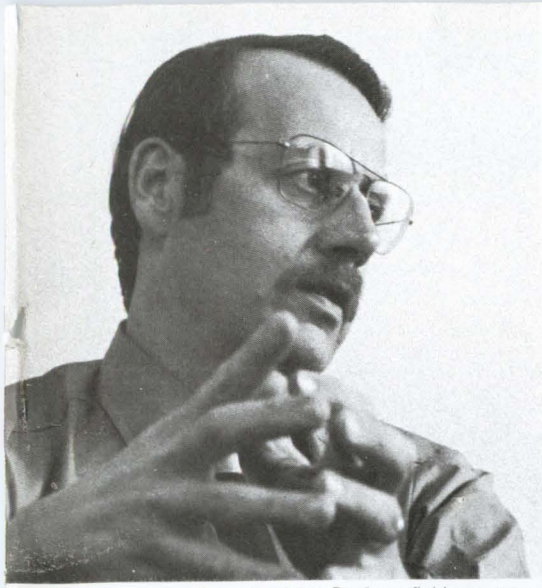
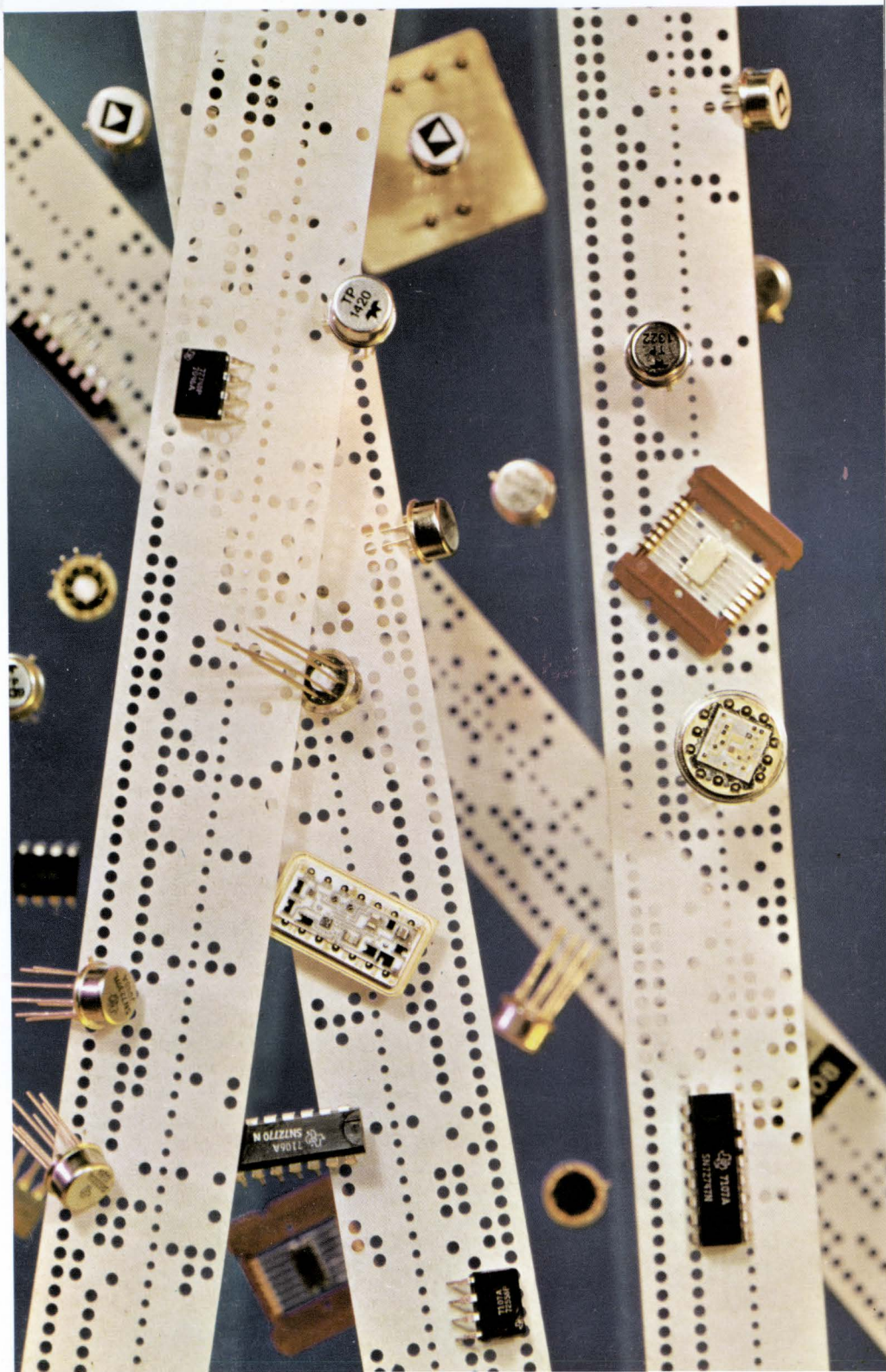


Can EEs clean up pollution? EPA's Dr Greenfield answers.

CHILTON'S

THE ELECTRONIC ENGINEER

VOL. 30 NO. 7
JULY 1971



What's the latest in op amps?

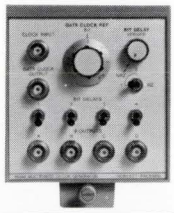
Memory course—systems storage

The environment: challenge for electronic engineers

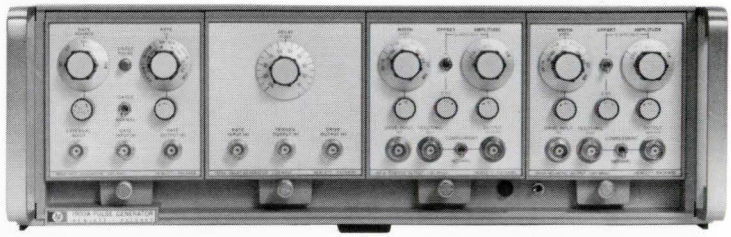
What's available in op amps? See our computer-aided list.

From HP – Three new dimensions in "pulser power" ...

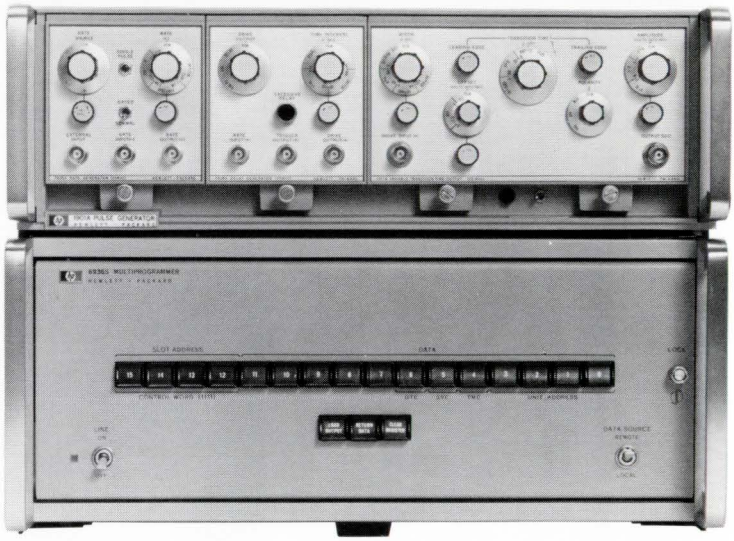
1. Multiphase MOS Testing



2. 125 MHz Capability



3. Digital Programmability



Hewlett-Packard's 1900 System, the pacesetter in pulse generation, now has three new capabilities that put it even farther ahead of all competitive pulsers.

1. Multiphase MOS Testing—The new 1934A Multiphase Clock plug-in lets you use the 1900 System to design and test MOS circuits with a minimum of effort. It gives you four-phase outputs to 12.5 MHz, or two-phase to 25 MHz... with variable phase pattern and variable phase overlap. The 1934A can be used with either high-threshold drivers (the 1915A) or low-threshold drivers (the 1917A); but the 1934A's price is strictly low-threshold... only $775.

Circle Reader Service #**4.**

2. 125 MHz Capability – Now, there are two 1900-System plug-ins that let you generate pulses at rep rates up to 125 MHz. The new 1921A (for positive pulses) and 1922A (negative pulses) are designed for testing fast T^2L and ECL logic—in computers and high-speed digital communications. Both have a fixed transition time of <2 ns, variable amplitude to 5 V, and variable ± 5V offset. Both have switch-selectable complement capability, plus feed-through pulse-adding capabilities and pulse shaping capabilities. And both are compatible with other 1900-System plug-ins such as the 1930A PRBS generator. Yet you can get either the 1921A or the 1922A for only $950.

Circle Reader Service #**5.**

3. Digital Programmability – Now, your 1900 System can be computer-controlled, for high-speed automatic testing applications... thanks to HP's new 6936S Multiprogrammer. Its 16-line parallel input lets you interface your 1900 System to a computer quickly and easily, using only one I/O slot... and the result is a fully programmable pulser system suitable for almost any testing or control purpose.

To tie together your 1900 System and the 6936S, HP provides an interfacing package (Option 005), which includes cables, program cards and software. This lets you assemble the combination of capabilities best suited to your own particular needs. For example, you can get the 1900 with three popular plug-ins (1905A rate generator, 1908A delay generator, and 1917A variable-transition-time output) *plus* the 6936S Multiprogrammer and interfacing option 005, for $5950.

Circle Reader Service #**6.**

For further information on any aspect of the pace-setting 1900 System, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

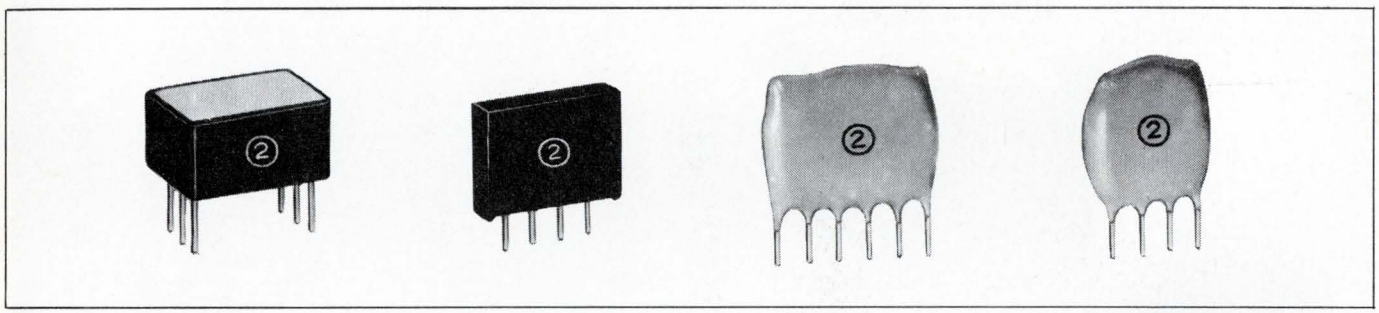
081/15

HEWLETT hp PACKARD

SIGNAL SOURCES

Now from Sprague Electric!

Your *custom* pulse transformer is a *standard* DST® transformer



Some of the case styles in which Sprague DST Pulse Transformers are available. Note the in-line leads.

You can select the transformer design you need from the new Sprague DST Family, a fully-characterized series of Designer Specified Transformers which Sprague Electric has pioneered. It's easy. Start with the two basic parameters dictated by your circuit requirements: primary (magnetizing) inductance and volt-second capacity.

New Sprague engineering data gives basic information from which all nominal sine wave parameters are derived. This data allows you to specify the one transformer from thousands of possibilities which will optimize performance in your application.

Design Style A minimizes magnetizing inductance change as a function of temperature. Typically it's $< \pm 10\%$ change from 0 to 60 C; $< \pm 30\%$ from -55 to $+85$ C.

Design Style B and C give you broad bandpass characteristics, and still keep magnetizing inductance change $< \pm 15\%$ from 0 to 60 C.

Design Style D is *fast*. Associated leakage inductance and coupling capacitance are kept at a minimum. This style is just what you need for interstage and coupling devices in computer drive circuits.

The Sprague DST Series packs a lot of transformer into minimum volume packages — epoxy dipped for minimum cost, or pre-molded. The 100 mil in-line lead spacing is compatible with integrated circuit mounting dimensions on printed wiring boards.

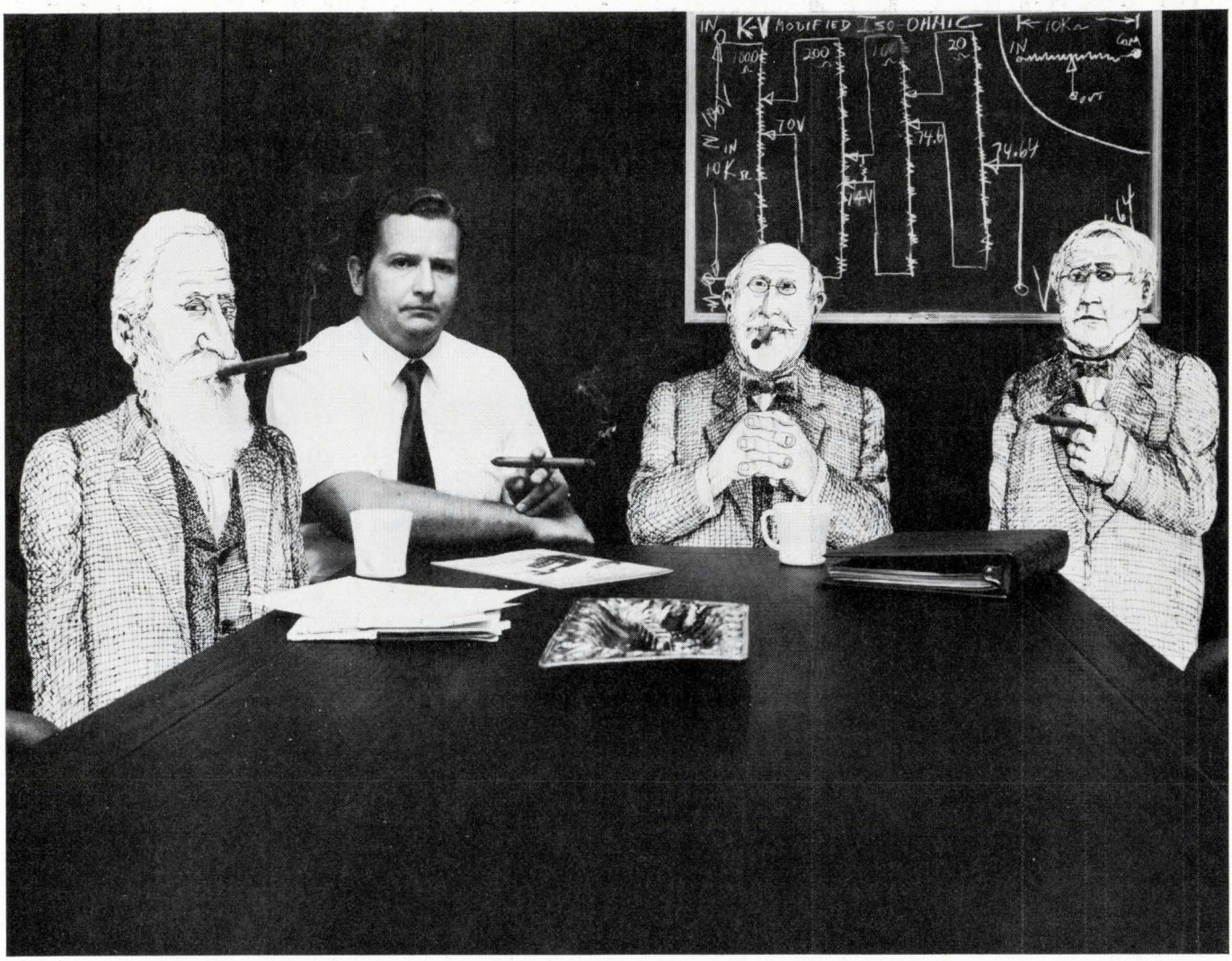
To solve your pulse transformer design, start now. Write for Engineering Bulletin 40,350 to the Technical Literature Service, Sprague Electric Company, 233 Marshall St., North Adams, Massachusetts 01247.

SPRAGUE COMPONENTS

PULSE TRANSFORMERS	INTEGRATED CIRCUITS	CERAMIC-BASE PRINTED NETWORKS
THIN-FILM MICROCIRCUITS	INTERFERENCE FILTERS	PACKAGED COMPONENT ASSEMBLIES
TRANSISTORS	PULSE-FORMING NETWORKS	BOBBIN and TAPE WOUND MAGNETIC CORES
CAPACITORS	TOROIDAL INDUCTORS	SILICON RECTIFIER GATE CONTROLS
RESISTORS	ELECTRIC WAVE FILTERS	FUNCTIONAL DIGITAL CIRCUITS

SPRAGUE®
THE MARK OF RELIABILITY

'Sprague' and '②' are registered trademarks of the Sprague Electric Co.



The Great Idea...by Kelvin, Varley, Poggendorff and Porter.

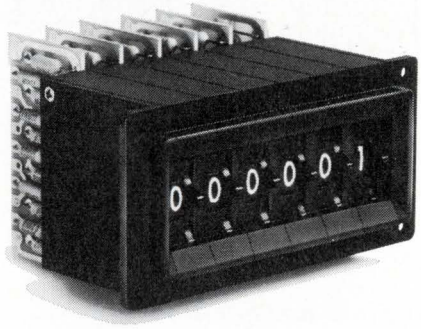
Porter is the gentleman seated second from the left. With a little help from his friends, Hank Porter came up with a great idea. Or really, two great ideas. The DIGIVIDER® and the DIGIDECADE®.

The DIGIVIDER is a voltage divider that comes in two configurations. The Kelvin-Varley-Porter version and the Poggendorff-Porter configuration. They are Thumbwheel Switches that act like ten-turn potentiometers, only better. Now you can "click" the dial settings to whatever voltage you want (as an output) and that's exactly what you get. And you don't need a magnifying glass to read the digits.

DIGIVIDER accuracies range from 0.1 to 0.025% full scale voltage ratio (0.01% available) with resolutions to 0.0001% and input impedances from 100 to 100,000 ohms. Trimming options are also available.

The Poggendorff-Porter DIGIVIDER configuration can also be used as a resistance decade. Again, similar to a ten-turn potentiometer, only in this case, resistance as well as voltage settings are directly related to dial settings.

The DIGIDECADE also comes in a different circuit configuration without anyone's name attached to it. Here, as a resistance decade, it utilizes a weighted code of 1-2-2-2-2-, using five resistors to achieve nine discrete steps of resistance from (0-9) or multiples thereof. It is a linear progression that yields the desired total resistance.



DIGIDECADES have accuracies to 0.1% of setting, resistance ranges from 10 ohms to 1 megohm and step sizes of 1 to 100,000 ohms.

As with all DIGITRAN products, you can count on stability and quality. You won't get more than a 5 milliohm change in contact resistance through 100,000 accurate switching operations.

So, write for our new catalog on DIGIVIDERS and DIGIDECADES, or even better, give us a call. That's a great idea too.

THE DIGITRAN COMPANY

A Division of Becton, Dickinson and Co. B-D

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Pictured l. to r.: William Thompson Kelvin, 1824-1907, England, Hank Porter, U.S.A., Cromwell Fleetwood Varley, 1828-1883 England, Johann Christian Poggendorff 1796-1877, Germany.

THE ELECTRONIC ENGINEER

July 1971 Vol. 30 No. 7

Cover: Top left. The decisions of the man pictured here will in a large measure determine the fate of electronics in cleaning up the environment. He, Dr. Stanley M. Greenfield, as Assistant Administrator for Research and Monitoring of the fledgling Environmental Protection Agency, will be responsible for deciding the direction of much of the electronic applications in fighting pollution. For what Dr. Greenfield and others have to say, see p. 32. (Photo: G. Purdon) **Bottom right.** Operational amplifiers, like those shown here from Analog Devices, Texas Instruments, Zeltex, and Teledyne Philbrick, originally were discrete circuits designed to perform such operations as integration, differentiation, etc. However, with the advent of IC technology and the popular 709, the name has become a misnomer. For a complete, computerized listing of the most popular op amps by input bias, slew rate, voltage drift, and price, check p. 21.

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The Chilton Electronics and Instrumentation Group
The Electronic Engineer
Instruments and Control Systems
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PUBLISHER'S COMMENT

"TAKE ME TO YOUR COMPUTER . . ."

One of the most useful contributions from your editors comes in the form of what we call our annual "IC op amp report" which keeps you up-to-date on operational amplifiers.

This year the report became a matter of concern when it was revealed that while over 500 IC operational amplifiers had been introduced in the past 12 months, ***only*** 10 to 15% had been reported in the pages of this and other publications.

It was clear that this had to be corrected. But then it was realized that there was no quick, ***conventional*** way to classify 588 devices by company, input bias current, slew rate, voltage drift, construction and price. And that's not all. The editors still had to plot 588 x 3 points on the chart.

Editors Wilkins (L) and Boyle study a printout.

Editor Socolovsky instructed an editorial team consisting of Lynda Rothstein and Debbie Wilkins and headed by Technical Editor Art Boyle to come up with the report for this issue. They took the engineering approach and asked Philco's time-shared computer (a Burroughs 5500) for help.

The computer now arranges the op amps by company and then divides the devices into two classes, hybrid and monolithic. If we ask the computer to sort by input bias current, it will start with the lowest value, list each op amp with that value, its manufacturer, model number, construction type and its price. And within each value it can give us price from the lowest to the highest. Since op amp manufacturers are constantly introducing new products, we could include them in our report almost up to press time thanks to the computer, which sorted and retyped the list in a matter of seconds!

The editors get back in a moment what might well take hours using conventional tabulating methods. Just imagine arranging each of 588 devices into 4 different formats and having to keep each company's device, model number and construction in mind each time!

While we regard the editors' effort as no more than a minor miracle, we suggest that you turn to page 21 for our now famous op amp report and a very special offer.

K. Robert Brink

K. Robert Brink
Publisher

A breath of fresh air in data communications

In a landmark decision, the Federal Communications Commission has allowed competition among common carriers in data communications.*

The economic significance of this decision by the FCC will become apparent during the next few years. It will provide tremendous impetus to the fields of data communications and digital equipment for the rest of this decade. Accompanying this economic opportunity, we feel, will be employment opportunities for electronic engineers.

To this magazine, the FCC's decision is particularly satisfying because it provides the right climate to develop jobs for electronic engineers on a sound economic basis. Since the increased competition among carriers will result in lower costs for data transmission, many commercial companies will find it economical to buy digital equipment and transmit their data from one point to another. Therefore, in addition to an increasing demand for communications equipment such as, transmitters, receivers, modulators, demodulators, repeaters, antennas and transmission lines, we expect a parallel increase in the demand for data terminals, small computers, modems, data-entry and retrieval equipment, and large computers with communications front-ends. And the talent and skills of electronic engineers will be needed to work on them.

However, these jobs will develop slowly. The data communications market is mostly a commercial market, which obeys the laws of economics, unlike the defense and aerospace jobs which employed most of EEs during the late 1960s. As this magazine has pointed out in its recent presentation to government officials in Washington,** for the same economic activity, the number of engineers that commercial enterprises require is four to five times lower than the number of engineers required by aerospace industries. For example, when a company such as Lockheed or Sandia loses $10 million worth of contracts for a year, it lays off about 65 engineers, whereas the same amount of money at the communications plant of General Electric or at Datran provides jobs for only 10 or 15 engineers. The new activity in data communications, we estimate, will signify about $250 million worth of sales in 1972, which would translate into jobs for 2500 to 3000 engineers of all specialties.

The FCC decision is encouraging, and we have been advocating it because we feel that in the self-adjusting mechanism of the free enterprise lies the true solution to the engineering unemployment crisis. But we need more. There are similar opportunities for U.S. manufacturers (and, hence, employment opportunities for U.S. engineers) in the development and production of data terminals, of electronic wristwatches, and of educational equipment.

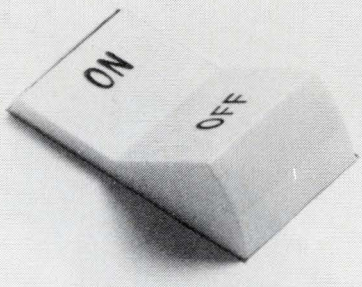
To support the efforts of our readers in the now expanding field of data communications, **The Electronic Engineer** magazine will start a new section on that subject (called DATA COMMUNICATIONS) with the next issue, in August 1971. In it you will find ideas for your designs, guidelines for your ideas, and a forum for your opinions.

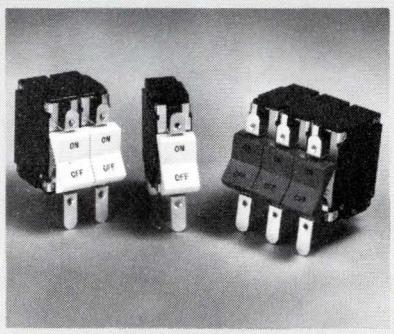
Alberto Socolovsky
Editor

*The decision on the FCC Docket 18920, dated May 26, 1971, states that the FCC will consider "technically and economically sound" applications from new carriers (such as Datran and MCI), and that it will permit the existing carriers (AT&T and Western Union) to compete "fairly and fully" in the sale of data transmission and other specialized communications services.

See "Appointment in Washington," **The Electronic Engineer, May 1971, pp. 28-29.

And it doesn't look like a circuit breaker.





Therein lies its beauty.

When you use the JC rocker-handle circuit breaker as a front-panel on-off switch you get overload protection, too. Without the expense of using a switch and a breaker.

Behind that handsome rocker handle is the engineering and construction you know Heinemann for. Hydraulic-magnetic protection. Which means precise ratings from 0.020 to 30 amp. 32, 50, and 65V DC; 125 and 250V at 60 Hz and 400 Hz. Job-matched time delays or non-time-delay response. Temperature-stable trip points. Optional special-function internal circuits. One, two, or three-pole models. And a five-year warranty.

Oh, yes. The rocker handle comes in white or gray.

A pretty attractive package. All around.

Write us for Bulletin 3381. Heinemann Electric Company, 2806 Brunswick Pike, Trenton, N.J. 08602. Or Heinemann Electric (Europe) GmbH, 4 Düsseldorf, Jägerhofstrasse 29, Germany.

HEINEMANN

4933

EASY ECL 9500

3 Output capacity
Fan out of 16; or 10 loads on 50 ohm line;
40 mA DC current output.
Speed does not degrade with fan out.
DC noise immunity is higher because of higher output capacity, and requires no series terminating resistors.

4 Cross talk & power pins
Center power pins.
Easier board layout.
Reduces, if not eliminates completely, cross talk and on-chip noise.
Allows non-symmetrical loading of outputs.

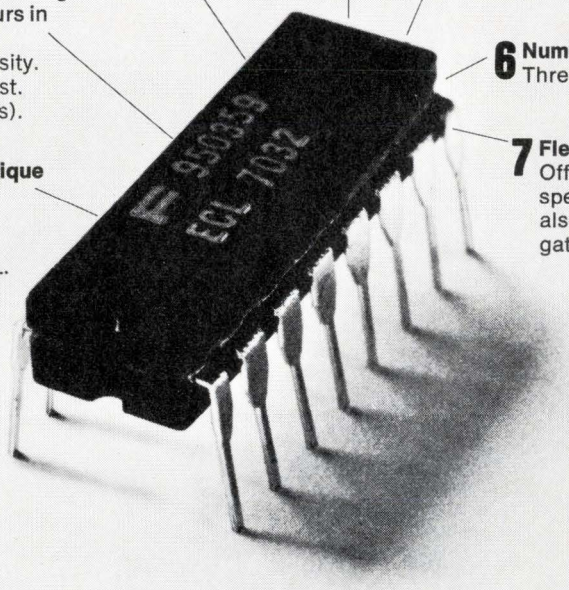
5 Thermal Management
DC parameters specified in still air.
No air flow required to meet DC specs on temperature.

2 Pull down resistors
Internal pull down resistors; no external resistors needed for lines less than 8" long and fan out of less than 16 (this occurs in 95% of all connections).
Higher active component board density.
Low assembly and parts stocking cost.
Higher reliability (fewer connections).

6 Number of MSI functions now available
Three (as of 5/1/71)

7 Flexibility
Offers low input impedance in standard speed (2.5nS) and high speed (1.5nS) gates; also offers high input impedance low power gates, (20mW).

1 Temperature dependence correction technique
Temperature compensation.
Logic levels remain constant.
Noise immunity remains constant.
Same cooling requirements as standard TTL.



Fairchild Easier ECL

Our 9500 series Easy ECL general purpose logic family is designed for high-speed application (1.5nS-2.5nS). It is *easier* to use because it is temperature compensated to maintain noise margins while simplifying cooling requirements. It's easier and *less costly* to use because the required optimum pull down resistors are built into each device, saving additional parts and assembly cost while preventing speed degradation as fan-out increases.

The Easy ECL family is already large. And getting even larger. It includes three MSI devices now in stock, and more on the way.

All of which means ever increasing freedom for the systems designer.

Make it easy on yourself

Send for our new ECL catalog, over 100 pages of detailed data sheets and applications notes. Then, when next you think about a new high speed system, make it easy on yourself. Think about Fairchild EASY ECL. It's the easiest.

Fairchild 9500 announcement schedule

Available now in quantity

9502	Dual 4-Input OR/NOR Gate
9503	Triple 2-Input OR/NOR Gate
9504	Quad 2-Input NOR Gate
9505	Quad OR-AND Gate
9528	"Dual D" Flip Flop
9538	3 line/8 line Decoder
9581	8-Input Multiplexer
9582	Multifunction Receiver/Schmitt Trigger
95H90	High Speed VHF Prescaler
9595	Level Converter

Available 3rd Quarter 1971

9507	Quad-AND-NAND Gate
95H02	High Speed 9502 (Dual 4-Input OR/NOR Gate)
95H03	High Speed 9503 (Triple 2-Input OR/NOR Gate)
95H04	High Speed 9504 (Quad 2-Input NOR Gate)
95L22	Low Power Dual Gate
95L23	Low Power Triple Gate
95L24	Low Power Quad Gate

VS. MECL 10,000

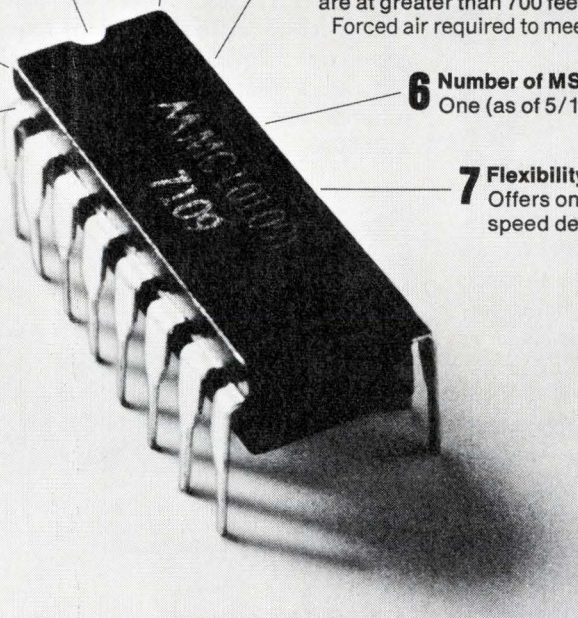
3 Output capacity
Fan out of 6; 25 mA DC current output.
Speed degrades with increasing fan out.
DC noise immunity is lower and requires series terminating resistors for fan out greater than 6 because of low output capacity.

2 Pull down resistors
Need at least one external resistor on each output for lines less than 6″ long. If the line is greater than 6″ long and the fan out is greater than 4, two or three more resistors are needed for each output. This is an average of 12 to 16 more connections for each 16-pin package.
Lower active component board density.
High assembly and parts stocking cost.
High system cost.

1 Temperature dependence correction technique
Temperature tracking.
Logic level voltage varies.
Noise immunity varies.
Special cooling requirements.

4 Cross talk & power pins
Corner power pins.
Requires special layout considerations.
Increased cross talk and decreased noise immunity.
Requires both true and complement outputs to be loaded symmetrically to maintain system performance.

