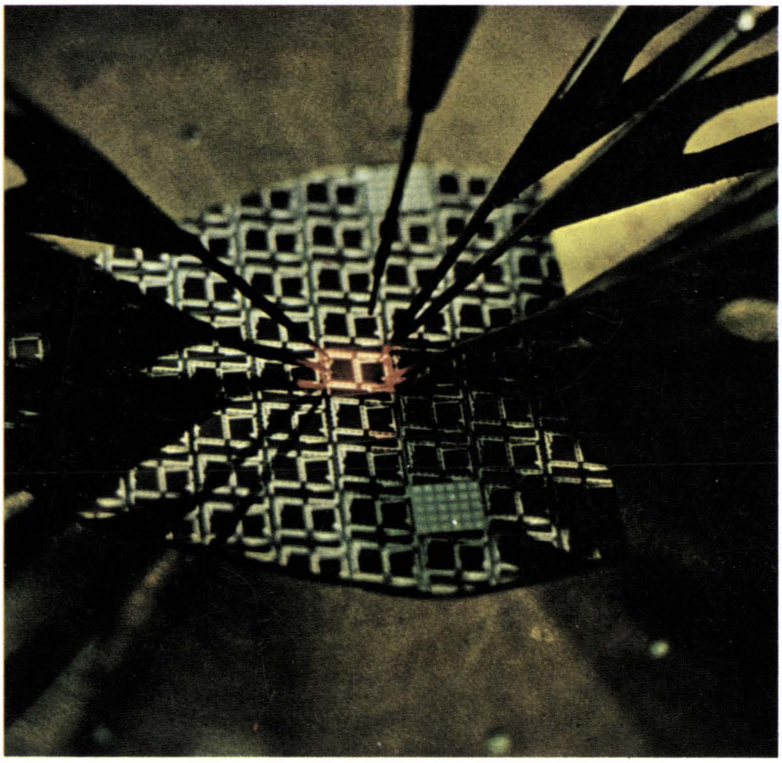
VOL. 29 NO. 7
JULY 1970

CHILTON'S THE ELECTRONIC ENGINEER



An enlightening course on a bright new field—optoelectronics, p. 39

Course on MOS ICs, part 5b

Innovating for the 21st century

IC op amp selection charts

A new course—optoelectronics, part 1

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

What's new in HP Scopes? 18 GHz, dual-channel sampling! New, faster HP diodes now extend sampling capability through 18 GHz. For the first time, you can directly view and measure 18 GHz CW signals (or 20 psec risetime pulses).

But there are more new scope innovations from HP. There's the new, easy-to-use, 250 MHz real-time scope . . . and new, direct read-out TDR with ¼" resolution . . . and new variable persistence and storage scopes for measurements up to 100 MHz . . . and a whole new series of low-cost 500 kHz scopes.

AND, *there are more eye-popping scope ideas just around the corner!*

Next time you see your HP field engineer, ask him what's new in scopes. You'll be surprised by all that's happening to give you better, more economical scope measurements. One thing, we bet you'll get a new (and better) answer, every time you ask!

Are you thinking about a new scope? Are you wondering whether you should continue down the same old road? Or is it time you took a look at another manufacturer? The HP road means going with the demonstrated leader – maker of performance champs.

Call your HP field engineer, right now, if 18 GHz sampling is your interest. Complete 18 GHz sampling system available with delayed sweep, or w/o delayed sweep. If you already have an HP 12.4 GHz sampling system, add the new 18 GHz HP 1430B remote sampler. Write Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

080/6

Circle 2 on Inquiry Card

SOLID TANTALUM CAPACITORS

BOARDABLE & AFFORDABLE

RIGHT ON THE MONEY
FOR PRINTED WIRING BOARDS
IN INDUSTRIAL, COMMERCIAL,
AND ENTERTAINMENT
ELECTRONICS

Sprague Type 196D Dipped Solid-Electrolyte Tantalex® Capacitors cool the performance/budget argument. Newly broadened line—now available in all popular 10% decade values between 0.1 μF and 330 μF. Voltage range: 4 to 50 vdc. Hard insulating resin coating is highly resistant to moisture and mechanical damage. Straight or crimped, long or short leads. Operate to 125 C with only ⅓ voltage derating. Write for Engineering Bulletin 3545A.

Technical Literature Service
Sprague Electric Company
233 Marshall Street
North Adams, Mass. 01247

SPRAGUE®
THE MARK OF RELIABILITY

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

4SM-0139

Whether you want fast-acting or slow blowing fuses, whether you want signal indicating/alarm activating fuses, subminiature fuses or rectifier fuses, you can meet the requirement with a selection from the complete BUSS Quality line.

If you need fuse-holders, BUSS has in-line, panel-mounted and miniature types, as well as RF interference-shielded, lamp indicating, and space saver varieties. The BUSS Quality line also includes all types of fuseblocks and related mounting hardware.

So, save time and trouble by standardizing on the BUSS Quality line. You'll not only find the right fuse and fuseholder everytime, but you'll simplify stock handling and inventory problems too.

For fuses and fuseholders of unquestioned high quality for every protection need

SUPPLIED THE ECONOMICAL WAY . . .
THRU DISTRIBUTORS

BUSS QUALITY
FUSES

Bussmann Mfg. Division, McGraw-Edison Co., St. Louis, Mo. 63107

Circle 6 on Inquiry Card

CHILTON'S THE
ELECTRONIC
ENGINEER

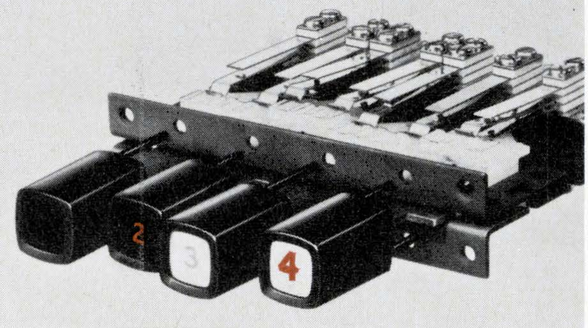
July 1970 Vol. 29 No. 7

Departments

FEATURES

COVER
Optoelectronics is the newest emerging technology, and it is moving at a very rapid pace. So rapidly that right now there are no good text books or other guides for you to learn about this subject. Hence we have designed a course to give you, our readers, a good foundation in this area, see page 39. Solid-state readouts by Monsanto illustrate one form of devices now available.

NOW! "ILLUMINATE" YOUR NON-ILLUMINATED SWITCHES!



ECONOMICALLY...WITHOUT LAMPS, WIRING OR HEAT

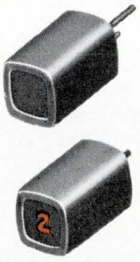
SWITCHCRAFT'S REVOLUTIONARY NEW

GLO-BUTTON*

THE NEW THIRD DIMENSION IN SWITCH BUTTONS

Get this: no lamps, no wiring, no heat, no separate power supply—yet, when you push these ingenious buttons they "glow" brightly giving a clear, visual indication of the circuit's condition! They add a brilliant, problem-solving third choice to the engineer who's looking for the instant visibility of illuminated buttons (especially on crowded control panels) with the multiple economies and simplicity of non-illuminated buttons.

SIMPLE, FOOL-PROOF, POSITIVE OPERATION . . .



Pusher "legs" on back of button are connected to internal fluorescent illuminator which actuates the "glow." When you push the button "in" the internal fluorescent illuminator is put in contact with the front screen and legend glows brightly . . . even in very high or very low ambient light situations. Release, it's out. Won't lose its brilliance. 2 types: white-face button has visible legend whether button is "in" or "out," black-face button has visible legend only when button is "in."

VIRTUALLY UNLIMITED APPLICATIONS . . .

Use the "Glo-Button" Series X on all pushbutton switches with standard .050" x .187" plungers, such as Switchcraft Series 7000, 8000, 35000, 70000 and 71000 "Multi-Switch"® switches, or other switches with maintained plunger action and maximum fallback of 1/16". Ideal for computers, control panels, instrumentation, commercial and industrial equipment, or any place that pushbutton switches must be combined with economical, reliable visual signaling. Write on your letterhead for a sample.

SEND FOR BULLETIN 155, or see your local Switchcraft Authorized Industrial Distributor for immediate delivery at factory prices.

*PATENT APPLIED FOR

SWITCHCRAFT® INC.

5539 North Elston Ave., Chicago, Illinois 60630

CANADA: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto, Ontario

THE ELECTRONIC ENGINEER

Vol. 29 No. 7 July 1970

K. Robert Brink, *Publisher*
Alberto Socolovsky, *Editor*
John E. Hickey, Jr., *Managing Editor*
Smedley B. Ruth, *Associate Editor*
Sheldon Edelman, *Western Editor S.F.*
Stephen A. Thompson, *Western Editor L.A.*
Arthur J. Boyle, *Technical Editor*
John McNichol, *Assistant Editor*
Dr. O. M. Salati, *Consultant*
Anne Axe, *Editorial Assistant*
Alice C. Bach, *Editorial Assistant*
Lynda Rothstein, *Editorial Assistant*
Deborah P. Wilkins, *Editorial Assistant*
Mae Moyer, *Editorial Reader Service*
Andrew Mittelbrunn, *Chilton Art Director*
Phaue Featherson, *Artist*
George Baker, Neil Regeimbal, *Washington News Bureau*

Chilton BPA

Executive and Editorial Offices:
One Decker Square, Bala-Cynwyd, Pa. 19004
Tel. (215) SH 8-2000

Address Mail to: 56th & Chestnut Sts.
Philadelphia, Pa. 19139

Western Offices:
Stephen A. Thompson, 1543 W. Olympic Blvd., Los Angeles, Calif. 90015
Tel. (213) DU 7-1271

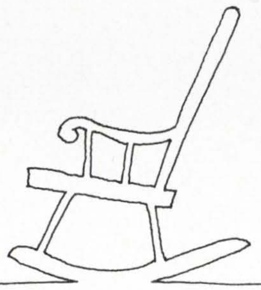
Sheldon Z. Edelman, 199 First St. Rm. 335
Los Altos, Calif. 94022
Tel. (415) 941-6655

Chilton Officers & Directors: Chairman of the Board: G. C. Buzby; President: R. E. McKenna; Financial Vice-President: S. Appleby; Senior Vice-Presidents: J. Kofron, L. King; Publishing Vice-Presidents: C. W. Hevner, W. A. Barbour, R. H. Groves, K. Robert Brink; Treasurer: James Miades; Secretary: J. A. Montgomery, Jr.; Other Directors: T. J. Casper, S. H. Collmann, R. Rimbach, Jr., J. P. Kushnerick, R. O. Nelson; Asst. Secretary: I. C. Holloway.

Monthly publication of Chilton Company, Chestnut & 56th Sts., Phila., Pa. 19139. (Area Code 215) SHerwood 8-2000. Controlled circulation postage paid at Philadelphia, Pa. $1 a copy. Subscription rates U. S. and U. S. Possessions: 1 yr. $12.00; 2 yrs. $20.00. Canada 1 year $14.00; 2 yrs. $25.00. All other countries 1 yr. $20.00; 2 yrs. $35.00. © Chilton Company 1970. Title Reg. U.S. Patent Office. Reproduction or reprinting prohibited except by written authorization. Microfilm reproductions of **The Electronic Engineer** and its predecessors, **Electronic Industries** and **Tele-Tech,** may be obtained from University Microfilms, 313 N. First St., Ann Arbor, Mich.

The Chilton Electronics and Instrumentation Group ●
The Electronic Engineer ■ Instruments and Control Systems ■ Instrument & Apparatus News ■ Medical Electronics News ■ Electronic Component News

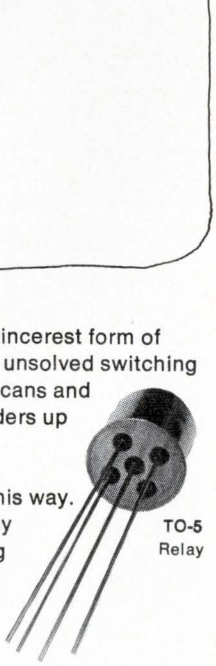
We can't afford to be complacent.



Seven years ago we shook the relay world with the birth of the TO-5 (SPDT) relay. It was quite a breakthrough in the state of the art. Your demands for other configurations in the TO-5 transistor can led to the introduction of magnetic latching and sensitive relays. In 1966, we performed another relay miracle by combining a transistor and a relay in the same TO-5 can. Would wonders never cease? We did it again in 1969 with what we fondly call our "Solid Citizen;" a series of solid state relays for industrial and military applications.

Our competition has increased, we know this, and further we welcome it; after all, isn't imitation the sincerest form of flattery? We know that as long as there are unsolved switching problems we can't afford to sit on our little cans and watch the world go by. We have other wonders up our sleeves and will let the world know when we're ready.

No, sir, no easy chairs for us. We like it this way. We invite you to write or call and ask for any technical assistance regarding our growing family of little switching devices.



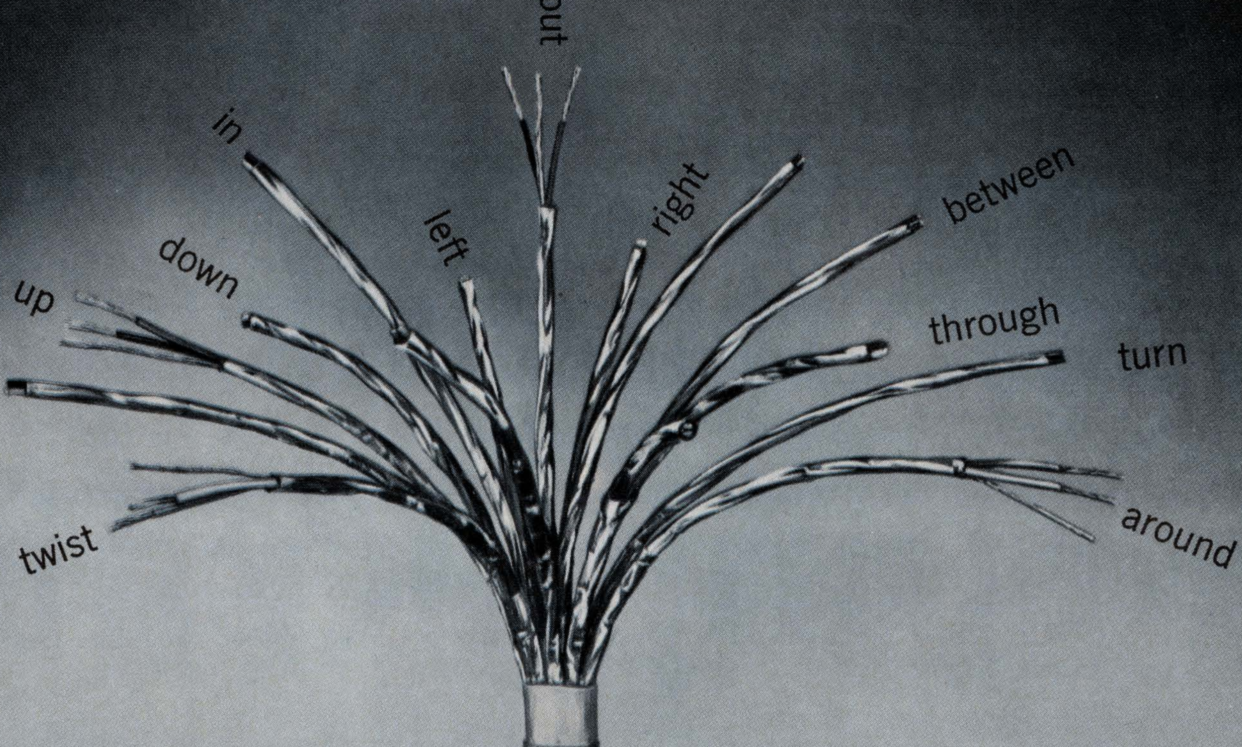
TO-5
Relay

TELEDYNE RELAYS

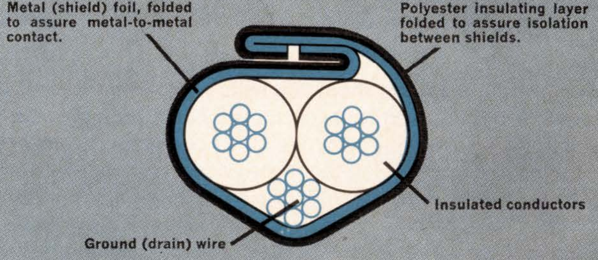
3155 West El Segundo Boulevard, Hawthorne, California 90250 / Telephone (213) 679-2205

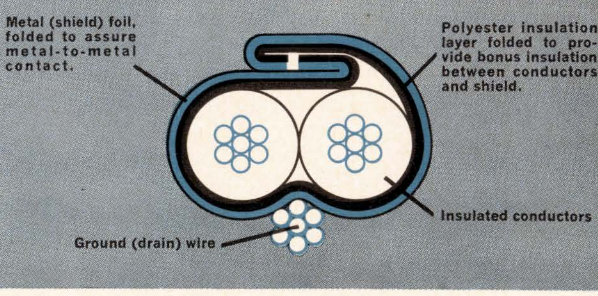
Circle 8 on Inquiry Card

Feel Free To Flex



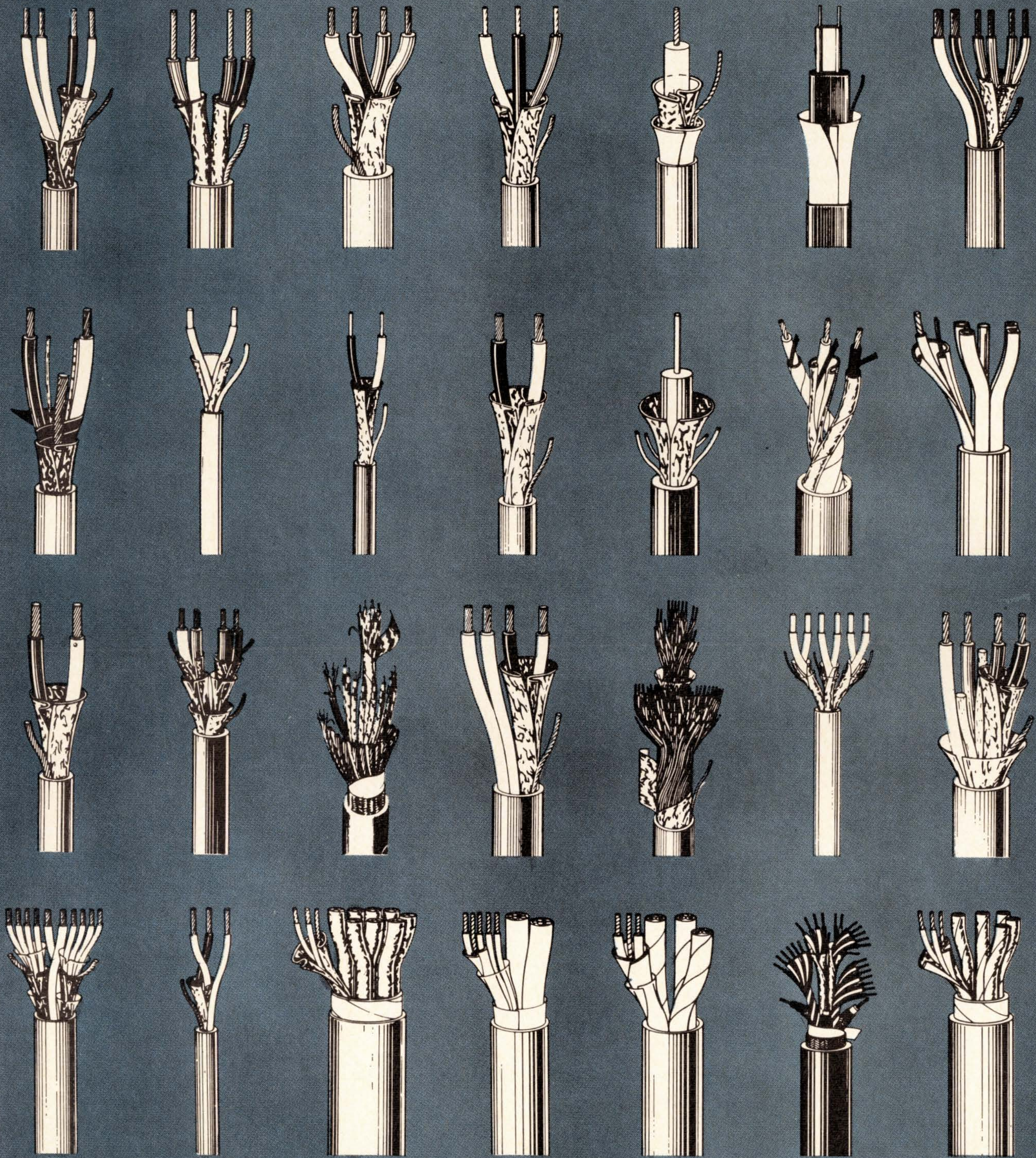
Yes, we know . . . we used to recommend Beldfoil Shielded Cable only for fixed applications. We were too modest. Extended testing proves Beldfoil, even after repeated flexing, provides more physical shield coverage than braided wire or spiral wrapped (served) shields. And greater shield effectiveness. ☐ Beldfoil is a layer of aluminum foil bonded to a tough polyester film (for insulation and added strength). A Belden invention. We apply it in different ways for different applications. We can even form a unique shield that's like a continuous aluminum tube. This we call ISO-Shield™. ☐ When new (or in fixed applications) Beldfoil ISO-Shield is extremely effective in limiting crosstalk or interference . . . whether from outside sources or between shielded elements in the same cable. ☐ Under frequent flexing minor separations may occur in the foil. But special Beldfoil construction features prevent performance from becoming seriously affected. We do, however, recommend that you tell us if cable flexing is to be extreme. We have *special* designs available to meet severe flexing requirements. ☐ Beldfoil makes possible a small, lightweight cable that terminates easily and is modest in price. Your Belden distributor stocks or can quickly obtain just about any size or type you need . . . from single conductor audio and sound cable up to data cable having 27 individually shielded pairs (more pairs available on special order). Ask him for the latest "Belden Electronic Wire and Cable Catalog." Or for technical information, contact Belden Corporation, P. O. Box 5070-A, Chicago, Illinois 60680; phone (312) 378-1000.





Beldfoil® Shielded Cable

-shield effectiveness remains outstanding



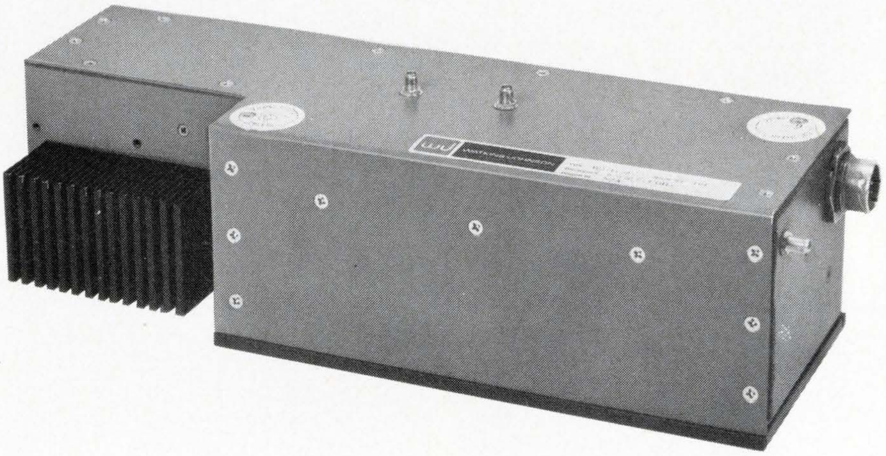
BELDEN

8-5-9A

new ideas for moving electrical energy

Circle 9 on Inquiry Card

2 FOR 1



ONE TWT AMPLIFIER

TWO MODES OF OPERATION

You have a choice with the WJ-1129. From 1 μsec pulsed to CW operation, all in one package.

Performance? This C-band amplifier gives 20 watts power output CW with 37 dB max. noise figure and 38 dB min. saturation gain. And primary input is only 250 watts max.

The compact WJ-1129 measures 4 x 4.625 x 14 inches and weighs 14 lbs. max. It's qualified for operation in the temperature range −55°C to +85°C and will perform from sea level to 15,000 feet.

The clincher: a phase jitter spec of 10 degrees peak.

WATKINS-JOHNSON

3333 HILLVIEW AVE., STANFORD INDUSTRIAL PARK, PALO ALTO, CALIF. 94304 • (415) 326-8830

EDITORIAL

No time for dropouts

"The beauty about them is that they are bio-degradable," said the pitchman, pointing to a kit of household cleaners. "With all this new concern about pollution, you'll make a bundle selling this stuff and be a hero."

The five engineers listened to the pitchman apprehensively. Two of them had already been laid off from a large aerospace company in the area, while the other three felt that the axe was quite near. Judging from their thoughts on electronics in general, and aerospace applications in particular, they would rather sell soap than design circuits or let their children study electronic engineering.

The scene has been repeated in Orange County, Calif.; in Boston, Mass.; in Long Island, N.Y.; in Seattle, Wash.; in Houston, Texas; and in just about every other place in the country where the fortunes of aerospace and defense contracting have hit a low ebb. Admittedly, this is the worst slump we have seen since the cancellation of the Skybolt and Dynasoar programs in 1962 and 1963. Since close to forty percent of all EEs work in aerospace and defense projects, and about one out of every four of those has lost his job recently, the unemployment rate among EEs is about 10 percent—twice as large as the national figure.

And yet, is dropping out of electronic engineering the only outlet available for such talent and knowledge? We think not: we submit that the nation needs the electronic engineers and, further, it can provide work for all of them, and challenging work at that. Such work, however, may not have the status, the salary and the lower efficiency that have become associated with defense jobs. To create the new opportunities for electronic engineers will require a certain amount of belt tightening, and a lot of cost consciousness and fortitude.

The first task is to break the incestuous nature of the electronics business. As long as other electronic firms are the main customers for the products and equipment made by electronic firms, we will always ride high in times of plenty and take a hard fall in leaner times. To be sure, there are electronic products, such as the new telephones and the digital computers, that have developed healthy applications for the consumer, for banks and for airlines.

We need more of these. Take, for example, the problem of automobile repairing. Have you noticed the electronic exhaust analyzers, wheel balancers, wiring trouble-shooters, and dual-trace scopes that have been appearing in auto repair shops? Are you familiar with the names of their manufacturers, such as Allen, Auto-Scan, Marquette, or Sun? Auto mechanics pay from $200 to $3500 for such equipment to reduce the time and improve the quality of repairs. And they will buy more equipment in the future to help them, not just in repairing, but also in diagnosing the faults.

There are many such applications that need your talent. We will keep you informed about them, on ways to get more information, and on ideas to develop.* This is not a time to drop out, but to stand up and fight. And **The Electronic Engineer** magazine will be on your side.

Alberto Socolovsky

Editor

*For ideas, we are listing some of the Byproducts of NASA's technology, on page 101 of this issue, and we will continue to list them in future issues.

Memories are made of this—two diodes

A new semiconductor memory, under development by Bell Labs, may offer the twofold advantages of low cost and low power, with very simple construction. The new memory is a simple arrangement of two diodes, of two types, for each memory cell. Experimental cells and arrays of cells made thus far show a potential memory capacity of 100,000 bits/in.^{2} of IC material. Read speed rates to 50 billionths of a s/bit are expected.

Called "charge transfer diode memory," it is expected to offer low production cost because of the simplicity of construction and high density of memory components on a silicon chip.

The low power requirements for this circuit, about a billionth of a watt/cell to maintain the diode charge, may also make it useful for large computer memory stores as well as the smaller high-speed systems.

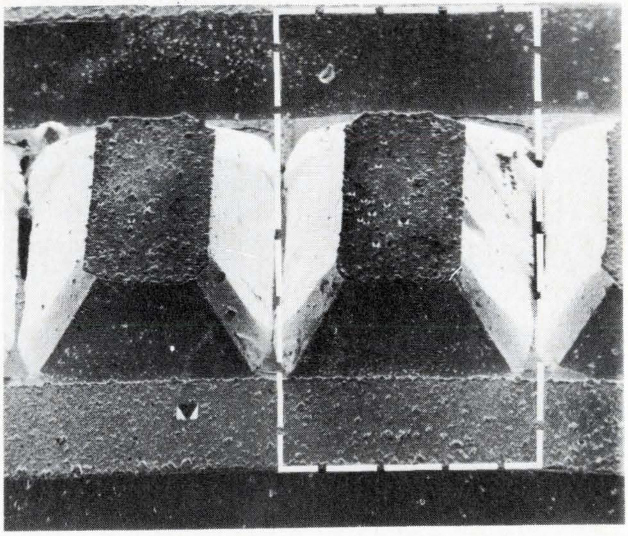
A memory cell consists of a metal semiconductor (Schottky) diode with a large guard ring connected in series with a diffused pn junction diode. Each interconnected cell, occupying an area of 15 sq mils, can be individually accessed in a memory array. Cells are arranged in an x, y structure using a metal beam for "x" and a silicon bar for "y." Experimental arrays have been made using photolithography, silicon etching, and air-isolation methods.

The cell can be used to store information in the form of a large or small charge (1 or 0) placed on the reverse biased Schottky diode. Since the charge dissipates at a known rate, it is replenished every twentieth of a second with 1 x 10^{-9} W/cell (per bit).

The design has been called "charge transfer diode memory" because one of the diodes in the memory is given a charge to represent the stored information 1 or 0. This charge is temporarily transferred to the other diode during the read and write operations. The charge stored in a single memory cell is detected by sensing the amount of forward charge flow through the x, y array leads in response to interrogation pulses. If the diode memory cell is not read every twentieth of a second, the memory is refreshed with simple circuitry.

Silicon technology permits compatible integration of metal semiconductor (Schottky) diodes and diffused pn diodes. The pn junction diode is primarily for entering or removing information from the memory cell, and for cell isolation. The cell provides a large sense signal, nearly 1 V.

