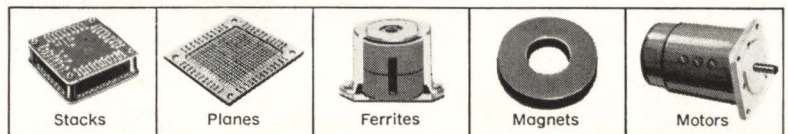


Compact, plug-in molded frames produce expandable stacks

Another IGC first! Pluggable, molded frames which interconnect to form a memory stack which is expandable in both word size and bit length. Solder connections are eliminated unless required by mil specs. Standard, in-stock planes are stacked to most any bit length in minutes. Price? Competitive with conventional frames.

Indiana General can focus more design capability in your memory products needs than any other manufacturer in the industry. For more information, write: Thomas Loucas, Sales Manager, Memory Products Division, Indiana General Corporation, Keasby, New Jersey.

INDIANA GENERAL



CIRCLE NO. 2 ON INQUIRY CARD

COMPUTER DESIGN

FEATURES

FOR ENGINEERING PERSONNEL RESPONSIBLE FOR THE DESIGN & APPLICATION OF DIGITAL CIRCUITS, EQUIPMENT, AND SYSTEMS IN COMPUTING, DATA PROCESSING, CONTROL AND COMMUNICATIONS.

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over 20,000

9 PHOTOCROMIC GLASS - A NEW BINARY SWITCH?

Special glass compositions that "switch" from light to dark may be used in future optical memories.

12 THE DIGITAL COMPUTER IN REAL-TIME CONTROL PART 5 - REDUNDANCY TECHNIQUES

This concluding article of the 5-part series analyzes various redundancy schemes, their shortcomings, and their possible effectiveness in providing the required reliability.

16 MAGNETIC TAPE RANDOM ACCESS STORAGE

Design details and performance characteristics of a new random access memory that features 50 million-bit interchangeable tape cartridges.

24 CAUSES AND CURES OF NOISE IN DIGITAL SYSTEMS PART 3 - CONTROL OF EXTERNAL NOISE

Previous parts of this 3-part series covered potential sources of noise in the internal design of digital systems. This concluding part describes methods of external shielding and techniques of avoiding noise from being transmitted through external cables. Special power supplies and filters are also discussed.

DEPARTMENTS

4 INDUSTRY NEWS

32 NEW PRODUCTS

- Circuit Components • Circuit Packaging • Circuit Modules
- Input-Output Equipment • Console Equipment • Power Supplies
- Test Equipment • Memories • Systems

46 LITERATURE

48 ADVERTISERS' INDEX

Another Revolution at...

VALLEY FORGE

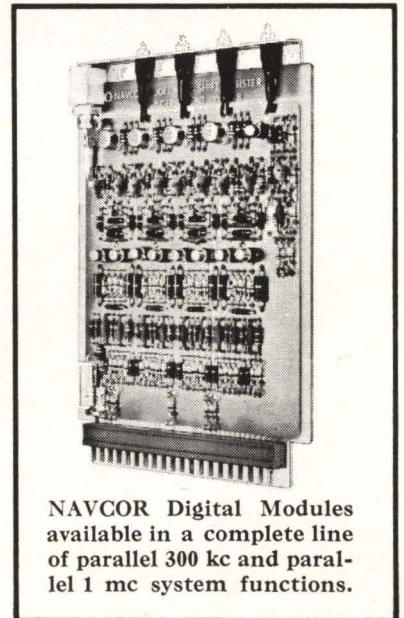


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CIRCLE NO. 3 ON INQUIRY CARD



AN ORDER FOR MOTOR-GENERATORS THAT CAN SUPPLY CLOSELY-REGULATED POWER FOR COMPUTERS DESPITE INTERMITTENT LOSSES OF UTILITY POWER HAS BEEN AWARDED TO BOGUE ELECTRIC MFG. BY NASA'S GEORGE C. MARSHALL SPACE FLIGHT CENTER. The first group of 60 kw generators will be used at Huntsville, Alabama to operate digital computers requiring constant voltage and frequency stability. The units are designed to maintain a temporary power output with variations of less than one per cent, despite wide changes in input power conditions and generator loading. Similar generators are planned for use at the Kennedy Space Center. By serving as a source of closely-regulated power during critical periods, the generators will help to assure against an interruption in the effective functioning of computers engaged in such operations as monitoring launch vehicle status during countdown.

COMPUTER CONTROL COMPANY, INC., HAS RECEIVED AN ORDER FROM THE UNION SWITCH AND SIGNAL DIVISION OF THE WESTINGHOUSE AIR BRAKE COMPANY (WABCO) FOR A DDP-24 which will be the heart of a mass transit supervisory and control system which electronically surveys traffic conditions and instructs trains where and when they may travel. A stored program in the DDP-24 with daily scheduling information allows train routing to be conducted automatically. Additional instructions can be entered into the DDP-24 by operating personnel. The DDP-24 will be used in a demonstration of Automatic Train Operation for the San Francisco Bay Area Rapid Transit District.

AMPEX CORP. HAS DELIVERED TWO TAPE HANDLER/CORE MEMORY SYSTEMS TO EDUCATIONAL TESTING SERVICE, PRINCETON, N.J. FOR USE WITH TWO SPECIAL MARK-SENSING COMPUTERS IN THE PROCESSING OF STUDENT TEST INFORMATION. The two Ampex TM-4111 tape handling systems and the two RVQ memories comprise a tape buffer system and will be used as part of a "SCRIBE" system which consists of scanning units, computers, tape handlers, memories, and typewriters. The two mark-sensing computers scan each answer sheet as it passes through. If a mark is sensed in a proper position, the computer tabulates it as a part of the student's overall score. The tape buffer system will enable ETS to feed evaluated test data from each of the two computers to the print-out devices. The tape handling system records data as it comes out of the computer at a high rate of speed. The printer, however, can't accept the data at this rate of speed, so the RVQ memory is used as a buffer.

FOR USE IN BASIC RESEARCH INTO THE NATURE OF MATTER, A PDP-7 COMPUTER HAS BEEN ORDERED BY STANFORD UNIVERSITY'S PHYSICS DEPARTMENT FROM DIGITAL EQUIPMENT CORP. The computer will function chiefly as the central element of the SCANS (Stanford Computer for Analysis of Nuclear Structure) system. The system will gather, reduce, and analyze data originating primarily in particle detectors used with the university's tandem Van de Graaff accelerator. The National Science Foundation is providing funds for the computer and the tandem accelerator as well as the associated research program.

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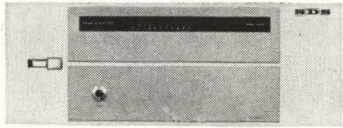
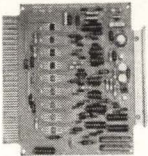

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If you keep a digital components file, here are three good reasons why it is out of date

 <p>A to D converter 80,000 12-bit conversions per second integrated circuits</p>	 <p>D to A converter complete conversions in 5 μsec - 0°C. to 60°C. integrated circuits</p>	 <p>Combination A to D converter and multiplexer integrated circuits</p>
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SDS has added three new digital components to their silicon analog/digital building block line. The A to D converter offers almost triple the speed of any unit previously available at no increase in price. The D to A converter features virtually no drift over a wide temperature range. The combination A to D and multiplexer unit plugs directly into any SDS computer without extra hardware for interfacing.

In addition, these new analog/digital units now contain integrated circuits to increase reliability and operational ability of the equipment. The integrated circuits also allow greater packing density permitting more equipment to be put in less rack space. At no increase in price, built-in buffer registers have been added to all D to A units. Addition of the registers permits simultaneous conversion of all channels in a system.

The comprehensive 100-model line of SDS converters, multiplexers, amplifiers and digital modules is fully compatible within itself and with all SDS equipment including SDS digital computers. This makes possible the construction of fast, ultra-reliable systems at minimum design and equipment cost.

If you would like to update your digital components file, just write for full details to Scientific Data Systems, 1649 Seventeenth Street, Santa Monica, California.

SDS SCIENTIFIC DATA SYSTEMS
1649 Seventeenth Street, Santa Monica, Calif.

Sales offices in New York, Boston, Washington, Philadelphia, Pittsburgh, Huntsville, Orlando, Chicago, Houston, Albuquerque, San Francisco. Representatives: Brogan Associates, Inc., New York; Ammon & Champion Co., Dallas; Cane, Jessup, Seattle. Foreign representatives: Instronics, Ltd., Stittsville, Ontario; CECIS, Paris; F. Kanematsu, Tokyo; RACAL, Sydney.

CIRCLE NO. 4 ON INQUIRY CARD

INDUSTRY NEWS

WESTERN UNION RECENTLY ANNOUNCED THE OFFERING OF A NEW "BROADBAND EXCHANGE SERVICE", INITIALLY IN 19 MAJOR CITIES COAST-TO-COAST, that will permit subscribers to select various broadband connections by pushbutton telephone for the direct, two-way exchange of data, facsimile and voice communications. Previously, Western Union offered broadband circuits only on a full-time leased, point-to-point basis. Now, broadband circuits can be automatically selected by Western Union telephone, in seconds, with toll charges based on distance, bandwidth, and line time used—with a one-minute service minimum. Broadband service provides for the automatic selection of high-quality circuits, at the touch of a finger, for high-speed transmission of various forms of analog and digital data communications. Such communication includes the exchange of data in the form of punched tape, punched cards, or magnetic tape; facsimile at high and low speeds; and voice on an alternate basis.

During the introductory period, broadband exchange service will be offered in two bandwidths, one with two kilocycle spacing and the other having four kilocycle spacing — equivalent to a half voice band and a full voice band respectively. Transmission speeds in these bandwidths range from conventional teleprinter speeds up to a magnetic tape device's equivalent of 4800 words-per minute, or a facsimile speed of three minutes for an 8½ x 11" page. It is expected that predominant use of the new service will be in the four kilocycle classification. Wider bandwidths, nominally of 8, 16, and 48 kilocycles, are intended ultimately to be offered. In these wider bandwidths, computers will be able to communicate with each other at rates up to 40,000 words per-minute, or the data equivalent.

Data terminal sets are furnished by Western Union while data processing equipment and station wiring for data transmission purposes are furnished by the subscriber.

BECKMAN INSTRUMENTS, INC., AND SCIENTIFIC DATA SYSTEMS, INC., ANNOUNCED RECEIPT OF A CONTRACT IN EXCESS OF \$1 MILLION FROM NASA for an analog-digital computer system to simulate the actual conditions of space flight. The new Beckman/SDS Integrated Computing System will be used in a wide range of NASA's space programs, including those of Project Gemini and Apollo. The computer will be used for the "real-time" simulation of orbital trajectories, the study of interplanetary space probes and to simulate the physiological reactions of astronauts.

A WEST TEXAS DIVISION OF A MAJOR OIL COMPANY HAS ORDERED WHAT HAS BEEN TERMED THE FIRST "LEASE AUTOMATION" SYSTEM USING A STANDARD GENERAL-PURPOSE BUSINESS DIGITAL COMPUTER IN A REAL-TIME CONTROL AND TELEMETERING CONTROL LOOP. The computer will perform automatic well test cycling, transmitting commands to each remote lease site to place individual wells in the "production", "test", or "shut-in", mode of operation. Accumulated flow and production data, along with any alarm signals, will be transmitted back from each remote station to the computer control center on a programmed interrogation basis. Sub-routines in the computer program will optimize each well's production by placing the well in production time cycles unique to each well's optimum producing characteristics. Some wells operate best on continuous production, others in "spurts". In addition to performing lease automation control functions, the computer will be utilized for daily business routines.

The computer-operated lease automation system will feature a solid-state "double scan" control, telemetering, and alarm system manufactured by Moore Associates, of San Carlos, Cal. This system provides the communication-control link between the computer and the unattended equipment at the remote station. "Double-Scan" high security coding, as features in other computer-operated control systems, provides 99.9998% accuracy in transmission of control and telemetering information.

CALLED THE AN/MSM-42 FAULT LOCATOR, A "CHECKOUT" DIGITAL COMPUTING SYSTEM HAS BEEN ACCEPTED BY THE U.S. AIR FORCE FOR FLIGHT LINE CHECKOUT OF A CLASSIFIED AIRBORNE SYSTEM. First production units will be delivered next year. According to Sperry Gyroscope Co., the MSM-42 also could be adapted for use in large repair installations or on automated industrial production lines to keep expensive electro-mechanical manufacturing facilities in top working order. Sperry engineers claim that the system can cut manual checkout time from several hours to a few minutes. The heart of the MSM-42 is a digital computer which draws from its memorized repertoire of more than 500 different instructions to make the necessary electrical connections and measurements through cabling from its small trailer. On its first job for the Air Force, the computer will order signal generators to simulate the full range of electronic signals that the airborne system would actually "feel" in an operational flight. The computer processes data at a rate of one million bits per second (each word is 28 bits long) and stores some 32,000 test instruction at one time. Three instructions are required to order one automatic measurement. The system is designed to work with a human operator in manual, semi-automatic, or fully-automatic modes. Only five push-buttons kick off a complete system check, or a single test, so that even semi-skilled operators can run complicated test routines. The computer is a single address, one megacycle clock rate unit with a two million bit magnetic rotating memory. Confidence and diagnostic tests are stored together in the computer facilitating instant branching from one to the other.

LARGEST DIGITAL-COMPUTER-DIRECTED CONTROL SYSTEM EVER BUILT BY LEEDS & NORTHRUP CO. will automatically regulate the electric-powder production facilities of the American Electric Power System in Canton, Ohio. Including associated digital and analog telemetering equipment, the \$1 million control system will link some 15 generating stations, including some 40 turbine-generators. It will also include control of some 38 tie lines.

1.8 *usecond*

1.0 *usecond*



NEW COINCIDENT CURRENT MEMORIES

Newest of the proven R Series systems, the RS and RZ are practically identical—except for memory cycle time speeds and price. And the price of the 1.0 RS averages only 20% higher than the 1.8 RZ. If your immediate requirements are for a 1.8 system, but you might need a 1.0 in the future, the RZ is an ideal selection. It can be quickly (24 hours) and economically converted into a 1.0 RS—just by plugging in a new stack, replacing two card types and making minor component changes. Both models have a capacity of 16,394 words—in 4,096 modules, 8 to 56 bits per word. (Illustrated is the 8 K model.) Temperature range is 0°C to 45°C without the use of current compensation, stack heaters or other compromising gadgetry. MTBF is high—a product of the stringent derating practices that have yielded unswervingly high performance from the Ampex R Series systems. Because of their modular magnetics, both systems are easily expandable with minimal circuit redundancy. A wide variety of options are available: data bus selection, zone control, parity generation and checking, built-in or remote tester. For details, call your Ampex representative, or write Ampex Corp., Redwood City, Calif.

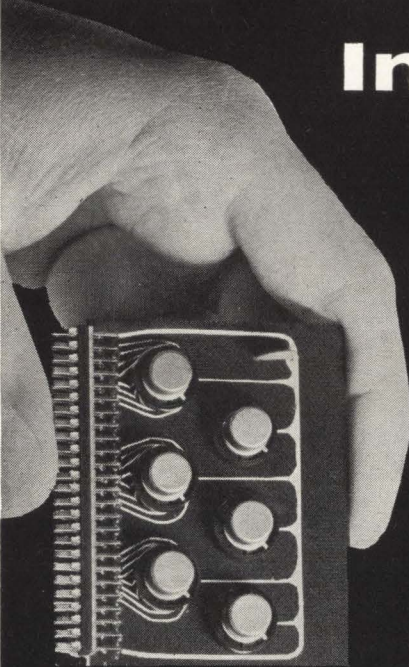
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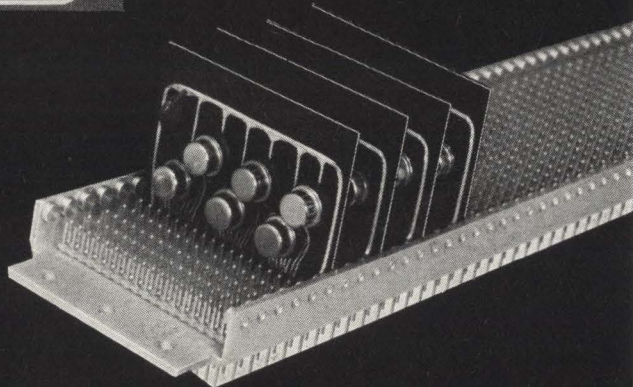
CIRCLE NO. 21 ON INQUIRY CARD

NEW

Integrated Circuit Modules



Abacus has developed a full line of integrated circuit modules—for the specific purpose of providing the systems engineer with all the necessary building blocks to build a complete, integrated circuit digital system.



- SYSTEM Operation To 5 mc.
- NOISE Rejection Margins In Excess Of 1 Volt.
- TYPICAL Drive: 12 NAND Gates And 200 pf Stray C.
- PACKING Density: Over 4000 NAND Gates/Cu. Ft.
- MODULAR Approach Simplifies Checkout And Maintenance.
- PERIPHERAL & Interfacing Circuits Available.
- PACKAGING Hardware, Racks And Power Supplies Provided.
- INTERCONNECTIONS By Wire Wrap, Solder Or Weld.

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INDUSTRY NEWS

THE AIR FORCE HAS SELECTED BURROUGHS CORP. TO PROVIDE 151 B263 EDP SYSTEMS to replace punched card accounting machines now being used in U.S. and overseas installations by base sub command, major air command, and Air Force headquarters managers. The 151 computers will be leased rather than sold to the Air Force. Lease cost when all the systems are installed will be approximately \$4.9 million annually. Major components of the equipment will be manufactured at Burroughs facilities in Plymouth, Mich., and Pasadena, Cal., with assembly of the systems being accomplished at Pasadena.

CHARACTERIZED AS A MAJOR TECHNOLOGICAL ADVANCE IN DOCUMENT STORAGE AND RETRIEVAL, A NEW SYSTEM CALLED VIDEOFILE, REPLACES CONVENTIONAL FILE FOLDERS WITH TELEVISION RECORDINGS that may be viewed and kept up to date electronically. Developed by Ampex Corp., first of the new systems will be delivered to NASA, Huntsville, Ala, under an \$875,000 contract. "Videofile is a proprietary Ampex product which is capable of doing for filing what computers have done for data processing," C. Gus Grant, V.P. — Operations, said. "For the first time, it permits micro-storage of documents with complete flexibility for rearranging, deleting or changing the contents of the file at the touch of a button. Ampex foresees widespread use of Videofile in commercial, industrial and government applications calling for frequent access to a large volume of documents. It is estimated that the world market for equipment of this type will grow to \$1.5 billion annually within the next decade. Videofile goes far beyond conventional methods in its ability to permit individual file entries to be replaced, relocated or deleted without replacing an entire section of the file. In effect, it brings the file promptly to the user either as a television picture or a printed copy and offers higher speed and lower operating costs than present methods."

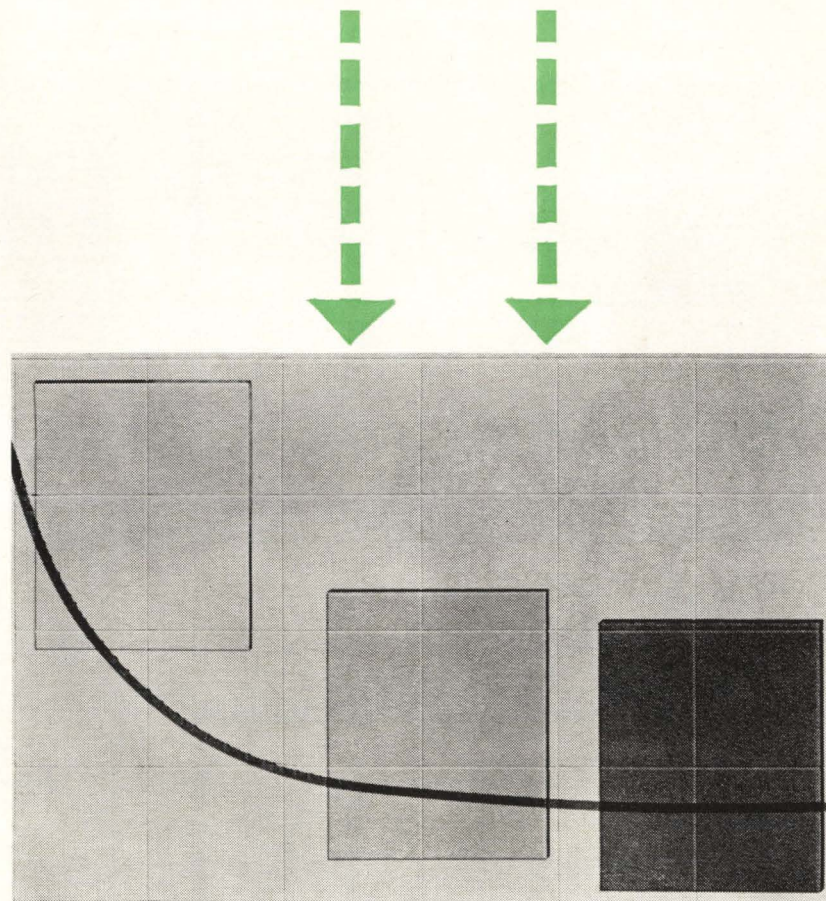
PHOTOCHROMIC GLASS — A NEW BINARY SWITCH?

For many years, scientists have known that ultraviolet light or other high energy radiation can cause color changes in many materials, including some types of glass. In nearly all such cases, the change takes a long time and/or the material lacks the quality of reversibility. Recently, however, research scientists at Corning Glass Works developed a series of special glass compositions that quickly change color on exposure to light and are completely reversible.

Called photochromic glass, this light-sensitive material is still a laboratory development. Potential applications are under evaluation at Corning's research facilities. Experimental work has indicated that these glasses might be formed into products such as optical memory and self-erasing display devices, and as "light valves" in many types of new optical systems.

Corning scientists have melted and tested thousands of different photochromic glasses. Specific properties, including darkening and clearing characteristics, vary with each particular glass composition. The wave lengths that produce darkening are typically the near ultraviolet. Dominant wave length and spectral range depend on the chemical composition of the glass. A typical glass darkens in daylight, but remains clear under normal indoor lighting. The darkened color of the glass is usually gray, sometimes tending toward brown or purple.

In sunlight, the darkening generally approaches maximum intensity in a matter of seconds. Degree of darkness increases with intensity of light. Re-



Photochromic glass darkening depends upon light exposure time (vertical scale) and degree of transmittance (horizontal scale). The curve indicates the drop in light transmission as the glass darkens from exposure to ultraviolet.

action to light can be almost instantaneous. A single one-millisecond flash of a photographer's electronic flash gun, having a capacity of 40 watt-seconds, decreased optical transmittance of a piece of glass to 25 per cent of the original value.

The time required for photochromic glasses to regain original transmittance ranges from minutes to hours, depending on glass composition, previous heat treatment, and temperature of the material. Before darkening, photochromic glass can be as clear as window glass. After darkening, the optical transmittance of a one-fourth-inch thick piece of photochromic glass has been measured to

be as low as 1 per cent. The clearing rate upon removal of the light source increases with temperature. Fast clearing glasses are more temperature sensitive than the slower clearing materials.

