COMPUTER DESIGN

THE DESIGN AND APPLICATION OF DIGITAL CIRCUITS, EQUIPMENT & SYSTEMS

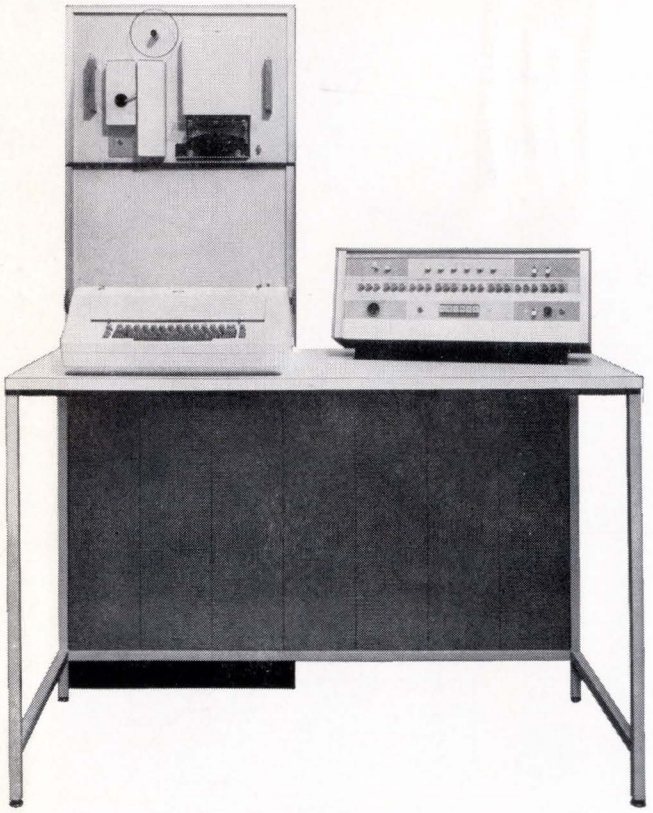
FEBRUARY 1966

Product Reference File-
DATA LOGGING PRINTERS

MOS MICROPOWER LOGIC

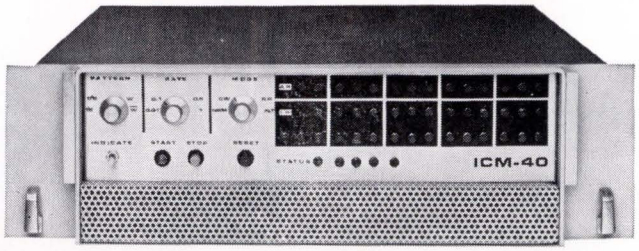
ONLY 3C OFFERS

TOTAL INTEGRATED CIRCUIT CAPABILITY: μ-PACS, MEMORIES, AND COMPUTERS



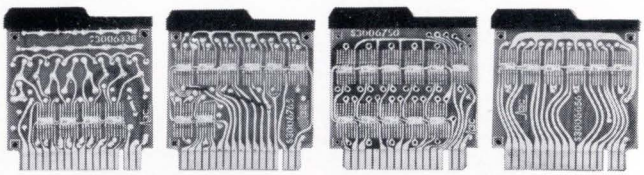
MICROCIRCUIT DDP-124

24-bit word DDP-124 features monolithic integrated circuit μ-PAC[tm] construction; fast, reliable, and flexible logic configuration — binary, parallel, sign/magnitude, single address with indexing, powerful command structure. Over 285,000 computations per second. MEMORY: 8192 words (expandable to 32,768) directly addressable; cycle time 1.75 μsecs. INPUT-OUTPUT: Typewriter, paper tape reader and punch. (Strong optional I/O capability and broad range of peripheral equipment.) SOFTWARE: FORTRAN II and IV, assembler, executive, utility and service routines. Fully program compatible with DDP-24 and DDP-224 general purpose computers.



INTEGRATED CIRCUIT 1 μSEC CORE MEMORY

New ICM-40 microcircuit, coincident current, random access core memories feature full cycle operation in 1 μSEC (less than 500 nsec access time). ICM-40's feature price, size and reliability advantages of integrated circuit μ-PAC[tm] logic. Word capacities to 16,384 in a 5¼″ high unit for mounting in a standard relay rack. Design permits pull out front rack access. Operating temperatures from 0°C to +50°C, with broad margins. Clear/Write, Read/Restore and Read/Modify/Write are standard modes of operation. ICM-40 interfaces comfortably with both discrete component and integrated circuit systems. Low power dissipation.



μ-PAC LOGIC MODULES

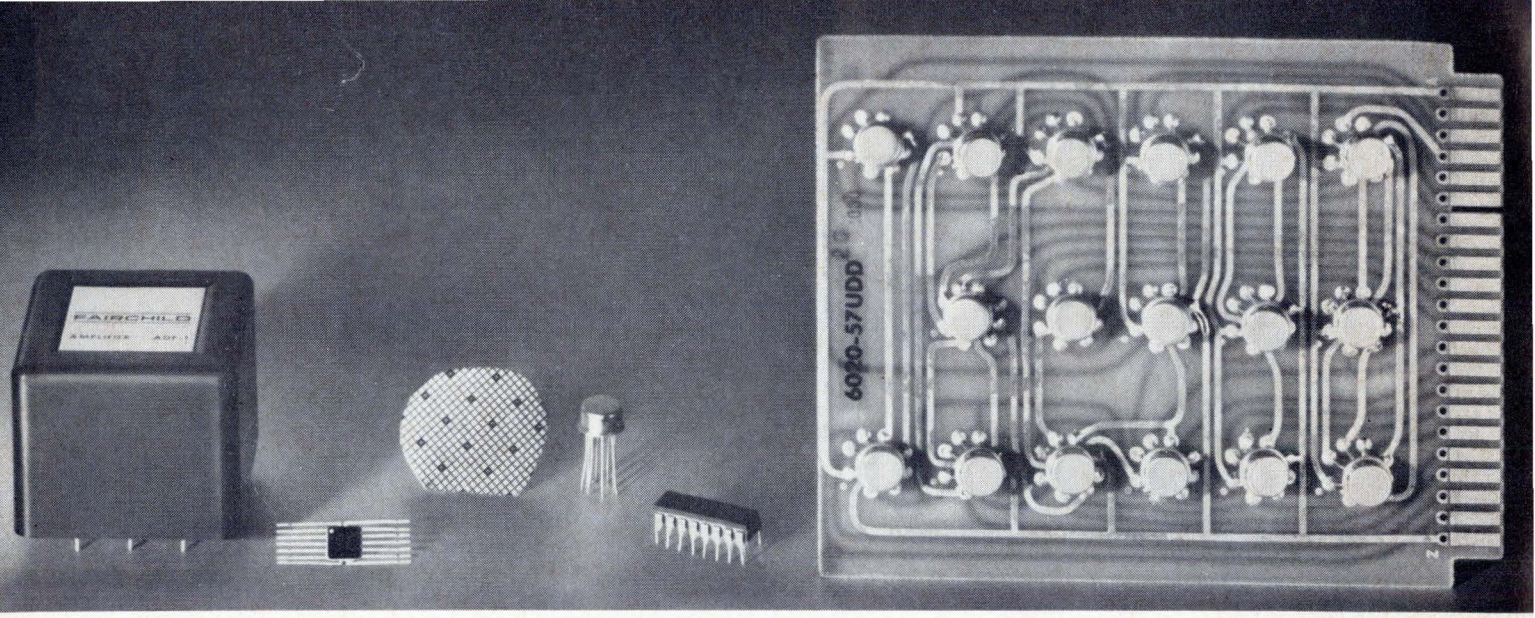
3C is the world's largest supplier of digital logic modules. With several years of in-house funded research and design, 3C has developed a broad line of standard, fully integrated, monolithic, 5mc circuit modules with the flexibility of 3C's long established discrete package lines. This has been achieved while retaining advantages inherent in the integrated circuit — price, size, reliability.

3C

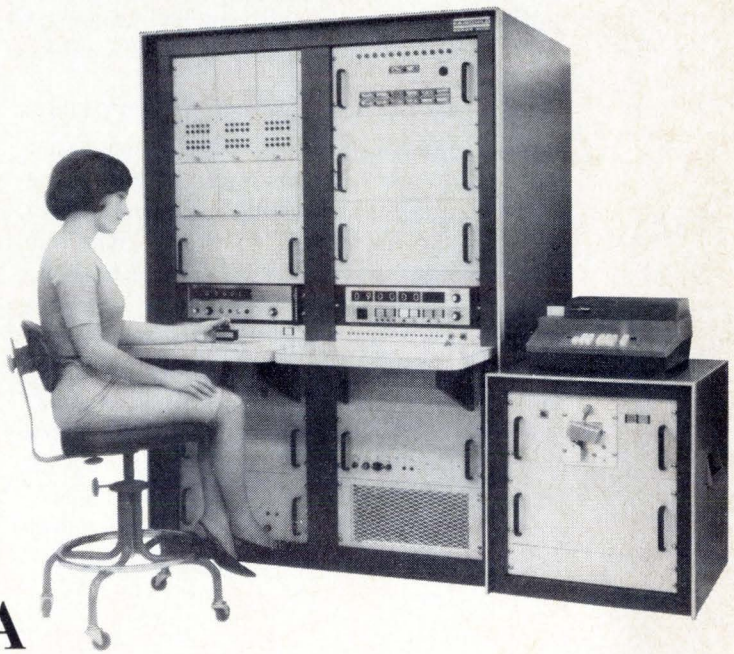
3C SALES OFFICES: NEEDHAM, MASS.; FOREST HILLS, N.Y.; LEVITTOWN, PA.; SYRACUSE, N.Y.; SILVER SPRING, MD.; HOUSTON, TEXAS; HUNTSVILLE, ALA.; COCOA BEACH, FLA.; DES PLAINES, ILL.; DETROIT, MICH.; WEST CARROLLTON, OHIO; LOS ANGELES, CALIF.; KENT, WASH.; ALBUQUERQUE, N.M.

COMPUTER CONTROL COMPANY, INC.
OLD CONNECTICUT PATH, FRAMINGHAM, MASSACHUSETTS 01702

CIRCLE NO. 1 ON INQUIRY CARD



Test all these circuits five ways with one system:



Fairchild Series 4000MA

1. Function Check. Each test sequence includes logic performance check. If the circuit passes, the system will automatically switch to the next test mode.

2. DC Testing. The 4000 makes sixty tests per second with resolution of ±.1mV and ±.1nA. Readout is Go/No-go with optional direct digital display or data logging.

3. Linear Measurements. The 4000 automatically measures: input offset voltage, input bias current, input common mode rejection ratio, open loop voltage gain, output impedance, output voltage swing, V+ and V− supply current, total device power, input common mode ratio, differential voltage gain, output common mode voltage, maximum voltage between V+ and V− terminals, BV_{CBO} at 10μa and up, differential input impedance and open loop voltage transfer function.

4. Switching Time. An automatically programmed switching time option measures storage time; propagation delay; pulse rise time, fall time and width; saturation voltage and pulse height and sag.

5. AC Voltage Measurements. Sinusoidal measurements can be made on a variety of circuits, with ±1% accuracy.

Economical Testing. The simple magnetic disc programming lets an inexperienced operator switch to 36 different test programs on a single disc in just seconds. This means you can program and test printed circuit cards, integrated circuits, flat packs, dual in-line packs, potted modules and even micrologic wafers at a single test station.

For a complete list of options and the full range of Series 4000 capabilities, get in touch with your nearest representative or write Fairchild Instrumentation.

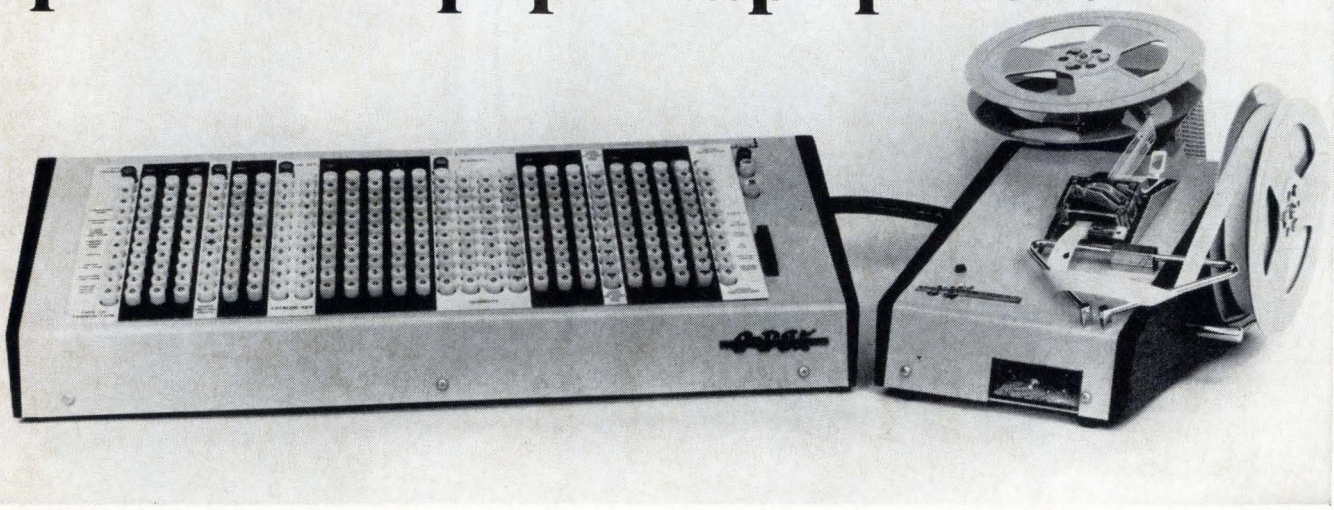
FAIRCHILD
INSTRUMENTATION

844 CHARLESTON RD., PALO ALTO, CALIFORNIA, 962-2451 ■ TWX: 910-373-1256 ■ FAIRCHILD INSTRUMENTATION, A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORP.

CIRCLE NO. 2 ON INQUIRY CARD

F/S-5-33-A(1)

Look what Colorado Instruments did with Roytron's plain little paper tape punch.



Colorado Instruments was developing a data collection device that would turn source data into computer-usable punched tape. And they were looking for a particular kind of tape punch.

Since it just happens that ROYTRON™ produces punches for every conceivable paper tape requirement, it was only natural for us to get together. (The resulting computer data entry system is already in use in over one hundred retail outlets of one of the nation's largest mail order houses.)

Roytron's basic tape punch mechanism suited Colorado's needs to a "T." But we could have delivered it either desk or rack-mounted. With or without electronic circuitry or logic. Reader incorporated or not. Either 20, 50 or 75 CPS. In 24 different models.

Roytron offers more than just the widest range of models. Our clients get punches with the most desirable operating features. Features like efficient electromagnets and off-center springs for smooth, trouble-free punching. In addition, Roytron paper tape punches operate on unusually low power (24 volts, 75 ma).

And they come with a meaningful warranty backed up by a nationwide system of service centers.

However you like your Roytron paper tape punches, that's how you get them. Customized. And we also have a price story to tell. So, before you go a step further with a punched tape system, consider Roytron.

For detailed specifications on the Roytron paper tape punch that fits your exact requirements, write: Roytron, Royal Typewriter Company, Dept. 35BV, 150 New Park Avenue, Hartford, Connecticut 06106.

A DIVISION OF LITTON INDUSTRIES **ROYTRON™**

CIRCLE NO. 3 ON INQUIRY CARD

FEBRUARY 1966 • VOLUME 5 • NUMBER 2

COMPUTER DESIGN

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

Editorial & Executive Offices
Professional Bldg.
Baker Ave. • W. Concord, Mass.
Tel. 369-6660

Computer Design is published monthly. Copyright 1966 by Computer Design Publishing Corporation. Accepted as controlled circulation publication at Post Office at Boston, Massachusetts. No material may be reprinted without permission. Postmaster: CHANGE OF ADDRESS — FORM 3579 to be sent to Computer Design, Circulation Dept., P. O. Box B, Arlington, Mass. 02174. Subscription rate to non-qualified subscribers is $15.00 per year; $1.50 per issue. Subscription rate to all foreign subscribers is $25.00 per year; $2.50 per copy.

BPA

Circulation
over 24,000

FEATURES

DEPARTMENTS

That's all there is!

Just 5¼ inches of rack space for a full 4096 word, 24 bit VersaSTORE Core Memory. And it's all accessible from the front panel, including the core stack. VersaSTORE comes in capacities from 256 to 4096 words of up to 24 bits. Any VersaSTORE may be field expanded to the maximum size.

If you like our compact package, look inside, VersaSTORE is loaded with features! Like the continuous lamp display of all the registers for immediate data identification. Integrated circuits for maximum reliability. 2μsec. cycle time with half cycle operation. A flexible interface, either PNP or NPN for easy integration with your system. VersaSTORE requires only ±12V. ± 5% to operate. Buffered input from 3V. to 24V. and output from 1V. to 12V. Plenty of output drive for system requirements. Random access. A servoed current drive that maintains good operating margins at temperature, without stack heaters. The exclusive "Dataguard" that protects the memory content during system checkout. Options include sequential and sequential interlace addressing and self-test.

If you like our compact package and our features, you'll really like VersaSTORE's compact price.

For a VersaSTORE brochure, full of facts and figures, write to:

dci **DECISION CONTROL, INC.**

1590 Monrovia Avenue, Newport Beach, Calif. Tel. (714) 646-9371 • TWX (714) 642-1364

CIRCLE NO. 4 ON INQUIRY CARD

Programmers: Let's take a look at your future.

Programmers at IBM enjoy professional status. Get full support from management. Work closely with systems designers.

As an IBM programmer, you'd rub elbows with the profession's leaders. Be exposed to all aspects of advanced programming. Have an active part in helping to advance the frontiers of programming knowledge.

You'd get the chance to grow. Take on new responsibility. And realize all the accompanying rewards. You'd enjoy continuing career-oriented assignments.

Soon, IBM programmers will be writing control programs for post-lunar launches. They'll develop time-shared systems for overlapping missions. They'll work on multiprocessors, dynamic storage allocation, and adaptive, self-organizing systems.

They'll even use computers to design other computers. But that's in the future. Your future with IBM. Let's talk about *now*.

We have immediate openings in our Federal Systems Center in Bethesda, Maryland. These positions require a B.S. or B.A. degree, or equivalent, and at least one year's experience in programming. To learn where your programming talents could take you in IBM's Federal Systems Center, mail the coupon today.

We'll contact you within a week. IBM pays relocation expenses. An Equal Opportunity Employer.

Mr. J. B. Farrington
Dept. 540-0
IBM Federal Systems Center
7220 Wisconsin Avenue
Bethesda, Maryland 20014

IBM®

I am interested in career opportunities in programming at IBM.

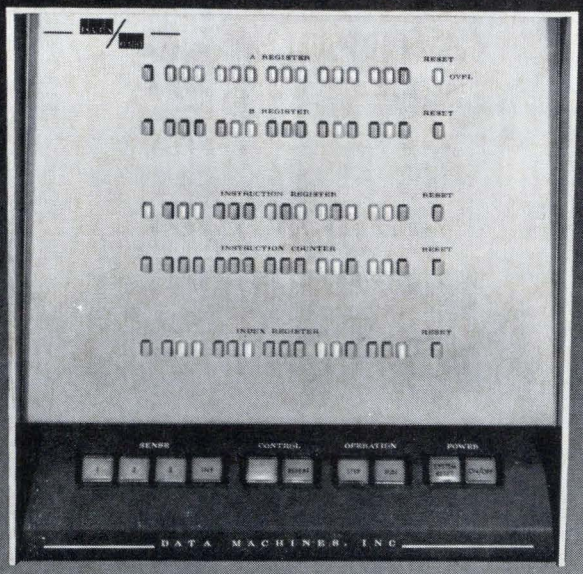
Name _____

Address _____

City _____

State _____ Zip Code _____

NEW



DATA/620

The ONE computer / built to MATCH!

DATA / 620 *Matches your System*

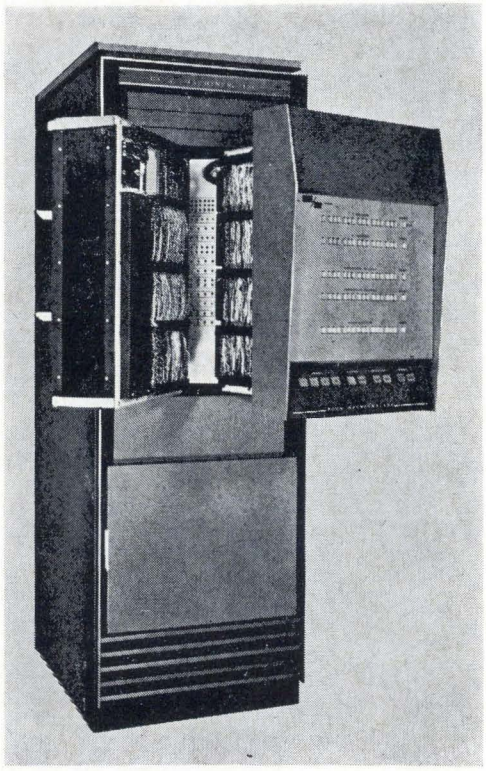
Designed for integrated information, processing, and control systems. Independent GP Memories for simultaneous operation—Two memory access channels standard, 555KC and 200KC—Party-Line I/O communication for time sharing and plug-in expansion—Micro-Exec for sub usec processing rates—Six types I/O facilities and up to 64 devices—Simultaneous I/O rates of over 500,000 words per DMA—Power and thermal failure protect with interrupt standard.

DATA / 620 *Matches your Engineering*

Specifically designed to provide engineering flexibility and economy—16 or 18 bits, 1.8 usec core memory—Over 100 machine commands, 9 hardware registers, universal bus organization—Modular construction for varied configurations—Front access, 26¼ inches of rack space—0-45°C.—7500 hours MTBF—0-12V Logic levels, 4V noise rejection—VersaLOGIC circuits, VersaLOGIC modules for interfacing.

DATA / 620 *Matches your Budget*

Designed for today's and tomorrow's systems. Economical to program and use—FORTRAN in 4K, Assembler, Aid, Maintain, all open-ended—Low initial cost ($27,900.00) and low subsequent operational cost—Low incremental plug-in expansion cost.



We have the complete DATA/620 *story* in a fact filled 36 page brochure. If you would like one, write to:

DATA MACHINES

1590 Monrovia Avenue, Newport Beach, California • Telephone (714) 646-9371 TWX (714) 642-1364

Division of DECISION Control, Inc.

CIRCLE NO. 5 ON INQUIRY CARD

from our man in Washington

The National Bureau of Standards was the only sizeable group in the Government to have a long delay in receiving the recent retroactive pay raise. The blame in the pay delay was attributed to NBS's own computer which is supposed to be one of the most sophisticated in the business. It seems an inexperienced employee fed the computer the wrong data leading the machine to write an incorrect payroll.

.....

The Federal Deposit Insurance Corporation (FDIC) is embarking on a computer program designed to provide it with additional tools with which to carry out its continuing responsibility to the public to foster strong, efficient, and competitive financial institutions. Through computerization, FDIC plans to develop information which can be used in the analysis of market penetration and concentration, for cost studies and comparative studies of financial institutions by type, size, or area, and in many other areas pertinent to bank supervision. These analytical tools, it is believed, will be useful to both the FDIC and to banks across the nation.

.....

Uncle Sam is looking for new executive talent for the civilian National Defense Executive Reserve — especially personnel with scientific training or experience with automated control methods. NDER is composed of business executives, mostly from the role just below the company president, who would, in the event of a dire emergency, work in Washington in the areas of wage and price control and material rationing. If interested, communicate with Bufford Ellington, Director of Emergency Planning, Executive Office Building, Washington, D. C.

.....

An Information Center at the Office of Economic Opportunity (OEO) will aid in the Administration's War on Poverty. Leon Gilgoff, a systems expert, has been named head of the new office. OEO's Center will use modern computer, communications, and display techniques to bring together data on poverty programs and progress at all levels. The Center will include a computer complex, a communication center, and a reference and inquiry section. In effect, according to OEO, "it will be the National Control Room for the War on Poverty."

.....

Independent of the executive branch, Congress should adopt the use of computers to provide itself with better information, suggests Kenneth Janda. A Northwestern Univ. political science professor, Janda believes that with a computer-type information processing system a member of Congress could be notified automatically of the introduction of bills of interest to him and other necessary background information. A member called to the floor to vote on a bill with which he is not completely familiar, it was pointed out, could instantly obtain from his office the issues involved, summary information of the sponsorship of the measure, the voting position of the President and party leaders, and possible effects of the legislation on his constituency. Janda said the cost of such a system could be kept below $300 million, which, he contended, would not be excessive considering the gains that would be achieved.

Recent Defense Department Contracts .....

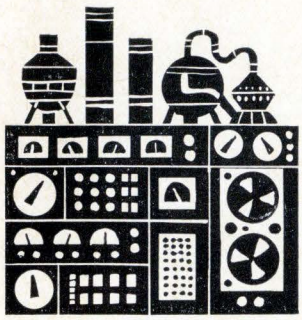
MAGNAVOX CO., Urbana, Ill., issued a $5,641,432 fixed-price contract for gun direction computers. The Frankford Arsenal awarded the contract after competition in which 33 bids were solicited and 11 were received.

GARRETT CORP., AiResearch Mfg. Co., Div., Torrance, Cal., a $1,375,000 fixed-price contract for computers for F-4B aircraft. The contract was issued by the U. S. Navy Aviation Supply Office, Philadelphia, Pa.

UNIVAC, Div. of Sperry Rand Corp., Wash., D. C., awarded a $1,571,760 fixed-price contract for various items of data processing equipment. The Defense construction Supply Ctr., Columbus, Ohio, issued the contract.

SYSTEMS DEVEL. CORP., Santa Monica, Cal., awarded a $58,000 contract by the Justice Dept. to design a computer-based management information and retrieval system. The system will provide Justice attorneys with rapid access-to-case information.

BUNKER-RAMO CORP., Silver Spring, Md., received an extension of a contract to prepare an automated reporting system that will gather and process cost data for the U. S. Weather Bureau.



INDUSTRY NEWS

AN RCA 301 COMPUTER SYSTEM, INCLUDING TWO MASS MEMORY STORAGE AND RETRIEVAL UNITS, HAS BEEN ORDERED BY THE CALIFORNIA DEPARTMENT OF JUSTICE IN A PROGRAM TO BUILD A STATE-WIDE CRIMINAL DATA GATHERING NETWORK. The system will be one of the first such EDP installations in the country for centralized storage and retrieval of criminal information. Initial application will be to take over the record-keeping of criminal activities, storing information, and making it immediately available to authorized inquiry.

FOUR MICROMINIATURE DATA PROCESSING SYSTEMS, CONSTRUCTED ENTIRELY OF MICROELECTRONIC CIRCUITS, AND OPERATING ON A FRACTION OF A WATT OF POWER, ARE BEING BUILT BY GENERAL INSTRUMENT CORP., UNDER CONTRACT FROM NASA. The processors are for use in the OGO-E (Orbiting Geophysical Laboratory) research satellite. Two of the data processors weigh less than 16.5 ounces each and two less than 5 ounces. They will be used in cosmic ray experiments to collect information on space conditions from the satellite's sensing devices and feed it, on command signal, into a central data system.

A NEWLY-DEVELOPED SYSTEM OF BINARY GAIN CONTROL PERMITS PETROLEUM GEOPHYSICISTS TO RECORD SEISMIC WAVES IN THEIR TRUE AMPLITUDES FOR THE FIRST TIME IN THE HISTORY OF THE INDUSTRY, according to T. L. Slaven, Vice President, Western Geophysical Division of Litton Industries. "Employing digitally-controlled gain levels, the system records seismic amplitudes directly in digital form with an absolute accuracy of one tenth of one percent," Slaven said. "The system also makes extensive use of monolithic integrated circuits to reduce size and power consumption, both important in field operations." An initial order for several of the new systems placed by Western Geophysical at a price in excess of $500,000 was announced by M. H. Hayes, Jr., President of SDS Data Systems of Pomona, California, a subsidiary of Scientific Data Systems. SDS Data Systems has named its binary gain controlled system the Series 1010 Geophysical Digital Recording System. According to Mr. Hayes, the recording systems will accept 24 analog inputs from seismic amplifiers, one time break and one uphole signal, one auxiliary analog input, and one test signal from the system performance analyzer. Channel scan time may be set at one, two, or four milliseconds. The new approach to geophone signal amplification employs digital logic techniques to increase the gain in precision steps as the seismic signal declines. With 15 gain levels, this automatic gain-ranging amplifier adds another 84 db to overall system resolution, making 168 db in all. Furthermore, since true amplitudes are recorded, computer reconstruction of signal amplitudes is no longer required. For field quick-look, the digital values of 26 channels are converted to analog and applied to a recording oscillograph. A digitally controlled automatic-gain-control unit smooths the digital-to-analog output, providing camera traces in the accustomed form.

LATIN AMERICA REPRESENTS A POTENTIALLY LARGE MARKET FOR CONSULTING AND TECHNICAL SERVICES FOR COMPUTERS ALREADY IN COMMERCIAL USE — BUT NOT FOR RESEARCH AND DEVELOPMENT OF NEW COMPUTER SYSTEMS AND COMPONENTS. The statement was made by Dr. R. L. Barnoski, senior staff member of Measurement Analysis Corporation, Los Angeles, Cal., and lecturer at the First Pan-American Congress of Mechanical and Electrical Engineering recently held in Mexico City. Dr. Barnoski said that Latin American countries are actively interested in advances in the state-of-the-art of computer technology and in applying that technology to commercial development. "But, their basic economies are in a stage of development that makes it unlikely these countries will spend money for development of specialized computer systems," he said. "Emphasis will be on new applications with existing computer systems."

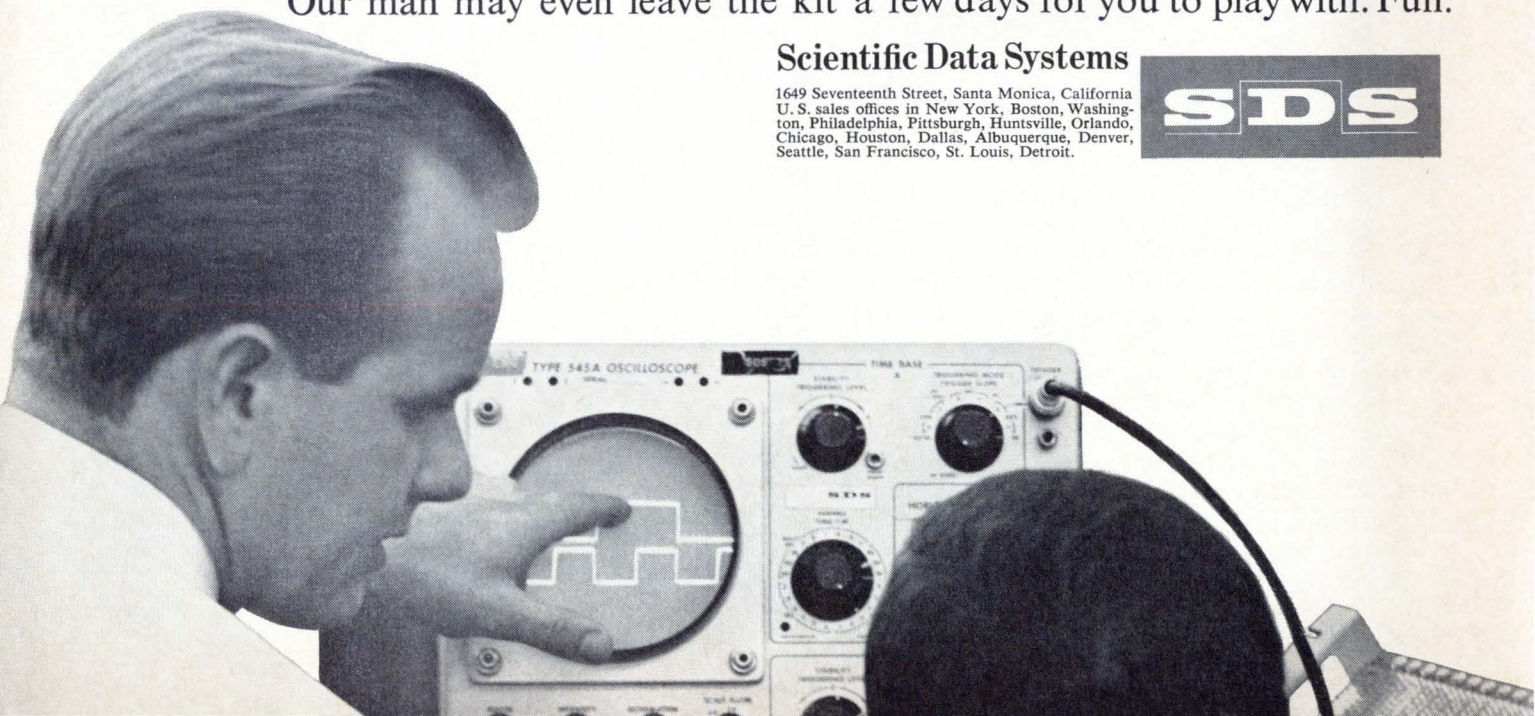
Like to see our new T Series modules perform? Warm up your scope, we'll be right over.

Our new T Series integrated circuit logic modules are so fast and flexible that we can hardly blame you if you doubt the amazing specs: Fan out of 14. Noise rejection up to 1.8v. 18 nanosecond gates. 40 nanosecond flip-flops.

So we've given our men demonstration kits and you can see for yourself.

Each kit contains an assortment of module cards and has its own power supply and timing source. You furnish the problems and the oscilloscope.

Our man may even leave the kit a few days for you to play with. Fun.



Scientific Data Systems

1649 Seventeenth Street, Santa Monica, California
U. S. sales offices in New York, Boston, Washington, Philadelphia, Pittsburgh, Huntsville, Orlando, Chicago, Houston, Dallas, Albuquerque, Denver, Seattle, San Francisco, St. Louis, Detroit.

SDS

INDUSTRY NEWS

THE UNIVERSITY OF MICHIGAN HAS RECEIVED A $1.3 MILLION CONTRACT FROM A DEPARTMENT OF DEFENSE AGENCY TO DEVELOP A COMPUTER LANGUAGE SO MAN CAN BETTER USE THE NEWEST GENERATION OF COMPUTERS. The new language will help computer users carry out with relative ease much more complicated operations than they can at present, according to the project director, U-M engineering Prof. Frank H. Westervelt. Such complex and intricate tasks range from the study and description of nerve networks and synthesizing speech to the design of defense systems and automobiles. Users will be able to "draw" complex illustrations on television-like display tubes. Not only will the illustration be available, but the physical object represented will be completely described mathematically inside the computer, Westervelt explained. Once described, any view of it — inside or out, from any desired angle, of any magnification — can also be projected. Westervelt said the two-year award from the Advanced Research Projects Agency will build on the U-M Computing Center's earlier development of the "highly successful MAD language." MAD, which stands for Michigan Algorithm Decoder, is an English-like translator of instructions which computer users employ to tell the computer what to do in solving a problem. It is much broader and more flexible than most computer languages and permits computer users to work on an extremely wide range of problems.

THE AVERAGE MAN AND WIFE WILL USE A COMPUTER AS CASUALLY AS THE AUTOMATIC WASHER-DRIER AND POWER TOOLS IN THEIR BASEMENT, according to Dr. Edward E. David, Jr., of Bell Telephone Laboratories, and Dr. Robert M. Fano of Massachusetts Institute of Technology. Unless they do so, according to the two scientists, we may not survive the increasing complexity of our society. Presenting a paper before the recently-held Fall Joint Computer Conference, the two scientists said, "Many years ago it must have seemed equally inconceivable and perhaps sacrilegious to allow the average housewife to turn on powerful motors and operate complex machines, and we would have winced at the thought of allowing teenagers to monopolize such a priceless creation of human inventiveness as the telephone. We are now at that stage with computers. Technical means are now available for bringing computing and information service within easy reach of the public."

THE CONTROL SYSTEM FOR THE WORLD'S LARGEST STEAM-ELECTRIC GENERATING UNIT, RECENTLY ORDERED BY THE TENNESSEE VALLEY AUTHORITY, WILL BE SUPPLIED BY BAILEY METER COMPANY, WICKLIFFE, OHIO. Bailey has been awarded the contract in excess of $1,000,000 for the automatic control systems for the 1150 megawatt unit that will go on line in 1969. TVA's generating facility will be controlled through an integrated boiler-turbine-generator control system that will include a Bailey 760 Solid-State Digital Control System for cyclone burner management and a Bailey 721 Solid-State Analog System for combustion control.

EASTERN AIRLINES AND IBM CORP. HAVE TEAMED UP TO DEVELOP A NEW, INTEGRATED CIRCUIT, DIGITAL AIRBORNE DATA PROCESSING AND RECORDING SYSTEM. Phase I of the program is already aloft — a digital "record only" system in operational testing aboard an Eastern Boeing 727 Whisperjet. Later, a miniature computer in the aircraft will provide real-time data reduction in flight. Design goal is to provide a digital computer system, packaged in a ½-ATR box and weighing about 40 pounds excluding recorder and display units, that is capable of monitoring about 300 key airframe, engine, and sub-systems parameters.