Tiny memory cells are a new type of silicon semiconductor memory, called charge transfer diode memory. Each cell holds one "bit" of information. Some of the dust particles in the photo are the size of a wavelength of light.



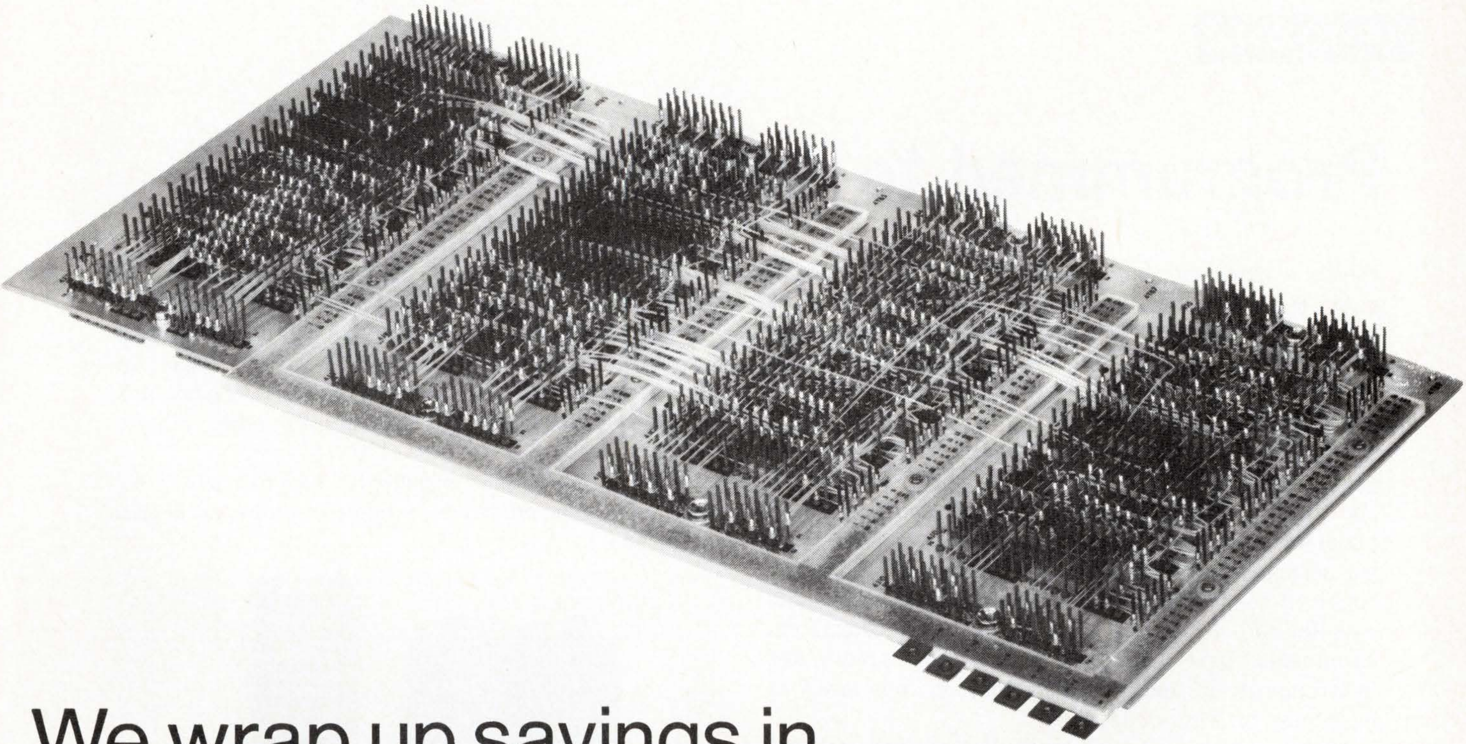
The transformer came unwound

A solid-state, piezoelectric, ceramic "transformer" is the basic element in a new starter-ballast unit for fluorescent and other gas-discharge lamps made by the Piezoelectric Div. of Gould Inc., 232 Forbes Rd., Bedford, Ohio.

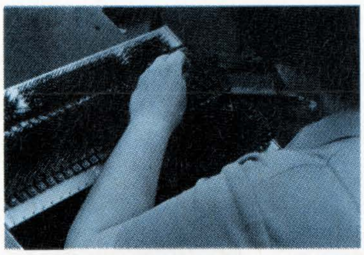
This unit, one of a series of practical transformer models, is made possible by higher-Q ceramics. Other models are adaptable for TV sets, oscilloscopes and equipment requiring a high-voltage supply.

One typical unit consists of a 1½-in. diameter ceramic disc, 0.070 in. thick, with a proprietary ring-and-dot patterned electrode on one surface and full electrode on the opposed surface. The central dot-electrode is the transformer primary and the ring the secondary, with the full electrode on the opposite side being com-

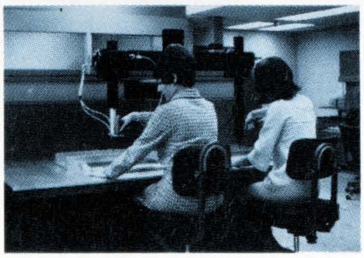
(Continued on page 12)



We wrap up savings in interconnection packages three important ways.



Hand wrapping



Semi-automatic machine wrapping

Fully automatic Gardner Denver machine wrapping

Our "Total Packaging Service" has helped a lot of our customers save a lot of time and money. And it's helped make us the largest manufacturer of metal plate back panel interconnection systems.

It's complete interconnection system packaging from design to wire wrap termination.

We deliver in six weeks.

That's it in a nutshell. Now, here's how it works:

You can call us in on the design stage. We'll sit down with you and help design a p.c. board or frame or metal plate back panel system to do exactly what you want it to do. With our experience we can save you problems. And problems cost money.

Next come the connectors. We have all you're likely to require; several hundred thousands of them. All standard. Maybe they used to be special, but now they're standard. You save again. For square or offset grids. On .100", .125", .150", or .200" centers. Or non-standard configurations if you need them.

And, finally, your wire terminations. (You could send us your back panels and your wire list even this late in the game and we could still save you enough money to make it worth your while.)

You have three choices here: hand wrapping, semi-automatic machine wrapping, or fully automatic Gardner Denver machine wrapping. We handle the computer programming for the automatic and semi-automatic wire wrapping so you get not only accuracy, but minimum wire lengths and densities, too. You save again.

Add it up: three important ways you can save on your back panel interconnection systems. And we haven't even mentioned the remote possibility (perish the thought) of something not being quite right with the final package. Single source responsibility can save you all kinds of time and money.

For the rest of the details, call our Interconnections Manager, Jim Scaminaci, at (213) 675-3311, Ext. 235. Collect. Or write Elco Corporation, Willow Grove Pennsylvania. 19090.
(215) 639-7000.
TWX 510-665-5573

ELCO Interconnection Systems

Circle 11 on Inquiry Card

Programmed to tell time

Pulsar, a new solid-state wristwatch—oops—wrist computer, is programmed to tell time. Developed jointly by Hamilton Watch Co., Lancaster, Pa., and Electro/Data Inc., Garland, Tex., Pulsar has no hands, no moving parts, and gives the time only when queried by pressing a demand button.

When you press the button, a matrix of light-emitting diodes (LEDS) "light-up" to form the numbers for hours and minutes. They remain lit for 1¼ seconds. If you maintain pressure on the button, the hour and minutes will disappear and seconds will appear and continue to count off for as long as you keep the button depressed.

A built-in, light-sensory mechanism that detects environmental light conditions automatically adjusts the light intensity of the dot martix through four levels of brightness for ease of reading.

Accurate to within 3 s/month, Pulsar computes and displays time electronically, using logic circuitry and LEDS.

It contains 44 complementary-symmetry MOS ICS. Equivalent to almost 3500 transistors, they consume much less power than the more conventional bipolar and non-complementary MOS ICS.

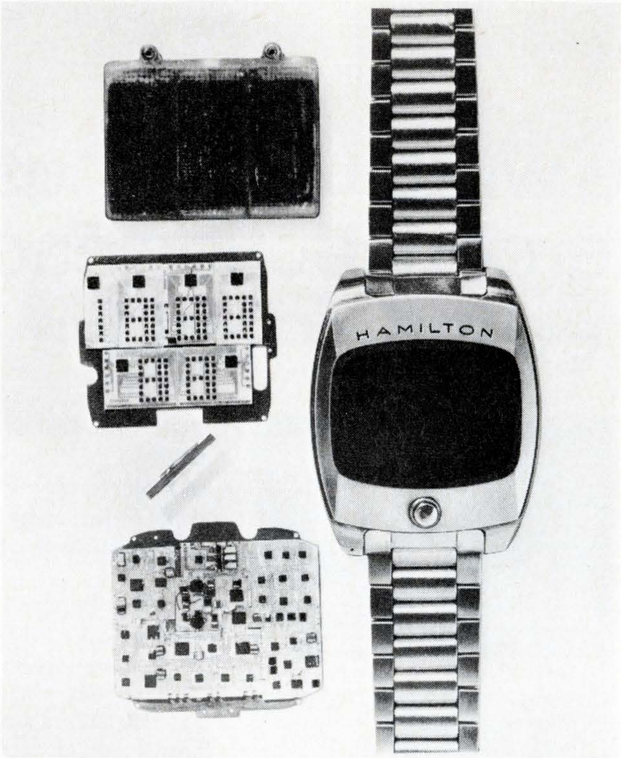
Pulsar needs no maintenance and runs for months on a high-energy rechargeable battery. The battery stimulates a quartz crystal timebase which vibrates at precisely 32,768 Hz. These vibrations are then reduced to one pulse/s by a multi-stage IC binary counter which passes the pulses through a time computer to time display stations. This high rate of vibration, which is four times greater than that found in electro-mechanical quartz crystal watches, is responsible for Pulsar's high accuracy.

Each Pulsar will be sold with an extra rechargeable battery and recharging unit. The timepiece will not stop operating when the battery is replaced because a second energy source permanently located inside the electronic module has enough power to operate it during this brief period.

If you must reset the time, you can do it by depressing one of two clearly marked recesses on the back of the case.

An interesting feature of the fixed program computer is that other programs are possible making other applications conceivable. For example, it could be programmed to count down instead of up for space program applications, or it could be built to display time in 24-hour sequences for military or other requirements.

Pulsar production is expected to begin in 1971. Initially it will be offered in a limited edition at a price of $1,500.



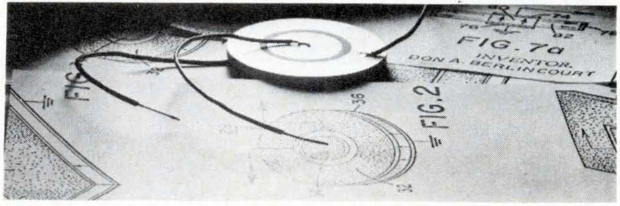
Pulsar's major components are (top to bottom), a 4½-V rechargeable battery, a computer module (display side), a quartz crystal, and the logic side of the computer module. They all fit into a case the size of a normal wristwatch (rt.). The time will appear on the face of the timepiece only when the demand button is pressed.

(*Continued from page* 10)

mon to both.

Driven by a transistor switching oscillator controlled by the transformer at its fundamental resonance, the entire element vibrates at a relatively high amplitude. The resultant strain generates a high voltage. Efficiency is around 90%.

Piezoelectric device functions as high-voltage transformer.



Save money and get tighter specs.

Still using conventional components in your circuit design? Get out your pencil and start your next design with Ferroxcube ferrite pot cores. Now you can produce circuits that deliver better electrical performance at lower cost.

Here's how. Pot cores are completely self-shielding. They are rugged. They deliver high Q, high stability of inductance, plus small size. And they can meet exceptionally tight tolerances with utter reliability. They come pre-adjusted or adjustable. These characteristics can help you make cost-savings throughout all associated circuitry. Ferroxcube pot cores are ideal for automated production, too, including automatic PC board insertion.

Explore the pot core design approach with Ferroxcube.

It's the broadest line in the industry...97 types in 12 sizes and 5 materials. Plus prototype production quantities off-the-shelf from eight Stocking Centers nationwide. No one else makes pot cores so instantly available.

Send for our latest Linear Ferrite Catalog now. Once you've used pot cores you'll know why so many magnetic component designers are going to pot.

Ferroxcube
Saugerties, New York
A NORTH AMERICAN PHILIPS COMPANY

STOCKING CENTERS: Boston—(817) 449-1406; **Burbank, Calif.**—(213) 849-6631; **Chicago**—(312) 833-4020; **Dallas**—Gillett Industries, (214) 363-0107; **New York—Kahgan Sales,** (516) 538-2300; **Philadelphia**—Eastern Components, (215) 927-6262; **San Francisco**—Wm. J. Purdy Corp. (415) 347-7701; **Woodstock, N.Y.**—Elna Ferrite Labs, **(914) 679-2497;** **Toronto, Ont.**—Philips Electron Devices, Ltd., (416) 425-5161.

SALES OFFICES: Baltimore—Eastern Components, (301) 322-1412; **Cedar Rapids, Ia.,**—Thomas & Modricin, (319) 377-6261; **Columbus, Ohio**—Mulligan & Mathias, **(614) 486-2976; Denver**—Wm. J. Purdy Corp., (303) 794-4283; **Huntsville, Ala.**—Cartwright & Bean, (205) 852-7670; **Kansas City**—Thomas & Modricin, (913) 432-2131; **Minneapolis**—(612) 920-1830; **Orlando**—Cartwright & Bean, (305) 425-8284; **Phoenix**—(602) 264-3129; **Rochester, N.Y.**—R. P. Kennedy Co., (716) 271-6322; **Saugerties, N.Y.**—(914) 246-2811; **St. Louis**—Thomas & Modricin, (314) 338-6446.

Circle 12 on Inquiry Card

IT HAPPENED LAST MONTH . . .

The editors of THE ELECTRONIC ENGINEER have sifted through the various technical and significant happenings of the past month and selected the items that would be of the most interest or use to you.

International standards . . . The 1970 General Meeting of the International Electrotechnical Commission (IEC) recently took place in Washington, D.C. It was hosted by IEC's U.S. National Committee which is affiliated with the American National Standards Institute (ANSI). The purpose of the meeting was to draft standards for symbols, definitions and test methods, and dimensional standards for the simplification of international trade. The latter would also serve as a base for national standards. Among the electronic subjects discussed were tubes (including microwave), capacitors, resistors, switches, crystals, magnetic components, printed circuits (including multilayer), signal generators, bridges, meters, oscilloscopes, environmental testing and reliability. Most of the standards drafted still must be approved by IEC's committees and will probably be issued before the end of the year. They will be available through ANSI, 1430 Broadway, New York, N.Y. 10018.

More modularization . . . Consumer electronics will be moving more rapidly toward more modularization, through actual modules and more integrated circuits. This fact was obvious at the Chicago Spring Conference featuring TV and broadcast receivers. RCA, Fairchild, Motorola and Sylvania were all pushing ICs for color TV applications. Sprague sponsored modules made with a thick-film process on a ceramic substrate and designed to plug into low-cost connectors. Any circuit configuration can be made to suit the user's needs.

Telecommunications takeover . . . Louis A. deRosa was appointed to a newly created post, Assistant to the Secretary of Defense (Telecommunications), in a continuing effort to strengthen this country's telecommunications posture. Formerly with Philco-Ford (vice president of engineering and research) and ITT, deRosa will interface with the Defense Communications Agency (DCA) and the military services. DoD Secretary Melvin Laird describes the new post as "a primary action office in developing and reviewing telecommunications' fiscal programs as well as participating in the development of R & D plans for telecommunications."

High-gain integrated pnp's . . . The linear IC research lab of Motorola has developed a new way to integrate pnp transistors with npn's in integrated circuits. The new pnp, which looks like a dual transistor with a common collector, has a β of about 300, ten times higher than that of the "lateral" pnps used today in complementary pairs for ICs. Also, f_T can be as high as 100 MHz. The most attractive feature about these transistors—still proprietary with Motorola—is that they are made with the same technology as conventional ICs. If proven practical for production, these transistors may advance op amp technology as much as the "super β" npn's did when National Semiconductor introduced them last year.

Help the handicapped . . . RCA is presently marketing a radio intended for the visually handicapped: its dials and switches are all marked in Braille. The radio receives am, fm, and the sound emitted from local vhf and uhf TV stations.

Liquid crystals . . . In an experiment using blue and green "liquid crystals," Marconi Company Ltd., of England, developed a two-color display. The crystals were made of liquids whose molecules all point in the same direction (nematic). The liquid, about one one-thousandth of an inch thick, is sandwiched between two pieces of conductive glass. When a voltage is applied to the glass, the normally transparent unit is capable of displaying letters, figures, words and diagrams. Although the images decay in a short time, they appear long enough to be read.

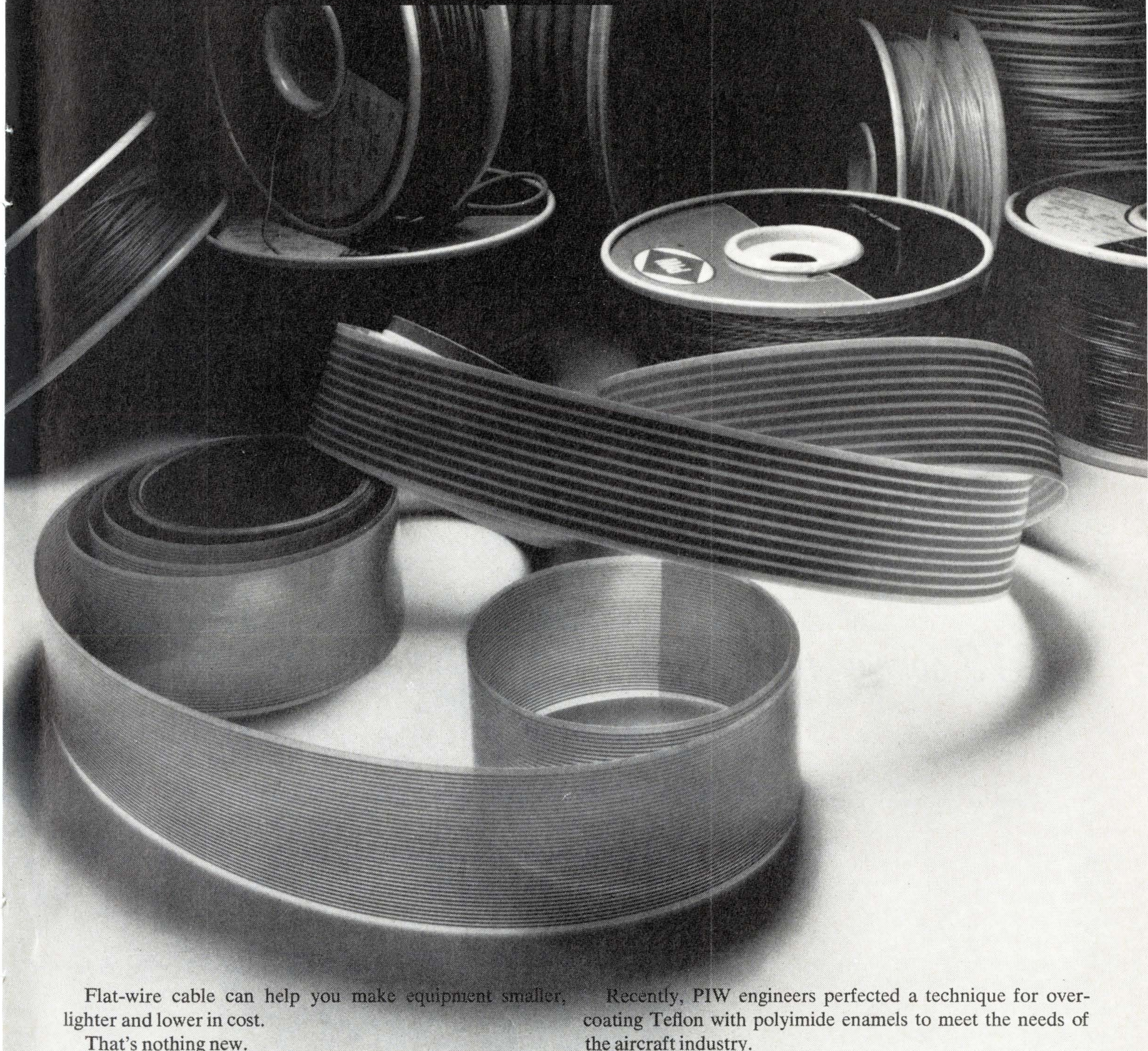
Laser communications . . . A team of Lockheed scientists and engineers simultaneously transmitted all available vhf television channels, a computer display link on a 46-MHz carrier, and an fm music channel on a 450 MHz carrier over an argon laser beam. High-quality pictures were produced on a series of TV sets, demonstrating an extremely wideband laser communication link. The theoretical information capacity, by the Shannon formula, is 4 gigabits/second. This has great promise for relaying messages between satellites in space. Analog signals can be sent in directly measurable form, such as voltage, instead of being relayed as numbers or digits. This is the first concrete evidence that such wide bandwidth signals can be sent over laser beams.

For microwave ovens . . . the U. S. Department of Health, Education and Welfare has already proposed radiation standards. If accepted, the standards will be effective July 1, 1971. The new requirements stipulate that ovens have a maximum radiation of 1 mW/cm^2 at the time of sale, and that they emit no more than 5 mW/cm^2 of radiation throughout their productive life.

Safety bible . . . The IEC has developed standards for safety to be released before the end of this year. Even though these standards deal with all kinds of electric appliances, they do include electronic equipment, microwave ovens, for instance. After publication, safety standards will be available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

Circle 13 on Inquiry Card⟶

We've made our cable line bigger, so you can make things smaller.



Flat-wire cable can help you make equipment smaller, lighter and lower in cost.

That's nothing new.

What's new is that now you can buy it from Sylvania.

What's more, we've also developed an "instant capability" in flexible insulated wire and cable products.

If you are wondering how we achieved this capability overnight, the answer is simple: We integrated Philadelphia Insulated Wire Co. into our Parts Division.

PIW is one of the oldest wire companies in the country. Although they are old, their capabilities are brand new. Their product line includes wires insulated with Kynar,* and Teflon.†

Recently, PIW engineers perfected a technique for overcoating Teflon with polyimide enamels to meet the needs of the aircraft industry.

In development operations, they are working with a brand new material, Tefzel.† This resin combines the excellent electrical properties of Teflon with mechanical properties similar to Kynar.

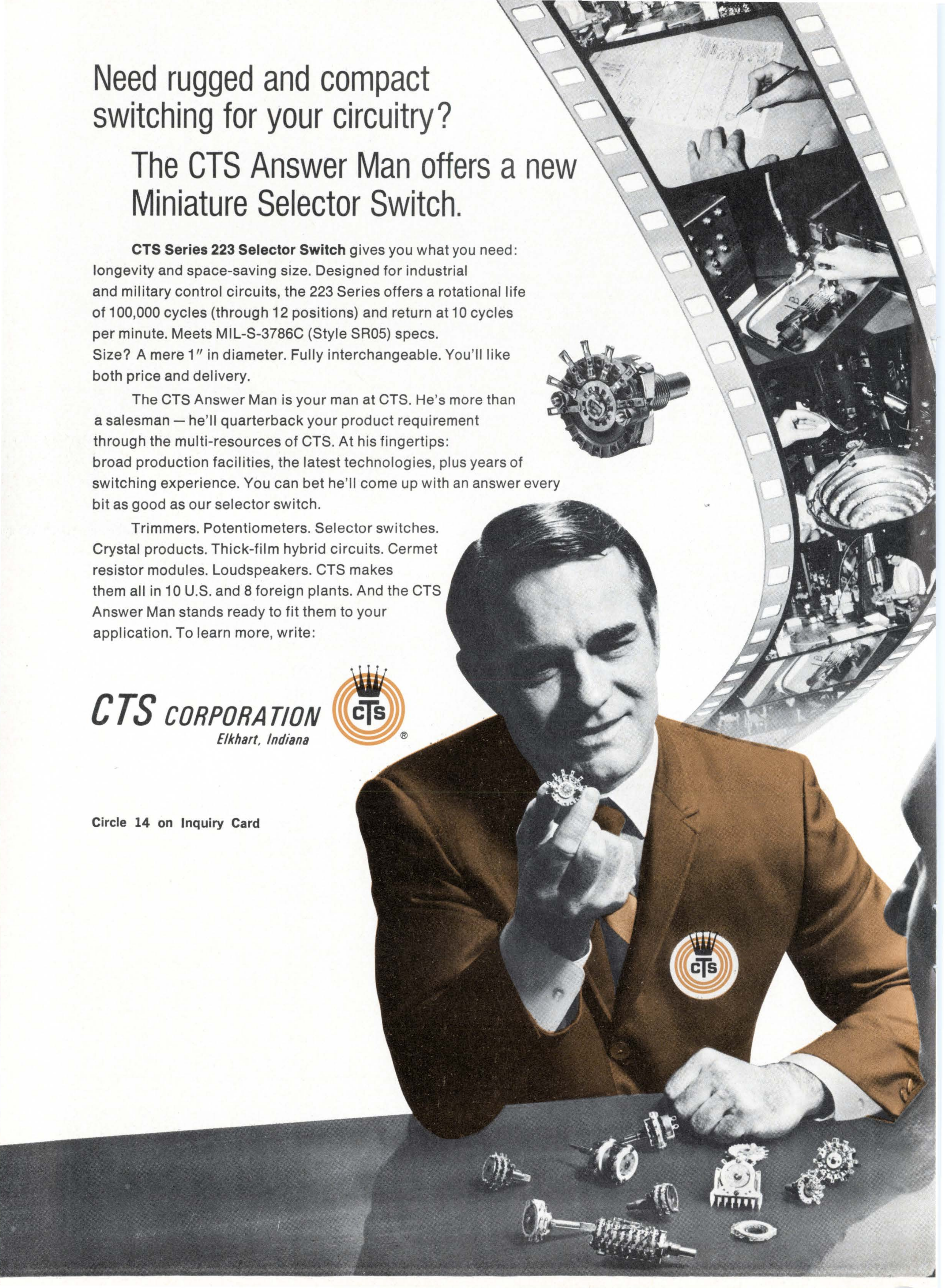
Your Sylvania sales representative now has one of the broadest lines of wire and cable products in the industry. He's the man to talk to when you've got wiring problems.

Sylvania Precision Materials, Parts Division, 12 Second Ave., Warren, Pa. 16365

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

---

*-Trademark of Pennwalt Chemical Company.
†-Trademark of DuPont.



Need rugged and compact switching for your circuitry?

The CTS Answer Man offers a new Miniature Selector Switch.

CTS Series 223 Selector Switch gives you what you need: longevity and space-saving size. Designed for industrial and military control circuits, the 223 Series offers a rotational life of 100,000 cycles (through 12 positions) and return at 10 cycles per minute. Meets MIL-S-3786C (Style SR05) specs. Size? A mere 1″ in diameter. Fully interchangeable. You'll like both price and delivery.

The CTS Answer Man is your man at CTS. He's more than a salesman — he'll quarterback your product requirement through the multi-resources of CTS. At his fingertips: broad production facilities, the latest technologies, plus years of switching experience. You can bet he'll come up with an answer every bit as good as our selector switch.

Trimmers. Potentiometers. Selector switches. Crystal products. Thick-film hybrid circuits. Cermet resistor modules. Loudspeakers. CTS makes them all in 10 U.S. and 8 foreign plants. And the CTS Answer Man stands ready to fit them to your application. To learn more, write:

CTS CORPORATION
Elkhart, Indiana

CTS®

Circle 14 on Inquiry Card

AT THE E. C. C. . .

The Electronic Components Conference took place May 13-15, 1970, at Washington, D. C. For a copy of the Proceedings of this conference send $10.00 to the Order Department of the IEEE, 345 East 47th St., New York, N. Y. 10017.

Magnetic bubbles in garnets . . . Since Andrew Bobeck of Bell Labs first introduced magnetic bubbles at the 1968 International Magnetics Conference, the Labs have continued advancing the technology with Bobeck reporting on those advances. At the Electronic Components Conference (ECC), Bobeck reported on the latest one (which he had already previewed at the 1970 Intermag Conference) about the presence of cylindrical magnetic domains (bubbles) in garnets. Since the materials' technology for garnets is rather well-known, while orthoferrites are very difficult to grow without crystal dislocations, garnets hold the promise for a practical application of bubbles to mass memories. Although bubble mobility is about 100 times slower in garnets than in yttrium orthoferrites, the size of bubbles is smaller in garnets. The net result is that garnets have potential data rates of about 1 MHz, similar to those possible with orthoferrites.

Low-inductance capacitors . . . H. F. Puppolo and M. Markarian of Sprague Electric described a very compact aluminum electrolytic of 120,000 μF, 5 V, which was built as a "book" (by stacking the aluminum foil, instead of winding it) to reduce the equivalent series resistance. Parallel-plate transmission lines serve as terminals. This construction reduces the two-terminal inductance to 0.522 nH, about six times lower than that of an equivalent capacitor built with wound foil, and reduces the equivalent series resistance by a similar factor. The capacitor was designed for the power supply of an IBM computer, to improve filtering of high frequency noise produced by digital switching. P. R. Mallory is also designing a capacitor for the same application.

"Safe handling" . . . J. W. Kanz of McDonnell Douglas Astronautics Co., discussing thick-film hybrid circuit fabrication, warned that severe problems may be present in such relatively "safe" areas as ink drying, substrate handling, and trimming. For example, tests indicated that the position of a substrate on the drying tray in an oven could affect its "resistance." Also, the longer a tray of substrates sat exposed to room air after resistor screening (before being placed in the oven), the higher the substrates' resistance and the resistance gradient along the rows of substrates. Another problem area was the air abrasive trimming system—its nitrogen supply caused extensive contamination. Buildup of static charge on the trimmer's nozzle also caused some headaches.