5 Thermal Management
DC parameters are specified with 500 linear feet/minute air flow and published typical thermal conditions for determining DC levels are at greater than 700 feet/minute air flow.
Forced air required to meet DC specs.



6 Number of MSI functions now available
One (as of 5/1/71)

7 Flexibility
Offers only high input impedance standard speed devices; gate power, 25 mW.

95H29 High Speed J-K Flip Flop
9534 Quad Latch
9578 Quad Exclusive-OR Gate/4-Bit Comparator
9579 Quad 2-Input Multiplexer
95H84 High Speed 2-Bit Adder/Subtractor

Available 4th Quarter 1971

95H00 High Speed 4-Bit Universal Register
95H10 High Speed Synchronous Decade Counter
95H16 High Speed Synchronous Binary Counter
95H28 High Speed Dual D Flip Flop
95H39 High Speed Multiport Register
95400 High Speed 64 Bit Scratch Pad
95H55 High Speed 5-Bit Comparator
9580 Triple 2-Input Multiplexer

In accordance with Fairchild's technical exchange agreement, N. V. PHILIPS (The Netherlands) is an alternate source for the 9500 ECL series in Europe.

FAIRCHILD
SEMICONDUCTOR

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Circle Reader Service #13

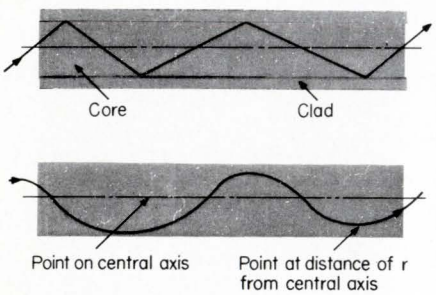
UP-TO-DATE

A new light guide

Nippon Sheet Glass Co., Ltd., of Osaka, Japan, has a new light-focusing fiber guide called SELFOC™. It's prepared by means of an ion-exchange treatment of a special composition glass. The process causes the index of refraction to vary, whereas conventional optic fibers have a constant index core with a lower index cladding.

The advantage of this new construction is that light headed for the periphery is always pulled back toward the axis, and it's transmitted along a sine curve path. Light in conventional fiber optics is transmitted via multiple reflections which distorts waveform and phase, making high frequency light transmission difficult. With the new fiber, however, light stays in phase because light that travels longer paths passes through material of lower refractive index in proportion to the distance it travels. Since this allows higher frequency light transmission, this could be a boost to optical communication cables.

SELFOC also has a lens effect which conventional fibers do not. By cutting to the proper length, micro lenses for optical instruments can be made. Other applications are in laser guides and conical light guides.

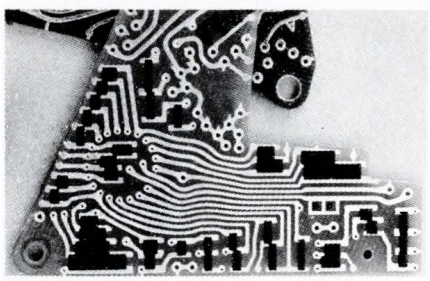


Top sketch shows the structure for the common fiber optic material. The structure is made up of two layers, each having a different index of refraction. Lower sketch shows Selfoc®. With this material refractive index gradually descends from center to periphery according to the formula $N=N_0 (1-\frac{1}{2}ar^2)$. N_0 is the highest refractive index in the center, and N is the refractive index at distance r from the center.

Tired of soldering? Try screening.

Electronic Engineering Company of California (EECO) is silk-screening resistors directly onto printed circuit boards, a process which could aid mass production in many areas.

Resistor rule values are 350 and 3,000 ohms per square, and inks can be mixed to come up with intermediate values. Application is at room temperature and curing takes 10 hours at 315°F after one hour at 212°F. This stabilizes the resistors by driving off binders. Final tolerances are ±20%, which compares to early thick film tolerances. The temperature coefficient is linear up to at least 80°C.



Resistors can be screened onto a printed circuit board using a special ink. The dark rectangles are the resistors.

Since traditional thick film design techniques apply (designing circuits, for example) one pot or trimmed resistor is needed. (See "Hybrid resistor trimming," The Electronic Engineer, Oct. 1970.) Anyone with a knowledge of thick film technology should have no trouble with this.

They've been using rigid, glass epoxy boards as substrates, at least 1/16-in. thick. This prevents resistor separation and cracking because of board bending. EECO plans to sell inks and will design and manufacture boards for anyone. For further information contact EECO, 1441 E. Chestnut Ave., Santa Ana, Calif., 92702, or

Circle Reader Service #252

Credit checker has solid-state display

American Regitel, of San Carlos, Calif., has added a credit-checking unit to its line of point-of-sale equipment. (**The Electronic Engineer,** May 1971, pp. 47-50.) A terminal in itself, the Areg connects to the Regitel central control—a Data General Nova mini—via a three-wire line.

To check the status of a customer's credit, the salesperson enters the customer's credit-card number into the Areg's 12-key, touchtone-style keyboard. Immediately above the keyboard is a five-digit, solid-state display (from Litronix, of Cupertino, Calif.) that gives a visual verification of the entered number.

The salesperson then enters the whole-dollar amount of the transaction, and the computer responds with a five-digit code word descriptive of the customer's account status.

Even though many account numbers may run to 10 and 12 digits, Regitel chose a five-digit display because five digits take care of most purchases (the spillover on larger purchases will be obvious to the salesperson); five-digit-or-less codes are common in retailing; and a long account number that moves across the display like ticker-tape is not a hindrance to the salesperson.

The display represents the most expensive component in the Areg: even in quantities of 25,000 pieces, Regitel is paying Litronix between four and five dollars per digit.

Litronix is supplying their Data-Lit 8 for Regitel's display. The Data-Lit 8 is a GaAsP leadframe LED display.

The first Areg units are going to Bullock's, a California retail giant, which already uses Regitel's point-of-sale system.

For Areg, Circle Reader Service 253

For Litronix, Circle Reader Service 254

¢-LINE PROGRAMMABLE UNIJUNCTION TRANSISTORS

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37 Newbury Street, Boston, Massachusetts 02116

Please send free samples of PUT checked below (including data sheet).

Check for Sample	Unitrode Type No.	Forward Voltage Rating Volts max.	Peak Point Current μa max.	Valley Point Current μa min.	Check for Sample	Unitrode Type No.	Forward Voltage Rating Volts max.	Peak Point Current μa max.	Valley Point Current μa min.
☐	2N6119[1]	40	2.0@10V[3]	70@10V[4]	☐	2N6138	100	10@10V[5]	40@10V[6]
☐	2N6120[2]	40	0.15@10V[3]	25@10V[4]	☐	U13T3	100	2.0@10V[3]	70@10V[4]
☐	2N6137	40	10@10V[5]	40@10V[6]	☐	U13T4	100	0.15@10V[3]	25@10V[4]

1. Formerly U13T1 2. Formerly U13T2 3. R_G=1MΩ 4. R_G=10KΩ 5. T=-55°C, R_G=10K 6. T=+125°C, R_G=10K

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____ ZIP_____

Circle Reader Service #13

International TV . . . With ITT's new TV system, you don't change the picture—just the language. The system, developed by ITT in Germany, features broadcasts of international events, permitting the viewer to select a language as he selects a channel—with the flick of a switch. The basic 12-channel system can be expanded to 24 sound channels for an even greater variety of languages. Applications for the system include continent-wide or even world-wide coverage of news, educational programs, and/or sports events.

Larger chip, larger ROM . . . Electronic Arrays of Mountain View, Calif., has put a 12,000-bit MOS ROM on a 135 x 141-mil chip for one of its European calculator OEM customers. Arranged as 1024 12-bit words, the memory has an access time of about 2 μs, dissipates 250 mW (total), and operates from a single-phase clock. EA's European sales are handled by the Philips organization, and the memory will probably first appear in Europe under a Philips' part number. Even though it's slow, the memory has possibilities in microprogramming.

Circle Reader Service #230

Fine-grained alumina substrates . . . Western Electric has a new way of making alumina substrates for thin-film microcircuits. Fine-grained active alumina powder is ball-milled in a polyunsaturated oil deflocculent. After casting and drying, the alumina particles are tightly packed and fired at 1500°C. Substrates made by this method are relatively free from surface defects and greatly improve the adhesion of lead wires. Western Electric has licensed several companies to make these substrates.

Blocking light reflection . . . Most phosphors used in display tubes are light in color and have a high reflectivity. This causes the display information to "wash out" in high ambient light. Westinghouse has come up with a method of attenuating the ambient light both before and after it is reflected from the phospor. The result is a high display luminance against a much less intense background. They call this process contrast enhancement.

Expandable computer controlled testing . . . Instrumentation Engineering has made the first deliveries of their System 390 Universal Computerized Tester. The System 390 can be used for component and subsystem testing, as well as printed circuit board testing. It performs go-no/go screening and fault isolation for such uses as production testing and service repair. The system has been engineered so that you can buy as little or as much of the system as you require. It can be expanded later without any problems. Computer instructions are via a fairly simple English language program.

Buy connections, not connectors . . . Bennett W. Brachman, VP of Marketing for Amphenol, estimates that 90% of all connector failures occur in the assembly of cables to connectors, usually done in the field. His solution is a total package buy with assembly completed at the factory.

Semiconductors way off . . . According to the EIA Marketing Services Dept., U.S. factory sales of semiconductors for January was $89.7 million. Compared with $112.3 million last January, the dollar decline is 20.1%. Unit volume dropped from 295 to 209 million, or 29.3%.

Aluminum wire boost . . . Alcoa recently demonstrated a new liquid flux and low-temp solder for joining dissimilar metals. Combined action of the new materials improves corrosion resistance and electrical stability of soldered aluminum joints. A company spokesman said that the new flux/solder combination is available for commercial evaluation, and predicted that it would accelerate the use of aluminum wire.

Circle Reader Service #231

It's anybody's market . . . In a landmark decision, all seven federal Communications Commissioners voted to open up the microwave specialized communications area (where many firms will handle high-speed data) to competition. Any firm with adequate financial backing and technical capability can now enter this field without an FCC hearing. One result: this will open it up to what Commissioner Nicholas Johnson calls "the great American tradition of bankruptcy."

Mr. Package . . . Bryant C. (Buck) Rogers, President of Diacon, in San Diego, Calif., is Nepcon's "Packaging Man of the Year." He invented the dual-in-line package while at Fairchild Semiconductor and recently developed a leadless package for large multi-lead circuits. (See **The Electronic Engineer,** Feb. 1971.) Buck was our nominee for the award, and we are pleased that he was so honored. Congratulations, Buck!

Bits of information . . . The next moon landing will use an **RCA** color TV camera that can be remotely manipulated from earth by radio. The system allows the camera to be turned on and off, panned around, raised or lowered, zoomed in on or out from a subject. Even the light control may be remotely adjusted for the best picture . . . **Western Electric's** Allentown, Pa., plant has a new technique for producing amorphous silicon nitride. The method uses a standard diffusion furnace and the ammonolysis of silicon tetrachloride. The silicon nitride produced is used as a contamination barrier in the manufacture of beam lead chips.

Westinghouse claims to have the smallest TV camera ever built—1½ in. square by 5 in. long. It has a ½-in. diameter vidicon tube and weighs 9 oz. . . . Several new lines of **RCA's** color TV sets contain hybrid IC plug-in modules using material supplied by DuPont . . . **Raytheon Co.** has received a patent on an improved microwave phase shifter with dual polarization.

Naval Research Laboratories' scientists have achieved continuous laser oscillation from a free-burning, low pressure flame . . . **Motorola** has cut prices drastically on a large number of their high-frequency transistors. Some of the cuts go as high as 60% . . . **RCA's** new line of gas lasers includes a low-noise helium cadmium laser and a new multi-beam helium selenium laser.

No. 5: The Monomatic Bridge

Gone are the days of the "knobby" universal bridge. No more hard-to-read, interacting controls and annoying multiplier scales.

With HP's 4260A Universal Bridge, you get a direct, in-line digital readout with automatic decimal and units indication – plus a unique auto-balance system that allows "monomatic" (one-operation) use. No more two-handed struggles; just set your scale, turn one feather-touch crank... and the figure you're seeking appears in seconds, in digits.

To aid in selecting the proper scale and in fine-balancing the bridge, the 4260A has a unique neon-arrow indicator system that tells you whether you're up-scale or down—as well as a null-meter for final adjustment.

With the 4260A, you can measure C from 1 pf to 1000 μf, R from 10 mΩ to 10 MΩ, and L from 1 μH to 1000 H. Accuracy is $\pm$1% +1 digit on the middle ranges. Yet the 4260A costs only $595.

The 4260A is just one of HP's family of "Useables"—easy-to-use instruments for testing components. For further information on the 4260A, or on any of the "Useables," contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

09 1/10

COMPONENT-TESTING INSTRUMENTS YOU CAN USE

The Useables:

No. 1: 4342A Q Meter, No. 2: 4270A Automatic Capacitance Bridge, No. 3: 4328A Milliohmmeter, No. 4: 4329A High Resistance Meter, No. 5: 4260A Universal Bridge, No. 6: 4470B Transistor Noise Analyzer.

CALENDAR

JULY

11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

July 13-15: International Symposium on Electromagnetic Compatibility, Bellevue Stratford Hotel, Philadelphia, Pa. Addtl. Info.—Ralph Showers, Moore Sch. of EE, Univ. of Penna., Philadelphia, Pa. 19104.

July 19-20: Summer Computer Simulation Conference, Boston Sheraton Hotel, Boston, Mass. Addtl. Info.—Michael McCarthy, Wharton Sch. of Finance, Univ. of Penna., Philadelphia, Pa. 19104.

July 25-30: ISA's 1971 Research Conference on Instrumentation Science, Hobart and William Smith Colleges, Geneva, N.Y. Addtl. Info.—Instrument Society of America, Education Services Dept., 400 Stanwix St., Pittsburgh, Pa. 15222.

AUGUST

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Aug. 3-5: ACM's Quarter-Century Computer Conference, Conrad Hilton Hotel, Chicago, Ill. Addtl. Info.—George Capsi, ACM, 1133 Avenue of the Americas, New York, N.Y. 10036.

Aug. 11-13: Joint Automatic Control Conference, Washington Univ., St. Louis, Mo. Addtl. Info.—R. W. Brockett, Pierce Hall, Harvard Univ., Cambridge, Mass. 02138.

Aug. 23-28: European Microwave Conference, Royal Inst. of Tech., Stockholm, Sweden. Addtl. Info.—H. Steyskal, European Microwave Conference, Fack 23, 104 50 Stockholm 80, Sweden.

Aug. 29-Sept. 1: 1971 AIME Electronic Materials Technical Conference, St. Francis Hotel, San Francisco, Calif. Addtl. Info.—J. J. Tietjen, Publicity Chairman, Metallurgical Society of AIME, RCA/David Sarnoff Rsch. Ctr., Princeton, N.J. 08540.

'71 and '72 Conference Highlights

WESCON—Western Electronic Show & Convention, Aug. 24-27; San Francisco, Calif.

NEREM—Northeast Electronics Research & Engineering Meeting, Nov. 3-5; Boston, Mass.

IEEE International Convention and Exposition will be called INTERCON '72. It will take place on March 20-23, at the New York Coliseum and New York Hilton.

NOTICE: Location of the 1971 **WESCON** Show and Convention has been changed to Brooks Hall/Civic Auditorium, San Francisco, Calif.

← *Circle Reader Service #15*

Circle Reader Service #16

NEW BOURNS MODEL 3861 ...and more to come RV6 VARIABLE RESISTOR

...NEWEST ADDITION TO THE GROWING FAMILY OF BOURNS PANEL CONTROL UNITS!

NOW LISTED ON QPL FOR MIL-R-94C, RV6 STYLE, the new Model 3861 with its hot molded carbon element is the ideal answer when your requirements call for long, dependable control life . . . when frequent adjustment is needed . . . or for any RV6 Mil-Spec application. Advantages of the Model 3861 include: metal bushing and case; ½ watt power rating at 70°C; resistance to 5 megohms; and, tolerance of ± 10% . . . and a price of $1.15 each in 2500-piece quantities.

Also, take a look at the other members of the Bourns Panel Control family — many are cermet for added stability and higher power requirements:

Model 3852

Model 3859

¾″ dia., metal bushing, locking or non-locking, rated 2 watts at 70°C, resistance to 5 megohms, and tolerance of ±10%. The price: 81 cents each in 2500-piece lots.

¾″ dia., plastic bushing or quickly installed snap-in version, 2 watts at 70°C, resistance to 5 megohms, tolerance ±10%. In 2500-piece quantities, just 66 cents each.

Model 3862

½″ dia., rated 1 watt at 125°C, resistance to 5 megohms, tolerance ±10%. Price each in 2500-piece quantities, $1.18.

Complete technical data on these units is available from the factory or your local Bourns Trimpot Products distributor . . . write today!

BOURNS

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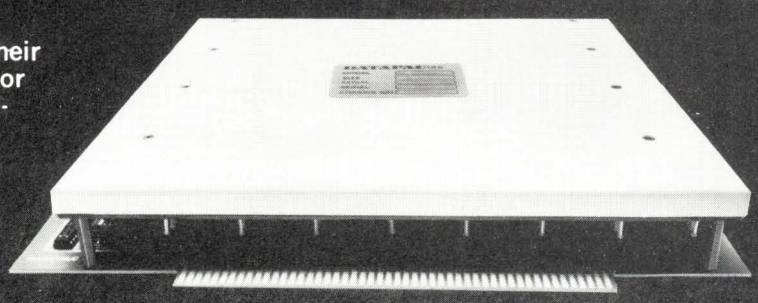
Datapac Read-Only Memory Systems are unique in their design to let you easily change individual bits, words or an entire memory in the field. Datapac ROMs are available in a wide choice of models, sizes and configurations. Capacities from 1K to 1 Megabit. Word lengths to 80 bits. Speeds as fast as 200 Nsec Cycle and 75 Nsec Access. Off the shelf delivery — 50,000 hrs. MTBF. Mil Spec compatible. And 1.5¢ per bit. Write today for our FREE brochure containing the complete Datapac story.



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Finally... there's a new and better way to transmit high-speed digital data.

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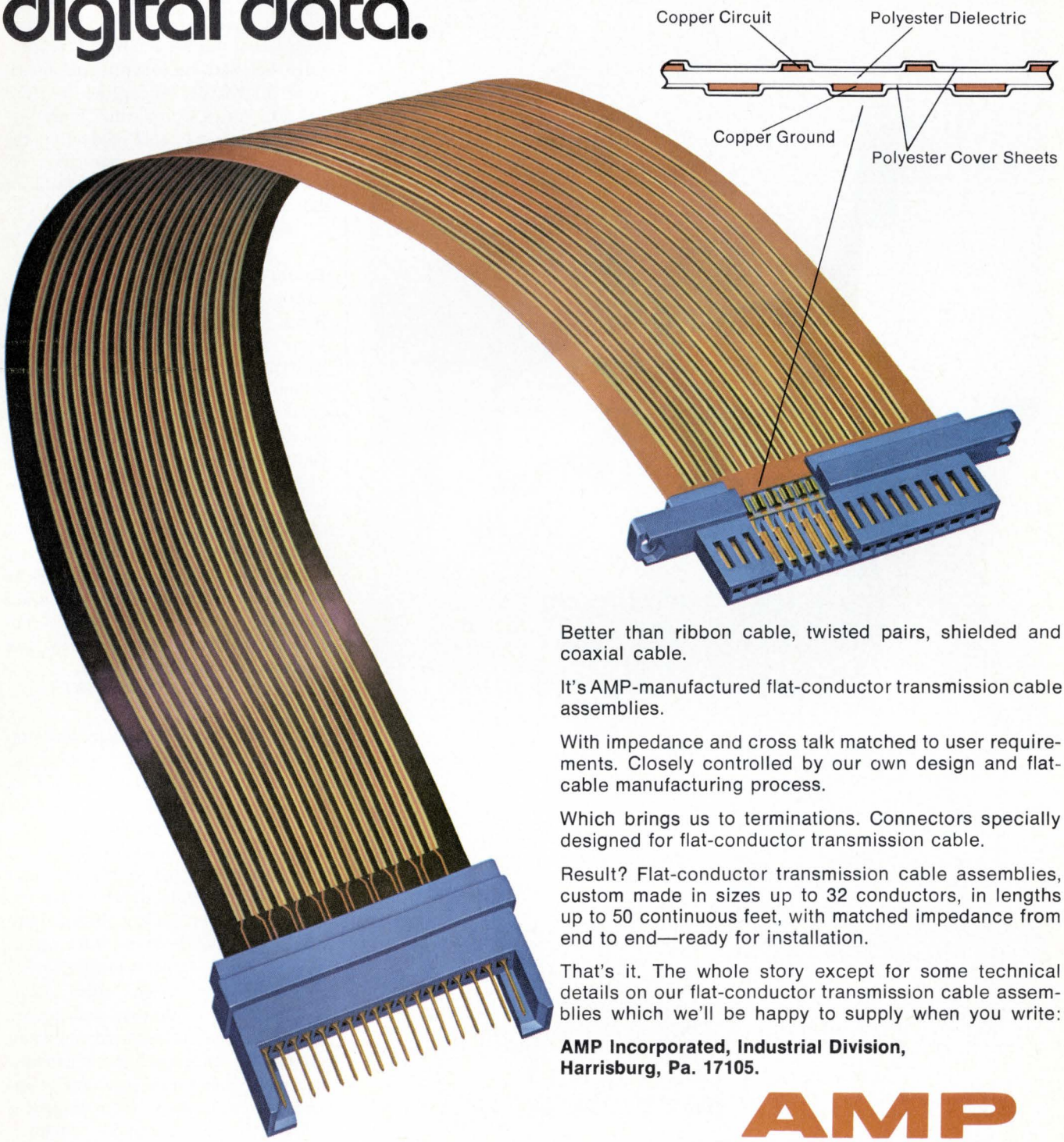

Better than ribbon cable, twisted pairs, shielded and coaxial cable.

It's AMP-manufactured flat-conductor transmission cable assemblies.

With impedance and cross talk matched to user requirements. Closely controlled by our own design and flat-cable manufacturing process.

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Result? Flat-conductor transmission cable assemblies, custom made in sizes up to 32 conductors, in lengths up to 50 continuous feet, with matched impedance from end to end—ready for installation.

That's it. The whole story except for some technical details on our flat-conductor transmission cable assemblies which we'll be happy to supply when you write:

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Manufacturing and Direct Sales Facilities in: Australia, Canada, France, Great Britain, Holland, Italy, Japan, Mexico, Puerto Rico, Spain, Sweden, United States and West Germany.

WELCOME

Interconnection devices

Specialties of the house at one year old Parlex Corp., located at 145 Milk St., Methuen, Mass., are systems for replacing conventional wire harnesses, thereby reducing connection costs. Designated the "inner systems," they utilize various technologies, including flexible PCs, multi-layer flexible PCs, combinations of flexible and rigid PCs, laminated bus bars, PC boards, and multilayer PC boards. According to Herb Pollack, Parlex's president, "inner systems" are a marketable product for the computer peripheral, medical electronics, instrumentation, and military and aerospace fields.

Circle Reader Service #418

Instant microfilm!

Micrographic Technology Corp. of Santa Ana, Calif., offers a complete in-house capability for making fiches in a variety of formats and camera magnifications. Their product is a combination camera-processor that photographs documents on 4 x 6-in. microfilm and automatically develops the film. A microfilm viewing system brings any selected page into view in 3 sec. when a cartridge (which can store up to 6,700 pages) is inserted and the fiche and page indicated by push-button. Microfiche storage-retrieval devices are also available. Applications include security microfilm, technical documentation, and product cataloguing.

Circle Reader Service #419

Testers for two-terminal semiconductors

Datalogic Systems Inc. recently introduced its first standard product—a tester for two-terminal semiconductor devices. The unit, designated Model 10RZ, measures from 1-nA to 1-A reverse current, and up to 10-A forward current for standard diodes, rectifiers, and zener diodes. Salient features also include the ability to measure up to 2000 V, and Z_z (zener impedance). It's a highly modular system, which can be customized for applications such as data logging and multiplexing and can be interfaced for all known diode-handling machines. Price varies according to desired options; however, the basic cost is $12,000. A new-generation computer-controlled tester, which has been sold to IBM, was shipped at the end of May.

Circle Reader Service #420

1¢ Sale

Amperex readout tubes

You pay the regular price of $3.00 for one ZM1000 ...you get two ZM1000's for $3.01

The ZM1000 was designed into more new products in 1969 and 1970 than any other numerical readout tube. Now, to introduce the ZM1000's to even more equipment designers, we are offering them in quantities from 2 to 500, for a limited time, at the special promotional price of 2 for $3.01. This introductory offer, not available through distributors, is restricted to O.E.M.'s...one purchase per customer...2 to 500.

The regular prices are just as exciting:

1-99	100-499	500-999	1000-4999	5000-9999
5.00	4.00	3.00	2.00	1.75

...at these prices, you can't afford *not* to design us in, wherever cost is a key factor.

The ZM1000 is rated at 200,000 hours of dynamic life expectancy. Its bright clear numerals are plainly legible at 35 feet. An 8 decade readout of ZM1000's fits into only six inches of panel space. Every ZM1000 has a built-in decimal point at no cost to you!

For immediate action, use the coupon provided and enclose your firm's purchase order.

For data, circle 1 on the magazine's inquiry card; to have our Sales Representative call on you, circle 2; to indicate an immediate application, circle 3. Or contact: Amperex Electronic Corporation, Product Mgr., Indicator Tubes, Slatersville, Rhode Island 02876. Telephone: 401-762-9000.

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Amperex Electronic Corporation
Slatersville, Rhode Island, 02876

Enclosed is our purchase order for_____ ZM1000's at your special introductory price of 2 for $3.01.

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Title _____

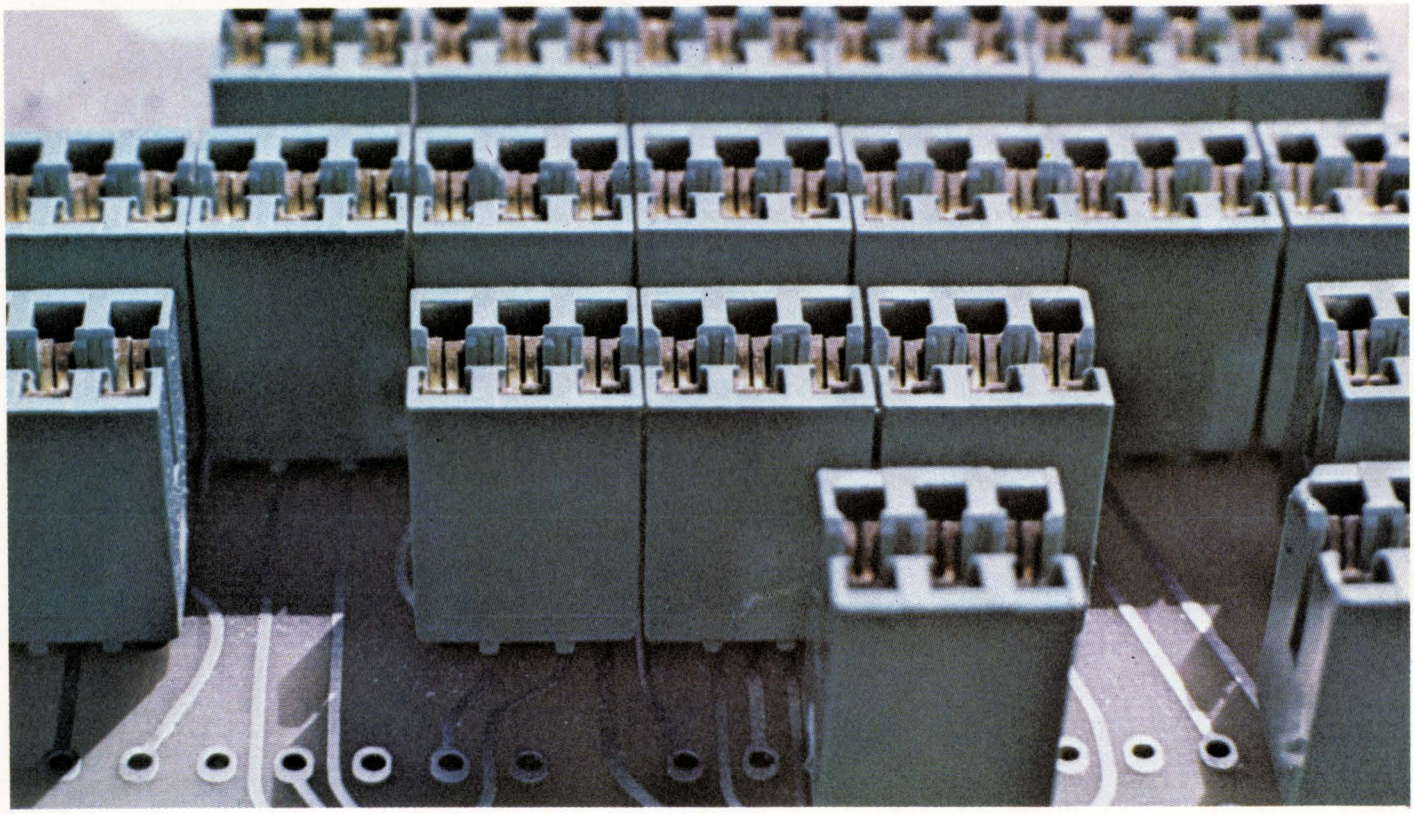
Company _____

Phone _____

Street _____

City _____

State _____ Zip _____



A NEW DIMENSION IN P.C. BOARD CONNECTING

Solderless connector modules with .156-inch spacing. In two sizes: all with dual readout contacts—center modules with six, and end modules with four. With these two sizes, you can custom design your connector to accommodate just about any size p.c. board.

Without soldering.

Simply push the contact tails of these Mojo™ connectors through the plated through holes of the p.c. board. And you'll have a gas tight, corrosion proof, vibration immune connection that's as electrically and mechanically sound as the best soldered joint. But more easily assembled than any soldered connection. More economically. And without the heating problems that automatic soldering methods often impose.

And Mojo gives you more.

Such as preloaded contacts that firmly grip the p.c. card, but keep their distance when the card is removed. Easily accessible square wire-wrapping posts in the event you have to make any extra back-panel interconnections. And you'll move smoothly and economically from prototype to production with just two connector modules to carry in inventory.

Did we say just two modules? Sorry, we meant four. Because Elco still makes available Mojo connectors with contacts at .150-inch centers. Same specs, same special features as the new .156-inch. Just that little .006-inch difference.

For full details and specifications on Mojo connectors, contact:

Elco, Willow Grove Division,
Willow Grove, Pa. 19090
(215) 659-7000

Elco, Huntingdon Division,
Huntingdon, Pa. 16652
(215) 659-7000

Elco, Pacific Division, 2200 Park Place,
El Segundo, Calif. 90245
(213) 675-3311

Operations in USA, Australia, Belgium, Canada, Denmark, England, France, Germany, Israel and Japan. Sales offices throughout the world.

OP AMP CHARTS GO ON-LINE!

By A. Boyle, L. Rothstein, D. Wilkins and the computer,
Staff, The Electronic Engineer

Again, we bring you our annual edition of The Electronic Engineer's "IC op amp selection charts," but this year we've done something quite unique. Every year, the task of compiling the material for these charts becomes more formidable. As new devices are introduced and more companies second source the more popular types, the number of op amps which we must process soon grows to amazing proportions. For this reason, no magazine can possibly announce all new op amps as they are introduced. So this year we asked the computer for help.

What you see below is a composite printout of that op amp information relevant to these charts. The information was extracted from a permanent data file on integrated circuit op amps. Because the greatest amount of activity is in the lower cost op amps, we have defined our data base as those products costing $30 and under (in quantities of 100), and we have asked the computer to sort them by construction type, that is, hybrid or monolithic. At present, our data base includes op amps introduced since July 1970, when we last published our op amp charts, plus previous models which have proven to be very popular with users (the 709, 741, and 101, for example).