These glasses apparently are unique among the photochromic materials in being permanently reversible and immune to fatigue. Sheets of glass have shown no deterioration in performance after more than two years of day and night outdoor exposure, and after indoor testing through thousands of cycles of darkening and clearing. Thus, it appears that this darkening and clearing cycle can be repeated indefinitely. END

42 new integrated circuits*

TTL, DTL, RCTL, and RTL

New multi-function semiconductor networks open way to lower-cost, higher-reliability systems. Catalog **SOLID CIRCUIT®** networks now total 78

Series 51 — RCTL

Two new multi-function gates and three new flip-flops bring to fifteen the number of Series 51 catalog semiconductor networks now available from TI. Series 51 networks feature low power drain . . . as low as 2mw — and high fan-out . . . up to 20. New multi-function networks with three and four circuits per package reduce system costs by lowering the cost per circuit function. Write for data sheets.

Series 53 — Modified DTL

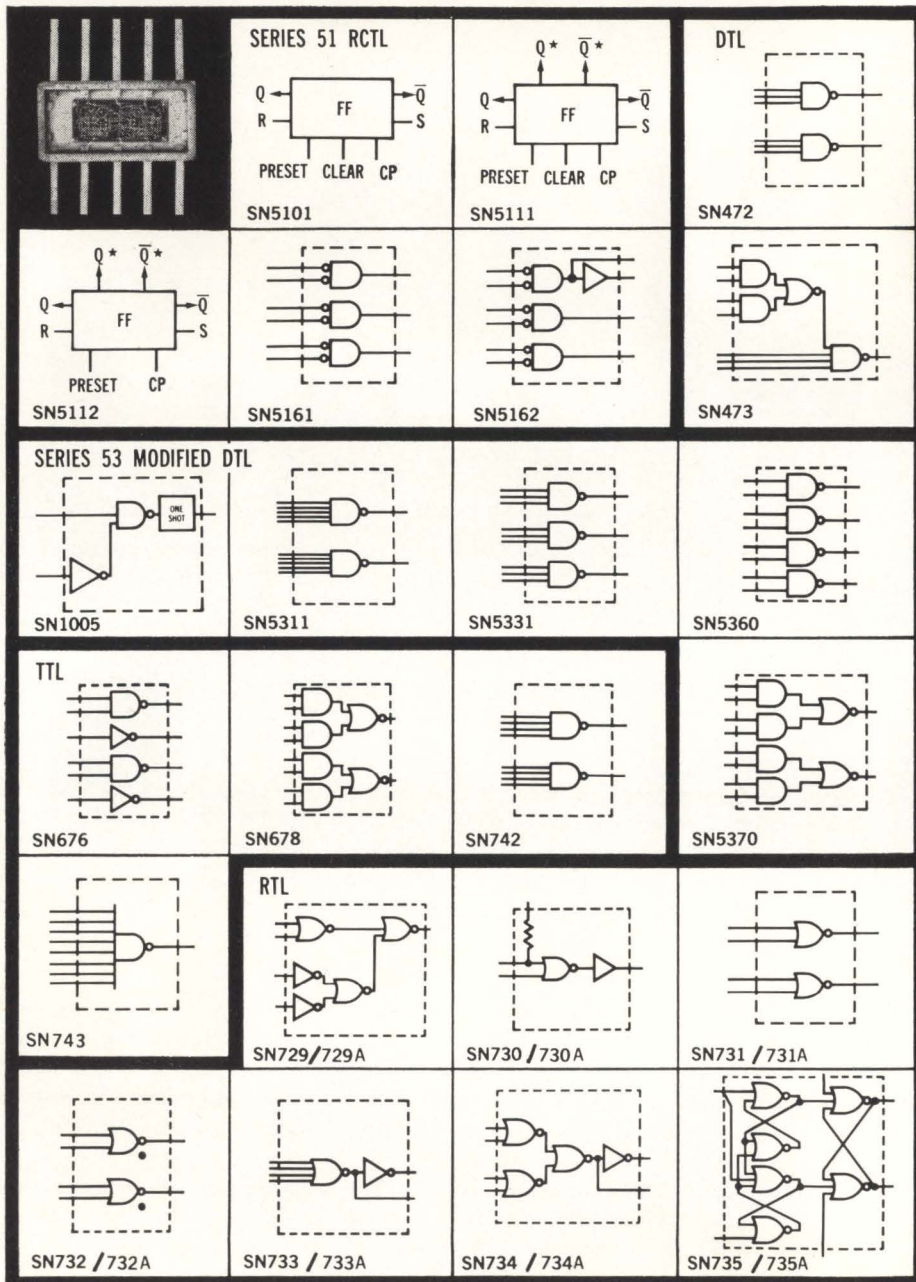
Four new multi-function gates and a one-shot multivibrator are added to the Series 53 line for increased reliability as well as lower system cost. Fewer packages per system mean fewer external interconnections and fewer opportunities for reliability problems. The eleven Series 53 medium-power networks feature high speed (5 to 45 nsec propagation delay) and high fan-out (10 per gate). Write for data sheets.

TTL

Features of this new high-speed series of four networks in the TTL logic configuration include 25 nsec propagation delay, 600-mv noise immunity, double-epitaxial structures, and single-ended outputs. Forty of the new networks, including this TTL series, operate over the full military temperature range of -55° to $+125^{\circ}$ C. Write for data sheets.

DTL

These two new DTL gates also employ double-epitaxial structures. Typical power drain is 5-15mw per gate, and noise immunity is unusually good at one volt (25° C). The AND-NOR-NAND gate (SN473) offers three levels of logic in a single package.



announced by Texas Instruments - logic plus two linear families

Operating temperature range is 0° to 125° C. Write for data sheets.

RTL

This new RTL digital line provides a useful compromise between speed (40 nsec typical propagation delay) and power dissipation (typically 2-5mw per stage). Again, double-epitaxial structures are employed for all seven circuits. TI's standard flat package or a modified TO-5 package is available with no price differential. Write for data sheets.

Series 51R networks for extreme environments

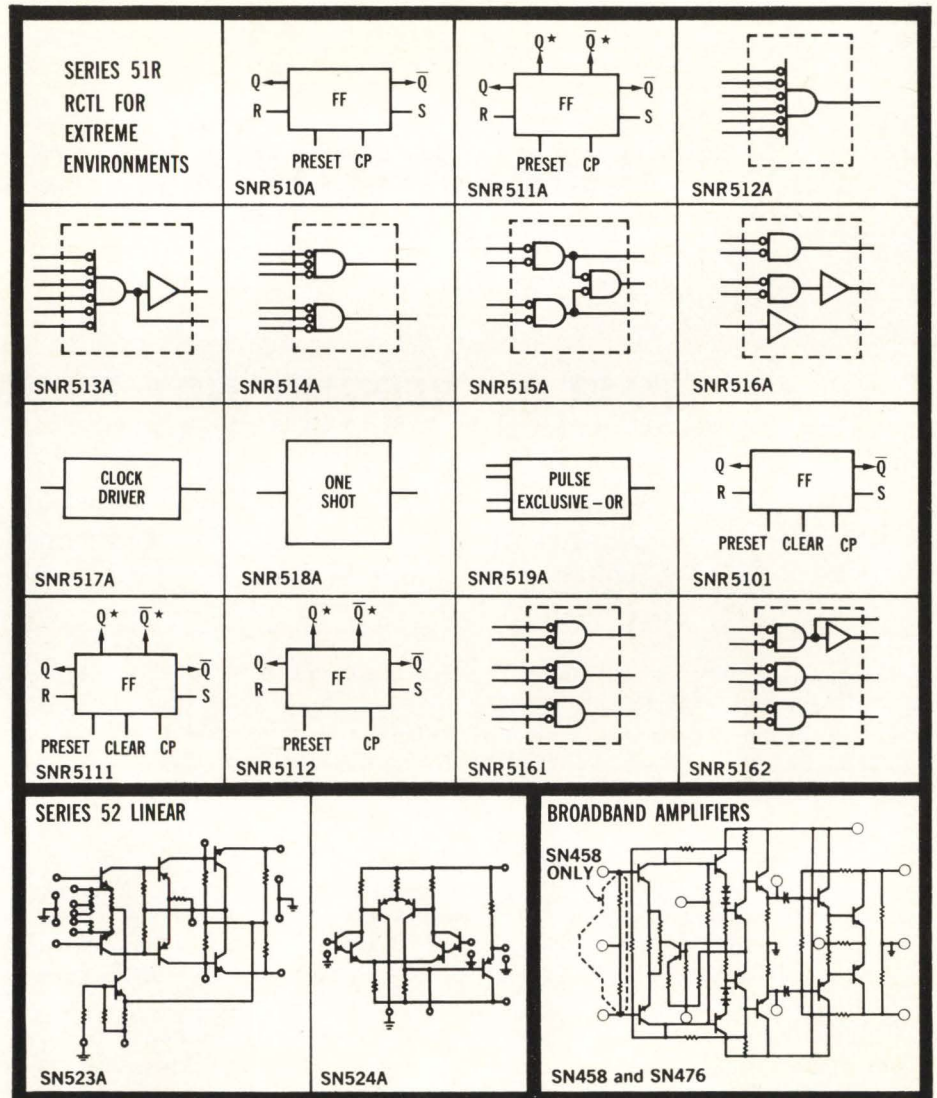
These 15 low-power digital networks are tested and processed especially for severe-environment military and space applications. Series 51R units are standard Series 51 networks that have been subjected to additional processing which includes a centrifuge test of 20,000-g constant acceleration in the critical Y_1 plane for one minute. Each device is dynamically "burned-in" at 125° C for 168 hours, and each is given a careful x-ray inspection. Write for the detailed specification.

Series 52 linear

Two new general-purpose differential amplifiers have been added to the Series 52 line which features fully isolated NPN and PNP transistors in the same monolithic structure. The SN523A offers an adjustable gain from 40 to 70 db, and the SN524A features a Darlington input which provides input impedance to two megohms. Frequency response for both networks is typically dc to 140 kc. Write for data sheets.

Broadband amplifiers

These two low-level broadband amplifiers offer a frequency response of dc to 10 mc. Typical gain is 36 db single-ended dc, and 51 db single-ended ac. Differential inputs and outputs are provided for maximum versatility. Master Slice bar includes 50 transistors, resistors and capacitors. Write for data sheets.



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THE DIGITAL COMPUTER IN

PART 5 – REDUNDANCY TECHNIQUES

This concluding article of the 5-part series analyzes various redundancy schemes, their shortcomings, and their possible effectiveness in providing the required reliability.

In Part 4 of this series, it was shown that the problem of measurement and prediction of reliability requires more faith and imagination than is commonly available and it was suggested that redundancy can provide the assured operation that will be required in real-time control installations. Tutorial works on redundancy and probability theory are readily available¹ and descriptions of particular redundancy schemes are well documented in the literature² and will not be discussed here. In this article, I will attempt to characterize and to categorize some basic features of redundancy in order to provide a broad vantage point from which to view the applicability and value of specific techniques.

Types of Redundancy

Redundancy in digital computers is a technique of repetition or duplication in order to increase the reliability of performance. Redundancy can be incorporated in *programs*, in *signal* paths, or in functional *logic*. In each case, the redundancy will entail either greater time or more hardware to perform a specified operation as compared to an equivalent non-redundant machine.

Programming redundancy is strictly time-domain redundancy and consists of repeating programs or using alternate procedures for solving a problem and checking to ensure that several successive answers are each reasonable and that all of them are in good agreement.

Signal redundancy involves both time and equipment

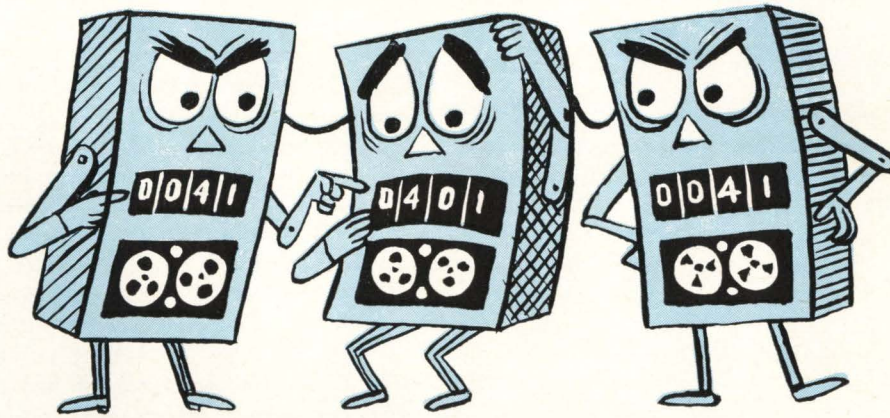
redundancy by using duplication of signals and cross-checking to ensure that correct transfers are achieved. Special encoding techniques permit a few bits to act as a check on the correctness of many bits and, through the use of special codes, the redundancy achieved by the addition of check bits can permit error correction for certain types of errors.

Logic redundancy, which is primarily equipment domain redundancy, uses components, circuits, functional sub-assemblies, assemblies or entire equipments which are duplicated a number of times and, generally operating in parallel, tend to produce a correct signal in spite of some failures.

When first investigated, each type of redundancy appears to be an attractive way of enhancing reliability. More intensive study reveals shortcomings of each technique which tend to reduce its usefulness. For example, programming redundancy implies a machine which can operate two or more times faster than really required to perform the tasks. Such a computer tends to be less reliable (or require more hardware) than a slower device.

Signal redundancy utilizes encoding/decoding operations which require additional hardware and additional time. Furthermore, the application of signal redundancy to arithmetic units is not convenient. Hardware redundancy involves sensing and switching operations (often implied but always costing either time or hardware) in order to operate effectively.

Each form of redundancy offers a gain, or loss, in reli-



REAL-TIME CONTROL SYSTEMS

A. S. BUCHMAN, CONTRIBUTING EDITOR

bility composed of an inherent gain due to the redundancy less the loss due to the extra time or apparatus required to implement the redundancy. The same concept is expressed in the observation that all redundancy techniques require the ability to *sense* improper operation and to *switch* to an alternate source. In some cases explicit sensing and switching are used and the associated hardware is obvious. In other cases, the sensing and switching operations are *implicit* but extra time or hardware is always required to accomplish these functions.

Programming Redundancy

As an example, programming redundancy will solve a particular problem twice and will then *sense* an error by means of a comparison of the results. If the results do not agree, the program must *switch* or branch, probably under executive control, to perform a third solution which can be used in a majority vote to determine the correct answer.

Obviously, such techniques do not respond to, or correct, conditions caused by permanent failure because multiple solutions (if the program continues to run at all) will all be identical in error. If alternate programs are used to solve a single problem, it is possible that some isolated errors can be avoided. But, in general, programming redundancy, while valuable in transient malfunction situations, does not appear to offer much value in obviating errors due to failure.

CORRECTIVE ERRORS	CHECK BITS									
	3	4	5	6	7	8	9	10		
ONE ERROR	4	11	26	57	120	247	502		
TWO INDEPENDENT ERRORS	—	1	2	4	8	14	22	34		
THREE INDEPENDENT ERRORS	—	—	—	—	—	—	—	4		
TWO BIT BURST ERROR	—	3	10	25	56	119	246	501		
THREE BIT BURST ERROR	—	—	—	9	—	55	—	245		
FOUR BIT BURST ERROR	—	—	—	—	—	—	—	83		

TABLE 1 Message Bits vs. Check Bits Required for Various Correction Capabilities

Signal Redundancy

Error-correcting codes are an elegant means for error correction under certain transfer conditions. Such codes *sense* error by inspection of the relationship between received information bits and the received check bits and can *switch* to the correct answer based on this relationship. When cyclic codes are used, the information and check bits are subtly interwoven and the sensing and switching operations are defined by the encoding/decoding algorithm.

Unfortunately, the number of redundant bits which are required and the amount of encoding/decoding hardware tends to be a very high price to pay in digital computers and there appears to be only a few cases where signal redundancy can be of value. For example, some well-

known codes require check bits as indicated in Table 1. Inspection of the ratio of check/information bits indicates that correction for one error or a two-bit burst error would probably be as far as would be practical to go in a computer.

It is interesting to note that there is a direct hardware interpretation of the operation of an error correcting code. Thinking in terms of a parallel register-to-register transfer, a correcting code effectively operates as though it switches in a spare register element to replace any single defective element. The encoding/decoding technique accomplishes this transformation without physical switching of the element but, if multiple errors are likely, a comparison of physical switching means versus correcting codes might be warranted.

Hardware Redundancy

The idea of redundancy achieved by physical multiplication of elements has given rise to a vast number of schemes. We will attempt to categorize these schemes on the basis of whether the sensing and switching is implicit or explicit. Examples of the former are Triple Modular Redundancy (TMR)³, Von Neumann bundling⁴, Quadded logic², etc. The basic concepts of such schemes are spelled out in a remarkable article by Moore and Shannon⁵.

To the best of my knowledge the only highly redundant computer ever built is the IBM aerospace computer for use in the Saturn V launch vehicle. The article by Rozenburg and Ergott³ describes the majority scheme which is used and provides the interesting information that, for a period of 2000 hours, the redundant machine (compared to a non-redundant machine) offered an improvement of 24 in reliability (ratio of failure probabilities) at a cost of approximately four times as much hardware and five times as much volume and power.

Obviously, a redundant machine doesn't eliminate component failures; in fact, since it has more components, in a given amount of time it has more failures. A redundant machine prevents the *error effect* from propagating. It is important to detect that failure has occurred (even though error hasn't) in order to allow repair before errors are propagated. Therefore, all redundant equipment must provide good failure indication and checkout schemes.

In addition, when voters are used, care must be taken to place the voter in the most effective position in the logical network.

Switched Redundancy

A scheme in which there are a number of identical elements which may be switched in to replace a failed element has several basic appeals. First, only the working elements need be turned on and thereby resulting in reduced power consumption and possibly longer life for the reserve elements. Second, if the spare elements can each replace any one of a number of working elements, the number of combinations of permissible failures rapidly increases. Third, the machine can be designed to operate properly as long as at least one of each of the required elements is working, thus providing a substantial improvement over majority schemes. Finally, switched redundancy

should permit rather simple expansion of redundancy by adding n-plicate reserve elements for each active one.

The difficulty is, of course, that the sensing-switching network is so complex that it is usually far less reliable than the element whose reliability we are trying to increase.

This introduces the fact that the *level* on which redundancy is applied is the second dominant characteristic to be considered in selecting a scheme. We would like to make the sensing-switching network more reliable than the logical network being controlled, but as we do this, the logical networks begin to get larger and therefore the redundancy is less effective. This can be easily shown by the example (Fig. 1) where we have paralleled two equipments each consisting of five serial elements. The reliability of each equipment is approximately 0.6 and the reliability of the redundant equipments is approximately 0.85. If the same ten elements were connected as shown in Fig. 2, the reliability of each of the five segments would be 0.99 and the reliability of the redundant equipment is approximately 0.95. This example indicates that we should apply redundancy on as low a level as possible but the sensing and switching requirement indicates that we should apply the redundancy on a high level. The correct answer lies in compromise between these conflicting demands and in development of more efficient sensing and switching schemes.

Fig. 3 indicates a two out of three majority network. We note that only one logic element can be permitted to fail and we can therefore imagine that one of the redundant elements was added to increase the reliability, and the other redundant element and the voter were added to provide the sensing and switching required. In general, it turns out that the voter has a complexity comparable to a logic gate and it herefore appears that the logic element should be of gate size or larger. On the other hand, if we had three complete computers it would not make good sense to compare the outputs and select on a majority basis which allows only one failure. A number of techniques, such as programmed reasonableness checks can be used to provide proper operation with two units failed thus decreasing the system failure probability.

Fig. 4 indicates three networks with an output sensor and a set of switching gates to select the desired unit. It is quite apparent that the logic elements being controlled

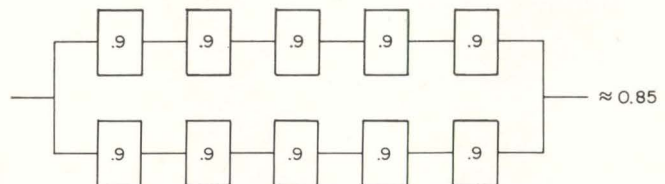


Fig. 1 High-Level Redundancy

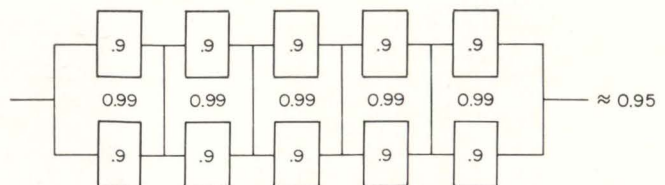


Fig. 2 Low-Level Redundancy

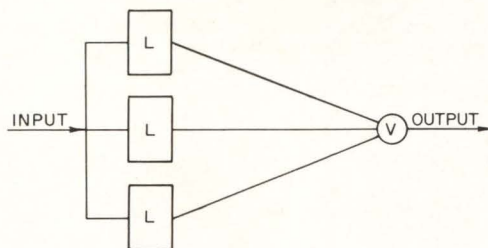


Fig. 3 Majority Logic

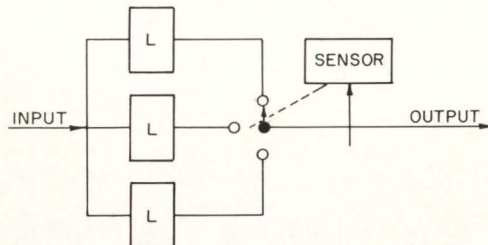


Fig. 4 Switched Redundancy

would have to be registers, arithmetic units, or other functional sub-assemblies, in order to prevent the unreliability from being vested completely in the sensor and switches.

To the best of my knowledge, no active switching schemes are in use in digital computers. Part of the problem lies in the fact that correction is not inherent in the logic algorithm and the computation process must delay while repair is being effected. This introduces conceptual and practical problems of the highest order.

The fact that most continuous processes would not suffer unduly if a delay of a few milliseconds occurs suggests that the use of time as a tradeoff against hardware might be quite effective. For example, why not use adaptive switching whereby an output failure would be partially diagnosed by an executive routine in order to localize the area of interest and then the computer could, under program control, selectively switch-in the available alternate elements one at a time and run an appropriate test program to determine if repair has been effected. This is a process not unlike that used by many semi-skilled repair men who replace the likely group of boards, one at a time, until the failure is corrected.

Redundancy is a very young and very difficult field and increases in basic component reliability are occurring so rapidly that simple machines are achieving quite high reliabilities and many applications may never require redundant treatment. At the same time, as computers become more important in control systems, the requirement for reliability is also increasing and, to satisfy the installations where assured operation can't be compromised, redundancy will continue to be a field of interest and value.

Series Summary

A brief *precis* of the other 4 parts of this series is offered as a reminder and guide.

The industrial applications of digital control, (Part 1 — January 1964 issue) can be divided into discrete process control and continuous process control. The former applications effectively utilize the natural capabilities of digital

techniques; the latter area can presently be served by analog as well as digital techniques but, when adaptive control becomes wedded to high-yield processes, the digital control system will become an essential and inseparable element of the system.

Aerospace applications of digital control (Part 2 — March 1964 issue) have a one-to-one correspondence with industrial usage but the stringent requirements for reliability have prevented the rapid implementation of aerospace digital control systems.