Praetersonics . . . Meaning "beyond sonics," and called also "microwave ultrasonics," this term refers to the propagation of elastic waves in solids, above the ultrasonic range. Both Max M. Yoder of the Office of Naval Research and Alan B. Smith of the Sperry Rand Research Center reviewed, in separate papers, the progress that has taken place in this technology. Most of the research work concentrated on developing delay lines, because the slow speed at which elastic waves propagate in solids yields practical delays with lines of small size. The latest developments have been in delay lines based on *surface waves* (such as Rayleigh or Love waves), which introduce less attenuation than elastic waves propagating through the body of the material. (In April, the Electronics Div. of Damon Corp. introduced commercial surface-wave delay lines made with lithium niobate and quartz. Damon's delay lines operate from 30 to 300 MHz, and provide delays from 0.5 to 10 μs.)

Matched impedance . . . An edgeboard connector that can be used as an impedance matching or a crosstalk control device as well as a conventional connector was described by J. Arruda of Texas Instruments. It consists of two identical sections which form the outer bodies, a spacer inserted between them, and contacts fitted in slots on the outer pieces. The spacer thickness may be changed to accommodate various board thicknesses. To achieve the desired impedance matching and crosstalk characteristics, the simple spacer is removed and a small PC card inserted in its place. An additional ground plane shim is also sometimes inserted. Another attractive feature is that this connector costs less than traditional coaxial connector systems.

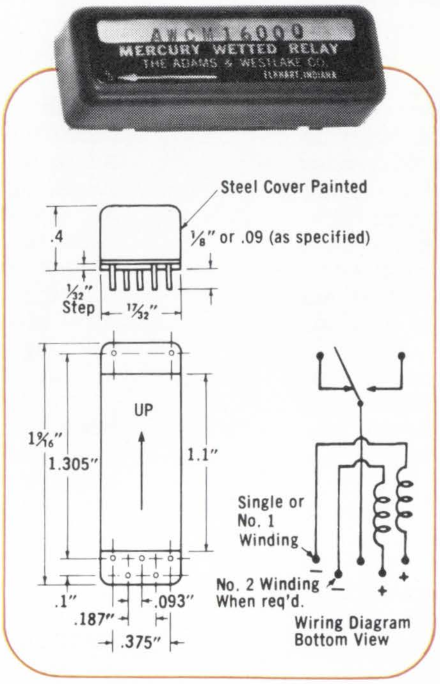
International standards for components . . . Leendert van Rooij, Head of the Standardization Dept. of Philips, explained to the conference the benefits of cooperating with the international standards program sponsored by the International Electrotechnical Commission. He pointed to three areas as the logical targets for standards: the *functional properties* of components, their *reliability,* and their means of *interfacing* with other components or circuits (such as dimensions for mounting and connection). As an example of advanced international standardization, Mr. van Rooij cited printed circuits, for which the distance between hole centers and between contact centers is the same, in the U.S., Europe, and Japan.

SENSITIVE MERCURY WETTED CONTACT **RELAYS**

Ultra-reliable, highest quality Sensitive Relays with mercury wetted contacts are ideal for critical applications, such as digital and analog computers, telecommunication systems, multiplex, industrial control equipment and power control devices. New type MWK (center off—SPST) is ideal for multiple channel switching.

ELECTRICAL (Type AWCM):

Contact Arrangements:
Form C and D
Insulation Resistance:
1000 Megohms minimum
Current Rating:
Up to 2 amps or 500 VDC
Contact Resistance:
50 milliohms maximum
Life:
1 billion operations
Contact Bounce:
NONE
Contact Rise Time:
10 nano seconds or less
Operating Speed:
To 200 operations/second



PACKAGING (Type AWCM):

Environmental Protection: Hermetically sealed contacts, potted metal case
Shielding: Internal shielding available
Shock and Vibration: Withstands all normal handling/transportation effects
Mounting: Printed Circuit

Advanced manufacturing methods and stringent quality control procedures assure highest quality. Many types available directly from stock. Engineering and applications assistance available. Surprisingly short delivery schedules.

MERCURY DISPLACEMENT RELAYS

Time delay and load relays meet the toughest, most demanding switching applications. Non-adjustable time delay relays offer contact forms A and B with delays up to ½ hour, current ratings to 15 amps. Load relays switch from 30 to 100 amps with contact forms A and B.

DRY REED RELAYS

Miniature, intermediate, and standard sizes offer A and B contact forms with from 1 to 4 poles of switching. Typical life is 20 x 10⁶ operations (rated load) or 500 x 10⁶ operations (dry circuit).

USE READER-SERVICE NUMBER FOR COMPLETE INFORMATION

Adlake SINCE 1857 **THE ADAMS & WESTLAKE** *COMPANY*
Elkhart, Indiana 46514 • (219) 264-1141 • TWX (219) 522-3102 • TELEX 25-8458 • Cable ADLAKE
SUBSIDIARY OF **ALLIED** PRODUCTS CORPORATION

Circle 16 on Inquiry Card

THE WESTERN COLUMN

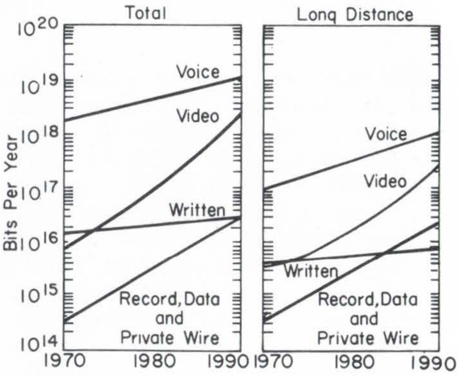
Conversation—the art may be lost, but oh that volume.

Before I met Roger Hough of the Stanford Research Institute, I shared the popular notion that some time in the seventies the volume of data transmitted via the black box called the U. S. Communications Network might increase to half that of voice transmissions. Roger presented a paper, "Information Transfer in 1990," that shattered that view at the AIAA's 3rd Communications Satellite Systems Conference in Los Angeles.

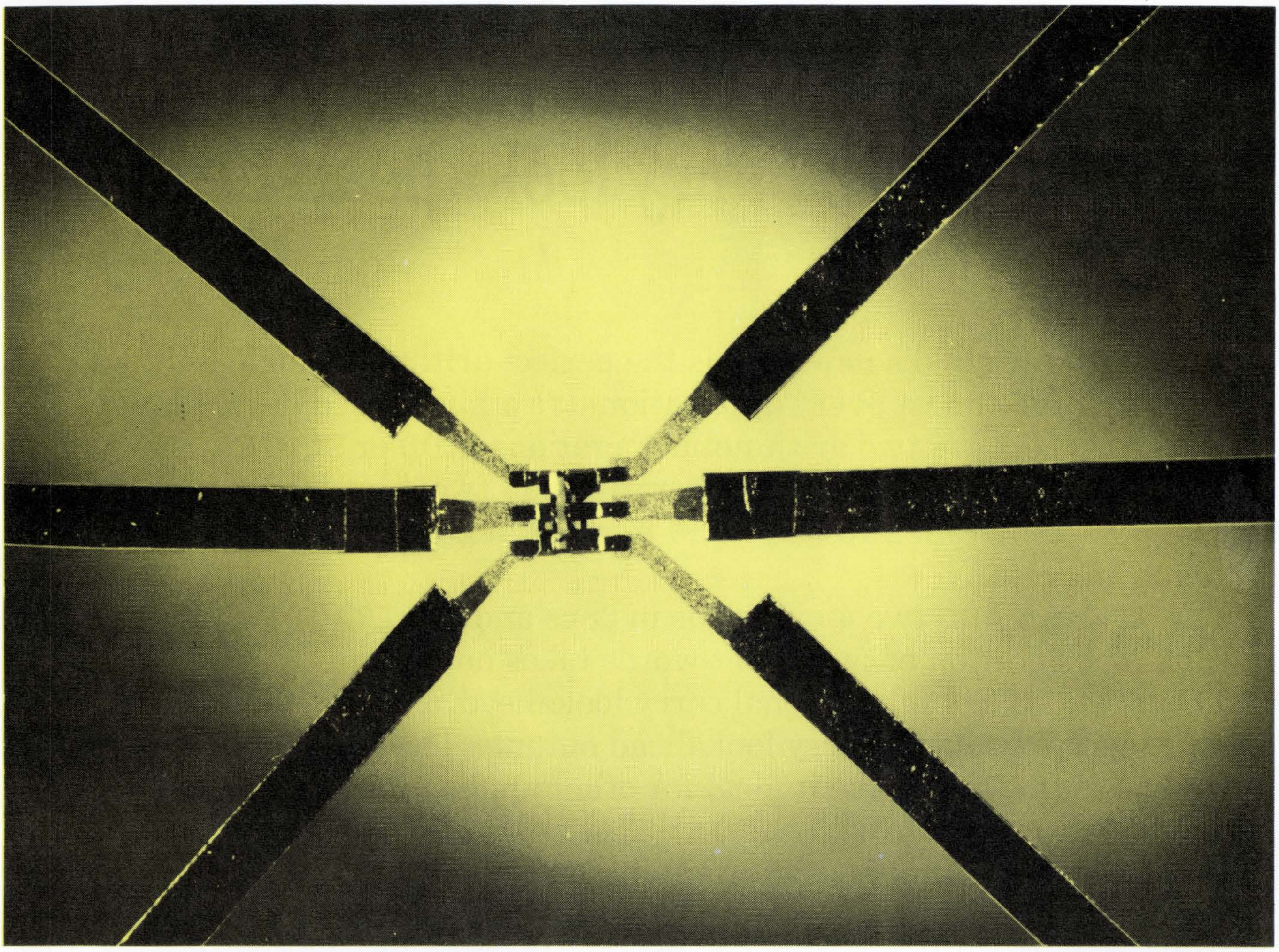
The key is assigning a bit/sec rate to voice transmission so it can be compared to data transmission. The current method of converting analog voice signals to digital form is pulse code modulation (PCM), and the conversion factor is 64,000 bits/sec. Videotelephone takes 6.3 megabits/sec and TV requires 64 megabits/sec.

If the PCM rate is halved, the voice identity of the person on the other end of the line is lost, and so is effective communication. The average call lasts six minutes and there will be 482 x 10^9 calls/yr by 1990, leading to a tremendous total bit count.

The chart below summarizes the projected information transfer volume from 1970 through 1990 for several methods. It predicts inputs into the system, and no allowance is made for simultaneous reception by viewers, listeners, or terminals. Computers talking to each other are buried in the record, data, and private wire category. The video and data categories are rising at much faster rates than voice, but unless a different method of evaluating voice transmission proves satisfactory, voice will be king of the information hill for a long time.



Western Editor



Silicon Hydride sort of grows on you...

That's why more and more semi-conductor producers have made the switch to Matheson Silane

Examine the *growing* ability of Matheson Silane and you'll switch too:

Ability to grow multi-layer devices with less diffusion into the epitaxial layer.

Ability to grow through oxide holes since there is no HCl vapor to deteriorate the oxide.

Ability to grow low temperature glass ($Si0_2$).

Silane advantages also include higher resistivity, 500 ohm-cm (N Type) . . . non-corrosive waste gases . . . lower deposition temperature . . . no back etching . . . reduced auto-doping from substrate . . . ideal for depositing silicon nitride.

How about mixtures? Matheson provides silane in the diluent gas of your choice — H_2 (U.H.P.), He (U.H.P.), N_2 (P.P.) and Ar (U.H.P.). We'll furnish any of these at any concentration from p.p.m. to percentage.

Send for Matheson's "Silane Summary." It contains informative reports, articles, and our new catalog E-2, "Matheson Gases and Systems for the Electronics Industry." Fill out the coupon and mail.

MATHESON GAS PRODUCTS
® A Division of Will Ross, Inc.
East Rutherford, N. J.; Cucamonga, Calif.; Gloucester, Mass.;
Joliet, Ill.; La Porte, Texas; Morrow, Ga.; Newark, Calif.;
Matheson of Canada, Ltd., Whitby, Ont.

For your "Silane Summary" send to Matheson Gas Products, P. O. Box 85, East Rutherford, N.J. 07073
23-70G

Name ....

Firm ....

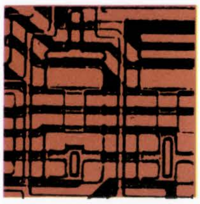
Address ....

City ....

State .... Zip................

Circle 17 on Inquiry Card

To make the lowest-cost arithmetic logic unit with carry lookahead built-in,

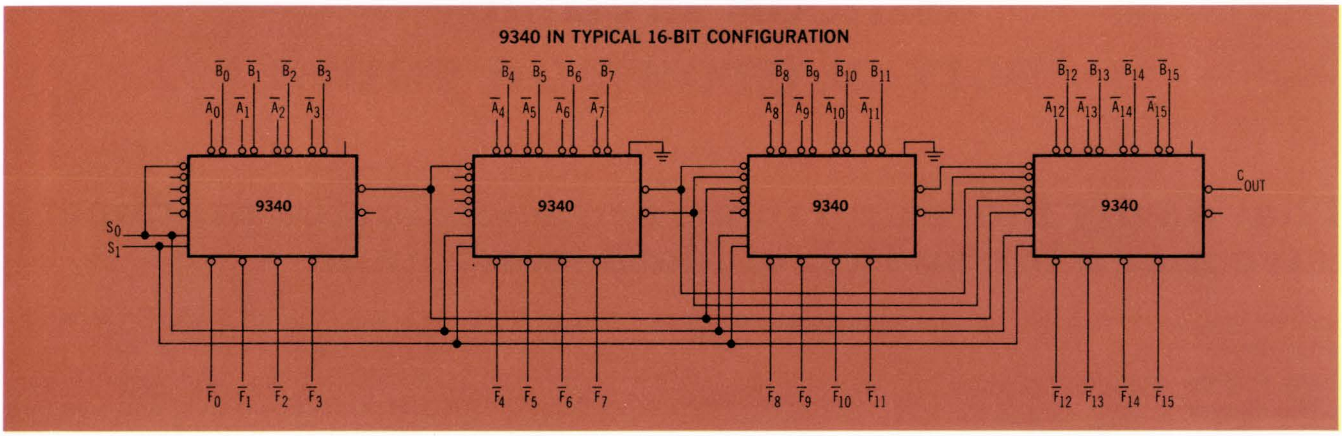


Fairchild's new 9340 is the perfect arithmetic logic unit for almost every application. It's a high-speed device that can perform two arithmetic operations (ADD or SUBTRACT) and any of six logic operations on two 4-bit binary words in parallel. To handle 16 bits, just hook up four 9340s. And nothing else.

The 9340 can ADD two 4-bit words in 28ns and SUBTRACT two 4-bit words in 33ns. The addition of two 16-bit words takes only 42ns.

The new ALU has full internal carry lookahead, and provides either a ripple carry output or carry lookahead outputs. The speed and flexibility of the 9340 make it ideal for other applications like multipliers, dividers and comparators.

Input clamp diodes are used on all inputs to limit high speed termination effects in the 9340. Input/output characteristics provide easy interfacing with all Fairchild DTμL, TTμL and MSI families.



9340 IN TYPICAL 16-BIT CONFIGURATION

To order the 9340, call your Fairchild Distributor and ask for:

PART NUMBER	PACKAGE	TEMPERATURE RANGE	(1-24)	PRICE (25-99)	(100-999)
U6N934059X	DIP	0°C to + 75°C	$20.90	$16.70	$14.00
U6N934051X	DIP	−55°C to +125°C	41.80	33.40	28.00
U4M934059X	Flat	0°C to + 75°C	23.00	18.40	15.40
U4M934051X	Flat	−55°C to +125°C	46.00	36.80	30.80

you have to get serious about MSI family planning.

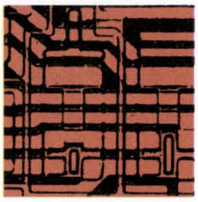
We put together a family plan by taking systems apart. All kinds of digital systems. Thousands of them.

First we looked for functional categories. We found them. Time after time, in a clear and recurrent pattern, seven basic categories popped up: Registers. Decoders and demultiplexers. Counters. Multiplexers. Encoders. Operators. Latches.

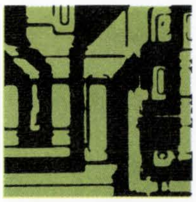
Inside each of the seven categories, we sifted by application. We wanted to design the minimum number of devices that could do the maximum number of things. That's why, for example, Fairchild MSI registers can be used in storage, in shifting, in counting and in conversion applications. And you'll find this sort of versatility throughout our entire MSI line.

Finally, we studied ancillary logic requirements and packed, wherever possible, our MSI devices with input and output decoding, buffering and complementing functions. That's why Fairchild MSI reduces – in many cases eliminates – the need for additional logic packages.

The Fairchild MSI family plan. A new approach to MSI that's as old as the industrial revolution. It started with functional simplicity, extended through multi-use component parts, and concluded with a sharp reduction in add-ons. Simplicity. Versatility. Compatibility. Available now. In military or industrial temperature ranges. In hermetic DIPs and Flatpaks. From any Fairchild Distributor.

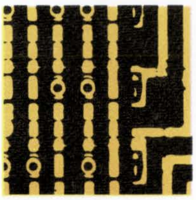


OPERATORS
9304 – Dual Full Adder/Parity Generator
9340 – Arithmetic Logic Unit

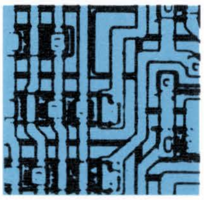


LATCHES
9308 – Dual 4-Bit Latch
9314 – Quad Latch

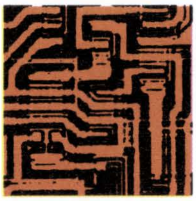
REGISTERS
9300 – 4-Bit Shift Register
9328 – Dual 8-Bit Shift Register



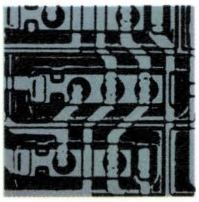
MULTIPLEXERS
9309—Dual 4 Input Digital Multiplexer
9312—8-Input Digital Multiplexer
9322—Quad 2-Input Digital Multiplexer



DECODERS AND DEMULTIPLEXERS
9301 – One-Of-Ten Decoder
9315 – One-Of-Ten Decoder/Driver
9307 – Seven-Segment Decoder
9311 – One-Of-16 Decoder
9317 – Seven-Segment Decoder/Driver
9327 – Seven-Segment Decoder/Driver



COUNTERS
9306 – Decade Up/Down Counter
9310 – Decade Counter
9316 – Hexidecimal Counter

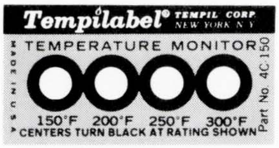


ENCODERS
9318 – Priority 8-Input Encoder

FAIRCHILD
SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation Mountain View, California 94040, (415) 962-5011 TWX: 910-379-6435

Circle 18 on Inquiry Card



SPEAK UP

You can't get there from here

Sir:

With reference to your article in **The Electronic Engineer,** May 1970, p. 30, several years ago I too had the hopeful idea that EE's could help the transportation picture. When LBJ initiated a study of high speed rail transport along the Northeast Corridor, I prepared an article entitled "Local transporation and the commuter problem." I did so because I believed that emphasis was being placed in the wrong area. The intervening years have merely served to corroborate my point.

EE's could be of great value in putting the "service" back into transportation. But engineers are neither lawyers nor politicians. Generating public interest in ideas comes hard to engineers. How many "engineers" are quoted in the public press? Yet the lowliest politician can get public attention for the most inane comments he utters! How then do you expect ideas generated by EE's to reach the general public?

The "green light for EE's may exist, if at all, on the payroll of some company whose work borders on transportation. Should an EE approach a transportation-oriented company he will likely be told that he "lacks experience in the proper field!" If the past is any criterion, we will be deluged with requests for experienced "computer-oriented electronic engineers with ten years background in applying integrated circuit technology to mass transit." Meanwhile the fellow who has initiative and imagination, plus the ability to cross-fertilize various fields, will be ignored unless he can afford the services of some high-priced public relations firm.

Yes, there will be opportunities, but much time will be lost before the new approaches are sufficiently developed to need the EE's services.

Charles A. Cady
Consulting Engineer
Wayland, Mass.

EDITOR'S NOTE: In his article, Mr. Cady advocated a high-speed monorail for the Northeast Corridor (Boston-Washington, D. C.). The sad experiences he predicts for EE's who may want to work in transportation are still not, unfortunately, a thing of the past, but it is engineers such as Mr. Beggs (the Under Secretary of the Department of Transportation, featured in our May article) who will help to change that picture, since he understands the contributions electronic engineers can make.

What? No acoustical engineers?

Sir:

In the interview article "You can't get there from here" [**The Electronic Engineer,** May 1970, pp. 30-39], Mr. James E. Beggs, Undersecretary of the Dept. of Transportation, is quoted as saying, with regard to acoustical engineers, ". . . we don't have many in the United States. Most acoustical engineers come from England, where their educational curricula include these subjects."

I am sure that my colleagues in the Acoustical Society of America and in the National Council of Acoustical Consultants will be surprised to hear of this. These two groups are composed chiefly of United States professionals who are practicing in this field, and who regard the Society as "home base." The Society fosters education in both acoustical science and engineering, and maintains a listing of schools where such training can be obtained.

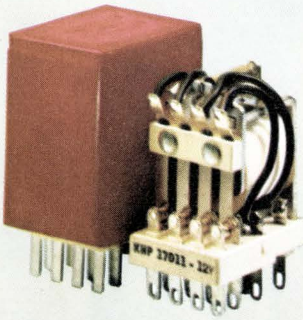
Vincent Salmon
President
Acoustical Society of America
(Stanford Research Institute
Menlo Park, California)

EDITOR's NOTE: Mr. Beggs' statement was correct in the formal sense. While there are no universities granting a degree called "Acoustical Engineer" in the United States nor in England, there are many EE or ME programs in both countries that include acoustical subjects. On the other hand, acoustical research is more intense in the United Kingdom than in the U.S., largely because the U.S. Navy sponsors many research programs in England, where research costs are lower.

The Department of Transportation is interested in acoustical engineering because its Office of Noise Abatement, headed by Mr. Charles R. Foster (a member of the Acoustical Society of America), is studying the problem of noise pollution.

Readers interested in the Society can obtain more information from Mrs. Betty Goodfriend, Administrative Secretary, Acoustical Society of America, 355 East 45th St., New York, N.Y. 10017.

Letters to the editor are published at the discretion of the magazine. Please say so if you do not want to be quoted. Signed letters have preference over anonymous ones



We'll stop adapting our KHP relay when you run out of new applications.

You have a tough relay requirement, right? You need a relay with the reliability of bifurcated contacts. Must have U/L Component recognition. Need .078 taper tab terminals and 400 milli-watts sensitivity. Color coded cases.

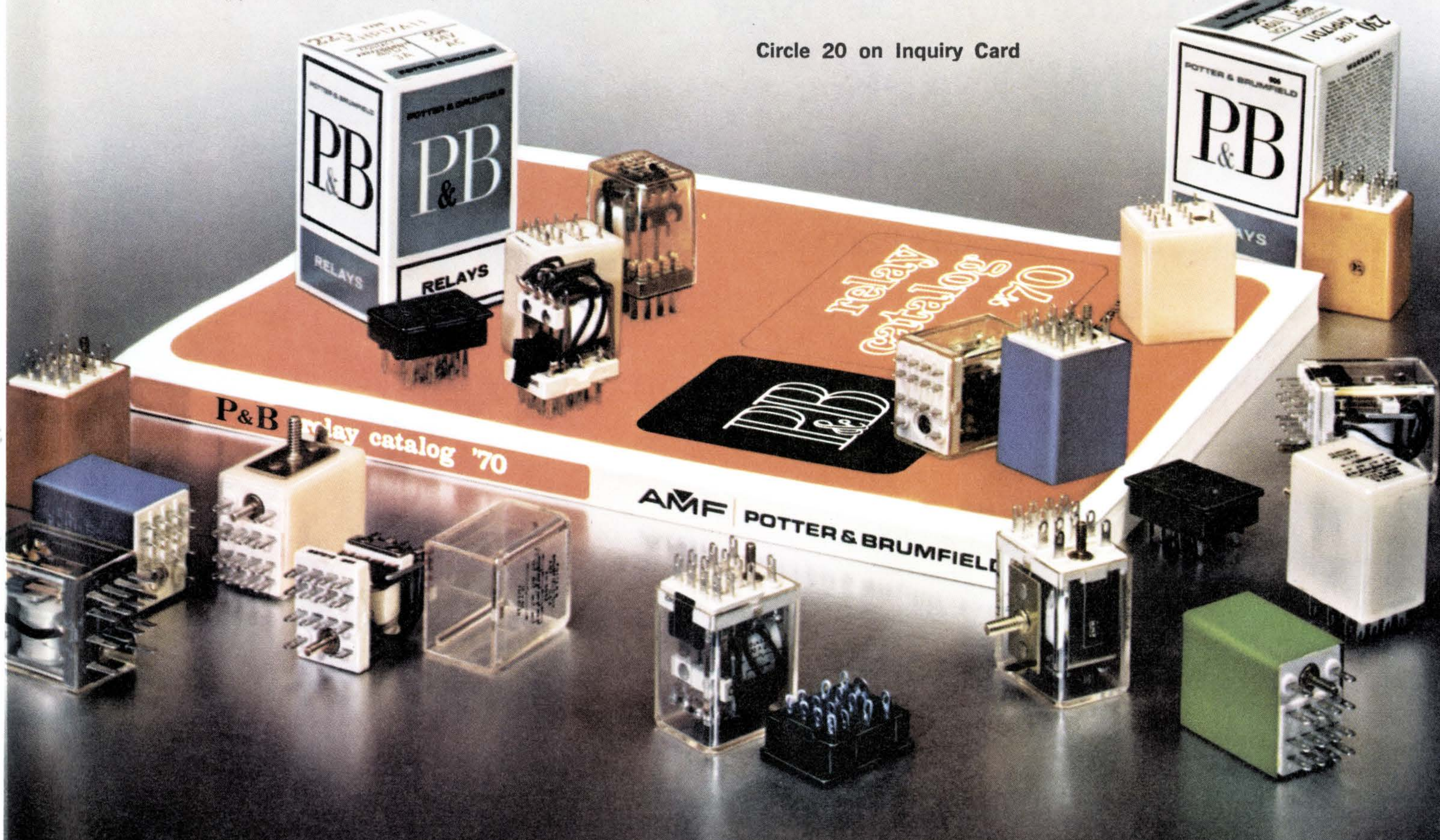
No problem. Just call us. We are all tooled and in production. Probably no other manufacturers of our KHP design can say the same.

You see, we've been making this relay longer than anyone because we designed it. We've made it for more different applications than anyone else. That's why we have more combinations of contact materials, terminals, sockets, and mountings than anyone else.

Available in 2 Form C, 4 Form C or Form Z contact arrangements. Contacts rated 3-amps at 30V DC or 120V AC resistive. Choice of 8 different mountings and 8 contact materials. Coil voltages from 6 to 120 volts.

Complete specifications and ordering information are in our new 194-page Catalog '70. Ask your P&B representative for a copy today. Or write us direct: Potter & Brumfield Division of AMF Incorporated, Princeton, Indiana 47570. Or call 812 385 5251.

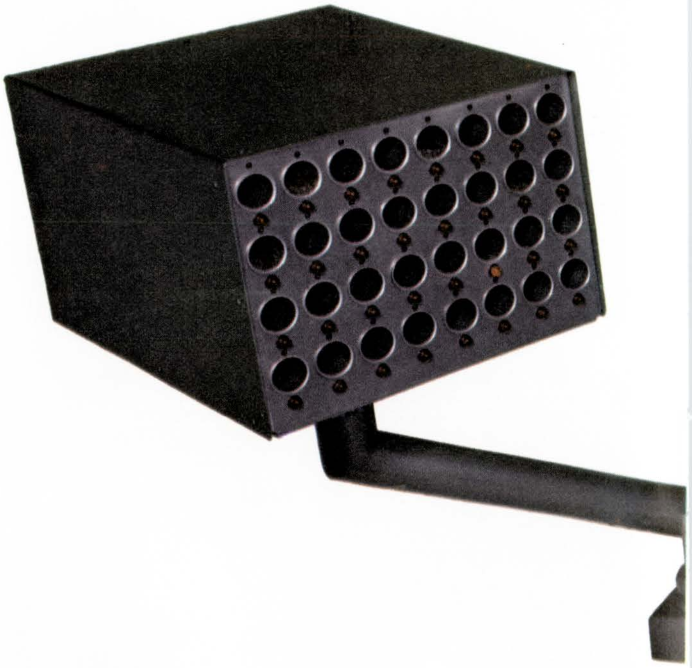
Circle 20 on Inquiry Card



AMF | POTTER & BRUMFIELD

locate point-to-point

New Gardner-Denver Wire-Wrap* Machine locates terminals with .001 accuracy.



Electronic production schedules up to one million wires per year can be wired with this new 14YN Wire-Wrap Terminal Locating Machine recently announced by Gardner-Denver Company. Positioning rate is adjustable from 120 to 360 inches per minute, and position resolution is .001 on both axes. Wrap area is 36″ on the "X" axis and 24″ on the "Y" axis.

Machine can be used with twisted wire pairs, as well as a wide range of wire gauges. Standard equipment includes the Terminal Locator, a lighted wire bin with 32 tubes, and a Gardner-Denver solid state tape reader and numerical control. Write for further information, or ask your Gardner-Denver Wire-Wrap Specialist about specifications and assistance in your wiring requirements.