TALKING COMPUTERS HAVE BEGUN GIVING LONG-DISTANCE TELEPHONE OPERATORS SPLIT-SECOND INFORMATION ON THE COST OF CALLING ANY OF THE MORE THAN 30,000 POSSIBLE TOLL CENTERS IN THE UNITED STATES AND CANADA. A matched pair of Honeywell 200 computers, installed at the Northwestern Bell Telephone Company, will make it possible for the telephone company to give its customers much faster service in determining charges on intercity calls. The new computerized toll rating system — to be used by long-distance operators in Iowa, Minnesota, Nebraska, North Dakota, and South Dakota — is designed primarily to calculate rates on the thousands of long-distance calls made each day from public telephones, motels, and hotels. It is expected to handle as many as 5,000 requests an hour from operators throughout the five-state region. The computer, whose "voice" is recorded on a small magnetic drum, "talks" by picking from the drum the words it needs to tell operators how much a call costs.

DATA COMMUNICATIONS

equipment for on-line, real-time processing

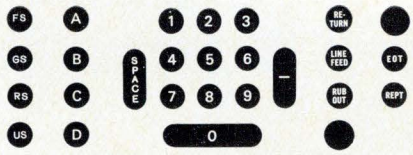
there are keyboards...and there are keyboards

Data communications vary, requiring a variety of different keys and even different keyboards. This is why there are Teletype sets available with 3-row keyboards, 4-row keyboards, and numeric keyboards, having a variety of special purpose keys.

The 3-row keyboard operates on the 5-level Baudot code. The new 4-row keyboard is similar to the standard office typewriter, and operates on an 8-level code that's compatible with the American Standard Code for Information Interchange. It can communicate directly with computers and other business machines in data processing systems. The numeric keyboard consists of 25 keys that are used primarily to speed transmission of coded numeric data such as used to control inventory and delivery in warehouses, supermarkets, etc. Though this Teletype set can send only numeric data, it is capable of receiving and printing all alphanumeric characters.

WHAT ARE THE "KEY" DIFFERENCES?

There are many different special purpose keys on Teletype keyboards. The most commonly used are the function or non-printing keys. On the 3-row keyboard, depressing the LTRS key transmits the letter characters shown on the lower keytops while depressing the FIGS key transmits the figure characters on the upper keytops.



NUMERIC KEYBOARD

On the 4-row keyboard, both the letters and figures are shown on the lower part of the keytops. Thus, the SHIFT key enables the code combinations to be generated for the printing characters shown on the upper keytops, such as "&" and "%". A CONTROL key is used to generate the code combination for the function characters shown on the upper keytops, such as "WRU" (who are you?) and "EOT" (end of transmission).

ERROR DETECTION AID

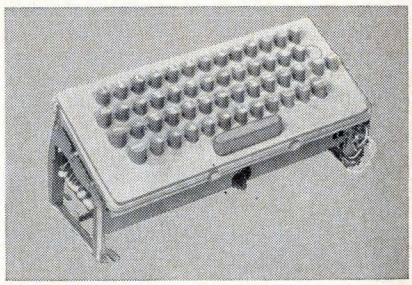
The 4-row keyboard can generate an "even parity" which is used to aid in error detection. Even parity provides for adding a marking pulse whenever the number of marking pulses in a code combination is odd. Thus, if a code having an odd number of marking pulses is received, it indicates an error. The eighth level is used for providing even parity.

machines that make data move

On friction feed typing units, depressing the LINE FEED key causes the paper to advance one line. Sprocket-feed typing units are equipped with both LINE FEED and FORM-OUT keys that cause the platen to advance a printed business form either one line or a sufficient distance to bring the next form to the starting position.

SELF-CONTAINED KEYBOARDS

Self-contained 4-row keyboards are available to provide direct-parallel-wire entry of variable data into computers and business machines.



ALPHANUMERIC KEYBOARD

The versatility of Teletype keyboards is another reason why they are made for the Bell System and others who demand reliable communications at the lowest possible cost. If you wish further information on Teletype equipment write: Teletype Corporation, Dept. 71B, 5555 Touhy Avenue, Skokie, Illinois 60078.

TELETYPE

CIRCLE NO. 7 ON INQUIRY CARD

DATA COMMUNICATIONS

equipment for on-line, real-time processing

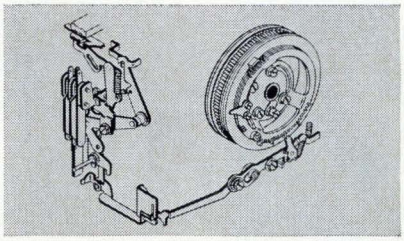
there's more than that to a page printer!

Is most of your data coded in numbers? Need a page printer that will print in 2-colors? Neither is difficult in data communications, because Teletype page printers offer a wide variety of print-out capabilities.

The Teletype numeric keyboard has keys similar to an office adding machine to provide fast, efficient collection, integration, and transmission of numerically coded data. It can be used by branches to record and transmit numeric data to processing or distribution centers to simplify ordering and inventory control, as well as speed shipping. Though this Teletype set transmits numeric data only, it will receive and print-out all alphanumeric characters.

TWO-COLOR PRINTING

There are many applications of 2-color printing, including tie-ins with business machines. Accounting and statistical departments can use Teletype machines to transmit data in 2-colors to the home office or a centralized data processing center. For instance, the red can be used to indicate "loss" figures and the black to indicate "profit" figures. Page printers can also be used to report plant operations, using black for normal conditions and red for abnormal conditions.



HORIZONTAL TABULATOR

AIDS TO DATA COMMUNICATIONS

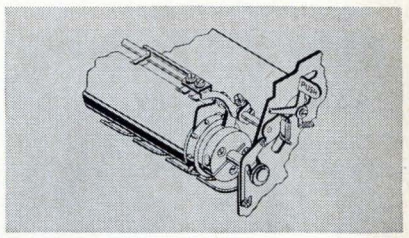
There are many additional Teletype page printer features that further improve your data communications capabilities. These include: vertical and horizontal tabulators; a variety of type styles and sizes; and sprocket feed platens that enable you to type on multicopy business forms.

There are also a variety of platen widths to accommodate most standard size forms. Another important feature is the automatic forms feed-out. With one key stroke, you can advance a business form, bringing the next one to the starting position automatically.

KEEPS MANAGEMENT UP-TO-DATE

The capabilities of Teletype page printers have found wide application in both business and industry. For example, a large aircraft plant uses nearly 50 Teletype Model 35 page printers throughout the plant to report production information to two real-time computers. In this way, management is provided with instant information on the status of plant operations. This system has helped management to tighten control over in-plant functions, shorten production time, and reduce overall manufacturing costs.

And there's more to Teletype equipment than just page printing—such as automatic and keyboard send-receive sets, and a variety of paper tape punches and readers to name only a few. That's why these Teletype machines are made for the Bell System and others who need dependable communications at the lowest possible cost. A brochure on the applications of Teletype equipment is available by writing: Teletype Corporation, Dept. 71B, 5555 Touhy Avenue, Skokie, Illinois 60078.



SPROCKET FEED PLATEN

machines that make data move

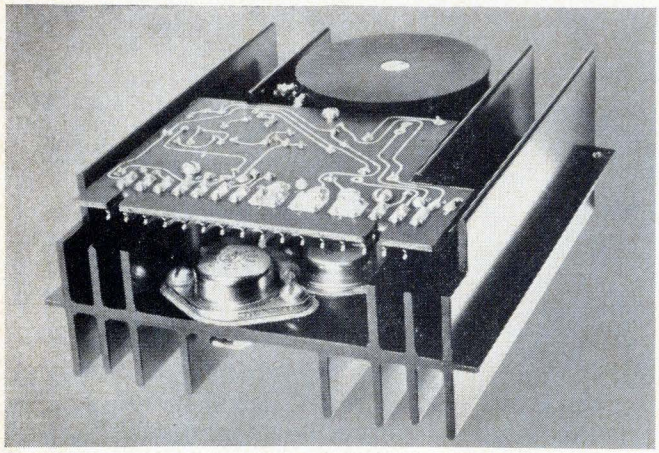
TELETYPE

CIRCLE NO. 9 ON INQUIRY CARD

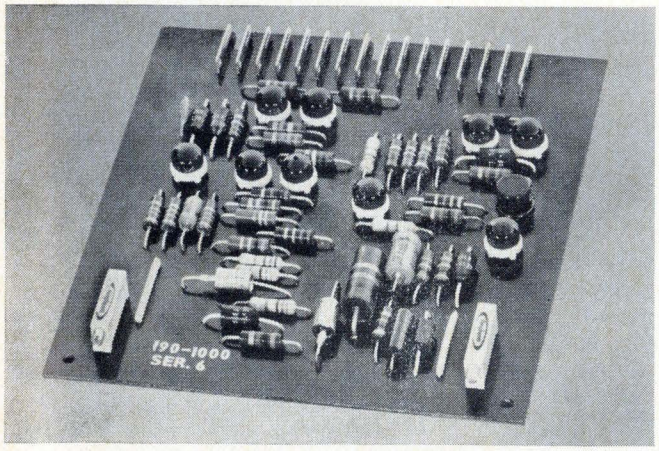
Does your present custom power supply give you...

70% to 90% efficiency? ?	Instant fault repair by plug-in module replacement? ?	Add-on power capability by using more modules? ?	Ability to handle full load steps while maintaining out put in regulation band? ?

New Omnimod does!



Omnimod power control module.



Omnimod control amplifier.

OMNIMOD gives you all these features—*and* more—*and* at a lower price! Want to know more?

OMNIMOD is a dc to dc converter using transistors in a CONSTANT PULSE WIDTH, variable repetition rate switching mode to regulate output voltage or current. Two small plug-in units make-up the OMNIMOD concept—a power control module and a control amplifier.

Output can be regulated between ± 2 and ± 60 dc at up to 20 amperes using the OMNIMOD family of modules WITHOUT MODIFICATION OR ADJUSTMENT. Higher current ratings are obtained by paralleling power control modules.

Any number of power controller modules can be controlled by one amplifier. OMNIMOD has a current limiting parameter, over voltage protection, voltage sequencing, and remote sensing.

To design a custom power supply, one must simply

1. design one input power converter to change unregulated line ac power to unregulated dc power

2. select the number of plug-in OMNIMOD power control modules to supply the power needed for each output

3. package these elements with filter capacitors and a plug-in amplifier module for each output

All the power used by every element in a typical data processing system could be supplied by custom power supplies constructed with interchangeable OMNIMOD modules.

Isn't this enough to consider OMNIMOD for your custom requirement? We will design an OMNIMOD custom power supply to your specs, or will help you design your own system using our plug-in OMNIMOD modules.

Write for the complete story. We'll have it to you within 48 hours.

CONTEMPORARY ELECTRONICS

EXTRA SERVICE TO THE DATA PROCESSING INDUSTRY

128 North Jackson, Hopkins, Minn. 55343 Telephone 935-8481—Area Code 612

CIRCLE NO. 10 ON INQUIRY CARD

DATA COMMUNICATIONS

equipment for on-line, real-time processing

how modular can you get?

Teletype machines are modular by design, as are all the special purpose control and operating functions. As a result, Teletype equipment provides many more opportunities for you to improve on your capability to communicate data. This is also why Teletype sets are the best equipped to prepare data for transmission, as well as to transmit and receive it.

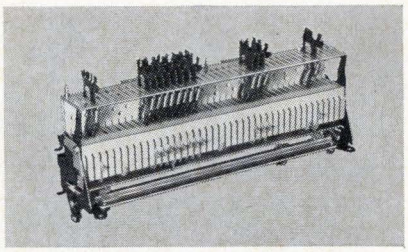
FRICTION OR SPROCKET FEED?

Teletype sets can be equipped with either a friction feed platen that prints on single or multiple copy paper, or a sprocket feed platen that positions multi-copy business forms for printing. Projecting pins engage perforations in the business form to provide for continuous, accurate multi-copy alignment.

Also, horizontal and vertical tabulators can be provided on Teletype Model 35 equipment to speed typing and improve efficiency. Teletype sets can be equipped with a form-out feature that with one key stroke will advance a business form, bringing the next one to the starting position.

NON-PRINTING FUNCTIONS

The stunt box can control many non-printing functions that add to the versatility of Teletype sets. Among these functions are carriage return and line feed, plus the ability to activate other apparatus including paper tape punches, paper tape readers, and business machines.



STUNT BOX

OTHER CONTROL FUNCTIONS

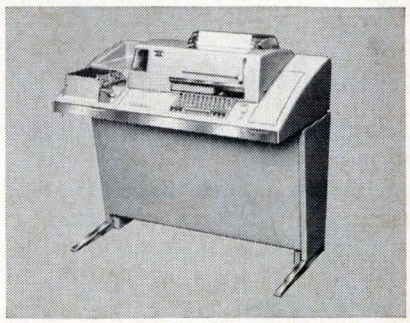
Control circuits for operating auxiliary input and output devices can be utilized, such as on the Teletype Model 35 ACS (Automated Communications Set). This is basically an automatic send-receive set with an additional tape reader for internal programing capabilities.

The auxiliary devices include: push button addresser that automatically calls in a preselected remote receiver, a push button generator that automatically types in repetitive stored data to further simplify the filling-out of business forms, and an auxiliary page printer and tape punch.

ADDITIONAL TIMESAVERS

To further aid the operator in preparing business forms, Teletype machines are equipped with a copy-holder to hold papers for easy, convenient reading and handling. Also, there is a form supply box for storing unused and completed business forms.

We have indicated only a few of the features that are or can be incorporated into Teletype sets. This versatility is one of the reasons why they are made for the Bell System and others who require dependable communications at the lowest possible cost. The new Model 35 ACS is described in an 8-page brochure, which you can obtain by writing: Teletype Corporation, Dept. 71B, 5555 Touhy Avenue, Skokie, Illinois 60078.



MODEL 35 AUTOMATED COMMUNICATIONS SET

machines that make data move

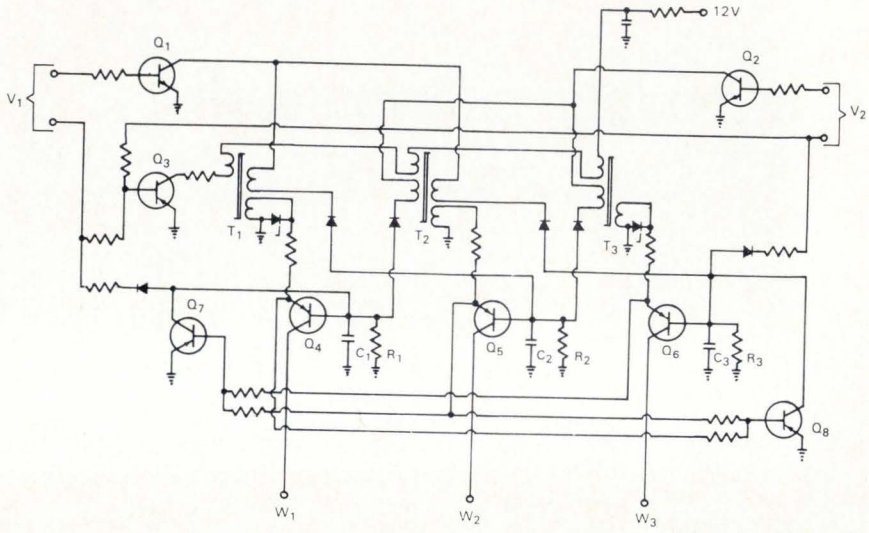
TELETYPE

CIRCLE NO. 11 ON INQUIRY CARD

NASA TECH BRIEF

A SUMMARY OF A SPECIFIC TECHNICAL INNOVATION DERIVED FROM THE SPACE PROGRAM. ISSUED BY THE TECHNOLOGY UTILIZATION DIVISION OF NASA.

Magnetic-Shift-Register Circuit Controls Step Motor Operation



THE PROBLEM

To design a controller to perform the signal conditioning required for bidirectional operation of a phase-pulsed step motor. Previous solid-state designs have the disadvantages of appreciable power drain in the standby mode plus susceptibility to switching transient interference due to their regenerative characteristic.

THE SOLUTION

A single line magnetic-shift-register circuit that draws no power in standby and is nonregenerative and therefore insensitive to switching transients. Separate input terminals make it possible to drive the step motor either forward or backward.

HOW IT'S DONE

Drive pulses are applied at V_1 for forward operation and at V_2 for reverse operation. Transistors Q_1 and Q_2 perform switching functions for "storage" selection. The square-loop magnetic core memory elements T_1, T_2 and T_3 hold the pulse data until operation of the single shift line through Q_3 shifts the data to the temporary storage elements R_1 C_1, R_2 C_2 and R_3 C_3. Output pulses are taken from terminals W_1, W_2, and W_3 through transistors Q_4, Q_5, and Q_6, respectively.

For forward operation, the input pulse is applied directly to C_1 and an output pulse is produced at W_1. Subsequent pulses shift the pulse data from T_1 and T_2 to produce output pulses first at W_2 and then at W_3. Feedback through inhibit transistor Q_7 prevents pulses from appearing at W_1 during this interval. For reverse operation, the input pulse is applied directly to C_3 and stored in T_3 and T_2. Feedback in this mode is through inhibit transistor Q_8.

NOTES

1. This design can accommodate any number of stages.

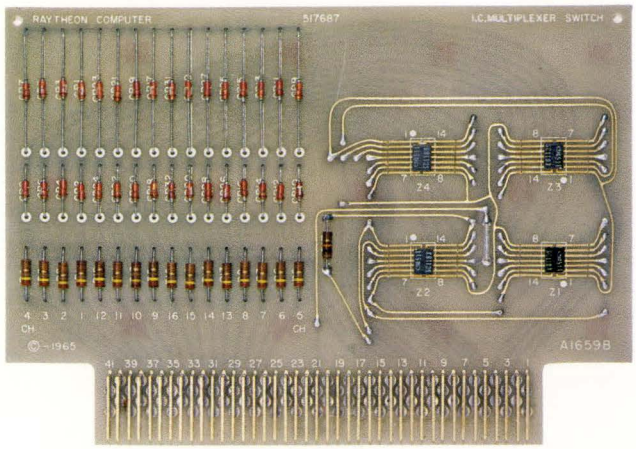
2. This invention should have wide application in step motor drive systems.

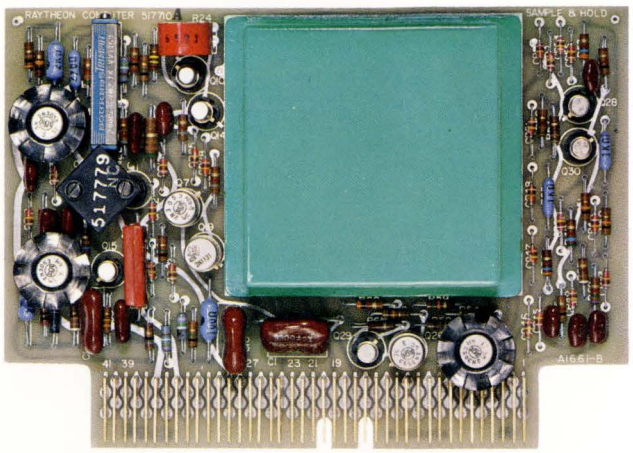
3. Inquiries concerning this invention may be directed to: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Maryland, 20771, Reference: B65-10226.

PATENT STATUS

NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546. **END**

This is a MULTIVERTER®. An integrated circuit Multiplexer, Sample and Hold Amplifier and Analog-to-Digital Converter in a single chassis. You can buy one from Raytheon Computer and nowhere else. RAYTHEON





MULTIVERTER FEATURES

Complete Front-End System in Single 5¼″ Drawer
- Multiplexer
- Sample and Hold Amplifier
- A/D Converter
- Power Supplies

Integrated Circuit Multiplexer with 96-channel capacity
- Plug-in expandability in 8-channel increments
- Circuits packaged 16 channels/circuit card

High Input Impedance
- 100 megohms for selected channel
- 1000 megohms for unselected channels

High Performance—Total System to within 0.02%
- Linearity within 0.01% ± LSB
- Drift, 0.01% typical

High System Throughput Rates
- 51KC at 12 bits
- 28KC at 15 bits

High Performance Sample and Hold Amplifier
- Aperture time less than 50 nanoseconds
- Settling time (0.01%) less than 4.0 microseconds for full scale input

Temperature Stability within 10 ppm/°C
- Five proportional controlled ovens
- Reference Oven Stability — ±0.1°C

Built-in Systems Timing and Control
- Single pulse operation for timing
- Sample and Hold internally controlled
- All sub-system interconnections made internally

Four Standard Operating Modes
- Sequential
- Random Address
- Digitize Only
- Manual

System Isolation
- Transformer Coupling
- Isolated Transistor Junctions
- Reversed Biased Diodes

Low Cost—Approximately 30% less than conventional equipment

Technical representatives and company sales offices:

Alabama, Fact-Tronics, P.O. Box 1135, Huntsville, (205) 539-7193; Raytheon Computer, Holiday Office Center, Suite 47, Huntsville, (205) 881-2844; **Arizona,** Barnhill Assoc., 30 Pima Plaza, Office 20, Scottsdale, (602) 949-0132; **California,** Home & Western Regional Office, Raytheon Computer, 2700 South Fairview Street, Santa Ana, (714) 546-7160; Williams & Hedge, Inc., 4341 West Commonwealth, Fullerton, (714) 521-7410; Williams, Hedge & Martin, Inc., Suite 308, Fayette Townhouse, 2675 Fayette Drive, Mt. View; **Colorado,** Barnhill Assoc., 1170 So. Sheridan Blvd., Denver, (303) 934-5505; **Connecticut,** Eltron Engr. Sales, 2341 Whitney Avenue, Hamden, (203) AT 8-9276; **Florida,** Fact-Tronics, P.O. Box 3202, Orlando, (305) GA 3-7069; **Georgia,** Fact-Tronics, 254 East Paces Ferry Road, Atlanta, (205) WX-4000; **Illinois,** Pivan Engineering, 3535 West Peterson Avenue, Chicago, (312) KE 9-4838; **Indiana,** Pivan Engineering, 10447 North College Avenue, Indianapolis, (317) VI 6-5805; **Iowa,** Pivan Engineering, P.O. Box 1274, Cedar Rapids, (319) 365-6635; **Maryland,** L. G. White & Co., 880 Bonifant Street, Silver Spring, (301) JU 5-3141; **Massachusetts,** Eltron Engr. Sales, 246 Walnut Street, Newtonville, (617) DE 2-6975; Raytheon Company, Bedford Laboratory, P.O. Box 508, Bedford, (617) 274-7100; **Michigan,** WKM Associates, Inc., 1474 East Outer Drive, Detroit, (313) 892-2500; **Minnesota,** Pivan Engineering, 3203 North Highway 100, Minneapolis, (612) 537-5626; **New Jersey & Met. New York,** Kenneth E. Hughes Co., Inc., 2035 Lemoine Avenue, Fort Lee, (201) 944-1600; **New York,** DB Associates, Inc., 3307 Erie Boulevard East, DeWitt (Syracuse), (315) 446-0220; DB Associates, Inc., 22 Biscayne Drive, Lancaster, (716) TF 5-6186; **New Mexico,** Barnhill, Assoc., 319 A Wyoming, N.E., Albuquerque, (505) 265-7766; **North Carolina,** L. G. White & Co., P.O. Box 2356, Winston-Salem, (919) 725-3612; **Ohio,** WKM Associates, Inc., 6741 Ridge Road, Cleveland, (216) 885-5616; WKM Associates, Inc., 6085 Far Hills Avenue, Dayton, (513) 298-7203; **Pennsylvania,** L. G. White & Co., 100 N. Essex Avenue, Narberth, (215) MO 4-6505; WKM Associates, Inc., 90 Clairton Boulevard, Pittsburgh, (412) 892-2953; **Texas,** Carey-Wolf Co., 3327 Winthrop Avenue, Ft. Worth, (817) PE 8-1702; Carey-Wolf Co., 2510 Broad Street, Houston, (713) MI 3-2114; Raytheon Computer, 204 East Main, Arlington, (817) CR 5-5361; **Washington,** The Thorson Co., 1767 15th Avenue, So., Seattle, (206) EA 5-5000; **Washington, D.C.,** Eastern Regional Office, Raytheon Computer, 4217 Wheeler Avenue, Alexandria, Va., (703) 836-7616; **Wisconsin,** Pivan Engineering, P.O. Box 437, Waukesha, (414) 547-5131.

RAYTHEON COMPUTER, 2700 SOUTH FAIRVIEW STREET, SANTA ANA, CALIFORNIA 92704

RAYTHEON

A GENERAL ALGORITHM FOR FINDING THE ROOTS OF NUMBERS

John J. Sciarra*

An algorithm for finding the root of a number A can be developed from Newton's Method, which is discussed in all basic calculus texts. To illustrate the method, let us assume that it is desired to find the square root of a number A, and that x_1 is a first approximation to the root. Then a chosen approximation x_2 can be found by use of the relationship:

$$x_{n+1} = \frac{x_n + \frac{A}{x_n}}{2}$$

Repeated applications of this equation allows the root to be found to any desired accuracy.

For example, let A = 30 and x_1 = 5, then:

$$x_2 = \frac{5 + \frac{30}{5}}{2} = 5.5,$$

$$x_3 = \frac{5.5 + \frac{30}{5.5}}{2} = 5.4773, \text{ etc.}$$

Even if x_1 is not a good approximation to $\sqrt{A}$, note that x_n rapidly approaches $\sqrt{A}$; let A = 30 and x_1 = 1; then:

$$x_2 = \frac{1 + \frac{30}{1}}{2} = 15.5$$

$$x_3 = \frac{15.5 + \frac{30}{15.5}}{2} = 8.72$$

$$x_4 = \frac{8.72 + \frac{30}{8.72}}{2} = 6.08$$

$$x_5 = \frac{6.08 + \frac{30}{6.08}}{2} = 5.51$$

$$x_6 = \frac{5.51 + \frac{30}{5.51}}{2} = 5.47$$

To find *any* root of a number, note that if

$$x^m - A = 0 = f(x),$$

then x is the m^{th} root of "A". Newton's method states that if x_1 is a first approximation to a root of f(x), then a second approximation is given by $x_1 + \Delta x$, where:

$$\Delta x = -\frac{f(x_1)}{f'(x_1)}.$$

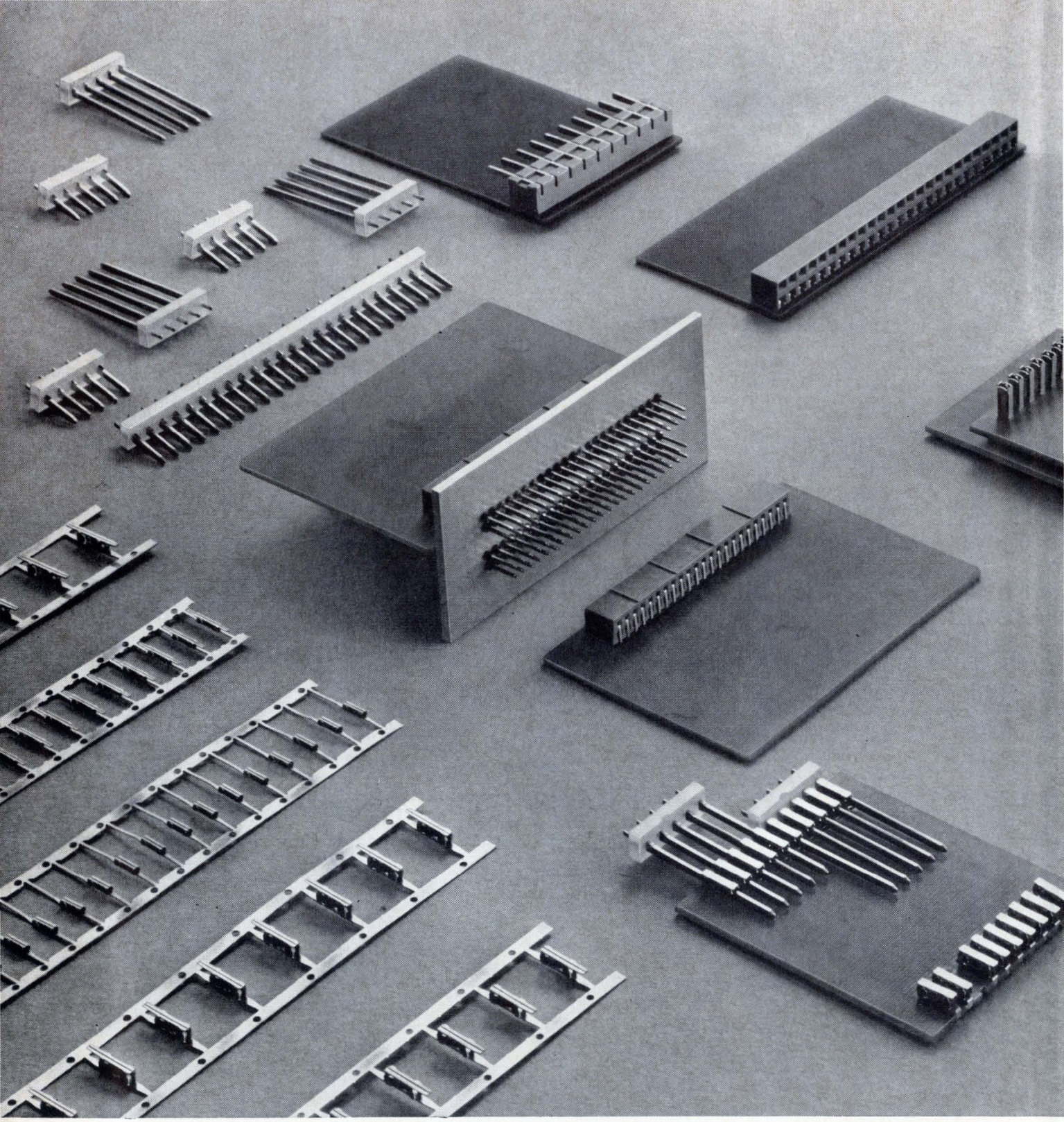
Therefore the iterative equation for finding the m^{th} root is:

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} = x_n - \frac{x^m{}_n - A}{m x_n{}^{m-1}} = x_n - \frac{x_n}{m} + \frac{A}{m x_n{}^{m-1}}$$

$$= \frac{(m-1)x_n + \frac{A}{x_n{}^{m-1}}}{m}$$

When m = 2, this reduces to the square root formula. **END**

*When this article was written, Mr. Sciarra was a computer engineer at the Steam Division of Westinghouse Electric Corp. He is now employed at the Vertol Division of Boeing Aircraft Co.



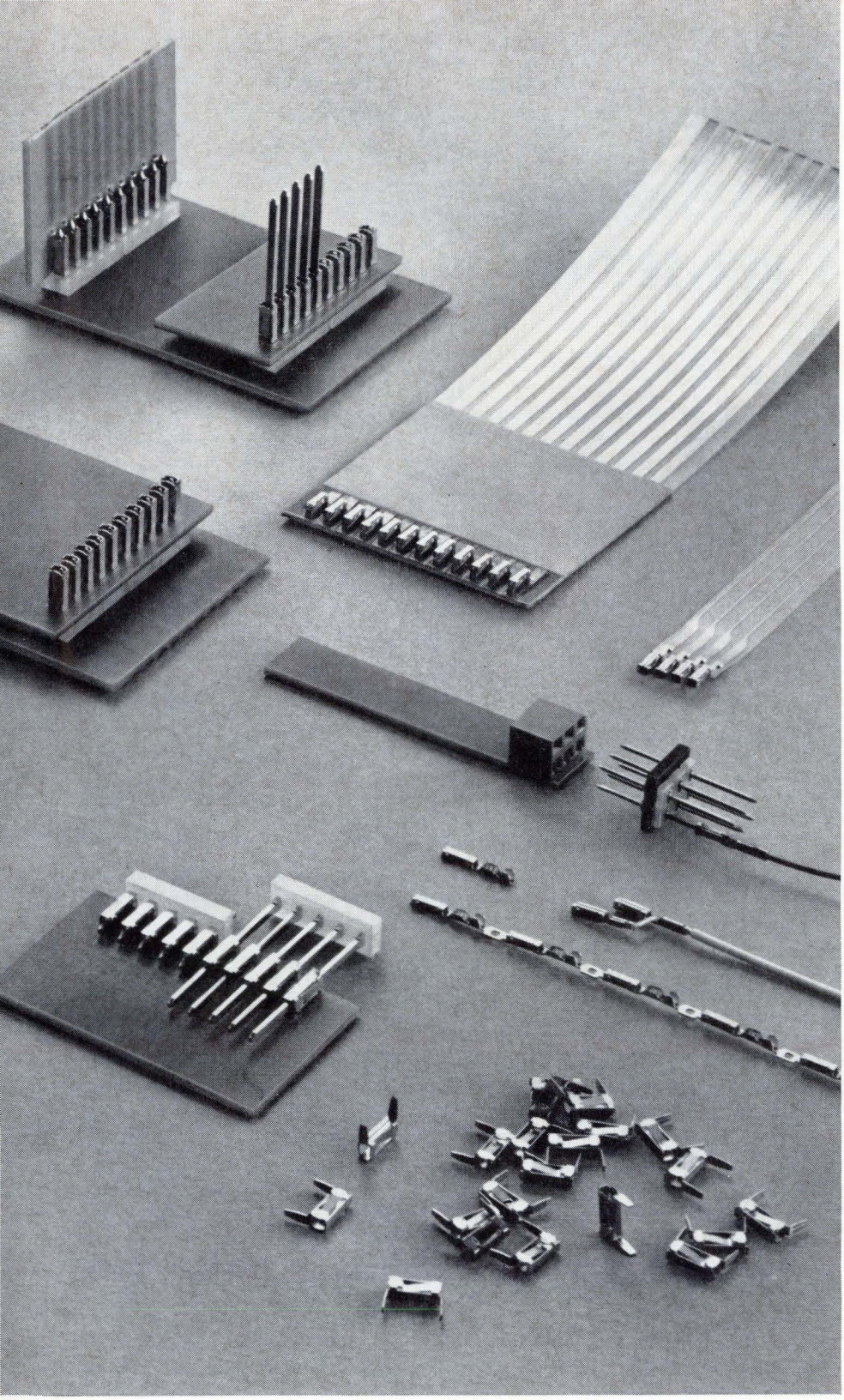
Go modular the easy way

This entirely new approach to modularization is the AMPMODU* Interconnection System. It permits almost unlimited design flexibility, high production speed, and economies resulting from automation and low per line cost.

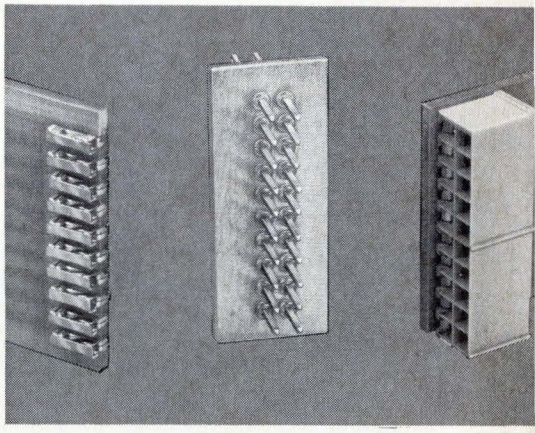
Specifically designed for modular applications using printed circuit boards, it enables mounting module cards at 90° to a mother board, stacking them, or putting them end to end. The female contacts may be staked directly to a printed circuit board or enclosed in molded housings. Male contacts may be staked directly to a printed circuit board, used in nylon incremental connectors, or mounted with nylon bushings in aluminum grid plates. Two sizes of contacts are available: the standard size, which uses .031 x .062″ posts for mounting on .156″ centers, and the miniature size, which uses .025 x .025″ posts for mounting as dense as .100″. Electrical and mechanical efficiency are enhanced by the simplicity of the female contact design, which includes dual cantilever-beam springs for redundant contact action and anti-overstress devices to ensure reliability. The long life of the phosphor bronze contacts is a result of AMP's special gold plating.

New modular ideas don't have to dead-end at the design stage. For information on how you might use the AMPMODU Interconnection System to modularize your product and lower your costs, write us today.