The power of adaptive control techniques (Part 3 — May 1964 issue) lies in their ability to control effectively, a process for which there is no rigorous mathematical model. Adaptive control techniques will, in the future, provide the basis for high-yield processes and for self-regulating discrete control. Such systems will not be operable without the computer, thereby imposing a crucial demand for high reliability.

The cause of erroneous computer outputs (Part 4 — September 1964 issue) can be attributed to either transient malfunctions or permanent failures. Malfunctions can be partially prevented by means of careful control of electrical noise and in those cases where noise, power transients, or other infrequent transients do destroy information, curative measures may be effected by means of various programmed "rollback" techniques. Permanent failure can also be prevented to some extent by careful design, selection of components, and quality control. Nonetheless, when the basis of evaluating reliability is explored, it appears that many installations may require the use of redundancy.

Conclusion

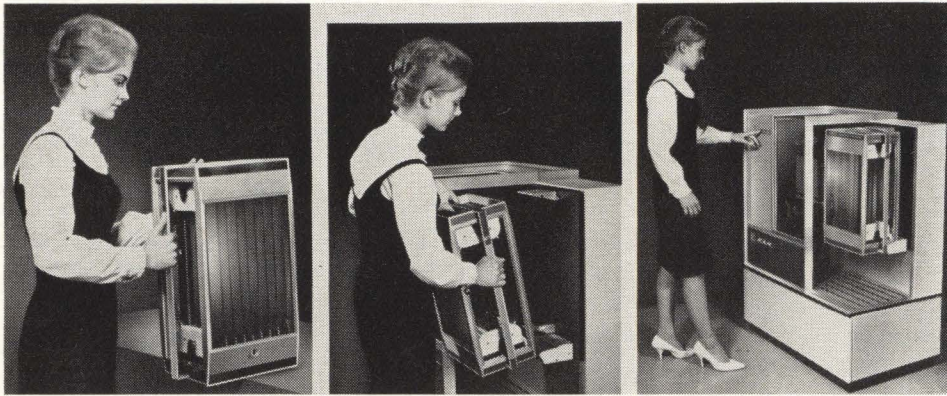
It has been my intention, with this series of articles, to reach readers who are users of digital control systems as well as those who specialize in the design of control equipment and computers but who have not lately had the opportunity to "step back" and take an overall look at the application and use of digital control systems.

Improved control processes and equipment are leading toward important economic and productive changes. Users and design specialists alike are obligated to attempt to understand and respond to each other's problems. It is my hope that this series of articles has added clarity and depth to this mutual understanding.

END

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4. Von Neumann, *Automata Studies*, Princeton U. Press, 1956.
5. Moore & Shannon, *Jnl. of Franklin Institute*, V 262, Nos. 3 and 4, Sept. and Oct. 1956.



OPERATOR SELECTS
MAGNETIC TAPE CARTRIDGE

PLACES CARTRIDGE
ON THE LOADING CARRIAGE

PRESSES "LOAD" PUSHBUTTON

Fig. 1 The loading operation for the new Potter random access memory unit takes approximately 15 seconds. The cartridge is placed on the machine carriage; a latch snaps it secure. From this point everything is automatic. The operator simply presses the "LOAD" pushbutton and walks away, leaving the machine to load the cartridge, start up automatically, and signal the "ready" condition, all within a few seconds.

MAGNETIC TAPE RANDOM ACCESS

Unveiled at the recently held Fall Joint Computer Conference was a new random access storage device that features interchangeable magnetic tape cartridges each with a capacity of over 50 million bits. Here are the design details and performance characteristics of this new unit.

In announcing their new design approach to a random access memory, Potter Instrument Co. of Plainview, N.Y., claimed the following advantages over competing devices:

- 50% faster in all modes of operation
- Unique check-read-after-write capability
- Recording medium "wear-out" dramatically reduced
- Critical mechanical adjustments eliminated
- Storage cartridges not damaged by rough handling
- High storage capacity
- Small size
- Uniform playback waveforms for all points.

And, they reported, the new unit, tradenamed RAM, is available at less than half the cost of any comparable system.

Here are the major design features of RAM, its operating principles and performance characteristics, that support the above claims.

Basic Storage Element

A 30-inch long, continuous loop of standard computer grade magnetic tape forms the basic storage element (see Fig. 2). The loops are first cut to length and then spliced using an ultrasonic sealing process. Special tooling permits the fabrication of loops without manual handling, and

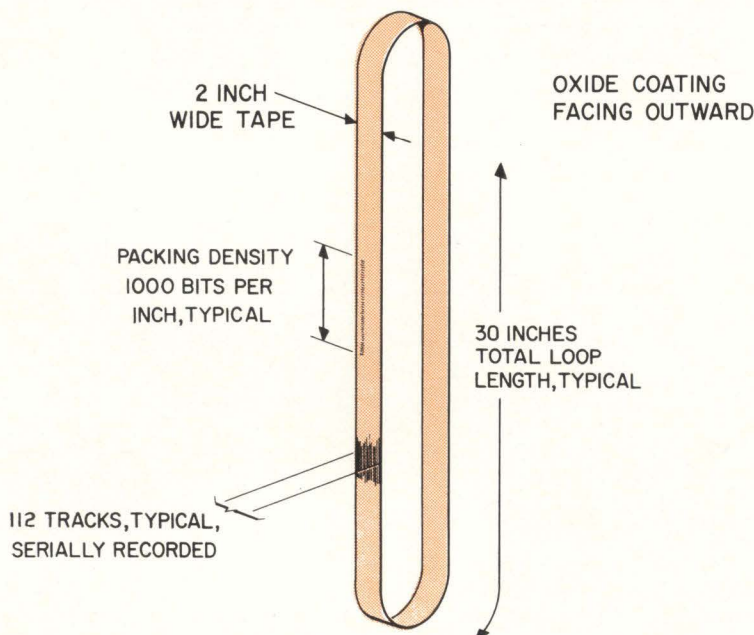


Fig. 2 The basic storage element of the RAM system

STORAGE

with mechanical handling only in the immediate vicinity of the seam. When recording on the loop, the splice area is magnetically sensed and avoided. Thus, the longitudinal recording format is keyed to the splice.

The tape is recorded serially a single channel at a time with a longitudinal density of 1000 bits per inch. There are 112 tracks recorded across the 2 inch width of the tape. Fig. 3 is a schematic illustration of an individual tape drive unit in the "drive" condition and Fig. 4 illustrates the "standby" condition. Wear and contamination of the tape loops are greatly reduced by the use of "air-floating" techniques. As shown in Fig. 3, the upper and lower "turn-arounds" (stationary cylinders) for the tape are equipped with holes through which air is forced to provide the "air bearings". In addition, the vacuum created draws the uncoated side of the tape in against the capstan. Because of the "air lubrication" or "air-floating", the tape drag is extremely small and is easily overcome by the very light pressure between the tape and the moving surface of the capstan. No pinching of the tape is necessary.

The Multiple-Loop Cartridge

Fig. 5 shows how an array of 16 loops is contained in a single cartridge. Since the turn-arounds air-lu-

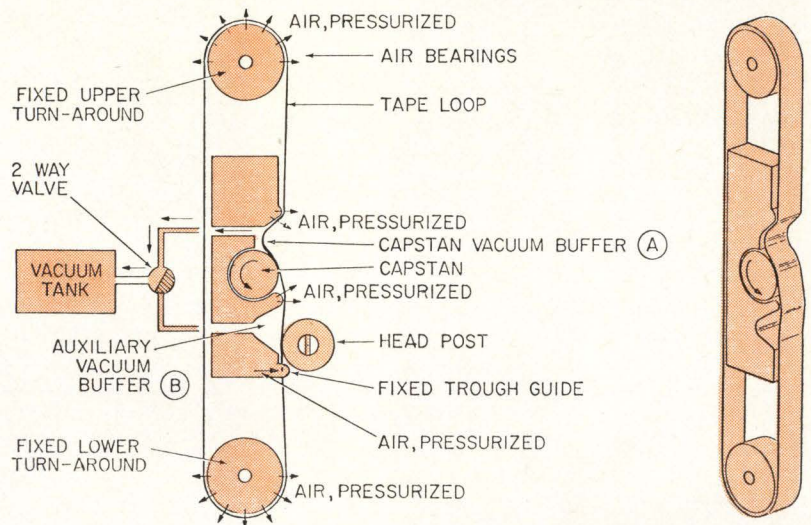


Fig. 3 Individual tape drive unit in the "drive" condition. The upper and lower turn-arounds are hollow cylinders containing air holes which supply pressurized air for the air bearings. The "two-way valve" is shown to be evacuating buffer "A" (capstan vacuum buffer), causing the tape to be wrapped around the constantly-turning capstan. The wrap and air pressure combined with the friction between the tape and the rubber coated capstan are sufficient to drive the loop which, as a result of air lubrication, offers virtually no drag. Thus, tape drive is afforded by friction against the non-coated side only. Examining the coated side, the only questionable point is the head since there is nothing else on the coated side with which the tape could make contact. While there is no pressurized air supplied to this point by the machine, the tape flies on air-cushion nevertheless, for the fast moving tape (600 inches per second) and cylindrical head column form a perfect foil bearing. Thus, the pressure which provides the tape with an air cushion at the head is derived from aerodynamic effects. The flying altitude of the tape may be controlled by tape speed, tape tension, and radius of head column. However, for a given set of these conditions, the flying altitude remains remarkably stable and consistent.

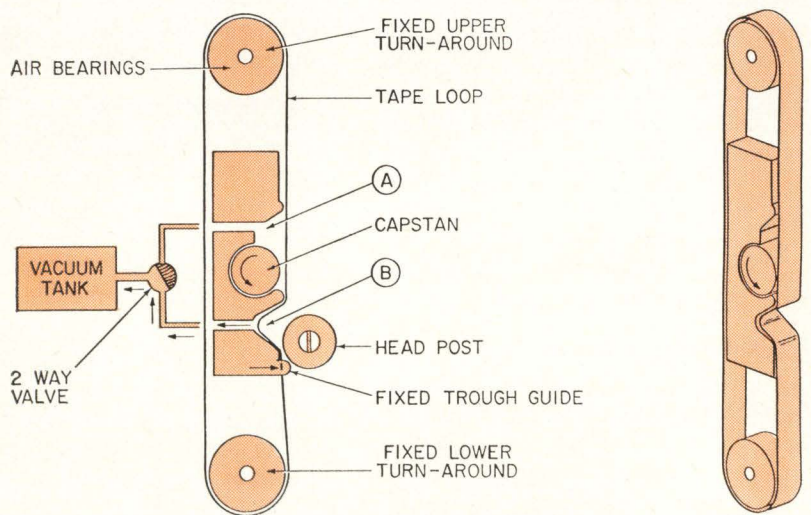


Fig. 4 Tape loop in "standby" condition. Note that the 2-way valve now evacuates buffer B. In this condition, the tape is drawn away from both the capstan and the head and consequently remains stationary. This is the standby condition for any loop not in the process of data transfer.

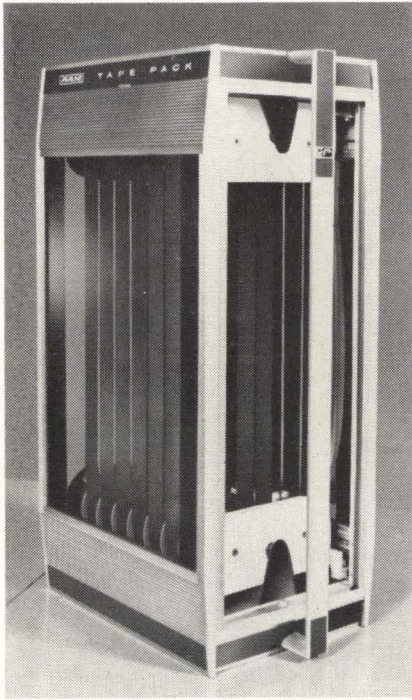


Fig. 5 Model ACC-8606 Tape Pack Cartridge contains 16 basic storage loops for a capacity of over 50 million bits.

bricate every loop, each loop is able to move or stand by independently.

The shell of the cartridge keeps the loops enclosed and protected from dust. However, owing to the flexible medium, the loops are far less sensitive to dust than random access storage devices using rigid media. Since the loops are floated, they are less critical to environmental conditions than tapes in conventional handlers.

While the cartridge is fully enclosed for shelf storage, one side may be opened when the cartridge is loaded into the machine. During operation the front plate of the machine covers the removed side of the cartridge with a small clearance to allow outward air flow from the pressurized turn-arounds.

Multiple Drive Blocks

Individual drive blocks are arranged in two compact groups with a common capstan serving each group as shown in Fig. 6(a). A common vacuum supply is connected to all of the buffer chambers so that all loops are engaged in the driving position simultaneously, as part of the automatic load cycle. The twin capstans run in specially designed long-life

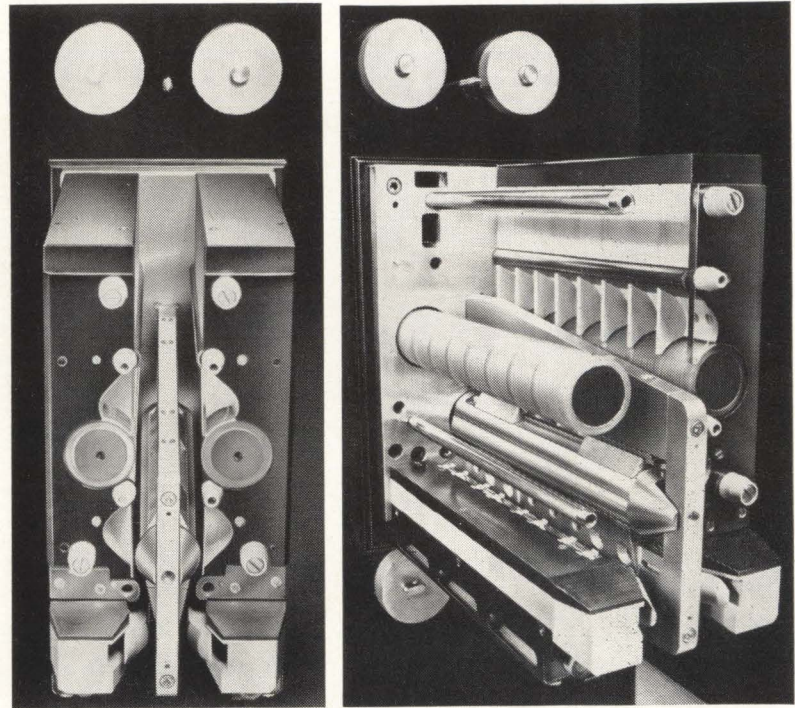


Fig. 6 (a) Multiple drive block assembly is arranged in two compact groups with a common capstan serving each group. (b) Another view of the drive assembly with one group of drive blocks removed to provide access to the head post. The two long cylinders in the center are the twin capstans that drive all tape loops simultaneously. The long metal cylinder below the capstans is the write-read head post assembly.

bearings. Fig. 6(b) shows the appearance of the drive assembly with one group of drive blocks removed to provide access to the head post. The vacuum and pressure porting can be seen and also the location of the capstan threading the remaining group of drive blocks. There are sixteen drive block sections in all providing a 16 loop drive.

Head Post Assembly

All of the write/read heads are mounted in a common head post located between the two groups of tape loops. The position of the head post can be seen in Fig. 6(b). The lower row of heads provides the writing function and the upper row the reading function. The heads are arranged in sections so that seven writing and seven reading heads are presented to each of the eight recording surfaces. A similar arrangement prevails on the other side of the head post to furnish reading and writing functions for the alternate group of eight loops.

The profile of the head post is contoured with a smooth surface finish to define the desired stable flying atti-

tude for the tape. The head post forms a rigid beam structure which permits the heads to be traversed over the recording surfaces under the control of the head post positioning mechanism.

Head Positioning Mechanism

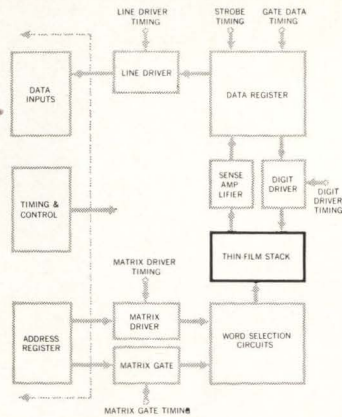
Fig. 7 is a schematic illustration of the head positioning mechanism. Four solenoids with mechanical stops adjusted for equal strokes act as prime movers. Each actuator has two discrete mechanical positions, thus the complete system may be regarded as a mechanical digital-to-analog converter having a four-bit binary input. The levers, called whiffle-trees, and linkages, connect the head post with the actuators through backlash-free flexural spring pivots, thus, errors arising from bearing inconsistencies and wear are eliminated.

By means of a not-too-complicated mathematical analysis of this mechanical system, it can be shown that the maximum output positioning error can never be greater than the largest of the four input errors. In contrast to this, the output error of a compet-

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A

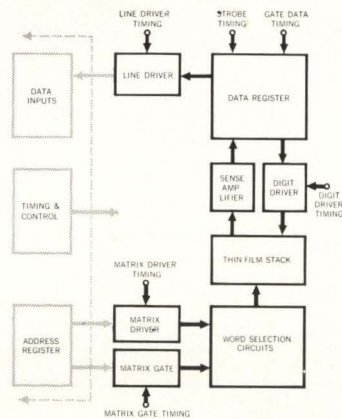


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Word-organized • High-speed destructive readout • Use with small memory systems designed for 100 to 500 nano-second cycle times • Each plane contains 128 words of up to 39 bits each

	Min.	Typ.	Max.	Units
Word Select Current	400	450	—	ma.
Digit Current	120	160	200	ma.
Output-Amplitude	—	1.2	—	mv.
Switching time	—	20	—	nsec.

B



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Data Inputs: 40 ma @ 0 v. each bit line, including current to 120-ohm termination resistor to -4 volts.

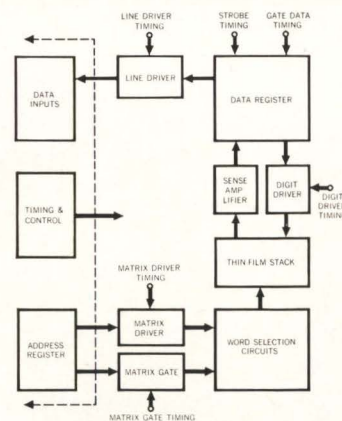
Address Inputs: True and complement required at 65 ma—0 volts, including 120-ohm termination resistor to -4 volts.

Matrix Gate and Driver Timing Pulse: Each group of 256 words requires two 80 ma @ 0 v. pulses.

Digit Driver, Gate Data and Strobe Timing Pulse: Each 6 bits of memory word length requires a 70 ma. @ 0 v. digit timing pulse, a 70 ma. @ 0 v. gate data pulse, and a 45 ma. @ 0 v. strobe pulse. Termination resistors are included.

Line Driver Pulse: Each 9 bits of memory word length requires a 120 ma. @ 0 v. pulse. Termination resistors are included.

C



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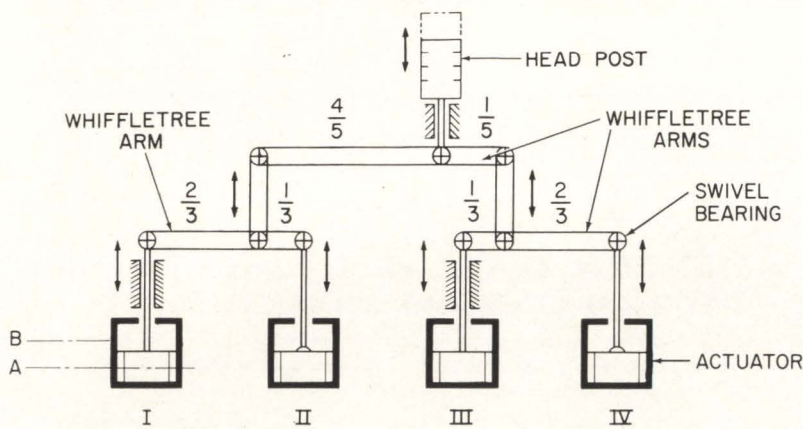


Fig. 7. Head positioning mechanism may be regarded as a mechanical digital-to-analog converter having a four-bit binary input. The levers, called whiffle-trees, and the linkages, connect the head post with the actuators through backlash-free flexural spring pivots, thus, errors arising from bearing inconsistencies and wear are eliminated.

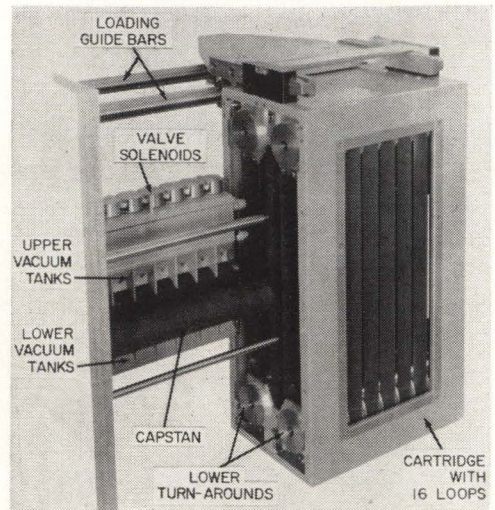


Fig. 9 An experimental cartridge in pre-loading position with the head post and one of the tape drive blocks removed for clearer visibility.

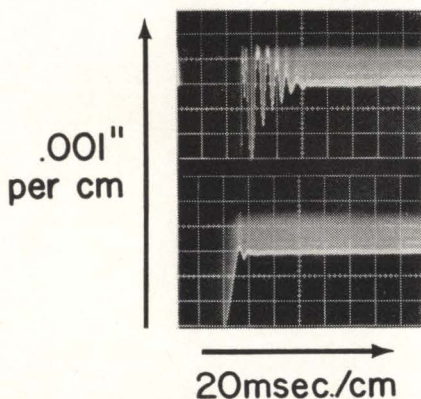


Fig. 8. Dynamic responses of the whiffle-tree positioner (head positioning mechanism). Upper trace: max. stroke; lower trace: minimum stroke.

ing system, according to Potter, is the direct algebraic sum of all the input errors. Another advantage attributed to the whiffle-tree positioner is that it permits a fixed mounting of the actuators so that ordinary solenoids can be used. Hydraulic actuators with all the attendant requirements are not needed.

Typical dynamic responses of the whiffle-tree positioner are shown in Fig. 8. The two oscillograms show head position vs. time for minimum and maximum strokes, respectively. It may be seen that the head is positioned to within 0.001" in 50 msec for the minimum stroke and 80 msec for the maximum stroke.

Cartridge Loading

The smooth execution of moving the loops into operating position, and out of the machine, requires certain features from the machine. The conical nose of the head post and retractible constraining arms act as tape deflectors during loading and unloading of the cartridge. Fig. 9 is a photograph of an experimental cartridge in pre-loading position with the head post and one of the tape drive blocks removed for clear visibility.

The loading and unloading involve several automatically cycled steps such as extruding and retracting the constraining arms, turning air pressures on and off, etc. Total loading time, after the cartridge is manually inserted, is 18 seconds.