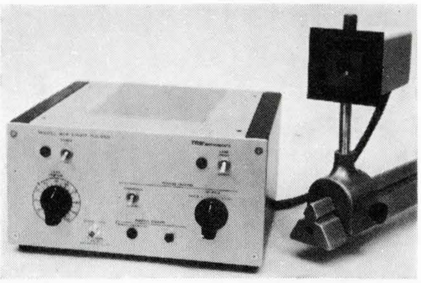
GARDNER-DENVER

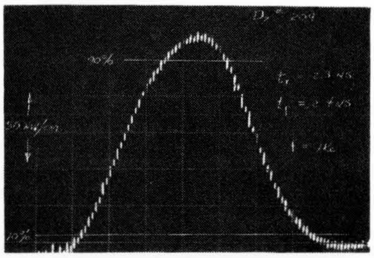
Gardner-Denver Company, Quincy, Illinois 62301

* Wire-Wrap is a registered Trademark of Gardner-Denver Company

Circle 21 on Inquiry Card

GARDNER-DENVER Wire-Wrap





CALENDAR

JULY

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

July 12-17: IEEE Summer Power Meeting & EHV Conf., Biltmore Hotel, Biltmore Hotel, Los Angeles, Calif. Addtl. Info.—Doyt H. Steele, Bechtel Corp., Box 58587, Vernon Branch, Los Angeles, Calif. 90058.

July 14-16: Int'l Electromagnetic Compatibility Symp., Grand Hotel, Anaheim, Calif. Addtl. Info.—Jim Senn, Lectro Magnetics, Inc., 6056 W. Jefferson Blvd., Los Angeles, Caifl. 90016.

July 21-23: IEEE Conf. on Nuclear and Space Radiation Effects, University of Calif., San Diego, California. Addtl. Info.—R. A. Poll, Systems, Science and Software Box 1620, La Jolla, Calif. 92037.

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. 3-6: An IFAC Symp. "The Operator, Engineer and Management Interface with the Process Control Computer," Purdue Univ., Lafayette, Indiana. Addtl. Info.—T. J. Williams, Gen. Chairman, Purdue Lab. for Applied Industrial Control, Purdue Univ., Lafayette, Indiana 47907.

Aug. 4-6: Photovoltaic Specialists Conf., Olympic Hotel, Seattle, Washington. Addtl. Info.—Joe Loferski, Brown Univ., Div. of Engrg., Providence, Rhode Island.

Aug. 18-21: Int'l Conf. on Microelectronics, Circuits & Systems Theory, Univ. of New South Wales, Kensington, Sydney, Australia. Jt. Conf. Secretariat, IREE, Austrailia, Box 3120, GPO, Sydney, 2001 Australia.

Aug. 25-28: Western Electronic Show & Convention (WESCON), L. A. Hilton Hotel, Sports Arena, Los Angeles, Calif. Addtl. Info.—WESCON Office, 3600 Wilshire Blvd., Los Angeles, Calif. 90005.

Aug. 30-Sept. 2: 12th Annual Conf. of the Electronic Materials Committee of The Metallurgical Society of AIME, Statler-Hilton Hotel, N.Y. City. Addtl. Info.—F. V. Williams, Monsanto Company, 800 North Lindbergh Blvd., St. Louis, Missouri 63166.

SEPTEMBER

		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			

Sept. 1-3, Association for Computing Machinery—25th National Conference, New York Hilton, New York, N. Y. This unconventional conference will represent the first attempt to interface the computer industry with the problems of society. Highlights of the conference will include Ralph Nader's keynote speech, a town hall meeting at which laymen will have the opportunity to ask questions about computers, a computerized chess tournament, an arts and music festival dealing with the role of computers in the arts, and a career guidance session for non-college students. Joel R. Weber, ACM 70, 1133 Avenue of the Americas, New York, N. Y. 10036.

Sept. 15-16: 4th Annual Instrumentation Fair, Washington Hilton Hotel, Washington, D.C. Addtl. Info.—Norm Ward, AD-TECH, P.O. Box 475, McLean, Virginia 22101.

Sept. 21-24: 1970 IEEE International Conf. on Engineering in the Ocean Evironment, Auditorium/Panama City Marina, Panama City, Florida. Addtl. Info.—Calvin B. Koesy, Program Chairman, Long-range planning staff, Naval Ship Resch. and Development Lab., Panama City, Fla.

Sept. 21-Oct. 2: The Machine Tool Show, Chicago's Int'l Amphitheatre, Chicago. Addtl. Info.—Wash. contact: Christopher Bevevino, NMTBA, 2139 Wisconsin Ave., N.W., Washington, D.C. 20007 and N.Y. contact: Ed Greif, Banner & Greif, Ltd.. 369 Lexington Ave., N.Y.

Sept. 27-30: Jt. Power Generation Conf., Pittsburgh Hilton, Pittsburgh, Penna. Addtl. Info.—W. S. Morgan, Am. Elec. Pwr. Svc. Corp., 2 Bdwy., New York, N.Y. 10008.

'70 Conference Highlights

WESCON — Western Electronic Show and Convention, Aug. 25-28; Los Angeles, Calif.

NEC—National Electronics Conference, Oct. 26-28; Chicago, Illinois.

NEREM—Northeast Electronics Research Engineering Meeting, Nov. 4-6; Boston, Mass.

The beauty of this connector...

it saves you a pretty penny.

Sure, Amphenol's new Excellite audio/electronic connector is beautiful. It's strong and light weight, too. Made from the same tough, molded ABS plastic used in pro football helmets and golf club heads. The lustrous nickel plating enhances the look and value of your product.

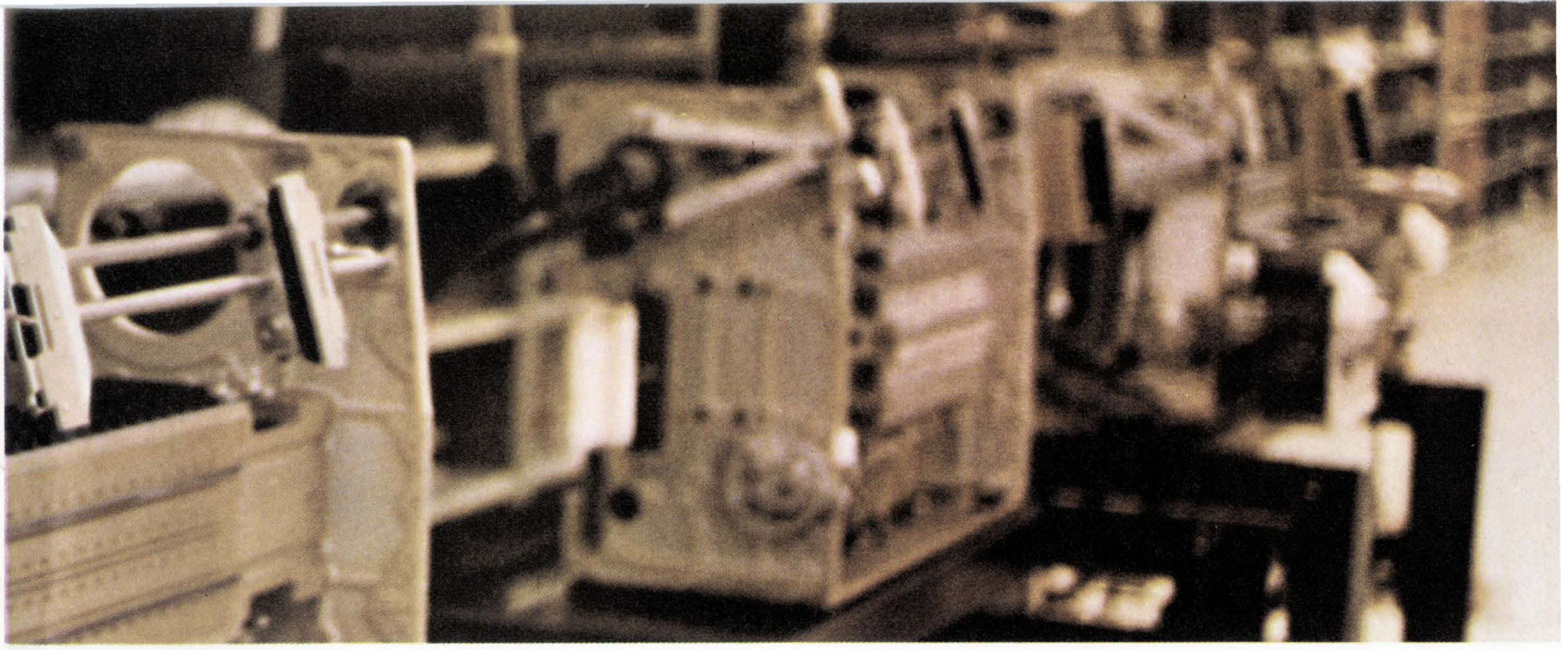
But where it really sparkles is on the money it saves you. First off, it costs less to buy. The savings from new, lower cost materials is passed on to you. Secondly, it saves you time in termination. Excellite cable connectors come completely assembled, not as a bag of parts. Your production people aren't burdened with assembly or bothered with parts that don't fit or are missing. We do all that.

The Excellite line provides a full complement of distinctive 3, 4 and 5 contact connectors that are completely interchangeable and intermateable with all latch-lock type audio connectors.

For complete information on Excellite audio/electronic connectors, send for your free copy of Catalog EX-1. Amphenol Industrial Division, The Bunker-Ramo Corporation, 1830 South 54th Avenue, Chicago, Illinois 60650.

AMPHENOL
TM
THE BUNKER-RAMO CORPORATION

Circle 23 on Inquiry Card



"We saw a gap in the printer field. Either you paid a lot of money to get a lot of speed and sophistication, or you could pay a little and get very little in return. We decided to aim our printer somewhere in between.

"Chain printers are mechanically simpler, easier to maintain, less expensive. Their flat face characters give good print characteristics, too.

"Our design requirements were rough. We wanted 300 lines- per-minute with such niceties as easily changeable fonts, and yet we wanted to sell it for less than $10K. It had to be small, and yet we couldn't lose accessibility. The design engineers grumbled, but they made it.

"The changeable font cartridge is great—an operator can quickly switch the font chain—and we're offering fonts from 16 to 128 characters.

"We designed a disposable ribbon cartridge to make ribbon changes quick and clean. Paper handling is enclosed to stay clean, too. And everything that could be modularized, was modularized.

"We considered noise reduction vital—anyone who has worked in a printer room knows why. Well, compared to other printers, you'd hardly know this one was working.

"We're selling the printer for $9500 in OEM quantities, and some variations cost even less. So you get a lot of performance in a very little printer—for very little money."

Mohawk Data Sciences Corp.
Herkimer, New York

MDS

Circle 24 on Inquiry Card

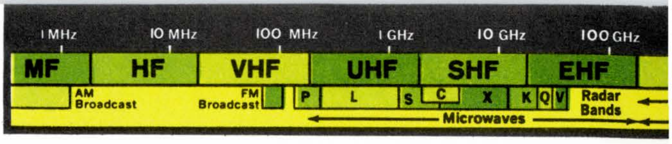
OEM MARKETING CENTERS: CORPORATE (315) 867-6475; NORTHEAST (617) 891-5870; SOUTHEAST (404) 631-3443; CENTRAL (312) 298-4141; WEST COAST (213) 685-5165.

CHALLENGE

INNOVATING for

Can we change our outmoded technical-political apparatus before the dawn of the new century? We won't, unless engineers like Dr. Myron Tribus prepare the way for the explosive growth of technology.

MYRON TRIBUS
of the Department of Commerce



the 21st century

John McNichol, *Assistant Editor*

Thirty years ago—1940. The Institute of Aeronautical Sciences predicted airplane speeds of 650 mph. Interest at savings and loan associations was to go to 2½%. Ads promised careers in radio repair at $30, $40 and $50 a week. As nations fell in Europe, the United States hesitated on the brink of World War II.

In another 30 years it will be the 21st century. Electronics, which started to toddle during World War II, has already reached a young maturity, And as we approach the coming century, communication links will handle more information, automation will increase greatly under computer control, artificial intelligence will deal with the nitty-gritty of everyday life, systems will multiply and take on life-like activities, and all forms of energy will be converted into electrical energy.

Gearing up

The rapid pace of this continuing revolution puts pressure on both the men and institutions involved. No one is more aware of the institutions and engineers' needs to adjust to this pace than Dr. Myron Tribus, Assistant Secretary of Commerce for Science and Technology. As head of the Department's scientific and technical programs, which account for more than half of the Department budget of $1.2 billion and its per-

---

THE MORE THINGS CHANGE, THE MORE THEY . . . ?

Changing an old bromide is a formidable task at the very least, and planning a government department for some 30 years in the future is a massive job, but if Myron Tribus has his way, "the more things change, the more things remain the same" will no longer be true and the Department of Commerce will be ready for the technological developments of the 21st century.

Dr. Tribus, who since March 31, 1969 has been the Assistant Secretary of Commerce for Science and Technology, is this month's CHALLENGER. Like others in this series, Tribus has much to say, and **do,** about shaping the Age of Technology. Implicit in this planning for the future is the role of the electronic engineer, who more than any other single professional, has the power to bring genuine progress to this new age.

A graduate of the University of California at Berkeley, Assistant Secretary Tribus received a B.S. degree in Chemistry in 1942. He received a Ph.D degree in engineering in 1949 from the same institution's Los Angeles campus. At UCLA he taught engineering between 1946 and 1960, rising from instructor to full professor. An innovator who championed the "unified curriculum" for engineering education, he was Dean of the Thayer School of Engineering at Dartmouth College from 1961 until he joined the Department of Commerce. Much of his research and teaching efforts were directed towards heat transfer, thermodynamics, fluid mechanics, computers, and applied physics.

As John Kemeny had revitalized Dartmouth's mathematics department a half decade earlier before becoming president of the college, so Tribus set about revamping the engineering school. He applied his principles: the encouragement of creativity, the bridging of gaps between various study disciplines, and the development of the student engineer as a dreamer, schemer and doer. Dartmouth was the first school to allow extensive free use of the time-sharing computer system for all undergraduates. In addition, a program was developed that would allow the student-engineers to work on large projects selected by themselves. The only criteria were that the project must have some social merit, be amenable to a technical approach, and have the potential of some sort of implementation. At least one of his students has started his own company marketing a product developed during this undergraduate program.

A dedicated photographer (he processes his own color shots), Tribus hasn't had the time to work in his dark room since joining DoC. He had previously served the Department of Commerce as a member of the Commerce Technical Advisory Board (CTAB) and the Department of the Interior as a consultant to the Federal Office of Saline Water.

Among his other responsibilities have been director, Aircraft Icing Research at the University of Michigan; advisor to NATO; member of the Board of Directors, Spaulding Fibre Co.; and director of Carpenter Technology Corp. Between 1950, when he served as a consultant in heat transfer, and 1969, Tribus had worked as a consulting engineer for General Electric Corp.

Dr. Tribus has received numerous awards for outstanding achievement including the Thurman H. Bane Award of the Institute of Aerospace Sciences (now the AIAA), the Wright Brothers Medal of the Society of Automotive Engineers in the same year, and the Alfred Nobel Prize of the Engineering Founder Societies in 1952. In 1964, he was the recipient of an honorary Doctor of Science degree from Rockford College for his work in the field of engineering education. In 1967 he was singled out as the "Master Designer of the Year" for efforts in this area.

The multi-faceted Assistant Secretary wrote a textbook, **Thermostatics and Thermodynamics** (see box), in 1961. The book studies thermodynamics from an information theory viewpoint. A newer book, which is being published, **Rational Descriptions, Decisions and Designs,** deals with decision making and information, its value and role in engineering.

sonnel, he is responsible for the National Bureau of Standards, the Patent Office and the Environmental Science Services Administration. In addition to these bureaus, he works with two special offices—the Office of Telecommunications and the Office of Standards Policy. Political forces in the near future (see **box**) **will** probably reshape the Department of Commerce, but much of the responsibility for the following should remain under Tribus:

- Development of more advanced research and technological services for the future.
- Provision of knowledge to improve man's understanding of his physical environment, such as collecting data on the properties of atoms and the nature of the universe.
- Technical information generated by the Federal Government's research and development programs.
- Standards for the nation's measurement system.
- Inventions as they are incorporated into the patent system.
- Technology and the development of telecommunications.
- Analyses of the technology gap between the U.S.A. and other countries.
- Understanding of the meaning of technological innovation in American economy.

Crystal ball

As bureaucrat and educator, Tribus sees his duties as twofold: one, to prepare the Department of Commerce for the 21st century; and, two, to encourage more engineers to serve as an interface between society and technology. With regard to the first role, the Assistant Secretary spoke of the 21st century and the demands that it would make on the technically oriented Department.

Tribus contends that only those who can read technology will be able to read the future. If this is so, Dr. Tribus is uniquely qualified—as engineer, scientist, educator, author and bureaucrat—to look ahead to the next 30 years in an attempt to foresee what the 21st century will mean to the engineering community.

Speaking of the changing complexion of the face of telecommunications, he stated, "Communications in this country has been criticized for many years as being inadequately managed, and this administration has promised to do something about it. The President's Reorganization Plan No. 1 for 1970 created the Office of Telecommunications Policy, to report directly to the President, and abolished the Department of Telecommunications Management (DTM). With this change our Department was given the charter for telecommunications research and analysis."

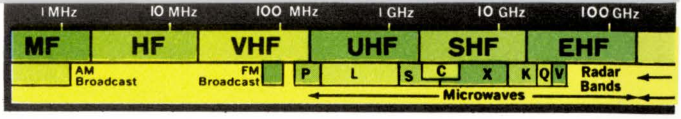
With the Institute of Telecommunications Sciences of the Environmental Science Services Administration (ESSA), the Department of Commerce has a strong background in telecommunications. The latter phases of this presidential reorganization will take the Institute from ESSA and combine it with the technical operations of the defunct DTM, which included the authority to monitor hardware and hardware assignments. Most importantly, Tribus believes the reorganization will generate an added capability for economic and systems analysis, technological and demand forecasting, and several aspects of technological assessment.

In his attempt to analyze the future, Dr. Tribus draws on a book written in 1887—A. M. Wellington's *Economic theory of the Location of Railways*. Wellington's thesis was that the location of the railroad directly affected the long-range potential of the surrounding area for growth and commerce. In an analogy with today, Dr. Tribus states, "If an engineer in 1887, without the aid of a computer or the discipline of systems analysis, could be smart enough, thoughtful enough and dedicated enough to approach his job with that breadth of view, certainly today's engineer can be expected to do much more."

Another organization being established by the Department of Commerce in preparation for the 21st century is the National Electromagnetic Compatibility Analysis Facility (NECAF)—a civilian counterpart to DoD's Electromagnetic Compatibility Analysis Center (ECAC). NECAF will compile information on a variety of technical matters, such as the characteristics of transmitters and receivers, the characteristics of local terrain, information as to who is using the air, the probability that the message will get through and the collection of data to improve spectral assignments.

Some of the projects that the Assistant Secretary feels are of great importance to the Department are:

- Computer teleprocessing.
- The labor force, its size and effectiveness—"Just when veterans are returning in great numbers, we are altering technology in ways that make it difficult for them to get, or even to hold jobs. We don't want to hold up technology—just know in which direction it's going."
- Accuracy of records.
- Legal status of records—"What is the legal status of records that can't be read by the eye, but which can be altered? For example, with the traditional records one writes with indelible ink, and if it's changed, there's a legal procedure that's followed. But you can't guarantee the integrity of computer or microfilm records."
- Computerizing the Patent Office and developing a special registration or patent for software.
- Medical care—"Certainly for better medical care we need computer aids. But when something goes wrong, who bears the responsibility? If the medical records get fouled up, who's to blame? If there's an error in a program that results in a patient's receiving medicine he's allergic to, who is responsible? We engineers must decide who has the ultimate responsibility: the



doctor, the machine or a third party. If we don't, the electronic engineer must lose any claim to professionalism."

Summing up, Tribus said that "People in technology often think, as I once thought, that if they perform their technological wizardry, society will adapt to it in one way or another. But anyone who has been at the frontiers of technology knows that we haven't been going as fast as we could, simply because society is not ready for it. The social aspects are even more important than the technological."

The new breed

Aside from developing a sound structure for technology to grow unimpeded into the 21st century, Assistant Secretary Tribus is deeply concerned with the role of the electronic engineer. He believes the engineer must develop himself as the interface between society and technology.

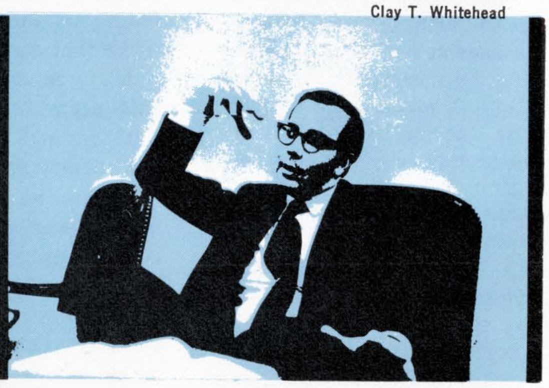
"There is a small group of men today," states Tribus, "who get involved in the interaction of society and technology at the interface level and find they actually enjoy it. Their only problem is a lack of preparation. Technical people should supplement their background with social and legal experience. It's absolutely essential for the future of this country that those who are able to read and understand **The Electronic Engineer** also be competent to do so with *The Congressional Record.*

"Today, at least 90% of the electronic engineers wouldn't be able to make this transition. Not because they are dull—far from it—but they have a self image that excludes this involvement. And unfortunately, they have been educated away from it.

"In a sense, this is what I was trying to do at Dartmouth—prepare the engineer not only for his technical responsibilities, but also for his political and so-

Myron Tribus

Clay T. Whitehead



THE POLITICAL STATE OF THE ART: TELECOMMUNICATIONS

Sprawling across several government agencies, bureaus and offices and vitally important to industry, telecommunications is a very hot topic now. Potential changes in the allocation of the radio-frequency spectrum, CATV, communications satellites, and recent FCC rulings on microwave networks have aroused great interest in the future of telecommunications.

Recognizing this, President Nixon appointed special assistant Clay T. Whitehead, an electrical engineer with a Ph.D in Management from MIT, to head the as yet unreleased study on telecommunications. Other actions that Nixon has taken in Reorganization Plan No. 1 include the creation of the Office of Telecommunications Policy and the abolishment of the Office of Telecommunications Management. The new Office, which will report directly to the President, will be staffed by 20 or so lawyers, engineers and economists who will delegate research studies and make policy recommendations to the President on all areas of telecommunications, including the civilian uses regulated by the FCC. As Whitehead states, the new Office will be interested in "flexible and economic use of the spectrum. The old ways of managing the spectrum no longer apply and the Government does not want to be in the position of hindering progress."

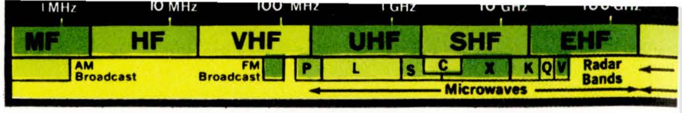
The Office of Telecommunications Policy (OTP) has three distinct functions:

- The President's principal adviser on telecommunications policy.
- Help formulate policies and coordinate operations for the Government's own vast communications systems.
- Enable the President to speak with a "clearer voice" and to act as a more effective partner in discussions of communications policy with both Congress and the FCC.

Working closely with the new OTP will be the Department of Commerce's Telecommunications Research and Analysis Center (TRAC), which will be formed within the next 6 months. It will be staffed with personnel from the National Bureau of Standards, the Boulder Office of Telecommunications Sciences, the now defunct Office of Telecommunications Management and others.

The importance of the reorganization occurring in telecommunications is, as Dr. John Richardson, Assistant Secretary of Telecommunications at DoC and one who is very closely involved with TRAC, stated, "This combination of organizations strikes us as extremely significant because of the lesson of the '60s that you cannot address technology piecemeal. The post-industrial society calls for new approaches."

CHALLENGE



cial responsibilities. It's unfortunate that many professors believe a wide range of interests inhibits a student's technical development. It's simply not true!

"It is essential for our survival that men of broader vision, who can encompass the technological and social implications of our society, take on broader responsibilities. We have to get away from the engineer's traditional 'tell-me-what-you-want-and-I'll-do-it' attitude."

Hard words for hard times

Assessing the contemporary scene, Dr. Tribus realizes that many of our country's problems are outside of the defense area—pollution, education and technical competition, to name a few. "Engineers will have to shift from one industry to another," he says. "How they make that shift depends to a great extent on their attitude. If an engineer asks, 'How do I find an industry that needs me and where can I make my influence felt?' instead of 'My God, where do I get that job?' the country will be a lot better off.

"There has been much talk about professionalism and the engineer. To say that 'the engineer in industry is not truly professional' is like many generalizations—both true and false at the same time. It is true that industry does not give the engineer credit for being professional. On the other hand, some engineers use this as an escape to avoid professional responsibility. The future of the country will depend partially on how these people respond to the challenge of conversion.

"Why, for example, can't a shirt manufacturing firm get professional engineers, even when so many are out of work? I don't know the answer, but if the engineer as a professional man asks 'How do I become most useful to society?' and not just 'How do I make the most money?' then we'll have the beginning of an answer."

A shadowy outline

Just as in the bleak days of 1940, 1970 seemed so far away, so too, the world of the 21st century seems just a vague outline to us. The one thing that we can be sure of is that technology will grow at an even greater rate, and that same rate will be directly affected by the structures we devise to handle this growth. That is why Dr. Myron Tribus, Assistant Secretary of Commerce for Science and Technology, is so interested in trying to look into the future and prepare for it.

WORDS AND CONCEPTS

A book by Tribus appeared in 1961: **Thermostatics and Thermodynamics.** It has been used as a textbook for engineering students in the upper undergraduate years; but it is hardly a text in the traditional pattern, for the author has taken an entirely new approach to the subject matter. He uses Shannon's Information Theory as the starting point for a unified treatment of thermodynamics, statistical mechanics, and statistical decision theory.

Shannon defined the transfer of information as the reduction of uncertainty in the mind of the receiver. The amount of uncertainty initially present is given by the expression $-\Sigma P_i \log P_i$, in which each P_i is the probability associated by the receiver with a particular outcome (symbol, character, message unit); all this before transmission takes place. Once the message is received, there is no longer doubt; the one P_i which came through now has acquired unit value (corresponding to certainty). Its log is zero, so the product vanishes and uncertainty drops to zero. (Legend has it that John von Neumann suggested to Shannon that he should use the word **entropy** for this expression denoting the amount of uncertainty.)

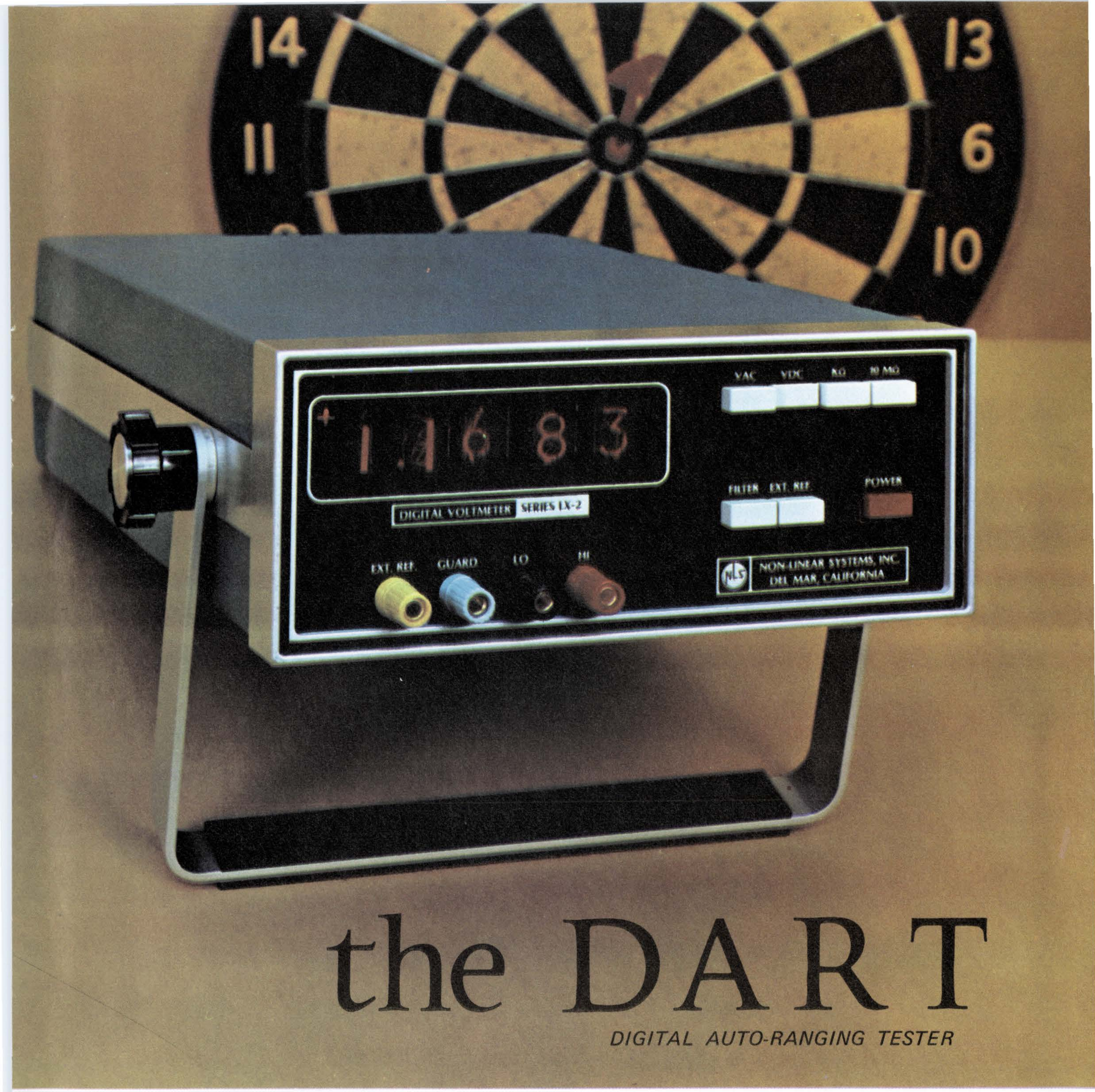
Tribus, following E. T. Jaynes, has shown what happens when Shannon's entropy expression is maximized, subject to certain possible constraints. Different probability distributions arise, notably the ones which describe the scatter in speed and in energy of the fast moving single-atom molecules in a tankful of helium gas at low pressure. This is the simplest case; but it leads on to a demonstration that the whole of classical thermodynamics can be viewed as a logical downstream consequence of Shannon's landmark concept.