Subscribe to our updating service

Throughout the coming year, we will continue to update our computerized files. We'll add new devices as they appear on the market, and we'll strike those that become obsolete. While we cannot republish these charts with each updating, we can offer you an opportunity to keep abreast of the latest in the field. Four times during the next 12 months (July and Oct. 1971, Jan. and April 1972) we will print out our updated op amp files. As in the printout below, this will list units by manufacturer, but will also include values for the three parameters included in our charts—input bias current, slew rate, and voltage drift—as well as current prices. For $5.00 we will send you these computer printouts on a quarterly basis for one year.

For an additional $2.00 per parameter you may select one or all of the three parameters and receive a printout which has sorted the op amps by that or those parameters you have chosen. The complete package costs $10, saving you $1. The following box explains how to order this service. Clip it out and mail it for your subscription to quarterly computer printouts.

Reading the op amp charts

Each of the following charts graphically illustrates the relationship between price and one of three important op amp parameters. The parameters we have selected are:

1). Input bias current
2). Slew rate
3). Input offset voltage temperature sensitivity

Each device in the chart guide has a number next to it. That number represents that op amp in all three charts. Please keep in mind that these charts generally represent typical values. Gene Tobey of Burr-Brown says ". . . the definition of 'typical' varies widely from one manufacturer to another (and from one production run to another for that matter), and the result is often misleading. For instance," he says, "a 741 at $3.00 with a voltage drift of $\pm 3\ \mu V/°C$ (typical) is rated on a par, for voltage drift, with the Burr-Brown 3054S/01 at $27.00 and $\pm 3\ \mu V/°C$ (max). The difference between the two amplifiers, as any user will soon discover, is that a relatively small percentage of 741's will meet the $\pm 3\ \mu V/°C$ specification, while all of the 3054S/01's will meet it. The reason is that the $\pm 3\ \mu V/°C$ specification is a 'typical' for the 741 and a 'maximum' for the 3054S/01. Many of the 741's may be expected to drift as much as $\pm 30\ \mu V/°C$. Similar comments apply to the other parameters (except price which is a 'maximum' in all cases)."

Input bias current (I_{IB})

Two definitions are frequently assigned to input bias current. The first (agreeing with the EIA glossary) states that it is the sum of the input bias current entering the two input terminals of a balanced amplifier, or, the bias current entering

These are the options you may choose from:

Basic printout
(all units sorted by manufacturer, listing model number, input bias current, slew rate, voltage drift, and price per 100 units) ..... $5 ☐

Basic printout plus parameters
(basic printout plus an additional printout for each parameter selected)
input bias current ..... ($5 +) $2 ☐
slew rate ..... ($5 +) $2 ☐
voltage drift ..... ($5 +) $2 ☐

Complete package
(basic printout plus three additional printouts, each sorted by one of the three parameters) ..... $10 ☐

This is a unique service you can't get elsewhere, so tell us which printouts you'd like (simply check which option you'd like above) and send your total $$ to:

Op Amp Computer Printouts
The Electronic Engineer
One Decker Square
Bala-Cynwyd, Pa. 19004

Name _____ Company _____

Address _____ City _____ State _____ Zip _____

And now, from the ROM capital of the world...

...4096 and 3072 bits.

With seven ROMs, we were already on top in the read-only-memory market.

Our two newest ROMs will keep us on top for a long time to come.

Each is worthy of special note.

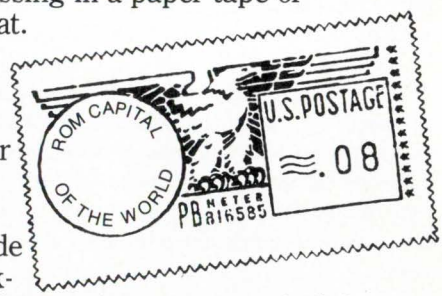
The MM4232/MM5232 is a 4096 bit static ROM organized in either a 512 word x 8 bit or 1024 word x 4 bit configuration controlled by a mode control input. With an access time of 1 microsecond. It features two mask programmable chip enable lines (CE_1 and CE_2), a clever innovation which provides logic control up to 16K bits *without external logic.*

Our other new ROM is the MM4241/MM5241 Vertical Scan Character Generator. A 3072 bit static read-only-memory organized in a 64 x 6 x 8 format with an access time of 750nS. The MM4241AAN/MM5241AAN is a standard 5 x 7 font available off-the-shelf.

Both of our newest ROMs use standard supplies (+5, −12V) and are bipolar compatible at the inputs and outputs. In addition, both have been designed with Tri-State™ logic outputs. (Another innovation, and one which gives you wire OR'd capability without loading common data lines or reducing the 750nS access time.)

Finally, both the MM4232/MM5232 and MM4241/MM5241 are mask programmable. Thereby allowing you to submit your own programs for processing in a paper tape or punched card format.

That's a look at our two newest ROMs. For more details on them, our other seven read-only-memories, our line of standard code converters and look-up tables, or a handsome picture postcard of the ROM capital of the world, contact us today.



National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051. Phone (408) 732-5000. TWX: (910) 339-9240. Cable: NATSEMICON.

Note: MM42xx refers to −55°C to +125°C temperature range devices; MM52xx to −25°C to +70°C

National

the input of a single-ended amplifier. Manufacturers of monolithic op amps generally agree to this definition and use it to specify their devices.

This definition, however, is far from universally accepted. In the case of a balanced amplifier, hybrid manufacturers take a different viewpoint. Their contention is that input bias current is the larger of the two currents rather than the average of both.

It's a good idea to keep this difference in terminology in mind when reading the bias current chart. A good rule of thumb is that if the op amp is monolithic, the bias is the average of the two inputs. If it's hybrid, in most cases the bias is the larger of the two inputs.

Slew Rate (SR)

Slew rate is the time rate of change of the closed-loop amplifier output voltage for a maximum-step signal input. (A maximum-step signal input is the largest input voltage step for which the amplifier performance remains linear.) This definition assumes that the amplifier is operating with unity amplification.

Offset voltage temperature sensitivity ($\Delta V_{IO}/\Delta T$)

The ratio of the change in input offset voltage to the change in circuit temperature for a constant output voltage defines this parameter. This is an average value for a specified temperature range.

Chart Guide to Manufacturers and Devices

HYBRID OP AMPS

UNIT NO.	MODEL	COST($/100)
AMPEREX		
1	ATF401	17.00
2	ATF404	20.00
ANALOG DEVICES		
3	AD503J	9.90
4	ADP511A	14.00
5	AD511A	14.00
6	AD503K	14.00
7	AD513J	15.00
8	ADP511B	17.00
9	AD511B	17.00
10	AD513K	17.50
11	AD506J	18.00
12	AD503S	18.00
13	ADP511C	21.00
14	AD511C	21.00
15	AD506K	21.00
16	AD516J	21.50
17	AD513S	21.50
18	AD516K	25.00
19	AD506S	26.00
20	AD516S	30.00
BURR-BROWN		
21	3227/03	9.50
22	3503A	9.90
23	3226/03	13.00
24	3503R	13.50
25	3503B	14.00
26	3503C	17.00
27	3503S	17.30
28	3352/03	17.50
29	3350/03	22.00
30	3503T	22.70
31	3349/03	30.00
BDC		
32	0-557C	9.00
33	1-557C	9.00
34	0-578C-2	10.00
35	1-578C-2	10.00
36	0-557B	11.00
37	1-557B	11.00
38	0-578C-1	12.00
39	1-578C-1	12.00
40	0-557A	13.00
41	1-557A	13.00
42	H50C-2	15.00
43	0-578B-3	18.00
44	1-578B-3	18.00
45	0-578B-2	20.00
46	1-578B-2	20.00
47	0-578B-1	21.00
48	1-578B-1	21.00
49	H50C-1	21.00
50	0-557A-4	22.00
51	1-557A-4	22.00
52	H50B-3	25.00
53	0-578A-2	29.00
54	1-578A-2	29.00
INTERSIL		
55	8500	28.25
56	8500A	29.75
MOTOROLA		
57	MCH2870CR	8.50
58	MCH1439G	12.00
59	MCH1539G	15.00
60	MCH2870MR	16.00
NATIONAL SEMICONDUCTOR		
61	LH0005C	7.00
62	LH0002C	8.50
63	LH740AC	9.00
64	LH0005	13.00
65	LH0020C	14.00
66	LH0002	14.00
67	LH0004C	16.50
68	LH0001C	17.00
69	LH0022C	18.00
70	LH0021C	18.50
71	LH740A	19.00
72	LH0033C	20.00
73	LH0024C	20.00
74	LH0003C	22.00
75	LH0020	26.50
76	LH0033	28.00
77	LH0032C	28.00
78	LH0005A	30.00
OPTICAL ELECTRONICS		
79	9406	19.00
80	9412	32.00
PRECISION MONOLITHICS		
81	SSS1458	2.80
82	SSS1558	5.45
83	MONMP04GQ	*****
84	MONOP04CQ	*****
SILICONIX		
85	L137CA	18.40
86	L137AA	26.25
TELEDYNE PHILBRICK		
87	1413	8.00
88	1019	*****
89	1025	*****
90	1420	15.75
91	1408-10	23.00
92	1408	23.00
93	1408-11	27.00
94	1408-01	27.00
TELEDYNE SEMICONDUCTOR		
95	2741CF	10.80
96	2740CE	10.80
97	2809CG	17.00
98	2709CG	17.00
99	2841CF	21.60
100	2740RF	22.00
101	2741CH	22.00
102	2741RF	22.00
103	2809RG	25.00
104	2741RH	25.00
105	2709RG	25.00
106	2841BE	26.60
ZELTEX		
107	ZC741E1	20.00
108	ZA801D1	25.00
109	ZA801E1	25.00
110	ZC741E6	26.00

MONOLITHIC OP AMPS

UNIT NO.	MODEL	COST($/100)
ADVANCED MICRO DEVICES		
200	307	2.75
201	301	3.25
202	741C	3.25
203	301A	3.45
204	747C	4.50
205	715C	4.95
206	AM1660	5.00
207	741	5.95
208	725C	7.50
209	201	7.50
210	207	7.60
211	747	9.95
212	308	10.00
213	201A	12.00
214	107	15.00
215	725B	15.00
216	101	15.00
217	715	20.00
218	208	20.00
219	308A	20.00
220	725	25.00
221	108	30.00
222	101A	30.00
ANALOG DEVICES		
223	AD301A	1.00
224	AD741C	1.00
225	AD741	2.00
226	AD741K	2.25
227	AD201A	2.75
228	AD101A	3.00
229	AD502JH	3.00
230	AD741L	6.00
231	AD502KH	6.00
232	AD502SH	7.00
233	AD308	8.00
234	AD502AH	9.75
235	AD505J	10.00
236	AD502LH	10.00
237	AD505K	12.00
238	AD505S	14.00
239	AD502BH	14.00
240	AD208	15.00
241	AD108	22.00
242	AD501A	27.00
BURR-BROWN		
243	3057/01	5.95
244	3500A	6.70
245	3053/01	7.50
246	3056/01	9.00
247	3501A	9.90
248	3500R	9.90
249	3500B	9.90
250	3055/01	12.75
251	3052/01	12.75
252	3501R	13.30
253	3501B	13.30
254	3500S	13.30
255	3500C	13.30
256	3054/01	14.25
257	3051/01	16.50
258	3501S	16.70
259	3501C	16.70
260	3500T	16.70
261	3050/01	18.00
262	3501T	20.00
263	3054S/01	27.00
FAIRCHILD		
264	MUA301A	1.10
265	MUA201	1.25
266	MUA709C	1.90
267	MUA777C	2.35
268	MUA201A	3.05
269	MUA101A	3.25
270	MUA741C	3.25
271	MUA776C	3.28
272	MUA101	3.95
273	MUA709	3.95
274	MUA777A	5.95
275	MUA741	5.95
276	MUA776	8.83
277	MUA709A	9.95
HARRIS		
278	RA-2625	10.70
279	RA-2620	17.85
INTERSIL		
280	748C	1.10
281	741C	1.25
282	301A	3.30
283	748	3.95
284	741	3.95
285	201	5.65
286	8008C	5.80
287	308	8.00
288	201A	8.00
289	101	8.00
290	8021C	10.00
291	8017C	10.00
292	4250C	10.00
293	101A	11.35
294	8008M	11.50
295	8007C	13.50
296	8017M	14.00
297	208	15.00
298	308A	17.35
299	108	20.00
300	8021M	28.50
301	4250	28.50
ITT		
302	MIC709	3.90
303	MIC741	5.95
304	MIC709A	9.60
MOTOROLA		
305	MC1709CP1	0.80
306	MC1709CP2	0.85
307	MC1709CL	0.98
308	MC1709CG	0.98
309	MC1748CG	1.25
310	MC1741CP1	1.40
311	MC1741CG	1.45
312	MC1709CF	1.50
313	MC1741CL	1.60
314	MC1741CP2	1.75
315	MC1709L	1.75
316	MC1709G	1.75
317	MC1439G	1.80
318	MCRC1709	1.85
319	MC1712CF	1.85
320	MC1437P	1.87
321	MC1435L	1.90
322	MC1435G	1.90
323	MC1439L	2.00
324	MC1437L	2.20
325	MC1712CL	2.25
326	MC1458CG	2.25
327	MC1420G	2.25
328	MC1456CG	2.35
329	MC1433L	2.45
330	MC1539L	2.50
331	MC1539G	2.50
332	MC1433G	2.65
333	MC1436CG	3.10
334	MC1458G	3.12
335	MC1709F	3.25
336	MC1537L	3.25
337	MC1741CF	3.50
338	MC1533L	3.50
339	MC1533G	3.50
340	MC1748G	3.85
341	MC1741G	3.90
342	MC1741L	4.00
343	MC1431G	4.35
344	MC1430P	4.35
345	MC1430G	4.35
346	MC1741F	4.50
347	MC1456G	4.90
348	MC1712L	5.25
349	MC1712G	5.25
350	MC1436G	5.60
351	MC1431F	5.60
352	MC1430F	5.60
353	MC1712F	5.70
354	MCR1709F	6.25

NOW You Can Sell Peripherals, Components and Instrumentation to the Prime OEM Computer and Systems Manufacturers WITH THESE SHOWS!

1

Computer Systems Design '72 WEST Exhibition

FEBRUARY 22, 23, 24, 1972
Anaheim Convention Center

2

Computer Systems Design '72 EAST Exhibition

APRIL 18, 19, 20, 1972
Hynes Civic Auditorium, Boston, Ma.

Here's the SCORE CARD on our Recent Computer Systems Design Exhibition in January!

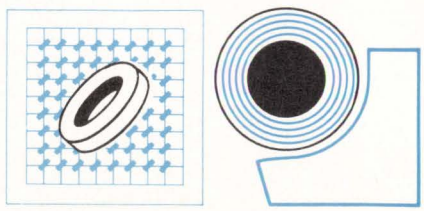
- **Attendance: Over 10,000**
- **Quality of Attendance: (Consensus of exhibitors) "Terrific, Serious, Qualified and Ready to Buy."**
- **Result: Much business written on the floor and currently being written after the show.**

The universally acclaimed success of this first OEM show specializing exclusively in the design and engineering of computers, computer systems and peripherals, points unmistakably to annual shows of this type for both major computer manufacturing areas—the East Coast and West Coast. Accordingly, two Conferences have been scheduled for 1972 and you can expect attendances of 15,000 or more for each show.

Each show features an exhibition of the newest peripherals, components, hardware, and instrumentation required to design, construct and test computers, systems and peripherals of all types at the OEM stage. Both exhibitions will be backed by a Technical Program conducted by the best professional talent available.

If you know the technical reputation of the Kiver organization . . . If you know the reputation for sales-effectiveness of the shows we conduct in many other areas, YOU KNOW THAT THESE SHOWS WILL SELL FOR YOU . . . THAT THESE SHOWS WILL BRING YOU MORE PROSPECTS IN 3 DAYS THAN YOU COULD POSSIBLY DISCOVER AND VISIT IN 3 MONTHS!

A sizable number of charter exhibitors have reserved large blocks of space to repeat their success in 1972. Don't delay making your booth reservations now.



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359	MC1520G	8.10
360	MC1535G	8.50
361	MC1531G	8.50
362	MC1530G	8.50
363	MC1535F	10.00
364	MC1531F	10.00
365	MC1530F	10.00
366	MC1520F	10.00
367	MC1538R	14.00
368	MC1536G	18.00
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371	LM747C	3.25
372	LM310	3.25
373	LM301AN	3.25
374	LM741C	3.25
375	LM301A	3.45
376	LM709	3.90
377	LM312	4.95
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379	LM747	5.95
380	LM741	5.95
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382	LH201	7.50
383	LM201	7.50
384	LM212	8.50
385	LM316	9.95
386	LM110	10.00
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388	LH101	15.00
389	LM101	15.00
390	LM216	19.50
391	LM112	19.50
392	LM316A	20.00
393	LM101A	30.00
	OPTICAL ELECTRONICS	
394	9300	4.90
395	9314	6.00
396	9302	10.00
397	9308	17.00
	PRECISION MONOLITHICS	
398	SSS741CJ	1.40
399	SSS301AJ	1.90
400	SSS307J	1.90
401	SSS841CJ	2.20
402	SSS747CK	2.80
403	SSS301AP	3.50
404	SSS307P	3.50
405	SSS741CP	3.50
406	MONOP01CJ	3.65
407	SSS741GJ	3.95
408	SSS841CP	4.05
409	SSS747CP	4.05
410	SSS841GJ	4.95
411	SSS201AJ	5.05
412	SSS207J	5.05
413	SSS741BJ	5.10
414	SSS747GK	5.45
415	MONOP01HJ	6.60
416	SSS725CJ	6.75
417	MONOP08CJ	6.75
418	MONOP01GJ	6.80
419	SSS741GL	6.80
420	SSS741GP	6.80
421	SSS747BK	7.50
422	SSS841GL	8.75
423	SSS841GP	8.75
424	SSS201AL	9.00
425	SSS201AP	9.00
426	SSS207L	9.00
427	SSS207P	9.00
428	SSS741BL	9.00
429	SSS741BP	9.00
430	MONOP08CP	10.15
431	SSS747GP	10.60
432	SSS725CP	11.30
433	SSS841J	11.50
434	SSS101AJ	11.50
435	SSS107J	11.50
436	SSS741J	11.50
437	SSS747GM	12.70
438	SSS747BP	13.25
439	MONOP01CP	13.35
440	SSS725BJ	13.95
441	MONOP08BJ	13.95
442	MONOP-01J	14.35
443	MONOP01HP	15.25
444	SSS747K	15.80
445	SSS747BM	15.90
446	SSS725EJ	16.30
447	SSS841P	16.45
448	SSS101AP	16.45
449	SSS107P	16.45
450	SSS741P	16.45
451	SSS841L	17.05
452	SSS101AL	17.05
453	SSS107L	17.05
454	SSS741L	17.05
455	MONOP01GL	19.45
456	MONOP01GP	19.45
457	SSS725BL	20.95
458	SSS725BP	20.95
459	MONOP08BL	20.95
460	MONOP08BP	20.95
461	SSS725J	21.60
462	SSS747P	22.40
463	SSS747M	26.80
464	SSS725EP	27.30
465	MONOP-08J	27.55
	QUALIDYNE	
466	QC301-G	1.89
467	QC307-G	1.89
468	QC741C	1.89
469	QC301A	2.85
470	QC201	3.25
471	QC207-G	3.35
472	QC748-G	3.85
473	QC1456-G	3.90
474	QC741-G	3.99
475	QC107-G	3.99
476	QC101	3.99
477	QC741	3.99
478	QC201A	5.53
479	QC1100C-G	6.70
480	QC1556-G	7.82
481	QC308-G	9.05
482	QC308A-G	10.85
483	QC101A	11.06
484	QC747-J	12.00
485	QC208-G	13.06
486	QC1735-1G	15.00
487	QC208A-G	15.70
488	QC108-G	25.80
	RAYTHEON	
489	RC709	1.90
490	RC4709	3.25
491	RC741	3.25
492	RM709	3.90
493	RM741	5.45
494	RC4741	7.00
495	RC101A	7.50
496	RM709A	9.35
497	RM4709	12.00
498	RM4741	20.00
499	RM101A	30.00
	RCA	
500	CA3029	1.18
501	CA3056	1.78
502	CA3047	1.90
503	CA3030	1.90
504	CA3010	1.90
505	CA3029A	2.28
506	CA3037	2.28
507	CA3008	2.52
508	CA3015	2.88
509	CA3047A	3.48
510	CA3033	3.48
511	CA3030A	3.48
512	CA3038	3.48
513	CA3016	3.48
514	CA3037A	3.48
515	CA3010A	3.48
516	CA3008A	4.08
517	CA3038A	4.68
518	CA3015A	4.68
519	CA3056A	4.74
520	CA3016A	5.30
521	CA3033A	5.88
	SIGNETICS	
522	N5709	1.65
523	N5741	3.00
524	S5709	3.75
525	S5741	5.00
526	NE533V	6.35
527	NE536T	6.50
528	NE531V	6.50
529	NE531T	6.50
530	NE533T	6.85
531	NE537T	7.50
532	S5748T	*****
533	N5748T	*****
534	N5748V	*****
535	N5748A	*****
536	N5741T	*****
537	N5741V	*****
538	N5709T	*****
539	N5709V	*****
540	S5741T	*****
541	S5709T	*****
542	N5741A	*****
543	N5709A	*****
544	N5740T	*****
545	N555AV	*****
546	N5558T	*****
547	S5558T	*****
548	N5556V	*****
549	N5556T	*****
550	S5556T	*****
551	N53A8T	*****
552	N5308T	*****
553	N53A1V	*****
554	N53A1T	*****
555	S5201V	*****
556	S5201A	*****
557	S5201T	*****
558	S51A8T	*****
559	S5108T	*****
560	S5107T	*****
561	S51A1T	*****
562	S5101T	*****
563	SE533T	10.00
564	SU536T	20.00
565	SE531T	20.00
	SILICON GENERAL	
566	SG741C	3.05
567	SG301	3.20
568	SG301A	3.25
569	SG741	5.80
570	SG201	7.00
571	SG201A	10.80
572	SG101	14.00
573	SG101A	28.00
	SILICONIX	
574	LM201H	7.50
575	L140CA	8.80
576	LM201D	10.50
577	LM201F	10.50
578	L140CL	11.80
579	LM101H	12.50
580	LH101H	12.50
581	L140AA	14.70
582	LM101D	15.50
583	LM101F	15.50
584	LH101D	15.50
585	LH101F	15.50
586	L143CL	16.10
587	L140AL	17.70
588	L143CP	19.10
589	L130BA	19.70
590	L143AL	27.75
591	L1300A	29.50
	SOLITRON	
592	UC4301A	3.25
593	UC4741C	3.25
594	UC4741	5.95
595	UC4250	*****
596	UC4101A	30.00
	SPRAGUE	
597	ULN-2741M	2.10
598	ULN-2741D	2.25
599	ULS-2741D	4.95
	TELEDYNE PHILBRICK	
600	1303	3.10
601	1301	3.10
602	1339	3.35
603	1319	5.00
604	1300	5.20
605	1317	10.00
606	1323	12.50
607	1321	12.50
608	1322	16.50
	TELEDYNE SEMICONDUCTOR	
609	709CE	0.90
610	748CE	1.20
611	MC1439CE	1.40
612	741CE	1.45
613	MC1437CJ	1.70
614	749CJ	1.90
615	811CE	1.95
616	709BE	2.00
617	739CJ	2.20
618	MC1458CE	2.50
619	MC1539BE	2.50
620	MC1537BL	3.10
621	810CJ	3.25
622	813CJ	3.25
623	841CE	3.25
624	748BE	3.90
625	747CE	3.90
626	741BE	3.90
627	749BN	4.90
628	709AE	5.00
629	MC1558BE	5.00
630	844CE	5.00
631	809CE	5.85
632	841BE	5.95
633	809BE	7.95
634	811BE	8.75
635	747BE	9.90
636	LM207CE	12.00
637	844BE	12.00
638	806CE	13.50
639	808BE	15.00
640	805CE	15.00
641	810BN	15.00
642	LM107BE	15.00
643	819BE	16.00
644	801DE	16.75
645	800DE	16.75
646	806BE	27.80
647	805BE	27.80
648	808AE	28.00
649	800BE	29.80
650	801BE	29.80
	TEXAS INSTRUMENTS	
651	SN72709P	0.88
652	SN72709N	0.90
653	SN72748P	0.94
654	SN72741P	0.94
655	SN72702N	0.96
656	SN72741N	1.06
657	SN72307P	1.14
658	SN72301A	1.14
659	SN72558P	1.68
660	SN72747N	1.73
661	SN52709L	1.87
662	SN52748L	2.03
663	SN52741L	2.03
664	SN52702L	2.04
665	SN52558L	3.66
666	SN52101AL	4.08
667	SN52747J	4.38
668	SN72771P	7.50
669	SN72770P	7.50
670	SN52107L	9.00
671	SN52771L	13.50
672	SN52770L	13.50
	TRANSITRON	
673	TOA1709	3.70
674	TOA1741	5.75
675	TOA4709	7.50
676	TOA7741	11.50
677	TOA7709	12.80

For further information on the manufacturers and their products, circle the following numbers on your reader service card:

Advanced Micro Devices	201
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Analog Devices	203
Burr-Brown	204
DDC	205
Fairchild	206
Harris	207
Intersil	208
ITT	209
Motorola	210
National Semiconductor	211
Optical Electronics	212
Precision Monolithics	213
Qualidyne	214
Raytheon	215
RCA	216
Signetics	217
Silicon General	218
Siliconix	219
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Sprague	221
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Teledyne Semiconductor	223
Texas Instruments	224
Transitron	225
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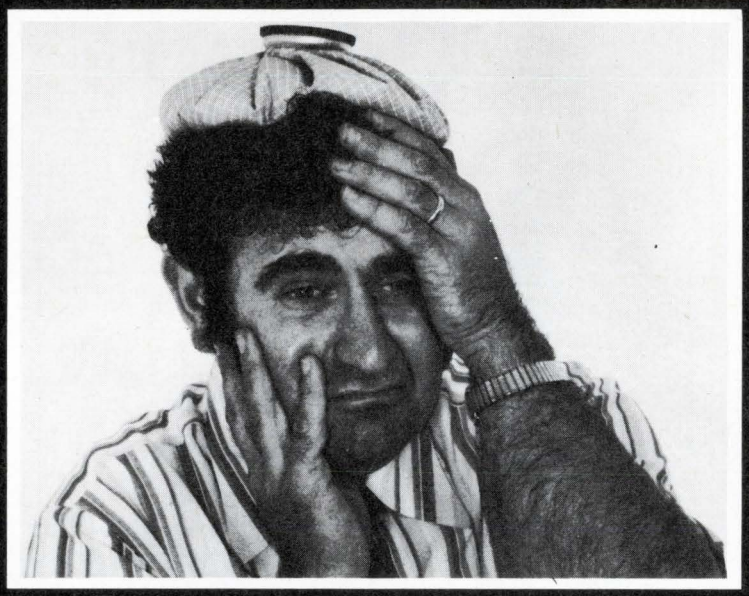

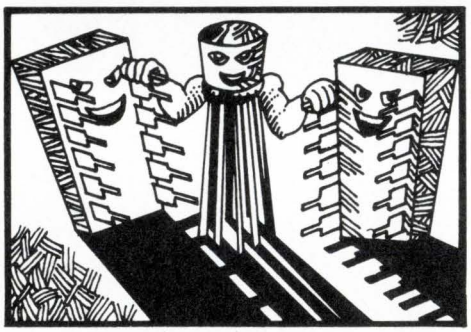

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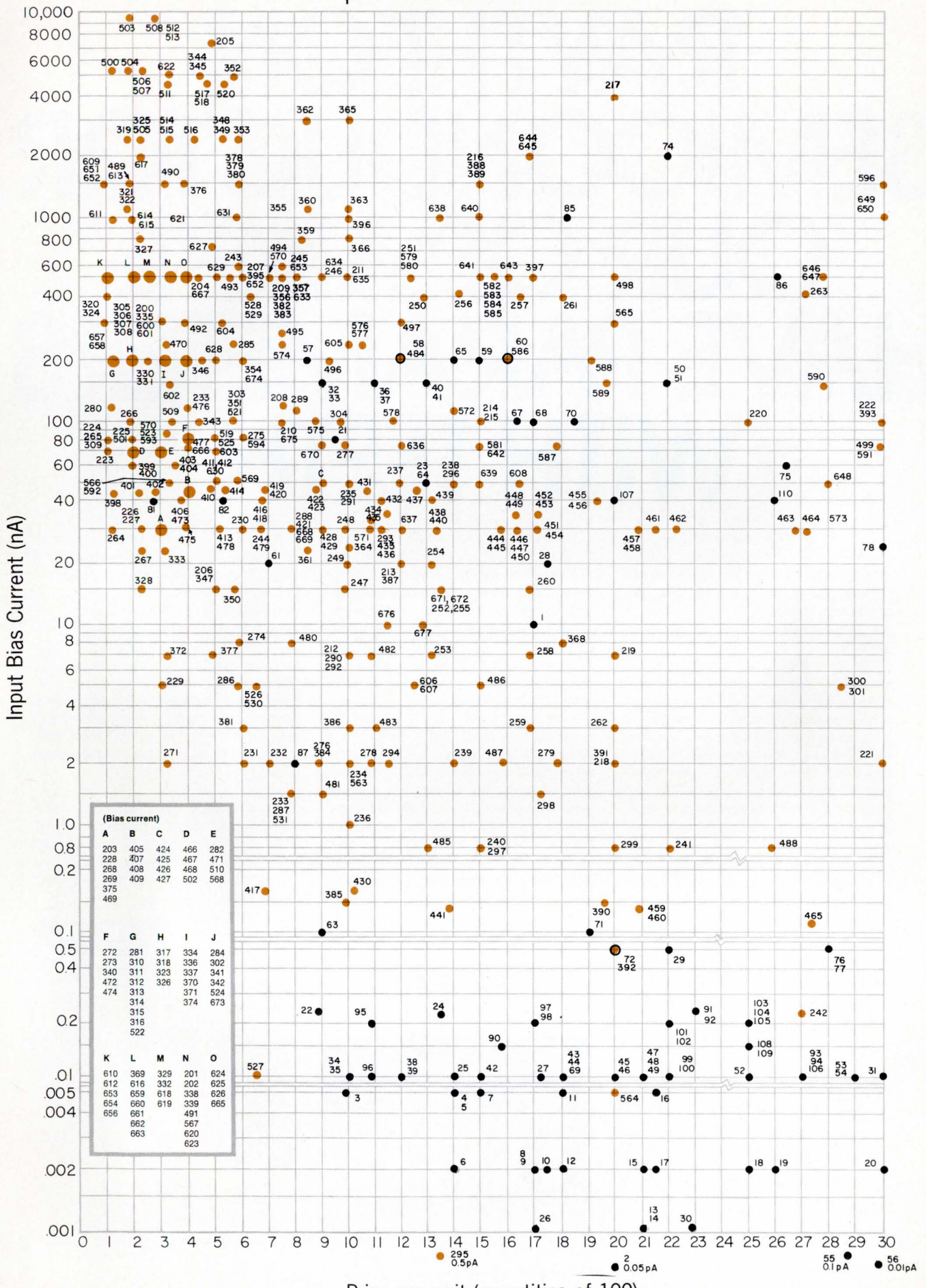
Input Bias Current vs Price
Input Bias Current (nA)
Price per unit (quantities of 100)
(Bias current)
A 203 228 268 269 375 469
B 405 407 408 409
C 424 425 426 427
D 466 467 468 502
E 282 471 510 568
F 272 273 340 472 474
G 281 310 311 312 313 314 315 316 522
H 317 318 323 326
I 334 336 337 370 371 374
J 284 302 341 342 524 673
K 610 612 653 654 656
L 369 616 659 660 661 662 663
M 329 332 618 619
N 201 202 338 339 491 567 620 623
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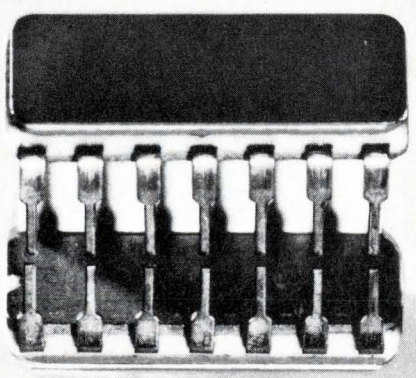
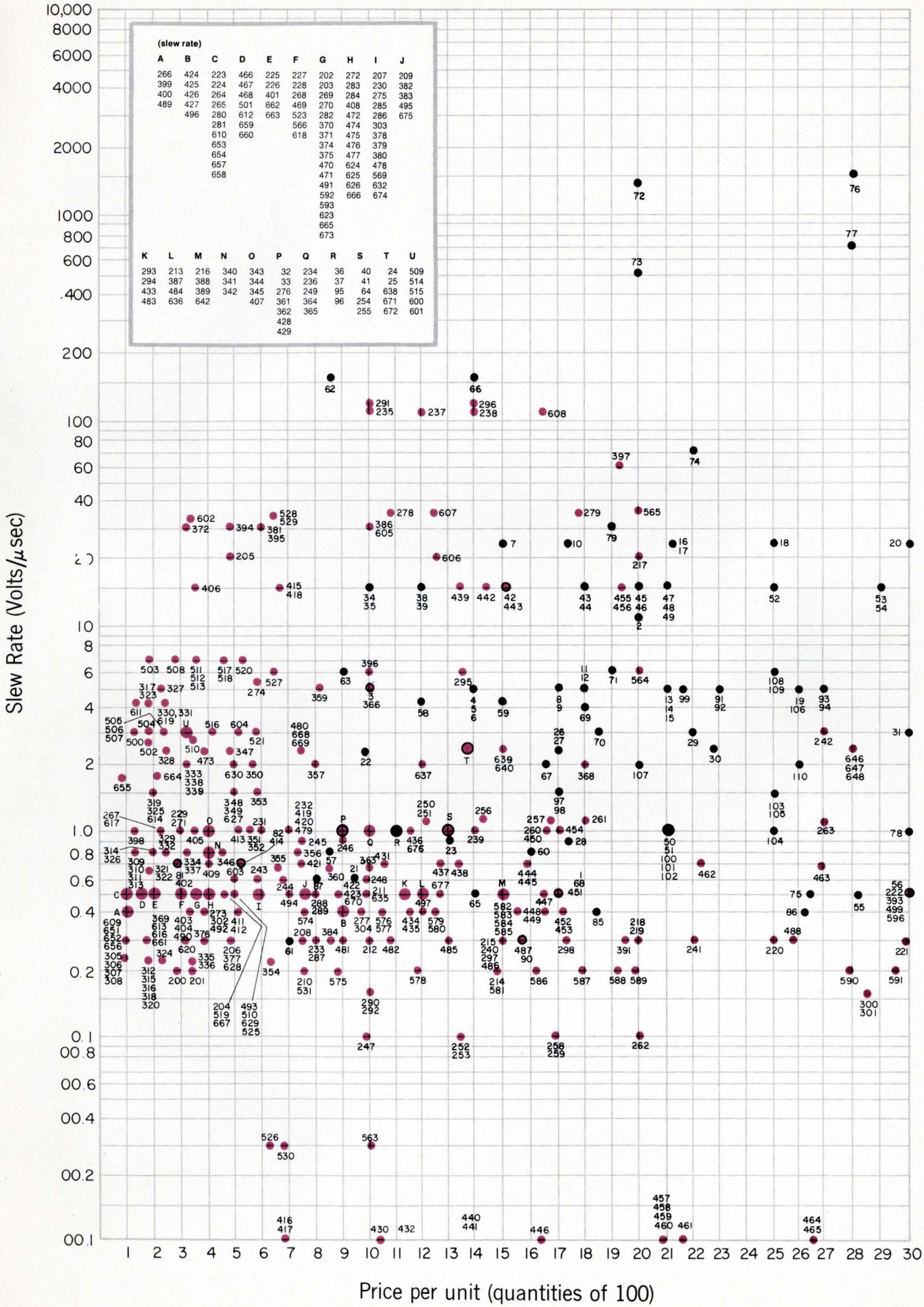