Performance Summary

One of the unique capabilities of the RAM is that it can check-read data *immediately* after writing. While other machines in its class are occupied with the extra revolution of the recording medium necessary to check-read, RAM has already started the next access. Information is recorded serially and any information may be written or read at random by transmitting address information to the unit together with an appropriate command signal. All channels have equal storage capacity and equal bit packing density. Thus, "zoned" arrangements, as used in other devices to

achieve reasonable storage efficiency, are not required.

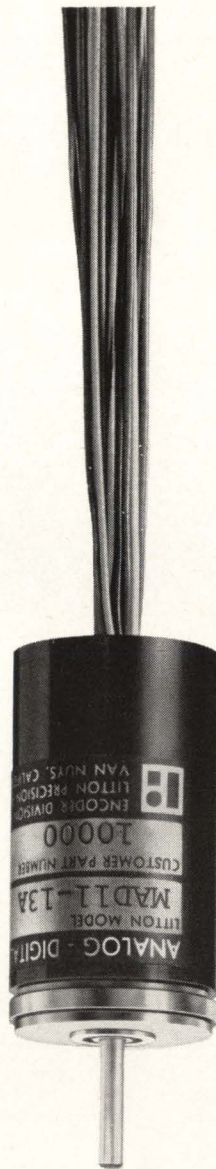
Specifications for Model TLM-4505 with a Model ACC-8606 Cartridge includes a storage capacity of 50.3 million bits, data transfer rate (bits) of 600 kc/s; average head positioning time - 62.5 msec; average latency time 25.0 msec; average access time - 87.5 msec; check read latency time - 1.7 msec; average check read/after-/write cycle time - 89.2 msec (based on average access time); time-to-scan track - 50.0 msec; read-write head separation - 1 inch, nominal; and cartridge life expectancy - 5 years, typical.

Typical prices for the RAM machine run from \$12,000 to \$18,000 depending on requirements. A tape cartridge costs from \$150 - \$200.

In addition to high performance at low cost, a high order of data security is claimed for RAM. According to Potter, the use of a flexible recording medium eliminates machine damage and information loss resulting from head and disc "crashes" encountered in other random access devices. Also, the sealed cartridges do not require the rigorous and elaborate machine room procedures which are essential to establish confidence in other devices.

Potter expects that the RAM will be available as production items by March 1965.

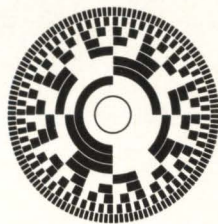
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CIRCLE NO. 7 ON INQUIRY CARD

NEW DATA-READING SYSTEM RAPIDLY DIGITIZES STRIP CHARTS

Strip charts can be digitized more rapidly and accurately with a new analog data-reading system, according to the Glenn Engineering Services, Inc., of Rockville, Md. The new system is reported to be operating at rates twice as fast as currently available analog-to-digital data conversion methods. In addition, the new system is capable of varying counts-per-inch to provide a finer analytical look at any selected point on a chart. Besides an ability to read "x" and "y" coordinates, it also has a "z" capability that provides improved versatility and greater operating range.

"The system holds genuine promise for breaking a bottleneck preventing the full utilization of computer technology in many areas," said Thomas Glenn, President of GES. GES is currently using the system to digitize multi-channel data telemetered from an unmanned Navy satellite.

The new system employs a Keuffel & Esser Electronic Coordinatograph and Recording System (ECARS). The machine, recently developed for use in photogrammetric and mapping work, has been adapted by Glenn for reading strip chart data. The ECARS comprises three components: an input coordinatograph with a cursor arm that moves over the graphic material, a control console and digitizer; and an output card or tape punching unit.

In operation, the strip charts are placed on a table on which the coordinatograph is mounted. The scale and origin of x and y coordinates of



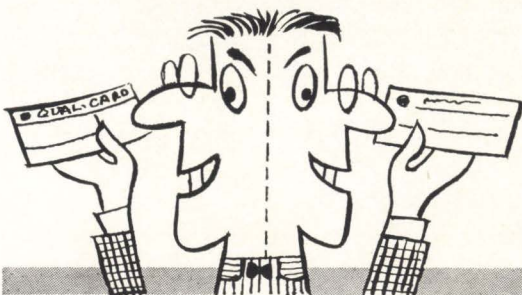
Moving the cursor arm over points on the chart, the operator closes a foot switch to record coordinates and all identifying codes automatically on punched cards or paper tape.

the charts are set on the dials of the console. Identifying codes pertaining to the sheet, job number, operator, etc. are set on a rack of 20 digital switches. The operator moves the cursor over points on the chart, and closes a foot switch to record coordinates, and all identifying codes, on a punched card or on punched paper tape. Up to 1200 points can be punched per hour.

Unlike conventional data readers, the ECARS is an analog device. The

reference or distance measuring portion of the ECARS is an extremely high precision wire-wound potentiometer or mandrel of a length equal to 30 inches — its longest measurable distance. A voltage is applied across the mandrel and a digital voltmeter is connected to a sliding contact driven by the cursor. The voltage read is in direct linear proportion to the distance of the sliding contact from the end of the mandrel.

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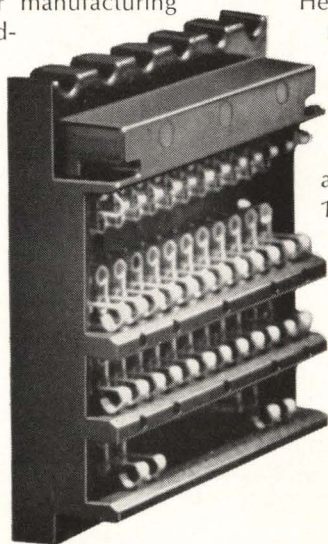
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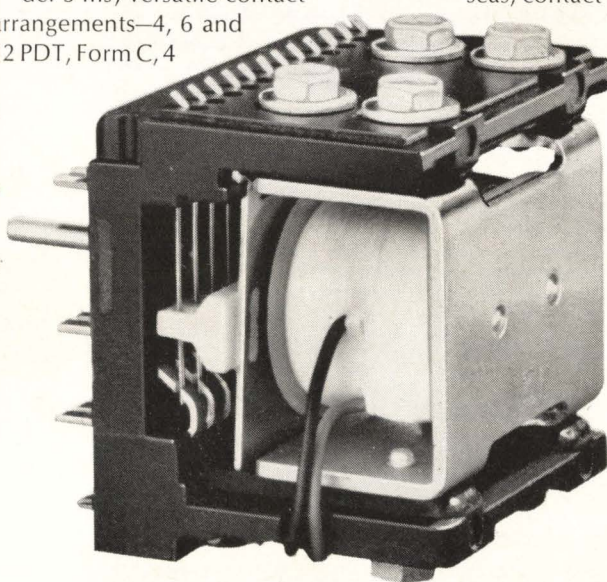
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CIRCLE NO. 8 ON INQUIRY CARD

Causes and Cures of Noise

in Digital Systems



Part 3 – CONTROL OF EXTERNAL NOISE

J. PAUL JONES, JR.,
President, Navigation Computer Corp.,
Norristown, Pa.

In the September and October issues, the previous parts of this 3-part series covered potential sources of noise in the internal design of digital systems. This concluding part describes methods of external shielding and techniques of avoiding noise from being transmitted through external cables. Special power supplies and filters for protecting digital systems from ac power line noise and from RF radiation are also discussed.

When digital systems are connected to external or remote equipment the routing of power and signal grounds presents many special design problems. The power and ground wiring system should *never* utilize the chassis or metal housing as a ground return. The ground currents in metal chassis are not predictable and they are subject to poor connections because of paint, corrosion, etc. Also, the chassis is usually connected to the outside housing, which *should* be used as an effective electro-static and electro-magnetic shield. The outer housing cannot be used as an effective noise shield if it is also carrying "ground" currents.

Fig. 3.1 shows a metal housing which has a metal chassis bolted into the front end. The dotted lines on the diagram of Fig. 3.1 show a "ground path" which is set up in the outside housing between the chassis and an external connector, which is leading to a power supply. This path would be directly susceptible to outside noise interference, since the noise source would have *direct access* to this common current path, as though it were an exposed conductor.

RULE: NEVER USE THE CHASSIS OR HOUSING AS A PART OF THE LOGIC GROUND SYSTEM.

When a system must be used to drive external equipment, or when several large pieces of equipment must be connected together, it is essential that the potentials of the housings should be stabilized in relation to each other.

Fig. 3.1 The ideal point at which to ground the housing is at the output connector where it is bolted in the mounting panel.

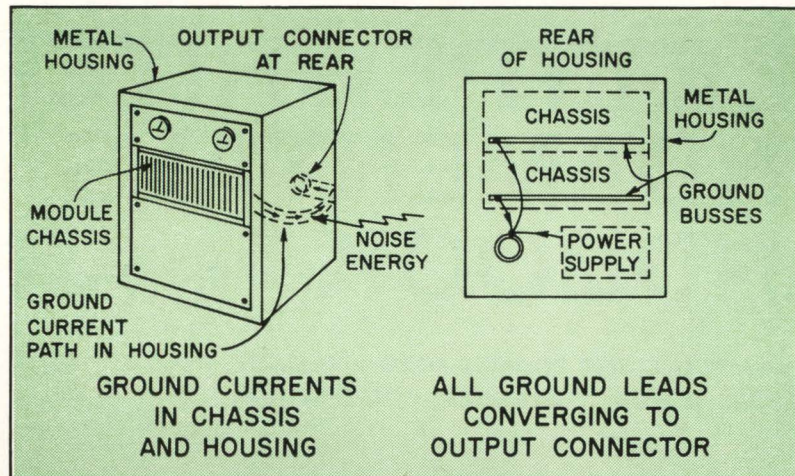
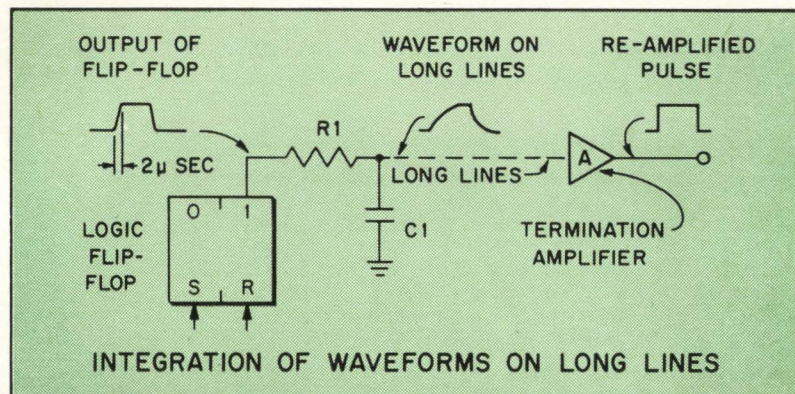


Fig. 3.2 Line integration and termination buffering.



It is therefore, necessary to ground the housings to a common reference, somewhere. The ideal point at which to ground the housing is at the output connector where it is bolted to the mounting panel. When cables are being run to external equipment, *all grounds*, including the power supply ground, should be brought to the same common point (See Fig. 3.1).

RULE: WHEN CONNECTING SEVERAL LARGE PIECES OF EQUIPMENT TOGETHER THROUGH CABLES, GROUND THE COMMON GROUND BUS OR CABLE SHIELD AT THE OUTPUT CONNECTOR ON THE HOUSINGS. ALL OTHER GROUND LEADS SHOULD CONVERGE TO THE SAME POINT.

Output Buffering

When triggerable circuits, such as flip-flops or one-shot delays, are used as a source of signals to be sent over long lines to external equipment, it is usually necessary to use individual buffer amplifiers on each output line. In some cases, output integration or line filters are sufficient.

RULE: NEVER USE A TRIGGERABLE CIRCUIT TO DRIVE LONG LINES OR EXTERNAL WIRING WITHOUT BUFFERING AND/OR PROPER FILTERING.

With reference to Fig. 3.2, notice that the simple integration network made up of a series resistor and a capaci-

tor to ground can be used deliberately to extend the rise and fall times of a fast transient pulse from a flip-flop. The integrating capacitor (C_1) serves two purposes: it slows down the 0.2 micro-second rise and fall times of the original flip-flop waveform to approximately 3 to 10 microseconds on the long lines; and it bypasses noise that may be picked up on the long lines, reducing the amplitude sufficiently to make picked up noise ineffective by the time it reaches the flip-flop through the series resistance (R_1).

If, for instance, the pulse rise and fall time to the long lines is slowed down to 3 microseconds, it represents a lowering of the rise and fall time rates by 15 to 1. When long lines are cabled together, this 15 to 1 slowing down of the line transients causes a corresponding increase in the X_c resistance of the crosstalk paths between the lines (Note $X_c = 1/2\pi fC$). In other words, it reduces the effect of the interwire capacitance between lines by 15 times. An amplifier or Schmitt trigger type pulse-forming circuit may be used at the termination of the long lines to reconstruct the pulses into their original fast transient form. The amount of delay that is picked up in the lines from the process of integration and re-amplification is surprisingly small, and can be held to a fraction of a usec.

Driving Diode Matrices

Line integration and termination buffering can be very useful when driving large mechanical configurations such

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as diode coding matrices. In the case of large diode matrices, the interplay of wires and the necessary fitting of cables, etc. to the mechanical configuration makes the chances for cross-talk noise especially high. In this case, as with the long lines, the slowing down of pulse transients will cause a corresponding reduction of cross-talk problems.

When wiring systems, the integration components, consisting of resistors (R1) and capacitors (C1), should be mounted on a terminal block that is located as close as possible to the outputs of the trigger circuits to avoid any noise pickup between the isolating resistor and the trigger circuit.

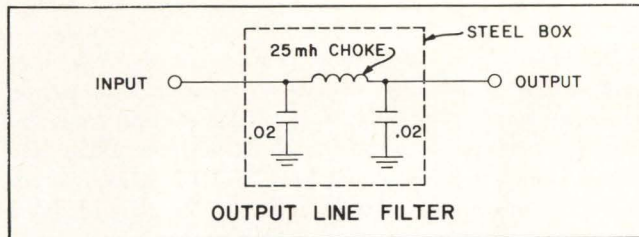


Fig. 3.3 Typical Pi-network output line filter that can be used with buffer amplifiers when lines are susceptible to outside noise pickup.

Output Filters

Fig. 3.3 shows a typical Pi-network output line filter that can be used with buffer amplifiers on trigger type circuits when lines are susceptible to outside noise pickup. This series filter network serves two purposes: it prevents high frequency noise disturbances from entering the equipment through the external lines; and it slows down the output waveforms to approximately 5 to 10 microseconds rise and fall time to reduce inter-wire capacitance cross-talk on the long lines in the cable. All these external lines should be considered as "antennae", which can pick up high frequency interference and conduct it directly into the equipment.

RULE: ALWAYS USE OUTPUT FILTERS WHEN DRIVING LOGIC LEVELS THROUGH EXTERNAL LINES TO REMOTE EQUIPMENT IN HIGH NOISE LOCATIONS.

Output Pi-network filters should be assembled on a terminal panel which is mounted on stand-offs in a steel box, as shown in Fig. 3.4. The terminal panel should be mounted so that both input and output wires can be

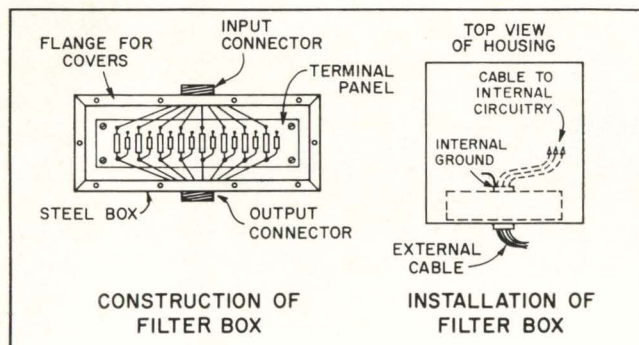


Fig. 3.4 Output filters should be assembled on a terminal panel in a steel box.

fanned out directly from the connectors to the terminals on the panel. When arranged in this configuration, they have a minimum capacitance to each other, and to the opposing set of leads.

The filter box should be made of steel rather than aluminum so that it can act as an effective electromagnetic shield. In addition, it should include steel covers that can be mounted on the flanges with self-tapping metal screws, so that the network is completely enclosed when mounted inside the system housing. This shield box is necessary because the output wires have not yet been filtered when they pass through the external cable connector and they can still be a source of *direct radiation* to the internal logic. The master ground bus from the terminal panel should be returned to the ground point at the *internal input connector* and all of the system and power supply ground leads should also converge to this connector.

Use of Coaxial Cable

In noisy locations, or when high frequency data is to be transmitted over long distances, noise pick-up may be greatly reduced by the use of shielded coaxial cable. When very low level signals are involved, it may be necessary to use a balanced pair of lines with a common coaxial shield which is held at ground potential. This latter type of balanced coaxial cable is usually required at locations where high inductive fields are present. Inductive fields cannot be properly shielded by the braided casing of the coaxial cable alone, since the casing is

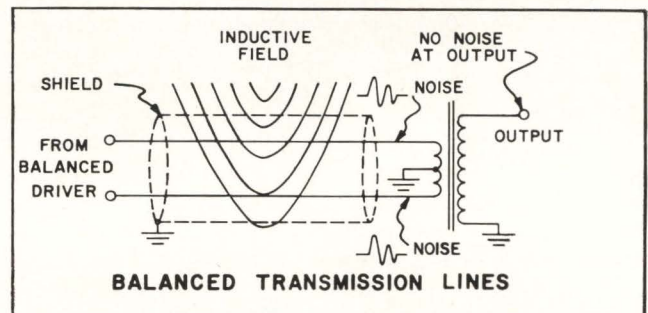


Fig. 3.5 Noise from inductive fields can be cancelled out at the input of balanced or differential type amplifiers.

primarily an electrostatic shield rather than an inductive shield. Inductive fields, when cutting balanced lines, will tend to generate noise voltages of the same polarity and amplitude in both lines. These can be cancelled out at the input of balanced or differential type amplifiers. The effect of an inductive field on balanced long lines is illustrated in Fig. 3.5.

There are two general methods for driving pulses through coaxial cable transmission lines. The simplest approach is to drive the full line capacity by brute force using high power line drivers (usually power transistors). If coaxial cable is not driven and terminated by its characteristic impedance, the total capacity of the full line length must be driven as a reactive load. Coaxial cable

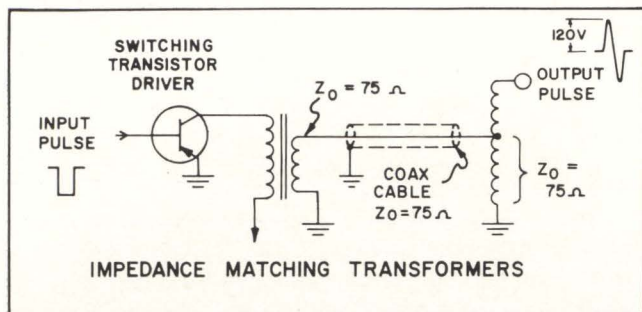


Fig. 3.6 Line matching transformers may be used to produce the proper line match and to develop the required voltages.

may run as high as 50 micromicrofarads per foot, consequently, the brute force driving of long lengths of cable may require considerable power. For example, 1,000 feet of coaxial cable at 50 uuf per foot will constitute a capacitive load of 0.05 microfarads. Thus, a 10 volt driver would require 3.2 ohms impedance and approx. 30 watts driving capability to charge and discharge this line capacity in *one* microsecond. These figures make it obvious that brute force driving of any appreciable length of lines would limit digital data to the 100 to 500 kc range.

When very high frequencies are to be transmitted or when the amount of driving power is limited, it may be necessary to use transformers for both driving and terminating the line at its characteristic impedance. When transmission lines are properly *matched*, the reactive components are balanced out and the entire transmission line looks like a pure resistive load to the driving source.

An example of the use of a matched transmission line for transmitting a low power, high frequency pulse is shown in Fig. 3.6. In the example shown, the problem is to transmit short duration pulses of 120 volts amplitude to flash a neon bulb for producing time marks on photographic film. The high voltage requirement, in combination with the low power levels desired, would make it quite impossible to drive such a pulse through long coaxial cables by brute force methods. With a combination of a *line matching* and *voltage step-up* transformer, as shown, it is possible to drive a pulse through the coaxial cable with very low power levels, and to produce an undeteriorated high voltage pulse at the termination of the line. Note that the impedance change through a transformer is the *square* of the turns ratio. For example, a transformer winding ratio of 2 to 1 would produce an impedance step-down ratio of 4 to 1. Therefore, line matching transformers may be used to produce the proper line match and to develop the required voltages.

There is an added advantage in using matching transformers when driving pulses through transmission lines. A step-down impedance match is usually required which results in fairly low voltages along the transmission line (on the order of 1 to 2 volts). If the line matching impedance, over a broad band of frequencies, should be slightly off, the power to drive the line capacities at these low voltage levels ($P=E^2 C$) would be much less, and therefore, would constitute less of a design problem.

External Noise

There are many sources of external noise, most of which

NOISE SOURCES	DIRECT RADIATION	THROUGH A. C. LINE
D. C. MOTORS	X	X
A. C. BRUSH MOTORS	X	X
SPARK COILS, BUZZERS	X	
CONTACT BREAKERS		X
WELDING, SPOT, ARC		X
CONTACT ARCING	X	X
LARGE SOLENOID FLYBACK		X
MOTOR SWITCH CLOSURES	X	X
GAS TUBE OSCILLATIONS	X	
RADIO FREQUENCY SOURCES	X	
LIGHTNING FLASHES	X	X

TABLE 1
COMMON SOURCES OF EXTERNAL NOISE

have broad band frequency characteristics, very high power levels, and high radiation intensity. The power levels at which typical transistor logic circuitry operates are extremely low, and are usually at an intermediate impedance level of below 10 kilohms. Both the wires and circuitry are directly susceptible to pick-up because of direct radiation from RF noise sources as well as from interference directly through the ac line.