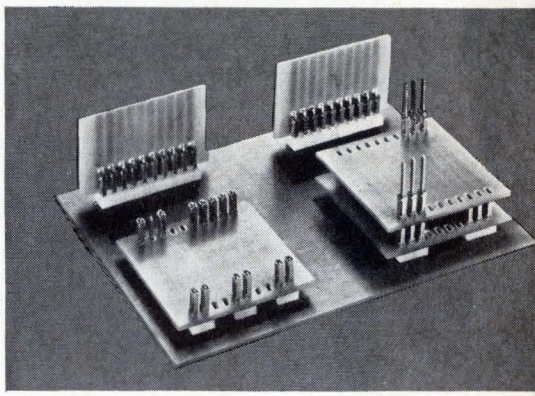
CIRCLE NO. 14 ON INQUIRY CARD



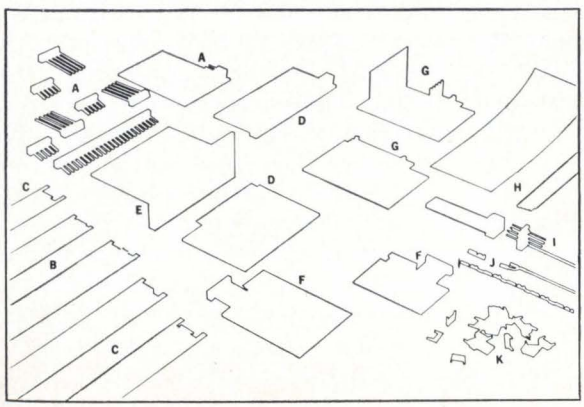
Automatic machines can stake contacts to printed circuit boards at rates of up to 1800 an hour



Miniature AMPMODU contacts may be mounted ten to the inch



The AMPMODU female contacts may be mounted in one of three ways for modular connection versatility



A. AMPMODU Male Incremental Connectors
B. Miniature AMPMODU Female Contacts in strip form
C. Standard AMPMODU Female Contacts in strip form
D. Miniature contacts in two-row housings
E. Grid Plate Header
F. Horizontally staked AMPMODU Contacts with incremental connectors
G. Vertically staked AMPMODU Contacts
H. Flexible tape cable AMPMODU Connectors
I. Molded-in AMPMODU Pin Header and printed circuit board connector
J. Miniature Crimp-Barrel AMPMODU Female Contacts
K. Individual Standard AMPMODU Female Contacts

AMP
INCORPORATED
Harrisburg, Pennsylvania

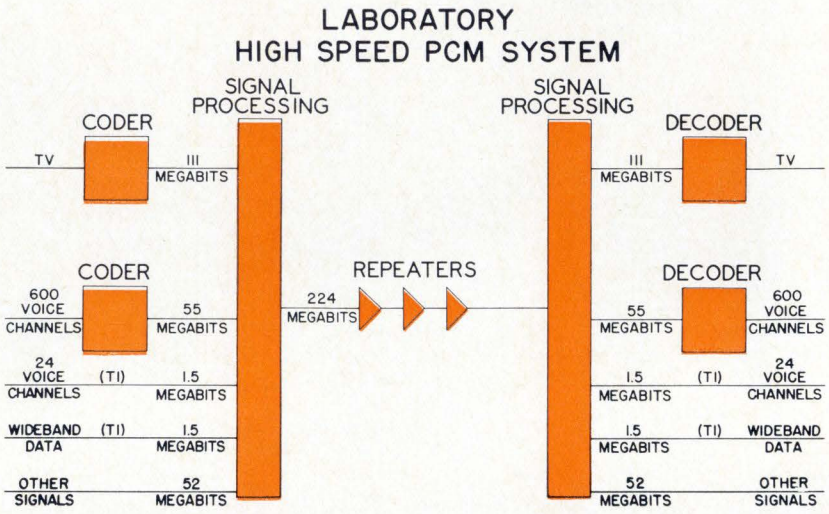
EXPERIMENTAL PCM SYSTEM TRANSMITS 224 MILLION BITS PER SECOND

An experimental pulse code modulation system that transmits 224 million bits per second over coaxial cable has been developed at Bell Telephone Laboratories. The system converts television, voice, and data signals into a stream of digital pulses capable of being transmitted over transcontinental distances. Signals can be taken from the digital stream and new signals can be added as desired along the route.

Designed to handle various combinations of signals, the experimental system can handle the transmission of 144 T1 signals, equivalent to 3456 voice channels. (T1 is the Bell System's commercial pulse code modulation system, which has a capacity of 24 voice channels on a 1.5 million-bit-per-second pulse stream.) Alternately, 36 T1 line signals, one television signal, and a "mastergroup" signal, comprising 600 frequency multiplexed voice channels, may be simultaneously transmitted on the 224-million-bit-per-second line.

The system's transmitting terminal includes:

- A television coder and auxiliary circuitry that convert samples of analog signal, taken at more than 12 million times per second, into a 111 million-bit-per-second pulse stream.
- A mastergroup coder and auxiliary circuitry that produce a 55 million-bit-per-second pulse stream.
- Multiplexing equipment for combining these signals with two T1 signals and the output of a random pulse generator (simulating high-speed data). The multiplexer also inserts control bits in the high-speed pulse stream. A novel solid-state encoder and a beam encoding vacuum tube are used interchangeably to code television and mastergroup signals. Both encode the signals to a nine-bit precision.



Block diagram illustrates Bell Telephone Laboratories' experimental high speed pulse code modulation system designed to transmit 224 million bits of information a second over coaxial cable. It can transmit simultaneously voice, television, and data. This diagram shows some of the combinations of these signals possible.

Pulse Stuffing

A new method of synchronization, called "pulse stuffing," is used to avoid the necessity of locking the bit rate of the lower speed signals to that of the high speed line. Furthermore, this technique makes it possible to drop and add information readily along the route. In this technique, pulses from each coder (or from lower speed digital lines) are written into a small digital store and then read out at a slightly faster rate, which is an exact submultiple of the line rate of the high speed system. Each time the store is about to be exhausted, an extra pulse having no information-carrying value is generated and "stuffed" into the stream transmitted on the line. This produces a pause in the read-out from the store and allows it to refill. Thus, input sources whose rates differ by small amounts are synchronized to the bit rate of the high speed line. At the receiving terminal, the pulses are demultiplexed and each signal is written into its receiving digital store and read out at the original rate which that signal had. This is possible because the transmitting terminal sends control signals to the receiver to inhibit the writing of stuffed pulses into the receiving store.

Pulses leaving the multiplexer are converted to a special three-level code called paired-selected ternary (PST). This code is chosen to facilitate timing in the reconstructive repeaters regularly spaced throughout the cable and to eliminate energy at dc, enabling transformer coupling of the repeater to the cable and allowing repeater powering at dc. The code also provides a means of monitoring the line pulse error rate. Three of these repeaters are included in the experimental system. These transistorized repeaters regenerate and retime the pulses after they have been spread out in time over some hundred time slots and attenuated to one-thousandth of the transmitted level during transmission over the cables. The system includes circuitry for simulating the

timing jitter introduced by 4000 miles of line.

The receiving terminal includes equipment for reducing the jitter to tolerable proportions. The jittered pulse train is written into a digital store and read out at a smoothed rate, controlled by an oscillator locked to the line rate. The receiving terminal also contains demultiplexing equipment and the decoders which reconstruct the original analog signals.

The performance of this experimental system indicates that even higher line rates are possible. The digital transmission techniques demonstrated in the experimental system appear ideally suited for application to waveguide or optical transmission media. **END**

VALUE ENGINEERING APPLIED TO HIGH-SPEED PAGE PRINTER

New chain printer is said to represent a radically new approach to the design of high-speed electronic printing. The new HSP 3502 printer requires only 200 different electrical and mechanical parts while competitive high speed printers are said to contain more than a thousand parts. According to the company, a revolutionary chain system and the use of integrated circuits make the new printer substantially lower in cost than competitive printers of equal performance. The new printer is capable of printing at speeds up to 600 lines per minute. Up to 192 different characters in up to 128 columns may be utilized. An exclusive automatic paper feed system is said to provide clear, sharp definition, precise vertical registration, and immediate visibility of the last line printed. Internal or external paper advance is automatic. The printer can be interfaced off-line with a magnetic tape transport for use as on off-line print station. Potter Instrument Co. Inc., Plainview, N. Y.

Circle No. 180 on Inquiry Card

AN EXPERIMENTAL 16-BIT MONOLITHIC MEMORY ARRAY CHIP

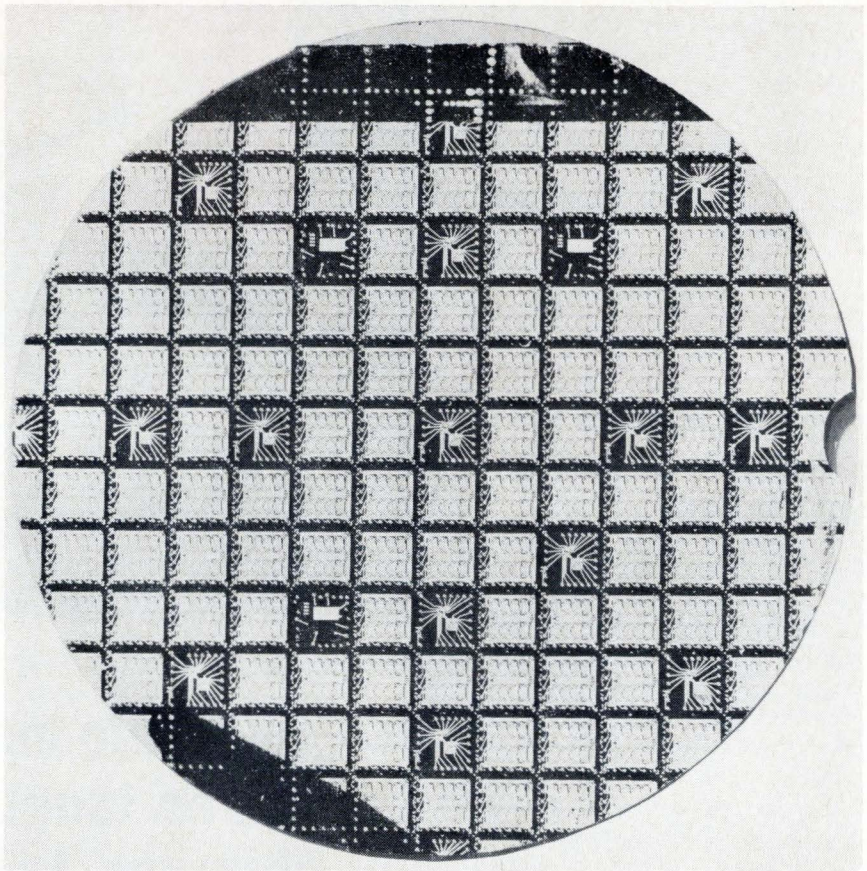
For use as a unit building block to structure an experimental three-dimensional, high-speed, scratch-pad memory, IBM Corp. has fabricated a 70 x 70 mil chip containing a 4 x 4 array of 16 storage cells. The complete array has 80 transistors, 64 resistors, and four clamp diodes. Planar NPN diffused structures with junction isolation were used throughout. The individual 14.5 x 12 mil monolithic cells are designed with aluminum interconnection patterns with P-type junction isolation.

The common resistor bed (N + epitaxially grown silicon) is tied to the most positive voltage (1.5v) to minimize parasitic junction capacitance and to insure a reversed biased condition for the boron diffused resistors. Isolation between devices is obtained by connecting the "P" isolation regions to ground — the most negative dc potential available. The transistors are each 10 x 10^{-6} square inches. Alignment tolerances are 0.0002 inches over the array.

Aluminum interconnections are 0.0003 inches wide and separated by a similar spacing. The circuits use a single-level, fixed-pattern interconnection scheme on thermally grown oxide. One underpass resistor on each cell is used for topological relief of the signal distribution system.

With these monolithic circuits, an integrated circuit memory can operate with the same logic levels and speed as the arithmetic and control sections of a computer. Driving and sense circuitry is built inherently into the integrated circuits.

Each of the 16 circuits contained in a single silicon chip contains a storage cell which performs the function of a ferrite core, an interrogation network which provides the read-write memory functions, and a selector network which directs the interrogation pulses.



Monolithic memory chips are fabricated on silicon wafers, eight-thousandths-of-an-inch thick. The spider-like designs interspersed throughout the wafer are test areas which enable IBM to test the chips for various electrical parameters while they are being fabricated.

A fast, economical batch processing technique was used in fabricating the circuits. The chips are made — 250 at a time — in a silicon wafer only an inch-and-a-quarter in diameter and eight mils thick. The surface of each monolithic chip is protected by a layer of glass, 60-millionths-of-an-inch thick. The glass is deposited by RF sputtering. Terminal contacts on the chip are provided by lead pads, 4.5 mils in diameter, around the perimeter of the chip. These pads allow chips to be turned over and contacted to a ceramic substrate for full compatibility with the IBM Solid Logic Technology circuits used in System/360.

Details of the memory chips were described at an IEEE Professional Group for Electronic Devices meeting in Washington, D.C. At this meeting, Dr. Benjamin Agusta presented a paper entitled "Sixteen-Bit Monolithic Memory Array Chip," co-authored by Dr. Paul Bardell and Paul P. Castrucci. **END**

Bell System Data-Phone service clears blizzards of bits for Standard Oil of Ohio

Bell System Dataspeed* data communications service at SOHIO'S Cleveland headquarters use regular telephone lines to transmit some 14,000 heating oil orders a day to 16 truck terminals in Ohio.

During the peak cold weather season, nearly one billion bits of data a month are interchanged between Cleveland and the terminals.

At the terminals, teletypewriter machines print out delivery tickets from the tape. The tickets give the drivers complete information, even telling them how to locate fill pipes.

After delivery, the exact amount of oil received by the customer is stamped on the tickets. A punched tape of the day's deliveries is made and this tape is fed into the terminal's Dataspeed unit. The data is automatically sent back to Cleveland, where computers process the information for billing and inventory control.

SOHIO installed its data system primarily to improve profit margins on heating oil sales. The system achieved this goal as it centralized operations, reduced paperwork, speeded cash flow and improved customer service.

Consider the advantages of Bell System Data-Phone* service for your data system. One of our Communications Consultants will be happy to go over them with you in detail. Just call your Bell Telephone Business Office and ask for his services.

*Service mark of the Bell System

Bell System
American Telephone & Telegraph and Associated Companies

CIRCLE NO. 16 ON INQUIRY CARD

LAMINAR BUS BAR ASSEMBLIES

For power distribution in digital systems — bus bars or wire harnesses? Here's one viewpoint favoring the bus bar approach.

Paul L. Anderson, Product Mgr.,
Rogers Corp., Rogers, Conn.

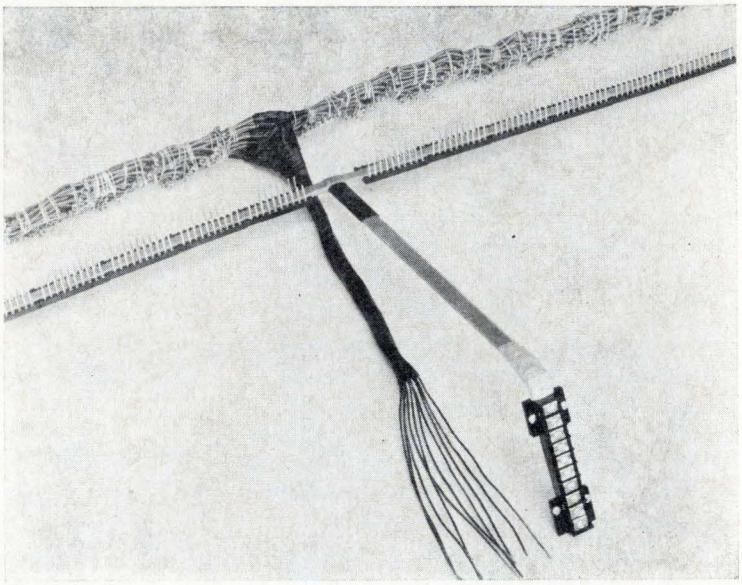


Fig. 1 Comparison of 10-layer bus assembly with equivalent wire harness.

Energy input and distribution and signal output can still be sources of problems even though the design of electronic equipment has advanced to such a sophisticated stage. To meet power distribution problems, more and more designers are looking toward the bus bar approach. The first bus bar assembly was designed in 1959 as part of a modular component system to reduce the size of computers. In the few years that have passed, the laminar bus has changed from an empirically-designed collection of conductors and insulators to a carefully engineered assembly.

Bus assemblies deserve consideration as a power distribution system in most cases where it is desirable to take off various voltage levels at different locations from a single distribution source. Major areas of application appear to be in EDP equipment and its peripheral units, and in communications systems (also rapidly becoming computer-oriented).

Bus bars offer many obvious advantages over spaghetti circuits. Physically, they require less space, they are more easily installed, they simplify trouble-shooting, and they are lightweight. Of prime importance, however, is the fact that the bus bar can be engineered to provide electrical characteristics, such as low

TABLE I

ELECTRICAL CHARACTERISTICS OF BUS BAR INSULATION

Material	Avg. Thickness	Avg. Cap.*	Vol. Res.**	Dielectric Str.***
Duroid 8111	.0005″	1610	1×10^{18}	1000
Duroid 8121	.00125″	1340	4×10^{14}	4000
Duroid 8111	.00075″	1000	1×10^{18}	1000
Duroid 8122	.00225″	800	4×10^{14}	4000
Duroid 8111	.00125″	580	1×10^{18}	1000
Duroid 8111	.00225″	311	1×10^{18}	1000
Duroid 2370	.005″	210	3×10^{14}	1000
Duroid 2380	.007″	141	3×10^{14}	1000

*Pico Farads per square inch at one megacycle

**Ohm-cm. per ASTM D-257-58 at 25°C.

***Volts per mil.

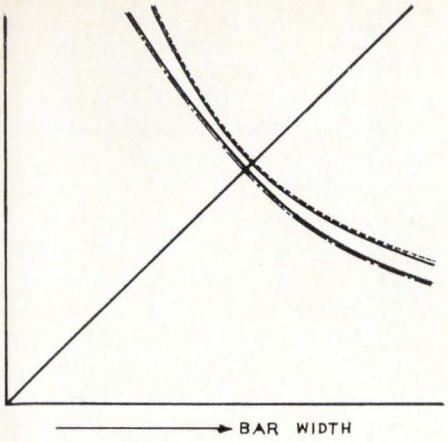


Fig. 2 Variations in electrical characteristics with change in bus bar width.

inductance, low characteristic impedance, and high capacitance. While there is no "typical" laminar bus, since each should be designed to meet its particular need, certain basic principles have evolved.

Because the normally-used power supplies cannot filter out high frequency voltage variations, the power distribution system is designed for highest capacitance, in order to achieve a minimum AC ripple. This is accomplished by careful selection of the electrical insulation employed, with particular emphasis on the dielectric constant, the thickness, and the dielectric strength.

To eliminate cross-talk, and thus increase sensitivity and reduce power requirements, the bus is engineered for high capacitance and low inductance. This is accomplished through the use of flat conductors assembled so that a ground plane is provided on either side of the voltage conductor. This construction provides a low impedance path to ground for induced AC currents and thus assures a minimum amount of electrical noise throughout the system.

By designing the bus assembly for an extremely low characteristic impedance, the power requirements are reduced Standing waves are eliminated and maximum power is made available.

An examination of an actual laminar bus assembly presently in use for computer applications will

serve to illustrate the points made. A 10-layer assembly is shown in Fig. 1. This bus is intended to provide electrical power at various voltage levels for interconnection to the intermediate connector blocks and from there to printed circuit card assemblies. The conductor layers are bars of half-hard ETP grade copper, from 0.010 inches to 0.100 inches thick by 0.500 inches to 2.000 inches wide, depending upon the current carrying requirement, which ranged from 30 amps to 100 amps per voltage layer. From five to twelve bars are laminated together with 0.005 inches thick Duroid 2370, a thin, high dielectric strength film insulation.

The edges of the insulation overhang the assembly and, during the curing operation, are molded together, providing a tight, moisture resistant seal. The copper bars are punched with tabs which protrude through the insulation for interconnection to the pin-blocks by soldering.

It is obvious, of course, that in addition to the electronic principles involved, a certain amount of manufacturing know-how is essential. Selection of the proper conductor and insulation material is of prime importance. The thickness and electrical characteristics of the insulation must be carefully maintained to provide a known capacitance between the voltage layers.

Table I shows some of the electrical properties of commonly-used bus bar insulation in typical thicknesses. The graph in Fig. 2 shows the effect on capacitance, inductance, and characteristic impedance when the width of the assembly is changed (curves are derived from standard formulas and are approximately correct for cases involving low impedance).

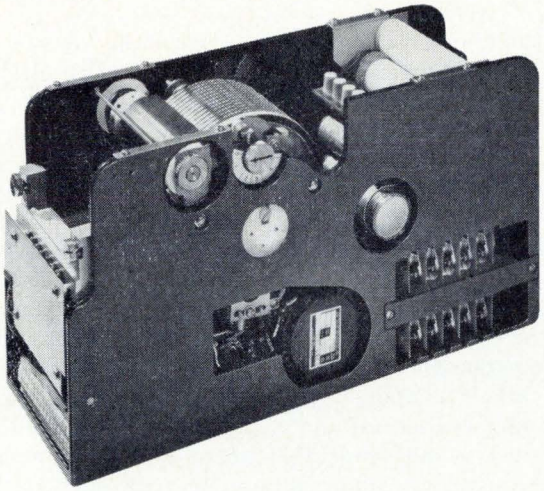
Laminar bus assemblies have entered the second generation and are now a highly reliable component. New designs incorporate still higher capacitance and greater reliability for high speed relay switching. The engineer should give consideration to the use of this type of assembly. Design assistance as well as specialized manufacturing capability can be obtained from the major producers of bus bars.

Circle No. 102 on Inquiry Card

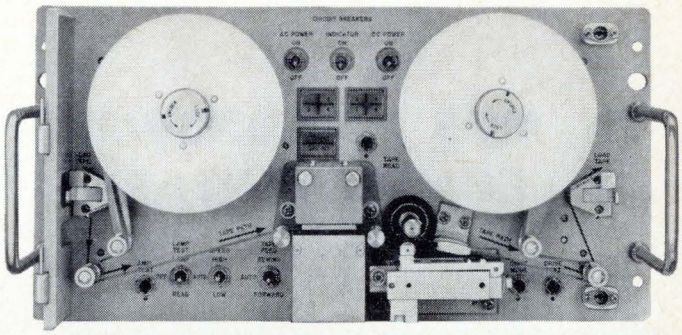
NOW—One Source

for Militarized Printers and Perforated Tape Readers

Potter Instrument Company



HSP-3604 High Speed Printer



PT-5000 Perforated Tape Reader

MINIATURIZED, LIGHTWEIGHT, RELIABLE, AND MAINTAINABLE
For Telemetry, Ground Support, Automatic Testing, Computer Readout on airborne, shipboard or ground systems

Potter's all-new HSP-3604 high-speed serial printer operates at an average print speed of 25 ch/sec. It has a self-contained paper supply, take-up spool and solid-state silicon electronics.

The drum is easily replaced for format interchangeability. The unit, only 5.4 W. x 15.8 D. x 8.8 H. provides three copy printout.

It uses Potter's unique patented double hammers in a system that reduces parts and makes for easy maintenance and speedy repair. It also features immediate visibility of the last printed line.

Potter's all-new PT-5000 perforated tape reader operates at dual speed, 250 or 500 characters per second. Its subassemblies are completely adjustment-free and include a network of built-in diagnostic test exercises and indicators.

Designed with standard hardware, the tape reader can be completely dismantled and assembled with only a screwdriver by operator personnel.

Measuring 18 W. x 8 D. x 9 H. this compact unit weighs 45 pounds and features modular construction throughout.

Both these high reliability units have a mean-time-between-failure in excess of 2,500 hours. They can be repaired in less than 15 minutes by operator personnel. Complete support documentation is available. Both printer and tape reader satisfy the specifications of MIL-T-21200, MIL-E-16400, MIL-Q-9858, MIL-I-16910 and MIL-I-6181. They operate within a temperature range of −25°F to +135°F.

PI 109

Contact Military Products Manager or fill in the coupon for full details.

Send details on perf tape readers and printers

Name_____

Company_____

Address_____

City_____ State_____

POTTER
INSTRUMENT CO., INC.

151 Sunnyside Boulevard • Plainview, N.Y. 11803
(516) CH 9-0790 • TWX (510) 221-1852 • Cable-PICO

CIRCLE NO. 19 ON INQUIRY CARD

MOS MICROPOWER COMPLEMENTARY TRANSISTOR LOGIC

Metal-oxide-semiconductor transistors show excellent promise for use in aerospace and portable digital equipment where low power consumption is a dominant requirement. Here is a description of the basic MOS device and a detailed discussion of MOS complementary logic arrangements.

M. M. MITCHELL and R. W. AHRONS,
RCA Electronic Components and Devices, Somerville, N.J.

In most computer module design, operating speed is emphasized far more than power consumption. However, there are many applications, particularly in aerospace and portable, battery-operated digital computing or communication equipment, in which the clock or operating rates are the order of several megacycles or less, and low power dissipation is paramount. These applications appear to be ideally suited to complementary transistor logic using metal-oxide-semiconductor (MOS)[1,2] transistors.

An additional factor becomes relevant in low-power digital systems: only a small fraction of the digital elements are operating during any given time period. It can be estimated that the average digital element in a digital system has a duty factor of between 0.1 and 10 per cent. Thus, it is evident that very-low-power operation of digital systems requires a basic element which dissipates very little in the quiescent state representing a 0 or a 1. A magnetic core operating in a memory is a good example of an element that does not dissipate at all in the quiescent 1 or 0 state, but only during each switching transient.

This article considers power dissipation as the sum of both quiescent-power and transient-power dissipation. The former is independent of operating rate, whereas the latter increases with operating rate, with the increasing capacitance of the logic element, and with the increasing voltage difference between the 1 and 0 logic levels. This transient power usually results from the charging and discharging of reactive components. In conventional bipolar transistor circuits, most of the power dissipated is quiescent power, which predominates because a resistance is used as the load for the bipolar transistor. The use of a complementary arrangement in which the load resistor is replaced by a transistor of opposite polarity results in appreciably lower quiescent-power dissipations. One other factor in quiescent dissipation is the dc input impedance, which is resistive in the bipolar case and capacitive (resistance more than 10^{14} ohms) in the MOS case.

In essence, then, minimum total power dissipation is obtained when both the quiescent and transient powers are considered. As a result, the general approach is to minimize the logic level swings, use true complementary loads, and minimize leakage currents as well as all output and load capacitances.

The MOS Device

As shown in Fig. 1, the MOS is a device comprising source and drain diffusions, such as n^+ into p-type material. The p-type material is called the substrate, and the region between the source and drain diffusion is called the channel. An insulator (usually thermally-grown SiO_2) is placed above the channel, and its metallic contact, called the gate, is placed on the oxide directly above the channel. When the gate is positively charged, a negative charge is induced in the channel at the interface between the silicon dioxide and silicon. This negative charge allows for conduction between the source and drain. The induced channel at the interface pene-

trates only in the order of 10 to 100 angstroms into the silicon. Thus, the device is a voltage-controlled switch with a capacitive input. The voltage present at the gate at which the device turns ON is called the threshold voltage, V_T.

The device shown in Fig. 1 is an n-channel MOS. The complementary structure, p^+ diffused into n-type material, is also available. Its operation is analogous to that of the n-channel unit. A negative voltage on the gate induces, in the channel, positively-charged holes which flow when a negative voltage is applied from drain to source. Fig. 2 shows the transfer characteristics of typical n-channel and p-channel units. The transfer characteristics shown are those obtained with the units operating in the high-impedance region.

The drain current, I_D, as a function of drain voltage and gate voltage, is described completely by the three regions of operation: 1) low-impedance ON; 2) high-impedance ON; and 3) high-impedance OFF. These conditions are shown respectively as equations (1a), (1b), and (1c) for the n-channel unit:

$$I_D = 2K_n \left[V_D(V_G - V_{TN}) - \frac{V_D^2}{2} \right] + I_L; \quad V_D < V_G - V_{TN} \tag{1a}$$

$$I_D = K_n [V_G - V_{TN}]^2 + I_L; \quad V_D \geq V_G - V_{TN} \tag{1b}$$

$$I_D = I_L; \; V_G \leq V_{TN} \tag{1c}$$

where

$$K_n = \frac{\mu_n \varepsilon W}{2 l t_{ox}} \tag{2}$$

and where V_{TN} = threshold voltage, V_D = drain voltage, V_G = gate voltage, μ_n = effective surface mobility for electrons (less than bulk mobility), ε = dielectric constant of the insulation, t_{ox} = thickness of the insulator, W = width (periphery) of the channel, l = length of the channel between source and drain, and I_L = leakage current.

The equations for the p-channel MOS are analogous to those of the n-unit except that the effective surface mobility of holes is considered. The threshold voltage for an enhancement unit is given by:

$$V_T = \frac{t_{ox} P}{\varepsilon} \tag{3}$$

where P is the initial density of surface charge from the bulk material plus that contributed by surface states.

For switching, it is important to know the input capacitance, as represented to the first order by the capacitance of the oxide, C_g, which is given by:

$$C_g = \frac{\varepsilon W l}{t_{ox}} \tag{4}$$

Added to this value is the capacitance of the gate metalization which is not over the channel, as well as the case and stray-wiring capacitance. For present MOS transistors, t_{ox} is in the order of 500 to 2500 angstroms and l is in the order of 0.1 to 1.0 mil. When l is decreased, the input capacitance is decreased and the current capability is increased; however, the drain-to-source breakdown voltage is decreased.

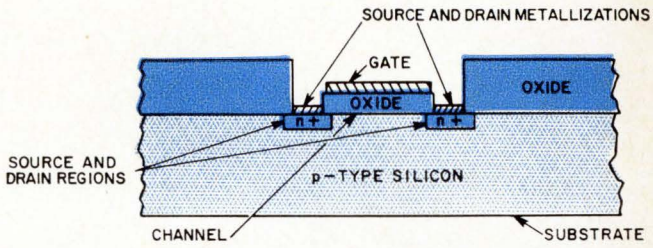


Fig. 1 Cross-section of n-channel MOS transistor.

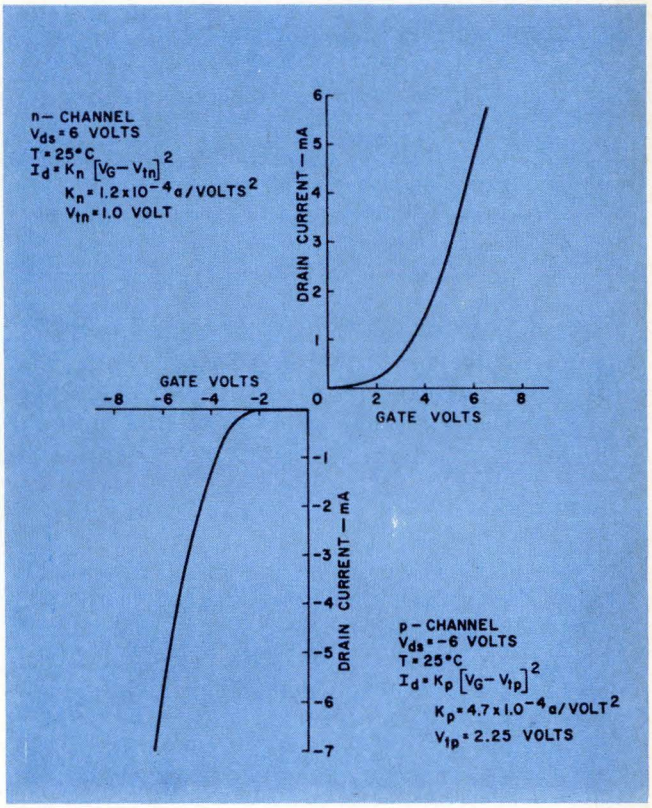


Fig. 2 Transfer characteristics of n-channel and p-channel MOS devices.

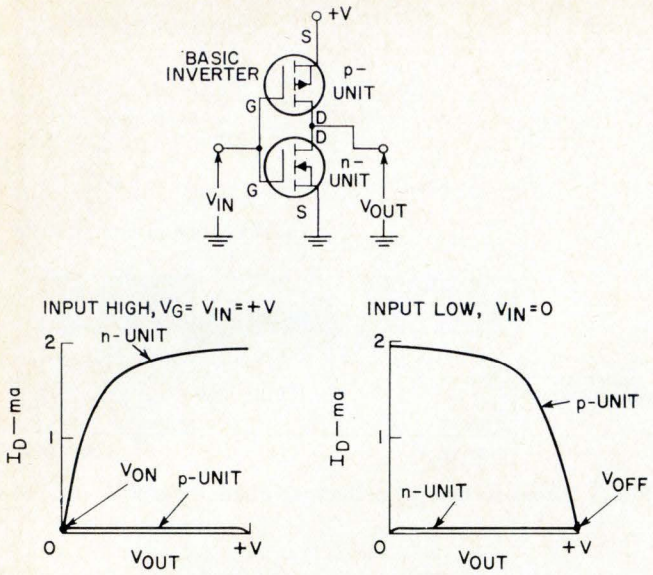


Fig. 3 Basic MOS inverter.

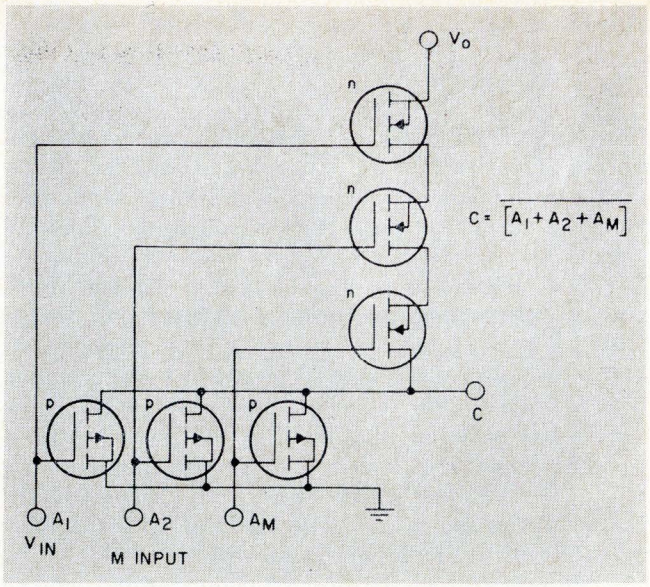


Fig. 4 M input NOR gate.

MOS Complementary Logic Circuits

Many discussions on MOS switching circuits have appeared in the literature. However, the best application of MOS transistors to micropower logic circuits lies in the MOS complementary logic arrangement[3,4]. This arrangement uses n-channel and p-channel enhancement units. The basic inverter circuit is shown in Fig. 3. The logical voltage swing is from 0 to the supply voltage, V. Upon application of +V (logical 1) at the input, the n-unit is turned ON and the p-unit is turned OFF; the output is in the low state (logical 0). This state is illustrated in Fig. 3 (curve on the left) by the intersection of the characteristics of the two units. Upon the application of 0 voltage (logical 0) at the input, the p-unit is turned ON and the n-unit is turned OFF. The resulting output is +V volts (logical 1), as shown in Fig. 3 (curve on the right).

Because in either state one unit is OFF while the other is ON, the quiescent power is only that of the supply voltage multiplied by the leakage current of the OFF unit. The transient power, as will be shown later, is that resulting from the charging of input and output capacitances.

The inverter may be extended to true complementary logic. The remainder of this article discusses negative logic (i.e., negative supply voltage with the n-channel units connected to the supply voltage node). In the logical NOR gate shown in Fig. 4, the p-units are in parallel and the n-units in series. Reversing the arrangement (i.e., the n-units in parallel and the p-units in series) produces a NAND gate, as shown in Fig. 5. Fig. 6 shows the last of the basic set of logic elements, the MOS set-reset flip-flop, which is formed by the cross-coupling of two NOR gates. This MOS complementary logic has the following advantages.[3,6,8,9]

- Microwatt standby power
- Simple one-supply, direct-coupled logic using only MOS transistors
- Large fan-out capability because of capacitive inputs
- Good noise immunity because of large threshold voltages
- Stable operation because of true complementary structure
- High-speed operation because output node capacitance is always charging and discharging through the ON unit(s)

TABLE I

FOUR-INPUT LOGIC AVAILABLE FROM MOS ARRANGEMENT WITH CHANGES IN METALLIZATION

$\bar{A} + \bar{B} + \bar{C} + \bar{D}$	NAND
$\bar{A}\,\bar{B}\,\bar{C}\,\bar{D}$	NOR
$(\bar{A} + \bar{B})(\bar{C} + \bar{D})$	(Exclusive OR when $C = \bar{A}$ and $D = \bar{B}$)
$(\bar{A} + \bar{B})\,\bar{C} + \bar{D}$	
$(\bar{A} + \bar{B} + \bar{C})\,\bar{D}$	
$\bar{A}\bar{B} + \bar{C}\bar{D}$	
$(\bar{A}\bar{B} + \bar{C})\,\bar{D}$	
$\bar{A}\bar{B} + \bar{C} + \bar{D}$	
$\bar{A}\bar{B}\bar{C} + \bar{D}$	
$(\bar{A} + \bar{B})\,\bar{C}\bar{D}$	

The MOS complementary logic is very versatile. For example, the ten different four-input functions listed in Table I can be constructed by simple interconnection changes on a gate of quad n-units and quad p-units. Fig. 7 shows formations of the gate for the function $(\bar{A} + \bar{B})\ (\bar{C} + \bar{D})$, which is the exclusive-OR function when $C = \bar{A}$ and $D = \bar{B}$. Examples of more complex functions, such as half adders, half-shift registers, and full adders can be found in reference 5. In true complementary logic, the circuit formed by the p-units is the dual network function of the n-unit circuit. The

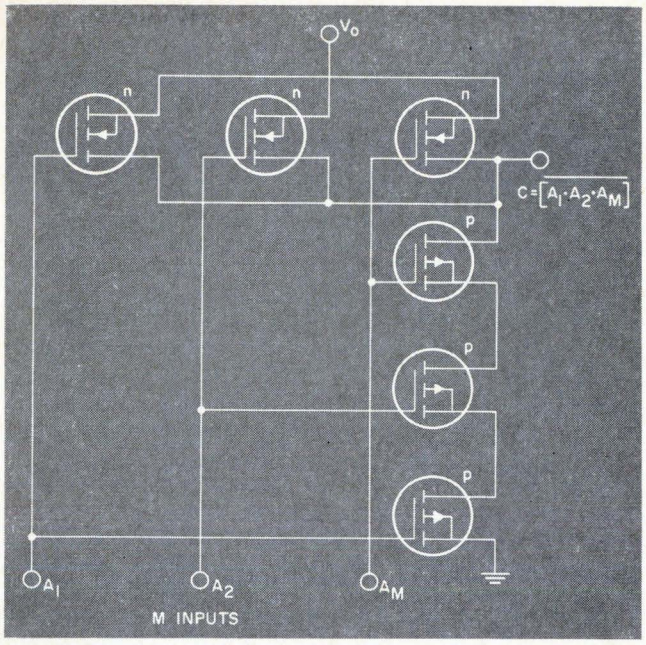
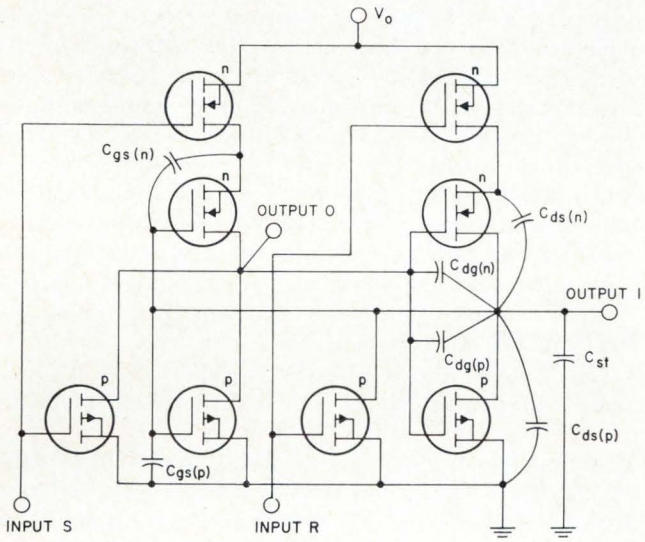


Fig. 5 M input NAND gate.



$$P = 2C_o V_o^2 f + P_s$$

$$C_o = 2C_{ds(p)} + 4[C_{dg(n)} + C_{dg(p)}] + C_{gs(p)} + C_{gs(n)} + C_{st}$$

Fig. 6 Set-reset flip-flop, showing pertinent device capacitances.

set of n- and p-type units are put in a series to form the complementary gate.