A more recent book is the to be published, **Rational Description, Decisions, and Design.** The title itself reminds one that Tribus is known to many electronic engineers as a "Bayesian Statistician"—one who views probabilities as an encoding of one's state of knowledge, not as absolute attributes of physical events themselves. Thus the Bayesian has a very neat way to make a decision (choose the most promising design approach) when confronted by incomplete information (design concepts insufficiently tested). He encodes his present limited knowledge in a form such that later increments of knowledge, from test and experience, can be smoothly fitted in. He then proceeds sequentially.

Not everybody agrees with Tribus. The controversy between the Bayesians and the "Classical Statisticians" can be expected to continue through the years (while good work continues to be done by people in both camps).

George E. Henry

INFORMATION RETRIEVAL
Careers



the DART

DIGITAL AUTO-RANGING TESTER

$995

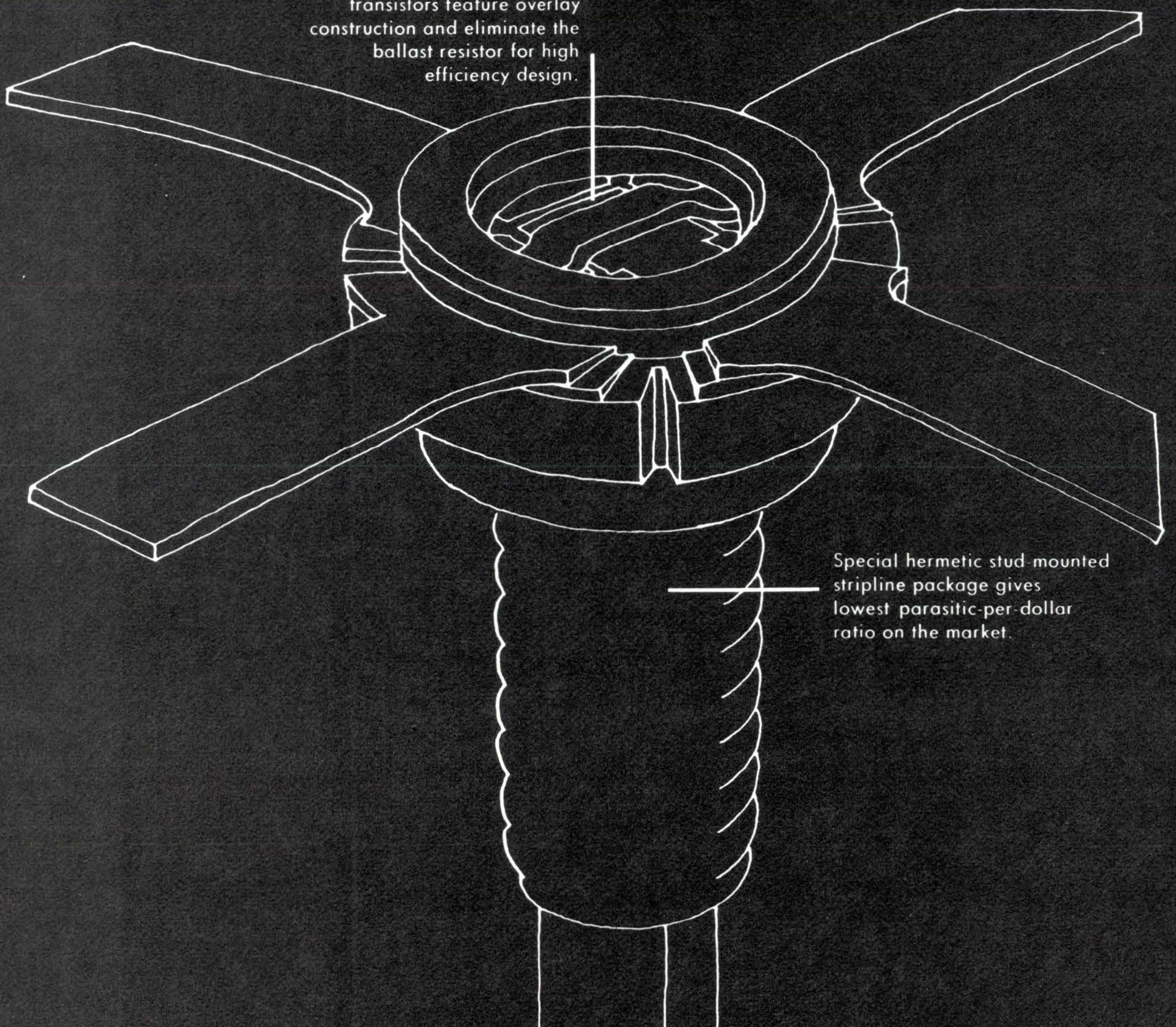
- **4 Ranges – DC Volts**
- **4 Ranges – AC Volts**
- **5 Ranges – Ohms**
- **Ratio Capability**
- **Automatic Range and Polarity**
- **Printout Option**
- **Battery Option**

RIGHT ON TARGET is the latest addition to the growing line of high quality, low cost, digital meters from NLS. Continuing the tradition of, "the finest instruments available at sensible prices," Non-Linear Systems is proud to announce the availability of the *NEW, LOW-COST SERIES LX-2 AUTO-RANGING MULTIFUNCTION DIGITAL VOLTMETER.* This superior instrument, born of engineering and manufacturing know-how, is sure to please the eye and the budget of the discerning instrument buyer. See it soon!

NLS
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

Circle 25 on Inquiry Card

Microwave power without all those tradeoffs.



Raytheon L and S band power transistors feature overlay construction and eliminate the ballast resistor for high efficiency design.

Special hermetic stud-mounted stripline package gives lowest parasitic-per-dollar ratio on the market.

Get them all right now at your Raytheon distributor's. The microwave transistors that make your system work better and longer.

And featuring . . .

Our own 2N5108A. A high-efficiency one-GHz transistor with leakage current lower by 3 orders of magnitude than the 2N5108. Here's the whole tribe.

RAYTHEON L- AND S-BAND POWER TRANSISTORS

Transistor Designation	Package Type	Frequency (Avg.)	Power (Min.)	Gain (Min.)	Efficiency (Typ.)	Price 100-999
LS2501	Stripline	2.0 GHz	1.0 W	5 dB	30%	$48.00
LS1610	Stripline	1.0 GHz	10.0 W	6 dB	60%	60.00
LS1605	Stripline	1.0 GHz	5.0 W	6 dB	60%	42.00
LS1604	Stripline	1.0 GHz	4.0 W	6 dB	60%	30.00
LS1602	Stripline	1.0 GHz	2.0 W	6 dB	50%	21.00
LS1701	Stripline	1.0 GHz	1.0 W	7 dB	50%	17.00
LS1501	Stripline	1.0 GHz	1.0 W	5 dB	45%	12.00
2N5108A	TO-39 Case	1.0 GHz	1.0 W	5 dB	40%	9.30
2N5108	TO-39 Case	1.0 GHz	1.0 W	5 dB	35%	9.25
2N4428	TO-39 Case	500 MHz	0.75 W	10 dB	35%	5.00
2N3866	TO-39 Case	400 MHz	1.0 W	10 dB	40%	1.50
2N3553	TO-39 Case	175 MHz	2.5 W	10 dB	60%	3.18

We tossed out the ballast.

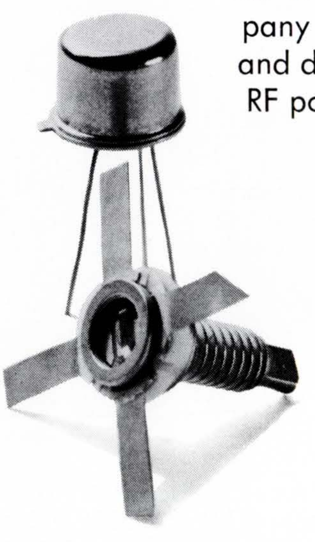
Exclusive Raytheon design eliminates the built-in ballast resistor. VSWR handling capability is increased at rated power, and so is system gain and efficiency, since you're not burning up watts on resistors you don't need.

And heated the seal.

Another exclusive. Our metal/ceramic temperature-sealed stipline packages completely do away with all the troubles inherent in epoxy seals, and allow our transistors to meet all the environmental requirements of MIL-S-19500.

Name your poison.

Or get them in TO-39 cases. And if these standard packages don't suit you, we'll put any transistor into any kind of custom package you need. Or we'll build it into a hybrid assembly to your specifications. Or we'll sell you the chip. Just ask the company that gets the ideas and delivers the goods in RF power, too. Raytheon Semiconductor, Mountain View, California. (415) 968-9211.



Immediate delivery from your Raytheon distributor.

Alabama
Huntsville
Cramer/Huntsville, Inc.
(205) 536-4493

Arizona
Phoenix
Avnet
(602) 272-6821

California
Culver City
Avnet
(213) 836-7200

Inglewood
Liberty Electronics
(213) 776-6252

Los Angeles
Kierulff Electronics
(213) 685-5511

Mountain View
Avnet
(415) 961-7700

Mountain View
Elmar Electronics
(415) 961-3611

Palo Alto
Kierulff Electronics
(415) 968-6292

San Carlos
Intermark Electronics
(415) 961-5222

San Diego
Avnet
(714) 279-1550

Colorado
Denver
Avnet
(303) 623-6255

Connecticut
North Haven
Cramer Electronics
(203) 239-5641

Florida
Fort Lauderdale
Cramer/Florida, Inc.
(305) 566-7511

Fort Lauderdale
Hallmark of
Ft. Lauderdale
(305) 563-3271

Orlando
Hallmark
Electronics Corp.
(305) 855-4020

Palm Beach Gardens
Industrial Electronics Assoc.
(305) 848-8686

Georgia
Atlanta
Cramer/Atlanta, Inc.
(404) 451-5421

Illinois
Rosemont
Hallmark Electronics
(312) 299-6602

Schiller Park
Pace/Avnet
(312) 678-6310

Kansas
Prairie Village
Avnet
(913) 362-3250

Maryland
Baltimore
Cramer/Baltimore, Inc.
(301) 354-0100

Baltimore
Radio Electric Service
Company of Baltimore
(301) 823-0070

Rockville
Cramer/Washington, Inc.
(301) 424-2700

Rockville
Pioneer Washington
Electronics
(301) 427-3300

Silver Springs
Radio Electric
Service Company
(301) 588-5140

Massachusetts
Burlington
Avnet
(617) 272-3060

Newton
Cramer Electronics
(617) 969-7700

Michigan
Detroit
Avnet
(313) 538-1000

Minnesota
Bloomington
Cramer Electronics
(612) 881-8678

Minneapolis
Avnet
(612) 920-5866

Missouri
St. Louis
Hallmark Electronics
(314) 521-3800

New Jersey
Jersey City
KRS Electronics, Inc.
(201) 435-3600

Pennsauken
Cramer Pennsylvania
(215) 923-5950

New Mexico
Albuquerque
Avnet
(505) 265-7926

Albuquerque
Century Electronics
(505) 265-7837

New York
Baldwin, L.I.
Hamilton Electro Sales
(516) 223-8000

East Syracuse
Cramer/Eastern, Inc.
(315) 437-6671

Elmhurst
Cramer/Esco, Inc.
(212) 478-4000

Great Neck, L.I.
Time Electronics Sales
(516) 487-0100

South Rochester
Cramer/Rochester
(716) 275-0300

Westbury, L.I.
Avnet
(516) 333-5800

North Carolina
Raleigh
Cramer/Raleigh, Inc.
(919) 876-2371

Ohio
Cincinnati
Cramer/Tri-States, Inc.
(513) 771-6441

Cleveland
W. M. Pattison
Supply Co.
(216) 441-3000

Pennsylvania
Hatboro
Avnet
(215) 052-6900

Pittsburgh
Cameradio Company
(412) 391-4000

Texas
Dallas
Avnet/Contact Electronics
(214) 638-2850

Utah
Salt Lake City
Cramer/Hyer
(801) 487-3681

Washington
Seattle
Avnet
(206) 623-8824

Seattle
Kierulff Electronics
(206) 763-1550

Wisconsin
Milwaukee
Hallmark Electronics
(414) 476-1270

Canada
Montreal
Avnet Electronics
of Canada, Ltd.
(514) 381-9127

Ottawa
Wackid Radio & Television
Labs, Ltd.
(613) 728-1821

Toronto
Avnet Electronics
of Canada, Ltd.
(416) 789-1838

RAYTHEON

Circle 26 on Inquiry Card

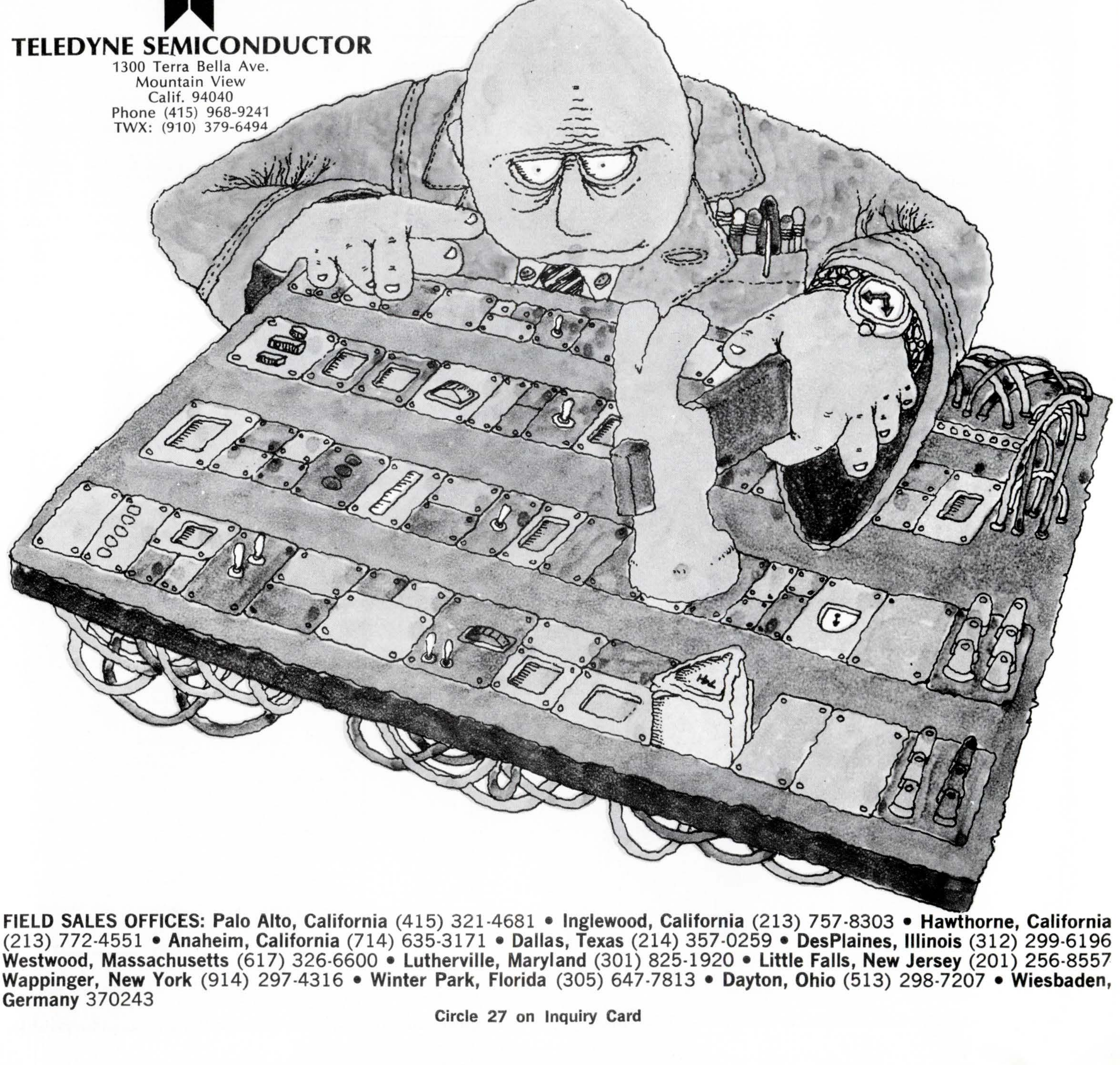
KNOWING THAT TELEDYNE SEMICONDUCTOR MAKES LINEAR MICROCIRCUITS CAN BE HELPFUL

If you don't know about Teledyne's Linear Microcircuits, mail the ad response card today and we'll send you our new catalog which contains specifications on over 75 different Operational Amplifiers, Comparators, Sense Amps, Voltage Regulators, Differential Amplifiers, RF/IF and Video Amplifiers.

After you've read all of that, and still want to know why we're the fastest growing Linear Microcircuit producer, call your local Teledyne field office or one of our 42 stocking distributors.

If you do know about us, you also know that we have a reputation for problem solving, quality manufacturing and meeting delivery dates.

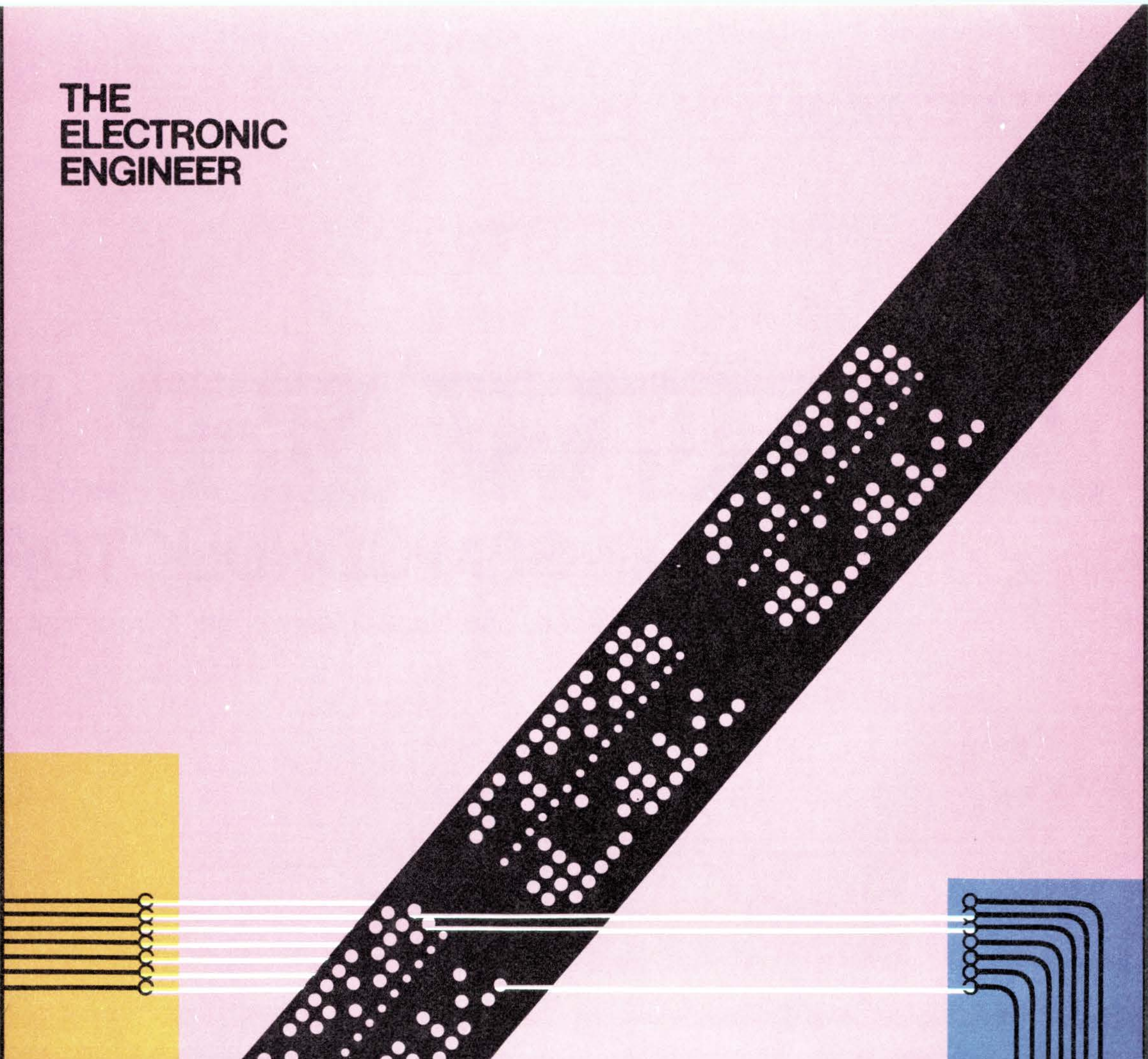
TELEDYNE SEMICONDUCTOR
1300 Terra Bella Ave.
Mountain View
Calif. 94040
Phone (415) 968-9241
TWX: (910) 379-6494



FIELD SALES OFFICES: Palo Alto, California (415) 321-4681 • **Inglewood, California** (213) 757-8303 • **Hawthorne, California** (213) 772-4551 • **Anaheim, California** (714) 635-3171 • **Dallas, Texas** (214) 357-0259 • **DesPlaines, Illinois** (312) 299-6196 **Westwood, Massachusetts** (617) 326-6600 • **Lutherville, Maryland** (301) 825-1920 • **Little Falls, New Jersey** (201) 256-8557 **Wappinger, New York** (914) 297-4316 • **Winter Park, Florida** (305) 647-7813 • **Dayton, Ohio** (513) 298-7207 • **Wiesbaden, Germany** 370243

Circle 27 on Inquiry Card

THE
ELECTRONIC
ENGINEER



A course on
OPTOELECTRONICS

Background on optoelectronics

Optoelectronic components

Applications of optoelectronics

OPTOELECTRONICS Part 1

A NEW ERA
FOR SEMICONDUCTORS

Simply stated, optoelectronics will enjoy rapid growth.

By John C. Haenichen, Vice President and Director of Operations and Services, Semiconductor Products Div., Motorola Inc., Phoenix, Arizona.

Since the invention of the transistor, the optical effects of semiconductors have plagued engineers in the field. If the transistor case was the least bit transparent, spurious performance would result because the unwanted light impinging on the surface of the crystal generated a charge.

Today, however, these same optical characteristics, present in a very narrow band within the electromagnetic spectrum, are quickly bringing us to the dawn of another major era in the history of the electronics industry: the era of optoelectronics.

As with every other significant technological development, the entire field of optoelectronics is coming to the fore because both the technology and the market are rapidly becoming practical realities. The emphasis is on the word "both."

Up until now, the development emphasis within the field of optoelectronics had been placed on sensors. The reason for this is that, during the past 20 years, the silicon technology became highly developed, and silicon devices have provided a useful response in the infrared and visible range. Over the years, the silicon technology matured as billions of transistors and integrated circuits were built. It just so happens that, with minor modifications in silicon processing, optical sensors such as photodiodes and photo-transistors can be built. Furthermore, using IC technology, arrays of sensors can be built on a monolithic piece of silicon. Arrays of sensors are already performing highly sophisticated tasks.

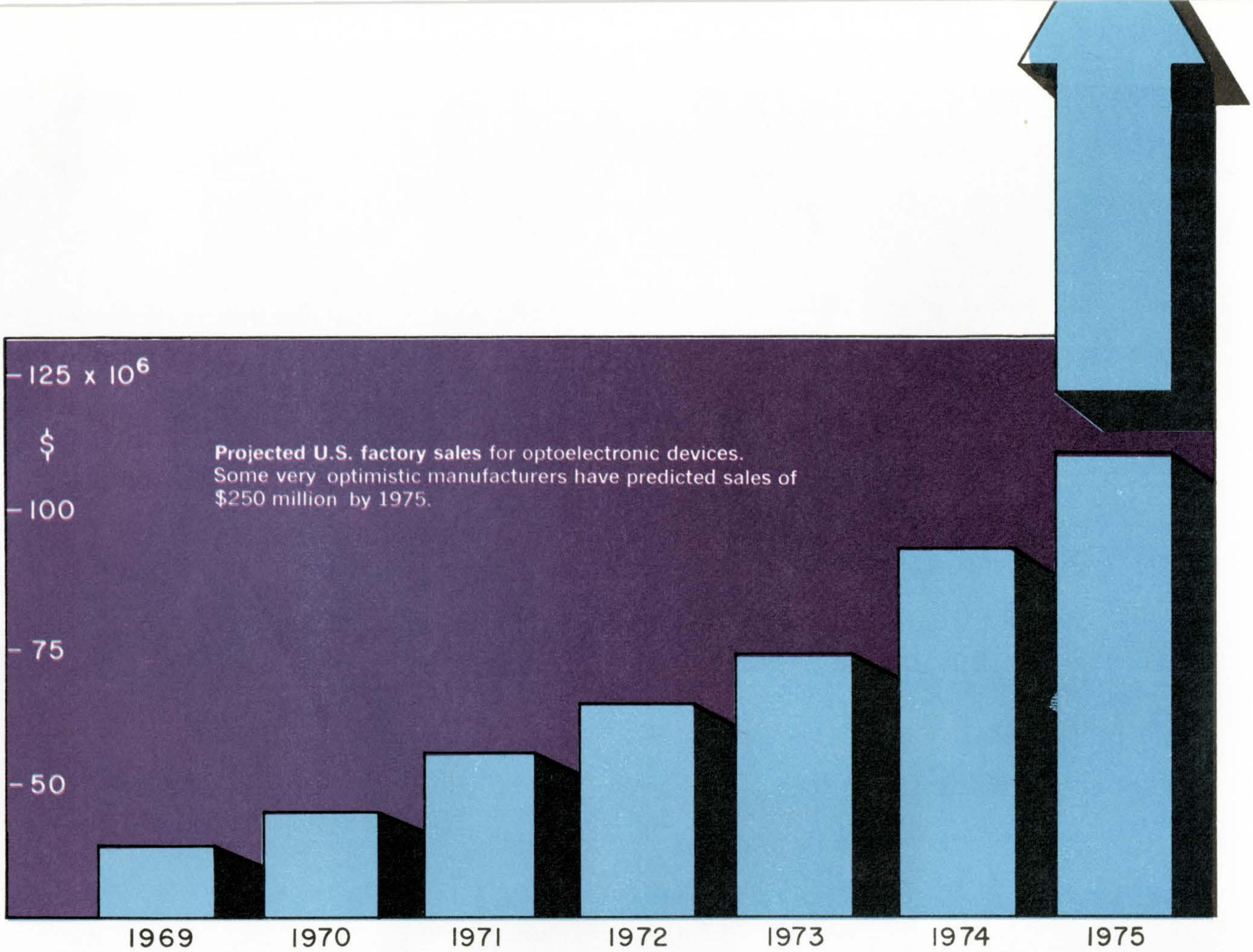
The delaying factor in the development of emitters, up to now, has been the fact that visible light emission does not take place in ordinary semiconductor materials, such as germanium and silicon. To get emission of the proper wavelength and hence visible to the human eye, metallurgists and chemists had to turn their attention to compound materials, such as gallium phosphide or the even more complex gallium arsenide phosphide.

Tremendous breakthroughs in handling these difficult materials are necessary, and these are occurring today at an increasing rate. In a sense, the complete technology exists today—although light emitters cannot yet be built in the very large quantities (and at the subsequent low prices) that will be required for mass implementation. This obstacle, however, will be eliminated within the next two years and the future looks very bright for visible and infrared devices.

Light sensors are starting to be used in large numbers today, mainly in applications requiring no human intervention. For example, equipment with light sensors is used to inspect plywood in saw mills, and fabric rolls in knitting mills. Computer card readers are employing more and more light sensing devices, not only because of the efficiency and reliability of the optical devices, but also because they can scan information at a fast rate. And, light sensors are being used in cameras of all types.

The years ahead

In the years immediately ahead of us, important developments will involve some interaction between semiconductors and the human eye. The optical sense has evolved over the years as man's primary sense, resulting in some very interesting developments. Countless products are sold on the basis of optical perception.



Projected U.S. factory sales for optoelectronic devices. Some very optimistic manufacturers have predicted sales of $250 million by 1975.

Styling, color and designs have a great influence on our everyday lives. But the most dramatic development and one which has a direct bearing on the future of optoelectronics, is the ability to transmit information, optical characteristics and even ideas, electronically, and to have their eventual interpretation in a visual form via a CRT or similar optical readout.

This leads to another point. After all of the obstacles in developing the optoelectronic technology have been overcome, the factor limiting the broad application of optoelectronic devices will move to a higher plane, in a marketing sense. If the greatest use for optoelectronic devices will be character recognition, as I believe it will be, then their growth will be limited primarily by the growth of the computer peripheral equipment business.

Let's just look at one possible use for optoelectronic devices in the highly-computerized world of tomorrow.

Recognizing people

Every human being has learned to recognize certain characteristics about a person that are specific to that person. Machines will eventually be made to make those same judgments in recognition, perhaps even more accurately than a person can. These machines for instance, will be able to determine a person's identity based on his facial features, on his signature, or even on his fingerprint.

This peripheral equipment, linked to a centralized computer, will be found in virtually every retail outlet in the country. Any customer requesting credit, will only have to sign his name or place his thumbprint on the machine's visual plane to be positively identified by the clerk. Such a system will eliminate the problems of credit card loss or theft with which we are faced today. This large market for optoelectronic devices will emerge before the end of this decade. This is slower than some optimists are presently predicting, but it's based on the speed with which our computer technology is reaching the lower, or retail levels of business.