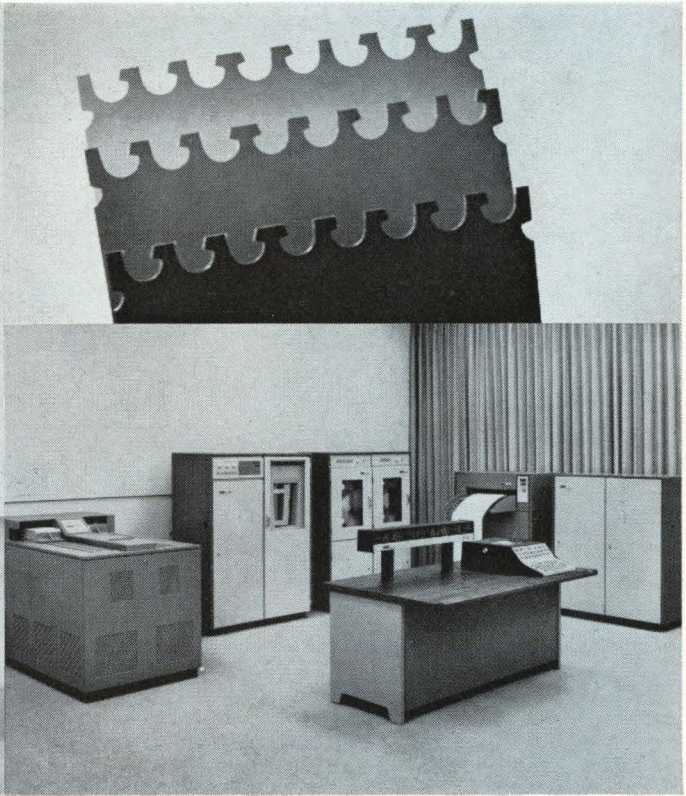
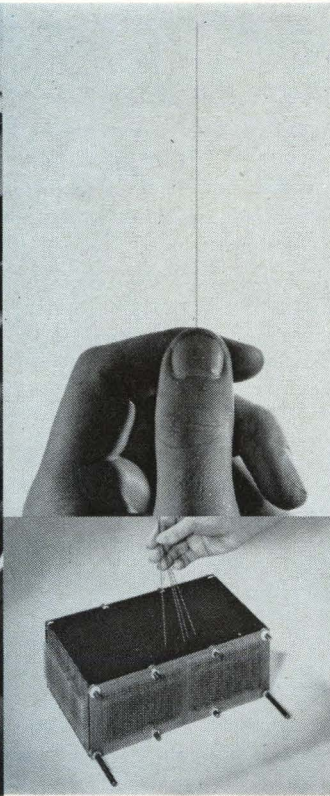
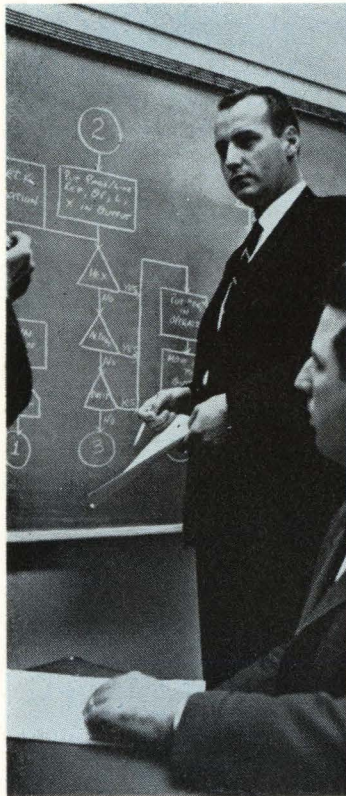
Table 1 lists some of the more common noise sources which may be encountered in a typical installation. These noise sources have the potential of entering the system either by direct radiation into the wiring and circuitry, or by entry through the ac power lines, or both. To prevent direct radiation pick-up, a properly shielded housing must be provided. In the case of the ac line noise, proper RF and low frequency filtering must be provided, and in some cases, provision must be made for maintaining proper circuit operation through momentary line "drop-outs".

With the exception of radio frequency sources, almost all of the noise sources listed in Table 1 under direct radiation, are very *broad band* frequency sources. They may contain strong frequency components ranging from several megacycles down to the first harmonic of the noise pulse. The noise which is observed on circuit lines is usually in the microsecond or fractional microsecond range, and usually has the appearance of a damped oscillation.

This "ringing" noise waveform is actually created by the self-resonant frequency characteristic of the individual leads. Every wire has a certain amount of inductance and a parallel capacitance to ground, which has a resonant frequency that can be excited by a broad band noise source. These wires will select the frequency component to which they are resonant and will "ring" at frequencies which are usually in the range of the trigger inputs to logic circuitry (generally 0.25 to 2 microseconds).

RFI-Proofing

If the outer housing of a digital system is to serve as a shield against high frequency interference, it must be made of steel. The front panel must also be made of steel. Particular attention must be paid to eliminating chassis ground current loops and to making proper electrical connection of all painted parts. When a painted front panel is to be assembled as a radio frequency interference shield, it must, for instance, be lightly counter-bored to remove the paint where the mounting screws are inserted



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into the main housing flange. For all high frequency noise sources up to approximately 100 megacycles, good metallic screw connections at regular intervals are usually sufficient. When there are higher UHF frequencies, such as may be encountered near radar installations, any gap between actual ground contacts may form a "slot-antenna". If the resonant frequency of this slot antenna falls on some fractional or multiple wave length of the radio frequency source, it will absorb energy and re-radiate it into the equipment. In places where very high frequency noise sources are involved, the RFI-proofing of the cabinet is most important and should be tackled as a system "circuit" problem.

When digital systems are located in close proximity to very high RF energy sources such as thyratron gas tube motor controls, it is also usually necessary to connect the outside cabinetry to a *good earth ground*, in addition to following all of the other precautions which have been outlined.

AC Power Line Noise

The ac power line input must always be considered as a prime source of both high frequency and low frequency noise. For example, an ac brush motor can cause exceptionally large amounts of high frequency noise, as well as line transients that may *exceed the regulation range* of conventional dc regulated power supplies.

A standard precaution against radio interference from

the ac line is a simple input filter network such as that shown in Fig. 3.7(A). When possible, the ac input should be located a short distance from the main output cable which carries the signal lines, and the filter capacitors should be connected to the central ground point at the cable connectors. This is the same point to which all the ground lines are routed. The RF noise from the arcing of brushes on dc type motors may be adequately filtered by this filter network. This filter will not, however, filter the low frequency *line-drop transients* that can be caused when motors are first turned on.

Line Drop-Out

When instruments or machine tools are switched on to local ac lines, the instantaneous current surge into a non-rotating motor winding, or input filter capacitor of an instrument power supply, can cause a momentary line drop. Often this may be as much as 40 volts. This line drop is caused by the inductive drop along the ac power lines and often exceeds the regulation range of the power supply, which is usually between 100 and 130 volts.

To overcome line drop-out problems, it is necessary to provide a device which will add "inertia" to the power input. One such device, shown in Fig. 3.7(B), is a *line isolation transformer* which has a *sixty cycle harmonic filter* as part of the unit. This transformer can be used to *extend the regulation range* of power supplies to line transients and, in addition, provide some inertia through the 60 cycle filter at the output of the unit.

A line isolation transformer, such as the one described, should always be considered as *standard equipment* in any installation which will be subject to industrial environment or similar noisy locations.

Power Supplies For Very High Noise Locations

When frequent line drop-outs and very high noise levels are involved at an installation site, it may be necessary

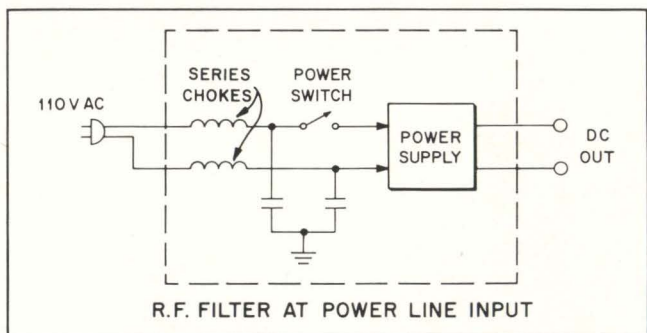


Fig. 3.7 (A) Simple input filter network can be used as a standard precaution against RF interference from ac line.

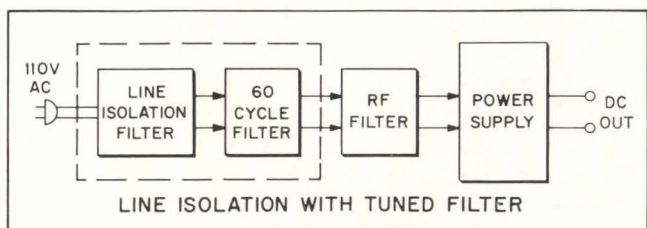


Fig. 3.7 (B) This line isolation transformer will add "inertia" to the power input, to overcome line drop-out problems.

to use one of the "high inertia" power supply systems. As shown in Fig. 3.8(A), one technique which can be used with availability of *very high capacitance* electrolytic capacitors is brute force filtering (in the order of several

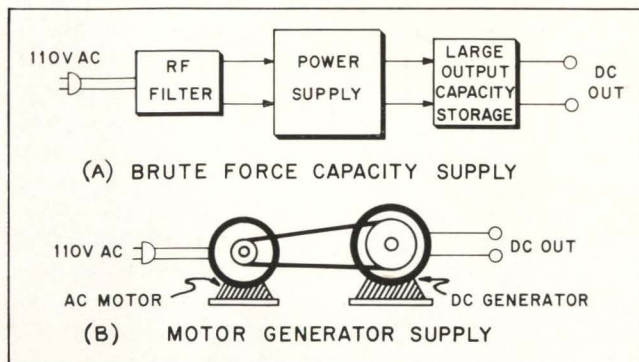


Fig. 3.8 Power supplies for very high noise locations.

hundred thousand microfarads) in the output filter. Enough capacitance can be used to make the output filter act almost as a dc battery which will maintain supply voltage levels over relatively long drop-out periods.

Use of a Rechargeable Battery

The second method that can be used to provide good noise immunity against *temporary or long term line drop-out* is a rechargeable battery supply (such as a nickel cadmium or wet cell) which is used to operate the system directly, and has an ac "trickle" charger. The trickle charge supply prevents the battery from discharging during normal operations. If, however, the line should momentarily drop out or even cut off entirely, the battery continues to supply the necessary voltage. In addition to acting as a voltage source, the battery acts as an extremely high value capacitor, therefore, it is also the equivalent of the large "brute force" capacity storage that is shown in Fig. 3.8(A).

Motor-Generator Supply

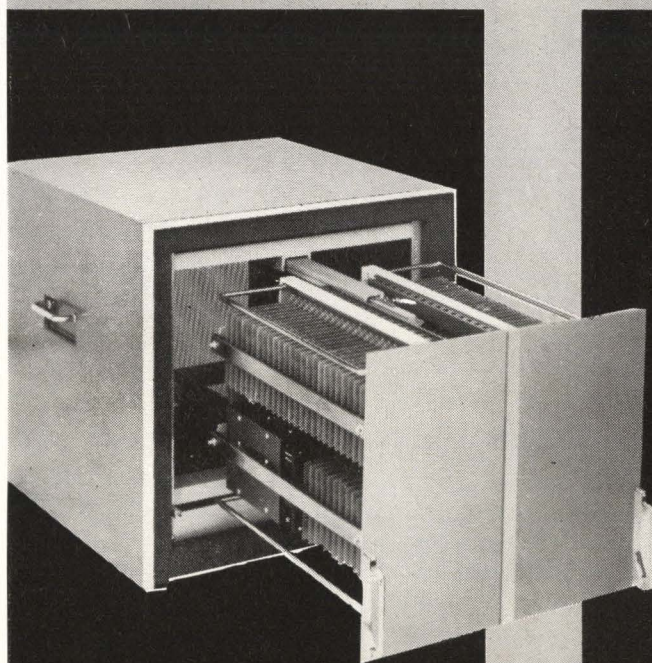
Fig. 3.8(B) depicts a motor-generator type supply which is often used in large systems when it is necessary to gain the greatest amount of isolation from the ac lines. In such a supply, the power from the ac line is used only to drive an ac motor which, in turn, drives a dc generator. This "Dynamotor" type supply has the advantage of complete electrical isolation from the ac line since the only connection between the motor and generator is a mechanical one.

For industrial environments, successful motor generator sets have been made from ordinary ac motors and high-quality automobile type generators. The dependability-to-cost ratio of these systems is very high and often has enough economic advantages to allow a dual supply system to be installed. In such a dual system, one of the units can always be checked out and on stand-by, ready to take over while the alternate is being repaired. END

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CIRCLE NO. 9 ON INQUIRY CARD



NEW PRODUCTS

DATA COMMUNICATIONS SET

A new data set, called the AE401E Datacom transmits alpha-numeric data from punched cards over standard, local, long distance, or private telephone lines. Although it is considered a low speed system (up to 20 characters per second), it is economical for organizations that need to collect relatively short messages originating from many stations. After establishing a telephone connection in the usual manner using the AE401 Datacom data set as a telephone, both stations switch to the data mode. With the system in the data mode, the transmitting operator inserts a pre-punched card in the card reader. The carriage holding the card is then pushed in until tones are heard coming from the speaker in the card-reader. The carriage is released, and the card is read automatically at a rate of 10 to 12 columns of punched holes per second. When the carriage stops, variable data is manually keyed in. Compared to verbally calling-in such data, the data set method reduces total ordering time, reduces the time on long distance circuits, and reduces errors. When not transmitting data, the set can be used as an ordinary telephone. Automatic Electric Co., Northlake, Ill.

Circle No. 184 on Inquiry Card

RTL CIRCUITS

A series of low-power integrated circuits in the milliwatt range features advanced double-epitaxial structures and a choice of packaging. The new series includes seven NAND/NOR digital circuits with guaranteed compatibility through the full temperature range of -55 to 126°C . Power dissipation for the series is typically 2 to 5 milliwatts per stage, with propagation delays typically nanoseconds. A major feature of the series is the availability of all seven circuits either in standard 10-lead flat pack or in a modified TO-5 package — with no price differential between the two packages. The network bar is fabricated in each case using planar-diffused double-epitaxial techniques. Texas Instruments, Inc., Semiconductor Components Div., Dallas, Tex.

Circle No. 163 on Inquiry Card

MAGNETOMETER

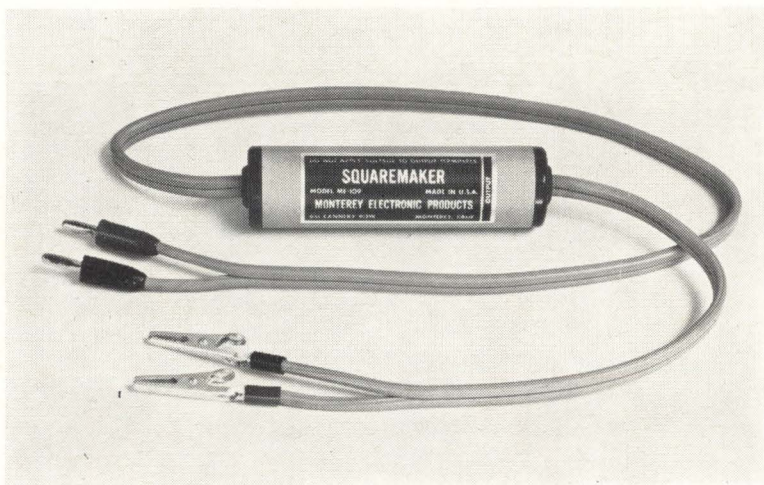
A low-level, magnetic instrument utilizes a sensitive detector which eliminates the amplifier conventionally employed in magnetometers and is designed to indicate the magnitude of static or "DC" magnetic fields from 10 milligauss to 1000 milligauss full scale in five ranges. Power consumption is only 4 watts. The probe measures 1" in diameter by $7\frac{1}{2}$ " long. A rugged taut band meter with a zero center scale is provided so that either polarity of field can be indicated without switching. Gammatronic, Inc., Dublin, Ohio.

Circle No. 133 on Inquiry Card

PC BOARD CONNECTOR

Designed to connect parallel PC boards, a new connector was developed for reliable, straight-forward packaging. Straight or right angle contacts permit any combination of board-to-board or board-to-panel connection. Features include reliability — only three different parts for entire pair, no springs for contact retention; machined pin and socket contacts; low cost — under \$2.00/pair for 10,000 standard units; and push out force 50 lb./contact and pull out force 30 lb./contact. AirBorn Inc., Dallas, Texas.

Circle No. 182 on Inquiry Card



SQUAREWAVE GENERATOR

A unique low-cost (\$15.95) instrument, called the Squaremaker, converts an audio or video oscillator into a high-quality squarewave generator. Batteries and power connections are not required as the transistors in the Squaremaker derive their collector voltage directly from the input sine-

wave. Frequency and amplitude are adjustable over a wide range by the oscillator controls. Typical performance data: 50 ns rise time; up to 35 volts output; useful as a trigger from 1 cps to 1 mcs; squarewave frequency range of 15 cps to 500 kcs. Monterey Electronic Prods. Monterey, Cal.

Circle No. 132 on Inquiry Card

NEW COMPUTER FAMILY

New digital computer systems are said to have characteristics which specially suit them to design, systems analysis, and on-line computation in many applications. The first two members of the computer family have been designated the 6020 and the 6040 computer systems. The 6020 is a small scale system priced below \$80,000 while the 6040 is a larger high-performance unit with extremely high-speed priced at slightly over \$100,000. Both computers feature a 1.9 usec memory cycle time and have a word length of 24 bits plus parity. The 6040 contains a high-speed arithmetic section which allows 9.5 usec multiply, and 11.5 usec divide instructions. Features common to both the systems include a complete line of peripheral equipment comprising high and low density magnetic tape units, card readers and punches, paper tape system, input/output typewriter, line printers, and incremental plotting systems as well as a new package of tested programming aids which include a one-pass Fortran compiler and one-pass symbolic assembler. All computer systems are upward compatible in both hardware and software. Advanced Scientific Instruments, Minneapolis, Minn.

Circle No. 183 on Inquiry Card

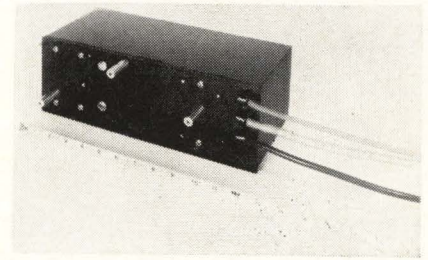
MICROMINIATURE RESISTOR

Considered to be the world's smallest resistor, a new unit was designed particularly for use in hybrid microcircuits. This resistor can be integrated in many of the hybrid circuits which are now employing silicon and are limited by the values of resistance that can be obtained. Stable microcircuits over a temperature range of -65°C to $+125^{\circ}\text{C}$ are possible with this new resistor. The unit, trademarked, Speck-Ohm, has a temperature coefficient of resistance of less than 300 ppm. The dissipation at 70C is 10 milliwatts. The resistor is available with 0.001" diam. platinum leads; the body of the resistor is spherically-shaped and approximates 0.020" at the maximum dimension. MSI Electronics, Richmond Hill, N.Y.

Circle No. 154 on Inquiry Card

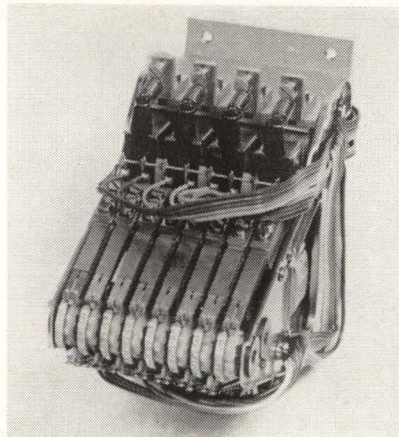
DIGITAL SERVO UNIT

Digital commands entering into the optional keyboard or rotary digit switch controls of a new digital servo unit determine the number of rotations and the final position of the unit's output shaft within ± 1 degree. The standard Model 1420 has a total digital input count capacity of 100. Operation is by direct wire connection of the control to two switching wafers, one for units and the other for decades. By special order the total count can be increased in powers of ten by the addition of switching wafers and control entry stations. Two additional wafers will provide a count of 10,000. The search rate is 17 digits per second with one output shaft revolution for 4 digits. Each stop is within $\pm 1.0\%$ of a digit position and resolution is equal for all count values. Bi-directional search in the digital servo is referred to as the "short way home" feature. In any



position change, the servo motor is instructed by a direction control transfer circuit to move to the new entry in the direction that makes the faster trip. An octal version of the unit can be supplied for manual or computer operation. Count capacities can be extended on both the decimal and octal versions. The Model 1420 is used for continuous loop search (circular positioning control pattern) or open loop search (linear positioning control pattern). Mast Development Co., Davenport, Iowa.

Circle No. 122 on Inquiry Card

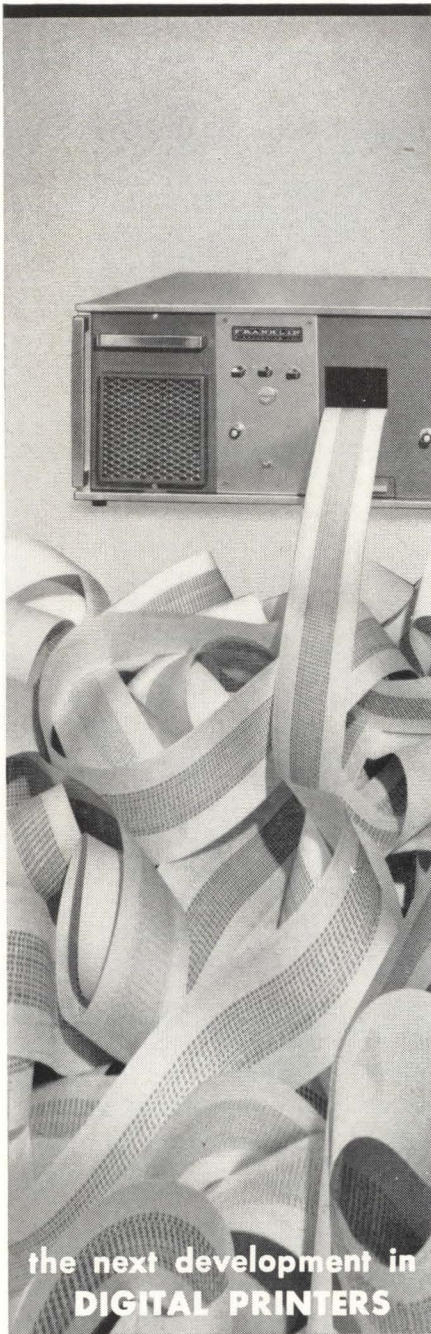


PRINTING UNITS

A new line of printing units for input series or in parallel features maximum speed of 25 cps or 50 cps. The versatility of these printing units is achieved by using a single or dual printing counter as the basic unit. These printing decades operate on electromagnetic principles and have

basically three functions: accumulate the numbers of pulses for print-out; electrical digital transfer to the next decade; and electric resetting with a self-interrupting circuit normally after printing of the result. As every decade has its own solenoid, the pulses to be accumulated can be put either in series into the first decade or in parallel separately into each individual decade. Therefore, these units can be used as printing counters or as printing devices only in connection with any kind of measuring equipment with a decade code output. These printing decades are normally combined with the power supply circuitry and the printing equipment including transportation of the ribbon as well as paper-feed; but they are also available as components to be inserted into users' printing equipment. Hengstler Numerics, Inc., Palisades Park, N.J.

Circle No. 159 on Inquiry Card



the next development in
DIGITAL PRINTERS

freedom from maintenance

Clean the air filter and give the drive motor two drops of oil a year. Only a Franklin Series 1000 decimal or alphanumeric printer requires so little maintenance.

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CIRCLE NO. 10 ON INQUIRY CARD

NEW PRODUCTS

COUNTING CONTROL SYSTEMS

A sequential counting control system is said to represent a new and less expensive approach to electrical and electronic recording, controlling, programming, and readout. Called the UNISYSTEM, it utilizes the advantages of company's decade counter and push button switch. Some of the functions the UNISYSTEM can perform include high-speed counting, remote readout, single or multiple level predetermining with automatic repeat cycling, programming, recording, batching, and timing. Four standard systems offer a choice of number of figures, mounting racks, type of reset and speed of recycling, adding up to a total of 90 model variations. Count speed is 40 counts per second. Power is 15 watts and voltage is 115v, ac 50-60 cycle. The UNISYSTEM has these advantages: accumulated data is always retained, even if power fails, life of unit is not subject to hours of usage; printed circuitry permits handling of high electrical loads; and counting, controlling, and readout is performed within the unit itself and does not require additional modules. Durant Mfg. Co., Milwaukee, Wisc.