Power Dissipation

The total power P dissipated in a complementary MOS set-reset flip-flop circuit such as that shown in Fig. 6 is given by

$$P = 2C_o V_o^2 f + P_s \qquad (5)$$

where C_o is the node capacitance, V_o is the supply voltage, f is the operating frequency, and P_s is the standby power. The term $(2C_o V_o^2 f)$ represents the switching or transient power. For low switching power, the supply voltage V_o must be reduced to the lowest possible value. The gate threshold voltages for the p-channel units

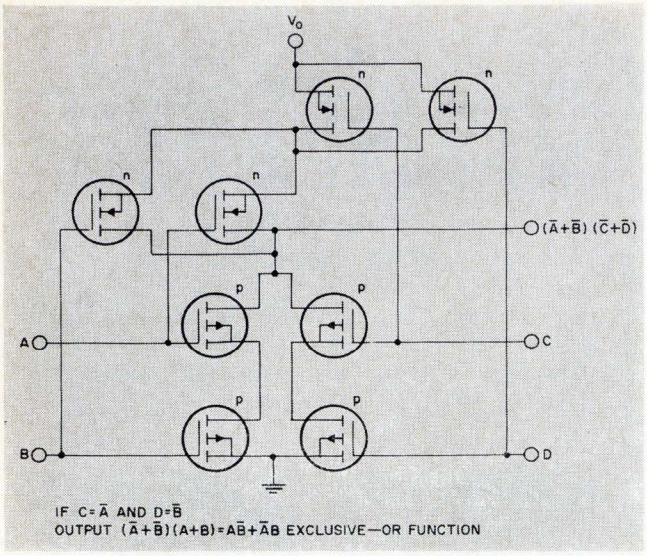


Fig. 7 The complementary $(\overline{A}+\overline{B})$ $(\overline{C}+\overline{D})$ gate.

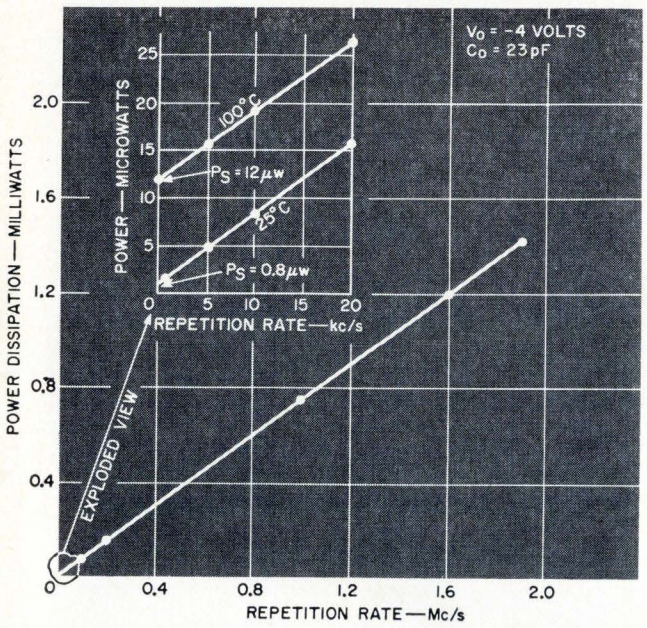


Fig. 8 Power dissipation as a function of repetition rate for the set-reset flip-flop of Fig. 6. (All data was taken using RCA's developmental semi-integrated MOS transistor circuits.)

(V_{TP}) are inherently larger than the gate threshold voltages for the n-channel units (V_{TN}) and, therefore, determine the minimum limit for the supply voltage. From practical considerations, the supply voltage must be appreciably above V_{TN} to preserve circuit stability and speed capability. As was shown in Fig. 2, typical values for V_{TN} and V_{TP} are 1.0 volt and 2.0 volts, respectively. The internal node capacitance C_o for the flip-flop is given by

$$C_o = 2C_{ds(p)} + 4\,[C_{dg(n)} + C_{dg(p)}] + C_{gs(p)} + C_{gs(n)} + C_{st} \qquad (6)$$

See Fig. 6 for definition of terms.

In Eq. 6, only the third and fourth terms ($C_{gs(p)} + C_{gs(n)}$) are considered active capacitances in that they are the precise terms which modulate the

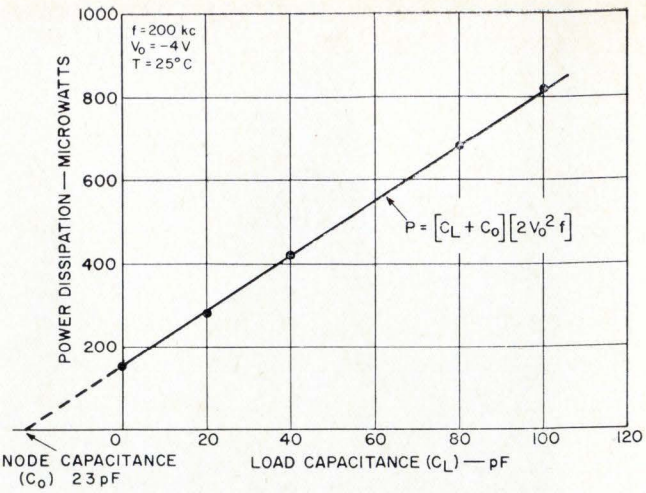


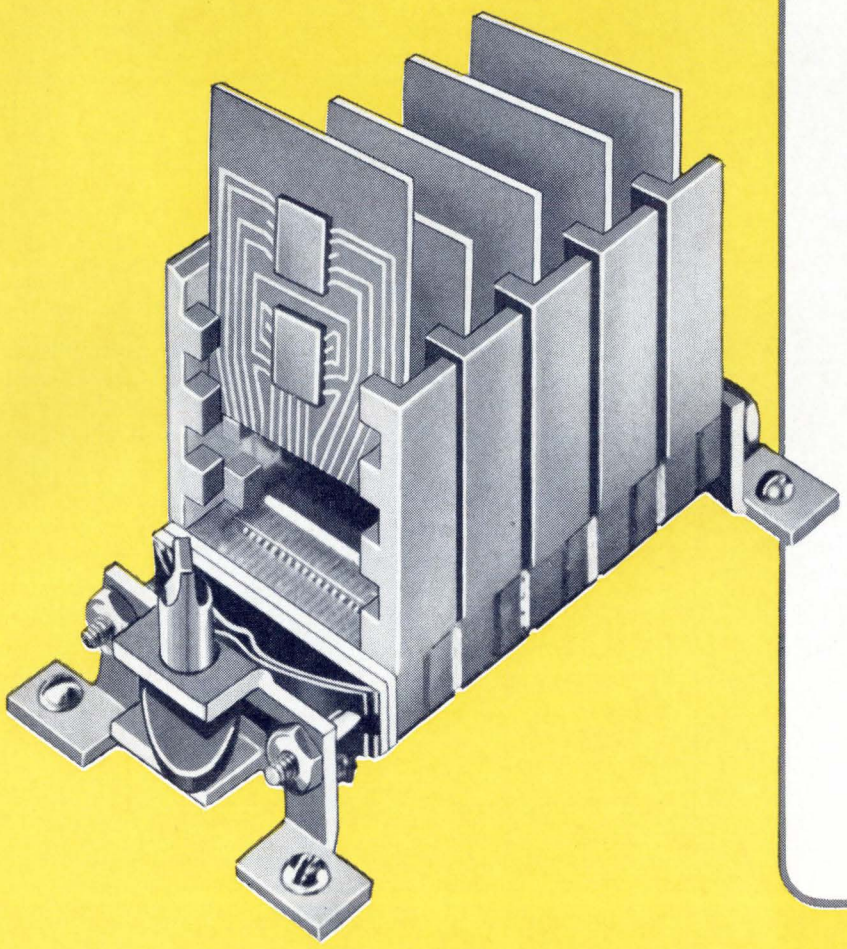
Fig. 9 Power dissipation as a function of repetition rate for set-reset flip-flop of Fig. 6.

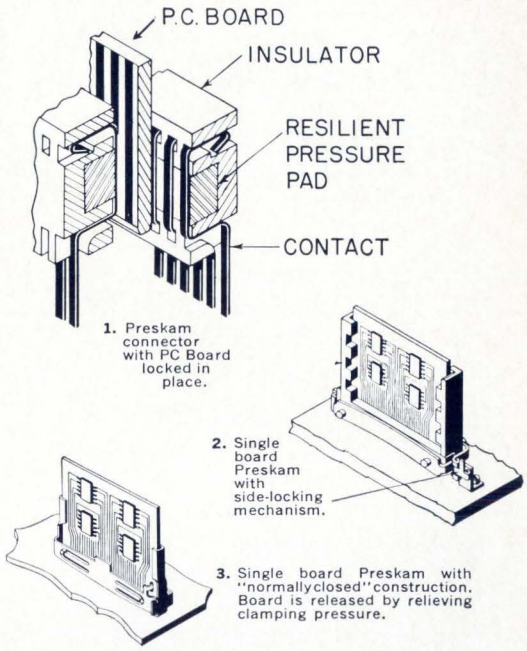
channel conductance to cause the MOS action. The remaining terms all contribute to reducing speed and increasing power dissipation, and as such they should be minimized. This minimization of inactive capacitances requires a device design in which the source and drain regions have a large periphery-to-area ratio and, in addition, one in which the gate-to-drain metalization overlap capacitance is minimized. For a semi-integrated flip-flop circuit (i.e., separate n-type and p-type chips each in its own package), inactive capacitance presently constitutes 30 to 50 per cent of the internal node capacitance. Continued optimization of geometries, packaging improvement, and the integration of more complex functions to reduce wiring capacity should result in a further decrease of switching dissipation and/or an increase in fan-out capability.

Fig. 8 shows the total power dissipation of the unloaded flip-flop circuit of Fig. 6 as a function of frequency (repetition rate). Fig. 9 shows power dissipation as a function of capacitive load C_L (representing fan-out) at a fixed frequency of 200 kc/s and a supply voltage of −4 volts. As expected from Eq. (5), the data indicates a linear relationship with each of the independent variables C_L and f. The value of the standby power (which is given by the zero-frequency intercept of Fig. 8) is about 0.8 microwatt at 25C and 12 microwatts at 100C. The standby power is proportional to the drain-to-source leakage current, which tends to be higher for n-channel units. However, the instability of the threshold voltage of the n-type unit, which previously resulted in large leakage currents at high temperatures over extended operating periods, has been essentially corrected by modifications of the oxide over the channel.

The instability of the n-channel MOS transistor, the primary cause of increased standby power dissipation over the extended operating periods, is explained in Fig. 10, which shows the two dominant drift mechanisms.[10] First, under extended positive-gate-voltage operation at elevated temperatures, the threshold voltage is reduced; for particularly unstable devices, threshold voltage can actually become negative (i.e., the unit operates in the depletion mode). This effect is shown as curve (2) in Fig. 10. The mechanism for this shift is a bulk-charge-migration effect in the insulating gate oxide. Altering the physical properties of the oxide prevents this migra-

Cinch capabilities in micro-electronic interconnection can solve your packaging problems





Ask Cinch about the new Preskam* System that permits connections that don't dwarf the circuits they join.

Either a board or male connector is dropped into place and then a cam actuated insulating bar clamps the board into the connector. High uniform contact pressure is maintained over an up to 70% greater contact area than in conventional connection means.

Contacts are on 25-mil centers and boards can be as little as 100-mils apart. Multiple boards may be controlled by the same locking device.

With contact disengagement before board insertion or withdrawal, the most fragile thin glass or ceramic substrate is undamaged even from repetitive insertions.

RELATE YOUR PRODUCT PLANNING TO THE STATE-OF-THE-ART INTERCONNECTION SYSTEMS WHICH ARE AVAILABLE FROM THE CINCH RESEARCH AND DEVELOPMENT PROGRAM. ASK CINCH FIRST: THEY MAY HAVE ALREADY SOLVED YOUR INTERCONNECTION PROBLEM.

Write Cinch Manufacturing Company, at 1026 South Homan Avenue, Chicago, Illinois 60624.

CM-6505

*Patent Pending

CINCH

DIVISION OF UNITED-CARR

CIRCLE NO. 21 ON INQUIRY CARD

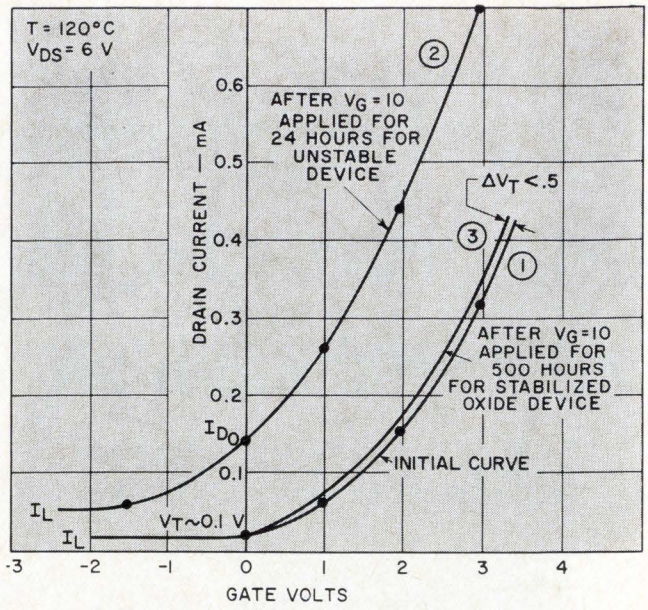


Fig. 10 Transfer curve showing shift of threshold voltage for n-channel unit.

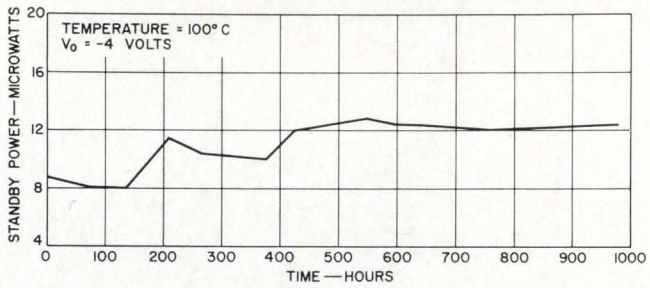


Fig. 11 Standby power as a function of time for flip-flop type circuits.

tion.[10] Curve (3) in Fig. 10 shows typical results on modified gate oxides. A second effect of lesser, but still significant, importance is an increase in the drain-to-source leakage current (I_L) that is not gate-controlled. This current arises from the formation of a parallel channel outside of the control of the gate voltage. Its effect is also increased by positive gate voltage at elevated temperatures. The formation of this shunt channel can also be prevented by suitable alteration of the oxide properties. Fig. 11 presents life-test data on complete circuits of the flip-flop type, which shows increases in standby power resulting from both mechanisms of the order of 3 microwatts after 1000 hours of operation at 100C.

Switching-Speed Response

A measure of the switching speed for iterative logic networks is the circuit-pair delay. By means of a computer analysis, performed by J. R. Burns, on an n-stage cascaded network of inverters[7], an expression was derived for the output voltage versus time response of the n^{th} stage as a function of the threshold voltages and of the gain factor K for both n- and p-channel devices. From this result the following analytical expression for pair-delay T_d was obtained:

$$T_d \cong \frac{0.9C_o}{V_o}\left[\frac{1}{K_n(1-\alpha_n)^2} + \frac{1}{K_p(1-\alpha_p)^2}\right] \quad (7)$$

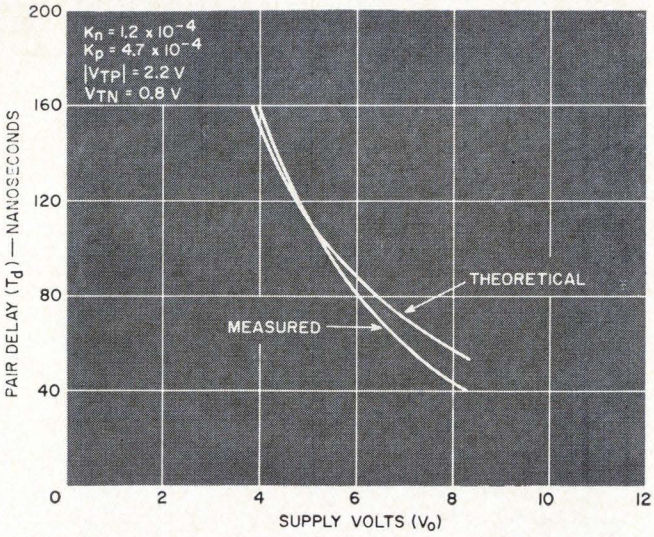
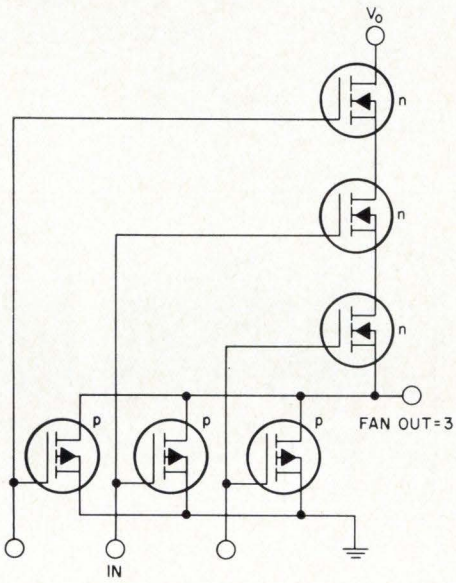


Fig. 12 Pair-delay as a function of supply voltage for circuit of Fig. 6.

TABLE II

OPTIMUM THREE-INPUT NOR GATE DESIGN



V_o (volts)	Kp_{eff} (a/volt^2)	Relative Periphery of n-unit to p-unit	C_o* (pF)	T_d (nsec)	Power at 1 mc/s (mW)
−4.0	4.8×10^{-4}	7.5	70	213	1.12
−5.0	4.8×10^{-4}	8.6	70	125	1.75
−6.0	4.8×10^{-4}	9.2	70	87	2.52

*Includes a fanout of three; equivalent to a load capacitance of 45 pF.

with the following limits: $\alpha_n + \alpha_p < 1.0$;

$$\frac{K_p}{K_n} \geq 0.2$$

where $$\alpha_n = \frac{V_{TN}}{V_o}, \quad \alpha_p = \frac{|V_{TP}|}{V_o},$$

$$K_n = \frac{\mu_n W_n \varepsilon}{2 l_n t_{ox}}, \quad K_p = \frac{\mu_p W_p \varepsilon}{2 l_p t_{ox}}$$

and where C_o = node capacitance and V_o = supply voltage.

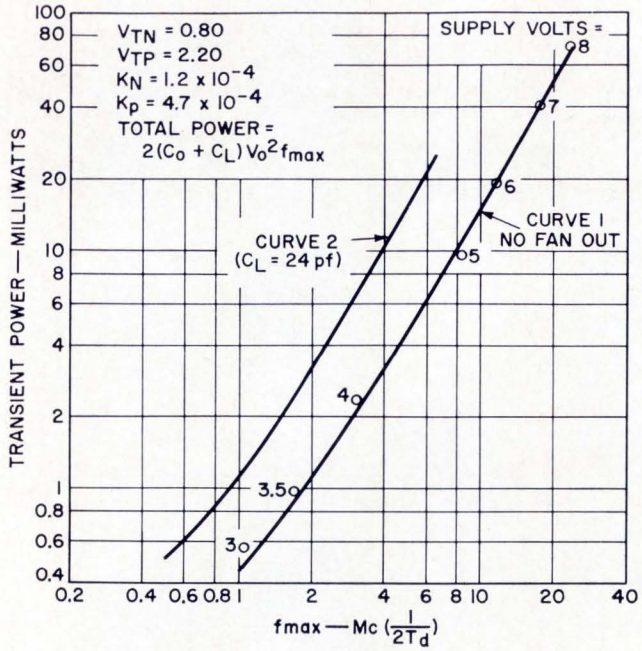


Fig. 13 Transient power at f_{max} as a function of $f_{max} = 1/2T_d$.

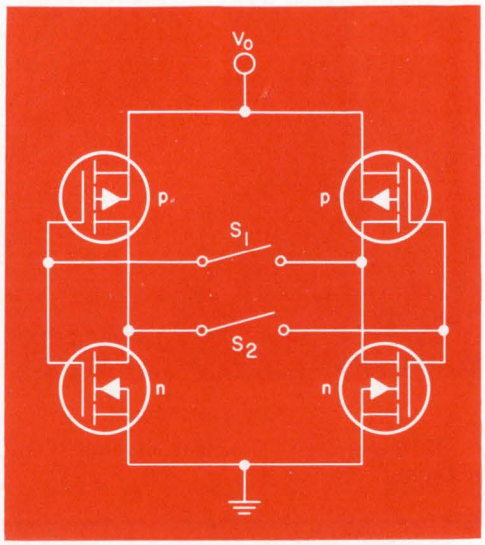


Fig. 14 Shift register stage.

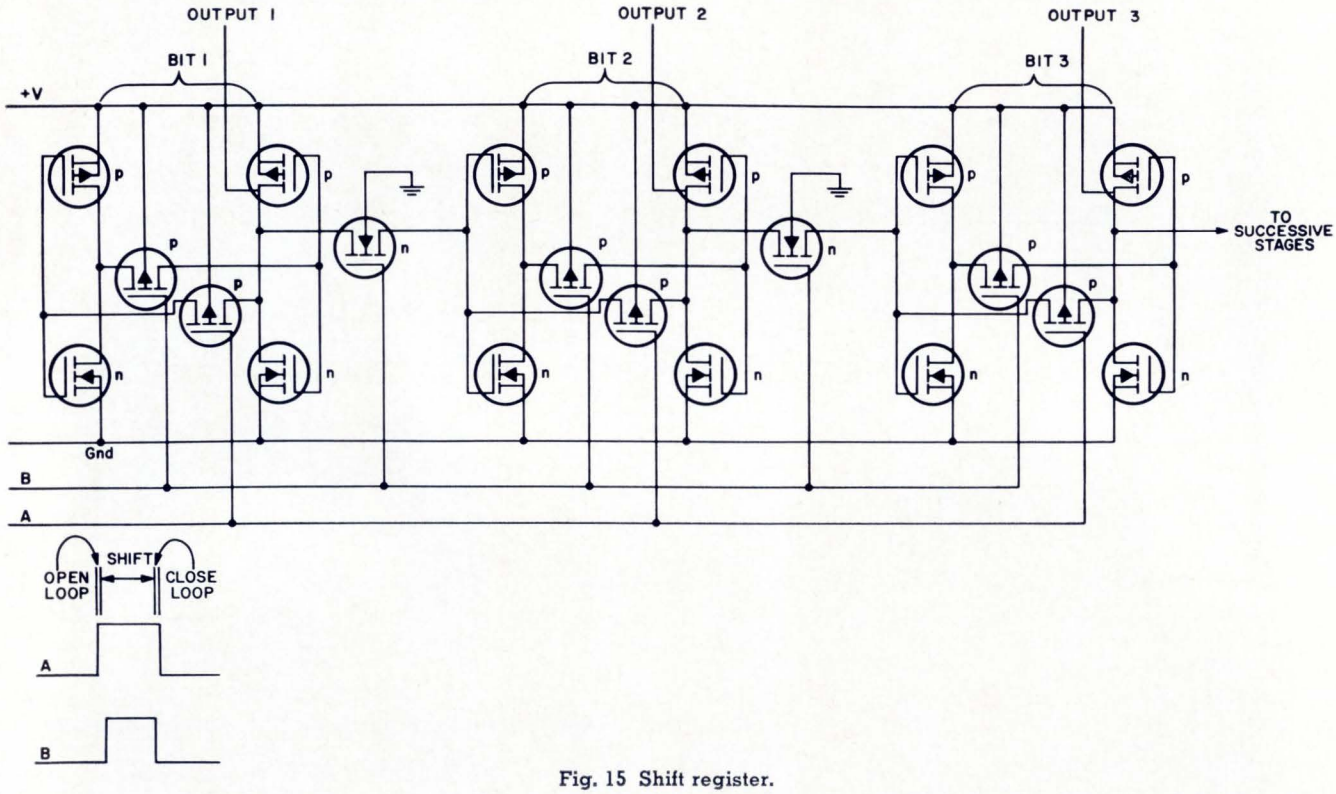


Fig. 15 Shift register.

This expression can be generalized for the more complex case of the series and parallel transistors found in NAND gates, NOR gates, and flip-flops, by modification of the parameters K_n and K_p to their effective values. For series units, $K_{eff} = \frac{K}{n}$; for parallel units, $K_{eff} = Km$, where n and m are the number of devices being switched simultaneously. Thus, for the case of parallel p-channel units and series n-channel units, as used in the flip-flop circuits of Fig. 6 (where $m = n = 2$), $K_{n_{eff}} = \frac{K_n}{2}$ and $K_{p_{eff}} = 2K_p$.

In general, C_o is not independent of $K_{n_{eff}}$ and $K_{p_{eff}}$. Because C_o is an area-dependent term, a useful approximation for it is given by:

$$C_o = A\,[K_{n_{eff}} + K_{p_{eff}}] \qquad (8)$$

where A is a proportionality constant. When Eq. (8) is substituted into (7) and either $K_{n_{eff}}$ or $K_{p_{eff}}$ fixed, a minimum T_d can be shown to exist as a function of

the variable K_{eff} term. This minimum occurs when:

$$\frac{K_{p_{eff}}}{K_{n_{eff}}} = \frac{K_p}{K_n}(m)(n) = \frac{(1-\alpha_n)}{(1-\alpha_p)} \qquad (9)$$

Eq. (9), established by varying the periphery (W term in K of Eq. 2) of either the n-channel or p-channel unit, serves as a useful criterion for designing series and parallel MOS transistors. It was used to provide an optimum design for the three-input NOR gate shown in Table II together with test results for 4-, 5-, and 6-volt supplies. Columns 5 and 6 of Table II clearly show the speed-power tradeoff inherent in this type of logic configuration. The greater speed capability inherent with the 6-volt supply is available only at the cost of greater power dissipation. Yet, a 4-volt supply results in a very respectable pair-delay of 213 nsec at less than half the 6-volt transient dissipation.

Eq. (7) shows that the pair-delay becomes infinite when either α_p or α_n is equal to unity. This relationship confirms that V_{TP}, the larger of the two thresholds, determines the lowest possible supply voltage. Fig. 12 shows measured and theoretical [calculated from Eq. (7)] values of pair-delay as a function of V_o for the flip-flop circuit of Fig. 6; the good agreement of the two curves substantiates the validity of Eq. (7). This data and the known internal node capacitance of 23 picofarads were used in Fig. 13 to plot the curve of power dissipation at any speed lower than f_{max} ($f_{max} = \frac{1}{2} T_d$) as a function of f_{max}. Power dissipation at any lower speed than f_{max} can be determined from this curve by linear extrapolation towards lower speeds. For additional capacitance, such as may result from increased fan-out loading, the curve shifts to the left, as indicated in curve (2) of Fig. 13. This shift indicates a reduced speed capability at a given power level.

Complementary MOS Shift Register Circuit

The p- and n-channel units can form a shift register using true complementary logic[5] with two flip-flops per bit for two-phase operation. However, a significant reduction in components can be obtained by use of (1) the excellent capacitance-storage feature of the MOS gates, and (2) the two halves of the MOS flip-flop, one of which will provide the function of delay. As shown in Fig. 14, opening S_1 and S_2, which are in series with the cross-coupling connections of the flip-flop, results in the formation of two separate storage elements, the left and right side of the flip-flop. Each side will store for an extended but finite period of time. Digital information from the preceding stage is next transferred to the left side through the gate, and possibly changes the state of the left side. At the same time, the right side transfers its information to the left side of the next stage. Closing switch S_2 first and then S_1 locks into the 1-0 information on the left side which was transferred from the preceding bit. A shift register based on these principles and using MOS units for switching is shown in Fig. 15. Effectively this circuit is a two-phase operation with simple MOS flip-flop comprising only a few components.

Integrated Circuits

Because the n- and p-type gates can be cross-connected

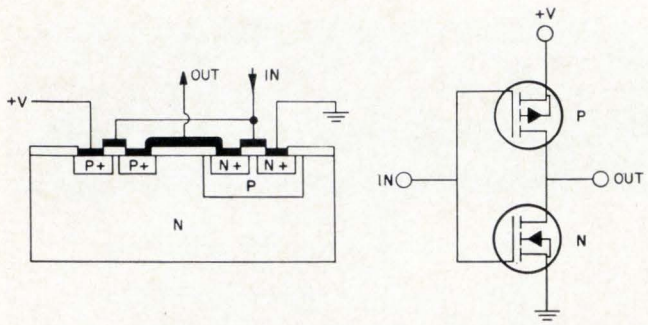


Fig. 16 MOS micropower integrated circuit using diffusion techniques.

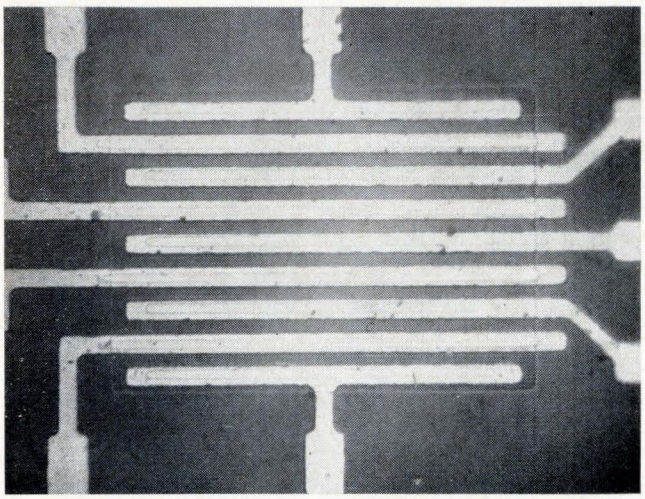


Fig. 17 Geometrical configuration of semi-integrated MOS unit (four transistors).

without one device hogging the input signal as in the case of bipolar transistors, complementary MOS circuits appear very attractive for integration. Successful integration was obtained with a p-type well in n-type material, as shown in Fig. 16. However, many problems remain to be solved in the compatible processing of the p- and n-type units to obtain the best characteristics of each. Some of these are in the area of isolation between n and p units, compatible metalization on n and p units, and compatible oxide growth.

Semi-integrated structures of multiple n-type and multiple p-type units, such as the sample shown in Fig. 17, have also been made. These units, which were used in obtaining the data on micropower complementary logic presented in the preceding sections, contain four MOS transistors having a common source-drain region. However, because the units are symmetrical in geometry, they can be used as four units in parallel as well as four units in series. Many other configurations are possible by simple changes in interconnections. Boolean expressions representing these configurations were shown in Table I.

Conclusion

The MOS complementary transistor logic has shown excellent promise for use with clock rates of several megacycles and below. These logic circuits feature low quiescent current for standby operation. Quiescent power is in the order of a microwatt. The low supply voltages required for low transient power dissipation necessitate the use of enhancement n-channel and p-channel units having low threshold voltages. Although a speed-supply voltage trade is evident, four-volt operation has been shown to be feasible, yielding circuit pair-delays of the order of 200 nanoseconds. Recent tests have shown that the MOS units can be made with more than sufficient dc stability over extended time periods for use in logic circuits. Single and multi-element MOS units of the same type are in the developmental state, with some presently becoming available. However, there are inherent advantages in integrating n- and p-type units on one chip. Although there have been some experimental successes with integration of the complementary structures, a number of problems remain to be solved.

ACKNOWLEDGMENT

The authors wish to express their appreciation to N. Ditrick and his staff for design and fabrication of MOS transistors and S. Peachey for his contributions to obtaining the experimental results and J. R. Burns for discussions on his computer analysis of the inverter circuits.

REFERENCES

1. S. R. Hofstein, F. P. Heiman, **"The Insulated Gate Field Effect Transistor"**, Proc. IEEE, Vol. 51, pp. 1190, Sept. 1963.

2. C. T. Sah, **"Characteristics of MOS Transistors"**, Trans. PGED Vol. ED-11, July 1964.

3. M. F. Wolff (Editor), **"Advances in Microminiaturization"**, Electronics, Feb. 15, 1963.

4. R. D. Lohman, **"Some Applications of Metal-Oxide-Semiconductors to Switching Circuits"**, Semiconductor Products and Solid-State Technology, May 1964.

5. A. H. Medwin, B. Zuk, **"Using MOS Transistors in Integrated Circuits"**, Electronic Design, Nov. 23, 1964 and Dec. 7, 1964.

6. G. E. Moore, C. T. Sah, F. M. Wanlass, **"Metal Oxide Semiconductor Devices for Micropower Logic Circuitry"**, AGARDograph 77 Micropower Electronics, Pergamon Press, 1964.

7. J. R. Burns, **"Switching Response of Complementary Symmetry MOS Transistor Logic Circuits"**, RCA Review, Dec. 1964.

8. M. M. Mitchell, J. R. Burns, R. W. Ahrons, **"MOS Micropower Complementary Transistor Logic"**, Digest of 1965 ISSCC, Feb. 1965.

9. M. M. Mitchell, R. W. Ahrons, **"MOS Complementary Transistor Logic"**, WESCON, 1965.

10. M. M. Mitchell and N. H. Ditrick, **"Stability Effects In MOS Enhancement Transistors"**, Solid State Design, Nov., 1965.

ENGINEERS AND SCIENTISTS

Phoenix, HM-99, Syncom, Colidar Laser Range Finders, ADO - 51, Surveyor, Maverick, Early Bird, TOW, Polaris Guidance Systems, AIM-47, Advanced Technology Satellites, VATE and more...

They're all at Hughes.

(Should you be there, too?)

Send your resume to: **Mr. Robert A. Martin**/Head of Employment/Hughes Aerospace Divisions/11940 West Jefferson Boulevard/Culver City 80, California.

Requirements: Accredited Engineering degree and a minimum of three years of applicable professional experience. U. S. Citizenship.

We promise you a reply within one week.

An equal opportunity employer.

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE DIVISIONS

ORGANIZATION OF ROTATING BULK MEMORIES FOR MINIMUM RANDOM ACCESS TIME

As an addition to the systems designer's "bag of tricks" for use in the art of digital systems design, here are some techniques which will help minimize the time required to retrieve, randomly, information stored in a rotating bulk memory.

Rotating bulk memories in use today vary widely in capacity, access time, and basic techniques used for storing and retrieving information. For each such bulk memory, there are a variety of schemes for the organization of the stored information. The observations and calculations in this article apply to a large class of information-storage problems; they also apply — either directly or by extension — to nearly all bulk memories which require that the read/write mechanism be physically moved from track to track, that is, memories in which there are many more tracks of information than there are read/write mechanisms.

Bulk Memory Characteristics

The bulk memory used as the basis for these observations has the following properties:

1. Information is stored on a large number, N, of tracks. In general, each track rotates with the same period, T, and contains the same number of bits; however, adjustment can be made if these conditions are not satisfied. It is immaterial whether the tracks are concentric, as on a disk, or cylindrical, as on a drum.

2. One positionable read/write mechanism services all the N tracks. (Note that memories having multiple (K) access mechanisms and N tracks can be related to this concept by considering each section of $\frac{N}{K}$ tracks and its single read/write mechanism.)

3. The time required to move the read/write mechanism from track N_i to track N_j is some function of the distance between them, $|N_i - N_j|$.