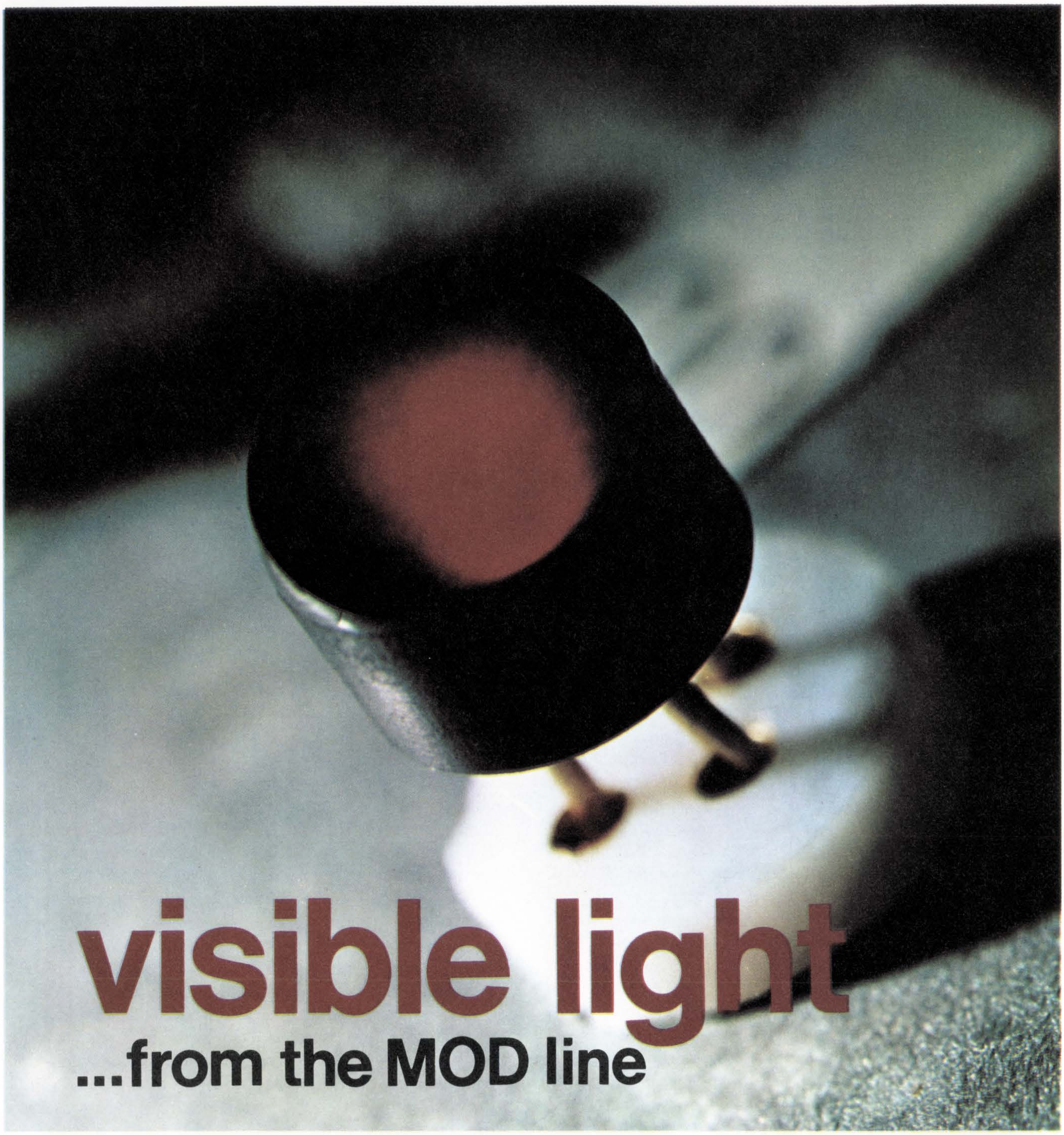
The application of character recognition equipment in the home is also an exciting possibility. When you consider that a multiplicity of optoelectronic devices will be required for each machine, you can see why the industrial predictions are so optimistic.

Another tremendous market which will develop as technological and price breakthroughs are made is the use of light emitters in visual displays. Simple numeric readouts are with us today, and these will increase over the next three or four years. Eventually, we will see the development of highly-sophisticated, multi-color displays, with thousands of light emitting diodes of different colors, placed side by side in arrays and excited by many sets of lines driven by ICs. This, of course, could lead to the development of the much talked about picture-frame TV receiver.

In the meantime, small but important steps are being made in the laboratories, in the production areas, and in the marketplace, to bring optoelectronics closer and closer to its ultimate potential.

INFORMATION RETRIEVAL

Optoelectronics, Semiconductors



If you need a visual indication of what is happening in your system, equipment or instrument you should be using the FLV100 or FLV101 light emitting diode. Either one will provide you with a bright red status indicator. These products feature ■ Low cost (99c in 10,000 quantities) ■ High brightness (typically 1500 foot lamberts for the FLV100) ■ Mechanical rigidity (impervious to mechanical shock and vibration) ■ Solid state reliability ■ Moisture resistance (65°C and 95% relative humidity) ■ Low power consumption (within drive capability of standard digital IC's) ■ Wide viewing angle (160 degrees for FLV101) ■ Plug in package for easy mounting

You can have either a large area, wide viewing angle indicator (the FLV101) or a highly intense point light source (the FLV100) for the same low price. Whether you need one lamp for an ON/OFF switch or thousands for a complex panel display you should contact Fairchild MOD.

Fairchild Microwave and Optoelectronics Division (MOD), in addition to these devices, makes a complete line of optoelectronic products.

Your local Fairchild MOD distributor, listed to the right, has sensors and emitters in stock. You can order the devices you need from him or if you need detailed information he will be glad to send you data sheets.

The FLV100 and FLV101 are the latest optoelectronics devices from Number 1. Keep watching Number 1 because more new products are on the way.

FAIRCHILD MOD DISTRIBUTORS

SCHWEBER ELECTRONICS
(516) 334-7474 (617) 891-8484 (416) 925-2471 (305) 927-0511
(301) 427-4977 (205) 539-2756 (216) 336-7020

HAMILTON/AVNET SALES
(213) 870-7171 (415) 961-7000 (713) 526-4661 (602) 272-2601
(714) 279-2421 (206) 624-5930 (303) 433-8551 (503) 255-8550

COMPUTER COMPONENTS CORP
(214) 239-0271

SEMICONDUCTOR SPECIALISTS, INC.
(312) 279-1000 (313) 255-0300 (513) 278-9455 (412) 351-3611
(317) 243-8271 (612) 861-3400 (314) 423-6500

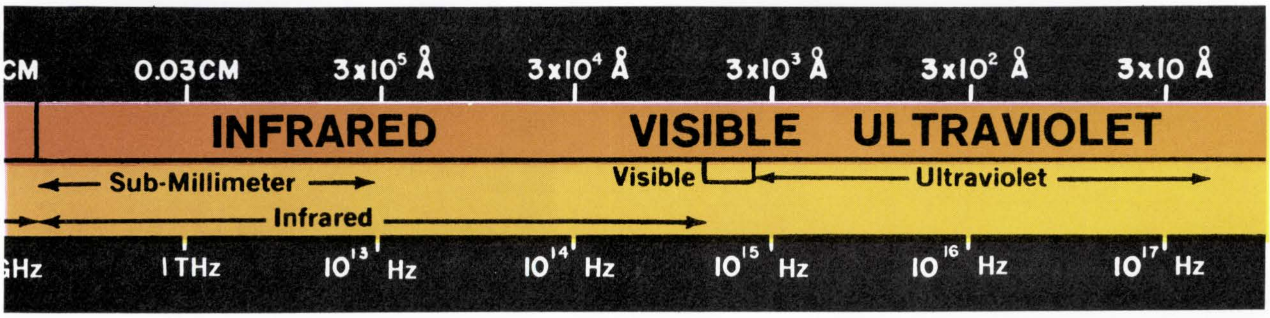
FAIRCHILD
MICROWAVE AND OPTOELECTRONICS
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION
2513 Charleston Rd., Mt. View, Ca. 94040

Circle 1 on Inquiry Card

OPTOELECTRONICS Part 1

THE BASICS

Ask any five engineers, "What is optoelectronics?" and you will get five answers. For now, let's say it involves a combination of solid state technology and light.



By Lin C. Wetterau, Jr. and Dr. Robert L. Williams

Optoelectronics, Texas Instruments Incorporated, Dallas, Texas.

Emerging now is an important technology—Optoelectronics, a field covering those electronic functions that respond to light.

Market history

Since the last decade the word "optoelectronics" has been commonly used to designate a field of electronics. The newer technology areas—silicon sensors, light emitting diodes, and lasers, when used in electronic functions—are the glamour areas of the field. Many areas that were not originally thought of as optoelectronics are being drawn into the new classification in spite of their development in older technologies. For instance, CdS photocells and phototubes have been in use for many years. In addition, newer technology, such as that which uses GaP photocathodes in photomultipliers, brings in a new semiconductor technology as does the silicon diode array vidicon. Evolution towards the new field appears to be taking place in all the areas that a broad definition of optoelectronics includes.

The use of light

Although we are relatively familiar with light and its characteristics, light combined with electronics to perform a task is only a recent development.

Light is radiant energy; and it is generated, focussed, transmitted, absorbed and detected in a variety of ways. Radiant energy which cannot be detected by the eye is often included in the term "light," providing it can be manipulated by the optical techniques used in the region of visible light. For the purposes of this course, light for optoelectronic devices will include radiant energy transmitted by wave motion at wavelengths from 0.3 to 30.0 μm. These given characteristics of radiant energy were established from years of experience with radio and microwave energy.

It is easy to use light. Simple lenses, detectors and sources, while small, are considered large when compared to the micrometer wavelength of this electromagnetic radiation. Because of the small wavelength, we can collimate beams with low cost lenses.

Light control

Reading IBM-type cards, is a common application using light. This application illustrates, in a very effective way, one of the unique characteristics of light—it is easily contained and controlled. (Later in the course you will learn about many other applications.)

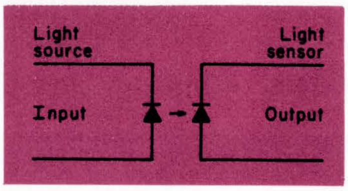
Most materials are opaque to light: paper, many plastics, metals—essentially all materials except glass and clear plastics. This array of materials to block and control light, however, is not available for microwaves.

We have shown that light is easily blocked or a light pattern is easily generated by simple, common materials such as paper or plastic. For microwaves, by contrast only metals will perform this function.

Isolation

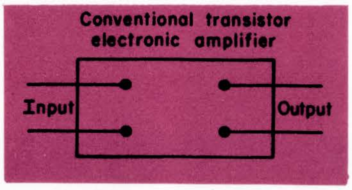
The very high isolation characteristics possible in optoelectronic systems is another aspect of the new technology not generally realized. A light source is a very, very poor light detector and, in the same way,

OPTOELECTRONICS Part 1



Coupling of signal imposed on output is isolated from input because:

1. A light source is a poor detector
2. Detectors generate little light
3. No common mode noise path exists



Coupling of signal at output to input is limited by:

1. Reverse feedback characteristic of transistor or
2. Common mode coupling path through associated circuitry.

a light detector is a very, very poor light source, hence, a good oscillator. An optoelectronic pair, source and detector, used to isolate input from output can easily have 120 dB of isolation. This is an effective contrast to high quality amplifiers where 60 dB is a good figure.

Transmission of light

As mentioned above, light is easily contained and controlled, but it must be transmitted to be used.

Transmission of radiant energy occurs through many media, air being the most common. Air will transmit energy with little attenuation at certain wavelengths. We are aware of the attenuation of visible light through fog and clouds. Not as well-known is the fact that the atmosphere transmits much more effectively at some wavelengths than at others. The atmosphere has windows for various spectral regions through which energy passes with little attenuation. Air, acting like an electronic bandpass filter, determines the effective operating wavelength for systems having long air paths. Again, certain wavelengths are better than others for transmission through the atmosphere, but an all-weather system comparable to microwaves does not seem likely.

The short wavelength of light leads to the scattering and absorption of light in the atmosphere, and it is this property that is required if holographic storage of data is to be achieved economically in small volume.

Absorption

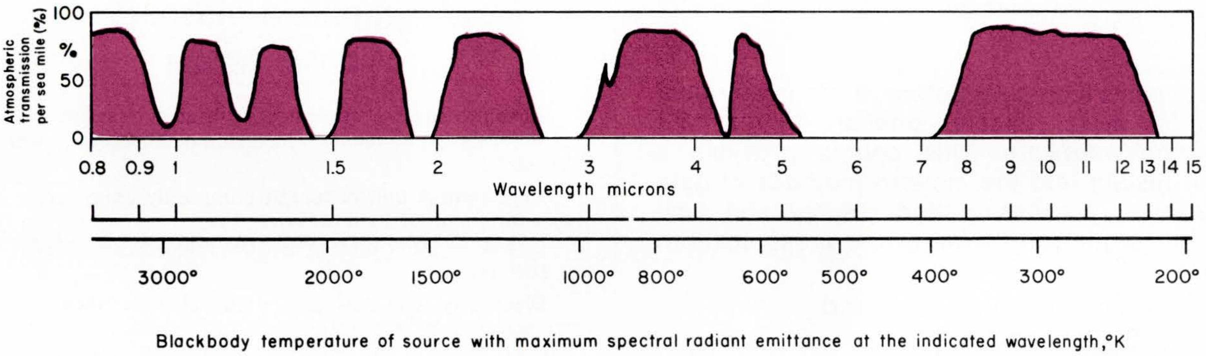
Absorption in materials is useful for the isolation and containment of radiant energy. Indeed, most systems are based to one degree or another on concepts of selectively absorbing energy in one place or transmitting it to another. Such elementary systems as door openers or tape transport loop controls depend on opaque or nontransmitting material interrupting the light beams.

The concept of absorption is important in considering the way in which a semiconductor detects radiant energy. For detectors, light must enter the semiconductor material. The light energy is absorbed into the material, creating hole-electron pairs which are then collected or measured by their effect on the semiconductor device. Materials absorb light at different wavelengths in varying amounts.

Semiconductor materials have been classified by their absorption limits, making the selection of a material for designing a detector a relatively simple process. For example, silicon readily absorbs radiant energy in wavelengths below 0.9 μm. Above 1.1 μm the silicon will absorb little light. Effectively becoming transparent to the longer wavelengths. This absorption characteristic places a limit on the longest wavelength for a system using silicon devices. Should system requirements dictate, other materials can be selected to extend or change the operating wavelength.

The absorption effects in light emitters are vital in optimizing the output from a semiconductor light source. Semiconductor light emitters generate radiant energy within the material and the material may be opaque or highly absorptive. The object, of course, is to get the generated light out of the device and to its

This plot of a portion of the "light" spectrum shows how transmission through the atmosphere can vary.



intended target. Any absorption would only reduce the overall efficiency of the light emitter. Again careful selection of materials can minimize the effects of this absorption at various wavelengths.

As you can imagine, the selection of any optoelectronic material involves a compromise of many considerations. Mechanical and technological reasons may often predominate in the selection of material as well. The great body of information and techniques available in silicon materials processing, for example, will cause Si detectors to remain a dominant factor in the optoelectronic market. A summary of optoelectronic materials is included in the wall chart "Guide to optoelectronic devices" appearing elsewhere in this issue.

Optoelectronic components

The components of optoelectronics are divided into two principle areas, detectors and sources.

Sources: The most established light sources are various incandescent lamps. Light emitting diodes and all types of lasers will have major optoelectronic impact in the near future. While these semiconductor devices may have efficiency and high intensity their total power is not yet high—a limitation to universal use.

More sophisticated functions require more elaborate sources. The simple requirement of a narrow spectral source can better be supplied by a light emitting diode than by a thermal source and a filter. In the extreme case of an optical memory very coherent radiation is required, and the source becomes very complex and costly. When the cost and size of laser sources are reduced, a much wider-spread use will occur.

Component performance

Measurement of detector performance requires an understanding of the light source. Tungsten bulbs create a variety of problems from the emission characteristics of the radiating element and encapsulation system, to the mechanical stability of the filament. Semiconductor emitters offer narrow spectral output without filtering, but introduce new problems of size and optical coupling with air and other transmission mediums such as glass fiber bundles.

Measurement of dc parameters common to semiconductor devices is not a great problem. But, measurement of optoelectronic performance immediately brings up the question, "What is the standard for light intensity and how can it be controlled?"

The concept of irradiance, or watts of radiant energy incident upon a surface, is important in the measurement of output from a wide variety of sources. The spectrum of a source is also important in determining how the radiant energy is related to various wavelengths.

The nature of a tungsten bulb causes it to shift its output power and spectral distribution as the temperature of the emitting wire is changed by current flow. Long-term calibration of light sources to ±5% can be achieved, but with much difficulty. This is a major difference between optoelectronic device specifications and those of standard transistors and ICs, where limitations are imposed only by the accuracy of ac-dc instrumentation.

Other portions which follow Part 2 of this course will cover in more detail the components which form key parts of optoelectronics and their application to important systems functions. For your convenience, a simplified glossary of basic optoelectronic terms has been included. You'll also find a list of references for more detailed study of this portion of the course.

A simplified glossary of basic terms

Absolute spectral response: Output or response of a device vs. wavelength in terms of absolute power levels.

Angstrom: A unit of length commonly used for measurement of light wavelengths.

One $\text{Å} = 10^{-10}$ meters $= 10^{-4}$ microns $= 3.937 \times 10^{-9}$ in.

Blackbody: The device to which all irradiance measurements are referenced. A blackbody is a perfect radiator and absorber of radiant energy.

Color temperature: The equivalent temperature of a blackbody source whose spectral output in the visible region nearly matches that of a non-blackbody source. It is given in °K, and serves to define the spectral energy density of a radiation source.

Dark current: The amount of current which will leak out of a photodetector under a given voltage when there is no radiation within its spectrum of sensitivity incident upon it. **Basically** it is a leakage current. The smaller the device's leakage current, the better.

Detector quantum efficiency: A ratio expressing the number of carriers generated, divided by the number of photons absorbed.

Foot candle: Unit of visible light power density.

Foot Lambert: Unit of visible light power density per solid angle.

Irradiance: Radiant power per unit area incident upon a surface. It is commonly measured in watts/cm^2.

Light current: Current which flows in a device due to light on the device.

Near infrared: Non-visible radiant energy nearest the red end of the visible spectrum.

Photon: The smallest unit of radiant energy.

Relative spectral response: Output or response of a device vs. wavelength normalized to the maximum value.

Spectrum: The range of wavelengths considered in a system.

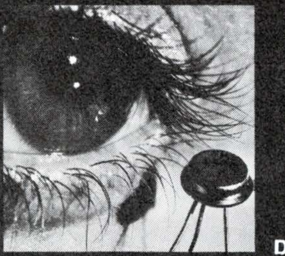
INFORMATION RETRIEVAL
Optoelectronics, Semiconductors

eye on

Published by
SCHWEBER
ELECTRONICS

Edited by
SAM KASS

OPTOELECTRONICS and DISPLAY DEVICES



DEFINITION

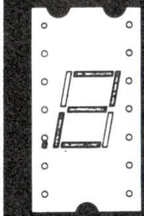
What does this big new word *Optoelectronics* mean? The *opto* part derives from the Greek word *optos* meaning visible; as for the electronics part, we assume you have some inkling as to its meaning. Putting the two parts together, we get Optoelectronics: a technology that creates visibility by electronic means. But not only the visible is optoelectronic, the invisible infrared is also optoelectronic; and by electronic you cannot assume only solid-state devices, for example, incandescent, fluorescent, and gas discharge devices also come under the heading of optoelectronic.

If you feel this does not quite define the term Optoelectronics, we agree with you. It would seem that people in the industry feel the same way because the word is conspicuously absent from the literature of the very manufacturers of these devices. Well, we've decided that the syllables of Optoelectronics carry the necessary authority and resonance to describe any device that is guilty of ostentatious display regardless of the materials and technology employed.

It may be worthwhile to list the synonyms now clustered under the Optoelectronics umbrella. Computer argot contributed the word Readout; NIXIE® tubes are called Indicators; there is the word Display which is usually preceded by such adjectives as digital, numeric, and alphanumeric; also light emitters and luminescent arrays. And finally that whole class of light detectors, more often called photo devices, light sensors, and optical arrays.

This is the territory covered by the title on the masthead — a real broad spectrum. Words change with the times. What was once called "hot" jazz is now called "cool" and so the usage and the times will do more to define the term than the dictionary.

50 FAR-OUT LIGHT MAKERS



A couple of years ago, Monsanto's far-out light makers weren't even mentioned in Optoelectronic roundups like this one. Now they're up there, with a full line of light emitting diodes (LEDs). Of the eleven listed, one emits an amber light, another puts out green, four others are bright red, and five are in the infrared region. They have nanosecond switching time and million hour life. A photo-coupled pair is also listed with detector and emitter in the same package that will give you a light-quick switch with 3 Kv isolation. Two Monsanto highlights are worth noting. One is a red LED, type MV50, which is the first low cost solid state visible light source. Selling prices: 1 to 99, 2.30 ea; 100 to 999, 1.95 ea; 1000 up, 1.50 ea.

The other highlight is the popular model MAN 1 which is a seven-segment alphanumeric display. It is compatible with integrated circuits, operating on the same voltages and packaged in a 14-pin DIP configuration. The size of the charactor displayed is ¼″; another version labeled MAN 3 has a character size of ⅛″. Check reader reply #50 for Monsanto catalog. Selling prices:

	1 to 9	10 to 99	100 to 999	1000 up
MAN 1	18.75	15.75	14.80	11.00
MAN 3	12.45	9.80	8.30	7.55

51 WIDE ANGLE DISPLAY

Drawing upon their long experience in making vacuum tubes, RCA's digital display device, labeled Numitron®, is an incandescent type packaged inside a 9-pin miniature circular-based vacuum tube. Segmented digits are viewed against a dark background which provides a sharp, high brightness display easily viewable in high ambient-light conditions. Segment voltage is low (4.5v) and light emission is of the wide spectrum type permitting the use of filters to obtain any desired color. The "up-front" display surface permits a wide viewing angle with uncluttered display. The Numitron can be driven by standard IC decoder/drivers, including a series made by RCA, and may be operated in either a direct or multiplex mode. Check reader reply #51 to receive data sheet.

52 IN THE BEGINNING . . .

Burroughs NIXIE® tubes were one of the first, and still remain one of the industry's most popular display devices for digital readout applications. There are five sizes from miniature to jumbo size; also available are side- and top-viewing; plug-in and lead versions; numeric and alphanumeric. The popular B5750 is a side-viewing tube of high quality and low cost: 1 to 24, 6.75 ea; 25 to 99, 5.75 ea; 100 to 499, 4.95 ea; 500 up 4.50 ea.

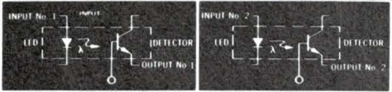
Complete wired assemblies of multidigit modules incorporating integrated circuit decoder/drivers, memories, and decade counters with NIXIE tubes included can be specified with a single catalog number. The C2502 has five decoder/driver ICs wired to five NIXIE tubes on a printed circuit board terminating in an edge-type connector. The C2504 is the same except that the memory function is included. The C2506 is a decade counter with a 4-bit strobed latch circuit and decoder/drivers. These three multidigit assemblies are stocked by Schweber. Check reader reply #52 to receive Burroughs NIXIE Specifying Guide, and the C2500 Series Multidigit Assembly Catalog.

53 AND NOW . . .

Burroughs has announced an invention trade-marked SELF-SCAN® panel display that permits time sharing in a flat panel display using gas discharge light emitters. Only three clock controlled cathode drivers are required regardless of the number of digits, a truly magnificent achievement. Check reader reply #53 to receive Burroughs SELF-SCAN panel display data sheet.

54 SWITCH WITH LIGHT

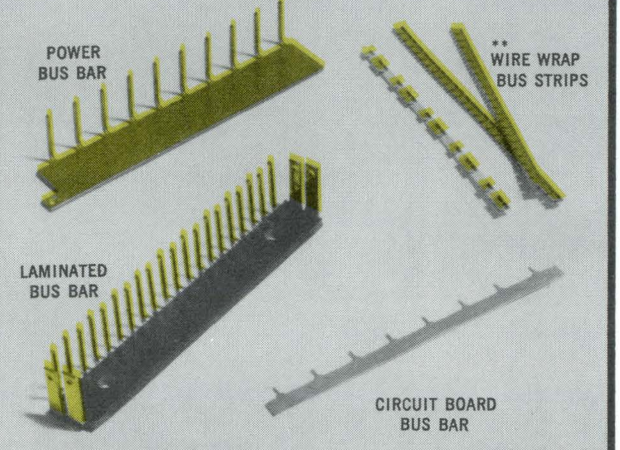
Photo coupled pair (Monsanto MCT-1) suggests possibilities of multiple input/multiple pole output combinations similar to relay arrangements. Check reader reply #54 for data sheet.



WESTBURY, NEW YORK: 516/334-7474 ☐ WALTHAM, MASS: 617/891-8484 ☐ ROCKVILLE, MD: 301/427-4977 ☐ CLEVELAND, OHIO: 216/333-7020
HUNTSVILLE, ALA: 205/539-2756 ☐ HOLLYWOOD, FLA: 305/927-0511 ☐ TORONTO, CANADA: 416/925-2471

SCHWEBER
ELECTRONICS

BUS BARS BY BUSSCO



CIRCUIT BOARD BUS BAR

Eliminates the need for a multi-layer circuit board by distributing power and ground on a card with distributed capacitance.

POWER BUS BAR

A solid conductor available in any thickness depending on current requirements. Choice of terminal types.

WIRE WRAP BUS STRIPS

Efficient and reliable devices for bussing rows of wire wrap posts.

Standard Grid Patterns in stock:
.100, .125, & .150
(Any grid pattern available per special request)

Current: #18 AWG equivalent

Lower cost per connection than automatic wire wrap

LAMINATED BUS BARS for SIGNAL, POWER & VOLTAGE DISTRIBUTION

Available in multi conductors with choice of terminals.

WIRE WRAP — SOLDER LUG — *AMP TERMI POINT

Conserves space and provides error-free, highly stable electrical characteristics.

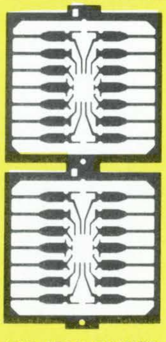
Reduces noise effectively in high-speed electronic systems

Low inductance with high capacitance

Write or call for catalog . . . today

**TRADE MARK: GARDNER DENVER CO.

*TRADEMARK: AMP, INC.



DIP LEAD FRAMES
Flatness Within .001

Inquiries invited.

BURR FREE STAMPING PROCESS

Bus bars, bus strips, DIP lead frames and custom stamped parts are produced from a unique, patented BURR FREE stamping process which provides consistency not found in ordinary stamping methods.

BUSSCO ENGINEERING, INC.

122 Penn St., El Segundo, Calif. 90245 (213) 322-6580 TWX: 910-348-6295

Circle 28 on Inquiry Card

Here is your
copy of a brand new
reference chart
sponsored by
TEXAS INSTRUMENTS
INCORPORATED

▼

Guide to OPTOELECTRONIC DEVICES

Tear it out, ▶

NOW

. . . and
mount it on
your wall

If the chart has been removed, Circle Number 41 on the Inquiry Card for a copy.

IC op amp selection charts

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

The three charts on the following pages graphically illustrate the relationship between price and the three most important op amp parameters. The three charts are:

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

The charts show a total of 389 devices—284 monolithic and 105 hybrid. Each device in the chart guide has a number next to it and each op amp is represented by that number throughout the three charts. The chart guide also lists the price per unit (in quantities of 100) to simplify the job of finding a particular device on the charts.

Slew rate (SR)

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 of slew rate assumes that the amplifier is operating with unity amplification.

Input 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. This is an average value for a specified temperature range.

Input bias current (I_{IB})

The input bias current actually has two different definitions. The first, which agrees with the EIA glossary, is that it is the sum of the input bias current entering into the two input terminals of a balanced amplifier, or, the bias current entering the input of a single-ended amplifier. In general, this definition is agreed to by manufacturers of monolithic op amps and their devices are specified according to it.

The definition above, however, is far from universally accepted. Hybrid (and also discrete) manufacturers take a different viewpoint in the case of a balanced amplifier. They contend that the correct definition is not the average of the two currents but is rather the larger of the two currents.

What all this means is that you must keep this difference in terminology in mind when using the bias current chart. A good rule of thumb is that if the particular op amp is monolithic, the bias is the average of the two inputs. If you are looking at a hybrid device, in most cases the bias is the larger of the two inputs.

For a copy of this article circle 350 on Inquiry Card.