Circle No. 192 on Inquiry Card

DIGITAL DECOMMUTATOR

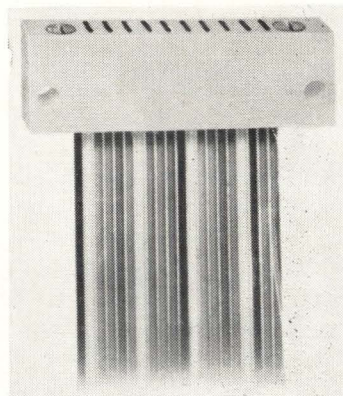
PAM/PDM decommutator accepts time-division multiplex signals and converts these serial waveforms into 10-bit and sign digital data. The digital data, which is available for processing by computer, or for storage on magnetic tape, is also applied to digital-to-analog converters to generate an output for analog recording devices. According to the company, the normal slope-off and limited responses encountered in analog decommutators does not occur with this unit. Model 2109-202 provides a 30-channel output. Astrodata, Inc., Anaheim, Cal.

Circle No. 218 on Inquiry Card

CAM-ACTUATED RELAY

General purpose, cam-actuated relay is said to be used by many manufacturers of computers and business machines. Available in all configurations through 6PST including 4PDT, the contacts are capable of carrying loads including low level signals. One model's dimensions, excluding terminals, are $\frac{3}{4}$ " wide by $\frac{15}{16}$ " high by $1\frac{3}{16}$ " deep. American Zettler, Beverly Hills, Cal.

Circle No. 139 on Inquiry Card



CARD READING LIGHT SOURCE

New unit is said to be the only available microminiature light source to mate with commercially available photo sensing heads. Ideally suited for punch card reading systems, 10 individual "Pinlites" are spaced on 0.100" centers and are mounted within the extremely light weight head (approximately 5 grams) with dimensions of only $1\frac{1}{8}$ " x $\frac{1}{4}$ " x $\frac{1}{2}$ " deep for the standard head. Individual color-code electrical connections to each lamp assure controlled uniformity of light output. The unit can be supplied with either soldered terminals, flexible leads, or plug-in connectors. Individual shielding of each lamp prevents any "spill-over" of light — each light source is contained within the 0.100" limits. Because of the Pinlite's small size (individual lamps as small as 0.016" in diameter) and concentrated light source, closer proximity to the working surface is attained thus benefitting by the square law relationship of light to distance. Easy mounting of the unit is also made possible due to these same characteristics. Pinlite Div., Kay Electric Co., Fairfield, N.J.

Circle No. 188 on Inquiry Card

HIGH-SPEED COMPUTER PRINTER

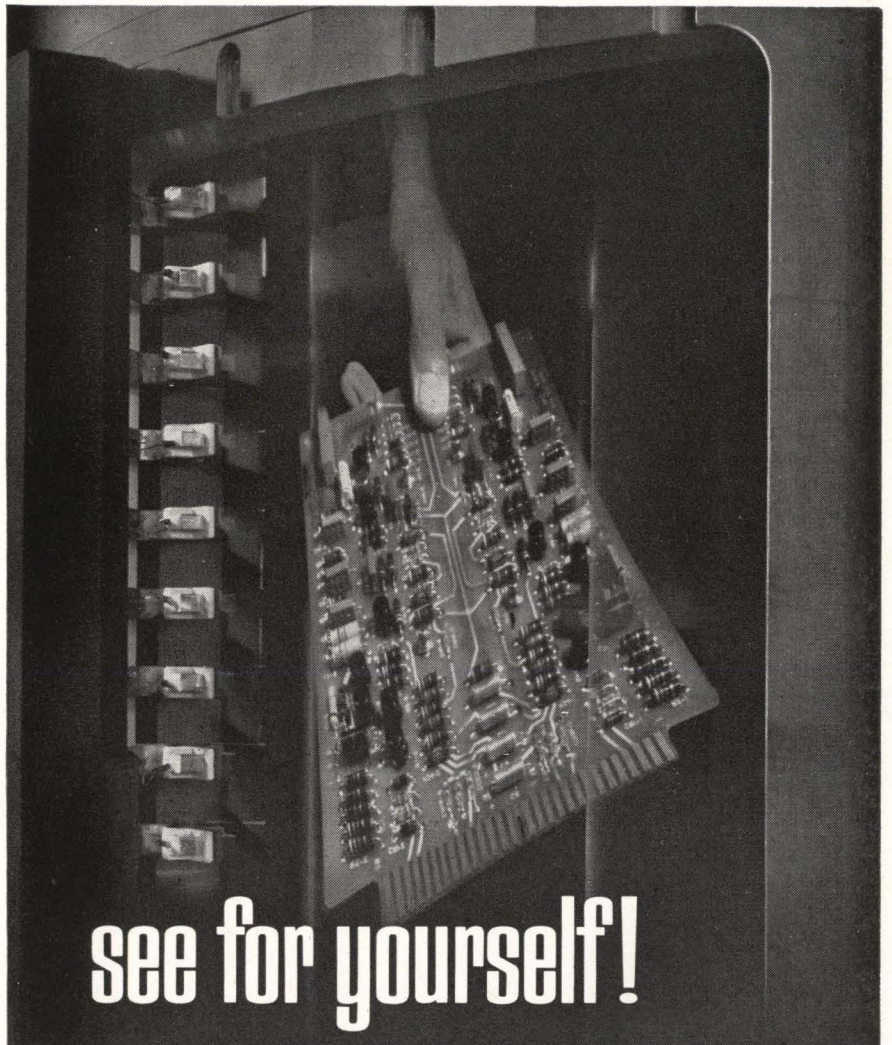
New computer microfilm printer is said to speed record retrieval and save several costly data handling steps. Capable of printing speeds of 62,500 alphanumeric characters per second, the new printer is designated the S-C 4400. Operating directly from a computer or from computer-generated magnetic tapes, the S-C 4400 translates digital signals into words, numbers and symbols. The output is recorded automatically, a page at a time, on either 16mm or 35mm microfilm. When operating the S-C 4400 on-line with the computer, there is no need to produce magnetic tape. The need for paper output from the computer is eliminated in many operations since selected pages can be produced on paper from the 4400's film output. The tasks of manually handling paper and magnetic tapes are also eliminated. In addition, the job of microfilming and coding the documents for retrieval purposes is performed automatically by the S-C 4400. The new printer produces microfilmed documents at a rate of 50,000 pages per shift. Visual indexing codes are compatible with today's most advanced information retrieval systems. Stromberg-Carlson, General Dynamics, San Diego, Cal.

Circle No. 175 on Inquiry Card

MEMORY DEVICES

A new core exhibits fast switching speeds at moderate drive currents. It is designed for use in memories having cycle times of $2\frac{1}{2}$ microseconds at a nominal drive current of 650 milliamperes. Core planes and core stacks available in either linear select or coincident current configurations are offered for operation at speeds of 2 microseconds, 5 microseconds, and 7 microseconds, with capacity of 64 to 4096 words of 2 to 64 binary bits. Planes and stacks can be furnished with either 80, 50, 30, or 20 mil cores with operating characteristics or size tailored to meet the specific application. Also available are nondestruct read-only rope memory devices. These units are extremely reliable and will withstand a broad range of stringent environmental conditions. Burroughs Corp., Electronic Components Div., Plainfield, N.J.

Circle No. 176 on Inquiry Card



see for yourself!

ELECTRONIC INTERFACES DESIGNED AND BUILT BY BRYANT OPTIMIZE DRUM SYSTEM PERFORMANCE—even when the customer has had little or no experience in magnetic recording technology! Complete systems—either custom-designed or built up from versatile standard designs—can be produced to meet a customer's interface specifications of data rate, capacity, control signals and mode of operation. □ Complex serial and parallel systems have been built containing address decoding, counters, shift registers, parity generation and checking, and logic level and error alarms. Drums now operating in customer installations utilize up to 50-bit parallel recording, precession loops, real-time delays, and read/write loop registers capable of giving access times down to 1.67 milliseconds. □ All systems are designed around Bryant's *complete line* of Series 8000 Electronic Circuit Modules. These circuits provide all required read, write, clocking, head switching, logic and power control functions. □ *See for yourself!* Write our Information Services Department for Auto-Lift Drum Brochure number BCPB-102-4-64-R2 and data sheets on Read Amplifier 8005, Write Amplifier 8010, Single Head Select 8020, Multi-Head Select 8025, Nand Circuit 8050, Gate Driver 8060, and Read Mode Switch 8090.

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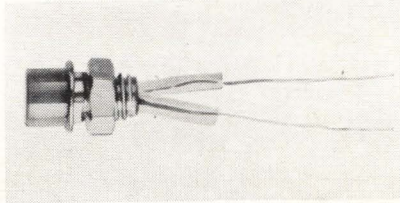
CIRCLE NO. 11 ON INQUIRY CARD

NEW PRODUCTS

PC BOARD RACKS

New extruded aluminum container is designed specifically for rack mounting of printed circuit boards and for use in constructing $\frac{1}{2}$, $\frac{3}{4}$ and full-width instrument cases. The new extrusion size is said to be ideal for computer card racks. Interior of the new package is precision grooved to permit easy insertion of circuit boards. Special clamp extrusions include a boss for mounting rack panels or front and rear panels for instrument cases. Extrudapak Inc., Gardena, Cal.

Circle No. 220 on Inquiry Card



FIXED INDICATOR LIGHTS

Featuring small size and long life, an ultra-miniature fixed indicator light mounts in a $\frac{13}{64}$ " diameter hole and is available with either MIL-spec or commercial bulbs. Overall length excluding leads is 0.438", the panel mounting space — 0.288" and front of panel projection is 0.175". Unit can be used with wire harness or on printed circuit boards. Sloan Co., Sun Valley, Cal.

Circle No. 194 on Inquiry Card

VOLTAGE STABILIZER

An up-dated line of constant voltage stabilizers is said to incorporate the latest in core techniques and improved insulation materials. The ferroresonant transformer employs a capacitor terminated control winding on the secondary portion of the core which induces flux saturation confined by a magnetic shunt to the secondary portion of the core. This circuit, the manufacturer claims, is highly responsive to system disturbances and provides a line-regulated input to critical loads. A 5% line voltage variation, for example, is recovered within one cycle. Wider variations are corrected in proportionately short time. These new stabilizers have a semi-square wave output, which it is contended, lends itself to more effective filtering, with less ripple, when used as a regulated supply source to solid state rectifiers for a direct current power supply. To provide for correcting a below normal dc voltage, the stabilizers have a special rectifier output tap. Acme Electric Corp., Cuba, N.Y.

Circle No. 180 on Inquiry Card

THIN-FILM DISPLAYS

Miniature thin film electroluminescent panels have crossed grid electrode configuration for X-Y drive of elements. Resolution is 33 lines per inch. According to the company, use of this minitaurized unit will, for the first time, allow organizations an opportunity to conduct their own experiments to evaluate the panel for many display purposes, at minimal costs. Chief characteristic of the panel is that the electrodes are 0.020 inch wide spaced on .030 inch centers with 0.010 inch gap between adjacent electrodes. Successive films of dielectric, electroluminescent phosphor, and a metallic electrode are developed by exclusive deposition techniques. The excited phosphor emission peaks at 5800 Ang. and is insensitive to excitation frequency. Panels may be driven with sinusoidal or square wave ac at frequencies from 500 cps to 100 kc/sec. or with dc. Exposed panel area, approximately $\frac{27}{32}$ inches square, reveals a 28 x 28 element matrix. Sigmatron, Inc. Goleta, Cal.

Circle No. 148 on Inquiry Card

ELECTROSTATIC PRINTER/PLOTTER

High-speed, electrostatic printer/plotter system performs as an analog recorder and a digital page printer, operating on information received from a data acquisition system or from playback of magnetic tapes. Data is electrostatically printed out directly on an $8\frac{1}{2}$ " or 11" wide paper web. Rocketdyne installed the system in a recording center at its Canoga Park, Cal., rocket propulsion field laboratory to record test results on rocket engines such as the F-1 and J-2, which will power the NASA Saturn vehicle for Apollo launchings. The system prints a permanent paper record of both alphanumeric data and analog curves at speeds up to 10 inches of paper web per second. Engineers get a fast look at test data to determine what test phases need further attention without waiting for film processing, printed forms, or other information display methods. At the data recording center each analog input is converted into a four-digit decimal number which is transmitted in digital form to the printer/plotter. The information passes first through the control unit which provides the proper signals for sequential delivery of data to the printing system. Within

the system is an exclusive character generator which is basically a monoscope-type cathode-ray tube comprised of an electron gun and an aluminum target. It receives the digital information inputs and converts and translates the coded computer language to readable alphanumeric characters at speeds up to 15,000 characters per second. This is accomplished by passing the electron beam across a selected character on the target, amplifying the resultant video signal, and applying it instantly to the printer/plotter's electrostatic printing tube. The electrostatic printing tube is a special cathode-ray tube with a matrix of fine metal wires sealed through its faceplate. The electron beam of the tube passes through the wires and places a latent electrostatic image directly on the surface of the moving paper web. A developing process makes the charged patterns visible and permanent. Through suitable control circuitry the electron beam can be directed in a linear sweep by video input signals or driven in response to digitally-coded input signals for accurate point plotting at over 83,000 points per second. A. B. Dick Co., Chicago, Ill.

Circle No. 162 on Inquiry Card



SHAFT ENCODER

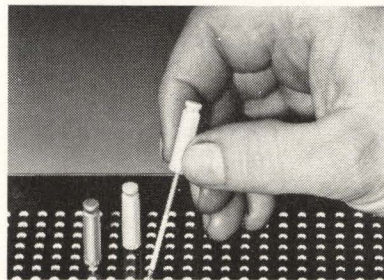
Said to be the first Size 11 non-contact shaft encoder, a new three-ounce unit converts analog data to 13 binary digits by using magnetic probes to sense the passage of a rotating encoded disk. Operating life of the new MAD 11-13A encoder is reported to be a minimum of 200,000,000 revolutions. Designed for advanced aero-

space computer systems requiring high reliability and fast interrogation speeds, it is directly interchangeable with contact Size 11 devices. Operating principles employed are expected to lead to development of encoders for commercial and industrial control systems where minimum maintenance is essential. Range is 8192 binary counts for 64 revolutions of the input shaft. Interrogation speed is 10 microseconds for a 13-bit parallel word. Tested to meet all appropriate mil specs, the MAD 11-13A has a length of 1.8250" and diameter of 1.062". Encoder Div., Litton Industries, Van Nuys, Cal.

Circle No. 135 on Inquiry Card

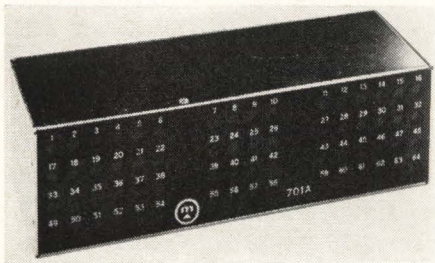
THREE-DECK PROGRAM BOARDS

Shorting pin for three-deck, miniature programming boards shorts decks 1 and 3 while skipping deck 2. Maximum electrical efficiency is obtained with either gold or silver plated contacts surface and Teflon insulation. The three-deck cordless programming board is designed for computer or automated machinery programming. Holes are provided at each X-Y intersection providing access to three decks of contact busses (three separate levels of circuit connection). By appropriate selection of pins any com-



bination of these three contact busses can be shorted. Sealectro Corp., Mamaroneck, N.Y.

Circle No. 123 on Inquiry Card



DIGITAL TEST SET

A digital test set features a plug-in unit with a code display by incandes-

cent lamps on the front panel. Continuous readout of the code configuration enables the operator to determine specific address or command codes generated by the system under test. Model 701A eliminates the tedious process of pulse counting on an oscilloscope. Pulse patterns are quickly analyzed by go-no-go observation of the status of the lamp display. Moore Associates, Incorporated, San Carlos, Cal.

Circle No. 138 on Inquiry Card

ENGINEERS . . . have you an

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FOR FORWARD THINKING IN MAGNETIC MEMORY DEVELOPMENT

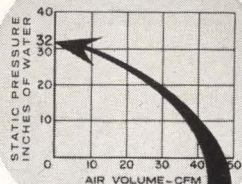
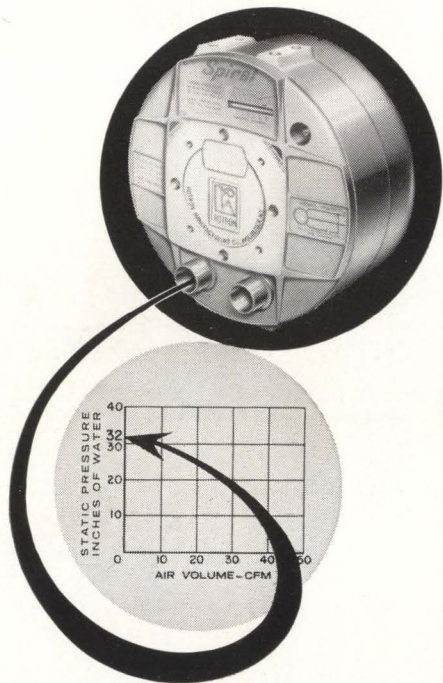
... using multi-aperture core techniques, for instance, or thin magnetic films?

UNIVAC-Twin Cities is a leading pioneer in both areas. The fastest ferrite memory system yet devised was developed here. Continuing laboratory research constantly nourishes our design and development efforts, revealing, for example, not only the "hows" but the "whys" of multi-aperture ferrite core behavior.

A recent exploitation of this knowledge at UNIVAC is an analog magnetic storage device — a practical application of time-limited, partial-switching representing significant technical progress in the field of simplified analog recording through the use of discrete magnetic elements. Transient effects are received as analog data and stored for later readout. Just one application is storage of radiation effects of underground nuclear testing. New ones are being studied.

Several other funded, advanced development programs are underway. They too require pushing the state of the art to meet new goals in size, speed, reliability, and manufacturability. Write us at once if your experience has prepared you for such an effort. Address Mr. R. K. Patterson, Dept. L-9, UNIVAC Division of Sperry Rand Corp., Univac Park, St. Paul, Minn. 55116. An Equal Opportunity Employer.

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UP TO 32 INCHES W.G.

Spiral (T.M.)

**HIGH PRESSURE/VACUUM
AIR MOVER**

■ ECONOMICALLY PRICED ■ ONLY 10" IN DIAMETER BY 5½" IN DEPTH ■ HIGH STRENGTH ALUMINUM DIE CASTINGS ■ ADJUSTABLE AIR TRIMMER VALVE (OPTIONAL) ■ AVAILABLE IN 1 OR 3 Ø 50-60 CPS MOTOR, 208

The "Spiral" is a high pressure/vacuum air mover suitable for applications in the computer and electronic industries for tape transports, pressure source for tape air bearings, differential source for card handling equipment, high speed paper sorting machines and as a source of cooling air for high density electronic packages. Optional accessories include an adjustable trimmer valve and a differential pressure gauge to permit instantaneous trimming to system requirements. New Rotron induction motor features precision cartridge ball-bearings. Elimination of RF noise makes the "Spiral" especially attractive for applications where spark generated interference is a problem. Call or write Rotron for complete technical details and the surprisingly low price!

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West Coast: Rotron/Pacific, Glendale, Calif.
Canada: The Hoover Co., Ltd., Hamilton, Ont.

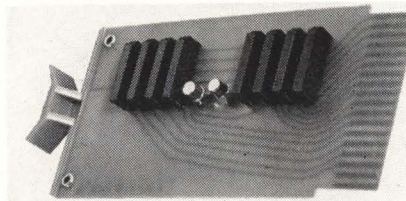
CIRCLE NO. 12 ON INQUIRY CARD

NEW PRODUCTS

PANEL LIGHT CONTROL

New automatic brightness control device controls the brightness of lighted messages on the viewing screen of readouts and other panel lighting. The "Level-Eye", as it is called, contains a light-sensitive cell with spectral response closely approximating that of the human eye and a solid-state control circuit. By adjusting lamp supply voltage according to ambient light conditions, the device protects the equipment operator from being dazzled by panel lights when the overhead lights are turned off; conversely, the Level-Eye eliminates the loss of information that occurs when high-intensity light is directed at a dimly-lit panel or readout. A "dark threshold" control is provided for adjustment to the individual operator's dark adaptivity; after this adjustment is made, the operation of the Level-Eye is completely automatic. Cal-Glo Co., El Segundo, Cal.

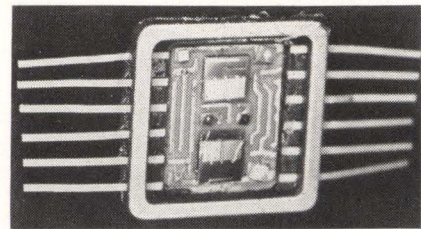
Circle No. 185 on Inquiry Card



"FLIP-CHIP" MODULES

New line of low cost, high reliability logic modules combines film circuits with discrete components. Called a "Flip-Chip" module, a single flip-flop costs \$9.50, and a quadruple flip-flop package is \$32.70, or slightly over \$8.00 per flip-flop. The new units are designed for automatic wiring. They come in plug-in form ready for insertion in precision engineered mounting panels with connectors for either wire-wrap or solder. Representative of the new line is the Type R201, shown above, a two-transistor flip-flop with direct set and clear inputs and five diode-capacitor-diode input gates. Digital Equip. Corp., Maynard, Mass.

Circle No. 129 on inquiry Card



SPACEBORNE FLIP-FLOP

A "first-of-its-kind" computer flip-flop is said to use less than one-third the power of any comparable device of its size. Its performance, according to the company, can be matched only by conventional circuits 140 or more times as big. Designated NCS-390, the multichip device has a total power dissipation of 3 milliwatts — with a supply voltage of 3 volts and a load of 2 kilohms. Comparable fully integrated microcircuits hitherto developed, according to the company, have a power drain and dissipation of 10 milliwatts or more. The new flip-flop has a speed of one half megacycle. The device employs eight separate microminiature chips: four transistors (2NPN and 2 PNP), two diodes, and two resistor-capacitor "networks". The smallest chip is only 20 one-thousandths of an inch square. The eight chips are interconnected on a small alumina (ceramic) wafer and the entire microcircuit is hermetically sealed in a nickel alloy case. The finished circuit is only three-eighths of an inch square and only five one-hundredths of an inch thick. General Instrument Corp., Hicksville, N.Y.

Circle No. 155 on Inquiry Card

CORDWOOD CAPACITORS

An all-film, miniature tubular capacitor was designed for cordwood packaging where voltages do not exceed 200 vdc. The capacitor has a polyester film-foil section enclosed in a film-wrap epoxy end seal case. According to the company, this style construction offers a size smaller than standard wrapped capacitor designs of comparable ratings, thus higher component density. The temperature range is from -55C to +85C at full rated voltage; standard capacitance tolerance is ±10%, with tolerances as low as ±1%. Cornell-Dubilier Electronics, Newark, N.J.