Average Access Travel

A quantity of interest is the distance which the read/write mechanism can be expected to travel for each access, since the average access time is dependent upon it. The problem can be stated as follows: the read/write mechanism is positioned at track N_i, and it must be moved to track N_j, where i and j can each be, with equal probability, any track between 1 and N. What is the expected value of the distance from N_i to N_j?

Mathematically stated:

Find $E[|N_i - N_j|]$,

$$\left.\begin{aligned} \text{Where } P(N_i = A) &= \frac{1}{N} \\ P(N_j = B) &= \frac{1}{N} \end{aligned}\right\} \text{ for all A, B: } [0 \leq A, B \leq N]$$

From basic probability theory,[1] assuming N to be sufficiently large ("Sufficiently large," in this case, requires that $\frac{1}{N}$ be negligible by comparison with N) so that N_i and N_j can be considered to be continuous random variables:

$$E[f(x_i, x_j)] = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x_i, x_j)\, p(x_i, x_j)\, dx_i\, dx_j$$

where $p(x_i, x_j)$ = the joint density function of x_i and x_j.

Since $P(N_i = A) = P(N_j = B) = \frac{1}{N}$

for all A, B: $[0 \leq A, B \leq N]$,

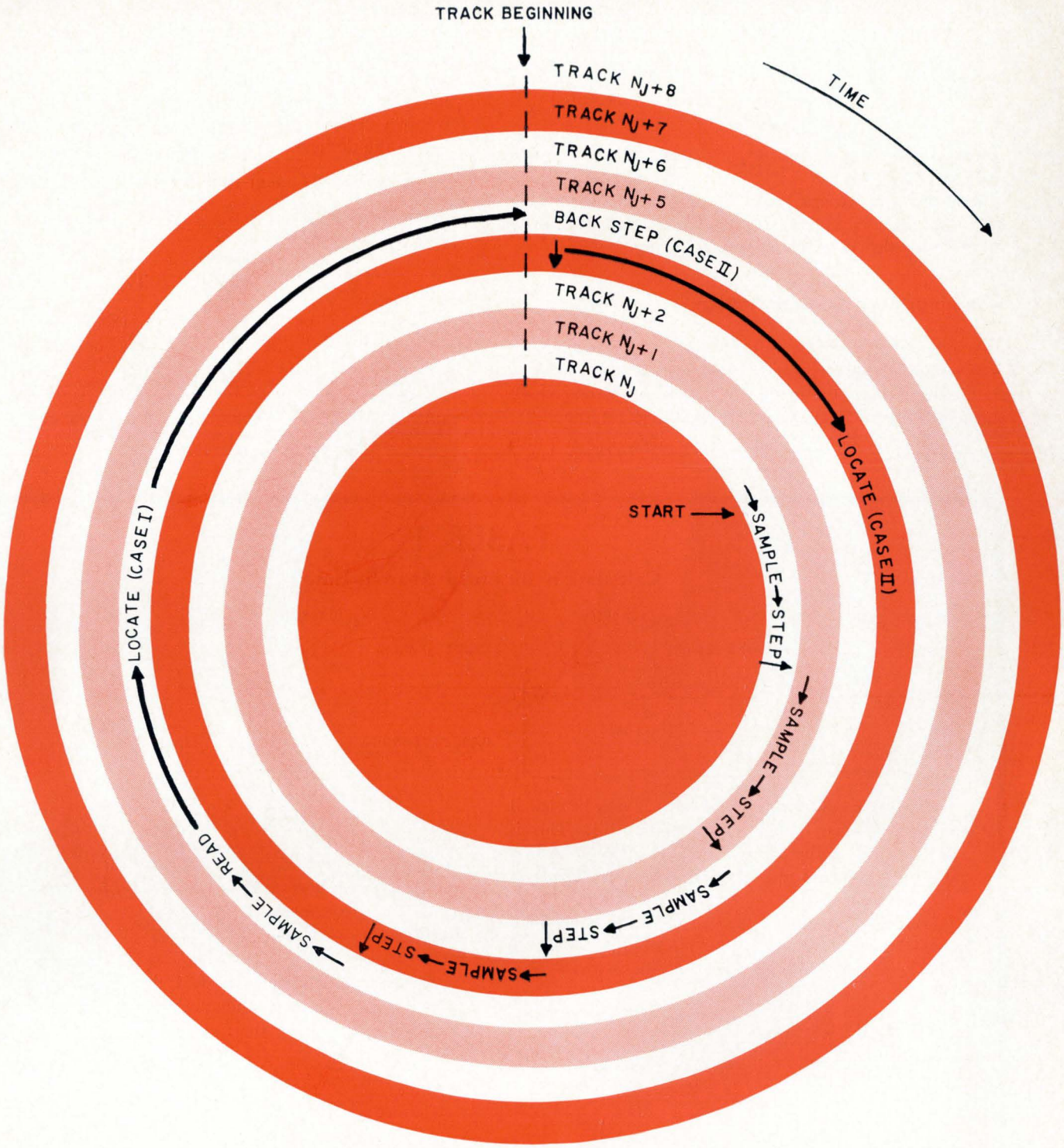


Fig. 1 Search-and-locate in group-directed ordered storage.

then $p(N_i) = p(N_j) = \begin{cases} \frac{1}{N} & 0 \leq N_i, N_j \leq N \\ 0 & \text{otherwise} \end{cases}$

and, since N_i and N_j are independant random variables,

$$p(N_i, N_j) = p(N_i)\, p(N_j) = \begin{cases} \frac{1}{N^2} & 0 \leq N_i, N_j \leq N \\ 0 & \text{otherwise} \end{cases}$$

Therefore $E\{|N_i - N_j|\} = \frac{1}{N^2} \int_0^N \int_0^N |N_i - N_j|\, dN_i\, dN_j.$

Since $|N_i - N_j| = \begin{cases} (N_i - N_j) & N_i > N_j \\ (N_j - N_i) & N_j > N_i \end{cases}$

Then $E\{|N_i - N_j|\} = \frac{1}{N^2} \int_0^N \int_0^{N_i} (N_i - N_j)\, dN_i\, dN_j +$

$$\frac{1}{N^2} \int_0^N \int_0^{N_j} (N_j - N_i)\, dN_i\, dN_j$$

$$= \frac{1}{N^2} \left\{ \int_0^N \left[\int_0^{N_i} (N_i - N_j)\, dN_j \right] \right.$$

$$\left. dN_i + \int_0^N \left[\int_0^{N_j} (N_j - N_i)\, dN_i \right] dN_j \right\}$$

$$E\,[|N_i - N_3|] = \frac{N}{3}$$

Therefore, the average travel of the read/write mechanism under the conditions of completely random access is across one-third of the total tracks in use.

Searching in an Ordered Storage

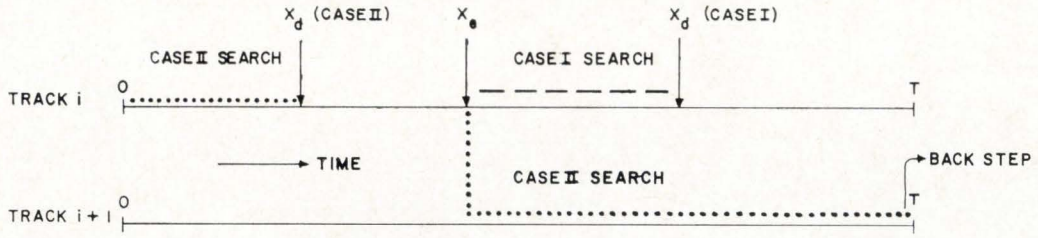
One method of locating information in a bulk memory is to create a directory which can, given identification of the desired data, designate the exact track on which the data will be found (see, for example, reference 2). For an N-track storage, and ordered data, this requires a directory having N bins, with each bin storing the identification of the highest (or lowest) ordered data entry on the corresponding track. For such an organization, the storage average access time $\bar{\tau}$ will be the time to move to the designated track, plus the time required to find the desired entry on that track. As shown above, the expected movement time is some function of $\frac{N}{3}$; the expected time to find the entry is half the rotation time T. Therefore:

$$\bar{\tau} = t\left\{\frac{N}{3}\right\} + \frac{1}{2}\,T.$$

In practice, the movement term, $t\left\{\frac{N}{3}\right\}$, is typically in the 10-100 ms range, and the entry scan time, $\frac{T}{2}$, is typically 10-20 ms. Note that when N is very large, e.g., 1000 tracks, a very large amount of data must be

TABLE 1

Calculation of Entry Search Time



For the purposes of entry search, a track may be viewed as the real line from 0 to track end (T). This is diagrammed in the above figure. If x_e is defined as the entry point on the i^{th} track, and x_d is defined as the desired entry location, then the probability of Case I occurring is equal to the probability that x_d is located between x_e and T. The probability of Case II is one minus P(Case I), since only the two cases can occur.

$$\begin{aligned} P(\text{Case I} &= P(0<x_e<x_d<T) \\ &= P(0<x_e<x_d,\ 0<x_d<T) \\ &= \int_0^T \left\{ \int_0^{x_d} p(x_e, x_d)\, dx_e \right\} dx_d \end{aligned}$$

Where $p(x_e, x_d)$ is the joint density function of x_e and x_d. Since x_e and x_d are independent, and are uniformly distributed between 0 and T, then:

$$p(x_e) = p(x_d) = \begin{cases} \frac{1}{T} & 0<x_e, x_d<T \\ 0 & \text{Otherwise} \end{cases}$$

and $p(x_e, x_d) = p(x_e)\ p(x_d) = \frac{1}{T^2}$

Therefore $P(\text{Case I}) = \int_0^T \left\{ \int_0^{x_d} \frac{1}{T^2}\, dx_e \right\} dx_d = \frac{1}{2}$

So P(Case I) = P(Case II) = ½

The second problem is to find the length of the search in each of these equiprobable cases. From the above illustration, note that:

Time (Case I) $= (x_d - x_e)_t,\ x_d > x_e$

Time (Case II) $= T_t - (x_e - x_d)_t,\ x_e > X_d$

Therefore

$$= T_{ent} = P(I)\ T_I + P(II)\ T_{II} = \tfrac{1}{2}(T_I + T_{II})$$

$$= \tfrac{1}{2}\left[(x_d - x_e)_t \Big|_{x_d>x_e} + T_t - (x_e - x_d)_t \Big|_{x_e>x_d} \right]$$

$$= \tfrac{1}{2}\left[|x_d - x_e|_t + T_t - |x_d - x_e|_t \right]$$

$$= \frac{T_t}{2} = \tfrac{1}{2} \text{ revolution.}$$

It is also interesting to note (and easy to show that:

$$E\left\{ |x_d - x_e| \right\} = \frac{TE}{6}.$$

stored in the directory; the directory then becomes a sort of bulk storage problem in itself. In storage devices where the movement time is small for single-track stepping, an attractive technique exists for drastically reducing the size of the directory required. (In devices where a large rest-inertia must be overcome regardless of whether the motion is to be over one track or a thousand tracks, this technique does not apply, since the movement time is of the form $t_1 + t_2 \left(\frac{N}{3}\right)$ where t_1 is relatively large (10-50 ms), and t_2 is two or three orders of magnitude smaller. The discussion here applies to devices (see, for example, reference 3) where t_1 is very small or non-existant.)

In this technique, the size of the directory is reduced from N bins to $\frac{N}{q}$ bins by grouping the tracks into groups of q tracks each, moving the read/write mechanism to the beginning of the group, and locating the correct track within the group by sampling each track. The additional access time needed with this technique is that time required to sample (on the average) $\frac{q}{2}$ tracks, and move-one track $\frac{q}{2}$ times. If this time is negligible compared with $\bar{\tau}$, above, then the price paid in access time for the significant reduction in directory size is well spent.

The search for a particular unit of data in the bulk storage is diagrammed in Fig. 1, which uses concentric tracks (as on a disk) for illustration. In this illustration, it is assumed that track N_j contains the lowest-valued data of the set of q tracks:

$$[N_j, N_{j+1}, N_{j+2}, \ldots . N_{j+q-1}].$$

The directory gives the address N_j, the read/write mechanism is moved there, and the search starts by sampling on track N_j. If the sampled data is lower-ordered than the desired data, a step command moves the read/write mechanism to the next higher track, N_{j+1}. This sample-and-step process continues until the sampled data becomes higher-ordered than the desired data, indicating that the desired data lies between the last two samples.

Assuming that this last sample is taken on track N_{j+k}, there are two possible cases for the location of the desired data:

Case I: The desired data lies on track N_{j+k}, between the sampled point and the end of the track. In this case, reading of the remainder of track N_{j+k} will locate the desired data.

Case II: The desired data lies on track N_{j+k-1}, between the beginning of track and the point on that track which was sampled. In this case, reading of the remainder of track N_{j+k} will not locate the entry, and a back-step must be generated to read track N_{j+k-1}, starting at track beginning.

Assuming that the sample point and the location of the desired entry are both random variables which are uniformly distributed on the track, it can easily be shown (see Table 1) that Case I and Case II are equiprobable and that the expectation of the time, from the time that the last sample is taken until the desired entry is located, is one-half of the track revolution time. Since the search time with an N-fold directory also takes one-half revolution, the additional time required is only that required for the sample-and-step process.

Redundancy As a Speed-Up Mechanism

Neglecting any contribution of the sample-and-step technique described above, the access time to a rotating bulk memory is made up of the two basic components of movement time, $t\left\{\frac{N}{3}\right\}$, and rotation time $\frac{T}{2}$. In applications where the stored data occupies fewer than half of the available tracks, full redundancy can, in many cases, provide a reduction in access time.

The desired redundancy is achieved by allotting to each track only half (or one-third, etc.) as much data as it would normally store, and writing the half-data block twice (or three times, etc.) on each track. This has the effect of reducing the track revolution time, T, to one-half (one third, . . .) of its original value; the negative effect is that the number of tracks, N, is doubled (tripled . . .). Therefore, if the original ac-

cess time were represented by the expression:

$$\bar{\tau} = \left(t_1 + t_2 \frac{N}{3}\right) + \frac{T}{2},$$

the access time with redundancy would be

$$\bar{\tau}_R = \left(t_1 + t_2 \frac{RN}{3}\right) + \frac{T}{2R},$$

where R is the redundancy factor, that is, the number of times the data is stored.

The optimum redundancy can be determined by setting $\frac{d\bar{\tau}}{dR}$ equal to 0:

$$\frac{d\bar{\tau}}{dR} = 0 = \frac{t_2 N}{3} = \frac{T}{2R_{opt}^2}$$

$$R_{opt} = \left(\frac{3T}{2t_2 N}\right)^{1/2}$$

Optimum redundancy can thus be evaluated in terms of the parameters T (rotation) and t_2 (stepping time) of the bulk storage in use, and the amount of data to be stored, since in this expression N represents the number of tracks required to store the data with no redundancy. The bulk storage obviously places an upper bound on RN.

Probabilistic Redundancy

If the entries in the bulk storage are not equiprobable of access, significant gains in access time may be made with non-uniform redundancy, at the same time reducing the requirement for excess storage. As an example, in the machine translation problem,[4] the stored information is by no means equiprobable of access. In English text, the single word "the" accounts for about 9.3% of all word occurrences; "of" for 6.2%; "and", "in", and "to" for 8.2%, and the next 11.2% is covered by only thirteen words. Therefore in a dictionary stored for machine translation, which might typically contain 100,000 entries, about 35% of the accesses could be to only 18 entries. There are a number of tricks which can be applied to this particular situation. However, the point here is to illustrate the use of partial redundancy.

Assume that the access time to the bulk memory used in a machine translator, under conditions of no redundancy, is given by the expression:

$$\bar{\tau} = 10\,N\ \mu\text{sec} + \frac{25\text{ ms}}{2},$$

where, as before, N is the number of tracks used to store the dictionary, and 25 ms is half the disk rotation time, T. Using a dictionary of 100,000 entries stored 250 to a track, N = 400 and $\bar{\tau}$ = 16.5 ms. If full-dictionary redundancy is used (R = 2), N is doubled to 800, T is halved to 12.5 ms and:

$$\bar{\tau}_{(R=2)} = 14.25\text{ ms}.$$

If partial redundancy is used, the probabilities of access to the various portions of the disk must be taken into account, that is

$$\bar{\tau}_{PR} = [\bar{\tau}_{R=1}]\,[P(\text{access to R} = 1\text{ area})] + [\bar{\tau}_{R=2}]\,[P(\text{access to R} = 2\text{ area})] + \ldots,$$

where the sum of all probabilities must equal one. Let us investigate the case where each of the 18 most probable entries is allocated a track of its own, i.e., R = 250 for those 18 entries. This creates 18 new tracks, making N = 418, and makes $T_{18} = \frac{T}{250} = 100\ \mu$sec. The average access time for these 18 entries is:

$$\bar{\tau}_{18} = (10)(418)\ \mu\text{sec} + \frac{100\ \mu\text{sec}}{2} = 4.23\text{ ms}.$$

The combined probability of occurrence of these 18 entries is 0.35. The remaining 99,982 entries have a probability of occurrence of 0.65, and an access time of:

$$\bar{\tau}_{\text{Remainder}} = 10(418)\ \mu\text{sec} + \frac{25\text{ ms}}{2} = 16.68\text{ ms}.$$

The total access time is then:

$\bar{\tau}_{PR}$ = (4.23 ms) (0.35) + (16.68 ms) (0.65) = 12.3 ms, which is 25% less than the non-redundant access time, and 14% less than the R = 2 case.

In most cases, some combination of different redundancy factions for several subsets of the stored data will achieve the minimum access time. (Note that in some cases the statistical characteristics of the data may alter the assumptions which led to the figure of $\frac{N}{3}$ for the expected travel time E $[N_i - N_j]$, and this effect must be considered.)

The most effective balance of redundancy techniques will be different for each combination of storage device characteristics, volume of data, and statistical characteristics of the data. In general, redundancy will be most effective when it is so devised as to equalize the amount of time spent in moving the read/write mechanism and the amount of time waiting for the disk to rotate. This can be readily seen by plugging the equation for R_{opt}, developed in the last section, back to the original equation to find $\bar{\tau}_{opt}$. Since a mathematical approach to the design of an optimum solution for a particular application becomes very messy when combinations of redundancy are used, the balancing of the requirements and possible solutions becomes another facet in the art of digital system design. **END**

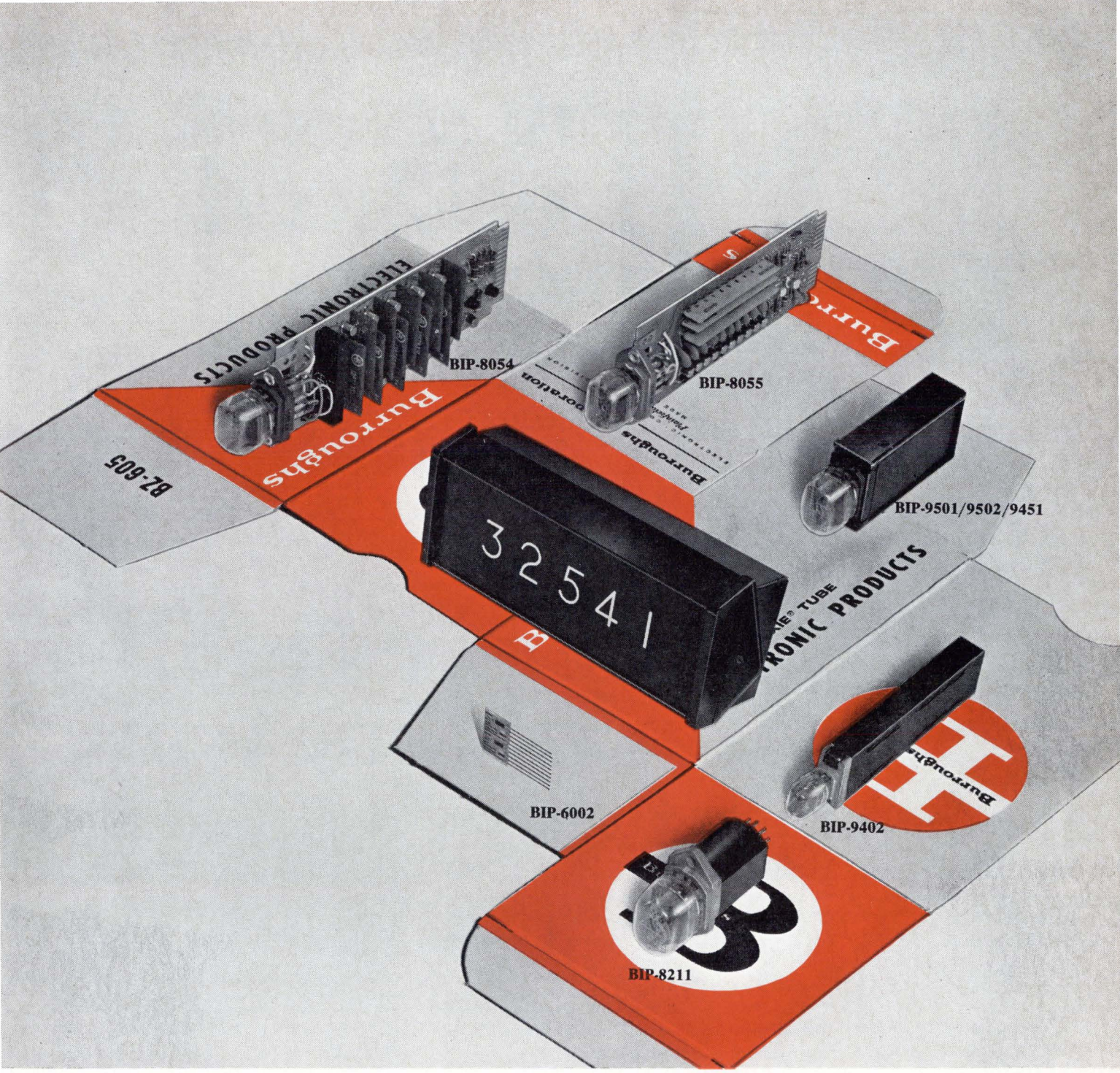
REFERENCES

1. Cramer, Harald: **"The Elements of Probability Theory"**, John Wiley and Sons, 1962; Equation (5.5.4), page 72.

2. Lennon, W. T. Jr., and W. F. Jordan, Jr.: "Auxiliary Memory Speeds Information Retrieval"; **Electronics,** XXXV, 19; May 11, 1962.

3. King, G. W., G. W. Brown, and L. N. Ridenour: "Photographic Techniques for Information Storage"; **Proc. Ire.** 41, 1421 (1953).

4. Bowers, D. M. and M. B. Fisk: "The World's Fair Machine Translator"; **Computer Design,** Vol. 4, No. 4; April 1965.



When Burroughs wraps up the package, your readout costs you less.

When you buy a NIXIE® tube package, you get a driver module designed with your input requirements in mind plus the finest readout available, at an extremely low cost per function.

For instance, 1000 lot prices for new driver modules, *including rectangular NIXIE tube readout,* are as follows: • BIP-9451, a BCD to decimal decoder with memory in a new hybrid circuit package, $35.50 • BIP-9501, a 10-bit memory driver module, $32.50 • BIP-9402, the world's smallest BCD to D decoder with memory, $49.00.

And these are only the most recent additions to a line which already includes a 150 KC uni-directional counter (BIP-8055), $50.00 with tube; a 110-KC bi-directional counter (BIP-8054), at $80.00 with tube, and a wide variety of socket pack drivers and decoder/drivers which range in price from $28.50 to $35.50, including readout. All prices apply in 1000 quantities.

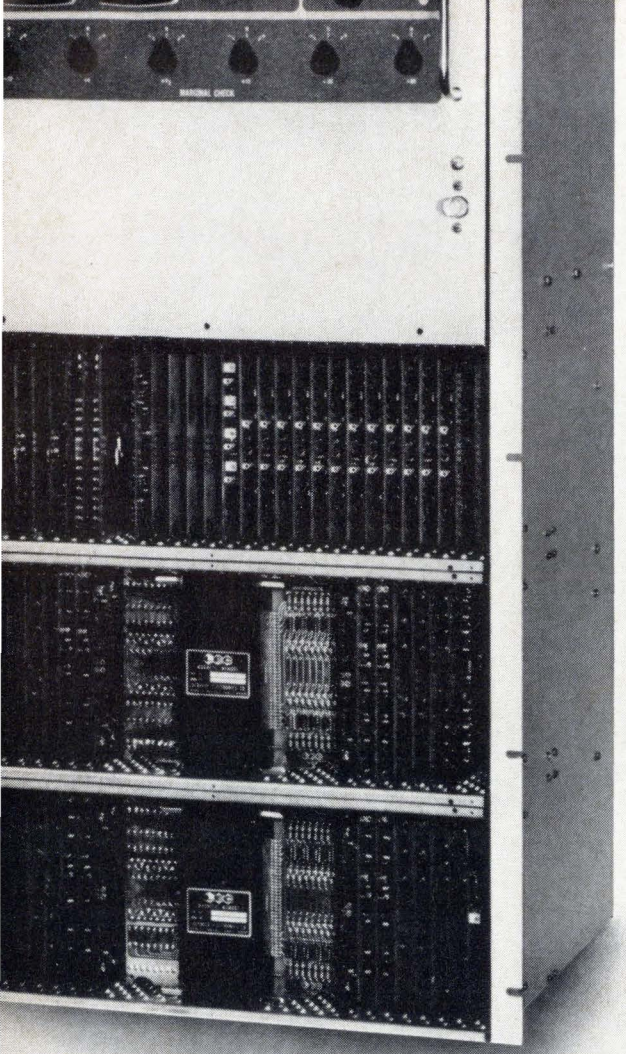
Burroughs readout packages save you electrical and mechanical design time, *and they are available.*

Write for complete information on NIXIE indicator tubes and associated driver modules.

Only Burroughs manufactures NIXIE Tubes.

Burroughs Corporation / ELECTRONIC COMPONENTS DIVISION
PLAINFIELD, NEW JERSEY

CIRCLE NO. 26 ON INQUIRY CARD



Put a Lockheed memory system out of action?

There's really only one way.

It definitely takes some outside intervention to stop Lockheed's high-speed memories. The reason: we've carried "worst case design" further than anyone else in the field.

Lockheed has built this approach into the largest commercial high-speed memory in operation today. It has 32,768 words, 74 bits and operates at 1 microsecond complete cycle time. Also into an integrated circuit memory for military aerospace use. It puts 4,096 words and 32 bits into a 10 lb. package of only 175 cu. in.

What specific "worst case design" features can Lockheed build into memories for you? Our standard CC-100 (1 usec.) and CC-200 (1.75 usec.) memory systems illustrate some basic ones.

Here's an example: our unique sense amplifier circuit. It provides a new order of accuracy because it subjects "1-0" signals to three types of discrimination, not the usual two. Signals must pass time, threshold, and width discrimination.

Then there's Lockheed's exclusive core driver circuit. We drive 76 bits with one circuit, not the usual two or more. An innovational design provides power to spare and greatly simplifies circuitry. Added dependability and economy result.

"Plug in" memory stacks are another Lockheed feature. You can economically enlarge a low-capacity system to fit expanding needs. Field conversion of a 1.75 usec. system to 1 usec. is easy, too.

More facts on Lockheed memories: operating temperature range 0° to 50°C · All-silicon semiconductors · Commercial or military specs · Standard rack or special mounting · Numerous operational and equipment options ·

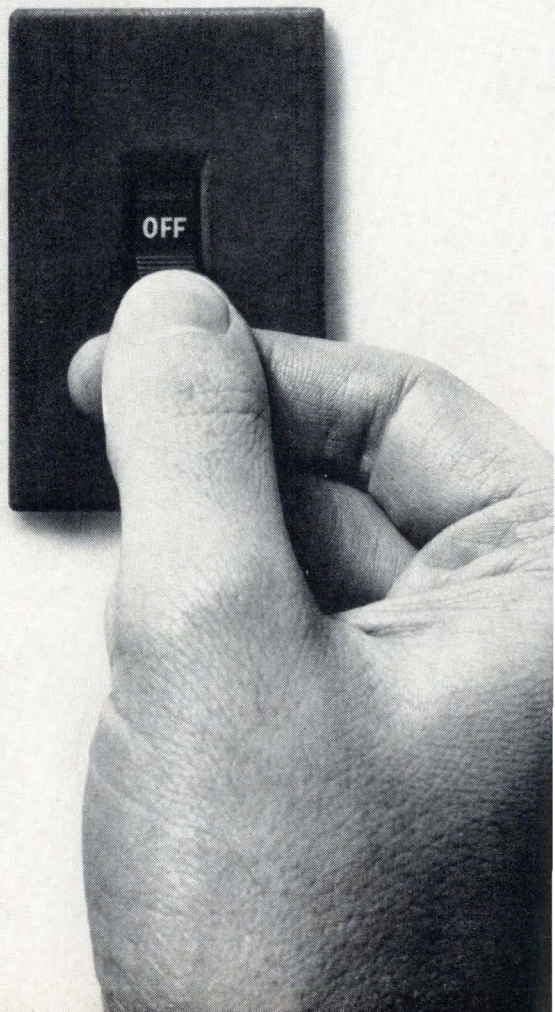
Write for full technical data now.

6201 E. Randolph St., Los Angeles, Calif.

Also, ask us for full information about memory/computer design engineering opportunities.

Lockheed Electronics Company

A Division of Lockheed Aircraft Corporation



1 2 3

HIGHEST QUALITY

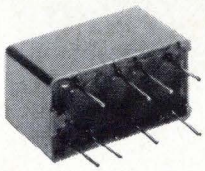
Quality and reliability demonstrated by a proven 4½ million hours MTBF

GREATEST VERSATILITY

Complete families of rugged potted germanium and silicon modules

LOWEST COST

For example, 100 Kcps S-R flip-flop module $3.95 each in quantities of 100

Practical reasons why so many engineers choose EMC  digital logic modules potted in *TIMONIUM*

Complete families of digital logic modules operate over an ambient temperature range of —55°C to +125°C

ELECTRONIC MODULES CORPORATION

Electronic Modules Corporation • COMPONENTS DIVISION

1949 GREENSPRING DRIVE • TIMONIUM, MARYLAND • TEL. (301) 252-2900 • TWX-301-252-0723

CIRCLE NO. 28 ON INQUIRY CARD

← CIRCLE NO. 27 ON INQUIRY CARD

P/R/F

PRODUCT REFERENCE FILE

Background concepts, selection criteria, and application information on a class of products used by digital design engineers.

DATA LOGGING PRINTERS

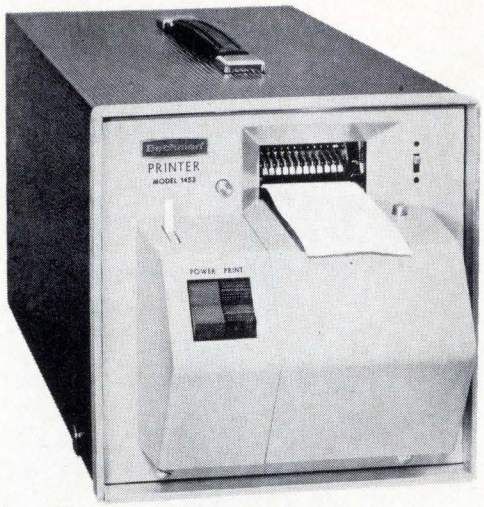


Fig. 1 Beckman Instruments' Model 1435 printer.

Part 2 - Manufacturers' Units

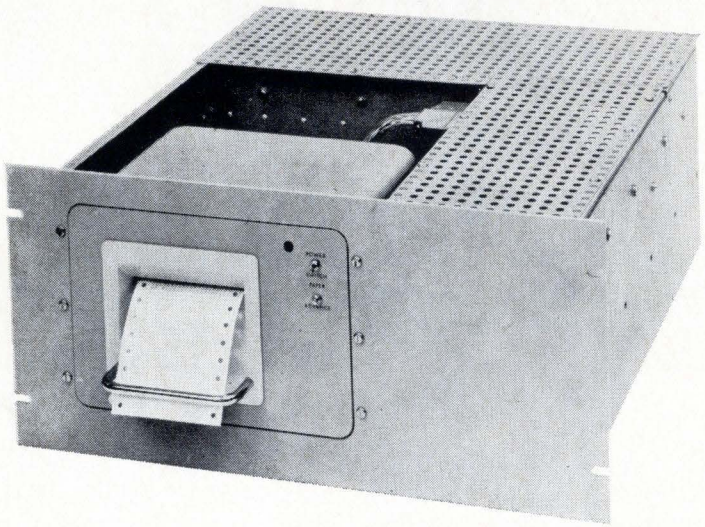


Fig. 2 Clary Corp.'s Model 4000 military printer.

In last month's issue, Part 1 of this Product Reference File survey article discussed the internal design and external system considerations that may influence the selection of a data logging printer. The term "data logging printer" as used in this 2-part survey refers to the types of printers that are frequently called strip printers, paper tape printers, listers, instrumentation printers, or digital recorders. The common denominator of these printers is that they do not print out a full page format (high speed page printers and automatic typewriters will be covered in a future survey article).

Here in Part 2, brief descriptions of the data logging printers offered by 17 manufacturers are given.

The performance characteristics of manufacturers' representative models are summarized in an accompanying chart. This chart is not intended as a basis on which to make a final selection of a printer for a particular application but rather as a good starting point for further investigation.

Manufacturers' Units

Beckman Instruments Inc., Richmond, Cal. — Beckman manufactures a "tab" type instrumentation printer to complement their line of electronic counters and digital voltmeters. This machine, shown in Fig. 1, can print out straight numeric information at the rate of 3 lines per second with up to 12 columns per line. The Model 1435 has a modular decoding system which can accept either of the 3 BCD codes or a ten-line input. Also, the machine has a color control for red or black and three optional interface circuits. This printer is a half-rack design which can come in a portable case, bench cabinet, or mounted in a rack adapter.

Clary Corp., San Gabriel, Cal. — Clary manufactures three printer models that use a unique printing mechanism which is a hybrid between a "tab" and "on-the-fly" mechanism. With this technique, the print drum pauses momentarily at each character while the hammers are actuated. Printing occurs only when the type wheels are stationary. This feature is said to eliminate timing problems. These three printers all use impact sensitive paper. The Model 2000 is a 12-character numeric printer providing a maximum of 21 columns at 15 lines per second. The Model 4000, shown in Fig. 2, is a militarized version of the Model 2000. The Model 7000 can operate up to 20 lines per second with a maximum 20 column capacity. These printers allow paper loading through the front panel.

Cincinnati Time Recorder Co., Cincinnati, Ohio — This company's Model TCP, shown in Fig. 3, allows for the printout of 8 columns of data plus the time and date at a rate of one line per second. This is a slow speed machine that lends itself to monitor and alarm printout applications. The printout is straight numeric, but any two column positions can be replaced with

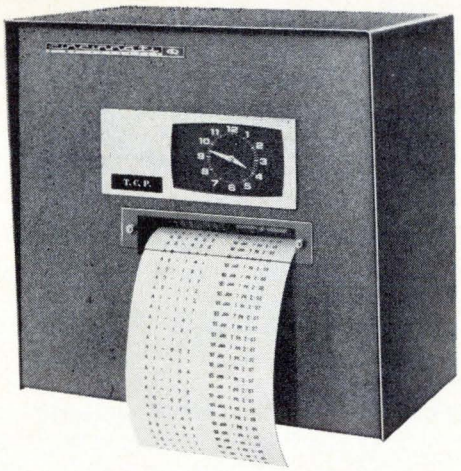


Fig. 3 Cincinnati Time Recorder's Model TCP printer.

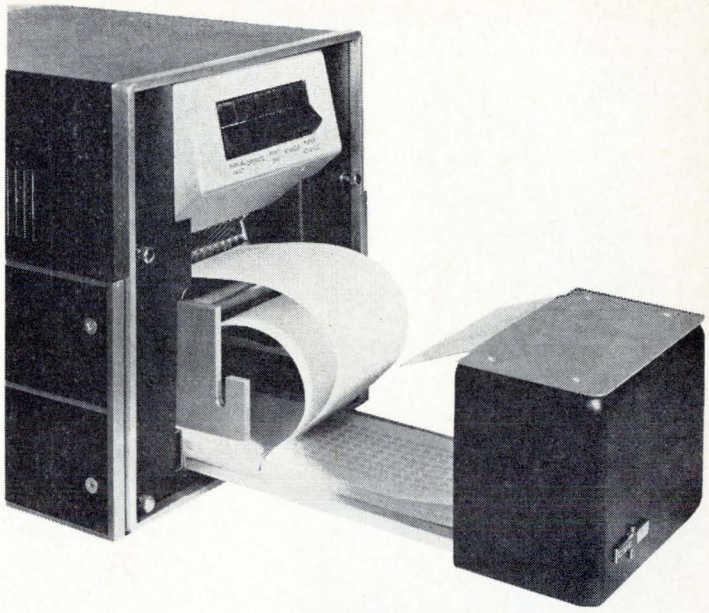


Fig. 4 Computer Measurements Co.'s Model 410A printer.