Chart Guide to Manufacturers and Devices

Hybrid op amps

	Amelco	
1	$ 15.00	2809CG
2	17.00	2709CG
3	25.00	2809BG
4	30.00	2709BG
5	58.50	2404BG
6	58.50	2405BG
	Amperex	
7	17.00	ATF401
8	20.00	ATF404
	Analog Devices	
9	26.00	P501A
10	31.00	P501B
11	42.00	P501C
	Burr-Brown	
12	5.95	3057/01
13	7.50	3053/01
14	9.00	3056/01
15	12.75	3052/01
16	12.75	3055/01
17	14.25	3054/01
18	16.50	3051/01
19	18.00	3050/01
20	27.00	3054S/01
21	30.75	3050S/01
	Data Device	
22	13.00	007C
23	13.00	107C
24	15.00	008C-2
25	15.00	108C-2
26	16.00	007B
27	16.00	107B
28	17.00	008C-1
29	17.00	108C-1
30	20.00	007A
31	20.00	107A
32	21.00	248C-2
33	25.00	008B-3
34	25.00	108B-3
35	27.00	008B-2
36	27.00	108B-2
37	28.00	248C-1
38	29.00	008B-1
39	29.00	108B-1
40	31.00	007A-4
41	31.00	107A-4
42	34.00	248B-3
43	39.00	008A-2
44	39.00	108A-2
45	42.00	248B-2
46	51.00	008A-1
47	51.00	108A-1
48	51.00	248B-1
49	51.00	H50
50	53.00	007A-3
51	53.00	107A-3
52	60.00	248A-2
53	60.00	HC50
54	68.00	248A-1
55	68.00	HB50
56	70.00	007A-2
57	70.00	107A-2
58	75.00	007A-1
59	75.00	107A-1
	General Instrument	
60	30.00	NC210B
61	41.50	NC210A
	Keithley	
62	125.00	302
63	150.00	301K
64	185.00	301
65	200.00	300
66	250.00	50200
	Melcor	
67	13.00	1821
68	49.00	1895
69	56.00	1672
70	82.00	1941
	National Semiconductor	
71	11.60	NH0002C
72	11.70	NH0005C
73	17.00	NH0001C
74	17.40	NH0005
75	18.00	NH0004C
76	20 00	NH0002
77	27.00	NH0003C
78	40.00	NH0005A
79	45.00	NH0003
80	48.00	NH0001
81	60.00	NH0004
	Optical Electronics	
82	24.00	9406
83	36.00	9412
	Philbrick-Nexus	
84	4.50	1301
85	4.50	1303
86	6.50	T-52
87	7.65	1300
88	11.50	T82AH
89	16.00	C1A-2
90	21.50	1406
91	25.00	1408/01/02
92	40.50	1404/01
93	45.50	1405
94	52.00	1407/01
95	63.75	1402/01/02
96	104.00	1412
97	137.00	Q85AH
98	153.00	Q25AH
	Zeltex	
99	18.00	ZA101D
100	25.00	ZA801D
101	49.00	161
102	54.00	161-10
103	69.00	161-03
104	86.00	162
105	105.00	162-04

Monolithic op amps

	Advanced Micro Devices	
201	3.25	748C
202	3.25	301
203	3.25	741C
204	3.45	301A
205	3.95	307
206	5.95	748
207	5.95	741
208	7.50	201
209	7.95	715C
210	12.00	201A
211	13.00	207
212	15.00	101
213	30.00	101A
214	30.00	715
215	33.00	107
	Amelco	
216	3.95	709B
217	7.95	809B
218	8.75	811BE
219	15.00	810B
220	15.00	808B
221	15.00	741B
222	16.00	819B
223	27.80	709A
224	27.80	805BE
225	28.00	808A
226	45.00	807BE
	Analog Devices	
227	5.80	502J
228	8.00	502K
229	9.75	801A
230	13.00	801B
231	15.00	801S

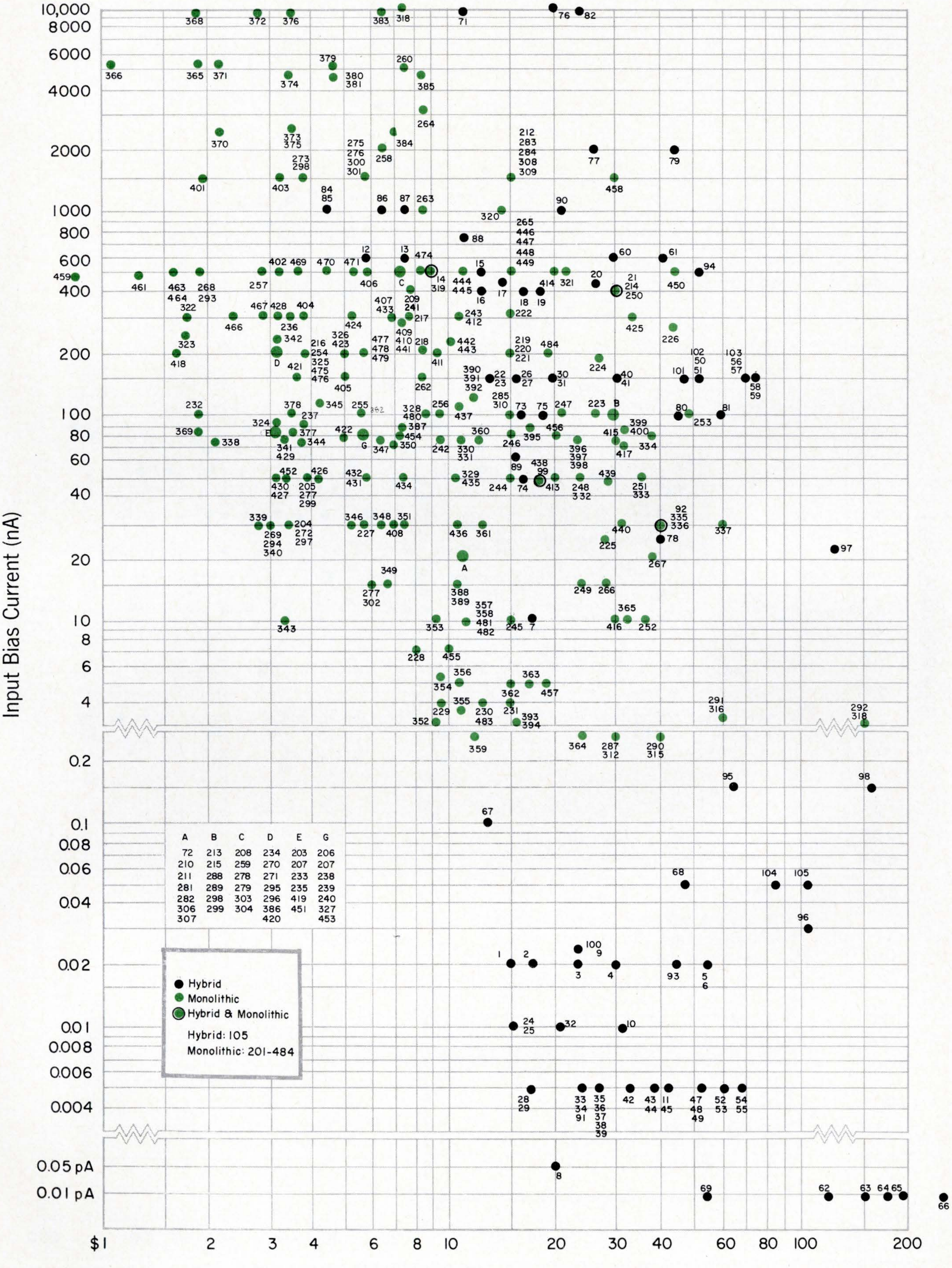
	Fairchild	
232	1.90	μA709C
233	3.25	μA741C
234	3.25	μA739C
235	3.25	μA748C
236	3.49	μA749C
237	3.90	μA709
238	5.95	μA741
239	5.95	μA747C
240	5 95	μA748A
241	7.95	μA715C
242	9.95	μA709A
243	11.95	μA749A
244	15.00	μA725C
245	15.00	μA735C
246	15.00	μA747A
247	22.50	μA740C
248	25.00	μA725B
249	25.00	μA735B
250	30.00	μA715A
251	37.50	μA725A
252	37.50	μA735A
253	49.00	μA740A
	ITT	
254	3.90	MIC709
255	5.95	MIC741
256	9.60	MIC709A
	Motorola	
257	3.80	MC1709
258	6.50	MC1520
259	7.50	MC1539
260	7.50	MC1712
261	8.50	MC1530
262	8.50	MC1531
263	8.50	MC1533
264	8.50	MC1535
265	15.00	MC1539G
266	28.00	MC1556
267	39.00	MC1536
	National Semiconductor	
268	1.90	LM709C
269	3.00	LM302
270	3.25	LM741C
271	3.25	LM748C
272	3.45	LM301A
273	3.90	LM709
274	3.95	LM307
275	5.95	LM741
276	5.95	LM748
277	6.00	LM202
278	7.50	LM201
279	7.50	LH201
280	10.00	LM308
281	12.00	LM201A
282	13.00	LM207
283	15.00	LM101
284	15.00	LH101
285	15.00	LM102
286	20.00	LM308A
287	30.00	LM208
288	30.00	LM101A
289	33.00	LM107
290	40.00	LM208A
291	60.00	LM108
292	150.00	LM108A
	Nucleonic	
293	1.90	LA709C
294	3.00	LA302
295	3.25	LA741C
296	3.25	LA748C
297	3.45	LA301A
298	3.90	LA709
299	3.95	LA307
300	5.95	LA741
301	5.95	LA748
302	6.00	LA202
303	7.50	LA201
304	7.50	LAH201
305	10.00	LA308
306	12.00	LA201A
307	13.00	LA207
308	15.00	LA101
309	15.00	LAH101
310	15.00	LA102
311	20.00	LA308A
312	30.00	LA208
313	30.00	LA101A
314	33.00	LA107
315	40.00	LA208A
316	60.00	LA108
317	150.00	LA108A
	Optical Electronics	
318	7.30	9300
319	9.00	9314
320	14.00	9302
321	23.00	9308
	Philco	
322	1.75	7709C
323	1.75	7712C
324	3.10	7741C
325	3.80	7709
326	5.00	7712
327	5.95	7411
328	8.80	7709A
	Precision Monolithics	
329	11.70	SSS741B
330	13.00	SSS201A
331	14.50	SSS207
332	24.00	SSS747B
333	36.00	SSS741
334	37.50	SSS725
335	40.00	SSS101A
336	40.00	SSS107
337	60.00	SSS747
	Qualidyne	
338	2.18	QC741C
339	2.85	QC301A
340	3.02	QC307
341	3.25	QC748C
342	3.25	QC201
343	3.32	QC1041C
344	3.99	QC741
345	4.36	QC101
346	5.53	QC201A
347	6.37	QC748
348	6.43	QC207
349	6.70	QC1100C
350	7.04	QC747C
351	7.50	QC2307
352	9.05	QC308
353	9.05	QC1456
354	9.60	QC1735-9
355	11.06	QC101A
356	12.00	QC1735-3
357	12.40	QC1041A
358	12.40	QC107
359	13.07	QC208
360	13.74	QC747
361	14.74	QC2207
362	15.00	QC1735-1
363	17.76	QC1556
364	25.80	QC108
365	33.50	QC2107
	RCA	
366	1.18	CA3029
367	1.90	CA3010
368	1.90	CA3030
369	1.90	CA3047
370	2.28	CA3029A
371	2.28	CA3037
372	2.88	CA3015
373	3.48	CA3010A
374	3.48	CA3030A
375	3.48	CA3037A
376	3.48	CA3038
377	3.48	CA3033
378	3.48	CA3047A
379	4.68	CA3008
380	4.68	CA3015A
381	4.68	CA3038A
382	5.88	CA3033A
383	6.48	CA3016
384	7.08	CA3008A
385	8.28	CA3016A
	Radiation	
386	3.50	RA2911
387	7.50	RA2909
388	10.70	RA2605
389	10.70	RA2625
390	12.80	RA2505
391	14.00	RA2515
392	14.00	RA2525
393	17.85	RA2600
394	17.85	RA2620
395	18.50	RA909
396	24.80	RA2500
397	27.25	RA2510
398	27.25	RA2520
399	33.00	RA2909A
400	36.30	RA909A
	Raytheon	
401	1.90	RC709
402	3.25	RC741
403	3.25	RC4709
404	3.90	RM709
405	5.00	RC4131
406	5.95	RM741
407	7.00	RC4741
408	7.00	RC4132
409	7.50	RC101A
410	7.50	RC107
411	9.35	RM709A
412	12.00	RM4709
413	20.00	RM4131
414	20.00	RM4741
415	30.00	RM101A
416	30.00	RM4132
417	33.00	RM107
	Signetics	
418	1.65	N5709
419	3.00	N5741
420	3.00	N5748
421	3.75	S5709
422	5.00	S5741
423	5.00	S5748
424	5.10	N516
425	35.00	S516
	Silicon General	
426	3.05	SG741C
427	3.10	SG748C
428	3.20	SG301
429	3.25	SG301A
430	3.75	SG307
431	5.65	SG748
432	5.80	SG741
433	7.00	SG201
434	7.10	SG747C
435	10.80	SG201A
436	11.80	SG207
437	14.00	SG101
438	17.10	SG747
439	28.00	SG101A
440	31.00	SG107
	Siliconix	
441	7.50	LM201H
442	10.50	LM201F
443	10.50	LM201D
444	12.50	LH101H
445	12.50	LM101H
446	15.50	LH101F
447	15.50	LH101D
448	15.50	LM101F
449	15.50	LM101D
450	45.50	L174
	Solitron	
451	3.25	UC4741C
452	3.25	UC4301A
453	5.95	UC4741
454	7.05	UC4747C
455	10.00	UC4250C
456	20.00	UC4747
457	28.00	UC4250
458	30.00	UC4101A
	Texas Instruments	
459	0.85	SN72709N
460	0.90	SN72702N
461	1.35	SN52709N
462	1.45	SN52702N
463	1.60	SN52709BN
464	1.65	SN52709AN
465	1.85	SN52702AN
466	2.40	SN72741B
467	2.95	SN72741N
468	3.18	SN72702F
469	3.72	SN72709F
470	4.66	SN52709BF
471	5.77	SN52709F
472	6.01	SN52702F
473	7.79	SN52702AF
474	8.36	SN52709AF
	Transitron	
475	3.70	TOA1709
476	3.70	TOA1809
477	5.75	TOA1741
478	5.75	TOA1747
479	5.75	TOA1748
480	7.50	TOA4709
481	11.50	TOA7741
482	12.80	TOA7709
483	13.95	TOA7809
484	19.50	TOA7748

For further information on the manufacturers and their products, circle the following numbers on the Inquiry Card.

Advanced Micro Devices	Circle Number 201
Amelco	Circle Number 202
Amperex	Circle Number 203
Analog Devices	Circle Number 204
Burr-Brown	Circle Number 205
Data Device Corp.	Circle Number 206
Fairchild	Circle Number 207
General Instrument	Circle Number 208
ITT	Circle Number 209
Keithley	Circle Number 210
Melcor	Circle Number 211
Motorola	Circle Number 212
National Semiconductor	Circle Number 213
Nucleonic	Circle Number 214
Optical Electronics	Circle Number 215
Philbrick-Nexus	Circle Number 216
Philco-Ford	Circle Number 217
Precision Monolithics	Circle Number 218
Qualidyne	Circle Number 219
RCA	Circle Number 220
Radiation	Circle Number 221
Raytheon	Circle Number 222
Signetics	Circle Number 223
Silicon General	Circle Number 224
Siliconix	Circle Number 225
Solitron	Circle Number 226
Texas Instruments	Circle Number 227
Transitron	Circle Number 228
Zeltex	Circle Number 229

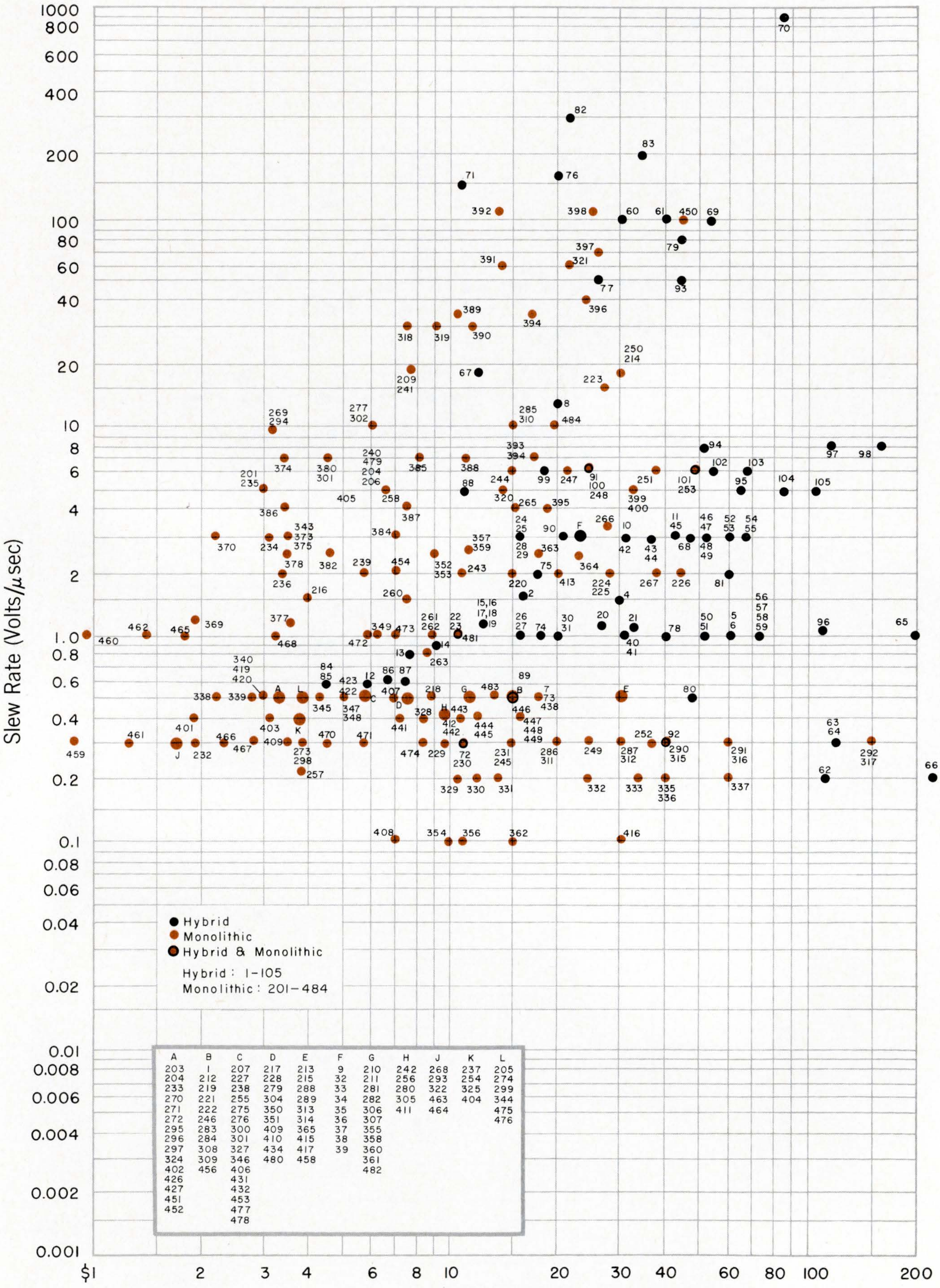
INFORMATION RETRIEVAL:
Integrated circuits, Circuit design, Semiconductors, Charts and nomographs, Amplifiers

Input Bias Current vs Price



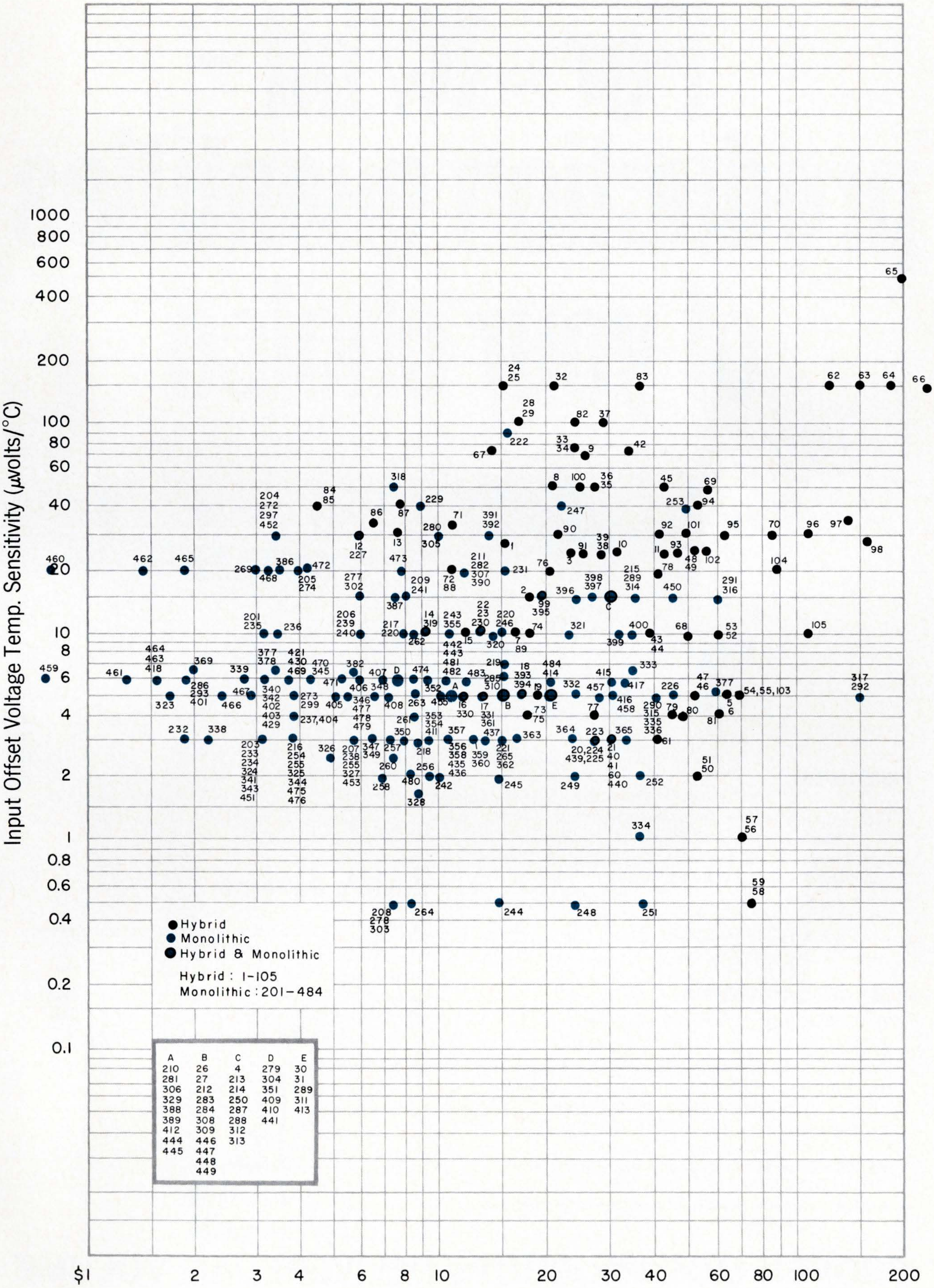
A	B	C	D	E	G
72	213	208	234	203	206
210	215	259	270	207	207
211	288	278	271	233	238
281	289	279	295	235	239
282	298	303	296	419	240
306	299	304	386	451	327
307			420		453

Slew Rate vs Price



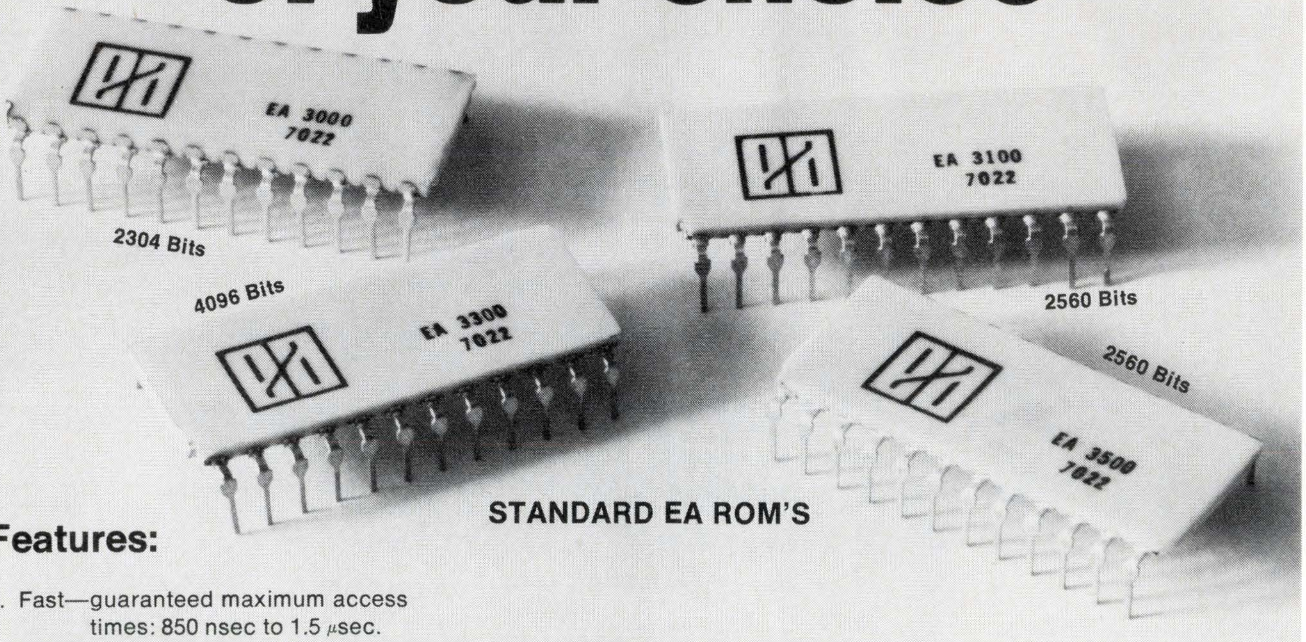
A	B	C	D	E	F	G	H	J	K	L
203	1	207	217	213	9	210	242	268	237	205
204	212	227	228	215	32	211	256	293	254	274
233	219	238	279	288	33	281	280	322	325	299
270	221	255	304	289	34	282	305	463	404	344
271	222	275	350	313	35	306	411	464		475
272	246	276	351	314	36	307				476
295	283	300	409	365	37	355				
296	284	301	410	415	38	358				
297	308	327	434	417	39	360				
324	309	346	480	458		361				
402	456	406				482				
426		431								
427		432								
451		453								
452		477								
		478								

Input Offset Voltage Temperature Sensitivity vs Price



A	B	C	D	E
210	26	4	279	30
281	27	213	304	31
306	212	214	351	289
329	283	250	409	311
388	284	287	410	413
389	308	288	441	
412	309	312		
444	446	313		
445	447			
	448			
	449			

For ≈ 1¢/bit – production quantities of your choice



STANDARD EA ROM'S

Features:

1. Fast—guaranteed maximum access times: 850 nsec to 1.5 μsec.
2. Low Power—90 mW typical.
3. Complete decoding within each ROM.
4. Wire-OR capability.
5. May be biased to be bipolar compatible.
6. Synchronous and compatible.
7. 24-pin dual-in-line packages.

Standard Patterns

available *today* at EA distributors

1. **EA 3001**—Starburst character generator and Selectric bail to ASCII code converter.
2. **EA 3101**—ASCII to Selectric Line Code and Selectric Line Code to ASCII code converter.
3. **EA 3307**—ASCII to EBCDIC and EBCDIC to ASCII code converter.
4. **EA 3501**—Row Scan Dot Code Matrix Character Generator.
5. **EA 3701**—Column Scan Dot Code Matrix Character Generator.

Custom Patterns

Any EA ROM can be programmed to your specialized bit patterns. Allow 6 to 8 week delivery.

For data sheets and forms for submitting your specialized bit patterns, contact your local representative or write Electronic Arrays, Inc., 501 Ellis Street, Mountain View, California 94040. (415) 964-4321.

electronic
arrays, inc.

PROVEN MOS PRODUCTS DELIVERED IN VOLUME

MOS course—Part 5B
Read-only memories

Performance and convenience trade-offs for MOS read-only memories p. 64

By Arthur J. Boyle, Technical Editor

If two partners were ever eminently suited for marriage they are the read-only memory and integrated circuits—particularly MOS integrated circuits. Read-only memories, which are certainly not a new idea, have been implemented over the years with magnetic, electrostatic, optical, and diode storage elements. However, it has taken integrated circuit technology to make the ROM economically attractive.

Why the IC ROM?

Read-only memories, which are simply regular arrays of the same basic circuit repeated many times in a matrix, are particularly well suited for integrated circuit processing. As a matter of fact, the basic circuit in a semiconductor ROM is about as basic as you can get—one transistor.

In addition, with computer aided design the problem of programming the memory has been simplified. The manufacturer can now produce standard arrays and use a custom mask generated by the computer to store the particular pattern of 1's and 0's that is required. This procedure has reduced turn-around times to an acceptable level, in most cases on the order of 4 to 6 weeks.

You can, of course, make a read-only memory with either bipolar or MOS devices. The trade-offs between the two are the same as we discussed in the very first installment of this course (February, p. 55). Bipolar circuits give you faster speeds and more drive capability. On the other hand, MOS circuits offer advantages in the areas of size and power consumption.

The read-only memory is one application that makes the most of the advantages of MOS. There is a great deal of pressure to make all memories smaller—score one here for the greater packing density of MOS. Of course, when you make things smaller, you are faced with a more difficult problem in removing the heat generated in the circuit—MOS scores here also with its reduced power dissipation.

Also, in many ROM applications, speed is not as critical as in some other parts of digital systems. An example is their usage as character generators. The time differential between getting an output from a MOS ROM and a bipolar ROM really is not significant enough to make much difference to an operator who is looking at the display.

The one area where bipolars do show a definite advantage is in programming. You can now buy bipolar ROMs which you can program yourself. These devices use fusible links to accomplish the programming. When you buy the ROM, it has a 1 stored in all locations. To write a 0, you pass a certain current through the circuit and the link opens. With today's technology, MOS ROMS must be programmed by the manufacturer with a custom masking operation. The impedance levels in MOS circuits are just too high to allow you to pass sufficient current to use the fusible link technique.

Where you'll find them

Semiconductor ROMs are at home in a variety of applications. Probably the best known are as character generators, code conversion tables and look-up tables. Another application is in micro-programming, where subroutines in a computer's operating program are stored permanently in a ROM.

Another area that holds a great deal of promise is the use of ROMs to do random logic. You can program a read-only memory to perform just about any logic function imaginable. As designers become more comfortable with this technique, you are going to find more and more semiconductor ROMs in tomorrow's systems.

MOS Course—Part 5B

Performance and convenience trade-offs for MOS read-only memories

You can't ignore the read-only memory anymore. MOS technology has transformed the ROM from a wallflower to the belle of the ball.

By Dr. Robert J. Proebsting

Mostek Corp., Dallas, Texas.