Circle No. 173 on Inquiry Card

SWITCH MODULE

New switch module is a versatile control element consisting of a complementing flip-flop, and AND gate, and a standardizing multivibrator. The multivibrator can be used either as a single-shot or as a flip-flop. The data to be controlled is applied to one leg of the AND gate, which can be inhibited either by resetting the complementing flip-flop or by applying a signal directly to the other input of the gate. This printed circuit module is particularly useful for such applications as gating a counter ON for a preselected interval or gating a certain number of shift pulses to a shift register. It can also be used to synchronize external signals with the system clock rate, or as a parity generator and checker. Navigation Computer Corp., Norristown, Pa.

Circle No. 177 on Inquiry Card

FIELD EFFECT TRANSISTORS

Insulated-gate field effect transistor exhibits very low capacitance characteristics and high frequency cut-off. Noise figure at 100 mc is 4 db, power gain is 20 db. The high ratio of transconductance to gate capacitance of the device provides excellent high frequency performance. The units are 4-lead TO-18 packaged. TRW Semiconductors Inc., Lawndale, Cal.

Circle No. 141 on Inquiry Card

DTL INTEGRATED CIRCUITS

Three new monolithic integrated circuits for use in DTL logic circuits are offered in either a TO-5 can or a flat pack. The new units are the RC221, a dual two-input NAND/NOR gate, the RC222, a single three-input NAND/NOR gate, and the RC229, a dual three-input NAND gate. Designed primarily for commercial and industrial applications, the RC221 and 222 feature high speed with a turn-on time of 22 nanoseconds and a turn-off time of 24 nanoseconds. Prices, in quantities 100 to 999, are \$12.10 each for each model in a TO-5 can and \$14.40 each in a flat package. Raytheon Co., Semiconductor Div., Mountain View, Cal.

Circle No. 146 on Inquiry Card

"FILE DRAWER" COMPUTER

A compact, low-cost industrial computer is available from Union Carbide Corp.'s subsidiary, Data Systems Inc. Small enough to fit into a file drawer, the general-purpose, real-time digital computer, without peripheral equipment, sells for as little as \$10,000. It can handle up to 320,000 operations a second, a rate said to be unmatched by any other unit in its size and price range. Designated the "DSI 1000", the new computer is designed as a separate unit that can be used either in existing industrial applications or in new data processing systems. In addition, fifteen separate pieces of accessory equipment are available for use in numerous combinations to provide complete computer systems for a wide range of industrial requirements. According to reports, the operations for which the computer are especially well suited include process control in the chemical, food, petroleum, steel, and pharmaceutical industries; numerical control of machine tools; communications systems; and data conversion. The DSI 1000 computer, can add in 3.2 microseconds and multiply in 94 microseconds. It can control as many as 4096 input-output devices. It handles 1024 (12 bit) words of internal storage, with up to 2048 words available with an additional mounting. Important factors contributing to its low cost and small size are the use of glass delay line memory and high speed serial logic. Data Systems Inc., Sub. of Union Carbide Corp., Linde Div., New York, N.Y.

Circle No. 134 on Inquiry Card

BCD-TO-DECIMAL DISPLAY

Display unit uses a new technique of decoding from BCD and driving numerical display readouts. For remote or repeater displays, the number of interconnecting conductors is said to be greatly reduced. New method of data transmission can provide complete electrical isolation from BCD-to-BCD, or BCD-to-decimal. The units are available in unmounted cards sets, or packaged for subsystem installation with or without power supply. Information Machines Corp., El Cajon, Cal.

Circle No. 170 on Inquiry Card

computer logic designers

en- rich

...yourself professionally.

Join UNIVAC-Twin Cities where the very shape of logical design itself is under intensive investigation...particularly algorithms used in arithmetic processes which permit a minimization of total hardware without sacrifice of performance. Studies focus on the control of stochastic systems.

Pioneering work such as this has kept UNIVAC in the #1 position technically in the computer field. New techniques and devices, usually UNIVAC developed, are put to the test of practical application without delay...in programs involving the very smallest aerospace computer to very large multiprocessor systems. They are applied in wide ranging uses — to guidance and control of the Nike-X anti-missile missile, to command and control systems and ASW systems, to reconnaissance and missile range instrumentation systems.

Assignments now open require men with BS or MS degrees to perform logical design of high speed digital equipment using solid state circuitry, and the logical design of systems taking into account the interfaces between the central computer and its input-output equipment.

Inquire about an enriching career at UNIVAC-Twin Cities. Write Mr. R. K. Patterson, Employment Manager, Dept. L-9, Univac Park, St. Paul, Minn. 55116. An Equal Opportunity Employer.

UNIVAC
DIVISION OF SPERRY RAND CORPORATION

NEW PRODUCTS

REED COMMUTATOR

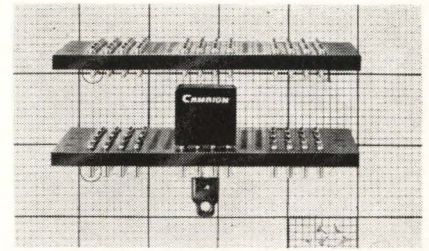
A five-level, ten point reed relay commutator is capable of accepting slave units to increase the number of points indefinitely to any integral number. The five level feature provides for many types of applications, ranging from switching both leads and shields in low level systems to scanning five line digital data. Hathaway Instruments, Inc., Denver, Colo.

Circle No. 127 on Inquiry Card

SILICON CONTROLLED RECTIFIERS

Rugged mechanical construction of new diffused silicon controlled rectifiers and their high-performance capabilities are said to make them ideally suited for switching and control applications, particularly in computer solenoid drive units for card read-out. Each unit is packaged in a modified DO-4 case with a massive annular heat sink for effective heat sinking. The generous design margin of these nine new SCR's eliminate the need for de-rating. All units employ "fatigue free" direct solder construction. Commercial Engineering, RCA Electronic Components and Devices, Harrison, N.J.

Circle No. 149 on Inquiry Card



COMPUTER MODULE BOARDS

Two new module boards, together with a new insulated jumper plug, are designed to provide the computer engineer with greater versatility in construction, and ease of patch work. Module board 1746 utilizes double-ended jacks with 0.040" on one side and 0.025" on the reverse. Module board 1747 utilizes the 0.025" jack with a single turret terminal on the reverse side. The jumper plug 2871 has a pin diameter of 0.040" and thus may be conveniently used as a jumper on module board 1747. These new items provide ease and facility in plugging company's digital modules, patching boards, and sockets for encapsulated plug-in assemblies. Cambridge Thermionic Corp., Cambridge, Mass.

Circle No. 130 on Inquiry Card



MAGNETIC SHAFT ENCODER

New size 18 magnetic non-contacting shaft-position digital encoder converts shaft angle directly to a binary-coded output and is expected to have broad applications in such areas as machine-tool control, fire-control and navigation systems, radar antenna positioning and tracking systems, digital servo-mechanisms, and similar applications where a digital output is desired from a shaft angle input. Because of its magnetic noncontacting readout the Model 645A is relatively unaffected by environment and wear encountered in brush-type readouts; thus it is specially suited to applications where reliability, unattended service or operation in poor environments are major factors. Model 645A incorporates self-contained interrogate and readout electronics. The new

unit operates from a dc input to provide dc level shift outputs for each of the 13 tracks. Outputs generated from two independent sets of sensors include nonambiguous 13-bit true binary and 13-bit code complement binary outputs, thus affording a true self-checking mechanism. The Model 645A achieves 13-bit resolution in 64 turns of the input shaft. Two units can be operated in series to provide the equivalent of a single encoder with 22-bit resolution. The encoder is rated for operation at rotational rates up to 10,000 rpm and is conservatively rated for life of 1 billion revolutions with MTBF of 20,000 hours per MIL handbook 217. Electro-Mechanical Research, Inc., Sarasota, Fla.

Circle No. 142 on Inquiry Card

DISTRIBUTION BUSES

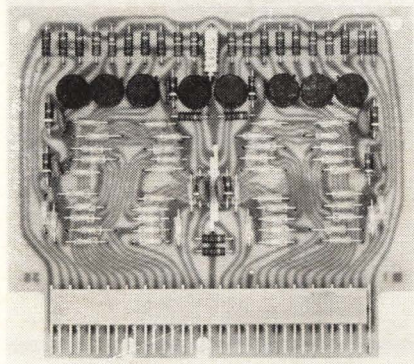
New concept in power distribution buses won first prize at a recently held conference. These space saving, laminated and molded buses replace bulky repetitive wiring. Typical bus system has five power levels interleaved with six ground levels. Each conductor is insulated and the entire bus is molded with insulation. Total bus thickness is 3/16" and the width of conductors is 1". The horizontal bus is "L" shaped and assembles mechanically into the vertical bus. Insulated spacers are used to separate each level. According to the company, the use of this concept, instead of the conventional cable harness technique, provides far lower inductance and resistance required for high speed, solid state circuits which demand relatively high current with low voltages. Magnetic fields are reduced, resulting in the control of unwanted noise. Eldre Components, Inc., Rochester, N.Y.

Circle No. 190 on Inquiry Card

DIGITAL PLOTTER

Designed for on-line operation with any medium scale general purpose digital computer, or off-line with magnetic tape input, a new incremental plotter can automatically produce fully annotated plots under computer control. Called the Draftomatic incremental plotter, this compact model is capable of drawing speeds up to 18,000 steps per minute and a high resolution of 0.005 inch. Plot dimensions are up to 29½ inches in width and 120 feet in length. The pen operates in a ball bearing slide for true performance. Alignment is easily accomplished since the pen point is always visible to the operator. Benson-Lehner Corp., Van Nuys, Cal.

Circle No. 147 on Inquiry Card



LOGIC DECODING

Series of digital logic cards for use as binary-to-octal decoders, as part of binary-to-decimal decoders, or as special matrix decoders are said to be ideal for use in controlling commutators, multiplexers, sequential timers, etc. Three models are available with frequency range of dc to 300 kc, to 2 mc and to 5 mc. Each card contains eight gates, with six input diodes per gate. Three diodes of each gate are permanently connected for octal decoding. Two diodes per gate are individually available for higher-order decode bits, or for special decoding inputs. One diode per gate is common and is used to select between cards in large decoders, or for clocking or sampling the matrix. Each gate operates as a negative-true NAND, to drive up to 10 unit loads. The output can also be used to drive medium-current lamps, relays, or loads. Computer Logic Corp., L.A., Cal.

Circle No. 191 on Inquiry Card

3 VDC SUPPLY LIGHTS NEON INDICATORS



If your design is limited to low voltage supplies, but requires the rugged, long life performance of neon lamps, specify TEC-LITE Low Voltage Neon Indicators. LVN Series' self-contained, transistorized circuitry steps up supply voltages as low as 3 VDC to high voltage AC that fires both elements of the neon lamp.

If desired, low level signals— as low as 2 volts— typically present in computers, industrial control, missile guidance and other solid state systems can be used to control these versatile indicators.

LVB Series Indicators offer features of the LVN Series plus an SPST normally open or normally closed switch rated at 100ma at 120 VAC, non-inductive. This combination indicator and switch simplifies design and conserves panel space. Specify reliable (life exceeds 10,000 hours) TEC-LITE Low Voltage Neon Indicators whenever high voltage is not readily available or not desirable in your design. Your TEC-REP has details, or write directly.

- Supply voltages: 6, 12, 18 or 24 VDC $\pm 10\%$ standard. Other supplies from 3 to 48 VDC available in custom designed models.
- Six cataloged models operate from a range of lamp control signals and polarities.
- LVN Series size: 9/16" dia. x 2" long backpanel. Price: As low as \$8.65 in 100-499 quantities.
- LVB Series size: 9/16" dia. x 2¾" long backpanel. Price: As low as \$9.95 in 100-499 quantities.
- Available with a variety of terminals, lens colors and styles.
- Mount on 5/8" centers.







*Originator of
Transistorized
Indicating Devices*

Transistor Electronics Corporation

Box 6191

Minneapolis 24, Minnesota

Phone (612) 941-1100

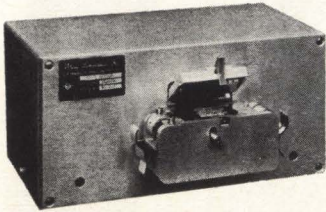
<p>3ma CONTROLS INCANDESCENT INDICATOR</p>  <p>TIL Series controls replaceable incandescent lamp with small current signal. TIB Series adds isolated SPST switch.</p>	<p>2 VOLTS CONTROL NEON INDICATOR</p>  <p>MTL Series controls neon lamp with small voltage signal. TBL Series combines same functions with isolated SPST switch.</p>	<p>2µSEC PULSE TURNS ON INCANDESCENT INDICATOR</p>  <p>TML Series with replaceable incandescent lamp turns ON with small signal, remains ON when signal is removed.</p>	<p>2 VOLT BINARY CODED INPUT SIGNAL CONTROLS DIGITAL READOUT</p>  <p>TNR Series display controlled by low level decimal or binary signals. Memory optional. Mounts on 1" centers.</p>
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TEC-LITE Transistorized Indicators are protected by one or more of the following patents: U.S. Pat. Nos. 2,985,874; 3,041,499. French Pat. No. 1,291,911, Italian Pat. No. 647,414. Belgian Pat. No. 604,246.

CIRCLE NO. 13 ON INQUIRY CARD

WANG DIGITAL SYSTEMS ENGINEERING

PUNCHED TAPE BLOCK READER



A versatile input device for numerically controlled systems.

- Tape:** Standard 1 inch, 5, 6, 7 or 8 levels, paper or Mylar.
- Capacity:** Up to 30 lines per reading (240 bits.), or more.
- Speed:** Up to 10 frames per second.
- Output:** Triple wire brush contacts, rated at 50v and 50ma non-inductive.
- Performance:** Tested for 500,000 readings without error. Automatic retract of reading head when changing tape.
- Price:** \$1200. (12-line reader).

10 MC DUAL PULSE COUNTER

MODEL NUMBER 7716



A. Ranges:

- | | |
|------------------|--------------------------------------|
| 1. Counting | 0/9,999,999 |
| 2. Frequency | 0/10MC |
| 3. Time Interval | } Depends on
External Clock Range |
| 4. Period | |

B. Accuracy: ± 1 count

- C. Resolution:** Minimum pulse spacing, .09 μ sec.
Minimum pulse width .04 μ sec.

D. Input:

- DC Coupled
- Voltage Signal Amplitude Range ± 15 Volts peak to peak
- Impedance: 1 K ohms in parallel with 50 μ fd
- Trigger Level ± 1 to -1 volt

E. Output:

- In-line display on 7 NIXIE tubes
- Electrical: BCD (1-2-4-8) at rear multipin connector 0/-8 $\pm 2V$ swing. Maximum load: 10 K ohms. Includes gate line for reset to zero on command.
- Carry pulse output on reaching count of 10,000,000.

F. Reset:

- Manual — Front panel push button for each channel
- Electrical — Via BNC connector on rear panel.

G. Operation:

- Manual — Toggle switch for selection of Start and/or Stop signals on Channel A, Channel B or Channels A and B, together. Separate push-button control for "Start and Stop" of count
- Electrical — External rear mounted BNC connectors for "Start" and "Stop." Gate pulse is $-6 \pm 2V$, with 1 μ sec. minimum width, .5 μ sec. rise and fall time.
- Temperature — 0/50° C

H. Sensitivity: 250 mv, peak to peak. Adjustment for sensitivities from 250 mv to 30 volts.

- I. Power:** 115V RMS $\pm 10\%$, 50-400 cps nominal, 35 watts

J. Size: 5 1/4" high x 19" wide x 15" deep

Wang Laboratories, Inc.

NORTH STREET • TEWKSBURY, MASS.

617-851-7311

CIRCLE NO. 14 ON INQUIRY CARD

NEW PRODUCTS

DIGITAL DELAY LINES

New series of ultrasonic delay lines for digital data storage is said to offer advantages in size, cost, environmental stability, and provide improved pulse timing and fidelity through low dispersion, wider bandwidths, low temperature coefficient and high signal-to-noise ratio. Working over a wide range of bit rates and delays, the units are capable of storing from 10 to 2000 bits at rates from 2 mc to 50 mc for RZ operation with delays to 800 μ sec. Overall loss varies from 10 to 80 db dependent upon total storage and type of transducer used. Size, environmental stability, and costs as low as a few cents per bit storage make this delay line memory, according to the company, superior to drum and core memories for many applications. Richard D. Brew and Co., Inc., Electr. Div., Concord, N.H.

Circle No. 156 on Inquiry Card

DIGITAL MODULES

General purpose digital building blocks are fabricated on etched circuit glass epoxy boards which will meet both MIL and UL requirements. Each module contains from 2 to 12 complete, independent circuits, depending on the particular type and configuration of the circuit. This series provides dc to 200kc switching for construction of the whole range of digital devices from the simplest of controls to an entire computer. The basic logic function employed is the NOR gate and from this all logic functions such as AND gating, OR gating, frequency division, storage, forward and backward shifting or counting and arithmetic operations can be performed. Negative logic is used throughout. The circuitry is built around the 2N1303 transistor, a germanium high speed switch whose high value of allowable collector voltage permits biasing so as to virtually eliminate sensitivity to noise. All circuitry is designed on a worst case basis. Computer Assemblies Corp., Port Washington, N.Y.

Circle No. 153 on Inquiry Card

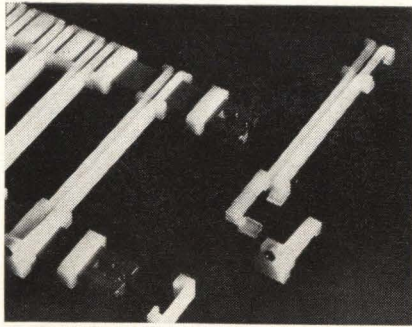
GRAPHIC DISPLAY SYSTEM

Based on the latest engineering concepts in digitally controlled display systems, a new automatic drafting system is said to offer greater speed, accuracy, and versatility than can be obtained from systems selling at several times its price. Features and innovations of the new systems include all digital control logic that is designed specifically for automatic drafting operations, an all-digital drive system featuring specially designed digital stepmotors that eliminate drift and fluctuations. Input formats in accordance with numerical machine tool control standards ensuring adaptability to any BCD formats, and a plotting table based on aeronautical design principles to provide a light but extremely rigid and stable display surface in a range of sizes 5' x 5' to 5' x 20'. This new system is, essentially, a continuous path automatic drafting machine capable of translating incremental dis-

tance input data into high quality graphic display on drafting film, vellum, cloth, template material, or comparator screen material. It can draw an accurate line of any slope and length, within the limits of the plotting surface, from a single command. The resulting graphic display is produced with an overall accumulative accuracy of $\pm 0.005''$ and repeatability of $\pm 0.002''$ anywhere on the plotting surface at speeds up to 250" per minute. For engineering applications, the new system is specifically intended for computer-aided design. The system can also be utilized wherever graphic retrieval of data from digital devices is desired. Displays can be made in conjunction with telemetry records, highway planning, statistical and test data, and various other applications. Computer output can be displayed directly by on-line operation. The Gerber Scientific Instrument Co., Hartford, Conn.

Circle No. 181 on Inquiry Card

COMPUTER DESIGN/NOVEMBER 1964



CIRCUIT CARD MOUNTING

Automatic alignment of cards with connectors is a key design feature of a new series of modular circuit card mounting hardware. Designated Series-T, it is made of molded nylon and includes card guides, spacers, and ejectors. Patented guides are designed so the connector mounting foot and guide slot interlock, which assures automatic alignment of the cards with the connectors as they are inserted. The lightweight guides are sturdily cross-sectioned for strength and are available in multiple lengths which can be combined to accommodate a wide variety of card types. In addition, the foot is available in several lengths to permit using cards of varying widths and connectors with various numbers of pins. Guides are offered with in-line or offset feet for use with edge or 2-piece connectors. Spacers are available in increments of 1/16" to accommodate mounting components of differing thicknesses. The lower silhouette cuts air flow impedance by almost half, which reduces system heating problems. Scanbe Mfg., Monterey Park, Cal.

Circle No. 164 on Inquiry Card

MIL ANNULAR TRANSISTORS

Mil annular transistors, USA 2N2904 through USA 2N2907, are glass passivated, high-voltage silicon PNP "Star" transistors for high-speed switching circuits, dc to vhf amplifier applications, and complementary circuitry processed to the requirements of MIL-S-19500/290-1. An annular process permits true surface passivation of high-voltage PNP transistors by eliminating the detrimental effects of uncontrolled channeling. Motorola Semiconductor Prods., Inc., Phoenix, Ariz.

Circle No. 197 on Inquiry Card

What has 9 lives, doesn't purr and won't fit in a flashlight?

What else but an Electronic Memories mil-stack?

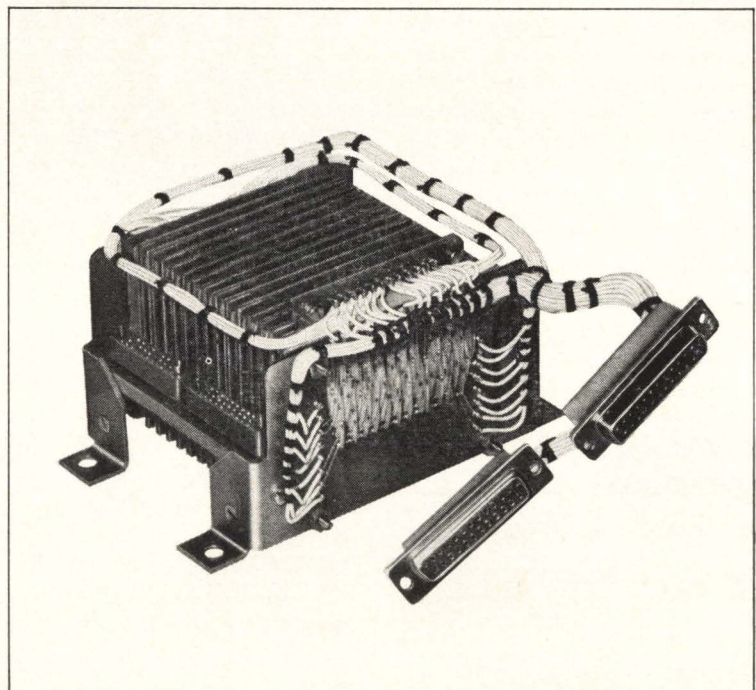
Electronic Memories severe environment mil-stacks have 9 lives because they are continuously wired. Continuous wiring means more than 80% of all soldered joints are eliminated. And that means a lot more reliability.

Because Electronic Memories has an engineering group devoted exclusively to the design of stacks for military environments, there are literally hundreds of DRO and NDRO mil-stack designs in our library. Many of them are presently being used in space probes, satellites, aircraft, shipboard and ground based systems. Extensive experience in supplying stacks for our own military memory systems means we have working units to meet and beat such severe environments as extreme shock and vibration, temperature ranges from -55°C to $+100^{\circ}\text{C}$ or -25°C to $+75^{\circ}\text{C}$, and all MIL-E-5400, MIL-E-16400-E and MIL-4158-B specifications.

But we still haven't found a way to make them purr or fit in a flashlight. If you are looking for a highly reliable severe environment mil-stack that doesn't have to purr or fit in a flashlight, call us. If you happen to know how to make one purr or fit in a flashlight, just let us know and we'll call you.