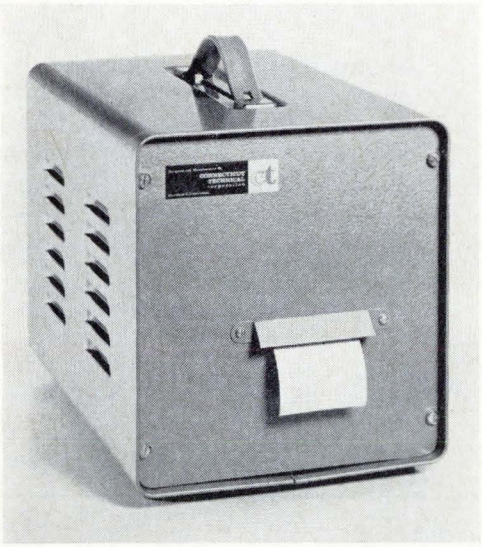


Fig. 5 Connecticut Technical Corp.'s Model S-220 printer.

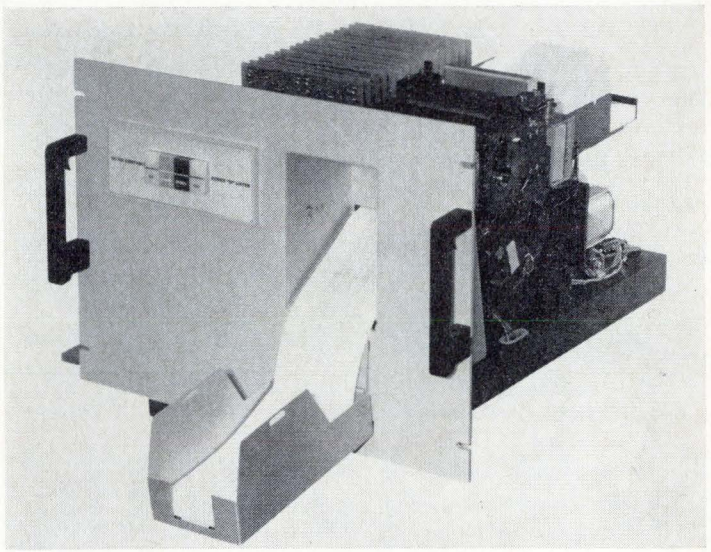


Fig. 6 Di/An Controls' Model NN printer.

a four letter word. Input is a 500 millisecond switch closure to each digit.

Computer Measurements Co., San Fernando, Cal. — The CMC instrument printer eliminates a font bar by using direct character formation. Each numeral is made up of a combination of 7 segment bars (segments that are commonly employed in digital readout devices) and when the decoded combination of bars are extended, they form the type face. Printing is accomplished by bringing the paper in contact with the segments in a rigidly-mounted character head with a standard typewriter ribbon, between the head and the paper, supplying the ink. The CMC Model 410A offers numeric printout at 10 lines per second and up to 12 columns. It also features a movable decimal point and a number of input logic levels and codes. This machine can optionally print out a limited alpha-character set. This model, shown in Fig. 4, is packaged in a half-rack size with front panel paper loading.

Connecticut Technical Corp., Hartford, Conn. — This company's printer is a low-cost, slow-speed machine that accepts serial entry data at the rate of 15 characters per second. The printer is a modified adding machine with the optional features of ADD, SUBTRACT, and TOTAL. Model S-110 prints approximately 1.8 lines per second and S-220 provides 3.6 lines per sec. Printer is shown in Fig. 5.

Di/An Controls, Inc., Boston, Mass. — Di/An Controls has three "on-the-fly" printers. All of their models use a microporous inking roller and feature electronic timing adjustments. The Model NN, shown in Fig. 6, is a 32 column numeric machine operating at 40 lines a second and the Model NA is an alpha-numeric counterpart operating at 20 lines a second. The Model DL is a 16-column numeric printer with a maximum speed of 40 lines per second. These printers have a number of input codes and data level options and can also be provided with

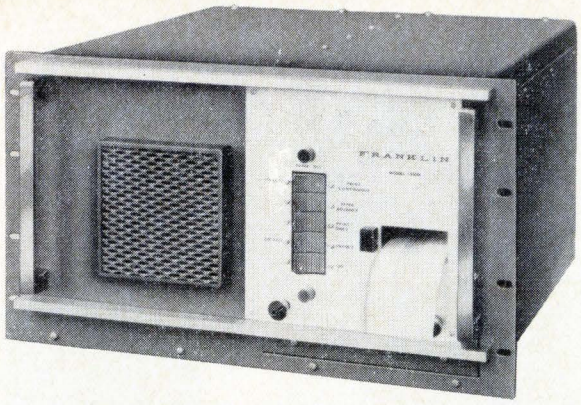


Fig. 7 Franklin Electronics' Model 1200 printer.

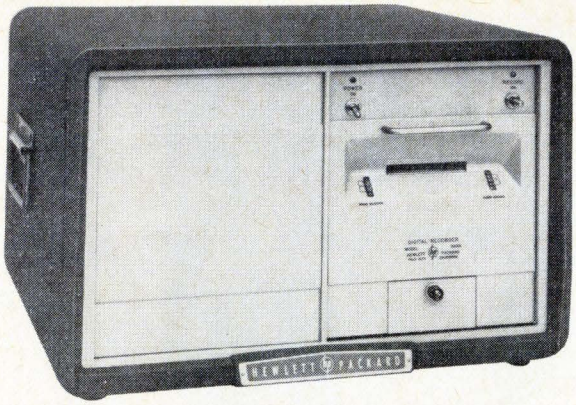


Fig. 8 Hewlett-Packard's Model 562A digital recorder.

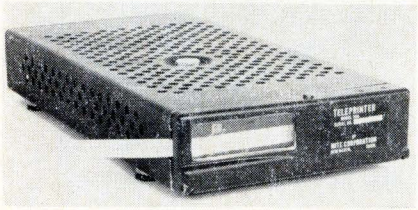


Fig. 9 Mite Corp.'s Model 118A strip printer.

line storage and character serial entry. The Model NN and NA are field expandable on a columnar basis.

Franklin Electronics Inc., Bridgeport, Pa. — Franklin manufactures a variety of "on the fly" printers which are capable of asynchronous operation. The Model 1000 is a 20-column machine providing 40 numeric lines per second or 20 alphanumeric lines per second. The Model 1200, shown in Fig. 7, is a 12-column numeric printer operating at 20 lines per second. The Model 2200 is similar to Model 1200 but has a bigger print drum that provides 22 columns with a 64 alphanumeric character set. Franklin has also announced a new alphanumeric strip printer, Model 120A, that prints 20 characters per second on a ½" wide tape. This model, weighing less than 5 lbs, is available as a printing mechanism without the associated electronics.

Hewlett-Packard Co., Palo Alto, Cal. — Hewlett-Packard offers several models of its basic digital recorder. Model 560A prints directly from a Hewlett-Packard counter. Model 562A, shown in Fig. 8, accepts a BCD input and has internal line storage. The basic printer is an 11-column, five line per second numeric "tab" type machine. The Model 562A has its decoder and comparator electronics on one-column boards. Optional boards are available to accept any of the 3 BCD codes and 10 line inputs. This printer also has an optional analog output with an accuracy of ±5%. Model 561B is a 10-line input.

Mite Corp., New Haven, Conn. — The Mite printer, shown in Fig. 9, is an alphanumeric strip printer that operates at 10 characters per second. It has a printing capability of 64 characters. This printer is a direct positioning "tab" machine which uses six input solenoids to position a single type bar through a unique cable linkage. The printer uses a ratchet and pawl mechanism to advance its impact sensitive paper tape. This small printer, 10" long, 5" wide, and 2" high, is said to be particularly suited for applications where space, weight, and available power are at a premium.

Monroe Datalog Div. of Litton Industries, San Francisco, Cal. — Monroe offers a variety of printer models. The Model MC 4000, shown in Fig. 10, is a 32-column numeric or alpha-numeric photocomposition printer which operates at a maximum speed of 100 lines per second. This model's optical printing technique was described in Part 1 of this survey article. The Model MC 1380 and MC 1040 are 16-column numeric "on-the-fly"

TABLE I

MANUFACTURERS' LITERATURE

For your product reference file, a complete set of manufacturers' literature can be obtained by circling, on the reader inquiry card, the numbers listed below.

COMPANY	INQUIRY CARD NO.
Beckman Instruments, Inc., Richmond, Cal.	80
Clary Corp., San Gabriel, Cal.	81
Cincinnati Time Recorder Co., Cincinnati, Ohio	82
Computer Measurements Co., San Fernando, Cal.	83
Connecticut Technical Corp., Hartford, Conn.	84
Di/An Controls, Inc., Boston, Mass.	85
Franklin Electronics, Inc., Bridgeport, Pa.	86
Hewlett-Packard Co., Palo Alto, Cal.	87
Mite Corp., New Haven, Conn.	88
Monroe Datalog Div. of Litton Ind., San Francisco, Cal.	89
Omni-Data Div. of Borg-Warner, Philadelphia, Pa.	90
Potter Instrument Co., Inc., Plainview, L.I., N.Y.	91
Reo Div. of Spectra-Strip Wire & Cable Corp., Garden Grove, Cal.	92
Shepard Laboratories, Inc., Summit, N.J.	93
Soroban Engineering Inc., Melbourne, Fla.	94
United Systems Corp., Dayton, Ohio	95
Victor Comptometer Corp., Chicago, Ill.	96

NOW, ALL OTHER CONTACT ENCODERS ARE OBSOLETE

Litton introduces the **pin** contact encoder. It makes brush-type encoders obsolete for two main reasons: 1) its multiple discrete contacts make true contact redundancy finally possible; 2) it achieves an MTBF that is 2-7 times longer than comparable brush encoders.

This adds up to reliability no brush contact encoder can guarantee. Tests prove it. If you're interested, send for Document 104 reporting competitive testing on 30 encoders.

Litton's new size 11 pin contact encoders have actually withstood the extreme environmental conditions of 150g shock as well as 30g, 5-2000 cps vibration. They are the only contact encoders that have been qualified to levels exceeding Mil-E-5272 (detailed reports available). The new pin encoders are available in 8, 13 and 18 bit binary — and in other codes for special system requirements. These encoders have been built and shipped and are now operating in combat environments.

Please call us direct with your specific needs or contact your nearest Litton regional engineering office. Encoder Division, 7942 Woodley Ave., Van Nuys, Calif. (213) 781-2111. New York: (212) 524-4727. Chicago: (312) 775-6697. Washington: (202) 462-8833.

ENCODER DIVISION
LITTON INDUSTRIES
OPTICAL · MAGNETIC · CONTACT ENCODERS

CIRCLE NO. 29 ON INQUIRY CARD

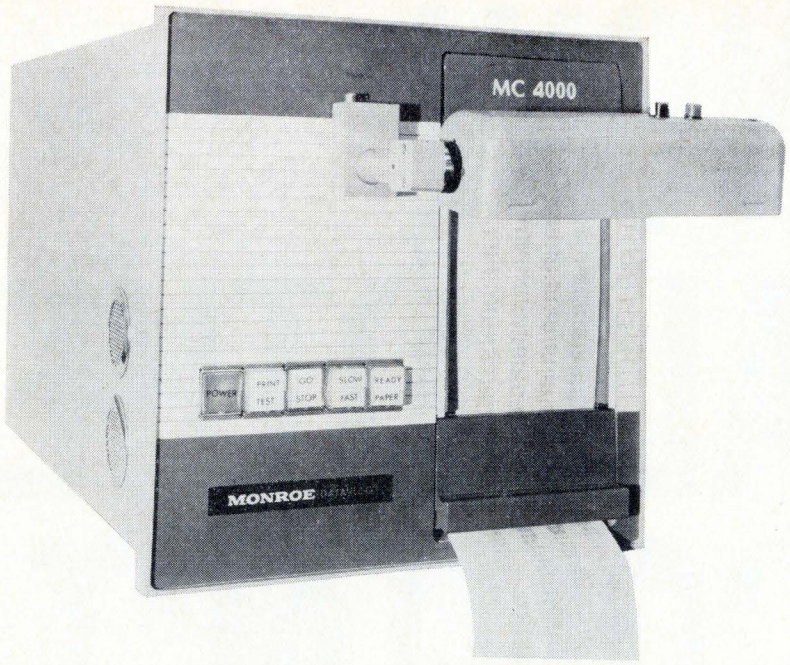


Fig. 10 Monroe Datalog's Model MC 4000 optical printer.

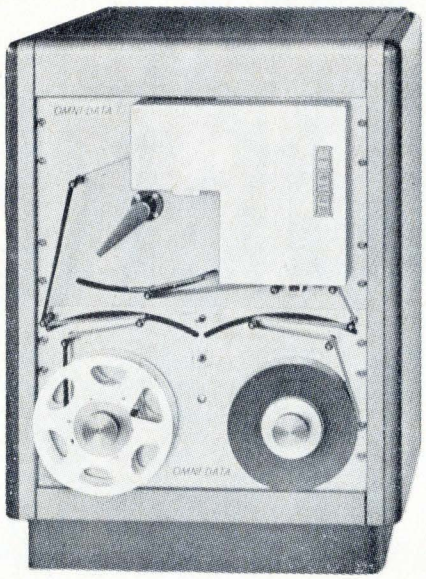


Fig. 11 Omni-Data's Model ITR-7 electrostatic printer.

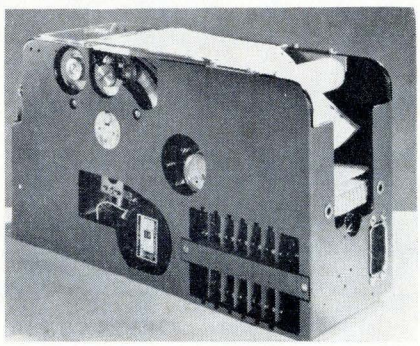


Fig. 12 Potter Instruments' Model HSP-3604 military printer.

printers, operating at 23 and 17 lines per second respectively. These two machines have optional input storage and input data levels. Another unit, Model MC 215, is a 3 line per second, 11-column numeric tab-type printer with a 10 line input and a tabulating carriage for output formatting. Other models by Monroe are modified numeric tabulating machines with either 10 or 14 columns, and operating at 2.3 lines per second while accepting 10 line inputs. Some models have keyboard inputs and punched tape outputs.

Omni-Data Div. of Borg-Warner, Philadelphia, Pa. — The Omni-Data ATR-7 is an electrostatic alpha-numeric strip printer providing 600 characters per second. Model ITR-7, shown in Fig. 11, is a numeric electro-static printer which will print up to 5 columns on a 1″ paper tape. The machine will print 300 lines per second. In asynchronous operation, the numeric unit offers speeds to 30 lines per second. Both machines can accept any binary code.

Potter Instrument Co., Inc., Plainview, L.I., N.Y. — Potter manufactures a number of "on-the-fly" printers that have been militarized to meet portions of MIL-E-16400, MIL-T-21200, and MIL-Q-9858. Some of the models use a unique hammer time-sharing design, where one hammer is used to print two adjacent columns by time-sharing the hammer with two different character sets on the drum. The Model HSP 3604, shown in Fig. 12, features immediate viewing of the last line printed and accommodation of four-part paper. This model

single bit alteration phase modulation recording?

Where else can you find this method of recording, less than 1 bit in 10^{12} bits transient error rate and less than 3 microseconds write to read recovery time – all at one megacycle data rate? At Magne-Head these are standard features not extra cost "options." Comparison is the key to your best buy. For Magnetic Drum Memory Systems – designed . . . engineered . . . and manufactured to your exact requirements, contact Magne-Head today.

MAGNE-HEAD *a division of General Instrument Corp.*
13040 South Cerise Avenue • Hawthorne, California 90250
213 679-3377/772-2351 • TWX 910-325-6203

CIRCLE NO. 31 ON INQUIRY CARD

MAJOR CHARACTERISTICS OF DATA LOGGING PRINTERS

MANUFACTURER	MODEL	APPROX. PRICE	CHAR. SET	PRINTING TECHNIQUE	THRU-PUT (CHAR./SEC)	SPEED (LINES/SEC)	MAX. LINE LENGTH (COLUMNS)	TRANSFER MEDIUM	DATA ENTRY	REMARKS
Beckman Instruments	1453	1-1.7K	10N*	Tab	36	3	12	Ribbon	Parallel	Modular Decoding System
Clary Corp.	4000	—	12N	Hypocycloid	315	15	21	Press. Sen.	Parallel	Military Printer
	2000	10-15K	12N	Hypocycloid	315	15	21	Press. Sen.	Parallel	Military Printer
	7000	1.8K	12N	Hypocycloid	400	20	20	Press. Sen.	Parallel	Optional Data Level Inputs
Cincinnati Time	TCP	—	10N	Tab	8	1	8	Ribbon	—	Also Prints Date & Time
Computer Measurements	410A	1480	10N	Segmented	120	10	12	Ribbon	Parallel	Moveable Decimal Point
Connecticut Technical	S-220	350	10N	Tab	33	3.6	9	Ribbon	Serial	Also Slower Speed Version
Di/An Controls	NN	2.5-6K	14N	On-The-Fly	1280	40	32	Ink Roll	Par. or Ser.	Line Storage Available
	NA	3-8K	48A**	On-The-Fly	640	20	32	Ink Roll	Par. or Ser.	Line Storage Available
	DL	2-2.5K	14N	On-The-Fly	640	40	16	Ink Roll	Par. or Ser.	Line Storage Available
Franklin Electronics	1200	2K	16N	On-The-Fly	240	20	12	Ribbon	Parallel	Also 30 and 40 lps models
	2200	2.7K	64A	On-The-Fly	440	20	22	Ribbon	Parallel	Optional Data Level Inputs
	120A	250	64A	On-The-Fly	20	—	1	Ink Roll	Parallel	Printing Mechanism Only
Hewlett-Packard	562A	1060	11N	Tab	55	5	11	Ribbon	Parallel	Several Models Available
Mite Corp.	118A	500	64A	Tab	10	—	1	Press. Sen.	Serial	Strip Printer
Monroe Datalog	MC 4000	5.6K	64A	Optical	3200	100	32	Photo-Sen.	Serial	Async or Sync Operation
	MC 1380	1.7K	10N	On-The-Fly	368	23	16	Ribbon	Parallel	Also 17.3 lps model
	MC 215	400	10N	Tab	33	3	11	Ribbon	Serial	With Tabulating Carriage
	MC 202	700	10N	Tab	23	2.3	10	Ribbon	Parallel	Other Similar Models Available
Omni-Data	ATR-7	—	64A	Electrostatic	600	—	1	Elec.-Sta.	Serial	Strip Printer
	ITR-7	—	10N	Electrostatic	1500	300	5	Elec.-Sta.	Parallel	Operates Async at 30 lps
Potter Instruments	HSP-3601	12K	16N	On-The-Fly	184	8	23	Press. Sen.	Parallel	Militarized
	HSP-3603	13K	16N	On-The-Fly	120	10	12	Press. Sen.	Par. or Ser.	Militarized
	HSP-3604	5K	64A	On-The-Fly	260	10	26	Press. Sen.	Parallel	Time-Sharing Hammers; Militarized
	HSP-3606	11K	64A	On-The Fly	100	10	10	Press. Sen.	Parallel	Militarized
Reo Div., Spectra-Strip	P8000	0.8-2.6K	10N	Tab	48	2	24	Press. Sen.	Par. or Ser.	Accepts Any BCD Code
Shepard Labs	Mini-Typer	—	12N	On-The-Fly	1920	40	48	Ribbon	Parallel	Built to Mil Specs
	Mini-Typer	—	64A	On-The-Fly	720	15	48	Ribbon	Parallel	Built to Mil Specs
Soroban Engineering	CT-1	—	16N	Tab	100	5	20	Ribbon	Serial	Also Alphanumeric Version
United Systems	610	750	12N	Tab	6.4	0.8	8	Ribbon	Parallel	Modified Adding Machine
Victor Comptometer	—	750	10N	Tab	30	3	10	Ribbon	Par. or Ser.	Modified Adding Machine

*N — Numeric **A — Alphanumeric.

also features a patented paper feed mechanism that is active only on the advance cycle, therefore, according to the company, it is less susceptible to failures. Model HSP-3601 is capable of printing up to 26 columns in a 30-column format with 16 characters available per column. Maximum operating speed is 12 lines per second.

Reo Div. of Spectra-Strip Wire & Cable Corp., Garden Grove, Cal. — The Reo Series P8000 data printers are tab-type units operating at 2 lines per second. The printers accept any standard 4-line BCD code. One to 36 column-units are available. The printers are constructed with interchangeable plug-in modules. Model is shown in Fig. 13.

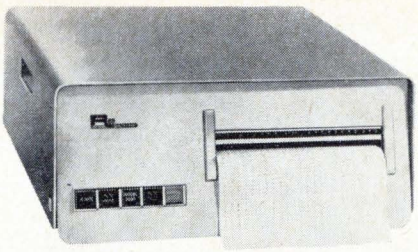


Fig. 13 Reo's P8000 data printer.

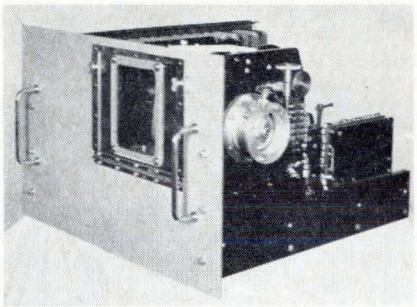


Fig. 14 Shepard Laboratories' "Minityper" printer.

Shepard Laboratories, Inc., Summit, N.J. — The Shepard Minityper is an "on-the-fly" printer with a maximum capacity of 48 columns. The printer will operate at 15 alpha-numeric lines per second or up to 40 numeric lines per second. The Minityper, shown in Fig. 14, features intermediate movement of ribbon for extended life. Impact sensitive paper can also be used and a paper advance control is provided to allow for line skipping. Units will accept any input codes of up to 6 binary digits.

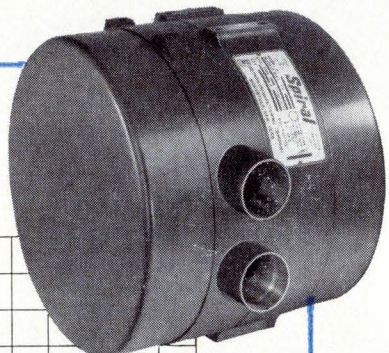
Soroban Engineering Inc., Melbourne, Fla. — Soroban's Model CT-1 is a tab printer utilizing direct positioning of a single font bar in combination with the sequential mechanical actuation of parallel hammers. The printer uses an octal decoding scheme. The Model CT-1, shown in Fig. 15, can also be supplied as an alpha-numeric printer operating at rates of 75 to 80 characters per second with a 64-character set. In this case, three octal characters are required for input to the printer.

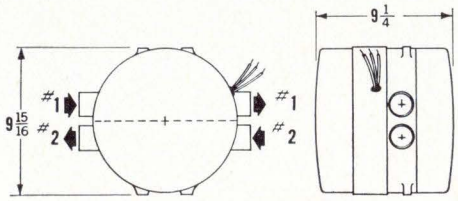
United Systems Corp., Dayton, Ohio — United Systems' Digi-Tec printer, Model 610, is a solenoid-operated adding machine which complements the company's digital voltmeter line. The printer prints out 8 numeric columns and accepts 1-2-4-8 BCD input code. Adding and

TWO INDEPENDENT AIR SOURCES

DUPLEX Spiral®

FROM ONE AIR MOVING PACKAGE





The Duplex SPIRAL provides three models for applications requiring greater flow, greater pressure, or two independent high pressure air streams. The Duplex SPIRAL fills a wide variety of applications such as . . . Power supply for fluid amplifiers . . . Magnetic tape slack control and capstan motor cooling in one package . . . Card handling equipment . . . Laser head cooling . . . Waveguide pressurization or cooling . . . Air bearings for tape or film . . . Printed circuit motor cooling . . . and hundreds of other applications calling for an economically priced, high pressure/vacuum air source with a **long maintenance free life.**

Consider these outstanding performance characteristics:

- **Pressures/vacuums to 2 PSIG (Model SL4)**
- **Airflow delivery to 94 CFM (Model SL5)**
- **Oil free air flow — No Contamination**
- **Low acoustical and electrical noise levels**
- **Low speed 3300 RPM**
- **Continuous duty — Long Maintenance Free Life**

The high performance characteristics of the Duplex SPIRAL are achieved by directly driving the impellers from an integrally mounted induction motor. No sliding vanes, seals, or speed increasing devices are employed.

The absence of brushes and commutators makes the Duplex SPIRAL incapable of generating troublesome RF noise. Adjustable trimmer sets performance — no power supply adjustment or pressure regulator required.

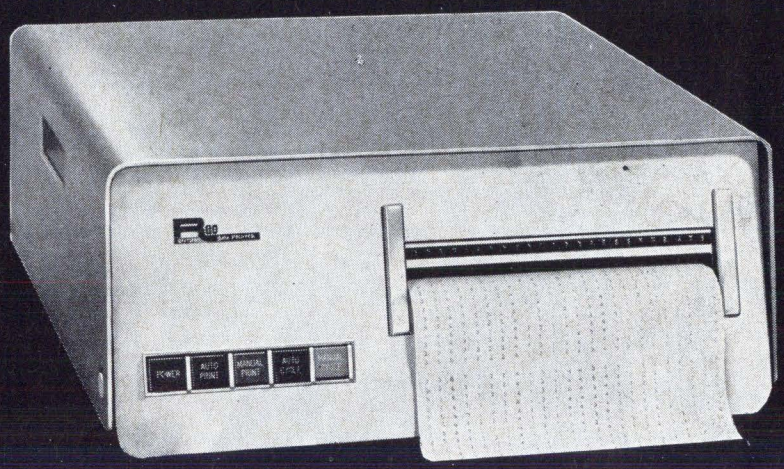
For full information on the Duplex SPIRAL write to . . .

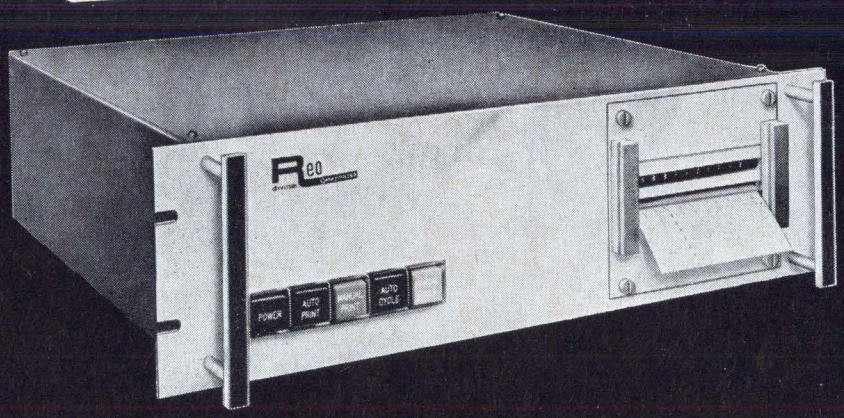
ROTRON®

ROTRON MANUFACTURING COMPANY, INC.
WOODSTOCK, NEW YORK

West Coast: ROTRON PACIFIC, Glendale, California
Rotron-Vactric Europa (N.V.) Breda, The Netherlands
Export Sales. AURIEMA INTERNATIONAL GROUP

CIRCLE NO. 33 ON INQUIRY CARD





A MAJOR BREAKTHROUGH IN DIGITAL PRINTERS

☐ READ-OUT/PRINT-OUT ☐ NO INK RIBBON ☐ ALL SILICON MODULAR DESIGN ☐ ACCEPTS **ANY** STANDARD FOUR LINE BCD CODE AT **ANY** STANDARD INPUT LOGIC LEVEL ☐ ACCEPTS 10 LINE CODE ☐ ANY NUMBER OF COLUMNS FROM 1 TO 36 OR MORE ☐ HIGH RELIABILITY ☐ UNATTENDED OPERATION ☐ LONG LIFE ☐ COMPLETE INTERCHANGEABILITY "PLUG IN" MODULES ☐ LOW COST ☐ RACK MOUNTING (ONLY 5¼" HIGH) OR CABINET MODELS ☐ SPECIAL PRINT CHARACTERS AVAILABLE ☐ NO MAINTENANCE

COST: EIGHT COLUMN $ 1145.

excellence in engineering

- RESEARCH
- ELECTRONICS
- OCEANOGRAPHY

Reo division DATAPRINTER

SPECTRA-STRIP WIRE & CABLE CORP.

Write, Wire or Call for information to: **Reo Division**

SPECTRA-STRIP CORP. P.O. BOX 415F, GARDEN GROVE, CALIFORNIA 92642 TEL: (714) 537-4530 TWX: (714) 530-0313

CIRCLE NO. 34 ON INQUIRY CARD

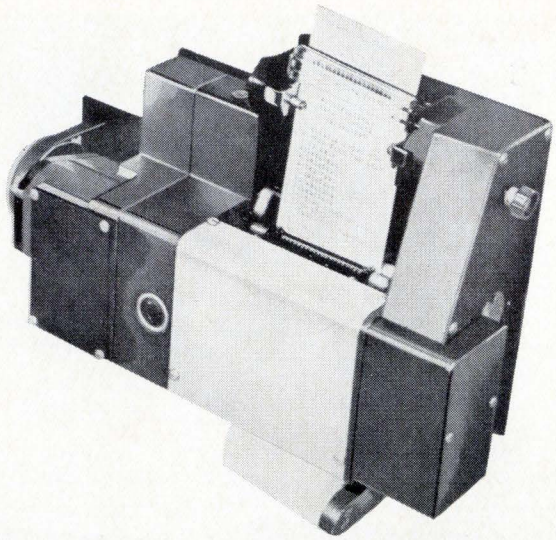


Fig. 15 Soroban Engineering's Model CT-1 printer.

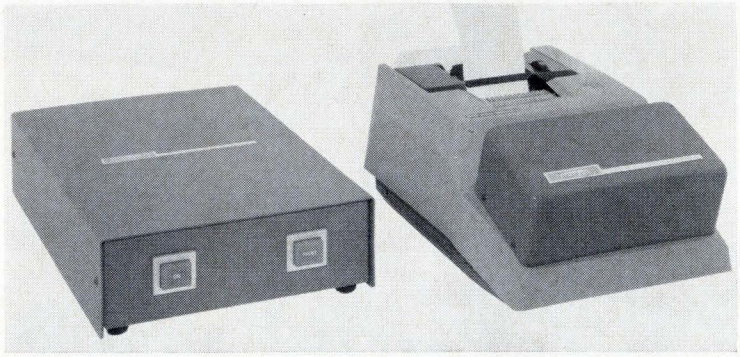


Fig. 16 United Systems' Model 610 printer with Model 620 printer control unit.

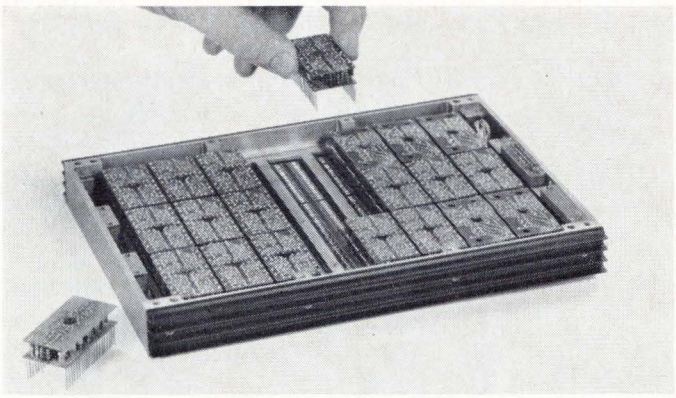
subtraction functions are available on special order along with time printout. The Model 610 printer and the Model 620 printer control unit are shown in Fig. 16.

Victor Comptometer Corp., Chicago, Ill. — The Victor "Digit-Matic" serial entry printers are modified calculating machines using direct font bar positioning. These printers have capacities of up to 11 columns and operate at a maximum of 3 lines per second with a straight numeric character set. One version of the Digit-Matic is a 14-column printer which uses the extra columns to print out the time of day from a self-contained 24-hour clock. Also, these machines are capable of printing out in either red or black ink. Parallel-entry model is shown in Fig. 17.

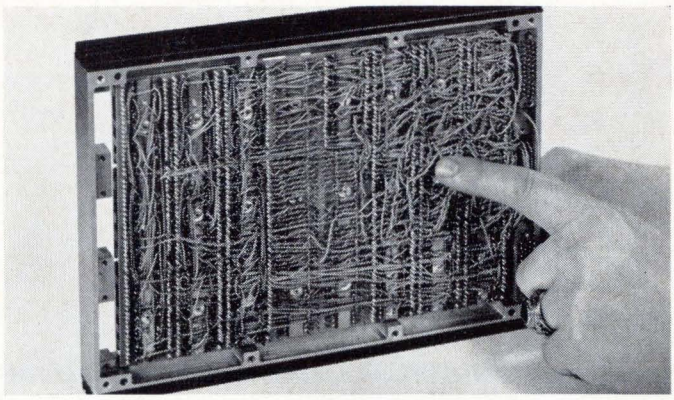
Fig. 17 Victor Comptometer's parallel-entry printer.

Summary

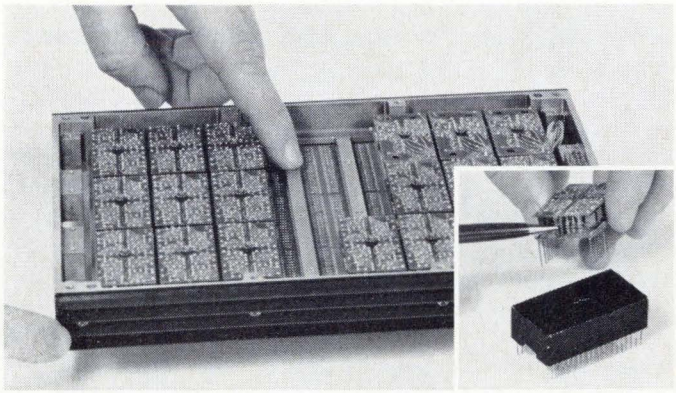
We conclude this 2-part Product Reference File survey with a brief reminder that the manufacturers' units mentioned here were just examples of each company's capabilities. For a complete reference file, we recommend that the reader supplement this article with a set of company brochures and data sheets. The list of manufacturers in Table 1 is keyed with reader service card numbers for your convenience in requesting this material.



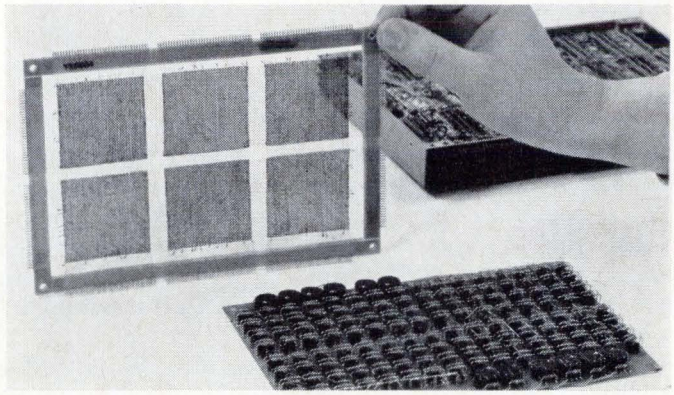
Economical circuit modules, mated directly through a parent-board assembly can be potted with light-closed cell foam if desired.



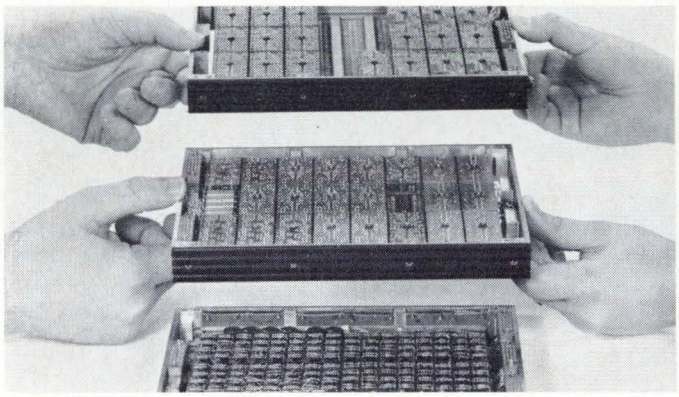
Wrapped wiring of circuit module terminations eliminates connectors, increases reliability, and yet retains easy replacement features.



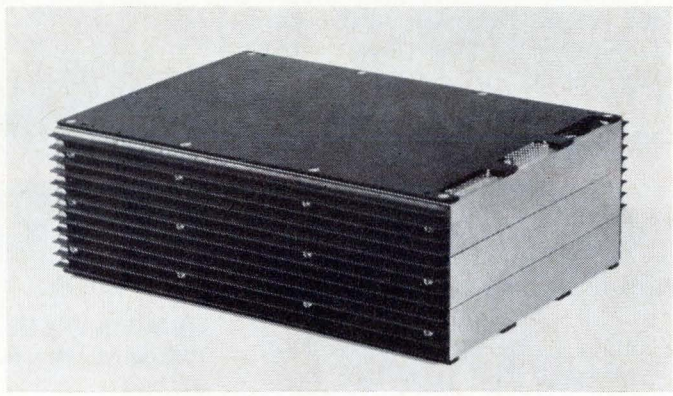
All heat-producing components mount directly to heat sinks. Inset shows how circuit modules each contain individual heat conductors.



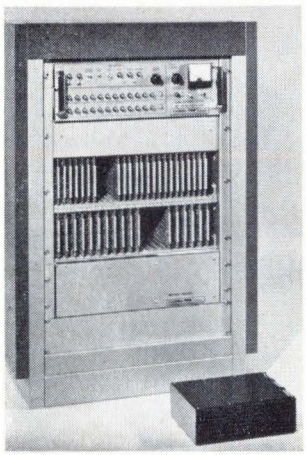
Memory stack consists of 64 x 64 core arrays mounted on rugged, laminated frames. Wide temperature cores are used. Planes can be potted.