Circle Reader Service #26

Slew Rate vs Price



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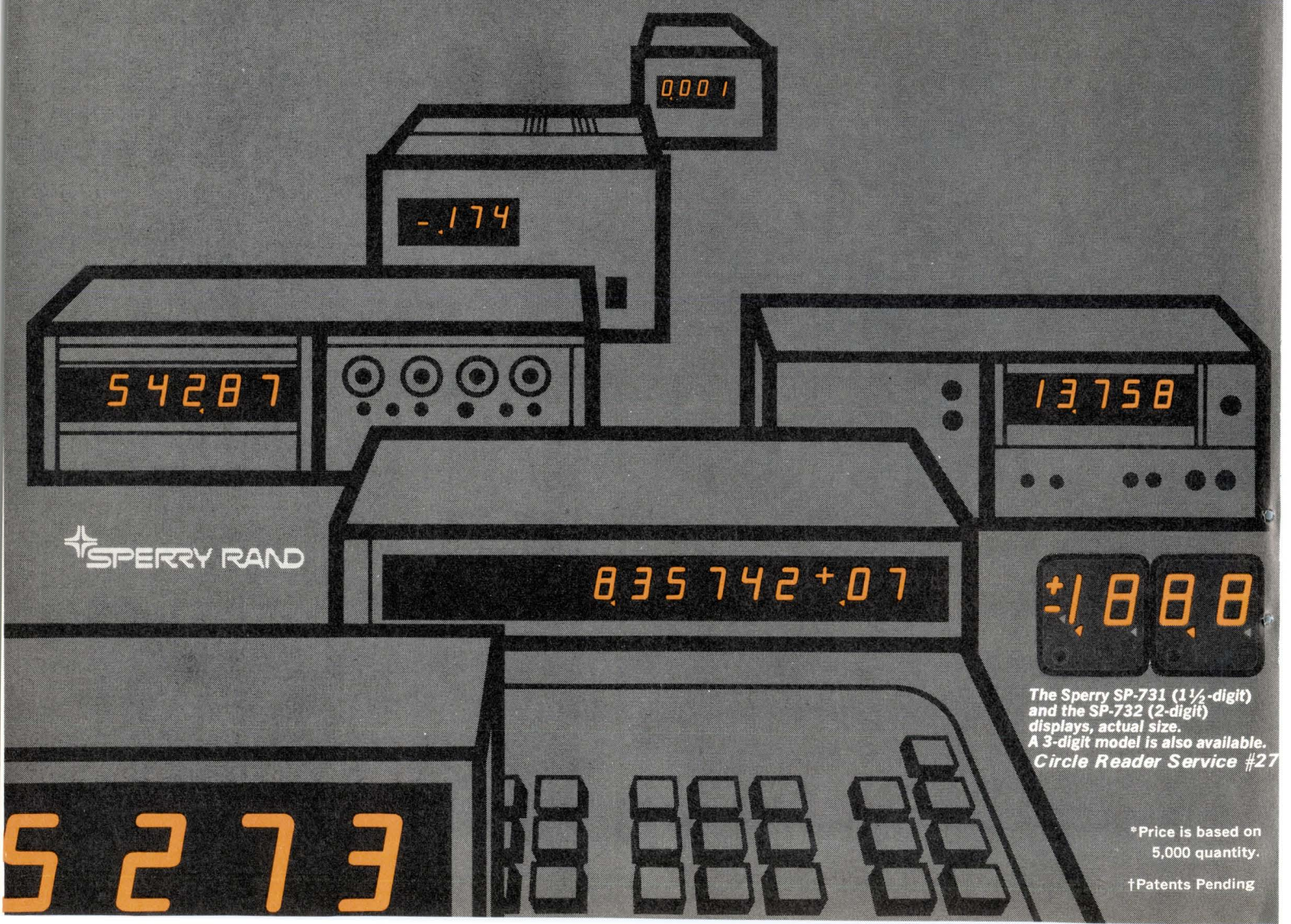

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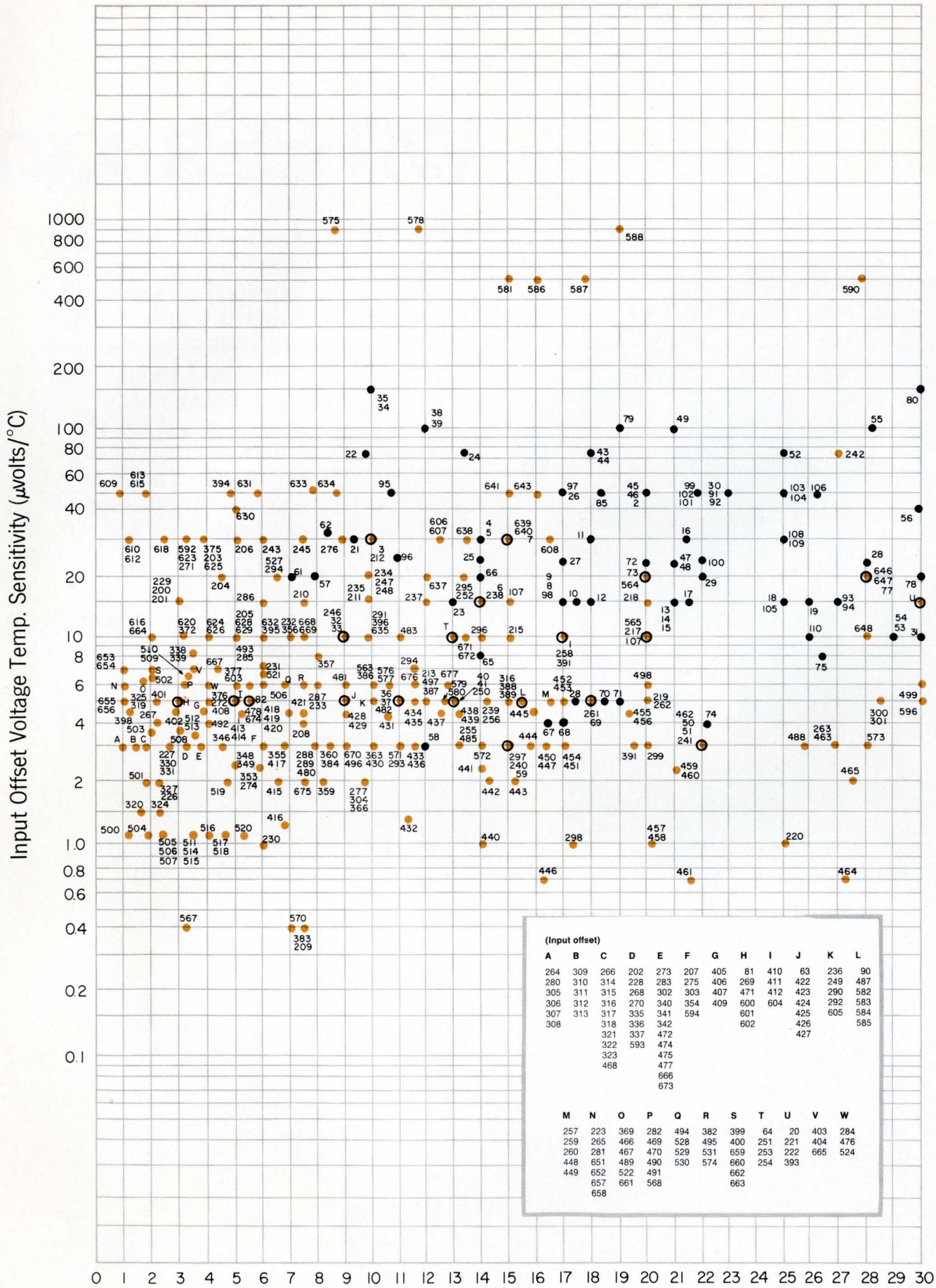
*Price is based on 5,000 quantity.

†Patents Pending

Input Offset Voltage Temperature Sensitivity vs Price



Will EEs join

Suffering from burning eyes, clogged sinuses, and a lighter wallet, it could be you're a victim of an insidious enemy—pollution. Although electronics hasn't been drafted as yet, the electronic engineer will definitely have a place in the war against pollution as the battle lines are drawn.

Dr. Stanley M. Greenfield
of the Environmental Protection Agency

the war on pollution?

John McNichol, New Directions Editor

You're in a large, cool, windowless room, dominated by an enormous display with an electronic map of the United States, its land masses and waters. Wall-size displays and clusters of CRTs *give off an eerie green light as some teletypewriters clatter away. Banks of computer hardware fill much of the room. Suddenly, there's a buzz of excitement as someone mutters, "Oil spill in the Mississippi."*

Approaching Cairo, Illinois, the last in a string of oil barges has broken loose. Drifting onto a sandbar with great force, part of the hull rips, releasing gallons of heavy crude oil. Soon the placid brown river has a heavy oil scum spreading downriver.

A nearby satellite monitor detects the oil and the information is telemetered to a master monitoring station five miles upstream. An emergency warning—a top priority environmental incident—is then relayed to the large room—the Environmental Protection Agency's 'war room.' Here the enemy is pollution.

Another display appears and quickly fills with graphics showing pertinent information about that stretch of the river from the accident to a point 100 miles downriver. Within minutes, at water treatment plants, reservoirs and industries along the river from Cairo, Illinois to Memphis, Tennessee, environmental strike forces are quickly gathered to contain and dissipate the oil.

None of the above is true. The 'war room,' resembling a scene from the movie, "Dr. Strangelove," doesn't exist at present. But if Stanley Greenfield has his way, it will. Dr. Greenfield, the first Assistant Administrator for Research and Monitoring of the fledgling Environmental Protection Agency (EPA)—its top technical man—speaks of the 'war room' as just one part of an overall electronic strategy to win the war against pollution.

"I'm thinking," he says, "of an environmental war room with a continuous display from a computer data base which will tell us 'Where we are now.'" (He calls this the "how goes it" monitoring.) "Then we'll be able to exercise the dynamic models we're producing, so that when you ask, 'What if I do this?', you'll get an answer."

DR. STANLEY M. GREENFIELD AND EPA

Reflecting President Nixon's challenge that "the 1970s absolutely must be the years when America pays its debt to the past by reclaiming the purity of its air, its water, and its living environment," the Environmental Protection Agency was formed Dec. 2, 1970. In the brief period since then, EPA has grown to some 5500 employees partially inherited from 15 ongoing federal programs. (EPA's concern with the environment on a federal level is shared with the President's Council on Environmental Quality and the Department of Commerce's National Oceanic and Atmospheric Administration.)

Although EPA has undergone some major reorganizational changes since its formation, the basic structure remains the same. Under Administrator William D. Ruckelshaus there are various staff offices; the line offices, such as Media Programs (Air and Water Programs), Categorical Programs (Pesticides, Radiation and Solid Waste Programs), and Research and Monitoring; and ten regional offices from Boston to Seattle.

The man who enthusiastically took over as Assistant Administrator for Research and Monitoring in February is Dr. Stanley M. Greenfield. A former governmental hand who worked with both NASA and the Air Force, Greenfield stressed the importance of line authority in his new job if he was ever to successfully implement the research and monitoring function.

Most recently, the mustached Greenfield, who speaks with great intensity of his new responsibilities, was formerly with Rand Corp., the California think tank. No newcomer to the ecological battlefield, his responsibility there was as head of the Department of Environmental Sciences and manager of the Rand program in Environmental Studies. A former associate of Greenfield's at Rand, Dr. R. Rapp notes that "Stan is the type of man to get hold of a problem and keep after until it's solved."

At the same time, Dr. Greenfield served on the NASA-Department of Defense Space Sciences Committee, as well as a consultant to the Advanced Research Project Agency's Committee on Meteorological Satellites. In addition, he was a consultant to the Committee on Upper Atmosphere Rocket Research of the Space Science Board, National Academy of Sciences.

An expert in the fields of geophysics and the upper atmosphere, Greenfield has conducted research in infrared radiation, atmospheric physics, and meteorological satellites, as well as on the physical phenomenon of radioactive fallout. In 1961, he was given a special award from the American Meteorological Society for research leading to a meteorological satellite.

Between 1959 and 1961, the EPA R&M chief was on a leave of absence from the Rand Corp. to serve as scientific advisor to the Air Force Director of Research and Development. He has also been a member of the Geophysics Panel of the Air Force Scientific Advisory Board and of the Advisory Group of the Air Force Space and Missile Systems Organization. He has been a member of the Science and Technology Council of the California State Assembly, and is on the panel of the International Environmental Institution Committee of the National Academy of Sciences.

Dr. Greenfield received his undergraduate degree in meteorology and physics from New York University in 1950. His Ph.D. in meteorology was awarded by UCLA in 1967.

Defining the enemy

At present, Dr. Greenfield's main concern is to develop an effective strategy to defeat pollution with technology's tools: *research* and *monitoring*. An enthusiastic, rapid speaker, he has defined *monitoring* as "meaning everything from data gathering for research purposes to that type of monitoring you need when you go into court to enforce standards." Included in this definition is continuous "how-goes-it" monitoring, which tells what is the ultimate effect upon the environment.

As for *research*, the EPA administrator sees it dealing with the problem of pollution abatement and control. As he puts it, "abatement and control serve to hold and repair, while preventative maintenance must be done on the atmosphere at the same time."

But Greenfield has not limited his department to the more narrow research categories of water and air. Pointing out that we really know very little about what causes environmental degradation, he has assigned one part of his operation to investigate such questions as what is the impact of a new transportation system on the environment from a broader all-inclusive (air, water, etc. pollution) approach. As he states, "The obvious pollution from vehicles may have the least long-run effect. Such secondary effects as increased people in the area may degrade the environment far more."

Obviously both research and monitoring will be big users of electronics: sensors for monitoring, telemetry equipment, communications networks, computer systems for modelling air and water systems, and, of course, the 'war room.'

Communications and computers

Dr. Greenfield sees three major areas where electronic engineers and electronic hardware will be needed: communications, computer technology, and monitoring. As for communications, the R&M chief thinks we have most of the technology. "For example, suppose we want to send graphics over a land line? Well, what I need then is a 200-kilobit line. It's expensive, but the technology is available.

"It's much the same with computers. The present generation, plus new machines like Illiac IV, are certainly adequate to do a large part of the job that we foresee." As for the omnipresent 'war room,' Greenfield envisions either a large central computer with a very large memory or a well-integrated network of several computers.

In addition to controlling the 'war room,' computers will utilize dynamic models for air and water basins. Many firms which were under contract to NASA, such as General Research Corp., TRW, and Argonne Labs, are now doing modelling work for EPA. "There is a great deal of modelling work that must be done," stresses Greenfield. "It's hard to point to any model today and say, 'By God, that fulfills all our criteria.' "

Monitoring—can we use existing equipment?

But monitoring remains the field of most explosive growth for electronics. Yet it has not really begun, and won't for at least a year. And, for the man responsible for developing and monitoring strategy, it's no easy task. "We have to," says Dr. Greenfield, "produce a monitoring strategy that's not too expensive, that's capable of picking up hazardous materials, and that will warn us as we approach danger thresholds, and also give us some indication of where we stand in terms of quality." That's a tall order, especially when you consider such frustrating question as "What kind of automobile engines will there be in 1975," and his tight schedule—he must have an initial monitoring strategy defined within a year.

Although Dr. Greenfield wants a monitoring strategy that's not too expensive, he admits that monitoring may become "the most expensive part of environmental protection." All this is complicated by a whole litany of questions he is asking: "What are the materials we're going after?; What standards are applied to these materials?; What is a reasonable, creative monitoring station?; What should be the spacing between these stations?; What measurements do we want?; How do you gather and process the data?" One thing he is sure of, however, is that electronics will play an important role in a global monitoring system. "I can't see how," he says, "you can carry on such a system without depending on electronics, particularly when you talk of remote sensing."

Perhaps all this electronic equipment has already been developed? So, another task for Greenfield is the evaluation of present-day instrumentation. "You have a gut feeling," he says, "that you should be able to pick up all the pollution on the ocean using infrared and optical equipment. You have a gut feeling that there are various types of equipment which can give you a particulate count of the atmosphere. And you have a gut feeling that laser backscattering should yield the particulate loading of the atmosphere. We haven't really checked this out yet, but we will."

Slim pickings for industry

This problem has not gone unrecognized by industry. Ed Truitt, New Product Manager of Hewlett-Packard's Avondale Division, tells of a recent conference where an EPA representative calling for a certain device was interrupted by an engineer. "We have already developed that instrument, and it works," cried the engineer. "We just need someone with money or we'll have to forget it!" H-P, itself, is interested in the pollution field since their gas chromatograph can 'fingerprint' or match up oil that has been dumped with the source. The same unit can identify the harmful agent in a fish kill by separating the molecules, which are then analyzed with a mass spectrometer.

Pinpointing one segment of a field can be confusing ven-

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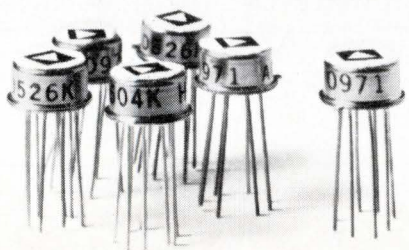


Circle Reader Service #28

ture, especially when the field is as new and untried as the pollution area. EPA's George Wirth, Chief of Technical Data for the Office of Water Programs, points out that only nine parameters of water pollution can be automatically sensed at this time. (They are dissolved oxygen, chlorides, pH, conductivity, solar radiation or sunlight intensity, temperature, turbidity, oxidation reduction potential, and flow.) "There are between 100 and 600 parameters that are measured now by dipping buckets and laboratory analysis, and the great need is for sensors to detect them," states Wirth. "One of these we need now is for heavy metals, such as cadmium, lead, mercury, and so on."*

Estimating the market for water sensors at $10 million a year within the next two or three years, Wirth contends that this conservative if you consider stream monitoring (3 million miles in the U.S.) and effluent monitoring at the source.

Another viewpoint is given by Irving Zuckerman, Manager of Environmental Systems, TRW Systems. Despite TRW's heavy involvement in such environmental activities as developing systems models and larger hardware, they have avoided the sensor market. Zuckerman stresses such factors as low dollar volume, a lack of agreement on standards for instrumentation, and an already competitive market as keeping TRW from making sensors. He noted, however, that as a "more concentrated, more identifiable market" formed, TRW would find the sensor market "more attractive."

Few jobs

At the same time, Dr. Louis Swaby of EPA's Physical Sciences Branch of the Office of Research and Devel-

*Environmental Sciences, Inc., Cambridge, Mass. has just announced a system to detect just such metals in quantities to 0.01 ppm, based on an electrochemical technique known as anodic stripping voltammetry.

'BIG EARS' AND ELECTRONIC COMPANIES—A USER'S OPINION

Dr. Stanley Greenfield's quest for an environmental 'war room' to aid him in his monitoring function may not be far-fetched at all. New York's Department of Environmental Conservation has developed a less-sophisticated version as part of a rapid intelligence system to monitor water and air quality. Nick-named "the Big Ear," the Environmental Alert Room, which has been operating only some two months, is still not completed. But so far, according to Ronald Maylath, chief of the Water Quality Surveillance Section, it's been highly successful, giving water readings every hour and air readings every 15 minutes at a cost of 14¢ a parameter.

To set up an automatic surveillance system for 70,000 miles of streams and 3.5 million acres of inland lakes, New York has been, since 1959, evaluating hardware, making feasibility studies, and developing mathematical models of various drainage basins. From this preliminary work, a 14-monitor station operating system has evolved with a 126 monitor system expected within five years. Major monitoring stations, which are self-sufficient and enclosed in a cab-inlike shelter, measure 10 or more parameters, while satellite monitors will measure four or less.)

The heart of the system is a Burroughs B-3500 computer. In a typical situation, an "environmental parametric" signal from a satellite monitor will be radioed or sent over leased telephone lines to a major monitor. At the major monitor, the signal goes through a Bell 103 A-2 modem to the computer, where an ASR-35 Teletype serves as a remote terminal.

To date, the system has cost $300,000 for water monitoring equipment, including shelters, telemetry terminals and installation. In addition, another $200,000 has been spent for operation and maintenance, including rental of the computer. Maylath has estimated that by 1975-6 approximately $750,000 a year (based on 1970 prices) will be spent on upgrading older equipment and acquiring new sensors. As Maylath says, "Hardware is not cheap, but when you consider the overall cost, we figure that such an automated process control system as we operate is less than 0.1% of the overall price of fighting pollution."

In the course of building such a system, Maylath has developed some strong opinions about electronic companies in the environmental field. One such, General Signal Corp.'s Cardion Electronics of Woodbury, Long Island, N.Y., which developed the telemetry equipment, Maylath singles out for particular praise. "Exceptionally good, in fact, we're going back to them. They listen and they offer good follow-up; they even cut costs." After gaining experience in the military field, Cardion's first civilian contract was with New York State, which the Water Quality Chief regards as a great success: "We can transmit data two-ways. The system is modularly designed and simple. With it, we can obtain the average of any parameter measurement within minutes."

On the other hand, Maylath had an unhappy experience with a sensor supplier. According to him, the firm grossly underbid a contract for a number of multiple sensor packages, and could not meet the terms of the agreement.

As a result, The Bureau of Water Quality has changed its purchasing philosphy—no more multiple sensor packages. "We don't look for a package any more," says Maylath, "we want flexibility so that we can change parameters." "Besides" he adds, "some manufacturers put cheap electronics and sensors in an expensive, attractive package. We just need the sensors, not the package."

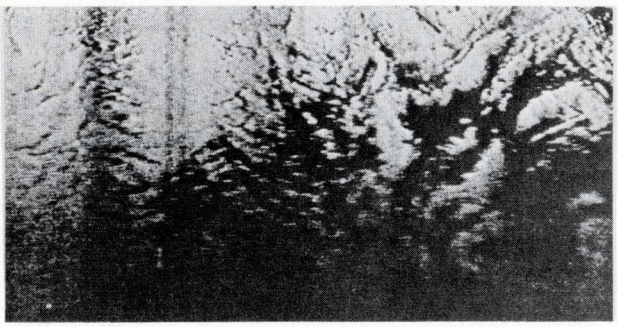
Some further Maylath viewpoints:

□ "Many firms have good electronic engineers, but without an environmental background. To us, electronics is strictly a tool—not an end in itself."

□ "Many sensors simply don't exist at the present. This is an area where the government should step in and help with money. It shouldn't be all up to industry, and purchasers shouldn't have to pay for all that design time."

□ "We see a number of spinoffs from space. For instance, General Electric had developed a sensor to measure phenol in Apollo just prior to liftoff. We're interested in using that same type of device to measure phenolic compounds in four of our major streams."

opment, feels that demand for electronic engineers to develop such devices will be small. "Of course, there is remote sensing equipment, but much of that equipment has already been developed for space. The other areas Swaby points to are the design of data handling and transmission equipment and automating treatment plants. For example, General Electric's Space and Re-Entry Division has been working for some years with Philadelphia's Water Department to develop and build automated water treatment plants.



Portrait of an environmental incident. This excerpt from an L-band (1228 MHz) strip map shows oil slicks (dark area) in the Chedabucto Bay area off Nova Scotia; the photo was taken by the Naval Research Laboratory. The oil coating greatly reduces the returning radar echoes because of the decreased radar cross section of the waves. The oil slick appears as a dark area bounded by the lighter, radar-reflective sea. This experiment was made after the tanker, Arrow, was wrecked on Cereberus Rock, depositing some 1.3 million gallons of crude oil on the waters.

A SLICK SOLUTION FOR TROUBLED WATERS

"We also need an electronic monitoring system to detect major oil spills off our coasts." Another CHALLENGER, not Dr. Greenfield, but James Beggs, Under Secretary of the Department of Transportation, said that (May, 1970, p. 39). But no matter who the source, the need is real enough. In 1970, an estimated 1.5 billion gallons of crude oil or petroleum products were spilled into the waters of the world. Half of these spills were within one mile of shore, doing incalculable damage to shellfish, seabirds, shorelines and beaches.

Devastating as the problem is, there was practically nothing any enforcement agency could do, until a means of systematically spotting and monitoring oil slicks was developed. In 1969, such a system was discovered by the scientists at the Naval Research Laboratory (NRL), Washington, D.C. Working with side-looking aerial radar (SLAR), in either or a real or synthetic aperture mode, NRL engineers were able to spot oil slicks from airplanes. Unlike the usual sea surface which causes radar backscatter, a thin film of oil (as little as 200 gallons in up to 10-knot waves) smooths the sea surface and makes it non-reflective, presenting a black, clearly outlined form on the screen.

Supported by Coast Guard funds, the program (called RAMOS for Radar Monitoring of Oil Slicks) depends on a technique of synthetic aperture radar mapping, developed by the University of Michigan. Although classified for some eight years, this technique, impervious to clouds, fogs and darkness, may have found its most important application.

That's no tree, that's my wife

Will cleaning up our environment with its need for electronics be the new aerospace for electronic engineers? Dr. Greenfield doubts it, "I don't see a large number of jobs requiring high technical training in the pollution control industry. It would be a cruel deception to retrain large numbers of aerospace engineers (to work in pollution control) in the hope that they're going to get a job. I would rather hold the training until we have a better idea of what we're going to need. In Los Angeles, where I come from, I see groups of engineers whose total thrust is, 'We've got the technology, and we're the technologists; therefore we're the ones to solve the problems of the environment.' It's such a blind approach, that I'm afraid that all they're doing is insuring they're not the group chosen. It's a multifaceted problem with its social and economic aspects, as well as the technical, and that's how it's going to be addressed."

Others in the environmental field take the same tack. EPA's Dr. Roger Shull of the Applied Science and Technology Division notes that although there will be a continuing need for the aerospace virtues of durability and miniaturization in monitoring equipment, some of his colleagues don't see much call for ex-aerospace types. "Some of them compare the change," says Dr. Shull, "to a Ph.D. in forestry becoming an M.D. because 'If you can heal trees, you ought to be able to heal humans.' "

Is there a place for EEs?

What must be remembered is that we've been talking about an agency, started in December of this past year, to fight an enemy that, except in Los Angeles, has just awakened public opinion within the last two years. Dr. Greenfield himself was only appointed in February of this year.

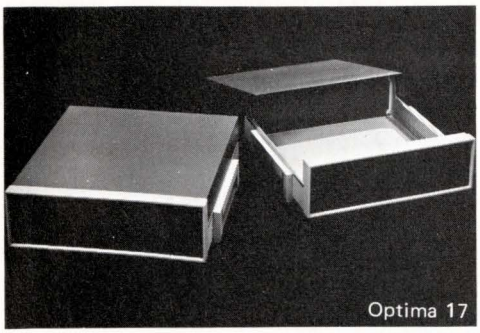
With the newness of the field, it must be remembered also that pollution has a thousand faces and is rarely a clear-cut enemy that can be defeated straightforwardly. Fighting pollution will not be a clearly defined task like going to the moon. Instead it is a complex one, demanding as Dr. Greenfield said, "multi-faceted solutions."

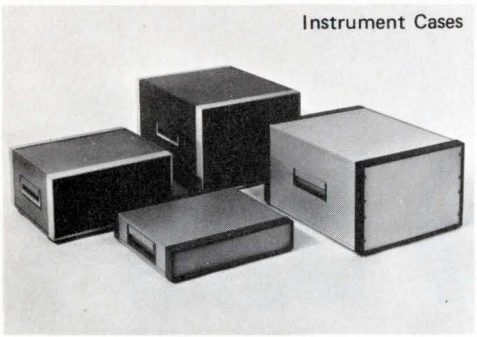
However, the inescapable truth is that there will be a place for the electronic engineer's skill and imagination in defeating pollution. Although EPA's immediate concentration on enforcement instead of research has led many to say that all the technology has been developed, it is simply not so.

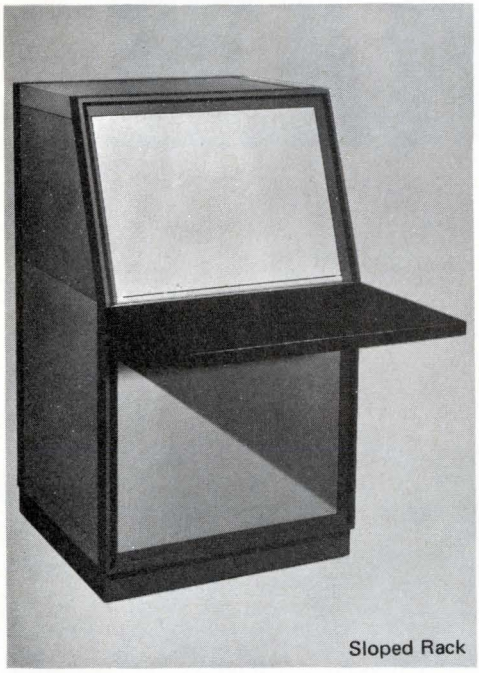
As strategies and concepts turn to RFQs (request for quotations), there will be an increasing need for electronics, whether in sensors, telemetry equipment, computers or 'war rooms.' Pollution will only be defeated with the aid of electronic engineers who understand the demands of the environment. The electronic content of such a job may not be as great at the moment as a space flight, but in the long run it may be far more meaningful.