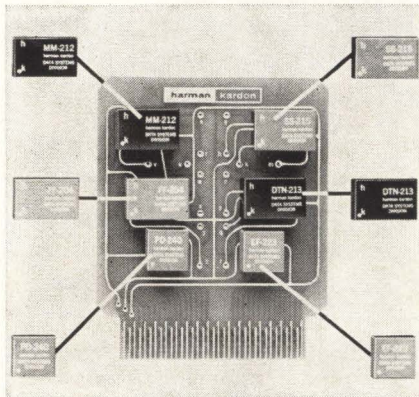
electronic memories inc.

12621 Chadron Avenue, Hawthorne, California



CIRCLE NO. 15 ON INQUIRY CARD

YOU MIX 'EM! WE MOUNT 'EM TO YOUR NEEDS



YOU CAN MAKE OVER 100,000 LOGIC CARD COMBINATIONS . . .

just mix and combine 65 standard Harman-Kardon encapsulated Logic Modules and 19 Flexi-Cards®. Modules and cards are available immediately from stock . . . at stock prices!

YOU specify your precise functional card groupings . . . flip flops, drivers, shift registers, inverters . . . you name it . . . we supply modules from stock . . . for your cards or ours . . . you assemble . . . or we assemble. Either way . . . no long lead times . . . complete design freedom at lowest cost. Modules are available in germanium (50kc, 250kc, 5/10mc) or silicon (250kc) . . . all completely compatible in voltage levels, physical characteristics, and power supply voltages.

Write or call THE ROBACK CORPORATION today for prices and listing of modules and cards now in stock. You'll save time and money with this unique approach to digital logic.

harman kardon

Data Systems Division of

THE ROBACK CORPORATION

Ambler, Pennsylvania

215 - Mitchell 6-8850

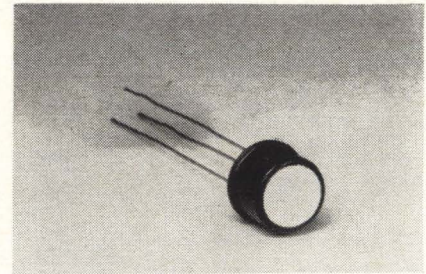
CIRCLE NO. 16 ON INQUIRY CARD

NEW PRODUCTS

INFORMATION RETRIEVAL

New model information retrieval unit is the heart of a "FileSearch" system which automatically stores and retrieves documentary information. Documents are stored on film immediately adjacent to their machine-readable indexes. In response to a request for information, the retrieval unit searches the indexes at a rate of 105 documents per second, and retrieves any relevant information as an image on a screen, card copy, or duplicate film copy. The film output is used for generating reels of film devoted to a specific subject from randomly-recorded materials. This permits users to automatically structure their files. Because documents can be indexed to any desired depth, and logically sophisticated requests can be made of the stored information, the system can be used effectively in many types of investigative files. FMA, Inc., Los Angeles, Cal.

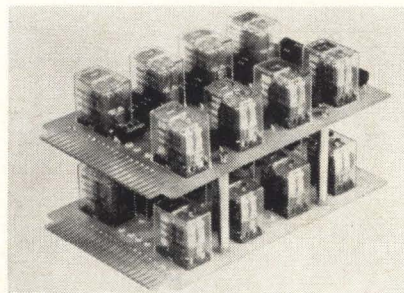
Circle No. 128 on Inquiry Card



INDICATOR LIGHT

A "Multi-lite" indicator is said to be a new concept in illumination and readout. With the parameter of a TO-5 transistor, it may be mounted directly to a circuit for flip-flop state indication, malfunction indication, or photo cell excitation. As a panel readout, it may be mounted separately in a 0.250 dia hole or ganged on a circuit board acting as insulator and mounting bracket. The unit is available with either one T-1 miniature lamp in a voltage range of 1.5, 2, 5, or 28 v and lamp life to 100,000 hrs., or two T-3/4 miniature lamps in a voltage range of 1.5, 2, 3, 4, 5, or 6 v with lamp life to 100,000 hrs. The legend can be engraved and filled by the manufacturer with any desired character. Leviathan Electronics.

Circle No. 172 on Inquiry Card



BCD VOLTAGE DIVIDER

New line of digital-to-analog converters includes relays mounted on one or two decks, and convenient input and output connections. Input signal can be a series of 1-2-4-2 or 1-2-4-8 decimal coded pulses of 10 milliseconds (or more) duration which are combined in the converter to provide an analog output. The units can also be used in either analog-to-digital or digital-to-analog converters as the decimal input or analog out-

put stage, respectively. They can also be employed as either the digital-to-analog coding input to various analog-type voltage sources or as the decoder for digitalized information at an analog output meter in other types of equipment. Two basic styles are available, one with constant input impedance, called RCD; the second with constant output impedance, called RCS. Accuracy of this four-digit unit is 0.003% standard and resolution is 0.01%. By matching relay-to-relay connections and selection of resistors, the input impedance is maintained at $100,000 \pm 100$ ohms and can accommodate an input signal strength of 1 to 100 volts. Relays are operated from an external source of 12 vdc with less than 65 milli-amperes drain for every relay. R-Tronics, Inc., Jamaica, N.Y.

Circle No. 166 on Inquiry Card

LOW CAPACITANCE CAPACITORS

For applications requiring low cost and stability at uncommonly low capacitances, a new glass-dielectric unit opens up a design area reaching 2 capacitance decades below 10 picofarads, said to be the approximate lower limit in the past for small, stable, low cost capacitors. A typical price for a "Lo-Cap" capacitor with 10 per cent tolerance in 1000-piece lots is 19 cents. Forty-six values are available in the 0.1 to 10pf range of the new unit, with tolerances of ± 5 , 10, and 20 percent. Maximum dimensions of the capacitor are 0.38" x 0.20" x 0.09" thick. The solid silver leads, weldable or solderable, are 0.375" x 0.1" x 0.002" thick. The unit can be used on circuit boards or in potted or cordwood assemblies. Corning Glass Works, Corning, N.Y.

Circle No. 236 on Inquiry Card

REED RELAYS

Four basic types of sealed-contact reed relays are described in an 8-page bulletin. The packages illustrated are types for wired assemblies and types for printed circuits. Information on relays for integrated printed circuit board assemblies and control modules for counting, selection, and logic functions is also presented. C. P. Clare & Co., Chicago, Ill.

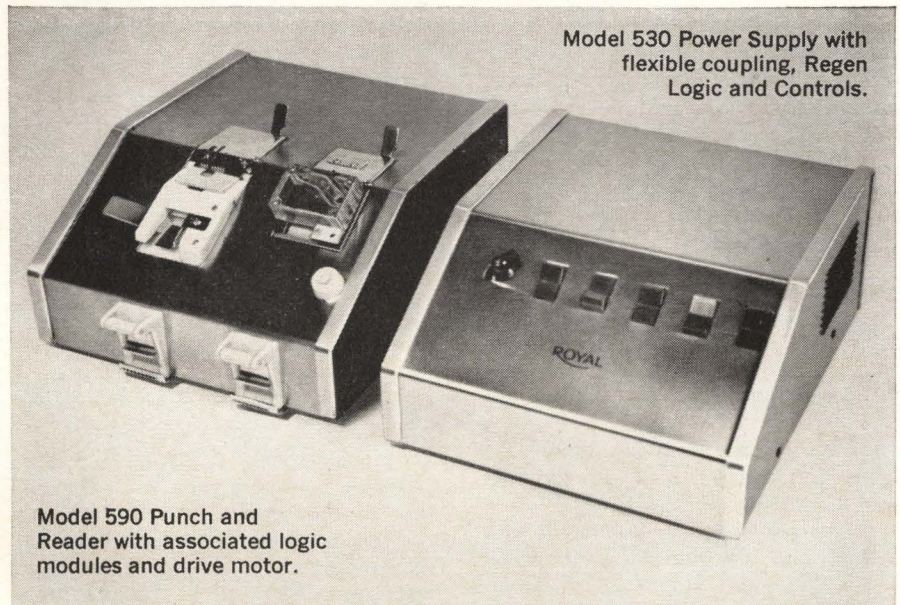
Circle No. 221 on Inquiry Card

HIGHLY-STABLE SUPPLIES

New power supplies are said to be ideal for such applications as analog digital systems, navigation systems, plotting tables, and numerous other systems where long-term reference voltage or current is required for field equipment. The new unit has a regulation versus temperature of $\pm 0.0025\%$ total over a 100°C temperature range. For worst case combination of line, load and temperature variations, it gives absolute voltage stability within $\pm 0.005\%$ for 60 days. Specs for a typical unit include an output voltage of 10 vdc at 0 - 100 milliamps and ripple of 1 mv rms. Glentronics Inc., Glendora, Cal.

Circle No. 167 on Inquiry Card

THE FASTEST most complete Paper Tape Regenerator in its class



Model 530 Power Supply with flexible coupling, Regen Logic and Controls.

Model 590 Punch and Reader with associated logic modules and drive motor.

*** 50 CPS * ONLY \$1950 * ONLY ROYAL McBEE**

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New design features: optional regeneration of delete codes, Regen lock and unlock, manual index control on Punch, Tape Feed control to put blank or delete feeds between messages. Takes wide range of tape sizes: 1", 7/8", 11/16" at 5, 6, 7 or 8 level. Optional auxiliary equipment available.

For complete specifications, mail the coupon. You'll find that the Royal McBee Paper Tape Regenerator out-performs anything near its price.

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CIRCLE NO. 17 ON INQUIRY CARD



Glass Regulators

Four-page engineering data sheet lists the characteristics and specifications for approximately 100 EIA registered glass silicon voltage regulators. The units make use of the regulating action of the reverse-current characteristics of silicon diodes. A wide variety of Zener voltages are listed with specified reverse current characteristics making it possible to select diodes for many applications directly from the data given. Although primarily intended for use in voltage regulating applications, at low power levels, these diodes are said to be equally suitable for clipping, clamping, coupling, and compensating circuitry. National Transistor Div., ITT Semiconductors, Lawrence, Mass.

Circle No. 140 on Inquiry Card

PC Connectors

Of special interest in a 44-page PC connector catalog is a 40 terminal micro-miniature unit with 0.050 center-to-center spacing assembled with a micro-module integrated circuit on a 1/32" printed circuit board. Complete electrical and mechanical specs, illustrations, outline drawings and ordering information are contained in the catalog. Continental Connector Corp., Woodside, N.Y.

Circle No. 125 on Inquiry Card

Digital Readout/Test Systems

Two booklets describe new digital readout systems for semi-automated, dynamic testing of switching devices and computer logic modules. The booklets contain detailed information about waveform measurement and digital conversion, test fixture and test circuits, electrical test inputs, digital data recording, and programming of typical systems. Also included in the booklets is a typical measurement program for a 3-input logic gate integrated circuit which serves to indicate the broad range of measurements possible with the systems. Tektronix, Inc., Beaverton, Oregon.

Circle No. 174 on Inquiry Card

Taper Techniques

A 48-page catalog discusses the special advantages of the taper wedge principle as applied to the termination of electrical/electronic circuits. The taper technique line consists of solid taper pins, formed taper pins, taper pin receptacles, and a large variety of mating taper pin blocks. General information, specifications, test data, tooling, and customer usage are covered. Amp Inc., Harrisburg, Pa.

Circle No. 202 on Inquiry Card

Computer Program Copyright

"Copyright Protection For Computer Programs", the first legal article devoted to this important topic, will be featured in the November issue of COLUMBIA LAW REVIEW. First submitted in draft form to the Copyright Office at their request, the paper was, in part, responsible for the Office's recent decision to register copyrights on computer programs. The author of the article, in fact, received the first copyrights ever registered on two programs he had submitted as test cases. The article examines the copyright-ability of computer programs, the scope of protection under a copyright, and the effects copyrights protection may have on the computer industry. It also considers the effect of the Copyright decision and the law as it would be under the new copyright legislation now before Congress. For your copy, write to:

COLUMBIA LAW REVIEW,
435 West 116 St.
New York, N.Y. 10027

Time Code Generator

An oscillographic time code generator for recording real time on a single channel or event channel of an oscillograph is described in a 2-page bulletin. Specifications and typical recording patterns indicate how the time of occurrence of events can be determined to better than 1/30th of a minute, regardless of chart speed. Chrono-log Corp., Broomall, Pa.

Circle No. 137 on Inquiry Card

Reed Relays

Catalog sheet describes a reed switch and new line of low-silhouette, multiple reedcapsule relays for PC board mounting. The assemblies consist of five basic units with from one to five capsules. These compact units are developed on a "system design" concept in which any relay package in the series occupies the same mounting area. Standard Gribby Inc., Melrose Park, Ill.

Circle No. 151 on Inquiry Card

Visual Data Analyzer

Booklet describes a system for converting visual data into digital form for computer analysis and record storage. The 4-page booklet includes a photograph of the entire system, information on various applications, and the technical specifications and parameters of the system. Digital Electronics Inc., Westbury, L.I., N.Y.

Circle No. 157 on Inquiry Card

Memory Cores Guide

A quick-reference guide summarizes the pertinent data for widely used ferrite memory cores. Information covers new wide-temperature range, low-drive cores as well as conventional cores. To use this quick-reference guide, it is only necessary to select the desired system cycle time and check the characteristics of the cores that are recommended for the required speed range. RCA Electronic Components and Devices, Memory Products Operation, Needham Heights, Mass.

Circle No. 152 on Inquiry Card

Zener Diodes

Zener diode catalog includes a thorough technical discussion explaining the characteristics, applications, and ratings of these voltage regulator diodes. This discussion is illustrated with appropriate curves and circuit diagrams. Another feature of the catalog is a JEDEC cross reference. This guide lists over 750 applicable JEDEC numbers. Sarks Tarzian, Inc., Semiconductor Div., Bloomington, Ind.

Circle No. 160 on Inquiry Card

Digital Design Manual

A new, 250-page catalog describes a complete line of 500-kc, 5- and 10-mc digital system modules and accessories. The catalog also includes an 85-page summary of Boolean algebra, basic logic circuits, and standard circuit configurations, as well as specific loading rules, signal definitions, and wiring hints for the system engineer with limited digital circuit experience. Over 200 different circuits are described. Digital Equipment Corp., Maynard, Mass.

Circle No. 169 on Inquiry Card

Thin-Film Substrates

Properties of Pyrex brand substrates for thin-film circuits are listed in an 8-page brochure. Pyrex brand substrates are drawn from Corning Code 7059 glass — a barium aluminum borosilicate composition that is nominally alkali-free. Typical analysis shows less than 0.2 per cent of alkali. Freedom from alkali is important in substrates. Alkali ions can migrate in high thermal and electrical fields generated by high value resistors, and frequently will react with the resistor material to cause a change in properties. Data listed in the brochure includes surface cleaning procedures, physical and electrical properties of the glass, effects of gamma radiation, chemical durability and thermal conductivity. Also included is a table of dielectric constant and loss tangent values at various temperatures and frequencies, and charts of volume resistivity, dielectric constant, optical transmittance in the visible and infrared regions, thermal expansion and loss tangent. Corning Glass Works, Corning, N.Y.

Circle No. 131 on Inquiry Card

Computer Capacitors

Engineering bulletin No. 3537 discusses the ratings and performance capabilities of economically-priced, metal-cased solid tantalum capacitors for use in commercial digital computers and other industrial equipment. Since these capacitors were designed for non-military applications, they employ a plastic resin end-seal rather than a more costly glass-to-metal solder-seal construction. Another bulletin No. 3536 discusses miniature-sized versions of the capacitors. Sprague Electric Co., North Adams, Mass.

Circle No. 126 on Inquiry Card

NEW from CHALCO:

—high power AC to DC modules in half- rack size



Choose from 600- or 1200-watt units, for 5¼" or 7" high RETMA racks. Series and/or parallel operation.

Higher output voltages—your choice of any range between 4 and 45 volts—continuously adjustable.

Higher output current—up to 50 amps.

Exceptional packaging efficiency—1.3 watt per cubic inch.

Remote programming and sensing.

Protective features: Transactors are short-circuit and overload proof... need no heat sinks. Regulation is $\pm 0.1\%$ for line and load combined. No positive voltage overshoot under any conditions. Units fully transistorized.

Input: 115, 208, 230 VAC $\pm 15\%$, 60 cps. **Sizes:** 600W units: 5¼"H x 8½"W x 15"D... 1200W units: 7"H x 8½"W x 15"D. Available with meters, circuit breaker, pilot light, rack adaptor.

Send for complete data. Bulletin W600 & W1200.

CHALCO ENGINEERING CORP.
15126 SO. BROADWAY, GARDENA, CALIFORNIA. FA 1-0121 (213)

CIRCLE NO. 18 ON INQUIRY CARD

PFM Telemetry

Recently-published paper describes pulse-frequency modulation (PFM) telemetry including principles of operation and advantages relative to other forms of aerospace telemetry. The paper describes in detail a PFM system typical of those used successfully on such satellites as IMP-1, Ariel I, and several of the Explorer series. Comparisons of PFM with FM/FM and PCM systems are described to show how a hybrid system results with many of the best features of both. Electro-Mechanical Research, Inc., Sarasota, Fla.

Circle No. 199 on Inquiry Card

Heat Sinks

Two technical bulletins cover two lines of recently-introduced heat sinks. Both bulletins provide construction information, natural and forced convection characteristics, mounting accommodations and ordering information. Wakefield Engineering, Inc., Wakefield, Mass.

Circle No. 136 on Inquiry Card

Film Reader

A 4-page brochure describes a semi-automatic film reader that provides fast, precise measurement of X, Y and Theta coordinates from filmed data when used in conjunction with company's automatic, high-speed digitizing system. The system is designed to fill the need for reading indistinct targets with the greatest possible resolution. Whittaker Corp., Electronics Div., North Hollywood, Cal.

Circle No. 216 on Inquiry Card

Wirewound Resistors

Bulletin on high reliability precision wirewound resistors carefully details the rigid test and inspection procedures governing their production. The information is shown in tables and charts and each of the test procedures is described in detail. Resistors are said to have failure rates better than 0.005%/1000 hours at a 90 per cent confidence level. Kelvin, Van Nuys, Cal.

Circle No. 121 on Inquiry Card

LITERATURE

Relay Catalog

A new 50-page catalog contains relay engineering handbook information. The catalog covers mercury-wetted, dry reed, and many other types of relays. Magnecraft Electric Co., Chicago, Ill.

Circle No. 213 on Inquiry Card

Microminiature Connectors

An 8-page catalog covers microminiature rack and panel connectors. This series is ruggedized and meets all applicable specifications of MIL-C-8384. The units can be supplied with 5 through 104 contacts, with such optional accessories as hoods, polarizing screwlocks, and cable brackets. Continental Connector Corp., Woodside, N.Y.

Circle No. 201 on Inquiry Card

Program/Patch Boards

A 10-page catalog devoted to programming systems and patch boards contains detailed drawings, pictures, and pertinent technical information on the systems developed to meet high reliability standards. Systems consist of manually-operated switches for low voltage circuits offering a variety of switching combinations through patch cords in a removable patchboard. Anderson Electric Corp., Leeds, Ala.

Circle No. 124 on Inquiry Card


Microcircuit Engineering

A 6-page brochure describes a broad range of microcircuit and integrated circuit services available to equipment and systems manufacturers from an independent engineering organization including staff education and seminars, integrated circuit design and prototype development, and the design and operation of integrated circuit fabrication facilities. Integrated Circuit Engineering Corp., Phoenix, Ariz.

Circle No. 217 on Inquiry Card

ADVERTISERS' INDEX

COMPANY	PAGE NO.
ABACUS, INC.	8
AMPEX CORP.	7
BENSON-LEHNER CORP.	Cover 3
BRYANT COMPUTER PRODUCTS Div. of Ex-Cell-O Corp.	35
CHALCO ENGINEERING CORP.	47
COMPUTER CONTROL COMPANY	Cover 2
DECISIONAL CONTROL ASSOCIATES	31
DIGITAL EQUIPMENT CORP.	Cover 4
ELECTRONIC MEMORIES, INC.	43
FABRI-TEK, INC.	19
FRANKLIN ELECTRONICS	34
IBM Industrial Prods. Div.	23
INDIANA GENERAL CORP.	1
LITTON INDUSTRIES	21
NCR ELECTRONICS	29
NAVIGATION COMPUTER CORP.	3
ROBACK CORP. Harman-Kardon	44
ROTRON MANUFACTURING CO.	38
ROYAL MC BEE CORP.	45
SEAELECTRO CORP.	30
SCIENTIFIC DATA SYSTEMS, INC.	5
TEXAS INSTRUMENTS, INC. Semiconductor-Components	10, 11
TRANSISTOR ELECTRONICS CORP.	41
UNIVAC Div. of Sperry Rand	37, 39
WANG LABORATORIES, INC.	42

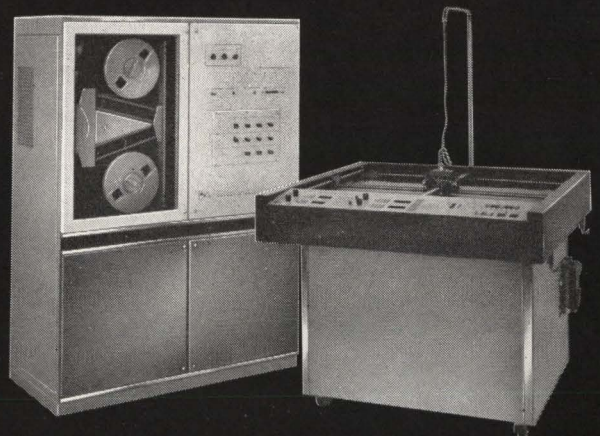


shortest distance between two points...

■■ SAVES COMPUTER TIME

Most computer prepared digital plotting tapes require a $\frac{3}{4}$ " record gap to separate the data points. But, not at Benson-Lehner. They have found a way to take the gap out of the tape. Therefore, by eliminating the *time-and-space* consuming record gaps, the shortest distance between two points on magnetic tape is Benson-Lehner's new tape format. By using this gapless method, the computer write time is shortened to $\frac{1}{14}$ of the time previously required. This means that you can write 14 times more information on the same length of tape! Or if you prefer, have some tape left over. And when you think of what it cost for computer time, the gapless way is the least expensive way to travel across a tape transport.

The Magnetic Tape Plotting System shown is capable of performing multi-color point-to-point plotting and line drawings, with scale markings, curve identification and alpha-numeric symbol printing.



benson-lehner corporation

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CIRCLE NO. 19 ON INQUIRY CARD

ANNOUNCING

TWO NEW COMPUTERS

WITH FLIP CHIP™ INTEGRATED CIRCUITS

PDP-8



- 1.6 μ sec cycle time
- 3.2 μ sec add time
- 12 bit word length
- 4096 word memory (expandable to 32,768 words)
- Fortran
- Field tested software
- 625,000 words/sec maximum transfer rate
- Reader punch and typewriter included

\$18,000

PDP-7



- 1.75 μ sec cycle time
- 3.50 μ sec add time
- 18 bit word length
- 4096 word memory (8,192 words directly addressable, expandable to 32,768 words)
- Field tested software including Fortran II
- 570,000 words/sec maximum transfer rate
- 300 cps paper tape reader
- 63.3 cps paper tape punch

\$45,000

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| DEC tape | Data communication equipment |
| CRT displays with light pen | Bulk storage drums |
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