System is composed of stacked modules. Number of modules depends upon memory capacity. This typical system has 3 modules and a capacity of 4,096 x 12.



This typical Series MC memory is 7.25″ x 9.375″ and weighs approximately 8 pounds. Max. power dissipation is less than 48 watts. Operating temperature range is —55° to 71°C.



Two Fabri-Tek 4,096 x 12 memories. The larger one is the 1 usec. Series MF. Dwarfed is the 4 usec. Series MC compact memory. Of course, the big one has integral power supply, self-test, and many other features.

A COMPACT, RUGGEDIZED MEMORY FOR SPECIAL-PURPOSE APPLICATIONS

This Fabri-Tek memory incorporates high-reliability packaging techniques intended to extend the MTBF to from 7,000 to 10,000 hours. Typical applications for this memory are: use in industrial atmospheres, geophysical van-mounted systems, special-purpose aircraft, and military applications. Fabri-Tek has used MIL-E-16400 and MIL-E-5400 as development criteria. Ask for information about the Series MC memory system. Write: Fabri-Tek Incorporated, Amery, Wisconsin. Call: 715-268-7155. TWX: 510-376-1710.

FABRI-TEK INCORPORATED

CIRCLE NO. 36 ON INQUIRY CARD

NEW PRODUCTS

SMALL TAPE PRINTER

Subminiaturized tape printer is said to offer advanced capabilities for both airborne and ground communications, and as a read-out device for computers and other types of data handling electronics. The Model 118A measures only 5″ wide by 10″ long by 2″ high, and weighs about 4 lbs. It prints approximately 22,000 characters on a self-contained 3-inch roll of tape at speeds infinitely variable up to 10 characters per second. If desired, a larger tape can be mounted externally or on top of the unit. No tools are needed for paper tape replacement. Characters are 0.098″ high x 0.062″ wide, with 9.3 to the inch. The last character printed is always visible. Any 64 character alphabet can be furnished. Mite Corp., New Haven, Conn.

Circle No. 148 on Inquiry Card

NICKEL-ALLOY MAGNETIC CORES

Familiar nickel-alloy tapewound or cased cores have been repackaged for lower cost as new standardized line of bobbin cores. Offered are direct size interchanges to 1½″ OD plus new narrow widths to 1/32″, even in Supermalloy. New packages allow the changing of alloys freely among ⅛, ¼, ½, and 1 mil gauges for best frequency response. Smaller enclosures, better tolerance of rough environments, custom processing, and many optional services are offered. Cores can be used in mag-amps, dc inverters, SCR firing circuits, shift registers, core-rope computer memories, and other digital circuitry. Infinetic, Inc. Wilmington, Del.

Circle No. 154 on Inquiry Card

NOISE TOLERANT FLIP-FLOP

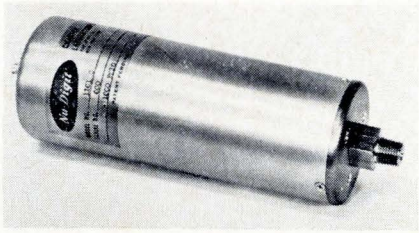
A 25 kc flip-flop is said to have outstanding noise rejection characteristics. Transients of 5 volts peak on the power supply line, 4 volts peak on the circuit output lines, and 1.75 volts peak on the input line will not cause the unit to malfunction. The flip-flop module, designated the Q-420, measures 2.0″ x 0.5″ x 0.725″ and is totally encapsulated. Unit is priced at $3.96 in quantities of 5000 or above. Engineered Electronics Co., Santa Ana, Cal.

Circle No. 142 on Inquiry Card

MICROMINIATURE REED SWITCH

Said to be the first microminiature magnetic reed switch commercially available, a single pole, Form A unit was specifically designed for ultra-high speed, low-level switching systems. The switch has a glass length of 0.375″ max., glass diameter of 0.090″ max., and overall lead length of 2″, which can be trimmed to overall length of 0.5″. Actuating time, with normal overdrive, is 0.5 millisecond average, including bounce so it can follow up to 300 cps. Resonant frequency of reeds is approximately 4.5 kc. The leads are electroplated gold with a contact surface of rhodium over gold. The open contact capacitance is approximately 0.25 PF and initial contact resistance is 300 milliohms max. at 150% overdrive. The life expectancy is over 10 x 10^6 operations at full rating and almost infinite at dry circuit loads. Hamlin, Inc., Lake Mills, Wisc.

Circle No. 121 on Inquiry Card



NUCLEAR DIGITAL PRESSURE TRANSDUCER

New line of pressure transducers are pulse-count units, using an alpha source to generate a highly stable pulse rate output of 0-10,000 pps, proportional to pressure. Outstanding advantages claimed for these units are constant high accuracy over long periods of time regardless of temperature, rough service, and other demanding environmental conditions. Called the Nu-Digit, the digital pressure transducer operates as follows: the pulse output is obtained by mechanical modulation of one of the world's most stable generators, a nuclear source (Alpha-emitting Americum-241, with a half-life of approximately 458 years is used), according to the company, no radioisotope license is required by the user. Modulation is accomplished by use of a bourdon tube, bellows, or other mechanical sensor to change the size of an aperture through which the alpha particles pass. Particles passing through the aperature and reaching the nuclear silicon diode detector generate pulses which are standardized by compact silicon solid-state electronics. Digital readout in engineering units is obtained by counting the output pulses for a programmed time interval, and/or by use of a count-rate divider. The measured variable is automatically averaged over the programmed counting time. A digital display and printed record of each measurement may be obtained by use of a Nu-Digit Model 1720 computing counter or various other commercially-available hardware. The company can supply either the transducers or the complete readout and control package. Charter Laboratories, East Northport, L.I., N.Y.

Circle No. 175 on Inquiry Card

DC-TO-DC CONVERTER

A new dc-to-dc converter was designed primarily to provide isolation and/or voltage step-up for a series of reference units. This device utilizes an inverter principle to accomplish this end. While this component is primarily used with the reference units, it can be provided for other applications such as isolated power units for differential amplifiers, etc. Specifications include an input range of 6 volts dc minimum to 36 volts dc maximum and output ratios of 1 to 1, 1 to 2, 1 to 3, and 1 to 6. Instrulab, Incorporated, Dayton, Ohio.

Circle No. 162 on Inquiry Card

DATA LOGGING SYSTEMS

Two new data logging systems were developed for scanning or multiplexing analog signals with subsequent digitizing and logging of the data on punched paper tape or hard copy. The systems provide a capability to scan continuously and log data at rates up to 120 characters per second on 8-level punched paper tape or 20 lines per second on printed hard copy. The Series 1510 can be operated in several modes, while the Series 1520 is operable in four modes for automatic, manual, or external control. Electronic Associates, West Long Branch, N. J.

Circle No. 146 on Inquiry Card

HALF-MICROSECOND MEGABIT MEMORY

A half-microsecond megabit memory system is said to be the fastest large-capacity memory commercially available. Called the Nanomemory 500, it is priced, according to the company, at a third more than current two microsecond memories, or a four-fold increase in throughput at an increase in cost of only 30 percent. The basic system has a capacity of 16,384 words of up to 84 bits, uses 2-½-D selection techniques, and employs an 18-mil core. Electronic Memories, Hawthorne, Cal.

Circle No. 155 on Inquiry Card

NEW PRODUCTS

INCREMENTAL RECORDER

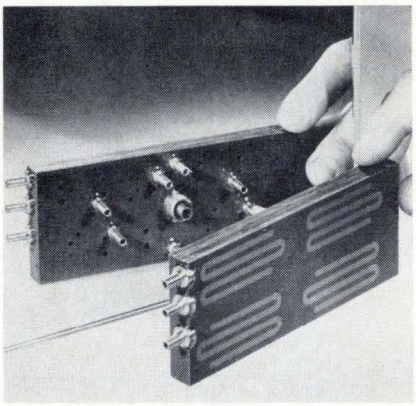
New incremental digital recorders are believed to contain fewer moving parts than any other digital stepping recorder currently available. The new recorder is capable of preparing IBM compatible magnetic tape. Data may be recorded asynchronously and at various rates, depending upon the model. Every recorder comes complete, ready to operate from normally available field signals. Each recorder is supplied with mating connectors and is available with either positive or negative polarity. Digi-Data, Bladensburg, Md.

Circle No. 138 on Inquiry Card

LOW-COST DTL CIRCUITS

Characterized as the lowest priced, plug-in packaged DTL integrated circuit family, a new series includes a J-K flip-flop, three multiple DTL gate packages (dual, triple, and quadruple NAND/NOR), a quadruple gate-input expander, and a dual DTL line driver/buffer element. The circuits are designed to operate in the 15C to 55C range. Unit prices in 100 up quantities range from $3.00 to $3.95, which corresponds to less than 90c per gate function for the quad gate element. The package body of the circuits is a solid block encapsulating both the circuit chip and the leads connecting it to the external plug-in pins, thus making the entire assembly a monolithic structure. Signetics Corp., Sunnyvale, Cal.

Circle No. 123 on Inquiry Card



FLUID BINARY COUNTER

Four fluid amplifier binary counter stages have been integrated in a monolithic four-bit counter. The new device counts 16 discrete numbers, re-setting to zero automatically at the count of 15. It shows a frequency response of more than 1000 cps. Versatility of the counter is pointed up by its random set and re-set capability. Since the user can set it to start counting on any number and to stop counting and return to zero on any number, the counter can handle any number sequence within the 16-digit framework. The counter is being marketed by Corning through distributors of the Imperial-Eastman Corp. By integrating four binary counter stages in one device, this unit is said to offer substantial cost savings. According to the company, fluidic system designers have been paying $120 for four individual counters required to do the same job as this new four-bit counter, which is priced at $80 list. The user of this new unit does not have to mount and connect 4 separate counters. Also, response times are reduced by integrating four counter stages in one package, since the length of connecting passages is reduced by 50 percent. The integrated counter is load insensitive, according to the company, so it is easily coupled in complex counting systems, staged to other parts of a fluidic system, or linked to readouts. Nominal supply required is five pounds per square inch gauge. Input signal required is one psig. Output is more than 1.5 psig. Exclusive of its fittings, the new counter has external dimensions of 6.375 x 2.25 x 0.500-inch. Corning Glass Works, Corning, N. Y.

Circle No. 179 on Inquiry Card

OPTICAL READER

A new high-speed optical reader, called the 420-2, can digest 52 lines of print per second at up to 32 characters per line for a maximum of 1664 characters per second. It reads business machine "journal tapes" with as little as 2 inches of printed data or as much as 1,560 inches. Produced as a by-product of normal operation, the journal tapes may be partly or wholly in NCR's special optical typefont and may be printed in purple, black, or red. Only the special typeface is read by the scanner. Any business can simply feed its journal tapes into the optical reader which can be either "on-line" to a computer or used as a control unit to automatically prepare punched tape or punched cards. Internally programmable, the new optical scanner features automatic tape editing, 10-second tape change, selective line output, and four programs for variable output formats. The tape transport system accommodates a variety of paper widths, and the scanner is said to feature an extremely wide tolerance for print variations. Typical transfer rate to the NCR 315 computer is 10 microseconds per character. Priced at $80,000, the new reader will have a basic monthly rental of $1,950. The monthly rate is $50 higher than NCR's 420-1 scanner, for which the user will obtain twice the basic speed as well as the new features and system improvements. National Cash Register Co., Dayton, Ohio.

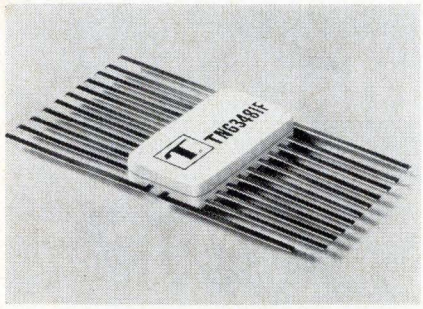
Circle No. 120 on Inquiry Card

LAMINATED BUS BARS

Miniature-size laminated bus bars are said to reduce noise in power or signal distribution systems. The buses can be fabricated to the most exact tolerances. Thickness of conductors is 0.005″ to 0.045″. Material length and width of conductor levels are optional and ground levels and tabs can be incorporated. Tabs can be soldered or wrapped and can be bent to any angle. Eldre Components, Inc., Rochester, N. Y.

Circle No. 190 on Inquiry Card

NEW PRODUCTS



22-LEAD FLAT IC PACKAGE

A new hermetically sealed, 22-lead flat package was developed for use with selected HLTTL integrated circuits. Construction of the 22-lead package utilizes ceramic-glass technology which insures a highly reliable hermetic seal. Nominal dimensions of the package are 0.250 in. (width) x 0.450 in. (length). The eleven leads on each side are 4 mils thick and 14 mils wide, and are located on 50 mil centers. The package has a gold-plated kovar bottom plate, allowing for greater power dissipation capability. The first circuits offered in the new package are: quad 4 input NAND/NOR gates and dual master slave JK flip-flops. Additional HLTTL functions which are expected to be available in this package in the near future include 2-stage shift register circuits and 2- and 4-stage counter circuits. Transitron Electronics Corp., Wakefield, Mass.

Circle No. 128 on Inquiry Card

AXIAL FAN

With a free air rating in excess of 300 cfm, a new 5½" shaded-pole axial fan delivers 270 cfm at 0.15" water static back pressure and 235 cfm at 0.25" static back pressure. All-metal construction and precision workmanship are said to guarantee 20,000+ hours operation, continuous duty, at 45C without maintenance. Pamotor, Inc., San Francisco, Cal.

Circle No. 136 on Inquiry Card

FLIP-FLOP MODULES

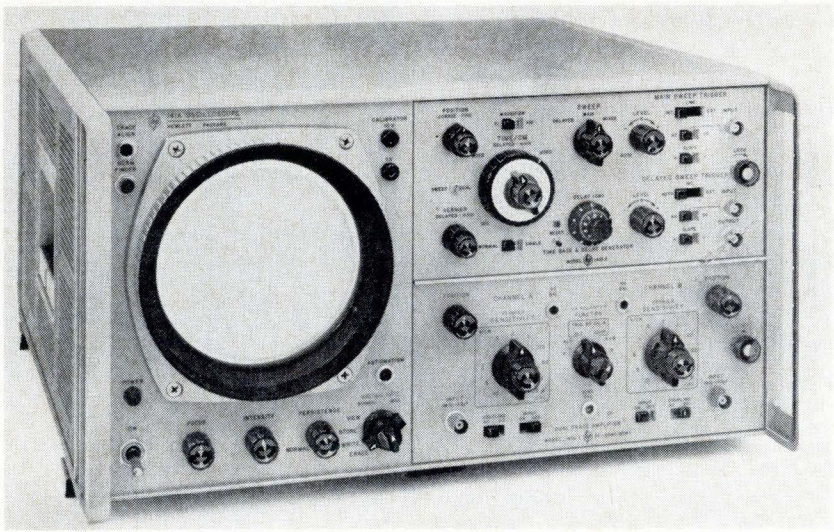
Two general-purpose flip-flop modules are said to be particularly useful in experimental or breadboard work. Designated 2FB-M and 2FB-H, the modules are spray etched and wave soldered to provide consistently uniform fabrication and eliminate the possibility of irregular etching and poor solder joints. The modules provide two independent JKRS type flip-flops with separate dc (RS), ac (JK), and steering inputs. Logic levels are -10 ± 2 volts at logical ONE, and -0.25 ± 0.25 volts at logical ZERO. Wyle Labs, Products Div., El Segundo, Cal.

Circle No. 141 on Inquiry Card

HIGH-SPEED READER/SPOOLER

New high-speed photocell punched tape reader/spooler combination includes on-off servo operated reels and electronic noise suppression to a level that effectively eliminates any possibility of interference with the most sensitive of systems including the new integrated circuit computers. It features speeds up to 300 characters-per-second with pushbutton or remote control rewind of 40 inches-per-second, typical average. Reels of 5 ¼ inch diameter are available with storage capacity of up to 500 feet of punched tape. Rheem Electronics, Hawthorne, Cal.

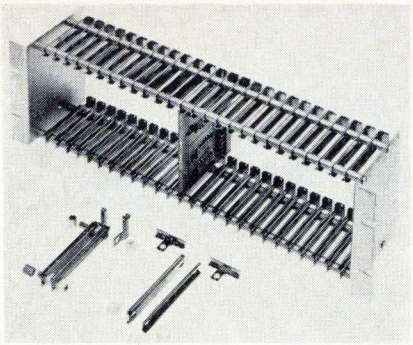
Circle No. 168 on Inquiry Card



VARIABLE-PERSISTENCE SCOPE

A new oscilloscope main-frame is said to perform functions which were previously unattainable. It behaves exactly like a conventional scope, until its PERSISTENCE or STORE knobs are operated. Then the new Model 141A will produce gradually-decaying traces whose persistence may be varied continuously from about 1/5 second to more than 1 minute. When switched to the STORE mode, it becomes a storage scope, yet retains the advantages of conventional scopes: dark background for contrast, long tube life, and non-glare internal graticule screen with no-parallax display. Waveforms may be observed up to 1 hour without degradation, and stored for days with the instrument turned off. With continuous variability of trace fade-time, slowly-swept traces may be kept continuously on display, by adjusting persistence to match sweep time. Annoying flicker is removed from slow sweeps; the trend of changing waveforms can be followed by superimposing successive traces with rate-of-fade adjusted to prevent confusion from the accumulation of too many traces. Meaningless random deviations from sweep to sweep may be rejected, since successive repetitive traces will add in brightness. Successive sweeps may be superimposed to observe trends in the behavior of the subject through a series of adjustments. Model 141A is priced at $1275, without plug-ins, Hewlett-Packard, Palo Alto, Cal.

Circle No. 191 on Inquiry Card



PC RACK

New concept of printed circuit board rack design uses standard components which can be assembled to any configuration and board spacing. The new PCB rack system consists of PCB guides, connector brackets, and spacers assembled on support rods between side plates. The steel guides, which are available in single and double (for multiple row assembly), come in lengths from 2-inch to 10-½ inches in ½-inch increments. Board spacing of ⅜-inch through 1-inch in 1/16-inch increments is easily accomplished by close tolerance spacers. Side plates and support rods are available in any size. The design of the connector brackets permits easy installation of any type of edge or pin-type connectors. Price range is from $0.50 to $1.00 per card station depending on size and quantity. The Birtcher Corp., Industrial Div., Monterey Park, Cal.

Circle No. 172 on Inquiry Card

MERCURY-WETTED RELAYS

A new line of miniature mercury-wetted contact relays is available with five standard contact configurations. These relays are said to permit use of printed circuit mounting in ½ the size previously possible. Units are available in 6, 12, and 24v nominal coil voltages. Contacts are rated for 1 amp at 28v with life of 10 million operations at full load, almost infinite at low level. Contact resistance is 50 milliohms with no bounce. Operate and release time is specified at 2 ms max. at nominal voltage. Douglas Randall, Inc., Westerly, R. I.

Circle No. 161 on Inquiry Card

NEW PRODUCTS

MEMORY TEST SYSTEM

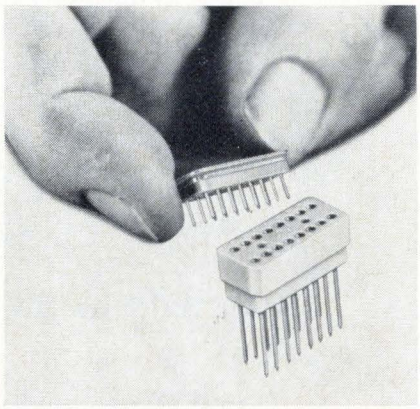
A new programmable pulse generator was designed for use in laboratory and production line testing of ferrite memory components. Designated the PPG 2120, the generator is a table-top system offering 4, 8, or 16-step testing programs for such devices as cores and films operating at speeds between 10 kc and 5 mc. It provides six output channels fed by high-speed current drivers, with individual adjustments for pulse width, shape, and position. Pulse width can be varied from zero to ten microseconds, and each pulse can be delayed after the start of a program step by up to ten microseconds. The system has two independent repeat channels, permitting the user to select step repeats at any program steps and pair repeats for any even-odd pair. Repetition intervals are continuously variable from 200 nanoseconds to 3 milliseconds. Digital Equipment Corp., Maynard, Mass.

Circle No. 124 on Inquiry Card

MASS MEMORY

New disc file memory provides a storage capacity of 200 million bits, a data-transfer rate of up to 42 million bits-per-second, and an average access time of 17 milliseconds. Called the Librafile 3800, the system was designed for use in large scientific computing centers, in message-switching centers, in military command-and-control installations, and in intelligence data processing systems. The mass memory is available in a basic 6-disc configuration which features a fixed-head per track, two methods of search and retrieval, and retractable head plates. Information is retrieved either through fixed address or record-content search. According to the company, search by record-content is their exclusive technique that permits any field to be used as an access key. Only the nature, and not the location, of data sought need be known. This feature is said to eliminate costly flagging and table look-up programs, saves central-memory space, and permits simultaneous off-line search. Librascope Group, General Precision Inc., Glendale, Cal.

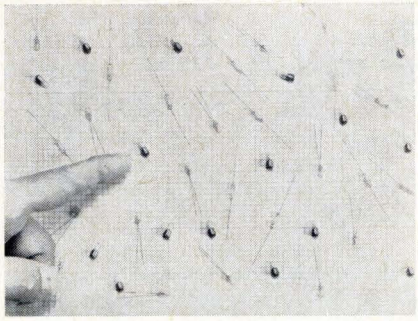
Circle No. 144 on Inquiry Card



IC CONNECTORS

A new, microelectronic connector allows the inter-connection of in-line or plug-in flatpack types of integrated circuits for purposes of testing, prototype design, and production packaging. Called the Pin Pack Connector, Model MPC4, the new device permits plug in and operation of up to 16 position plug-in flatpack integrated circuits in prototype systems as well as allowing the rapid and easy testing of these integrated circuit packages. This spring-loaded connector has 16 positions consisting of two rows, spaced 0.200″ apart, of eight lead sockets on 0.100″ centers. Socket locations are numbered both on the top and on the bottom of the connector and one corner is chamfered for easy indexing of devices. The connector features contacts consisting of gold plated beryllium copper helical springs permanently positioned in gold plated brass housing. In addition to providing a reliable contact for multiple insert applications, this type of socket prevents damage through the insertion of oversized probes (closed entry) and eliminates any possibility of solder fouling of the contact spring. Metals & Controls, Div. of Texas Instr., Inc., Attleboro, Mass.

Circle No. 192 on Inquiry Card



MICROMINIATURE LAMPS

A wide range of microminiature lamps is believed to be the most complete selection available in the industry. Bulb diameters as small as 0.094" and lengths as short as 0.145" make them ideal for applications where space is at a premium. Most lamps have lives approximately 100,000 hours, and they are designed to withstand both normal and unusual conditions of vibration, shock, and thermal variation. The lamps are available in voltages from 5.0 to 28.0 and in three styles: sub-midget flanged base, unbased with wire terminals, and with axial lead wire terminals. "Tipless" style bulbs permit undistorted end-viewing. The lamps are pre-aged and photometered to assure stability, reliability, and electrical accuracy. Quality control procedures meet or exceed MIL-Q-9858. Hudson Lamp Co., Kearny, N.J.

Circle No. 178 on Inquiry Card

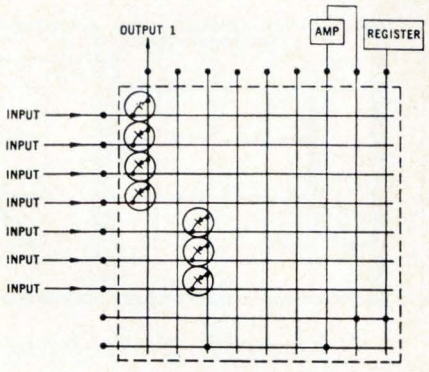
THUMBWHEEL SWITCH

New thumbwheel switch with dual common connections is said to be ideal for use in applications which cannot tolerate a floating or open input. By properly connecting the extra common, all unused lines will be grounded or connected to an alternate signal or voltage source. The new Model 257 converts dial setting to BCD with complement. Unit also features positive, no-hang-up detent action, large, easy-to-read digits, and rugged military type construction. All connections are made at the printed circuit card built into the back of the switch. EECo-Switch, Div. of Engineered Electronics Co., Santa Ana, Cal.

Circle No. 129 on Inquiry Card

LOGIC SWITCHING MATRIX

Digital logic assembly is said to be simple with a new program matrix board. By utilizing diodes in component holders, digital logic blocks of AND or OR gates may be patterned in a variety of input-output configurations by simply inserting the pins in appropriate holes. The board is a two-plane matrix, with bussed contacts, running at 90° to each other. Inserting a diode pin at the desired coincidence point between the two axes, connects the diode to the appropriate input-output points. Many other electronic components can be housed in standard or coaxial board pins and interposed between the two decks at the



"And" or "Or" Gates
Built With Sealectoboard

desired x and y coordinates by inserting the pin at the coincidence point. Sealectro Corp., Mamaroneck, N.Y.

Circle No. 132 on Inquiry Card

BIT-ERROR RATE MONITOR

A new monitor accumulates, stores, and displays bit-errors and compares serial data bits, dc to 2 mc. The solid-state monitor provides a means of comparing two serial NRZ data bit streams on a bit-by-bit basis. It accumulates the number of negative or positive comparisons over a bit interval selectable 10^3 to 10^7 bits or on a continuous basis. Provision is made for processing code forms other than NRZ. The number of bit-errors, or bit-matches, are presented on a visual three or four-digital display while presented simultaneously in BCD form as a printer output. It can be used in conjunction with PCM serial simulators to measure bit-error rate of PCM processing systems. It also has wide application as a general purpose comparator. Power supply is self-contained and input-output connections are provided on both the front and the rear of the unit. A built-in delay (0 to 5 bits) to compensate for delay of the processing system under measurement is provided. The unit has a frequency range of 0.8 bps to 1,200,000 bps. Defense Electronics, Incorporated, Rockville, Md.

Circle No. 158 on Inquiry Card

"NO-FAIL" POWER UNITS

A unique electronically-controlled "No-Fail Power System" instantaneously — without the loss of even a thousandth of a second — "takes over" the moment commercial power begins to fail. Designed especially to prevent even momentary "blackouts" of critical electronic equipment — computers, Teletype, and other data communications systems — the new No-Fail systems will be produced commercially in varied sizes ranging from 10 kilowatts to 250 killowatts. Unlike conventional "standby" engine generators, which take up to 10 to 15 seconds to assume the power load after utility power fails, the new No-Fail systems are designed for uninterrupted operation and instantaneous switchover. For computer and data transmission and processing operations, where even a momentary fluctuation of more than ½ cycle in electrical frequency will introduce errors in computer memories or garble important Teletype messages, the No-Fail systems provide 24-hour-a-day insurance against any "break", the company stated. Fermont Div., Dynamics Corp. of America, Bridgeport, Conn.

Circle No. 177 on Inquiry Card

NEW PRODUCTS

MILITARIZED DISC MEMORY

Militarized, high-speed disc-memory system includes an electronic subsystem that provides the necessary interface, control, and read-write electronics. Storage capacity is 25 million bits. The technique of information storage and retrieval is fixed-address. Average access time is 25 milliseconds. The disc memory features a flying-head design, plated cobalt recording surfaces, and retractable head bars, which ultimately prevent any head or disc wear. Each head-bar retraction mechanism is controlled by a programmed power-sequence network for automatic start-stop conditions. Data is organized in message blocks of eight 36-bit words and is written into memory 2-bit parallel, 18-bit serial. Each disc in the L-424M system provides storage for 36,750 message blocks of data. Word transfer rate is approximately 30 kc. Librascope Group, General Precision Inc., Glendale, Cal.

Circle No. 186 on Inquiry Card

DATA/COLLECTOR INTERFACE

A new system, called the Laboratory Data Collector and General Purpose Interface, was designed to provide a reliable, flexible and yet inexpensive digital data acquisition and recording capability for those who must collect, record, and process digital data from laboratory instruments or other sources, and record this data in digital form. The standard system allows the interfacing and control of a wide variety of digital output devices and instruments with almost any digital data recording device or direct computer interface. It eliminates the need for a new expensive "black box" for each new or different connection between such devices that becomes necessary in a laboratory or digital data aquisition system. The Laboratory Data Collector can be programmed and operated by laboratory technicians in a few simple steps, and does not require the experience of a computer programmer. It also allows automatic identification of data and automatic formatting and separation of data samples. It has built-in error checking and maintenance features which guarantee the validity of data processed and allows rapid repair of the unit by the technicians if this becomes necessary. The basic Laboratory Data Collector unit which will interface standard analog-to-digital converters and digital voltmeters, and control punched paper tape or incremental magnetic tape units, sells for $6,400. Various options including built-in analog-to-digital converters, digital multiplexors, digital data compressors, and digital clocks can be provided on a modular basis. Berkeley Scientific Laboratories, Berkeley, Cal.

Circle No. 184 on Inquiry Card

PNEUMATIC DATA LOGGING

Multi-channel data acquisition system for pneumatic process signals automatically multiplexes, digitizes, and records data from as many as forty-eight unique pressure signals in the range of 3 to 15 psig. A scanning type pressure sampling valve multiplexes each of the 48 pressure signals into a strain gauge transducer which converts the pressure signal into an electrical signal. The electrical signal is amplified with a low noise, high accuracy amplifier and digitized by a successive approximation analog-to-digital converter. The ten-bit binary output of the analog-to-digital converter drives an IBM 024 card punch machine which records the digitized pressure signals in a binary format, one pressure per card column. Up to 48 points can be recorded on a single punched card at rates up to 1.5 points per second. The digitized pressure signal is also presented on a control panel along with decimal channel identification number. The system initiates a scan cycle at fixed time intervals, and advances and digitizes sequentially through the input channels from channel number 01 to the highest channel number defined by the card punch's drum program card. The system can be equipped with interface circuits which are compatible for direct parallel input to a general-purpose stored program processor or alternatively, it can be interfaced with a data transmission system for serial data transmission over a voice-grade telephone circuit to a central processor. Houston Engineering Research Corp., Houston, Texas.

Circle No. 187 on Inquiry Card

UNATTENDED DATA TRANSMISSION

Bell System's Data-Phone service now enables business machines transmitting at speeds up to 2,000 bits-per-second (about 2,700 words-per-minute) to converse with one another without any human intermediary. Operating in conjunction with Bell System's 801-type Automatic Calling Units, the 201A Data-Phone data set now is compatible with computer-to-computer transmission as well as with machines that transmit punched paper tape, magnetic tape, and card media. With this new feature of the 201A Data-Phone data set, companies with several branch offices will be able to poll these offices automatically over the regular telephone switched network for sales, production, and other information. By making such polls in off-hours, companies will be able to take advantage of lower evening telephone rates and also reduce the transmission traffic which their telephone service must handle during regular hours. The typical equipment configuration would consist of an automatic calling unit and a data set at the headquarters location and a data set at each branch, along with the business machines. The telephone numbers of the locations to be polled would be stored in the computer system. Bell Telephone System, New York, N. Y.

Circle No. 152 on Inquiry Card

NEW PRODUCTS

DIGITAL TAPE TRANSPORT

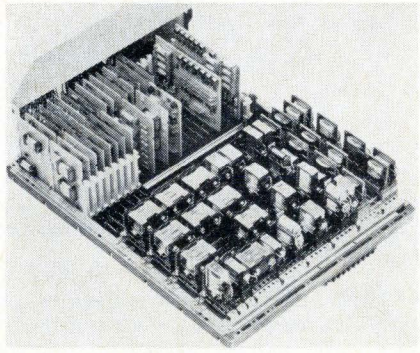
New series of digital tape transports provides a full range of compatibility with third generation computers with either 7 or 9 track recording format on half-inch magnetic tape. Available for single or multiple speed operation covering the range from 25 to 150 inches per second, and with recording densitites up to 800 bit per inch, the new transports offer data transfer rates to 120,000 characters per second. A complete system of data electronics offers options for either a single or multiple transport data bus, shared read output, read strobe, read buffer, lateral parity detection with programmable odd/even set, gap detection, LRCC error detection, and file mark detection. Midwestern Instruments, Inc., Tulsa, Okla.

Circle No. 176 on Inquiry Card

D-A CONVERTERS

A group of special circuit modules can be used to construct four basic types of digital-to-analog converters. Using the basic group of module types — ladder-adders, power supplies, and termination networks — either BCD or straight binary units can be assembled. Four basic module sets are available: 12-bit BCD with output of 0 to -5v at $\pm 0.10\%$ accuracy; 10-bit binary with 0 to -8v, $\pm 0.1\%$; 8-bit BCD with 0 to -2.5v, $\pm 1\%$; and 7-bit binary with 0 to -4v, $\pm 1\%$. In general, each D-to-A converter consists of two or more ladder-adder modules and a power supply. The ladder-adder modules provide a precision resistor network and the solid-state circuits to switch these resistors in or out of the chain, depending on the digital input signals. The power supplies provide operating voltage to the switching circuits and a precision reference voltage to the resistor network. Wyle Laboratories, El Segundo, Cal.

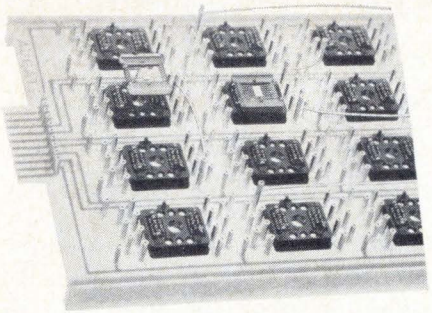
Circle No. 160 on Inquiry Card



CIRCUIT PACKAGING

A flexible circuit packaging system allows user to intermix solid-state and relay circuitry with a compact method for mounting and connecting printed circuit cards. The packaging concept is said to offer a system approach to circuit design problems. Two rectangular mounting frames are available. The Module I frame can accommodate six rows of single printed circuit cards, with 26 positions per row for a total of 156 card positions.) It can also be used to mount eight rows of wire contact or permissive make relays (separately or intermixed) for a maximum of 152 relays. Reed relays can also be accommodated in the system. A slightly larger Module II frame can be utilized to mount 10 rows of printed circuit cards, with each row containing 28 single card positions for a total of 280 printed circuit cards. Accessories available with Module I and Module II units are back panel wiring cards, ground planes, and voltage chains used to interconnect printed circuit cards. An exhaust fan and plenum assembly is available with the Module I frame for cooling components. Cable connector cards are also available to provide coupling between modules or to other units. Card socket terminals used with printed circuit cards have been designed for either solder or wire wrap terminations. IBM Corp., Industrial Prods. Div., White Plains, N. Y.

Circle No. 174 on Inquiry Card



IC BREADBOARD

A twenty-four pattern breadboard or test panel assembly with connectors installed permits breadboarding or testing of IC flat-packs in the carrier without the necessity of trimming the integrated circuit out of the carrier. Solderless jumper interconnections provide a rapid and flexible method of setting up and changing circuits. Price range is approximately $280.00 to $180.00, depending on quantity. Augat, Inc., Attleboro, Mass.

Circle No. 156 on Inquiry Card

FET/TRANSISTOR TEST SET

A general-purpose, easily-programmed test set was designed specifically to test electrical characteristics of p- and n-channel junction and MOS field-effect transistors. In addition, most small-signal and medium-power bipolar transistors and semiconductor diodes may be tested by adding other program modules. Outstanding features are said to include first test set designed to test FETs, p- and n-channel junction or MOS, ten picoamp leakage current resolution in an automatic set, modular construction with complete flexibility of test parameter order, test time programmable from 100 msec to 1 sec per parameter, and any transistor or diode within parametric limits of the equipment may be tested by changing test modules. The main chassis consists of a reed-relay commutator, integrated-circuit logic section, high performance operational amplifier, panel meter, function controls, and power supplies. Test modules are used to program each of eight test channels for device connections, biasing, test ranges, and test time. Siliconix, Inc., Sunnyvale, Cal.

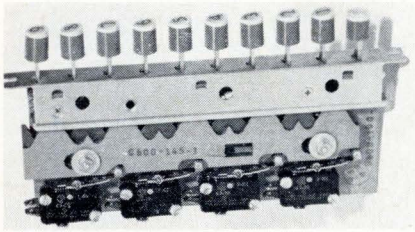
Circle No. 149 on Inquiry Card

NEW PRODUCTS

DELAY LINE MEMORY MODULE

One of a complete new line of 1-megacycle system logic modules, available in both germanium and silicon versions, delay line memory module can be used to store up to 2000 bits of information for 2 milliseconds. The information can be recirculated to increase the storage period, or, in the case of shorter records, can be recorded repetitively to decrease the access time. Delay lines of other lengths are also available on special order. A flexible array of input gating is incorporated on the module, and readout is via standard flip-flop outputs. Designated the Model 06, it contains its own clamp supply to minimize circuit susceptibility to noise transients. A heavy ground plane on the module provides additional shielding for the delay line itself. Price is $333. Navigation Computer Corp., Norristown, Pa.

Circle No. 157 on Inquiry Card



CODE BAR SWITCHES

New decimal code bar switch has a ten button decimal bank with 1-2-4 binary output contacts. Trouble-free encoding is accomplished with simple cam-type code bars and single-pole double throw snap action switches instead of multiple relay contacts usually employed for this purpose. A mechanical interlock permits only one pushbutton key to be depressed — any previously depressed button is automatically released. The switches are available with parity and with hermetic sealing for industrial use and they can also be provided to MIL E 5272 for airborne and ground-based equipment. C & K Components, Inc., Newton, Mass.