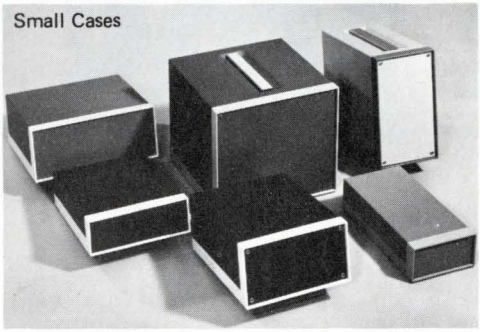
INFORMATION RETRIEVAL

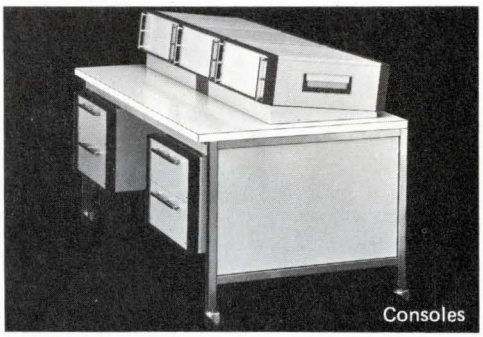
Careers

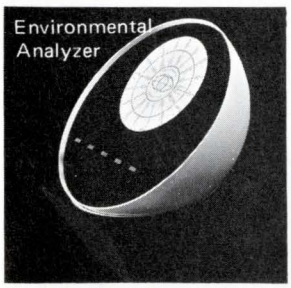


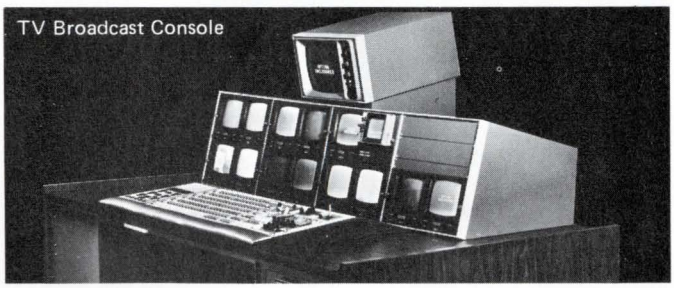


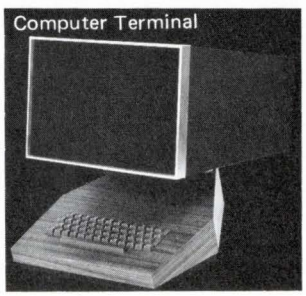












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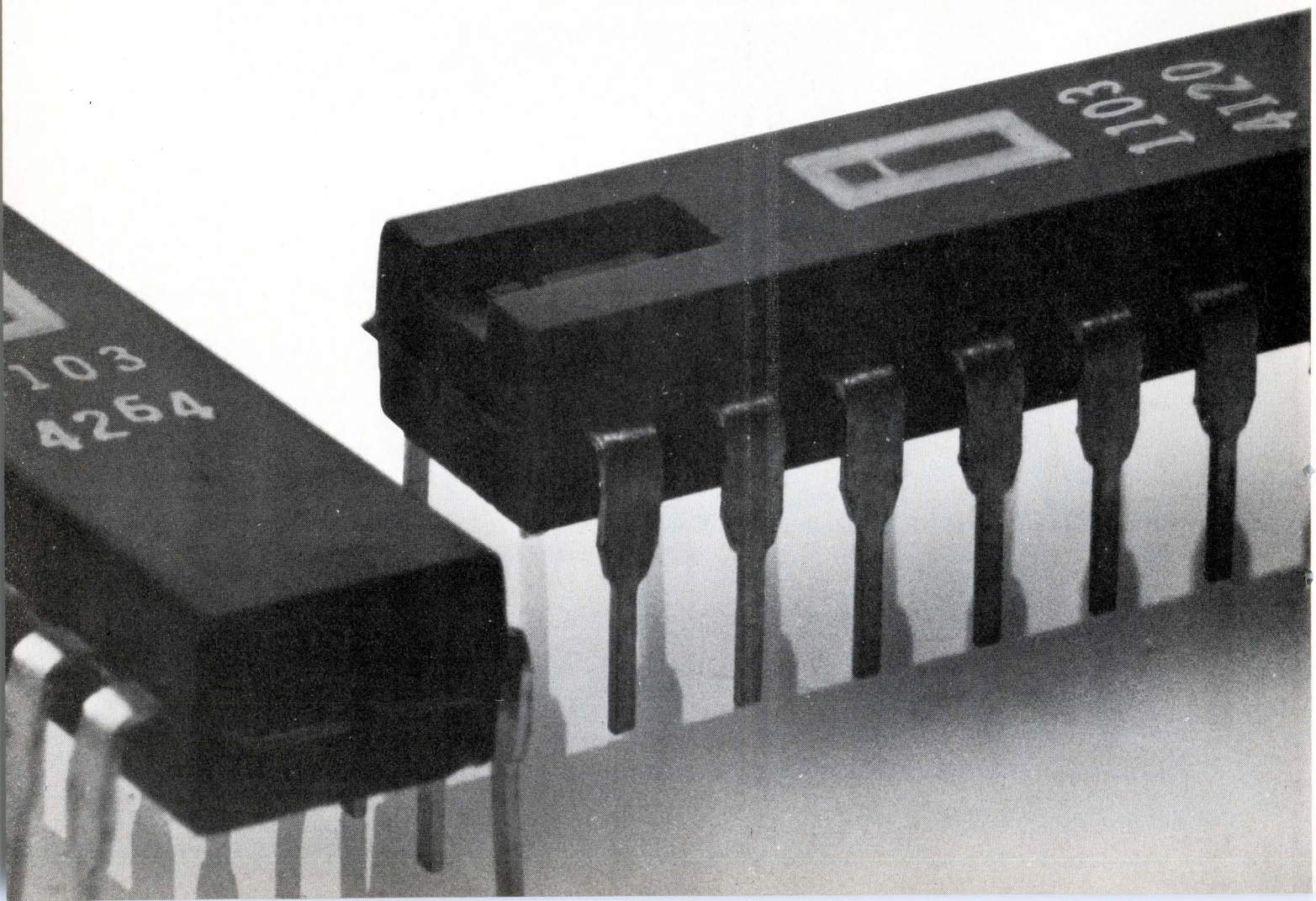
Main memories get 45,000,000 bits of 1103 MOS RAM.



As of June 21 Intel has delivered 45,000,000 bits of the 1103 MOS RAM for use in main frames, minicomputers, data terminals, controllers and scientific calculators.

We can't reveal the buyers as yet, but when you hear their names (perhaps at FJCC) you'll recognize some of the leading figures in the computer industry.

And the RAM they have tested and selected is Intel's 1103, the 1024-bit silicon-gate MOS RAM that's in production in a big way. Deliveries of the 1103 in June alone will total 17,000,000 bits. So if you're thinking of designing with semiconductor memory, don't overlook Intel's 1103. It's the RAM to reckon with.

The 1103's specifications have improved recently. Read cycle time is 480 ns, down from 540 ns. Precharge to data out has improved from 390 nsec to 310 nsec. As before, all AC and DC parameters are guaranteed from 0°C to 70°C.

For immediate delivery of the 1103 call your local Intel distributor, Cramer Electronics, Hamilton Electro Sales, Industrial Components, or Electronic Marketing. In Europe contact Intel at Avenue Louise 216, B 1050 Bruxelles, Belgium. Phone 492003. In Japan contact Nippon IC, Inc., Parkside Flat Bldg. No. 4-2-2, Sendagaya, Shibuya-Ku, Tokyo 151. Phone 03-403-4747.

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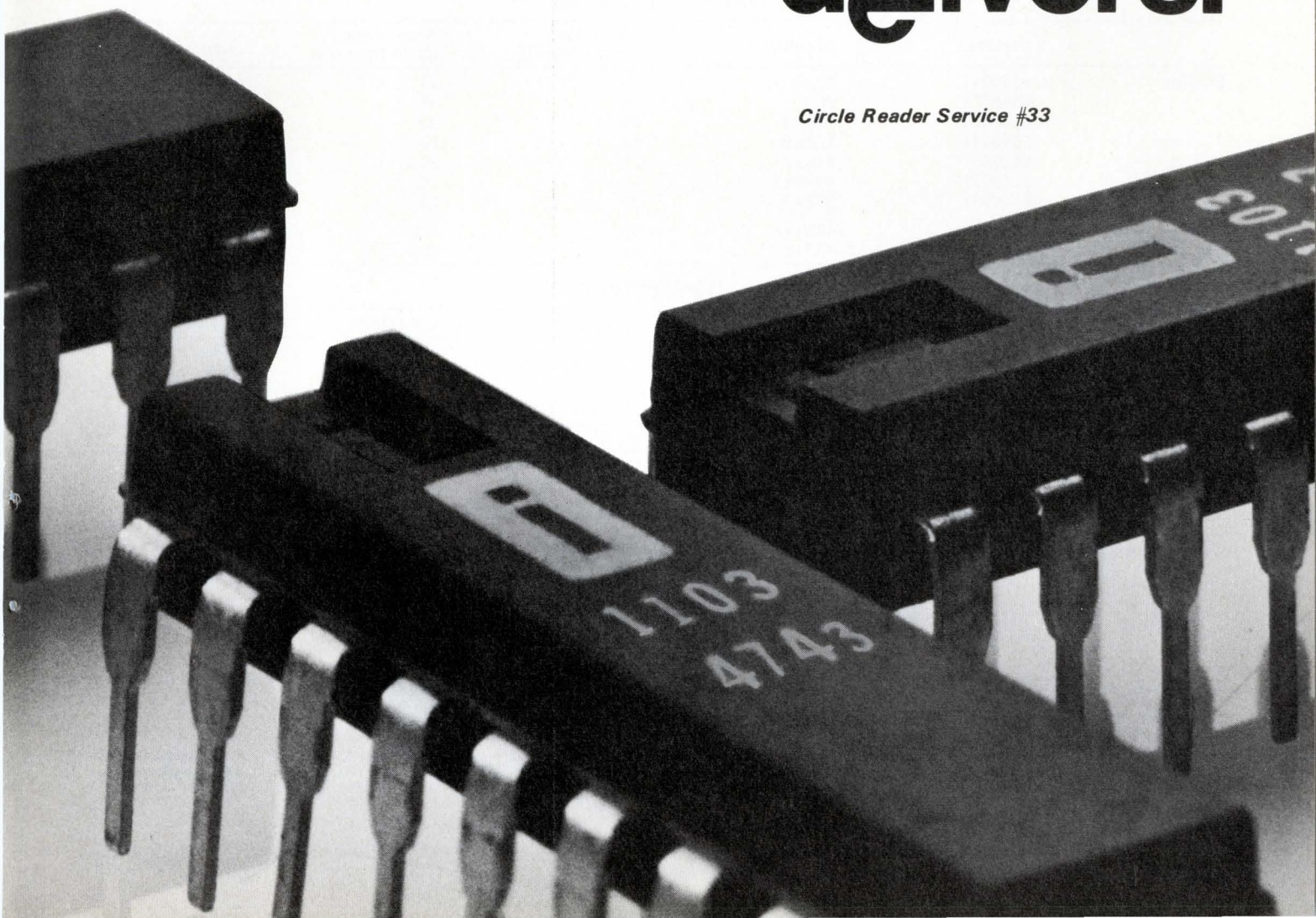

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	Part No.	Organization	Worst Case Access Time (ns)	Worst Case Cycle Time (ns)	Logic Levels
Bipolar RAM	1001	16 x 1	8	13	ECL
	1002	64 x 1	10	14	ECL
	1003	128 x 1	15	22	ECL
	1503	128 x 1	25	35	TTL
MOS RAM	6001	1024 x 1	350	535—read 860—write	MOS
	6002	1024 x 1	150	250	MOS

Memory Cards

	Part No.	Organization	Worst Case Access Time (ns)	Worst Case Cycle Time (ns)	Logic Levels
Bipolar	85100111	32 x 8	15	17	ECL
	85100211	32 x 9	15	17	ECL
	85100311	128 x 8	17	20	ECL
	85100411	128 x 9	17	20	ECL
	85100511	512 x 8	25	25	ECL
	85100711	4096 x 1	25	25	ECL
	85100811	512 x 9	25	25	ECL
MOS	85500311	4096 x 8	500	900	TTL
	85500411	4096 x 9	500	900	TTL

Systems

		Model	Avg. Access	Data Rate	Logic Levels
Serial/MOS	SSU/m	32K x 8	135 μsec.	8M bits/sec.	TTL
		32K x 16	135 μsec.	16M bits/sec.	TTL
		32K x 32	135 μsec.	32M bits/sec.	TTL
		32K x 64	135 μsec.	64M bits/sec.	TTL
RAM*	**MOS-RAM**	32K x 8-32	250ns access	400ns cycle	TTL

*To be announced—3rd Quarter, 1971.

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MEMORIES:

Putting them all together

Steve Thompson, Western Editor—Los Angeles

While you may not realize it from the time and space we have devoted to them so far, memories, as a separate entity, are really not worth very much. Only when you put them into systems, and have them talk to each other and to the outside world are they going to be of any use. It is this aspect, memories in a system, that we will discuss in this installment.

The first topic is hierarchical memory systems. An extremely important concept, we judged it to be important enough to include viewpoints from two different companies on the same subject. First, you will see how one of the large mainframe manufacturers, Burroughs Corp., approaches the topic. Then, you will find an article from IBM, the first company to use the concept, when they introduced the cache memories of their System 360 line.

The next subject concerns interfacing with memories—particularly core memories. After all, clever schemes for storing and organizing data in a memory are not worth very much if you cannot get the data into and out of the memory conveniently. Here, we have concentrated on core memories because that is the problem area. When you take two such dissimilar technologies as the magnetic core and the integrated logic circuit and attempt to interface them, you are bound to face some ticklish problems.

Next, we take a look at the characteristics of memories that are important in two fast-growing application areas—displays and minicomputers. Here you will see that the same memory that fits so nicely in a large mainframe may be a very poor choice for these applications.

We close this installment of the course with an article on how to perform logic with ROMs. The advent of large-scale integrated circuit ROMs has focused the spotlight on this particular application, as more and more designers are turning to it as a solution to their logic problems.

Segmented hierarchical memories

R. V. Bock, Burroughs Corp. Paoli, Pa.

Memories can combine into hierarchical systems with better cost/performance characteristics than the sum of the individual memories. We will use Webster's definition of hierarchy: *arrangement into a graded series.* Knowing how data is structured helps define the physical memory organization and the algorithms for moving data within the hierarchy.

If the fastest memory was the cheapest and available in large sizes, hierarchical systems would not be needed. If processors accessed data randomly, there would be no way to structure data to take advantage of hierarchy. Since neither situation exists, designers can exploit the best features of memories in graded systems.

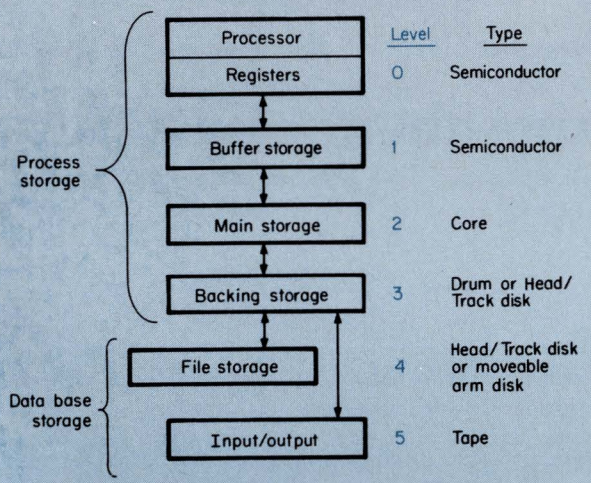
The idea of value is fundamental to the design. By value, we mean the probability that the processor will require an item next. The higher the probability, the faster the data can be read into the processor.

Hierarchical memory control

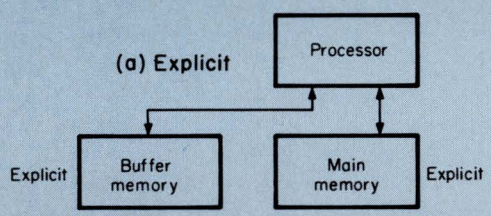
System control may be explicit or implicit. All pre-1960 systems used explicit control to manage multi-level storage. Today, most systems use a mixture.

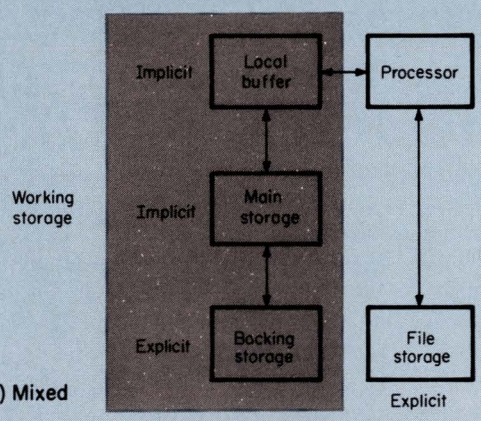
Explicit addressing means that each user is aware of sev-

eral addressing environments. System programmers are responsible for mapping data onto various memory levels and for moving it between levels. Each multi-processing user must be concerned about other users, for instance, when loading data into a shared buffer memory. All must be aware of a mapping convention, or each user will have to move data back to main memory before releasing the processor. Explicit control makes memory sharing very difficult, and frequently results in poor usage. The distributed responsibility results in each program doing what

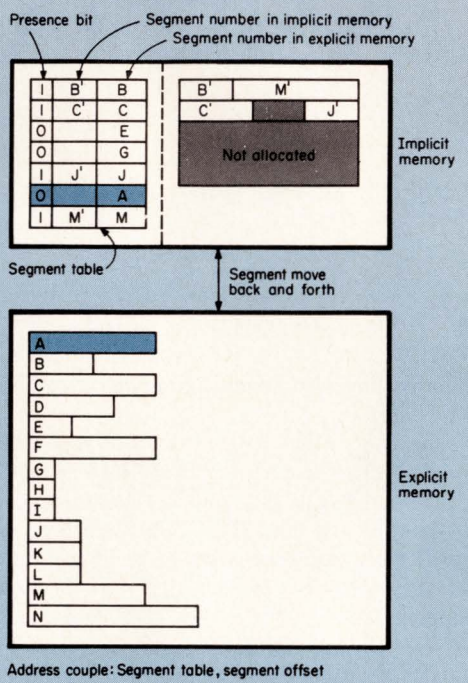


Typical hierarchical memory system. Each memory performs a storage function, which indicates the relative value of the data contained in the memory.

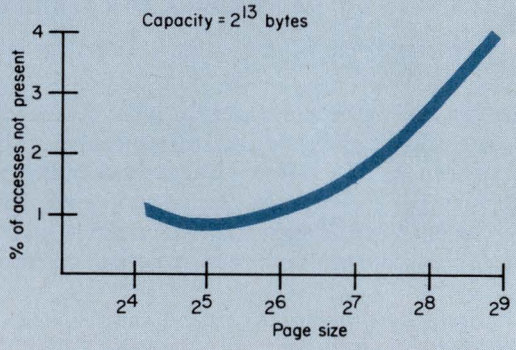




Explicit and mixed memory hierarchies. The system in (a) has two levels of direct address storage. In (b), the programmer manages two levels of explicit addressing, but the system manages data within the dotted line.



Segmented virtual memory. Assume the implicit memory is empty, except for the segment table. The processor presents the address couple (A,3). Index A addresses the segment table and examines the entry at A to see if the segment is in the implicit memory. It is not, so the explicit memory is addressed. The complete segment A is moved to implicit memory, and entry for it in the segment table is marked present (1). The segment offset (3) is used to move the third word of segment A to the processor.



Relationship of page size to fast memory capacity.

is best from its point of view, rather than considering the system.

Implicit control means that the system controls data mapping and movement in two, or more levels. The major benefit is optimized performance.

A measure of processor throughput is the ratio of useful (data transforming) cycles to total cycles. Reducing the waiting time for data increases this ratio. Fortunately, processors access data in patterns, which are functions of the application, the code language, and processor design. Dynamically accessed data contains variables that are accessed with varying frequency. The set also changes with time; some stop being accessed, while others start.

One model of implicit control is the virtual memory, which means that the user (programs) sees it as a composite of several characteristics. The size is that of the slower memory, while the average access time is slightly longer than that of the faster memory. The faster memory level represents windows placed over parts of the slower one. They allow fast access to data in the window, and slower access to data that require the window to move. The object is to keep windows over items having the greatest value.

Information is accessed in logical clusters. It is important to allocate space for data according to logical relationships such as, elements of an array, sequence of program code, or local variables in a block. Needed data is placed in the window with its logical cluster, because chances are good that neighboring data will be subsequently used.

Implementing virtual memories

Segmentation and paging are used to implement virtual memories. Both move data blocks between memories and use a third memory to link or control a high-speed and a main or backing memory. In segmented systems the memories may be of any type if access time differs by at least an order of magnitude, and size by a factor of 16. When segment tables, which access data in the implicit memory, are allocated as segments in the same memory, it is possible to remove inactive tables. Segments vary in size.

Many systems use paged virtual memories, where backing stores and fast stores (3-4,000 words) are divided into blocks (pages) of equal size, usually between 4 and 64 words.

Two approaches are used for mapping the pages of the back-up store onto the fast memory. Congruence mapping directly relates the backing store page address to a page in the fast memory by truncating the backing store address. Some performance is lost, because several processor requirements may compete for the same fast memory page.

Associative mapping links pages in fast memory with arbitrary pages in the backing store. A special memory holds the page table. Table entries are interrogated for each access. This is time-consuming unless an associative memory is used.

Paged hierarchical memories

Roger Cormier, IBM, Systems Development Div., Poughkeepsie, N.Y.

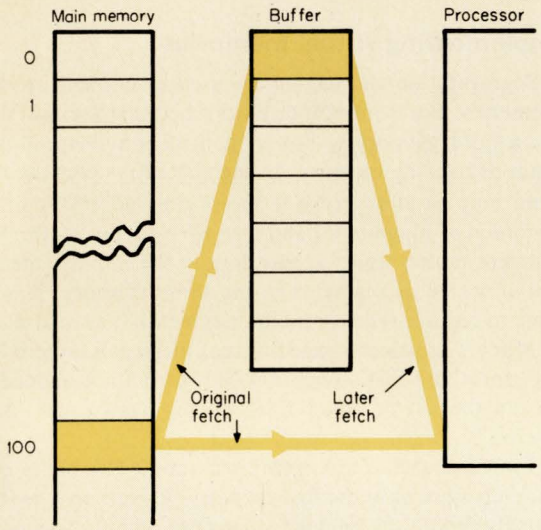
Two factors determine hierarchical efficiency. One is repeated access to the same information or information located near previously fetched locations. Data fetch cycles account for less than half of all cycles. Most cycles fetch programmed instructions and many programs consist of repeatedly executed instruction loops. If the buffer can contain the entire loop, the performance increase is obvious. The second factor is that the buffer unit contains only a small protion of the main memory. The algorithm that controls buffer content is important for system efficiency.

Some important considerations are not described in the figures. For example, after the buffer is loaded with information, a fetch cycle will occur for data not in the buffer, and for which there is no empty space. A decision must be made. Which information should be deleted from the buffer to make room? The common procedure is to replace the least recently used data.

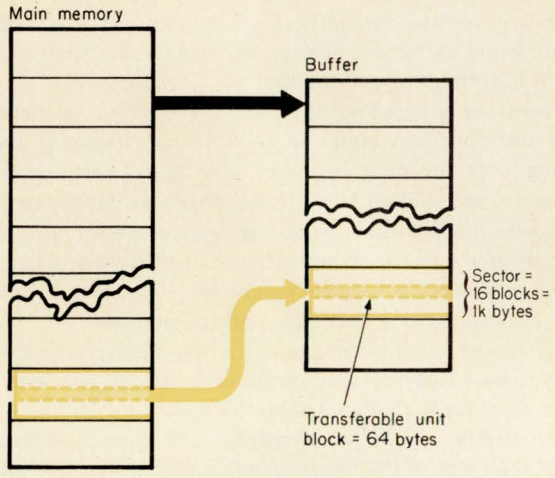
Hardware determines which item to delete; the procedure for deletion is determined by how the system handles store cycles. If no store cycles were performed, the buffer information is identical to the main memory, and therefore no action is required. However, if a store cycle was performed, the hardware must ensure that the latest version is kept in main storage. Two methods of handling store cycles are:

Store through—all store cycles are done in main memory, and in the buffer, if it contains a copy of that location. No special action is required when deleting an entry from the buffer; however, no advantage is gained by the buffer for store cycles.

Store wherever—a store cycle to a location in the buffer is performed only in the buffer. If the location is not in the buffer, the store cycle takes place in main memory. This scheme may require information transfer from the buffer back to the main memory as part of the procedure for deleting a buffer entry.



Hierarchical system principle. Assume that the buffer is empty and the processor wants data from location 100. The main memory is cycled, data is transferred to the processor and stored in the buffer. If the processor wanted information from location 100 again, a check verifies that it is validly contained in the buffer. For the second fetch, data is obtained by cycling the higher speed buffer, substantially reducing access time. Repeated references to buffer data reduces effective memory cycle time, approaching buffer cycle time in the limit.



Characteristics

	Total capacity	Cycle time
Buffer	16k bytes	80ns
Main memory	4M bytes	1.0μs

Typical partitioning in hierarchical memory system.

We can now show how an entire system could function. Assume a computer with 4 million bytes of main memory, and a cycle time of1 μs. Add a 16k-byte buffer with a cycle time of 80 ns.

When information is required, a test is made to determine if it is in the buffer. All 16k-bytes of the buffer cannot be tested individually within a reasonable time. Main memories and buffers typically divide into lk sectors, which sub-divide into 16 blocks (pages) of 64 bytes. (Blocks are the data units transferred between memories.) Each block has a validity bit that is initially reset when the buffer is empty. As main memory data is needed, data passes to the processor and the buffer and the block validity bit is set to 1. A subsequent request for the next block of this sector fetches it from main memory and turns on its validity bit. When it is necessary to reassign a section of the buffer to another sector of main memory, all validity bits are reset and the procedure is followed for the new sector. In short, the procedure for a memory cycle is:

□ Determine the sector. If it is not active in the buffer, delete the least recently used sector and assign the new sector to it. Reset the validity bits and transfer the block to the processor and the buffer.

□ If the addressed sector is active in the buffer, test the validity bit for the block involved. If the validity bit is off, obtain the block from main memory for the processor and the buffer. Turn the validity bit on.

□ If the sector is active in the buffer and its validity bit is on, fetch the data from the buffer. If the sequence of storage fetches were random, performance increases would be low. System analysis shows that 85-90% of all cycles are made to the buffer alone for many programs. Addressing patterns are far from random, and the buffer concept increases effective system speed.

Other methods have been identified for hierarchical systems. Random replacement algorithms and fixed partitioning methods can determine the sector to delete. Multilevel hierarchical systems may provide even more performance possibilities and greater cost advantages. While the methods discussed here can be refined, the basic idea of the memory hierarchy offers a considerable system advantage.

Interfacing with memories

Dale Pippenger, Texas Instruments, Inc., Dallas, Texas

Interfacing with core memories imposes some rather severe operating conditions on the circuitry involved. A large number of cores make a drive line appear highly inductive. Core address takes high X and Y drive currents, so normal logic gates cannot drive them directly. An interface called a core, or memory, driver is used.

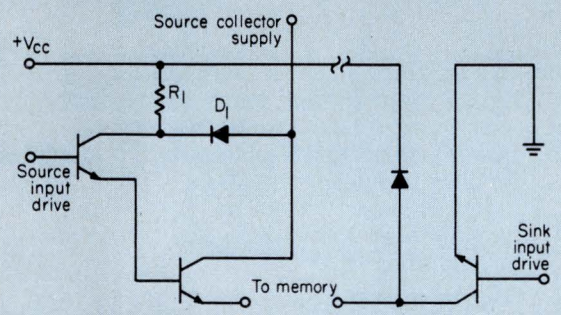
Power handling capability is important in this application. Current depends on core size and switching speed. A typical core size is 20 mils with reading or writing taking 800 mA. This means a driver half-current of 400 mA. Drive voltage increases as the number of cores. In a 64k-word by 4-bit, 3D system, an X or Y line threads 1,000 cores. This takes 12 V at 400 mA. Larger systems need the same current but more voltage. They usually divide into sections with separate drivers, though some monolithic drivers operate up to 24 V.

Drivers must be controlled by logic information. Strict timing considerations require separate sink and source strobing, as well as individual data addresses. Addressing and timing normally turn the source driver off before the sink driver.

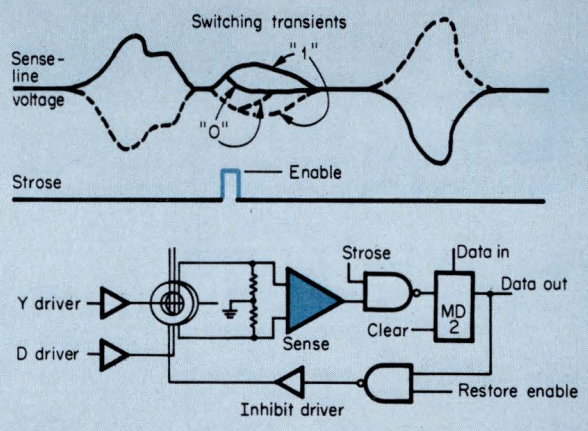
Sense amplifiers (SA) sense the amplitude of small sense line pulses when a core is interrogated. The amplitude of a 1 is about twice that of a 0. Polarity sensing is ruled out because the sense line threads the array to minimize noise, making two 1's or 0's from adjacent cores opposite in polarity. The "schmoo plot" is a graph of SA performance. It plots the operating range of a circuit or system for two or more variables.

Only state-of-the-art, direct coupled IC sense amplifiers meet requirements for coincident-current memories with cycle times below 700 ns and access times below 400 ns. Slower memories can use reactive coupling between stages or precision external resistor networks in conjunction with IC voltage comparators.

The high-gain, high-speed characteristics of sense amplifiers dictate proper bypassing of supplies and ground paths on the board. Reference and power supplies should be bypassed as close to the device terminals as possible. Input ground terminations should have separate paths to the supply from those of the output circuitry to reduce unwanted feedback and oscillations.



Core memory drivers furnish current to one end of the line and sink current to ground at the other. High operating speeds take low propagation delays. The output transistor must turn on, in saturation, immediately. Connecting the driver transistor in a Darlington configuration with the output produces the base drive required to pull the inductive load to $+V_{CC}$ (12-24 V, 500 mA). As soon as current stabilizes, the large base drive is no longer needed and may be reduced. Diode D1 is forward biased during turn-on. As current stabilizes, it is reverse biased, opening the Darlington connection and maintaining base drive through R1. During turn-off, the inductive kick could dangerously increase voltage at the current sink collector. To prevent breakdown, clamp the collector to a known level. Here, a diode clamps the collector to about V_{CC} + 1 V.



Read/restore loop for 3D. To discriminate when the signal-to-noise ratio is maximum, a strobe gates the amplified signal to the level detection circuit. Time and amplitude discrimination are performed on the sense signal, which may be as high as 5-8 mV for 0's and as low as 12-15 mV for 1's. When cores are read, data is lost. Memory drivers drive a separate inhibit line or the sense line to restore data. The inhibit driver usually gets its address from the memory data register (MDR), forming the data regeneration loop shown.