Circle No. 140 on Inquiry Card

SQUAREWAVE GENERATOR

A new general-purpose squarewave generator provides simultaneous positive and negative-going high-amplitude output pulse with a rise time of 12 nanoseconds or less, or a positive-going high-amplitude output pulse with a rise time of 12 nanoseconds or less. The fast-time output provides pulses of 50 millivolts to 500 millivolts amplitude into a 50-ohm load and has separate amplitude controls and output connectors for the simultaneous positive and negative-going signals. The high-amplitude output provides pulses of 0.5 volt to 12 volts into a 50-ohm load, 7 volts to 130 volts unterminated. Repetition rate of either output is selectable in decade steps from 10 Hz to 100 kHz. A continuously variable multiplier (uncalibrated) provides coverage between steps and extends the maximum repetition rate to 1 MHz. A symmetry control permits varying the duty cycle between 45% and 55%. The sync input accepts sinewaves of 5 volts to 100 volts peak-to-peak, and pulses or squarewaves of 2.5 volts to 50 volts. Price is $590. Tektronix, Inc., Beaverton, Ore.

Circle No. 143 on Inquiry Card

SINGLE-STAGE BLOWERS

Vortex-type single-stage blowers are said to feature excellent noise suppression without performance loss. Inlet and outlet are directly from the multi-blade impeller without any of the right-angle turns which can lower efficiency. Duplex operation — parallel for double the volume or series for double the pressure — is easily obtained by the addition of a second blower. The new blowers come up to 3350 rpm, where rated performance is delivered, in less than ½ second after power is applied. Static pressure head produced at no flow is 34 inches of water. Free air delivery is 60 cfm. Power consumption is approximately linear between these two extremes: 450 and 250 watts, respectively. Hydraulic efficiency approximates 27 per cent at a delivery of 35 cfm. Typical applications for the blower are as a vacuum source for tape transport mechanisms, a power source for fluid computers, inflating and maintaining pressure in collapsible structures, ice-making machines, or in any kind of pneumatic control device requiring low pressures. The Singer Co., Diehl Div., Somerville, N. J.

Circle No. 164 on Inquiry Card

FIXED-VOLTAGE POWER SUPPLIES

Fifty-one new all-silicon, fixed-voltage power supplies, in three package sizes, have multiple current ratings based on ambient temperatures of 40C, 50C, 60C, and 71C. In each of three package sizes, standard models are offered at 17 fixed-voltages ranging from 2 vdc to 48 vdc (plus or minus 5% voltage adjustment). In addition to the standard voltage ratings, any fixed voltage up to 65 vdc is available at moderate surcharge. Current ratings for E Package models (4-15/16" x 7-¾" x 11-⅞") range from 5.0 amps to 18.0 amps, with prices starting at $269.00. F Package models (3-½" x 19" x 16-½") are available with current ratings from 10.0 amps to 44.0 amps. Prices for these models begin at $380.00. Current ratings from 17.0 amps to 90.0 amps are offered in Package G models (5-¼" x 19" x 16-½"). Prices for these units start at $480.00. All current ratings for these convection-cooled power supplies are based on operation without forced air cooling. The ventilated construction of these units affords substantial increases in ratings with small amounts of air flowing over surfaces of the power supply. Adjustable, automatic electronic current limiting circuit limits the output current to the preset value upon external overloads including direct short, thereby providing protection for load, as well as for power supply. All of the models are available with built-in overvoltage protection. Lambda Electronics Corp., Melville, L.I., N.Y.

Circle No. 189 on Inquiry Card

CIRCUIT BOARD CHECKOUT

New auto-pneumatic circuit analyzer switching system automatically checks out high density circuitry boards. The system eliminates point-to-point checkout and features quick loading and locking of test circuit boards. Key to the equipment is the individual probe which applies uniform contact pressure on circuit check points of standard or irregular heights. Each probe is soldered to a coil spring and terminal connected. The terminals are retained in the bottom layer of a transparent 2-layer plenum chamber. All probes extend upward through the top surface. Upon application of air pressure, the probe extends through the top layer of the plenum chamber and makes contact with a specific component under test. Air pressure is supplied through a solenoid valve on signal from a circuit analyzer thus permitting an automatic step-by-step analysis of the circuit board. McKee Automation Corp., North Hollywood, Calif.

Circle No. 122 on Inquiry Card

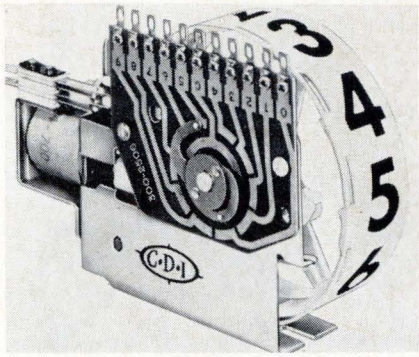
NEON TRIGGER TUBE

A subminiature neon trigger tube has a stand-off voltage rating, anode to cathode, of 190 to 210 vdc and is designed to be operated from transistors. The tube is ionized by a signal of 106 ±4 vdc applied to the third trigger electrode. Its maintaining voltage between anode and cathode is 100 ±2 vdc which will be sustained until the circuit is interrupted. Operating current range is 1.0 to 6 ma. Maintaining voltage is measured at 2 ma. Turn-on current is 1 ua maximum. Life expectance for continuous operation at operating current is greater than 25,000 hours. The new tube, Type TRQ-250, is said to be ideally suited for use in timers, ring counters, shift registers, memory cells, X-Y matrices, computer readouts, machine control, and other applications where electronic switching is performed. The high light output of the new tube also makes it ideal for use with photo resistors. Signalite Inc., Neptune, N. J.

Circle No. 188 on Inquiry Card

READOUT COUNTER-SWITCHES

New line of readout counter-switches has been designed for moderate speed counting applications. Life expectancy is said to exceed 1,000,000 operations. With maximum pulsing rates of 500 pulses per minute, units can be supplied in any voltage from 6 to 48 vdc and from 24 to 110 vac with or without electrical readout. The switch has built-in capabilities of electrical transfer between decades for sequential counting in addition to accepting pulses for parallel entry. The line consists of two small models for limited space applications and two standard models. The former has



numerals ⅜″ wide x ½″ high and the latter has numerals ¾″ wide and 1″ high. Price range is $4.50 to $12.00 per unit. Chicago Dynamics Ind., Chicago, Ill.

Circle No. 182 on Inquiry Card

FLAT-CONDUCTOR RIBBON CABLES

A full range of high-performance insulations are now available on flat-conductor ribbon cables. Included, in addition to the more commonly used polyester laminate insulation, is homogeneous TFE teflon, homogeneous FEP Teflon, and a Teflon/Kapton (polymide) laminate. Each type offers special benefits. The polyester laminate is noted for its excellent mechanical properties. It is extremely resistant to cut-through and abrasion and has a high tensile strength. For high-temperature applications TFE Teflon and FEP Teflon are recommended: the TFE for continuous use to 300°C., the the FEP to 200°C. When both high temperature and mechanical strength are considerations the Teflon/Kapton laminate is preferred. Standard constructions are available in 1″, 2″, and 3″ widths with conductor sizes ranging from 0.002″ x 0.025″ to 0.005″ x 0.100″ on 0.050″, 0.075″, 0.100″, and 0.150″ centers. Special cables can be supplied in a wide range of sizes and spacings. Prices vary from a low of $0.25 per foot to as much as $6.00 per foot depending on insulation type and thickness and size, type, and quantity of conductors. W. L. Gore & Assoc., Inc., Newark, Del.

Circle No. 167 on Inquiry Card

A-D MULTIPLEXER

A versatile switching unit is said to be especially suited to connecting test points to an analog-to-digital converter. This multiplexer features low leakage currents, and variable channel ON time. The low leakage currents permit use of large test point source resistances (with negligible error introduced as a result of leakage currents flowing through the test point source resistance). The channel ON time can be made as long as one millisecond to allow sufficient time to charge circuit capacitances through large test point source resistances prior to measurement. Analog switching elements are designed for and yield very low offset voltage over the full temperature range; drive circuit isolation is assured by using transformer coupling between the analog and logic circuits. A single multiplexer unit measures 6″ x 7″ x 17″ and contains a maximum of 128 channels. The number of channels may be any integral multiple of 8; two multiplexer units may be connected in parallel to provide a 256-channel multiplexer. Price varies from $55 - $65 per channel depending upon the temperature range required. General Dynamics' Electronics Division, Rochester, N. Y.

Circle No. 170 on Inquiry Card

NEW PRODUCTS

VANE-SWITCHED OSCILLATOR

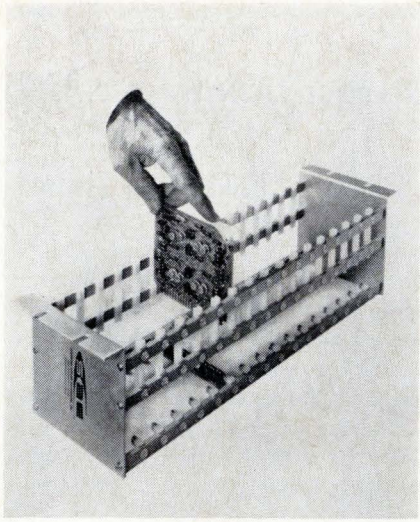
New addition to a line of logic modules is a vane-switched oscillator designed to control production in low-speed applications such as bi-directional counting, counting of revolutions, weighing or dosing, linear position switching (programming), foil continuity check, and the counting of small objects. The VSO is basically a transducer that transforms mechanical movement into an electrical signal. Because it operates as an electromagnetic relay without moving parts, it is said to offer a degree of reliability unattainable by the currently used mechanical switches. The unit consists of an oscillator and a diode rectifier which is connected to a separate coupling winding of the oscillator to provide an isolated dc output. The layout of the oscillator is such that whenever a piece of metal passes through the gap between the coil windings, the oscillation stops and the dc output drops to zero. The switched dc output can then be used to drive a Schmitt trigger, a pulse shaper, or similar circuitry. Since any metallic material can be used to switch it, the VSO is particularly suited to industrial positioning and control applications. The module is completely encapsulated in epoxy resin and its relatively small size allows it to be mounted in inaccessible locations. The supply voltage for the oscillator is 6 vdc or 12 vdc. Current consumption is 12 ma. Amperex Electronic Corporation, Digital Prods. Dept., Hicksville, L. I., New York

Circle No. 169 on Inquiry Card

LOGIC STAMPS

For quickly drawing logic diagrams, a set of six rubber stamps consists of the following MIL-STD-806B symbols: AND, OR, flip-flop, amplifier, single shot, and state indicator. Price: $4.95 per set. Continental Systems, Hicksville, N. Y.

Circle No. 147 on Inquiry Card



PC CARD PACKAGING

A printed circuit card guide system consists of a highly stable aluminum frame with nylon guides snapped into precise position. Card guides can be mounted for either single row or back-to-back card row configurations and can be ordered with color coded guides and part number identification. Maximum air ventilation is provided and any height or spacing requirement can be ordered. Printed circuit connectors are mounted through "molded-in" threaded bushings at the nylon foot at the base of the unit. Stanford Applied Engineering, Inc., Sunnyvale, Cal.

Circle No. 133 on Inquiry Card

IC LOGIC MODULES

New series of logic modules features monolithic integrated circuits used as flip-flops, buffers, and inverters. The cost of non-inverting, fully-buffered, AND-OR gates is now said to be as low as that of inverting NAND-NOR components. The use of AND-OR gates, alone or in conjunction with NAND-NOR gates, reduces system costs over conventional NAND techniques, often lowering the number of amplifiers by 50 per cent. In addition, a unique gate design permits three levels of logic to be performed with a single level of amplification. Also featured in the series are high current drive capability, and exclusive monolithic flip-flop design with unique control characteristics, connectors with 52 pins, and a wide variety of gating structures. Logic modules in the series include buffered AND gates, buffered AND-OR gates, decoders, buffer amplifier matrix, inverter matrix, NAND gates, NOR gates, and many other configurations of logic elements. Flip-flop configurations include a basic flip-flop for RS, JK, T, or D operation, gated flip-flop, high-speed counter, dc register, and shift register. Special functions are also available. Scientific Data Systems, Santa Monica, Cal.

Circle No. 125 on Inquiry Card

MOBILE DATA ACQUSITION

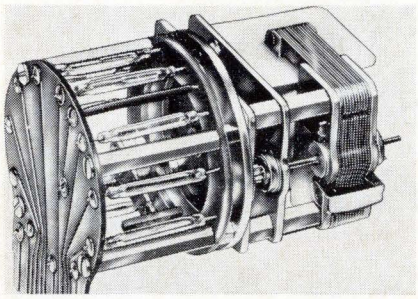
An improved mobile data acquisition system was designed for maximum flexibility in obtaining data and producing computer compatible tapes at remote test sites. This completely portable system allows engineers to easily check operating conditions in industrial or scientific equipment in isolated plant locations or in the field. Inputs representing pressures, temperatures, strains, flow rates, speeds, and other variables are recorded at rates up to 20,000 samples per second. The recorder is an integral part of the system. Called Mobidac, the system accepts fifty low-level analog inputs, seven high-level analog inputs, and two digital inputs which may originate either internally or externally. Patch panel programming permits selection of either binary or BCD formats, any one of several data acquisition rates, and allows high-level and low-level inputs to be intermixed in the program sampling sequence. Lower sampling rates than those obtained by subcommutation are available by start/stop recording. Nixie displays are provided for read-out of data and for record count. Data values are recorded in gapped or gapless format for direct analysis by a computer. System Engineering Labs, Inc., Fort Lauderdale, Fla.

Circle No. 151 on Inquiry Card

DIGITAL DATA MODEMS

Two new solid-state, adaptive, microminiature data communication modems offer data rates of 1200-2400 bits-per-second. Identified as the TE-215A-4S and the TE-215D-4S, the units are built in the half-ATR configurations: 7-½" high, 4-⅞" wide, and 19-9/16" long. The TE-215D-4S is a full duplex, diversity with doppler, four-tone digital data modem capable of 2400 bps on voice channels such as wireline, cable, carrier, microwave, and HF radio. The TE-215A-4S, also full-duplex and four-tone, provides 2400 bps on UHF radio as well as other voice channels such as wireline, cable, carrier, or microwave. Data rates of 1200 bps or 2400 bps may be selected from a front panel data rate switch and/or from a remote control which may be located up to 200 feet from the modem. Collins Radio Co., Newport Beach, Cal.

Circle No. 163 on Inquiry Card



TURRET STEPPING SWITCH

New stepping switch consists of a turret of magnetically-actuated sealed reed switches sequenced by a 2-wire stepper motor. New line can be supplied with many combinations, 6, 10, 11 etc. positions break before make, make before break, or shorting with dry reed or mercury wetted switches. As an alternate to the 2-wire stepper motor drive, a 3-wire motor can be supplied for higher speed operation. Step rates up to 40 pps are practical with the 2-wire motor and up to 100 pps with the 3-wire motor. Units may be stepped by individual dc pulses at one rate and homed to a reference position by energizing the motor with ac power. Haydon Switch & Instr., Waterbury, Conn.

Circle No. 137 on Inquiry Card

Does this look like an answer to global problems of ignorance, disease and physical deprivation?

Not yet. But we're getting closer.

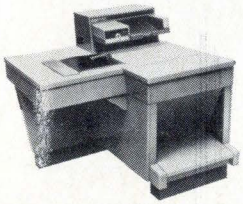
Behind this movement is a simple statistic with startling implications for all of us—*If you count all the scientists and engineers since the beginning of recorded history, ninety percent are alive today!*

We are now in the midst of the result—an incredible explosion of information from every corner of the globe. And somewhere within this explosion will be the ultimate answers to mankind's oldest, and newest problems.

The challenges are many. First, to understand the nature of this giant intellectual force. Then, to find the best way to collect it, classify it, store it... and distribute it appropriately and instantly to the people who need it.

In this light, you might consider today's Xerox products early and primitive steps along a difficult but fascinating path. You'd be right. Yet, has anyone taken these steps before us?

Your degree and background may be more appropriate to our advanced work than you imagined. We're as interested in talking with communication systems specialists as electromechanical designers, organic chemists as much as program analysts. This list is as broad as it is long. Maybe broader. You'll find several specific (and urgent) openings outlined at the right. If they suggest a possible community of interest, send us your resume. An equal opportunity employer (M&F).



The Xerox 914 Copier revolutionized the office copying industry when it was introduced in 1959... and really started us on our way.

Less than 3 years later, the 813 further extended low-cost, quality office copying. One-seventh the volume of the 914, it does just about everything the 914 does except copy solid, 3-dimensional objects.

Another revolution. An electromechanical-chemical-optical device called the 2400 because it produces 2,400 copies per hour *directly* from an original document. No stencil or "master" of any kind. You press a button.

XEROX

TOP PHOTO: LDX (Long Distance Xerography) scans, transmits and reproduces images over distances limited only by the transmission medium. Something like it may print the morning paper at your breakfast table some day, or help you manage a global business.

XEROX, 914, 813, 2400 AND LDX ARE TRADEMARKS OF XEROX CORPORATION

NEW PRODUCTS

CONVEYOR MEMORY

A new line of solid-state memories will control diverters or switches in conveyor systems where sorting decisions are made at one point and physical sorting takes place at one or more points further down the line. They are especially designed for systems in which items enter at irregular intervals, and may also vary their spacing in transit. Gravity conveyors and railroad classification yards are typical applications. Codes representing destinations of items are entered by an operator's keyboard or by an automatic code reader or inspection device. The memory stores the codes and controls the diverters, routing each item to its destination. A memory for controlling a single diverter, with storage capacity for up to 100 items in transit, is priced at approximately $2000. Dynamation, Inc., Wayne, Pa.

Circle No. 139 on Inquiry Card

DC POWER SUPPLY

Static line and load regulation of 0.005% with a maximum ripple and noise of 2 mv rms, and a recovery time of 50 microseconds are performance features of a new transistorized 50 amp dc power supply. Units are available rated from 0-40 volts for operation on ac inputs of 208/220/230/380/460 volts, 3 phase, 47-63 cps. Dynamic line regulation is ±50 mv for a ±10% ac step change. Dynamic load regulation is ±0.25v for a 50% step load change. Additional features include series or parallel operation, remote sensing, remote voltage programming, automatic overload and short circuit protection, adjustable current limiting, and course and fine voltage control with 10mv resolution. Units fit standard 19″ racks and measure 12¼″ high, 21″ deep, and incorporate cooling fans. Perkin Electronics Corp., El Segundo, Cal.

Circle No. 165 on Inquiry Card

PROGRAMMED FLOW CONTROLLER

Digital flow control valves and a punched tape command unit make up a new programmed, multichannel flow control system. The digital flow control valve assembly for each channel comprises eight sub-valves. These turn ON or OFF flow rates of 1, 2, 4, 8, 10, 20, 40, 80 units of flow respectively. Thus flows of 0, 1, 2, 3, ... 99, 100 units are instantly established by turning ON or OFF the appropriate combinations of sub-valves. Valves are operated by compressed air from a pneumatic tape reader. It takes less than ½ second to change from any combination of flow levels to any other combination. The system may be used for blending any number of components or for programmed flow. It can be provided for any flow magnitude, for any fluid, and for any number of channels. Numerical Control Corp., San Diego, Cal.

Circle No. 134 on Inquiry Card

DIGITAL DISPLAY CONSOLE

A load monitor digital display console serves as a readout source of computer information and an interrogation medium for desired computer information. In addition to presenting a 4-digit information display for any 10 channels, the console is equipped with call-outs for sign selection, scale designation, range indicator, selector switches, master control status indicators, and for transmission of information to the computer, thumbwheel BCD coded switches. Communication between the console and the main computer interface is by means of 4-line BCD input, which is correlated into the desired panel position by single line selection. Information is transferred upon command of a computer strobe signal. The digital readout system has associated with each digit a decoder/memory designed to work with negative going logic at −12 volts. It incorporates decimal point display with leading zero suppression. Gap Instrument Corp., Westbury, L. I., N. Y.

Circle No. 153 on Inquiry Card

LITERATURE

Pushbutton Switches

A 12-page bulletin describes "quick and easy" to assemble plug-in lighted pushbutton switches and matching indicators. A wide variety of display button shapes, colors, and sizes, including 2-color and 2-level combinations, provides complete display and arrangement flexibility. Charts and diagrams cover: mounting and wiring hardware; mechanical interlock "add-on" devices; mounting dimensions; circuitry, component listings; and replacement parts availability. Modular mounting system through box-girder framework assures strong, compact matrix arrays in minimum space to single panel cutout. MICRO SWITCH, a Div. of Honeywell Inc., Freeport, Ill.

Circle No. 203 on Inquiry Card

Reed Switches

An 8-page booklet describes and illustrates a complete line of printed circuit dry reed switches. Dimensional diagrams are used to illustrate nine basic forms with corresponding tables that list coil resistance and turns, and the operate-release-maximum voltage for nominal dc voltages. Automatic Electric, Northlake, Ill.

Circle No. 210 on Inquiry Card

Passive Circuit Components

An 8-page brochure covering the performance characteristics of micro-circuit resistors and capacitors contains 13 charts, a nomograph, a table and three photographs. The micro-circuit resistors described in the brochure are tin oxide film. The capacitors are alternate layers of screened gold and glass-ceramic compositions, encapsulated by a glaze. Substrate used is glazed alumina. Corning Glass Works, Corning, N. Y.

Circle No. 216 on Inquiry Card

Pulse Transformers

Comprehensive performance information on low power pulse transformers is contained in an engineering bulletin. It provides detailed measurement instructions and guides to proper application of pulse transformers. Sprague Electric Co., North Adams, Mass.

Circle No. 221 on Inquiry Card

Storage Drums

New brochure depicts the features, advantages, applications, and technical characteristics of a complete line of magnetic storage drums. Patented tapered drum on "uni-just aerodynamic heads" is said to assure top quality performance with fail-safe design. Bryant Computer Products, Walled Lake, Mich.

Circle No. 215 on Inquiry Card

Media Converter

Description and specifications of a media conversion system which converts computer data from punched paper tape to magnetic tape off-line are presented in a new brochure. The system reads 5, 6, 7, or 8-level punched tapes at 1000 characters-per-second. Ampex Corp., Redwood City, Cal.

Circle No. 217 on Inquiry Card

Voltage Regulation Manual

The theory, design, and operation of line-voltage regulators are fully covered in a new 12-page technical manual. The new manual is divided into two sections. The first deals with the power circuit of the line-voltage regulator, and the second explains its sensing and control circuit. Sola Electric Co., Elk Grove Village, Ill.

Circle No. 219 on Inquiry Card

Memory Cores

Seven new engineering data specification bulletins allow engineers to select from a wide variety of ferrite memory cores. Dimensions and typical operating conditions are given for the following memory cores: 80 mil (2 microsecond switching time); 50 mil (1.5 microsecond switching time); 30 mil (with 0.7, 0.3, and 0.4 microsecond switching times); and 20 mil (0.2 microsecond switching time). Typical performance curves are presented for each core. Indiana General Corp., Electronics Div./Memory Prods., Keasbey, N. J.

Circle No. 214 on Inquiry Card

PC Connectors

A 48-page connector catalog covers printed card and tape cable applications. Designated Series 600, these receptacle-type units are made in a variety of single and dual readouts with sizes from six to 210 contacts capable of accommodating board thicknesses of 1/32″, 3/64″, 1/16″, 3/32″ and ⅛″. Center-to-center contact spacing for different types includes 0.050″, 0.100″, 0.125″, 0.140″, 0.150″, 0.156″ and 0.200″. Complete electrical and mechanical specs, illustrations, outline drawings, and ordering information are contained in the catalog. Continental Connector Corp., Woodside, N. Y.

Circle No. 237 on Inquiry Card

Ceramic Components

A 16-page technical catalog contains complete data on a full line of ceramic products. Described are potentiometers, trimmers, resistor/capacitor modules, hybrid intergrated circuits and microminiature solid pellet fixed resistors. Tables on environmental performance specs, and electrical and mechanical specs are given on each product. In addition, a table of reliability data, based on 192,400,000 hours of testing is given on the hybrid integrated circuits line. CTS Corporation, Elkhart, Ind.

Circle No. 212 on Inquiry Card

LITERATURE

Digital Systems Capabilities

A 14-page brochure describes how a company helps process industries plan for digital computer control systems. The bulletin illustrates the company's ability to accept total responsibility for design, fabrication, and application of digital systems. It outlines the steps the company follows to supply a complete line of digital equipment, software, and computer-compatible instrumentation. The Foxboro Company, Foxboro, Mass.

Circle No. 204 on Inquiry Card

Systems Computer

A new 36-page brochure fully describes a system-oriented computer. Intended for the system designer, the brochure includes specifications, systems options, and available peripheral equipment. Also included is a complete description of machine commands and available software. User services, covering program exchanges and software library maintenance, are also described. Data Machines, Inc., Newport Beach, Cal.

Circle No. 227 on Inquiry Card

Printed Circuit Guide

New brochure, "An Engineer's Guide to Printed Circuit Design," provides information for the engineer-designer who is relatively unfamiliar with requirements for printed circuits, as well as a concise and valuable reference for those actively engaged in the field. Included in the brochure is material on preparation of artwork, location and alignment of holes, physical characteristics, conductors, plated conductors, solderability, selective area soldering, and printed circuit board markings. Reference table gives dimension tolerances for all printed circuit board parts. Lockheed Electr. Co., Printed Circuit Dept., Los Angeles, Calif.

Circle No. 207 on Inquiry Card

Computer Tapes

New computer tapes, described in an 8-page brochure, are said to be made with a process that assures perfect tape-to-head contact over the entire width of the tape and head during write, read, and re-read modes of operation. The new tape line is compatible with all of the major computer systems and tape transports. Reeves Soundcraft, Danbury, Conn.

Circle No. 224 on Inquiry Card

Tantalum Capacitors

Engineering bulletin describing custom-made tantalum capacitors includes technical data and characteristic curves on rectangular units, some of whose capacitance values range as high as 310,000 microfarads. Since these capacitors are custom made, units with capacitances up to 1 farad or above are possible. In addition to the standard units listed in the bulletin, an almost limitless variety of configurations and ratings can be constructed by combining one of the many available case sizes and shapes with the alternate mounting flange and terminal locations. A code system for specifying the specific units desired is also described. Tansitor Electronics, Inc., Bennington, Vt.

Circle No. 201 on Inquiry Card

Miniature Connectors

A new 36-page catalog details fourteen major series of miniature connectors. Miniature rectangular plug and receptacle rack and panel connectors, miniature hexagonal types, and others are covered. Many varieties of terminals, shields, and shells are described. The sixteen pages of detailed connector drawings in the catalog are said to be so complete that they may be copied from the page for specification control drawings. The catalog also contains special how-to-order guides. U. S. Components, Inc., Bronx, N.Y.

Circle No. 208 on Inquiry Card

Time Code Generators

A 2-page bulletin covers time code generators which generate time code formats for use in magnetic tape analog recording systems, telemetry systems, range-timing systems, and other real-time data acquisition systems. Among the time code formats which can be furnished are IRIG-A, B, C, D, and E; NASA-36 and 28 bit; and AMR D-5. Each time code generator provides a modulated carrier time code output, a level-shift time code output, a parallel digital output of the time to 0.1 millisec., and pulse rate outputs. Chrono-Log Corp., Broomall, Pa.

Circle No. 213 on Inquiry Card

IC Logic

Short form catalog contains information on double-diffused integrated circuits, including DTL, TTL, and RTL circuits. Epoxy transistors and a line of MOS subsystem functions are also covered. General Micro-Electronics, Santa Clara, Cal.

Circle No. 220 on Inquiry Card

Drum Memory System

Engineering specs for the design of an economical bit serial, magnetic drum system are given in a 12-page brochure. Explained and illustrated are the elements that make up a basic drum system and the advantages of the various options offered with this standard system. In addition, the functional relationship of the options with regard to the system are described. Bryant Computer Products, Walled Lake, Mich.

Circle No. 225 on Inquiry Card

Power Supplies

A new 20-page power supply catalog includes eight series of standard models and introduces 800 new power supplies. The catalog includes brute force, standard precision regulators, dc to dc converters, high voltage, commercial, aerospace, and military supplies. Elasco, Inc., Boston, Mass.

Circle No. 226 on Inquiry Card

SALES OFFICES

BOSTON

Lindsay H. Caldwell
Professional Bldg.
Baker Ave.
W. Concord, Mass.
phone: (617) 369-6660

NEW YORK

Robert J. Bandini
663 Fifth Ave.
New York 20, N. Y.
phone: (212) 421-4840

CHICAGO

Phil Holmes
410 N. Michigan Avenue
Chicago 11, Illinois
phone: (312) 467-6240

DETROIT

Robert T. Barrett
424 Lafayette Building
Detroit 26, Michigan
phone: (313) WO 1-0278

LOS ANGELES

David Barton
672 So. Lafayette Park Pl.
Los Angeles 57, California
phone: (213) 382-1121

LONG ISLAND — SO. CONN.

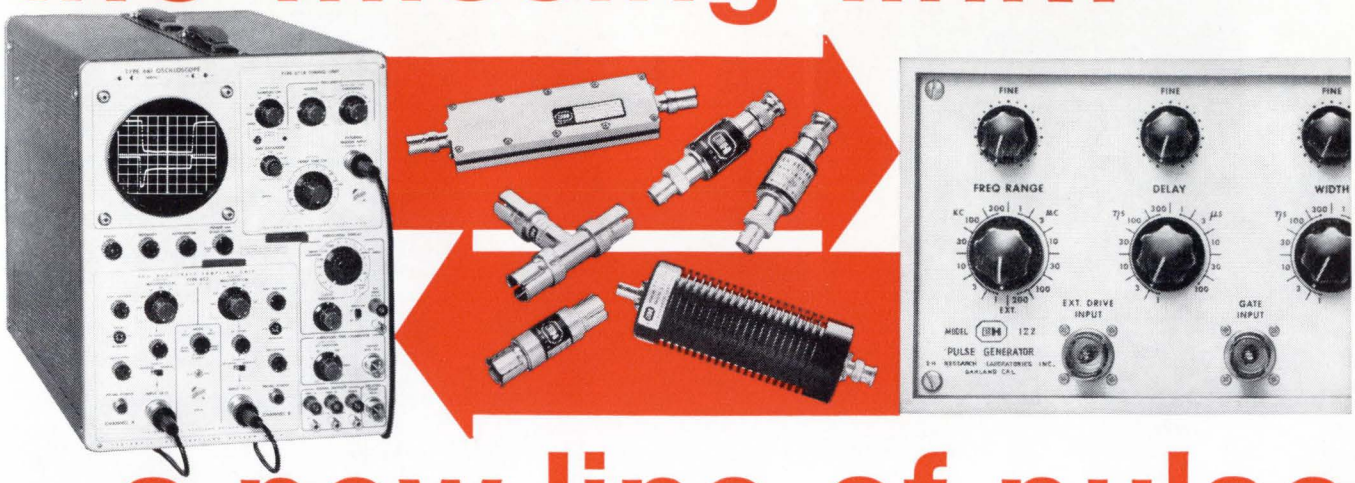
C. Lynn Coy
Robert C. Woodies
155 E. 50th St.
N.Y., N.Y. 10022
phone: (212) 751-2960

SAN FRANCISCO

David Barton
672 So. Lafayette Park Pl.
Los Angeles 57, California
phone: (213) 382-1121

ADVERTISERS' INDEX

Now E-H supplies the missing link:



...a new line of pulse accessories.

Now E-H supplies the missing link between your scope and E-H pulser – with the first complete line of accessories specifically designed for pulse applications. These E-H pulse accessories assure precise measurements – free from the distortions and component failures that are typical of improvised laboratory setups. In a word, they match the quality and performance of the costly sophisticated equipment with which you'll use them.

Find out more about this unique accessory line. Call your E-H representative.

GR SERIES

960/TAP-OFF. A 50 ohm transmission line sampling device. 100:1 pickoff ratio. No appreciable discontinuity introduced into 50 ohm systems to 3 Gc. GR connectors. **$90.**

972/PULSE TRANSFORMER. A fast inverting transformer for 50 ohm systems. Rise time better than 0.17 ns. GR connectors. **$90.**

950/TRANSISTOR MOUNT. A 50 ohm transmission line mount for measurement of transistor switching times to the sub nanosecond region. AC coupled output. BNC DC inputs, GR signal in and out. **$340.**

901/MARKER GENERATOR. A passive circuit designed to provide 1 ns markers for time-base calibration of oscilloscopes. 1% accuracy, requires fast pulse to activate. GR connectors. **$220.**

902/TUNNEL DIODE PULSER. Produces 450 mv pulse at less than 100 ps rise time from slower pulse or sine waveforms applied to input. –1 volt required to switch tunnel diode. BNC input, GR output. **$190.**

951/DIODE MOUNT. A 50 ohm transmission line mount for measurement of diode switching times to the sub nanosecond region. BNC bias input, GR signal in and out. **$340.**

971/RISE TIME INTEGRATOR. Produces fixed, repeatable rise times from fast pulse inputs. Made in std. times of 5, 2, 1, 0.5, 0.2 ns. ±10% accuracy. Printed circuit stability. GR connectors. **$170.**

970/DC RESTORER. Clamps baseline to ground to eliminate shift in AC coupled sub nanosecond pulse systems. Peak input 20 volts. Approx. 10% attenuation. Specify pos. or neg. GR connectors. **$90.**

BNC SERIES

ZT/PULSE TRANSFORMERS. Nanosecond transformers for impedance matching or inversion. Impedances 50, 93, 125, 185, 200 ohms. Any combination input to output with or without inversion. BNC connectors. **$35.**

RT/RISE TIME INTEGRATOR. For repeatable, fixed, known times from fast pulse input. Standard models at 5, 10, 20, 50, 100 ns. Special times on request. 10% accuracy, 0.5 amp max. average. BNC connectors. **$35.**

DT/DC RESTORER. Clamp designed to eliminate baseline shift in AC-coupled nanosecond pulse system. Peak input 20 volts. Approximately 10% attenuation. DTP for positive pulses, DTN for negative. BNC connectors. **$60.**

ZL-3, ZL-15/TERMINATIONS. Three watt and fifteen watt terminations for 50 ohm pulse systems. DC resistance accurate to 1%. VSWR <1.25 at 100 mc. Scope tap. BNC connectors. **$55, $75.**

TP-2, TP-5, TP-10 ATTENUATORS. High power fixed attenuators with 2:1, 5:1, 10:1 ratios. Division ratios accurate to 10%. 12 watts max. continuous dissipation. For 50 ohm input and output. VSWR <1.25 at 100 mc. BNC connectors. **$95.**

SP-10/SINGLE PULSE TRIGGER. A battery-operated triggering device for single-pulsing all E-H pulsers. Supplies a fast-rise 10 volt spike of either polarity. With cable. BNC connectors. **$45.**

Oscilloscope photograph courtesy of Tektronix, Inc.

E-H RESEARCH LABORATORIES, INC.
163 ADELINE STREET • OAKLAND, CALIFORNIA 94607 • (415) 834-3030 • TWX-910-366-7258
IN EUROPE: E-H Research Laboratories (Ned) N.V., Box 402, Eindhoven, The Netherlands

CIRCLE NO. 50 ON INQUIRY CARD

in data communications you want this....

TALLY BUSINESS DATA COMMUNICATIONS SYSTEMS ARE UTTERLY RELIABLE. THEY CATCH MISTAKES BEFORE THEY HURT. THEY MOVE DATA 120 CHARACTERS PER SECOND. THEY ARE REASONABLE. BUY OR LEASE.

TALLY BUSINESS COMMUNICATIONS SYSTEMS FILL THE COMPLETE NEEDS OF THE EDP USER FOR HIGH SPEED, DATA TRANSMISSION AND CONVERSION OF PAPER TAPE MESSAGES. WHETHER YOU REQUIRE ONE OR TWO-WAY DATA COMMUNICATIONS, ACROSS THE ROOM OR AROUND THE WORLD, YOUR LOCAL TALLY BUSINESS COMMUNICATIONS SPECIALIST HAS THE RIGHT TALLY-TAILORED SYSTEM FOR YOU.

FOR HIS NAME AND A COMPLETE FILE ON TALLY BUSINESS COMMUNICATIONS SYSTEMS, PLEASE WRITE ROBERT OLSON, TALLY CORPORATION, 1310 MERCER STREET, SEATTLE, WASHINGTON 98109. PHONE: (206) 624-0760. TWX: (910) 444-2039. IN THE U. K. AND EUROPE, ADDRESS HARVEY ULIJOHN, TALLY EUROPE LTD., RADNOR HOUSE, 1272 LONDON ROAD, LONDON, S.W. 16, ENGLAND. PHONE: POLLARDS 9199.

not this....

TALLY BUSINES *DATA COMMUNICATIONSSYSTEMS ARE UTERLLY/ REAIBLE. 8HET CATCH MISTAKES BEFORE4 THEY HU4T. THEY MOVE DATA 120 CHARA4TERS PER SECOND. 8HEY A4E REASONABLE4. BUY OR LEASE/

TALLY BUSINES COMMUNICASIONS SYST/EMS

TALLY®

CIRCLE NO. 51 ON INQUIRY CARD