Continued on page 49

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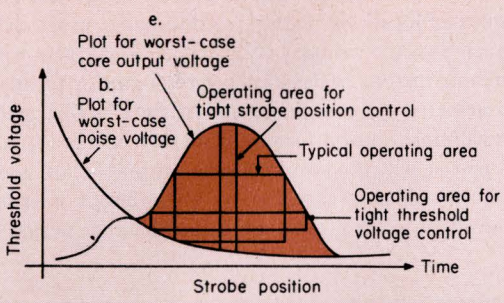
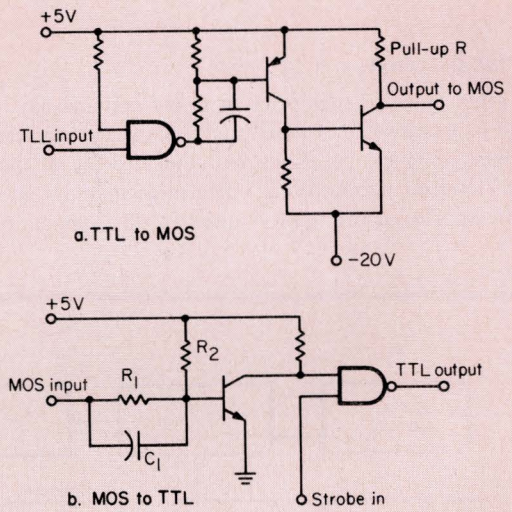
NORTH ELECTRIC

NSP-8



Typical sense amplifier Schmoo Plot. Operating range is between curves a and b. Practical operating regions are defined by rectangles. The vertical side represents the strobe position range. Its accuracy is affected by strobe width, skew, and amplifier delays. Sense amplifier threshold level tolerance is a function of the stability of the device to power supply and temperature variations, initial setting to the threshold level and the stability of the threshold reference voltage.



TTL and MOS drivers. Interfacing between memory logic levels is primarily a job of level shifting. Special monolithic circuits achieve the required combination of high-speed, low power, multi-channel, and high-drive current characteristics needed. If the output transistor in a, can handle large currents, a small output pull-up resistor will charge MOS circuit capacitance rapidly. In b, R1 and R2 forward bias the transistor when the input is near ground and reverse bias it during a negative MOS output. A speed up capacitor, C., improves switching speed.

Memories in displays

A. Maurer, Hazeltine Corp., Little Neck, N.Y.

Display systems need memories for buffering, character generation, and refresh. Since computer data is generally sent in blocks, time buffer storage is needed. Serial storage is possible, since data is ordered and addressed sequentially. Serial buffers need a parallel-to-serial converter and segmentation into parallel data paths.

Asynchronous high-speed RAMs are preferred in buffers, because they can be accessed to process a channel without interrupting inputs to other channels. Low-cost dynamic serial memories need data recirculation, which increases access time. Cores with cycle times of a microsecond or more are the most common for buffers larger than 25k bits. Smaller buffers find dynamic MOS RAMs an economic alternative. Refresh is usually a minor restriction, easily satisfied.

Display systems convert digital codes into CRT displays of characters or symbols. A stroke writer (beam wiggle) increments in X and Y over the face of the CRT. A dot matrix forms the characters. Character generators are generally implemented with ROMs when character information does not change. For electrically alterable requirements, non-volatile RAMs or RMMS (read-mostly memories) are used.

Some early display systems used diodes as large multi-input AND gates to decode character data. Today, specially masked MOS chips and braided-wire transformers are economical. To change character data by computer command, electrically alterable plated wire ROMs or core memories with data retention during power transitions are used.

The refresh rate is determined by the resolution (number of discrete video dots/line) and the number of lines. The standard TV rate is 30 frames/s, with a frame consisting of two interlaced fields. A 500-line, 550-dot/line display means that each dot is about 100-ns wide. This defines the refresh memory data rate.

Segmentation affects cost when a drum or delay line is

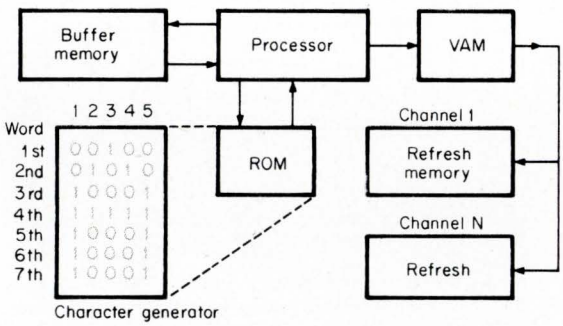
used. Many heads and read/write electronics are inherent in a heavily segmented drum, as are many lines and drivers for a similar delay line system. By contrast, the number of MOS shift register chips remains almost constant, since they are segmented into groups on the chip. High clock rates increase power consumption, and segmentation reduces it.

Radar displays

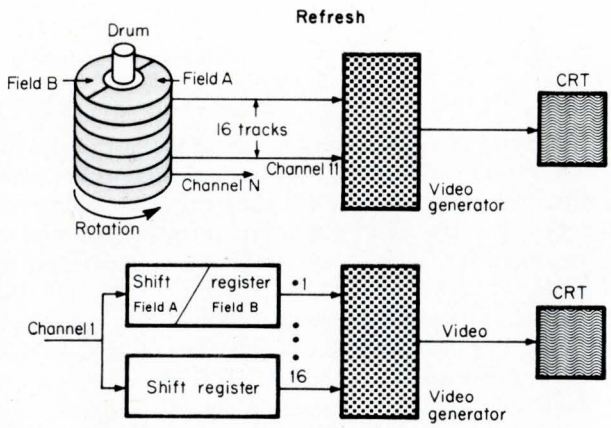
Target detector memories in radar systems have small word capacities and several microsecond cycle times. The number of target locations and the amount of data for each (altitude, azimuth, etc.) determine memory size. Dynamic MOS RAMS are highly suited to this application, because they are small, low-power, high-reliability devices. Volatility is not a factor; data refresh is inherent in the continuous sequential addressing.

Content Addressable Memories (CAMS) can reduce memory size. Instead of a memory word for each location, the CAM contains the amount of words associated with the maximum number of targets, usually much less than the number of locations. Target words contain range data, and at each box, the memory is searched. All targets with data matching the box in question are read out for processing.

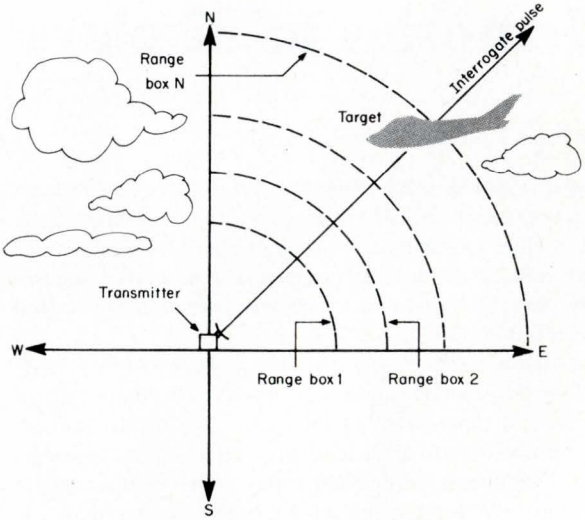
Telemetry systems make use of time buffer memories. For example, during reentry from space, there is a blackout period where communication with vehicles is cut off. Telemetry data is captured by an onboard memory and transmitted to the ground when the blackout period ends.



Display memory block diagram. To print an "A", the buffer contains the X and Y position coordinates on the CRT, and the code 1000001 (ASCII "A"). When the TV sweep is at the defined location, the 5 x 7 dot matrix ROM is addressed using the code and three address bits, which decode one of seven character lines. The sequence of words for a ROW output character generator is shown. Character generator ROMs have cycle times around half a microsecond. The generator can directly input words in sync with the raster scan into a single channel video generator. Multi-channel machines use a Video Assembly Memory (VAM) to formulate the entire picture before it is fed to the refresh memory. The ROM outputs seven sequential words for each character. The VAM is high-speed RAM with a storage element for every active dot on the CRT face. It can contain volatile information. The refresh memory provides data to periodically brighten the CRT phosphor, a memory element having a characteristic called persistence.



Refresh memories such as drums, discs, shift registers and delay lines have segmented serial outputs. The more segmentation, the lower the refresh memory data rate can be. A clock rate of 20 MHz is needed if a single register/channel generates a bit every 50 ns. If 16 registers are used, each is clocked at 1.2 MHz, providing 16 parallel bits every 0.8 μs. The video generator converts this data to serial form at 20 MHz.



A target detector memory contains a word for each range box during the transmission and reception of the interrogate pulse. Replies are stored in the word associated with that time period.

Minicomputers and controllers

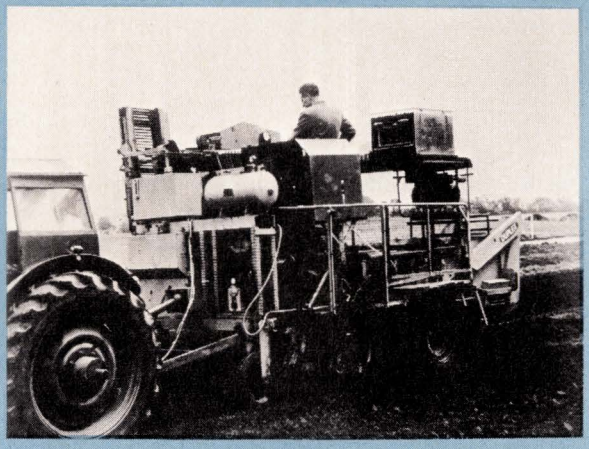
Stephen A. Kallis, Jr. Digital Equipment Corp., Maynard, Mass.

Both minicomputers and some forms of controllers have memories. The differences between minicomputers and large computers primarily relate to size and durability. The minicomputer opens up applications in low-cost areas and in uncontrolled environments that large computer systems could not tolerate.

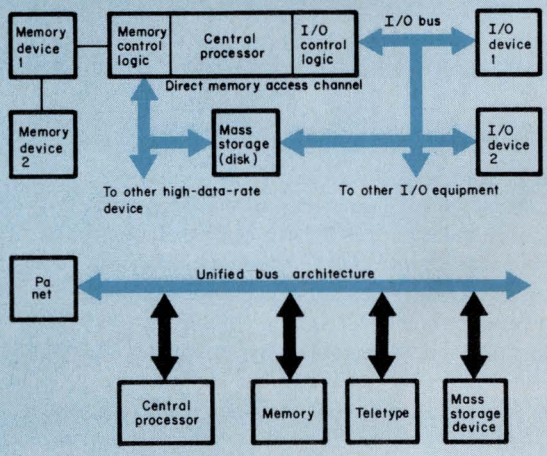
A rule-of-thumb for differentiating between the most sophisticated memory-bearing controllers and the least sophisticated computers is that controllers use ROMs; while computers use read/write RAMs. However, this distinction is blurred, as with our PDP-11. Called a computer, it has only hard-wired logic in some cases.

Smaller computer memories contain between 4 and 32k-words of 12-18 bits. Controller memories are often smaller, or nonexistent. Because of their limited storage, most small computers are "dedicated," that is, the entire program concentrates on a single objective such as calculation, instrument servicing, or process control.

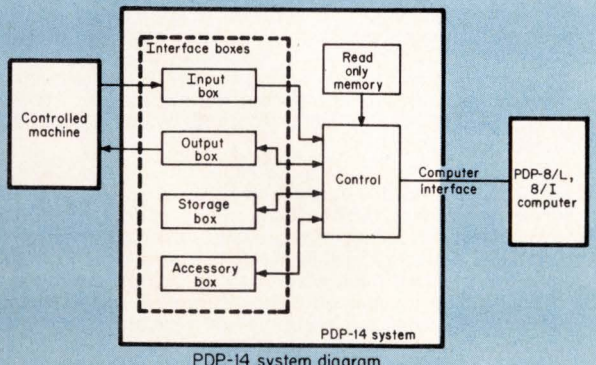
Minicomputers often use additional storage, such as mag tape or discs. With auxiliary storage, whole or partial programs can be transferred into and out of the computer memory, sharply enhancing its capacity. If necessary, it



Compact size and relative insensitivity to environment make the small computer an excellent data gathering or control system in the field, literally. Here, a PDP-8/L (top right of tractor) is used to examine the performance of an experimental farming machine. A large computer would be difficult and expensive to use.



Small computer architecture. In the traditional minicomputer, memory elements are isolated from I/O devices by the I/O control logic and logical elements of the CPU. Any direct memory access (DMA) must be performed via a separate data path. The unified bus arrangement shows all elements connected to one bus. Through a "priority arbitration" network, all elements, except memory, have equal status. Any one element can take control of the bus and address any other; thus, DMA is automatic.



PDP-14 system diagram

Major parts of the PDP-14 controller. Machine controllers are sometimes called special-purpose computers. When connected to a computer, the controller may form the lowest end of a hierarchy. Usually, the computer simply monitors and records the performance of its controller(s).

can perform different sequential tasks. This amounts to ultra-rapid rededication of the computer during the series.

A small computer can contain the required analytical program to solve a problem, but have insufficient storage left to handle all the elements. In such cases, small computers are connected to larger ones, forming a hierarchy. The small computer uses the large one as a form of memory extension. When a minicomputer cannot handle a problem, it accepts the input, manipulates the data, and transforms them into a form the other can handle with virtually no extra programming. The second computer receives the problem in its preprocessed form, solves it, and sends back the results. In typical setups, dedicated controllers act as the bottom level of a hierarchy and connect to a small supervisory computer.

Traditional minicomputer architecture called for one bus to connect the central processing unit (CPU) with the memory, and a separate I/O bus to each peripheral device. All memory inputs went through the CPU, unless a special Direct Memory Access (DMA) option, located in the CPU, permitted a device, say a disc, to communicate directly with the memory.

Many minicomputers now use a unified bus to parallel all computer elements. Any element, except the memory, can take control of the bus and communicate with any other element. All elements have access to the memory without going through the CPU.

This arrangement provides easy modular addition of elements. Plugging in extra memory elements adds memory. Memory elements mix easily: some plugged into the bus may be RAMs, while others may be ROMs.

Mixed memories are very useful for protecting parts of a program. Critical parts are put into ROMs, which are immune to manipulation or dumping. The single-bus architecture means that a small computer having ROMs and RAMs converts into a controller by unplugging the RAM modules. A controller converts into a computer by plugging in RAM modules.

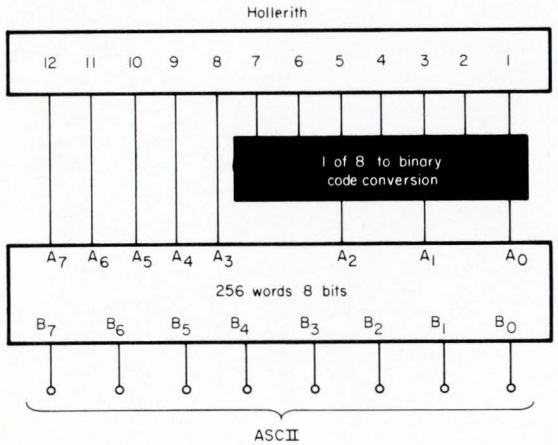
ROMs as logic

John Linford, Motorola Inc., Phoenix, Ariz.

An alternative to implementing digital systems with custom or standard ICs is to use semiconductor ROMs. This compromise choice can be thought of as both quasi-custom (custom mask patterns) and quasi-standard (standard, field-programmable parts).

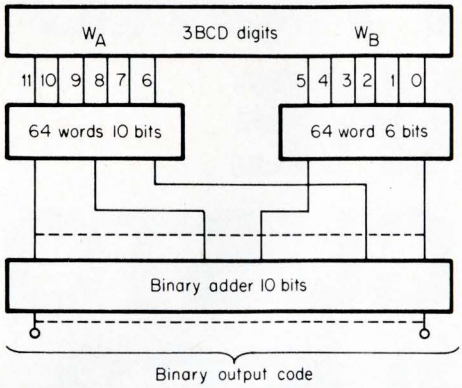
The field programmable ROM eliminates the manufacturer's four to six week turn-around time to program a ROM, as well as reducing part number inventories in the field. After prototypes are debugged using field programmable ROMs, smaller mask programmable ROMs can offer lower costs if large volumes are needed.

The desire to use LSI in system design has frustrated some designers. They attempt to partition systems into logic blocks that are large, yet repetitive enough so that quantities of custom circuits with many gates are feasible. Replacing logic blocks with ROMs often turns out to be a better answer. An even better approach may be to restructure the system organization to take advantage of ROM characteristics.



Combinational table look-up. To replace a multi-function (M) of variables (X) with a ROM, allow each combination of variables to select an address location programmed with the proper logic level. The input data, or address word, selects a stored word containing the output word in a simple table look-up arrangement. Design effectiveness is measured by comparing the number of bits actually used to the number purchased, which is generally a binary power.

To convert the 12-character Hollerith code to an 8-bit code such as ASCII would require 2^{12} words of direct address. However, characteristics of the code help reduce the bits required. Two or more bits in rows 1 through 7 are never activated simultaneously. These bits are really in a one-of-seven code which can be compressed into a three-bit binary code. With this compression, the Hollerith code becomes an eight-bit code, requiring only 2^8 words. The number of bits reduces from $2^{12} \times 8 = 32{,}768$ to $2^8 \times 8 = 2048$ bits, or two 1024-bit ROMs.



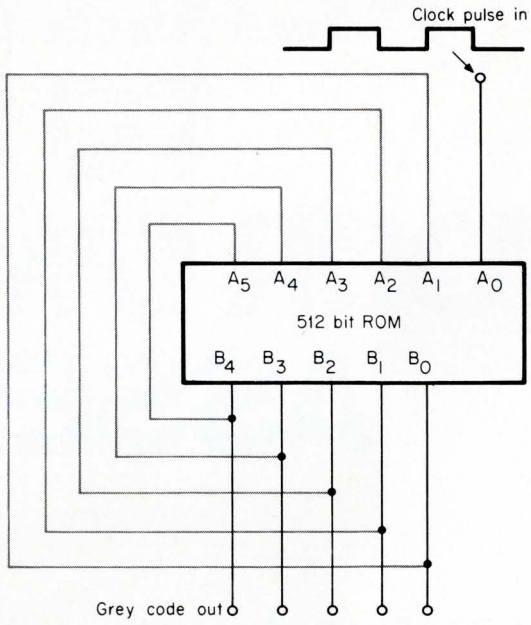
Segmentation divides an input word, W, into segments. Small ROMs translate each segment into the desired output code. Segmented outputs are combined using the appropriate algorithm. This technique is applicable to many conversions.

Consider a BCD-to-binary conversion involving three BCD decades. The input code has 12 bits. Direct conversion would take 2^{12} 10-bit words. By dividing the 12 input bits:

$W = b_{11}b_{10}b_9b_8b_7b_6b_5b_4b_3b_2b_1b_0$ into two segments:

$W = W_A + W_B = b_{11}b_{10}b_9b_8b_7b_6000000 + 000000b_5b_4b_3b_2b_1b_0$

each segment only contains six variable bits and six bits constrained to zero. Segment W_A has only 2^6 possible conversion states and can be converted into binary code with 2^6 possible states. The second segment, W_B, also contains 2^6 possible conversion states. Since it is composed of the last two bits of the middle four-bit BCD code (b_5 and b_4) and the entire four bits of the last BCD code (b_3,b_2,b_1,b_0) the largest input code that can be represented is decimal 39 (11-1001). Thus, only six output bits are required, and a 64-word, six-bit ROM can accomplish this part of the conversion. Outputs are added together with a 10-bit binary adder. The capacity for this conversion reduces from $2^{12} \times 10 = 10{,}240$ bits, to $2^6 \times 10 + 2^6 \times 6 = 1{,}020$ bits.



Sequence generation. Large ROMs can replace several flip-flops and counters as code sequence generators by connecting some outputs back to input address lines. Instead of addressing the ROM with a sequential binary counter and having it look-up the Grey code, a larger ROM sequence itself with only an external timing signal. The 512-bit ROM shown implements a five-bit Grey code counter by feeding back five outputs. The feedback eliminates the need for delay networks in the feedback paths, since only one Grey code output changes at a time. ROM outputs must be free from spurious signals that would address false states. A clock connected to the sixth input toggles between 1 and 0. It must remain stable for as long as the propagation delay through the ROM. The following table shows the first two states of the five-bit Grey code counter. A stable condition exists, and will persist when input and output agree. With the inputs and clock in the "All-0" state, the outputs are also all 0's, which is a stable condition.

	Inputs						Outputs				
	A5	A4	A3	A2	A1	A0	B3	B2	B1	B0	
initially	0	0	0	0	0	0	0	0	0	0	stable
clock step	0	0	0	0	0	1	0	0	0	1	
sequence	0	0	0	0	1	1	0	0	0	1	stable
clock step	0	0	0	0	1	0	0	0	1	1	
sequence	0	0	0	1	1	0	0	0	1	1	stable

When the input clock goes to the 1 state, the input word (000001) addresses a ROM location containing the stored word 00001. The five-bit output (00001) causes the six-bit input to become 000011. That input addresses a new memory location, which also contains 00001. Now the output corresponds to the input and a stable condition exists until the clock line toggles to 0.

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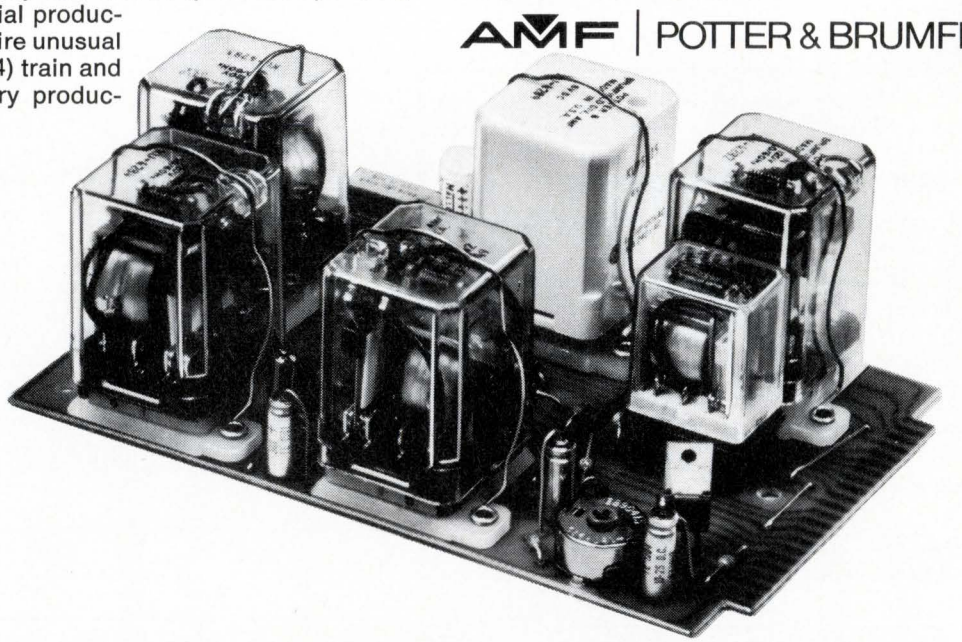

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IC IDEAS

THIS MONTH'S IDEAS **PAGE**

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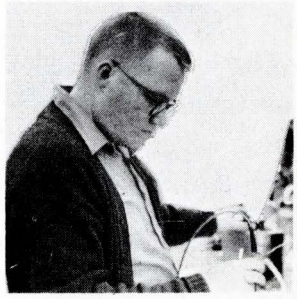
HOW YOU VOTED

The winning Idea for the February 1971 issue is "Solid state sine/cosine generator."
Our winning author, J. Rodney Cox, is an electronic engineer at the U.S. Naval Ordnance Station in Louisville, Kentucky. He is responsible for the design of electronic replacements for mechanical and electro-mechanical gear, and also is involved in several R and D projects. Mr. Cox has selected the Triplett Model 602 TVO as his prize.



IC IDEAS

An easy way to measure offset and bias currents

Jack Goldberg, Monsanto, Electronic Products Div.

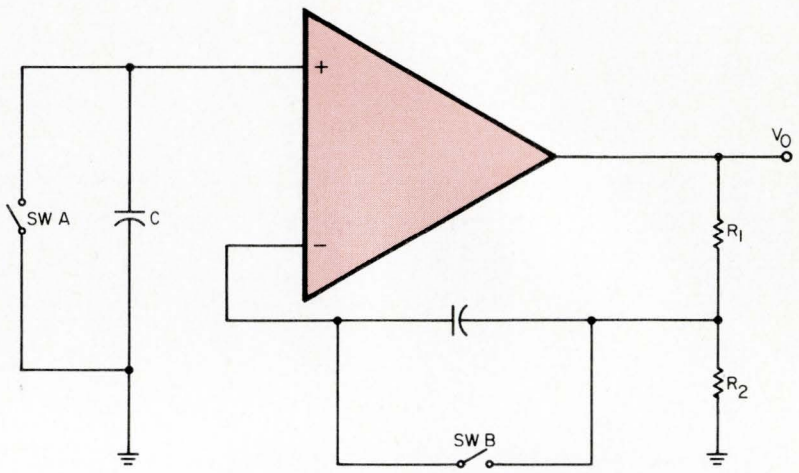
This circuit lets you measure the bias and offset currents of FET input op amps down to 1 pA.

If switch S_1 is closed and S_2 is open (or vice versa), the output voltage is related to the bias current by the following equation:

$$\frac{dv}{dt} = \frac{i}{c}\,\frac{R_1 + R_2}{R_2}$$

By monitoring V_0 for a known period of time, you can find the bias current.

An example, assume C is a 0.001 μF polystyrene capacitor R_1 is 9.0 kΩ, R_2 is 1.0 kΩ, and the time period is 10 s. Working through the math will give you the fact that $i = dv\ 10^{-11}$. If V_0 changes by 0.1 V during the 10 s, then the bias current is 1 pA.



You can also use this curcuit to measure offset currents by opening both switches. For measuring offset and bias currents which are orders of magnitude larger than 1 pA, use larger capacitors.

To vote for this IC Idea, circle 981 on the Reader Service Card.

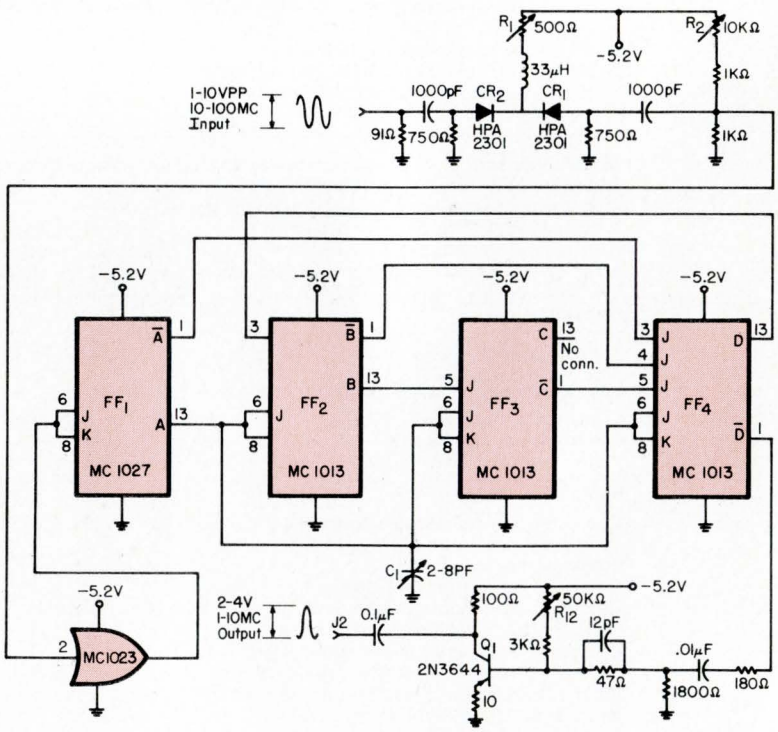
Inexpensive divider extends range of 10 MHz counter to 100 MHz.

R. L. Starliper, Western Electric Co.

You can extend the range of most 10 MHz counters with this circuit. The diode limiter (CR_1 and CR_2) allows signal amplitudes up to 10 V pk-pk without damage to the integrated circuits. Variable resistor R_1 controls the bias point of the hot carrier diodes and should be adjusted for −3.2 Vdc at the anode of CR_1.

The signal from the limiter is shaped by the 1023, a high speed dual clock driver. The input to the clock driver should be biased to 1.15 Vdc, which is set by R_2. The output from the clock driver goes to FF_1, a 120 MHz J-K flip-flop. This divides the signal by 2.

The output from FF_1 goes to the divide-by-five circuit consisting of FF_2, FF_3 and FF_4. The divided down output from FF_4 drives transistor Q_1 to obtain a 2-4 V swing at the output. Capacitor C_1 is adjusted to insure a proper frequency division with a 9 MHz CW input.



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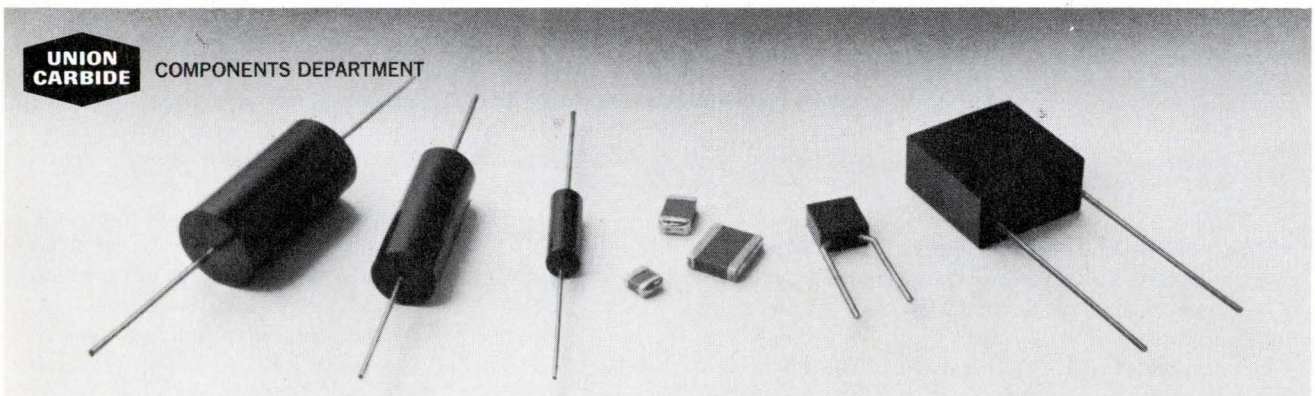

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IC IDEAS

Addition and comparison in one operation

John T. Hannon, Jr., Computer Sciences Corp.

A frequent situation in digital systems is the one in which you must compare two digital numbers. Often, one of these numbers will be from a BCD counter, which counts from zero to nine, while the other number may be from a thumbwheel switch which has an output of one to ten. In order to select the inputs from the switch as one to ten, you must add one to the input from the counter. One easy way to accomplish this function is to combine the addition and comparison functions with one 4-bit binary adder such as the SN7483.

One set of inputs to the counter is connected to the counter outputs, and the other is connected to the thumbwheel switch. The switch has BCD outputs, and the common line of the switch is connected to ground in order to provide an inverted BCD output of the number selected. The carry input of the adder is connected to logic one (+5 V) to provide for the necessary addition of one.

As an example of the circuit operation, let's suppose the thumbwheel switch is set to a five. The BCD code for five is 0101, but with the grounded common line the outputs become 1010. When the counter reaches four, the inputs to the adder are as follows:

Switch	$\overline{5}$—0101
Counter	4—0100
Carry	1—0001
Total	1111

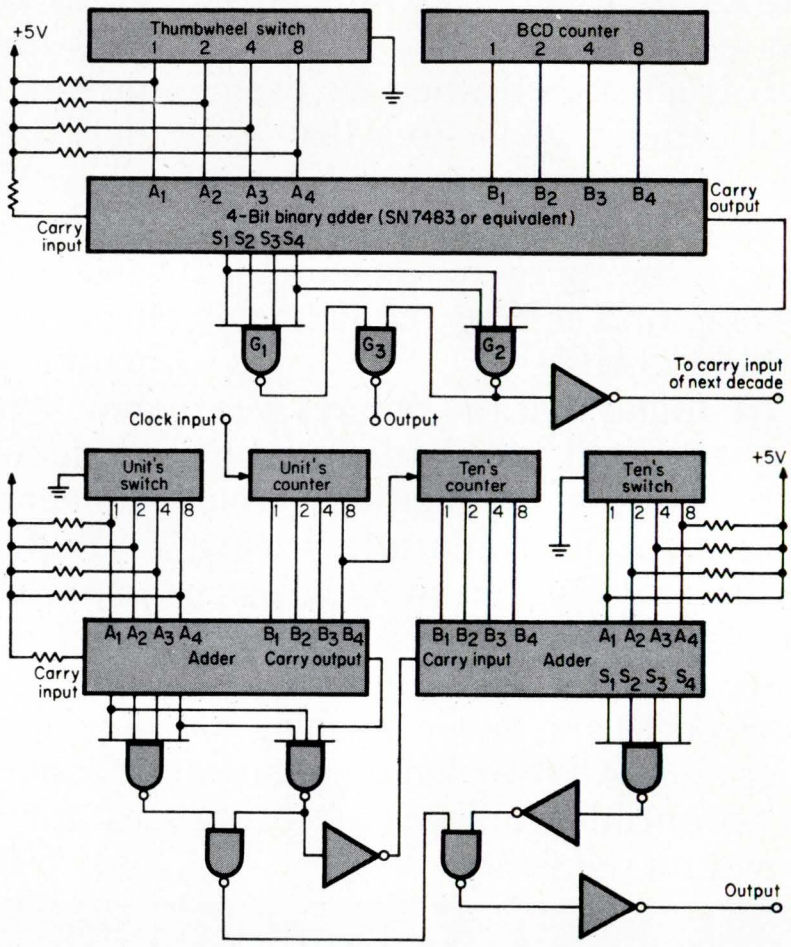
All four of the summation outputs go high, causing G_1 to go low. Gate G_3 then goes high to enable the function as required.

The purpose of G_2 in the circuit is to enable the zero on the thumbwheel switch to select the count of nine. This feature can be used with a second comparator for up to 99 different compare selections. For a comparison with the zero selected (10, 20, etc.), the inputs to the adder would be:

Switch	$\overline{0}$—1111
Counter	9—1001
Carry	1—0001
Total	1-1001

The output of G_2 then goes low, and G_3 goes high. The output from G_2 is also inverted and applied to the carry input of the next adder. This is because it is only necessary to add one to the ten's digit when there is a nine to zero transistion in the unit's digit.

The bottom circuit shows how to connect two BCD counters to provide for the selection of up to 99 functions. You can expand this method for as many decades as required. With availability and low-cost of the four-bit binary adder, the result is a unique comparison that is no more expensive than a standard comparison.



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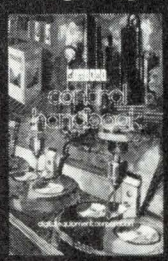

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digital

Digital Equipment Corporation
Main St., Maynard, Mass. 01754
(617) 897-5111

A funny thing happened on the way to the bench.

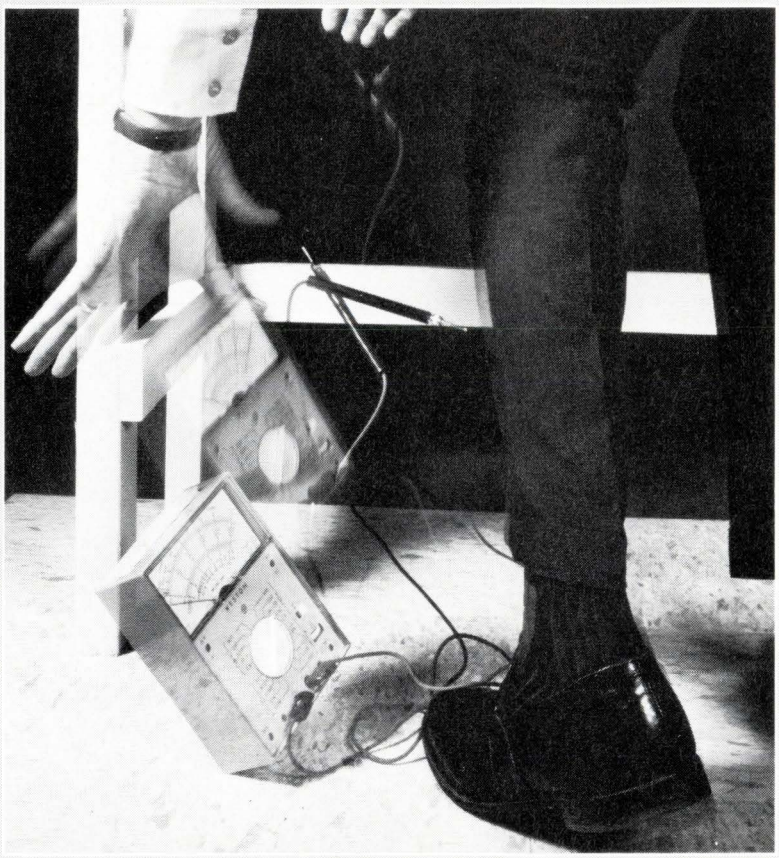


Photo courtesy Electronic Engineer

This Weston VOM will come through a five-foot fall and continue to work. We *engineered* our new 660 series VOMs to be virtually indestructible. And we back up this claim with a written warranty.

In addition to sparing you the embarrassment and inconvenience of a broken instrument, we've designed in all the features you expect in a modern VOM—plus a few more that may surprise you, considering that you pay no more for industry's smallest precision multitester.

For example: all models have diode-protected meter movements, with full circuit overload protection optional. All are equipped with a custom taut-band mechanism, self-storing handle, polarity reversal switch, externally replaceable fuse, and a single range selector switch.

Basic accuracy is 2% on DC and 3% on AC ranges — an accuracy they'll maintain in extreme environments because they're *temperature compensated,* too.

The 660 series drop-proofed line includes a 35-range general-purpose VOM, a VOM with resettable relay for 220-volt circuit overloads, and a high-accuracy version of each. There's also a high impedance unit with four push-button selectable modes and 37 ranges designed especially for semiconductor troubleshooting, but rugged enough for any field servicing need as well.

See your Weston distributor, or write for details on these "bouncing" new baby VOMs with more of everything . . . except price.

WESTON®

WESTON INSTRUMENTS
614 Frelinghuysen Ave., Newark, N.J. 07114
a Schlumberger company

Circle Reader Service #40

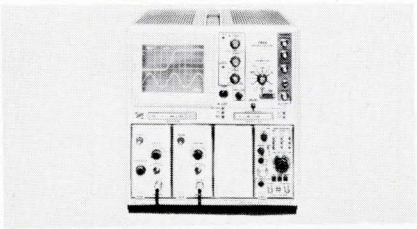
NEW PRODUCTS

The great scope race: Tektronix leads by an octave

For almost two years, Hewlett-Packard's Model 183A has reigned supreme as the fastest real-time oscilloscope you could buy. Introduced at WESCON in 1969 (**The Electronic Engineer,** Aug. 1969, pp. 93-94), the 183A boasted features not previously found on vhf real-time scopes: high sensitivity; good brightness; and a normally sized viewing area.

But at that same WESCON, Tektronix introduced its 7000 series. Starting with two mainframes and 13 plug-ins, the 7000 series has since grown to six mainframes and 22 plug-ins. And the most recent additions to this series—the sixth mainframe and the 21st and 22nd plug-ins—leapfrog Tektronix ahead of HP with a walloping 500-MHz real-time response and full plug-in capability.

The CRT in Tektronix's 7904 mainframe is similar to that found in HP's 183A in that both use helical delay-line deflection electrodes. With a direct connection to the CRT, the 7904 displays 1-GHz signals at a 5-V/cm deflection sensitivity on an 8-x-10-cm viewing area. Writing speed is 10 cm/ns. With fogging techniques, the 7904 offers a writing speed of 20 cm/ns.



Circle Reader Service #232

The standard 7904 mainframe costs $2900 and includes CRT scale-readout. An optional CRT with a 4-x-5-cm viewing area extends writing speed to at least 30 cm/ns. And with a P31 phosphor, this CRT—Option 4, which ups the price of the mainframe by $350—lets you see low rep-rate uhf signals even under high ambient-light conditions.

The new plug-ins complement the performance of the mainframe. A single-trace, vertical amplifier plug-in, the 7A19 uses fast hybrid circuits to give an overall system bandwidth of 500 MHz. Vertical sensitivity is 10 mV/cm, and the input impedance is 50 Ω. For high input-impedance measurements, you can use the P6051 FET probe. This gives a 1-MΩ input impedance and holds a 450-MHz system BW.

The 7A19 costs $500. Option 1, which adds a variable delay for transit-time matching of two 7A19s, increases the price to $700.

A new time-base plug-in has sweep rates from 500 ps/cm to 0.2 s/cm. The 7B92 dual time-base offers three display modes: delayed sweep; intensified delaying sweep; and alternate, which gives you a simultaneous display of the first two modes. The 7B92 costs $1400.

And now back to Hewlett-Packard. It should be obvious to users that HP hasn't been asleep on the job. After all, HP already has logic ICs operating above 500 MHz. And if digital circuits come, can linears be far behind? But the question isn't only one of time; it's also a matter of how high the frequency. It wouldn't suprise us if, when HP makes its move, it jumps right-on-up to a 1 GHz instrument.

In the meantime, for more information on the 7904 system (availability, fourth quarter of this year), write Tektronix, Inc., Box 500, Beaverton, Ore. 97005. (503) 644-0161.

For Tektronix
Circle Reader Service #232

For Hewlett-Packard
Circle Reader Service #233

Functional computer: custom style

For the OEM who has absolutely defined his problem and does not want to pay for a general-purpose minicomputer, Digital Equipment Corp. has announced a custom-designed "functional computer," the PDP-16. The potential user takes advantage of DEC's Chartware program to generate microprogramming instructions for a custom PDP-16. DEC claims a custom design can be done in an hour, though four hours is the best a customer has done to date. Anyone with doubts about his problem definition can buy a minicomputer and take advantage of its programmability to compensate for his uncertainty.

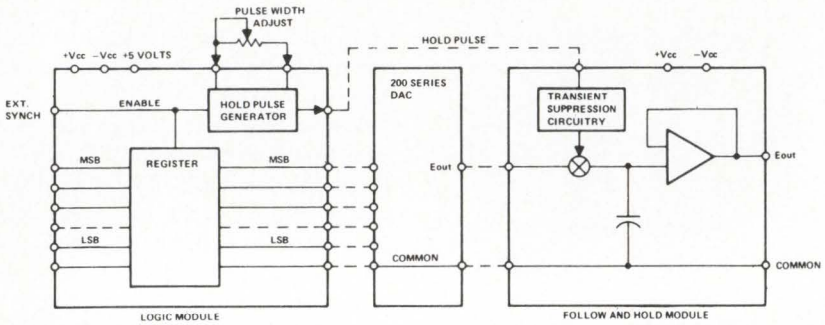
In the no-memory $800 version (prices range up to $3,000), TTL ICs are hard-wired into the custom PDP-16. Reprogramming is done by rewiring back panels. Up to 1024 words of braided wire ROM and 512 words of bipolar scratchpad RAM can be achieved in the costlier models. Add times are in the 400-500 ns range.

A typical application might be comparing a process control signal at the high and low limits and alerting another computer when the signal falls outside the band. Digital Equipment Corp., Maynard, Mass.

Circle Reader Service #234

High speed D/A conversion for display systems

This set of three modules is aimed specifically at providing the high resolution and accuracy required in display systems and high speed test equipment. The set consists of the D/A converter itself, plus a logic module and a follow-and-hold amplifier. The three units together provide the kind of glitch-free conversion that is required by large screen CRT displays.



The D/A converter, which you can use as a stand alone module, comes in 10-, 12-, and 13-bit binary versions plus a 3-digit BCD configuration. The converters include switching network, current sources, output amplifier and an internal reference which is externally completed. This reference arrangement lets you make full scale adjustments or use an external reference if you wish. One very practical feature is that you can gain access to the precision resistors for the most significant bits. This means as resistor aging starts to affect your accuracy, you are not faced with a fairly expensive throw-away unit. Instead, you can recalibrate the converter and bring it back within the spec.

The second unit, the logic module, performs the function of cleaning up the digital inputs into the conversion system. It includes an input buffer register for parallel data entry, plus the circuitry which generates the hold pulse for the follow-and-hold amplifier.

The follow-and-hold module contains the hold driver, transient supression circuitry and the output drive circuits.

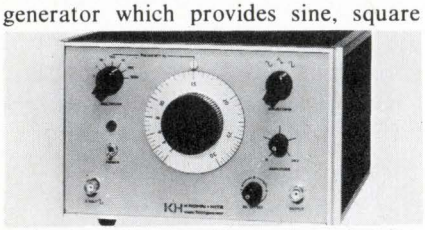
In a typical application of driving a CRT, the system will give you a minimum output slew rate of 200 V/μs. The settling time to ± 1 LSB is 500 ns maximum, and typically comes in at about 200 ns. The output is ± 11 V at 40 mA.

Some typical prices (in 1-9 quantities) are $135 for the 10-bit D/A converter, $195 for the 13-bit D/A, $45 for the 10-bit logic module, $75 for the 13-bit logic module and $125 for the follow-and-hold amplifier. Dynamic Measurements Corp., 6 Lowell Ave., Winchester, Mass. 01890.

Circle Reader Service #235

FUNCTION GENERATOR

Model 5000 is a low-cost function generator which provides sine, square

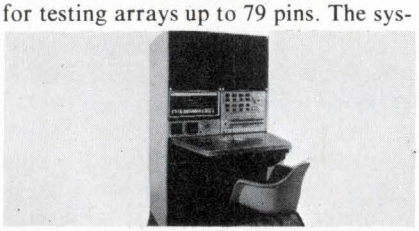


and triangular waveforms from 0.2 Hz to 3 MHz. Maximum output for all functions is 20 V p-p. An additional 5 V p-p sq. wave output can be used for synchronization, gating, blanking, etc., while the main output is providing another function. $295.00. Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge, Mass. 02139.

Circle Reader Service #236

MOS/LSI ARRAY TESTER

Model 1036 is designed exclusively for testing arrays up to 79 pins. The system is built around DEC's PDP-8 with 4K to 32K of core available depending upon options. As a function of the computer's peripherals, the I/O bus and the software allow as many as 20 completely independent circuit testers to be run by a single computer. LSI Testing, Inc., 2280 S. Main St., Salt Lake City, Utah 84115.



Circle Reader Service #237

If you design or use optoelectronic products that require light sensing at precise levels, you should know...

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Our packaged Opto-Hybrids™ (complete subsystems with "built-in" light sensors and amplifier / digitizer with DTL / TTL compatible output) and light emitting diodes are proving their superiority in many circuit applications for card and tape readers, mark sensors, position controls, isolators, character recognition, optical switching, intrusion detection, encoding, etc.

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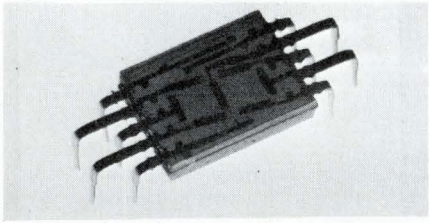
zeners, temp.-compensated devices, tunnel diodes, rectifiers, semiconductor chips, hi-rel hybrids and photovoltaic products

LED DISPLAY

Data-Lit 8, seven segment display has digits that mount on 0.3 in. centers.



This feature provides advantages over DIP-type displays in uses such as desk top calculators, portable and bench top instruments, data terminals and medical instruments. Litronix, Inc., 19000 Homestead Rd., Cupertino, Calif. 95014.

Circle Reader Service #240

HIGH DENSITY PLUGBOARDS

These boards are punched with an overall grid of 0.042 in. dia. holes located on 0.1 in. centers. They will take any component with lead spacing on 0.1 in. multiples. Thus, IC packages, or sockets from 14 lead through 36 lead sizes may be mounted in any required density. Vector Electronic Co., Inc., 12460 Gladstone Ave., Sylmar, Calif. 91342.

Circle Reader Service #241

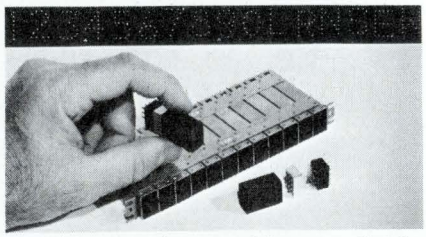
LIGHT DETECTORS

Two Sensor-LED assemblies, an Encoder and Mark Sense Reader detect interrupted or reflected light energy, respectively. Each OPB 120 encoder Assembly contains a GaAs infrared energy source and Si phototransistor. Optron, Inc., 1201 Tappan Circle, Carrollton, Tex. 75006.

Circle Reader Service #242

FIBER OPTIC READOUT

FRO series subminiature readouts feature low power requirements (100

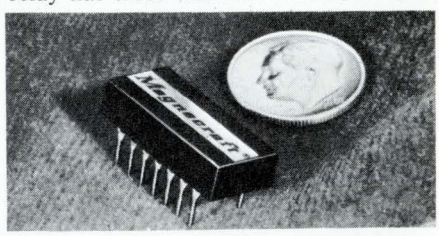


mW/char.) and non-ambiguous reliability (one lamp/char.) Although readout character height of 0.475 in. is larger than competitive 7-segment types, the housing size of 0.66 x 0.46 x 1.62 in. is smaller. Shelly Associates, Inc. 1562 Raynolds Ave., Santa Ana, Calif. 92711.

Circle Reader Service #243

DIP SOLID STATE RELAY

Class 5050QIC, dual-in-line, 14-pin relay has three different functions built



in—switching, latching, and timing. The latching function is easily achieved by shorting two pins on the PC tract. You merely add a simple resistor/capacitor network to accomplish the timing functions. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, Ill. 60630.

Circle Reader Service #244

DIGITAL READOUT TUBE

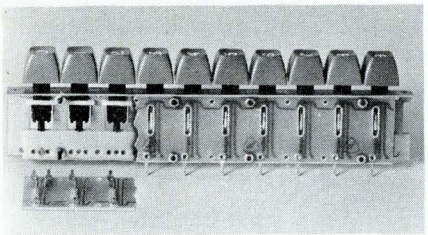
New low-voltage subminiature Y-4105 is a four phosphor segment, vacuum cathode-luminescent 10-pin base tube in a T-3 bulb. It offers sharp display of a numeral one, "plus" and "minus" symbols and decimal point for low drive and power levels. General Electric Co. 2100 Gardiner Lane, Louisville, Ky. 40205.

Circle Reader Service #245

NEW PRODUCTS

KEYSTRIP SWITCH

These switches may be used singly in control panel or console applications or



may be tied together in groups for data entry blocks. They may also be used in multiple units for complete and encoded std. or custom keyboards. Maxi-Switch Co., 3121 Washington Ave. No., Minneapolis, Minn. 55411.

Circle Reader Service #246

SOLENOID

This ½ in. dia. x 1 in. straight pull solenoid (Size 50) has an output force of 1.25 lbs. It is only 24 g and can move a load through a ½ in. stroke. Ledex Inc., 123 Webster St., Dayton, Ohio 45401.

Circle Reader Service #247

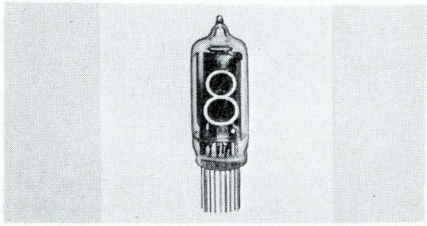
EPOXY COATING POWDER

Sensitive components can be coated at relatively low temps by spray, flow coat or aerated bed (dipping) with DK9 Blue, a homogeneous one-part epoxy powder. The electrical insulating coating fuses at temps as low as 250°F. Hysol Div., The Dexter Corp., Franklin St., Olean, N.Y. 14760.

Circle Reader Service #248

NUMERICAL READOUT TUBE

The NL-1222 readout is designed for

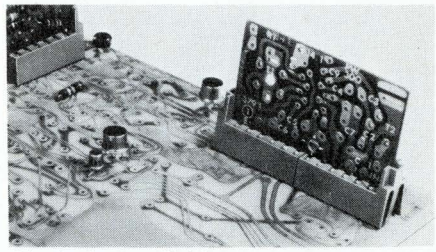


use at 170 Vdc. It operates equally well in the dc, strobe, or time share modes. National Electronics, Inc., Geneva, Ill. 60134.

Circle Reader Service #249

INTERCONNECTION BLOCK

BergLock™ modular interconnection



block is a reliable way to mount replaceable daughter-board modules in electronic assemblies. Locking tabs on the base of the housing anchor the blocks firmly into the mother board. Berg Electronics, Inc., New Cumberland, Pa. 17070.

Circle Reader Service #250

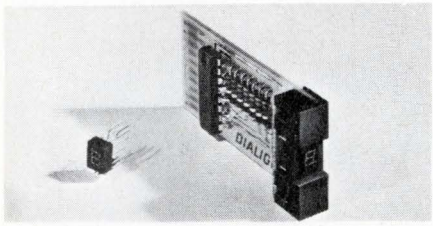
DIGITAL PANEL METERS

These flush-mount digital panel meters (Series K), for industrial environments, are available in 2½, 3, 3½, 4 and 4½ digit models. Datascan, Inc., Clifton, N.J. 07013.

Circle Reader Service #251

NEW PRODUCTS

NUMERIC DISPLAY



The Model 745 digital readout contains a GaAsP monolithic chip along with a separate decimal point chip at the lower right of the digit. Brightness is variable. $12.00 (1-9). Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237.

Circle Reader Service #326

COMPONENT PACKAGE

New DIP-PAK for dual-in-line packages is designed in standard DIL configurations for use with standard high speed insertion equipment. It fills the need for a ready made package that will eliminate costs of molding equipment, custom molds and hand encapsulation techniques. Universal Communications, 549 W. Washington Blvd., Chicago, Ill. 60606. (312) 641-2535.

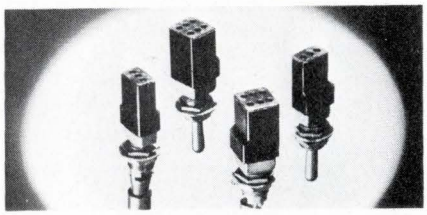
Circle Reader Service #327

DISPLAY LAMP

Long life is achieved in these displays by using a long-life lamp, a keep-alive element for pre-heating the lamp's filament, and a shockproof lamp housing. The built-in drivers are available for either positive or negative logic. Data Display Products, 8036 Westlawn Ave., Los Angeles, Calif. 90045.

Circle Reader Service #328

IWTS TOGGLE SWITCH



Built to Mil-S-8834 specs, these miniature positive action switches feature an integrated wire termination system (IWTS). The IWTS connection is made by inserting a small metal contact crimped onto a wire into a receptacle-like terminal. It provides a completely sealed, solderless termination. Cutler-Hammer, Inc. 4201 N. 27th St., Milwaukee, Wis. 53216. (414) 442-7800.

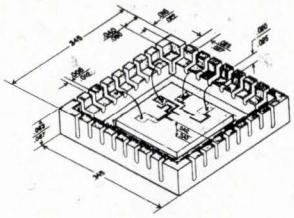
Circle Reader Service #329

GaAs SUBSTRATES

Six different standard, off-the-shelf GaAs wafers are now available for VLEDS, IR LEDS, opaque photocathodes, thin film devices, microwave diodes and injection laser device fabrication. Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif. 91109.

Circle Reader Service #330

SQUARE IC LIDS



These LIDS are expected to make inroads into 24-lead plastic MOS packages, for neither lead frames nor connectors are needed with the new ceramic IC carriers. Frenchtown/CFI, Inc., 8th and Harrison Sts., Frenchtown, N.J. 08825.

Circle Reader Service #331

ELECTROLYTIC CAPACITORS

New line of "Unidirectional mount, wide range Type R" capacitors are well suited for consumer and industrial applications. Ranges are 0.47 μF to 1000 μF, 6.3 WVdc to 50 WVdc, $-25°$ to $+85°$C. Illinois Elna Electronics Co., Dept. EE, 1607 W. Howard St., Chicago, Ill. 60626.

Circle Reader Service #332

TONE TRANSFORMERS

These tunable, multi-frequency tone transformers, featuring a high Q factor and good temp. stability, are for use in communications equipment. They come with 4 to 10 terminals suitable for mounting on PC boards. Bulova Watch Co., Inc., Electronics Div., 61-20 Woodside Ave., Woodside, N.Y. 11377.

Circle Reader Service #333

SS SWITCHES

These three SPDT switches feature 1 ns switching times and small plug-in packages suitable for PC board and stripline applications. Switching signal rejection is >45 dB at 10 MHz and >25 dB at 200 MHz. Isolation between outputs is >50 db (typ.) over the specified range of 10 to 200 MHz. Anzac Electronics, 39 Green St., Waltham, Mass.

Circle Reader Service #334

PROXIMITY SWITCHES

Maglock magnetic proximity switches come in three models: miniature, standard and vane. They eliminate mechanical linkages and complicated internal mechanisms. Electrical Controls, National Acme, 170 E. 131 St., Cleveland, Ohio 44108.

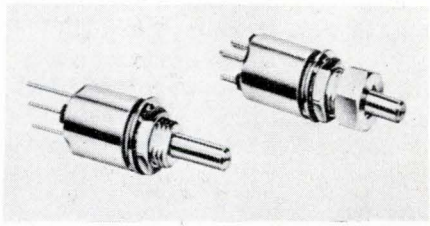
Circle Reader Service #335

ENCODING KEY SWITCH

Using a patented diode ring, this switch generates and transmits all std. binary codes. All encoding is done within the molded plastic switch. Industrial Echelons, Inc., Box 313, Huntingdon Valley, Pa. 19006.

Circle Reader Service #336

PANEL MOUNT POT



Type SP, ⅜ in. dia. stable cermet pot has a power diss. of 1 W at 70°C and a resistance range from 50Ω to 1 MΩ. Allen-Bradley Co., 1201 So. Second St., Milwaukee, Wisc. 53204.

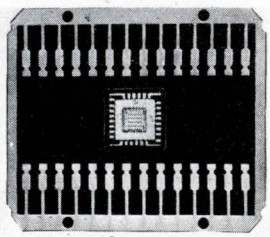
Circle Reader Service #337

REED SWITCH

MINI-DT, Form C, SPDT reed switch has a low profile (glass size 0.475 x 0.110 x 0.072 in.), making it well suited for packaging into the 0.187 in. high DIP relay configuration. Hamlin, Inc., Lake Mills, Wisc. 53551.

Circle Reader Service #338

PLASTIC IC PACKAGES

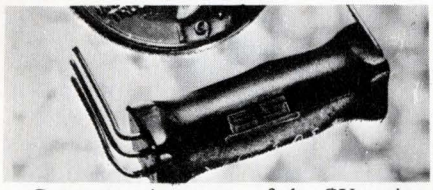


Designed for MOS, bipolar LSI packaging, this new line is available in a range of sizes from 14 through 42 leads. Prices will average between $0.10 and $0.15 ea. in volume. Interbond Systems, Inc., 1260 Alderwood Ave., Sunnyvale, Calif. 94086. (408) 734-3435.

Circle Reader Service #339

For quick information use the reader service card inside the back cover.

35-CENT REED RELAY



Contact rating specs of the SX series relays include 10 W switching capability, 500 mA max. current, typ. capacitance of 0.2 pF, 500 mΩ max. contact res., 500 μs operate time and 200 Vrms min. dielectric strength. Electronic Specialty Div., Datron Systems, Inc., 18900 N.E. Sandy Blvd., Portland, Ore. 97220.

Circle Reader Service #340

KEYBOARD SWITCH

You can specify any std. operating force from a min. of 3 to a max. of 16 oz ±0.50 oz (85, ±15 g) with this switch designed for PC board applications. Less than $0.40 ea. in prod. quan. Oak Mfg. Co., Crystal Lake, Ill. 60014.

Circle Reader Service #341

FLUX RING MEMORY STACK

These batch-fabricated memory stacks are for use in high-speed memory systems and in main memories for midi- and mini-computers. Cycle time is as low as 100 ns for NDRO or 250 ns for DRO Signal Galaxies, Inc., 6955 Hayvenhurst, Van Nuys, Calif. 91406. (213) 988-1570.

Circle Reader Service #342

CLOCK OSCILLATOR

The CO-232 crystal controlled clock oscillator generates a high stability TTL/DTL compatible output at any freq. in the 3 to 25 MHz range. Designed for PC board mounting, it operates from 5 Vdc. Vectron Lab, Inc., 121 Water St., Norwalk, Conn. 06854

Circle Reader Service #343

MINICOMPUTER SERIES

The Alpha 16 ($3350 ea.) has 1600 ns cycle time, 4 k core memory, hardware multiply/divide, three direct memory channels and three vectored priority interrupts. The 8-bit Alpha 8, with 4 k memory, 1600 ns cycle time, DMC and priority interrupts, is only $2800. Computer Automation, Inc., Newport Beach, Calif.

Circle Reader Service #344

MULTI-SPEED DATA SET

Model 911 switchable Intertran offers synchronous data rates of 2400, 4800 and 9600 bps. A fourth switch position accommodates any asynchronous rate up to 1800 bps. Computer Transmission Corp. 1508 Cotner Ave., Los Angeles, Calif. 90025.

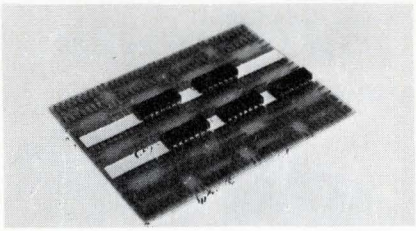
Circle Reader Service #345

CATV TRANSISTORS

Five new CATV devices are for line extender, trunk and bridger amplifier applications. The devices include SD1119 and SD1106 in a TO-39; SD1116 and SD1005 in an MT-59 stud; and SD1118 in a TO-60 stud. Solid State Scientific Inc., Montgomeryville, Pa. 18936.

Circle Reader Service #346

DIP BUS BAR



Dip-Buss™ provides a voltage and ground laminated bus bar which fits under DIPS and maximizes PC board surface use. Logic Dynamics, Inc., 118 Center St., El Segundo, Calif. 90245.

Circle Reader Service #347

IC SOCKETS

Type 561 accepts 14-pin dual-in-line ICS on 0.100 in. centers. Its contact entrance design affords consistently reliable mating of the IC package. Connector Corp., 6025 N. Keystone Ave., Chicago, Ill. 60646.

Circle Reader Service #348

CHIP THERMISTORS

"Lo Cap" thermistors have capacitance values of <1 pF from 5 to 20 MHz. They are available from 100 Ω to 150 kΩ at 25°C. Cal-R, Inc., 1601 Olympic Blvd., Santa Monica, Calif. 90404.

Circle Reader Service #349

THUMBWHEEL SWITCHES

Rated at 3 A and 115 Vac, these miniature 10-digit switches have a life expectancy of 1 million switch-point cycles while switching 0.125 A. Standard versions include decimal or BCD outputs. AMP Incorporated, Harrisburg, Pa. 17105.

Circle Reader Service #350

MICROWORLD

OP AMPS CUT ERRORS

The LM216 series offers input offset currents from 50 pA for the LM216 down to <15 pA for the 216 A. Input bias current range is 150 pA down to only 50 pA. All amplifiers draw <200 nA. at max. supply voltage of ±20 V. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051.

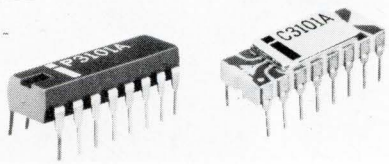
Circle Reader Service #255

ADDITIONS TO MECL 10,000

Two new devices have been added to this new emitter coupled logic series. The devices are the MC10110L, a dual 3-input/3-output OR gate and the MC10111L, a dual 3-input/3-output NOR gate. Both devices are in the ceramic dual-in-line package. Technical Information Ctr., Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, Ariz. 85036.

Circle Reader Service #256

FAST 64-BIT RAM



The 3101A uses Schottky clamped bipolar transistors to achieve an address-to-output access time of 35 ns max. and a chip-select to output time of 17 ns max. It is organized as 16 words of 4 bits ea., and is fully decoded and packaged in a 16-lead DIP with a "chip-select" lead for simple memory expansion. Intel Corp., 365 Middlefield Rd., Mountain View, Calif. 94040.

Circle Reader Service #257

4096-BIT MOS ROM

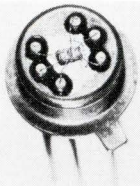
You can use the TMS4400 for look-up tables, code converters, microprogramming, and to perform random logic. With an access time of <1 μs, this large ROM can be used for any storage or memory function in such equipment as displays, computer terminals, calculators, and computers. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, M/S 308, Dallas, Tex. 75222.

Circle Reader Service #258

New TTL NAND gate. The DM7092/DM8092 is a dual 5-input gate that fills a gap in the 54/74 series. National Semiconductor Corp., Santa Clara, Calif.

Circle Reader Service #259

DUAL J-FETs



These monolithic dual J-FETs use dielectric isolation to separate two devices on a single chip. The technique permits packaging the monolithic duals in std 6-lead 2N packages. Older devices used a separate p-channel for isolation and required a seventh lead to maintain the p-channel most negative. Unisem Corp., Street Rd., Trevose, Pa. 19047.

Circle Reader Service #260

8192-BIT BIPOLAR ROM

The MM6280/MM5280 is organized as 1024 8-bit words. Access time is 100 ns; power dissipation, 60 μW/bit; input load current, 250 μA. Four ENABLE lines let you expand the memory to 16k words without additional circuitry. Sensing and decoding are on the chip. The MM6280 (0°-70°C) costs $74 ea., 100-249 pcs. Monolithic Memories, 1165 E. Arques, Sunnyvale, Calif. 94086. (408) 739-3535.

Circle Reader Service #261

FET AMPLIFIER

Model ZA801MI features 25 pA max. input current, 10,000:1 CMRR, 10^{11} Ω input impedance and 50 μV/°C max. drift. Lower drift versions (5 μV/°C and 20 μV/°C) also available. Zeltex Inc., 1000 Chalomar Rd., Concord, Calif. 94520.

Circle Reader Service #262

256-BIT RAMS

These two devices are designated the CM 1101 and CM 11011. Organized as 256 words by 1 bit, the DTL and TTL compatible devices are fully decoded with on-chip sense and address decode and feature max. access times of 1.5 μs (1101) and 1 μs (11011). Computer Microtechnology, Inc., 610 Vaqueros, Sunnyvale, Calif. 94086.

Circle Reader Service #263

Second source for 54/74. Fairchild adds the 7446, 7447, and 7448 BCD-to-7 segment decoders plus the 7494, a 4-bit shift register. Fairchild Semiconductor, Mountain View, Calif.

Circle Reader Service #264

Silicon gate RAM. The 2501 is a 256 x 1 fully decoded RAM with a typical access time of 800 ns. Signetics Corp., Sunnyvale, Calif.

Circle Reader Service #265

MONOLITHIC CHIPS

This new series of monolithic chips is suitable for use in hybrid microcircuits. The series includes single transistor and diodes, a line of amplifiers, Schmitt triggers, level detectors, operational amplifiers and other integrated circuits. Designed to be attached to either thick or thin film circuits by eutectic die bonding or by conductive epoxy, the chips are backed with a layer of gold approx. 0.3 μm thick, thereby achieving exceptionally low V_{CE} (Sat). Amperex Electronic Corp., Integrated Circuits Div., Cranston, R.I. 02920.

Circle Reader Service #266

SIX-CHANNEL MULTIPLEXER

The UC6410/7410 is a six-channel bi-directional MOS FET multiplexer built on a monolithic chip and featuring separate drains, gates, and a common source. The multiplexer's substrate terminals allow biasing for analog switching. Low R_{on} resistance (250 Ω max.) and low gate power requirements give the device exceptional switching characteristics. Solitron Devices, Inc., Box 1416, 8808 Balboa Ave., San Diego, Calif. 92123.

Circle Reader Service #267

SEMICONDUCTOR MEMORY FAMILY

The RAM 300 series includes 11 memory system configurations ranging from 2048 to 9216 bits. The new memories have 300 ns access times and 400 ns cycle times and inputs and outputs interface directly with TTL/DTL. They operate from ± 5 V power supplies and are controlled by a single clock. Minimum input 1 voltage is 2.0 V and max. 0 voltage is 0.8 V. Typical power consumption is as low as 627 μW/bit. Semiconductor Electronic Memories, Inc., 3883 N. 28th Ave., Phoenix, Ariz. 85017.

Circle Reader Service #268

OPTIMIZED 741s

These seven models of the popular 741 op amp provide high performance and low drift (Model 1319); wideband, high input impedance (1321); high slew rate (1322); micropower general purpose (1323); general purpose economy (1339); low bias current (1413); and general purpose FET input (1420). While the optimized 741s are pin-for-pin replacements for the current 741 types, their improved parameters are a result of a series of completely new designs. Teledyne Philbrick, Allied Dr. at Rte 128, Dedham, Mass. 02026.

Circle Reader Service #269

IC TRANSISTOR ARRAYS

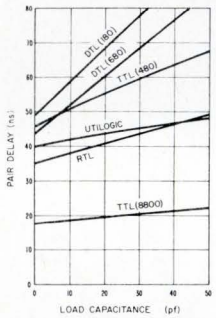
The CA3081 and CA3082 consists of seven high-current (to 100 mA) silicon npn transistors in common-emitter and common-collector configurations respectively. The CA3081 is capable of directly driving seven-segment incandescent displays; the CA3082 is particularly suited to driving light-emitting diode displays. The CA3083 is an array of five independent high current (to 100 mA) silicon npn transistors. Two of the transistors are matched at low currents (i.e., 1 mA) for applications requiring offset parameter controls. RCA Commercial Engineering, Harrison, N.J. 07029.

Circle Reader Service #270

LITERATURE

Applications handbook

Originally published in 1969, this fat paperback (some 400 pages) has been reissued, and still proves to be a most useful guide for the user of integrated circuits. There are 56 applications memos divided into eight groups: an introduction to digital logic; digital family



Switching speed vs load capacitance

considerations; decoding and steering; counters, registers and memories; interface and display elements; linear considerations; timing circuits; and parallel data handling. Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086.

Circle Reader Service #378

Power supplies

Power supplies and related power control equipment are covered in a 40-page catalog. The handbook provides technical information, specs, and model designations for modular supplies, Mil spec units, inverters, frequency changers, regulators, electronic protectors, and high voltage and high current generators. A section devoted to IC logic power supplies is also included. ERA Transpac Corp., 67 Sand Park Rd., Cedar Grove, N.J.

Circle Reader Service #379

Instrumentation training

The Instrument Society of America is offering a brochure titled "Instrumentation Training and Educational Aids." Films, texts, reference material, and a cassette study program available from the ISA are described. It is suggested as an aid for newcomers to the instrumentation field. ISA, Publication Dept., 400 Stanwix St., Pittsburgh, Pa. 15222.

Circle Reader Service #380

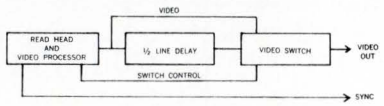
Resistors

Contributions to the resistor industry by this company include miniature ovals, grids, metal case, pressure connected resistors, and vitreous enamel resistors having a low temperature coefficient. This 12-page brochure details each of these models, supplying photos, applications, dimensional drawings, and spec charts. Milwaukee Resistor Corp., 700 West Virginia St., Milwaukee, Wis. 53204.

Circle Reader Service #381

TV video delay module

Typical applications are discussed in this booklet in addition to the descriptive information and the specs that you receive. It discusses stop motion (slow or stop motion playback by incorporating a video delay of one-half scan line), vertical enhancement (sharpening gray-scale transitions by storing



two successive video lines), and drop-out compensation (filling voids with video by storing previous lines and substituting these for defective frames). Corning Glass Works, Memory Products Dept., 3900 Electronics Dr., Raleigh, N.C. 27602.

Circle Reader Service #382

Solutions to automation problems

"Automation by Event Control" is the title of a very readable 20-pager offering practical solutions to automation problems plus a description of digital and analog techniques. Written by engineers, the informative booklet covers industrial applications of digital arithmetic, describes equivalent analog circuits, and compares equipment used in both. Also discussed are stretch measurement, set-point switching, the human interface with instrumentation, and the use of digital programmers as a computer interface. Airpax Electronics, Box 8488, Fort Lauderdale, Fla. 33310.

Circle Reader Service #383

Reed relays

Fourteen pin DIL reed relays which are mechanically compatible with ICs are discussed in a new catalog. Also covered are models operable directly from standard DTL and TTL logic levels suitable for automatic insertion, their low profile permitting 0.3-in. PC board stacking. Operating specs, terminal designations, mechanical specs, and schematics are included. Allied Control Co., 100 Relay Rd., Plantsville, Conn. 06479.

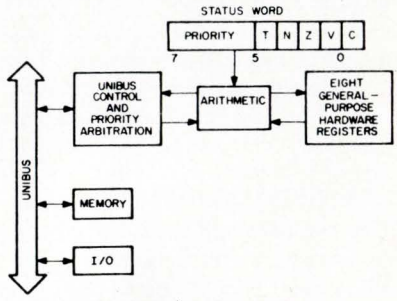
Circle Reader Service #384

COS/MOS ICs

The basic principles of the design and application of COS/MOS ICs are contained in a 160-page book. Device construction and theory of operation for monolithic ICs containing p-channel and n-channel MOS transistors on a single chip are also covered. Ratings, parameters, and design considerations for various devices are provided. Available for $2.50 from RCA Commercial Engineering, Harrison, N.J. 07029.

Digital products and applications

We have come to expect excellent literature from Digital Equipment Corp. (witness classics such as their Logic Handbook or the PDP-8 instruction manuals) and this catalog is no exception. It is the first time we have seen a catalog describing all of DEC's prod-



Central processor block diagram

ucts. And there's a brief, yet very interesting, introduction outlining areas of application for their computers, control products, and peripheral equipment. Digital Equipment Corp., 146 Main St., Maynard, Mass. 01754.

Circle Reader Service #385

Packaging applications

The total systems package, including proper selection and specification of termination procedures and connectors, is the subject of this 20-page collection of literature. A new design approach, the self-stripping "U" contact, is part of one solution suggested. Precise positioning of contacts and accurate alignment of flat cable are some of the results you'll get using these techniques. 3M Co., Electro-Products Div., 3M Center, Saint Paul, Minn. 55101.

Circle Reader Service #386

Graphic digitizer

A graphic coordinate digitizer, which quickly and easily converts graphic data into a digital format, is discussed in a short form brochure that includes applications, operating specs, and available software. The digital data can be stored in a variety of forms, as magnetic tape, punched paper tape, punched cards, and selectric typewriters. It can also be interfaced directly on line to a computer. Edwin Industries Corp., 11961 Tech Rd., Silver Spring, Md. 20904.

Circle Reader Service #387

Expanded data entry

Inforex's Intelligent Key Entry System is the subject of a 6-page bulletin. Features of the system, including expanded tape processing, communications, printer, and multi-system supervisor, enable it to meet the need for more powerful data handling requirements. A summary of Inforex's total data entry concept, operator efficiency, productivity, data integrity, flexibility, and growth potential, is included. Inforex, 21 North Ave., Burlington, Mass. 01803.

Circle Reader Service #388

There are modems—and modems

The performance of the Paradyne modem as compared with that of conventional types in systems using the IBM binary synchronous communication technique is the subject of a 6-page booklet. Effective throughput, line cost comparisons, front-end port comparisons along with operating characteristics are provided and are depicted graphically and in tables. Paradyne Corp., 2040 Calumet St., Clearwater, Fla. 33518.

Circle Reader Service #389

Magnetic visual controls

Magnetic and electronic boards for virtually any application are the subject of a 28-pager. Various sizes of the boards, along with accessories are discussed for such uses as computer scheduling, PERT planning, organization charts, sales incentive, stock market boards, and controls for production. Methods Research Corp., 105 Willow Ave., Staten Island, N.Y. 10305.

Circle Reader Service #390

Custom metal parts

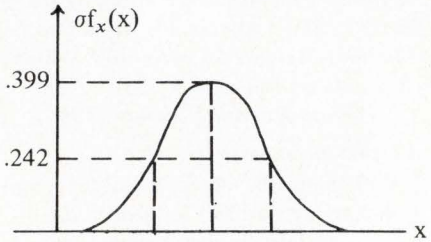
Capabilities in metal etching and die stamping are outlined for you in this 6-page booklet. Intricate metal parts, such as IC leads and small motor laminations, can be produced in the development stage by photochemical machining. And later, many of your designs can be produced on high volume etching equipment or on precision stamping presses. Buckbee Mears Co., 245 E. 6th St., St. Paul, Minn. 55101.

Circle Reader Service #391

LITERATURE

Probability analysis

Correlation and probability analysis is the subject of a very readable 20-page bulletin—TB14. Random variables, distributions, and densities involved in probability analysis, and concepts and properties of correlation functions and



Gaussian random variable

signal enhancement are all covered in the comprehensive article. Examples of functions are provided, as are pertinent equations and block diagrams. Signal Analysis Industries Corp., 595 Old Willets Path, Happauge, N.Y. 11787.

Circle Reader Service #392

Capacitors catalog

Two separate catalogs cover two separate product lines of capacitors. General Instrument's capacitor line is covered in a 32-page brochure including dipped silver mica types as well as aluminum electrolytic and polyester film capacitors. The Southern Electronics line features a range of Mil-approved ceramic types. Both catalogs include physical and mechanical specs, performance characteristics, and standard ratings. Both are available from Miconics Industries Inc.. Dept. C, 135 Eileen Way, Syosset, N.Y. 11791.

Circle Reader Service #393

Digital applications of ferrites

"Ferrite Components for Digital Circuits" discusses new developments in ferrite technology for digital systems applications. More specifically, the 12-pager serves as an idea source on how advancements in ferrite component development can be applied to the design of computer related products and digital circuit equipment. Application areas for ferrites which are covered include pulse transformers, recording and playback heads, keyboards, ROMs, modems and display. Indiana General, Electronic Products, Keasbey, N.J. 08832.

Circle Reader Service #394

Filters and synthesizers

A short form catalog describes a line of signal generation equipment and process instruments. Specs are provided for the company's precision variable analog filters, programmable digital filters, and frequency and speech synthesizers. Rockland Systems Corp., 131 Erie St., E., Blauvelt, N.Y. 10913.

Circle Reader Service #395

Voltage regulator

Applications for a dual polarity tracking voltage regulator are detailed in this 6-page note. Important discussions include the circuit, instructions for making external connections and adjustments, directions for use with external power transistors, and techniques for obtaining fold-back current limiting. Silicon General Inc., 7382 Bolsa Ave., Westminister, Calif. 92683.

Circle Reader Service #396

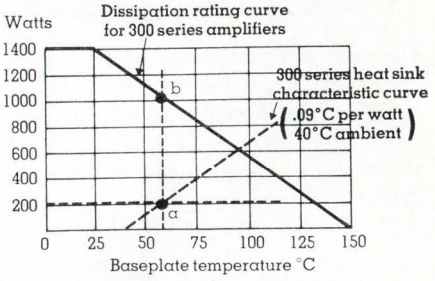
Keyboard price list

An illustrated keyboard price list has been prepared to aid designers of terminals, calculators, and other key entry devices. Over 22 keyboard configurations are listed in the price guide. Also included in the literature package is a Mercutronic keyboard brochure and a data sheet on the company's molded plastic keytops. Mechanical Enterprises Inc., 5249 Duke St., Alexandria, Va., 22304.

Circle Reader Service #397

High power op amps

Class B high power op amps, designed and packaged for driving dc servo motors, power inverters, hydraulic valve controls, and other rugged applications, are the subject of a short form



selection guide. Information needed for mounting, wiring, heat sinking, and selection are included. Torque Systems Inc., P.O. Box 167, 225 Crescent St., Waltham, Mass. 02154.

Circle Reader Service #398

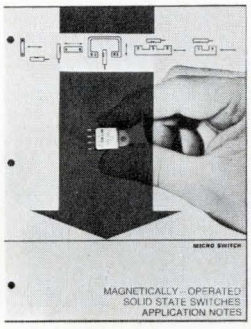
Programming devices

A 12-page quick reference catalog describes five lines of programming devices. Providing low cost, reliable programming and direct control of processes without intermediate circuitry, the devices are electro-mechanical in design. Descriptions are provided for programming switches, badge readers, static punched card readers, circuit selectors, and programming boards. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543.

Circle Reader Service #399

Switch applications

Hall effect solid-state switching application procedures and possibilities are reviewed in a 20-page document. Also featured are photos, schematics, graphs, diagrams, tables, and charts which review the ratings and characteristics of this series of Hall effect switches. The series features a combination of a Hall sensor with a trigger and amplifier in a single silicon IC. Micro Switch, 11 W. Spring St., Freeport, Ill. 61032.



Circle Reader Service #400

Interconnection system

Bulletin 111A describes a new interconnection system which is comprised of crimp-to-wire disconnects, wire-wrapping posts, and multiple contact housings for 0.100, 0.125, and 0.150 in. spacings. The disconnects described include a dual-metal PV receptacle, a mini-PV receptacle, and a continuous length of wire with insulated PV disconnects crimped at uniform intervals for jumper applications. Also discussed is a 0.025 in. square pin and ferrule assembly designed for high speed, close-tolerance stacking into 1/16 in. thick PC boards. Berg Electronics Inc., New Cumberland, Pa. 17070.

Circle Reader Service #401

Rectifiers, thyristors and triacs

An updated reference guide provides information on components for power control and rectification. Data is provided for thyristors, triacs, rectifiers and high voltage stacks with ratings to meet requirements from straightforward rectification to complex motor speed control. Schematics are included in the guide. Mullard Inc., 100 Finn Court, Farmingdale, N.Y. 11735.

Circle Reader Service #402

ECAP manual

Using ECAP (electronic circuit analysis program) through time sharing on the Tymshare system is explained to you in this 38-page manual. It begins with a sample program, gives a complete description of commands and editing features in the languages used, discusses input/output requests, and more. $2.00 Tymshare, 525 University Ave., Suite 220, Palo Alto, Calif. 94301.

LITERATURE

Circular connectors

All interconnection products in Amphenol's standard circular line are described in this 56-page catalog. A new glossary familiarizes you with terms, and a selection guide helps you to choose the right connector for your application. Photos, line drawings, electrical characteristics, and mechanical specs are provided as well. Amphenol Connector Div., 2801 S. 25th St., Broadview, Ill. 60153.

Circle Reader Service #403

Digital controls

"Digital Controls for Industry" describes a series of digital modules and instruments for measuring, displaying, and controlling measured parameters. Suggested as an aid to engineers in process control and instrumentation, automotive safety, and/or test cell monitoring, the handbook offers techniques to ease linearization in providing output signals proportional to input parameters. CGS/Datametrics, 127 Coolidge Hill Rd., Watertown, Mass. 02172.

Circle Reader Service #404

Programming applications

Here is a thorough discussion of programming techniques and circuits for electronic controls, instruments, and systems. Within its 16 pages you're given info on the five fundamental kinds of programming, the six basic types of programming hardware, and seven design constraints often imposed at the man/machine interface. In addition, each of 12 classes of programming for electronic applications is discussed. Interswitch, 770 Airport Blvd., Burlingame, Calif. 94010.

Circle Reader Service #405

Core memory systems

Core memory systems, especially suggested for computer applications that require high speed access to stored digital data, are discussed in technical specification SP51314-171. The 18-pager includes design features, specs, and options for the field expandable, highly reliable systems. Datacraft, Box 23550, Ft. Lauderdale, Fla. 33307.

Circle Reader Service #406

For quick information use the reader service card inside the back cover.

Technical films

Free! NASA has revised its list of "Selected Professional and Technical Films" and offers both the list and the loan of the prints to you at no charge. There are films on analog computers, thick film microelectronics, optical communication devices, and MOSFETs, to name a few. Your copy of the list and where to send for these films is available from NASA Headquarters, Code FAM, Washington, D.C. 20546.

Circle Reader Service #407

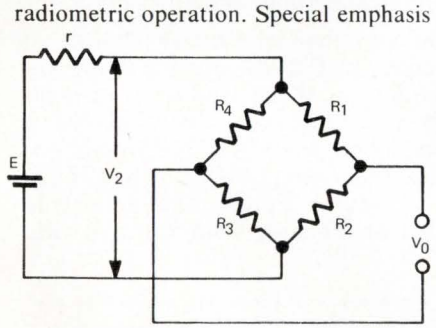
Multiplexer/digitizer

An analog signal multiplexing and converting unit is the subject of this 26-page brochure. Functional operations, hardware configurations, and digital control interface are among the topics discussed, and are fully supplemented with diagrams, tables, and charts. The unit offers relative accuracy up to 0.025% of full scale, with resolution of 8 to 13 bits, and throughput up to 133,000 samples per second. Xerox Data Systems, Systems Products Dept. M1-67, 701 S. Aviation Blvd., El Segundo, Calif. 90245.

Circle Reader Service #408

Radiometric operation

Application data on radiometric operation of Analogic's AN2500 series digital panel meters is covered in a new application note. An introduction to general radiometry leads off the note followed by the theory and practice of radiometric operation. Special emphasis



Strain gage bridge application of ratiometer

is placed on the company's model AN2510, a 3½ digit unit designed for normal or radiometric operation with 0.05% accuracy and low power dissipation over the −10°C to +60°C range. Schematics are included in the note. Analogic Corp., Audubon Rd., Wakefield, Mass. 01880.

Circle Reader Service #409

NOW...

the only one of its kind available!

A Course in MOS INTEGRATED CIRCUITS

The editors of *The Electronic Engineer* have just compiled a complete 9 part course on MOS technology, applications and costs which appeared originally in *The Electronic Engineer.* It is a definitive volume that provides you with all the background you need as a user or a designer to master this new technology.

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Physical definitions of optoelectronic terms . . .
Materials—for both sources and detectors . . .
Sources — Light-emitting diodes — Materials, efficiency . . .
Detectors—Photoconductors (or photoresistors) photodiodes—Materials, efficiency . . .
Amplifiers—Phototransistors, photoFETS—Materials, efficiency, sensitivity . . .

The Course also includes many simplified, practical applications for optoelectronic components such as light choppers, modulators, signal isolators, card and paper-tape readers, counters, sorters and detectors.

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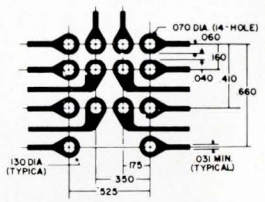
LITERATURE

1971 relays

Electromechanical, dry reed and mercury-wetted relays, solid-state time delays, and hybrid relays are all included in this comprehensive 212-page catalog. There's both an alphabetical and a type index (general purpose, impulse, crystal can, power, etc.) to help you find just



Suggested PC layout

the information you're looking for. And there's all kinds of supplementary information—comparison charts, wiring diagrams, mounting information, dimensional drawings, circuit diagrams, schematics and much, much more. Potter & Brumfield, Princeton, Ind. 47570.

Circle Reader Service #372

MOS polycell LSI

The MH and ML series logic cell families are fully described in this 167-page catalog. But as well as providing hundreds of schematics and diagrams to give you complete circuit information, the catalog establishes a background and basis for the MOS polycell LSI technology. Among the topics covered are chip design preparation, MOS technology, logic symbol standards, packaging, and typical design procedure. For your copy, write on company letterhead to Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036.

Modular and lab power supplies

Deltron's new company catalog contains engineering and application information on its line of highly regulated modular and laboratory power supplies. Included are specs, schematics, connection data, and accessory information for each series. A chart is also provided to facilitate selection of models, ranging from small dual output card types for op amps to large modular and system units. Deltron Inc., Wissahickon Ave., N. Wales, Pa. 19454.

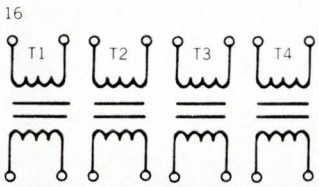
Circle Reader Service #373

Application engineering handbook

Focusing on nickel-cadmium batteries, this 200-page handbook will show you how to apply sealed and vented batteries to new product opportunities. It investigates design configurations, applications, and capabilities, and it details the many forms of nickel-cadmium batteries through the use of charts, diagrams, and definitive text. For use as both a reference guide and a handbook, copies of this book are available for $2.50 from General Electric Co., Box 114, Gainesville, Fla. 32601.

Inductive components

This 18-page catalog of inductive components contains information on pulse transformers in dual-in-line packages compatible with ICs. Typical electrical configurations, dimensions, and terminal configurations are provided for



these products. For encapsulated toroidal inductors you'll find performance graphs. And for all models you'll find photos, features, and specs. Dale Electronics Inc., East Highway 50, Yankton, S.D. 57078.

Circle Reader Service #374

Telecommunication instruments

Sierra's complete line of test instrumentation is described in this interesting and useful catalog. Easy to read and easy to use, its 114 pages are divided into four sections covering equipment for transmission (carrier and multiplexing technologies), N-carrier (intertoll and toll connecting trunk applications between central offices), T-carrier (pulse code modulation), and data transmission (digital machine language transmitted over analog telephone lines). A brief and clear discussion of each technology precedes each section. Sierra Electronic Operation, Philco-Ford, 3885 Bohannon Dr., Menlo Park, Calif. 94025.

Circle Reader Service #375

Stepping switches

A stepping switch and circuit selector catalog, B-2000, provides 32 pages of engineering information on remote switching. Organized for quick reference, the first of three sections covers common methods of remote switching, including applications, fundamentals and terminology. Specs and schematics for multi-pole stepping switch models are contained in the second section, and a building block guide for specifying made-to-order stepping switches and circuit selectors is included in the third. Ledex Inc., 123 Webster St., Dayton, Ohio 45401.

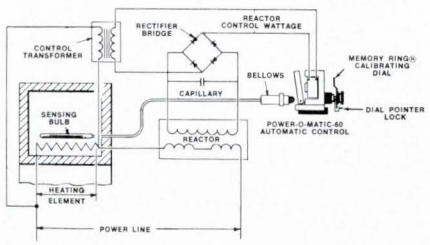
Circle Reader Service #376

Electroluminescence

"Light Emitting Thin Film Displays" is featured in this issue of Naval Research Reviews, a monthly publication highlighting research conducted by Navy labs and contractors. Also in this issue is an article titled "The Possibilities of a Solid State Display Panel with Integrated Storage." For $1.75 you can get a year's subscription to this publication by writing to Superintendent of Documents, U.S. Govt. Printing Office, Washington, D.C. 20402.

Equipment catalog

Included in this huge 216-page book are full descriptions, specs, and prices on ovens, water, oil and refrigerated baths, furnaces, temperature/humidity environmental chambers, and related temperature-controlled equipment. A section of technical bulletins discusses



various subjects related to temperature and temperature control. And still more useful information is incorporated into the temperature, measurement, and relative humidity conversion tables. Blue M Electric Co., 138th & Chatham, Blue Island, Ill. 60406.

Circle Reader Service #377

SAMPLES

Capacitors

Here's a variety of capacitors to choose from—aluminum electrolytic and metallized mylar. Some are "wrapped and filled" axial lead capacitors; some feature radial construction, and others, axial construction with high temperature thermo-set resin. There's a lot to choose from, so send for samples and choose the one best for your application. Illinois Capacitor Sales Co., Dept. EE, Box 352, Highland Park, Ill. 60035.

Circle Reader Service #410

Identification arrows

Pressure sensitive identification arrows for production operations are available in three sizes—¼, ⅜, and ¾ in. Among the various uses for these arrows are production assembly drawings, graphics, flow diagrams, and inventory control, or wherever you need to save time or speed up identification. Samples are offered to you by By-Buk Co., 4326 W. Pico Blvd., Los Angeles, Calif. 90019.

Circle Reader Service #411

Electronic pins

Pins, plugs, connections, contacts, terminals, and leads are custom made by this manufacturer. And if the product you need is not included in the sample pack you receive, you'll still have an idea of the custom work they can do and will do if you send your pin problem to them. Their automatic die swaging, four-slide, and cold heading machines are the key. Auto-swage Products Inc., 726 River Rd., Shelton, Conn. 06484.

Circle Reader Service #412

Solid-state lamp

Wherever a visual status indicator is required you'll want to use this new solid-state lamp—in PC boards, cameras, instruments, control systems, computer peripherals, and communications gear. And the line of lamps features lamps geared to various requirements so you get exactly what you're looking for. For a free sample of this new solid-state lamp, write on company letterhead to Fairchild Microwave & Optoelectronics Div., 3500 Deer Creek Rd., Palo Alto, Calif. 94303.

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Advertisers—July 1971

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SAMPLES

Lead wire

This copper-coated steel electronic lead wire is available in 24, 30 and 40 conductivity. You have a choice of coatings as well—electro lead-tin or bare. Technical data is provided for the wire types included on this sample card. National-Standard Co., 601 N. 8th St., Niles. Mich. 49120.

Circle Reader Service #413

Copper foil tape

Known as Cir-Kit, this material helps simplify your problems with the construction of prototypes or "one-of-a-kind" circuit boards. The pressure-sensitive backing simply peels off and the bond improves with time. It is available in 1/16 and ⅛ in. wide strips, or 6 x 12 in. sheets from Granite Graphics, Greenville, N.H. 03048.

Circle Reader Service #414

Shrinkable tubing

At 160°F you get 50% shrinkdown with this tubing. It can be used for electrical insulation on wires, mechanical protection for pipes and fittings, and as scuff-resistant jacketing for electrical cables and harness. Available in ¼ to 4 in. sizes, it's offered to you by Penntube Plastics Co., Inc., Madison Ave. & Holly St., Clifton Heights, Pa. 19018.

Circle Reader Service #415

Twisted pair

A new 50 Ω twisted pair has been designed especially for solderless wrapping. The conductor is a 30 AWG silver-plated alloy of cadmium, chromium, and copper, and the total diameter of the pair is 0.034 in. Samples of the new twisted pair are offered to you by Berk-Tek Inc., Box 60, R. D. #1, Reading, Pa. 19607.

Circle Reader Service #416

Cable ties

These are one-piece, all-nylon ties available in miniature, intermediate, standard, and heavy cross-section sizes. The ties, which feature self-locking heads, can easily be released and reused even after they have been pulled up snug on a harness. Free samples of this product are available to you from Panduit Corp., 17301 Ridgeland Ave., Tinley Park, Ill. 60477.

Circle Reader Service #417

Charge of the light brigade

Here are the LEDs you can order by the brigade full. HP's indicator lights—unbeatable for brightness and wideangle visibility. Use them on circuit boards—their tough leads will keep them firmly in place. Or mount them on a front panel; they just clip on. In fact, you can put them anywhere you want a small, tough bulb that needs only 2 volts DC to light the way.

Price? 65¢ in 10 K quantities. And they're available in any quantity you want. Call your local HP office for the exact figures and specs on the 5082-4440. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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Circle Reader Service #62

A new CRT for photographic reproduction of computer-generated copy

Introducing RCA-4506... a new, 7-inch diameter, high-resolution Cathode Ray Tube that is especially designed for photographic reproduction of computer-generated graphics. Bright, and sharp-focusing, this attractive CRT is already being used successfully in RCA's own Video Comp computer printing system.

RCA-4506 is a premium design, a natural development of RCA's long experience in display devices. Meeting all the criteria for blemishes, this extraordinary CRT features a .0009-inch maximum spot size for 1 μampere of cathode current measured at 50% of beam amplitude.

Because RCA uses one of the brightest phosphors available; because this phosphor has a persistence of less than 5 μs; and because once adjusted, the beam intensity remains essentially constant, the RCA-4506 also can be applied in flying-spot scanner systems, optical character recognition, geophysical surveys, and side-looking radar for mapping.

Custom variants with specific phosphors and bulb size, of course, are available upon inquiry. Discuss your needs with your local RCA Representative or your RCA Distributor. For technical data, write: RCA, Commercial Engineering,* Harrison, N. J. 07029. International: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

RCA

RCA-4506 High brightness, short persistence, and uniformity make RCA's new CRT useful in many applications. It has a useful screen diameter of 6¼".

* Section 59G/ZC9.