In the design of any product, there are a number of compromises that must be reached and MOS memories are no exception. This article will discuss the capabilities and limitations of MOS ROMs, as well as the trade-offs involved with many of the various possible design approaches. Some of this material also applies to MOS read-write, random-access memories (RAMs). But for RAMs, it is only part of the story. The basic storage cell of the RAM is still undergoing constant improvement, while the basic storage cell of the ROM is well defined as a single transistor.

Static ROM

We begin the investigation of the ROM with a description of the most convenient ROM currently practical: a static, binary input, fully decoded 4096-bit ROM having TTL/DTL compatibility on both inputs and outputs. Unfortunately, this is also the slowest configuration.

If the inputs of an MOS circuit are to discriminate the low-level voltage swings in a DTL/TTL systems, the circuit must use low-threshold MOS technology. Furthermore, the internal voltage swings in the MOS circuit must be considerably higher than those provided by the DTL/TTL gate in order to achieve higher speed. These conditions require a level translator between the DTL/TTL gate and the internal MOS circuitry. For convenience, this translator is usually contained on the low threshold MOS circuit but this convenience costs about 200 ns in propagation delay.

Next, the ROM must complement the internal high-level MOS input signals since both the true and complement input signals are required by the input-word decoder. Because of its high-level input, the complement generator delay is about half the input level translator delay, or about 100 ns.

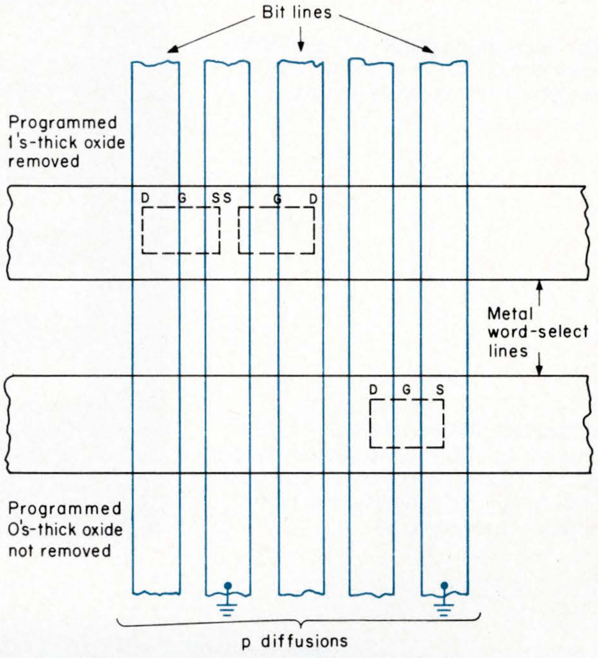
Both the true and complement input-data lines are fed into the decoder which selects a single word line corresponding to the input data. The propagation delay for the decoder is typically about 300 ns, so that its outputs become true approximately 600 ns after the DTL/TTL inputs become true.

The word lines feed the heart of the ROM, the data-storage matrix. This is simply a two-dimensional array of potential transistor sites with a transistor present where a logic 1 is permanently programmed and absent where a logic 0 is programmed. The MOS manufacturer does the programming to the customer's specifications. Since the storage array typically contains 1024 to 4096 bits of information or potential transistor sites, the size of each transistor site must be kept to a minimum. This in turn implies that the on resistance of the transistor (if programmed to exist) is relatively high. This high resistance, coupled with the relatively high stray capacitance associated with the physically long diffused matrix output lines, implies a very long propagation de-

The read-only memory (non-alterable memory or fixed-program memory) is a storage device containing digital information which cannot be altered during normal operation. The pattern of 1's and 0's for a word stored in a ROM is always the same for that word—you cannot write in new information.

MOS ROMs now on the market have the information stored during the manufacturing process. The most common method of storing the information (or programming the ROM) is through the use of a custom gate-oxide mask. The process consists of diffusing the normal p-type source and drain regions for the entire array and then growing a thick oxide layer over the wafer. The custom mask then defines the program. If a 1 is to be stored in a particular bit location, the thick oxide is etched away from the gate region for that location. In those locations that contain 0's the thick oxide is not removed.

The horizontal metal lines in the array serve as the word-select lines and the p-diffusions are the bit lines. Selecting one of the word lines turns on those transistors where a 1 is stored. The thick oxide over the 0 locations prevents the word line potential from forming a conducting channel and the output is 0.



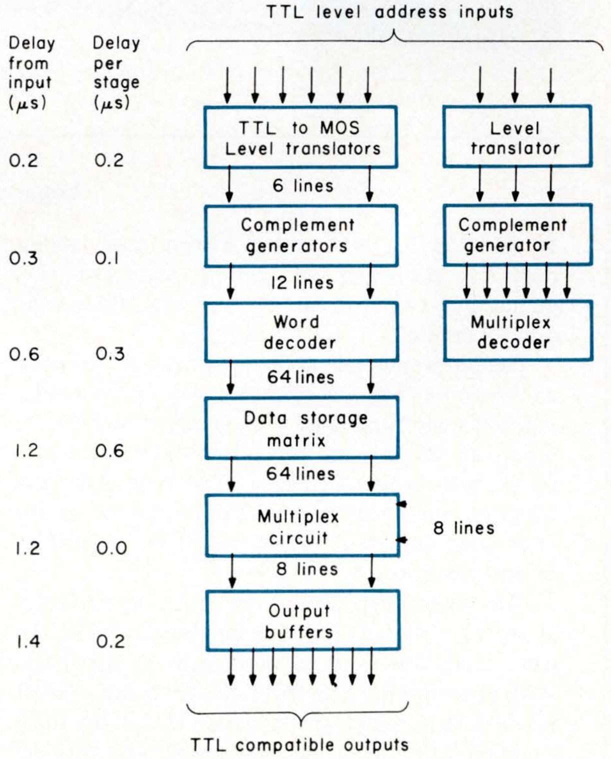
(Contributed by Dr. William Brunke of Texas Instruments Inc.)

lay through the matrix (typically about 600 ns).

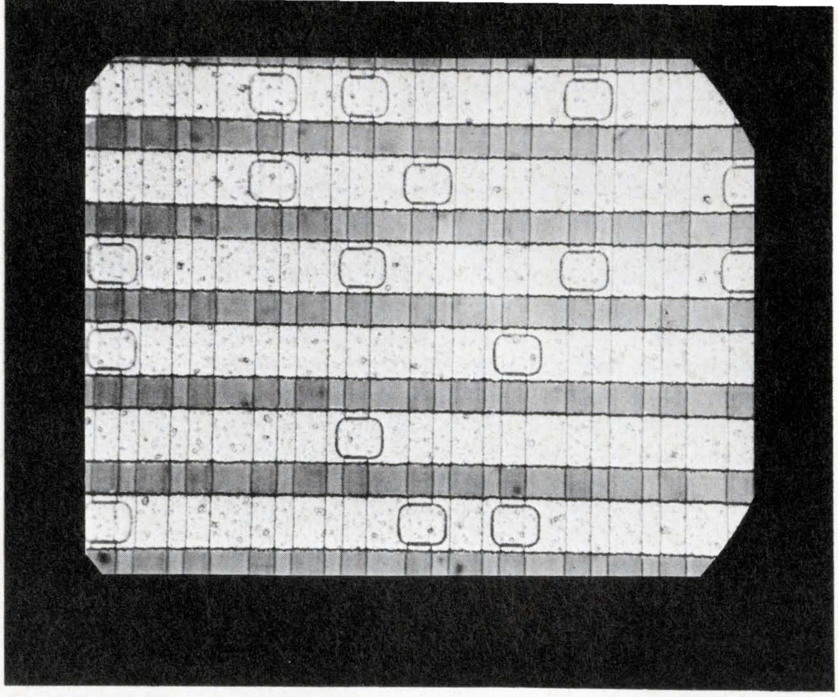
The matrix data outputs normally feed a multiplex circuit to select which data lines feed the output buffer. A typical memory matrix may have from 32 to 64 data outputs, but the ROM package will have only 4 to 8 outputs. The multiplex circuit picks which of the first group of matrix outputs feeds the first buffer, which of the second group feeds the second output buffer, etc. Typically, three of the input address lines pick which of each group of 8 matrix data lines is enabled. All other input address lines go into the main decoder. The multiplexer adds little delay to the circuit, because the switching times take place at the same time as the main decode switching times.

The multiplex outputs feed output buffers. For DTL/TTL compatibility and a fan-out of one, these buffers must be capable of sinking 1.6 mA with a voltage drop of only 0.4 V. This requires an output transistor that takes up a large amount of silicon area. Since the input gate of this large transistor has a correspondingly large capacitance, the propagation delay of this type of buffer is relatively long—about 200 ns. The DTL/TTL compatible output buffer is normally a push-pull configuration, but the current-sourcing requirements on the pull-up device are much less demanding than those of the pull-down device. Consequently, little additional delay is encountered by including this pull-up device.

We have now traced our signal from the DTL/TTL compatible inputs to the DTL/TTL-compatible outputs

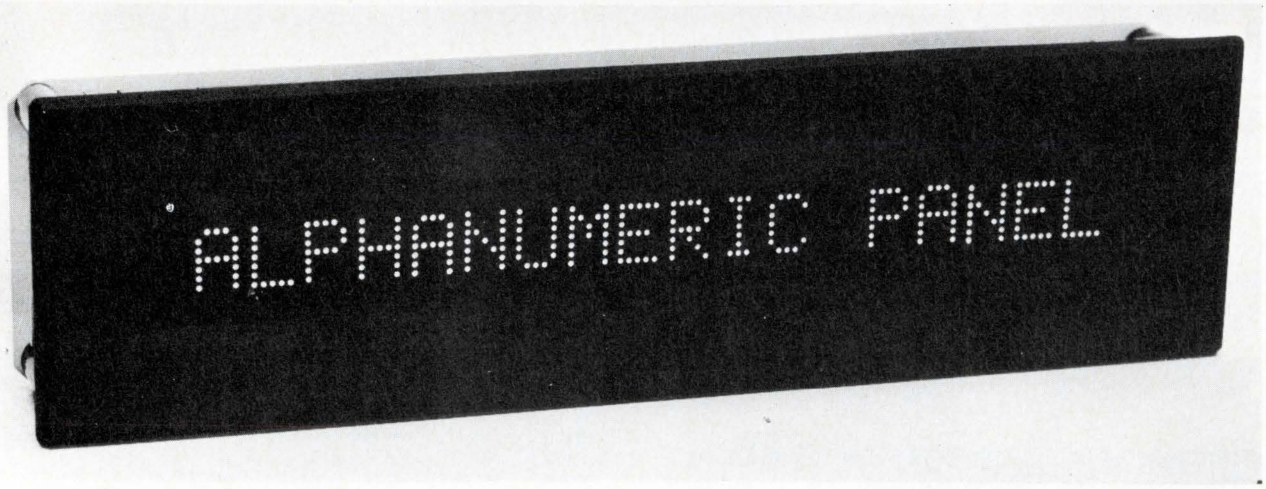


The propagation delays shown are typical of a static, TTL compatible, 512-word by 8-bit (4096 bit) ROM. You can get higher speeds with dynamic ROM systems or with mixed MOS-bipolar systems, but systems costs and complexities increase.



This microphotograph of an ROM shows the MOS transistors located throughout the memory matrix.

The Self-Scan™ panel display manufactured by Burroughs Corp. uses the 2240-bit ROM shown on the opposite page to generate 64 alphanumeric characters.



Logic with ROMs

In addition to their better known applications, read-only memories are getting increased play in the area of combinatorial and sequential logic implementation.

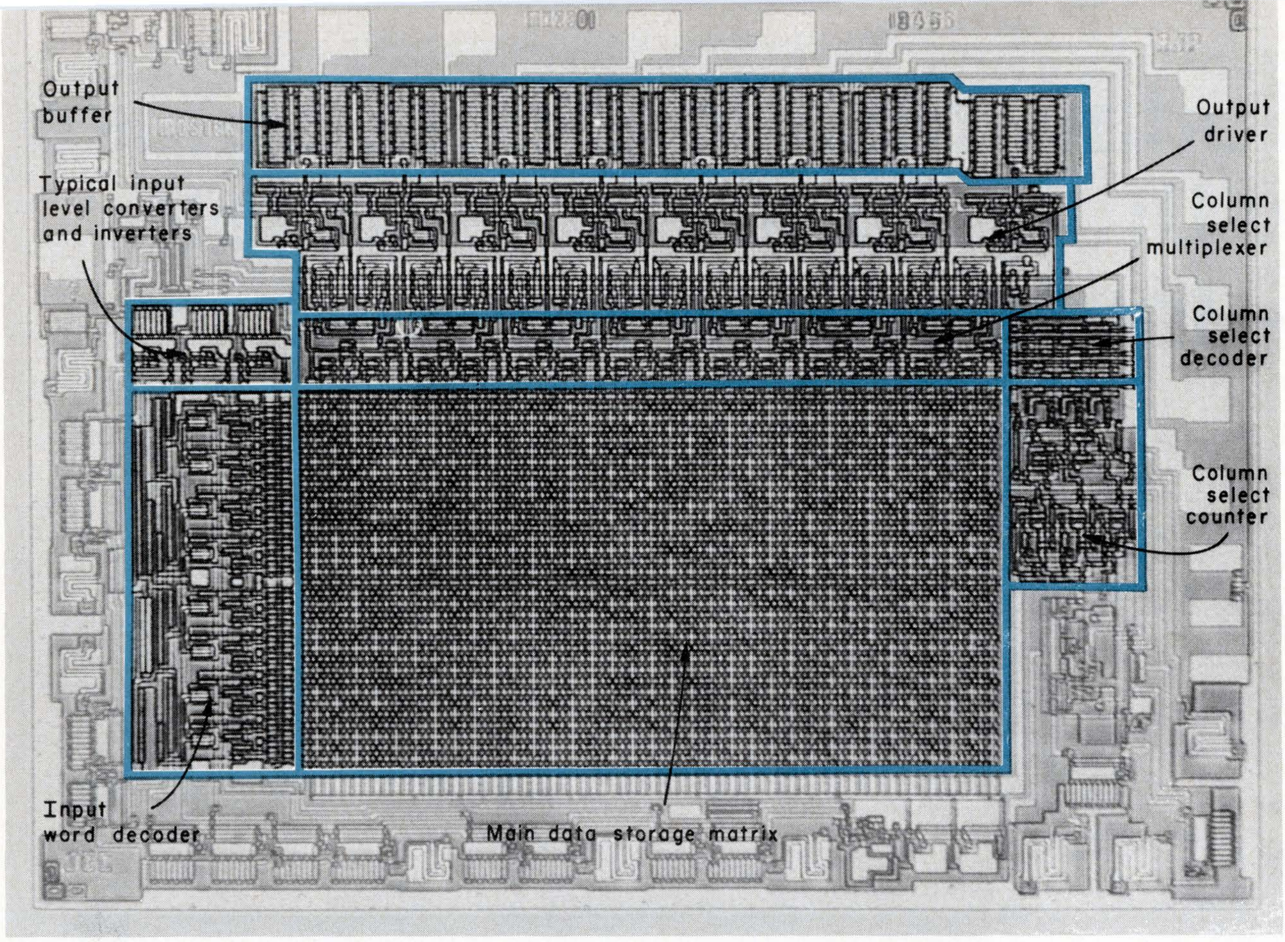
The conventional ROM applications (a code conversion table, for example) are really combinatorial logic functions. Forget about calling the inputs an address and instead consider them as a set of independent variables. The ROM gives you whatever set of output conditions you want for each possible set of input variables, regardless of past history.

One advantage of using ROMs to do combinatorial logic is that you can go directly from the truth table you want to implement to hardware. With conventional gate logic, the truth table is just the first step. Next, the designer writes the logic equations that define the truth table and then he carefully deletes all the redundant terms from these equations. Only when the logic equations have been reduced to their minimum form can actual hardware design begin. Read-only memories let you skip this intermediate step; you program the ROM directly from the truth table.

Sequential logic functions are also possible with ROMs by feeding back one or more of the outputs. As a simple example, consider a ROM where each memory location contains its own address plus binary one. By connecting all of the outputs back to the inputs and using a clock signal for control, the ROM now functions as a simple counter.

Read-only memories simplify many of the problems associated with sequential logic design. For example, with ordinary sequential circuits the designer always faces the problem of insuring that the sequence starts with the proper set of initial conditions. In our simple counter, to define the initial conditions all you must do is to supply the starting address.

(Contributed by Floyd Kvamme, National Semiconductor, Santa Clara, Calif.)



This completely decoded ROM shows the space allocations for the different types of circuitry required.

and found a typical total propagation delay of 1.4 μs for the 4096-bit ROM. For many applications, this speed is adequate and the convenience of static operation and direct interface dictate the use of this type of memory.

High-speed ROMs

Some applications require high-speed operation that can be attained at the sacrifice of convenience. System access and cycle times of 50 to 100 ns are possible, using MOS building blocks containing 2048 bits each. We will now go through some of the possible speed-convenience compromises.

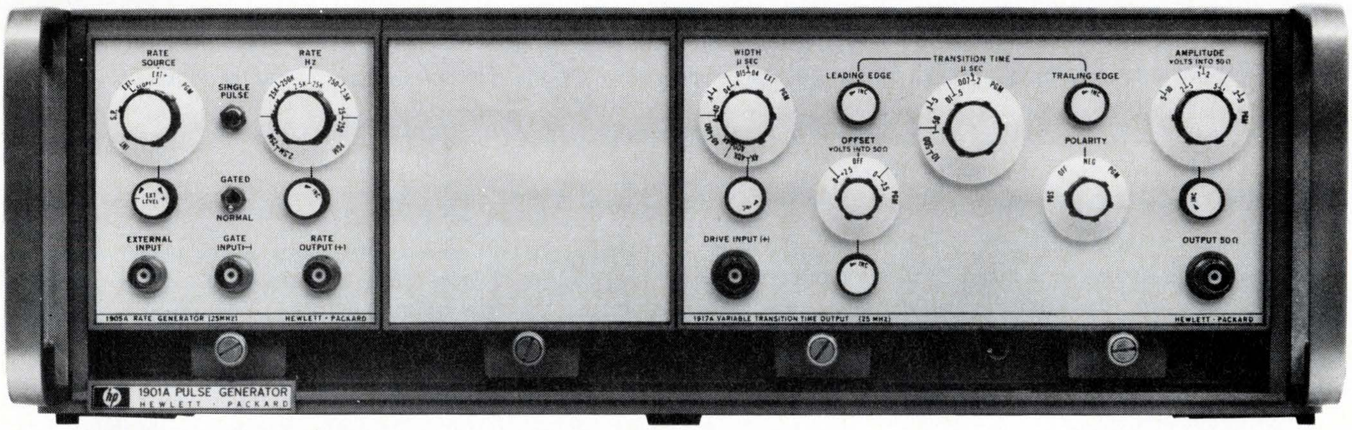
By providing high-level input signals, you can save some 200 ns. Going a step farther and providing both true and complement high-level inputs, saves you another 100 ns. This, however, not only requires the external generation of the complement address inputs, it also requires additional pins for the package and means a significant cost increase. Going yet another step farther and doing the decoding separate from the MOS chip, saves most of the 300 ns required for on-chip decoding. This step, however, requires still more off-chip circuitry and a further increase in pin count. Generally, off-chip decoding is only used for very high-speed systems. Momentarily bypassing the memory matrix and focusing attention on the output buffer, we can decrease the 200-ns delay in a DTL/TTL compatible buffer to under 100 ns by using a single-ended output that sources rather than sinks current. Such a circuit requires an external current source (a resistor to the negative supply) to sink at least 1.6 mA at 0.4 V to provide a TTL logic 0. The MOS output, if turned on, sources at least 2 mA at +2.4 V to override the resistor and provide a logic 1 output. It should be emphasized that this type of circuit is not only slightly faster than the truly DTL/TTL-compatible buffer, but also is significantly lower in chip area, power dissipation, and cost.

The ultimate speed improvement comes by eliminating both the matrix delay and output buffer delay. This is achieved by current sensing the matrix directly. Each output is externally terminated by a low-valued resistor to a supply voltage. The stored data is detected by the presence or absence of current from the addressed matrix cell. When this current is present it causes a drop of a few millivolts across the terminating resistor, which is sensed by a high-speed differential bipolar comparator.

Since the matrix outputs now swing by only a few millivolts as compared to the few-volt swing required to drive an output buffer, the time constant is reduced from about 600 ns to a few nanoseconds. With a delay of 20 ns in the differential comparator, you can realize a total savings of nearly 780 ns when compared to the circuit having a 600-ns matrix delay followed by a 200-ns output buffer delay.

Therefore by providing decoded high-level signals to the matrix word lines and to the multiplex lines, and by sensing output currents with high-speed differential comparators, most of the delays have been removed from

Today, fast, low-cost pulses with variable rise and fall —tomorrow, a system!



HP's new, all-solid-state 1900 Pulse System gives you the best of two worlds. **For only $1195, you can get a 7 ns variable rise and fall generator,** right away. Then, as your needs and/or funds increase, plug-in capability allows you to get additional features, without having to buy a whole new generator.

Our basic package consists of a rate generator, a pulse shaping output, and a mainframe.

The 1917A pulse shaping output provides 10 V pulses with variable rise and fall times as short as 7 ns, **reversible polarity, and dc offset.** It takes up only half of a mainframe, and can handle rep rates of up to 25 MHz. A unique external-width function allows the 1917A to be used as a **pulse amplifier,** also, maintaining width and spacing of externally-supplied pulse trains.

The 1905A Rate Generator ("clock") is a quarter-size plug-in. It provides output triggers at repetition rates from 25 Hz to 25 MHz in six decade ranges. Rep rate can be determined internally, by external triggering, or by single-pulse push-button. **Gating feature allows pulse bursts.**

The 1901A Mainframe is a standard rack size unit, and contains power supplies that can be used to power other 1900-series plug-ins. **Built-in EMI and RFI shielding are standard.**

Price of this three-part package (including a blank plug-in) is only $1195. As your needs change, available plug-ins include a 350 ps output, **a 16-bit (RZ, NRZ) word generator,** variable delay generators, fan-in and fan-out generators, and optional analog programming—plus a high power pulse-shaping output (1 A, 50Ω) and mainframe.

Call your local HP field office for ordering. For further information on the HP 1900 Pulse System, see pp. 254-261 in your 1970 HP catalog, or send for our new free brochure on pulse generators. Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

080/10

HEWLETT hp PACKARD

SIGNAL SOURCES

the MOS circuit itself. Only the inherent current response delay in the MOS transistor, measured in picoseconds, remains. It is then possible to build a system using ECL decoding and sophisticated level conversion circuitry that attains access times of about 50 ns for 4k-word by 16-bit memory systems. With TTL decoding, access times of about 100 ns are possible. But because of the high number of pins required for decoded input data and the peripheral circuitry required such a system costs about three times as much as one made of DTL/TTL-compatible memories. At 2 or 3 cents per bit in quantity, this is still the most economical approach known to the author for achieving these speeds.

So far, no mention has been made of dynamic memory circuits—those requiring one or more clock inputs to speed up the access or cycle times. The procedure is to precharge the internal nodal capacitances through low-resistance transistors during one clock period and then, depending on data, selectively discharge these nodes during the next period. This contrasts to the previously described static circuits in which circuit nodes must be charged by relatively high load resistances in order to preserve dc logic levels.

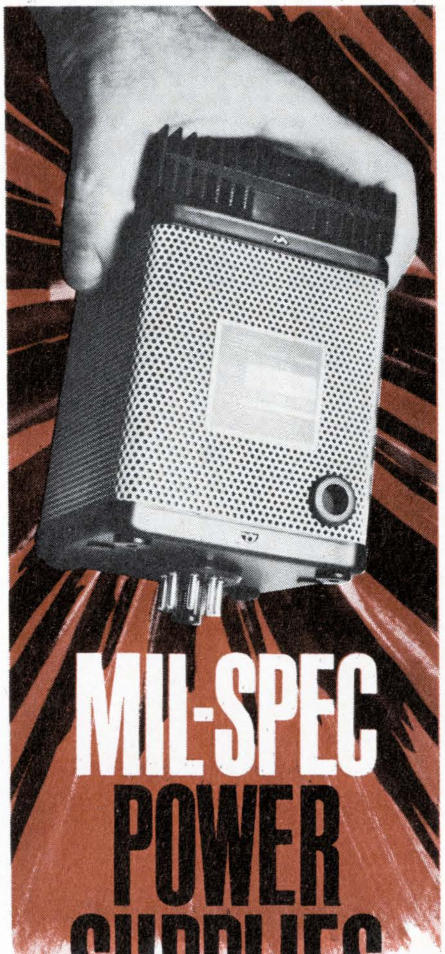
Although the speed of a dynamic circuit will usually be twice that of an otherwise equivalent static circuit, there are disadvantages to the dynamic circuit. Multiple clocks are frequently required and these may have very critical timing requirements. Both the internal data and the output data remain valid for only a fraction of a millisecond, necessitating a minimum operating frequency. The system designer must avoid standby conditions or be careful to ignore the first data from the ROM after standby. Testing and troubleshooting a dynamic system can be quite a problem, especially when the system contains very complex building blocks with access to relatively few test points.

Conclusion

There are a number of convenience-performance trade-offs possible in the design of MOS read-only memories. Only after evaluation of the requirements for a given application is it possible to choose the optimum approach for that application.

Once the optimum approach has been established by the ROM user, the decision must be made whether to use a standard catalog product (custom data pattern) or have one designed to his exact requirements. This decision usually depends on two factors: how close available memories come to meeting his needs and volume requirements. In general, the custom memory should not be considered for fewer than about 10,000 parts, since engineering and tooling costs are substantial. Similarly, a custom pattern of a catalog part should not be considered for fewer than 1000 parts for the same reason. But when the volume requirements justify either a custom pattern of an available part or the development of a custom part, MOS technology can provide the solution for most ROM applications.

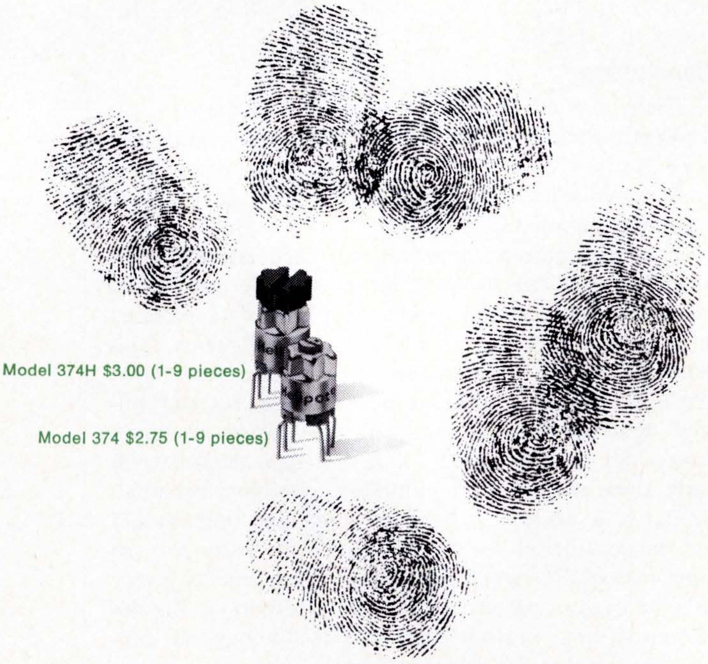
INFORMATION RETRIEVAL
Digital design, Integrated circuits, Computers and peripherals



There isn't another like it. A ¼-inch, single-pole, six position, 28-vdc. Helipot switch for PC boards.

Beckman® INSTRUMENTS, INC.
HELIPOT DIVISION
Fullerton, California 92634

INTERNATIONAL SUBSIDIARIES: AMSTERDAM; CAPE TOWN; GENEVA; GLENROTHES, SCOTLAND; LONDON; MEXICO CITY; MUNICH; PARIS; STOCKHOLM; TOKYO; VIENNA



Model 374H $3.00 (1-9 pieces)

Model 374 $2.75 (1-9 pieces)

Circle 32 on Inquiry Card

IC IDEAS

This month's Ideas

Vote **for the one you like best.**

Write the number of the Idea you like best in the box on the Inquiry Card, and send to us.

Send us practical, reproducible ideas that are original with you and have been implemented with linear or digital ICs.

- If we publish your idea you win a check for $25.00.
- If our readers vote yours the best of the issue in which it appears, you have your choice of a Simpson 270 or a Triplett 600 multitester.
- After 12 issues our readers will vote on the best idea for all 12 issues. The winner gets his choice of either a Hewlett-Packard 1206A or a Tektronix 310A oscilloscope.

Submit your IC Ideas to:
Alberto Socolovsky
Editor
THE ELECTRONIC ENGINEER
Chestnut & 56th Sts.
Philadelphia, Pa. 19139

Here's how you voted

The winning Idea for the February 1970 issue is, "Digital gain control for op amps."

William E. Peterson, our prize-winning author for the February 1970 issue, is an engineer at ITL Research Corp. in Northridge, Calif. Mr. Peterson has chosen the Simpson Model 270 multi-tester.

919 Simple high duty cycle one-shot

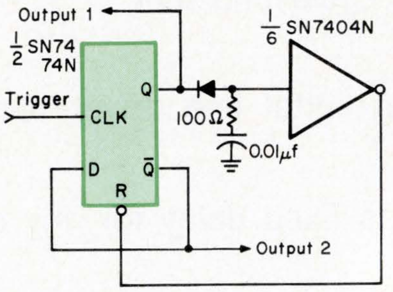
Parviz Ghajar

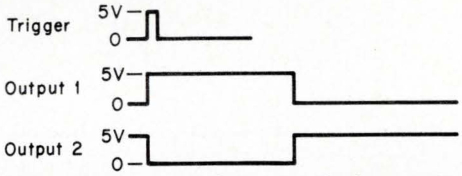
General Electric Co. Oklahoma City, Okla.

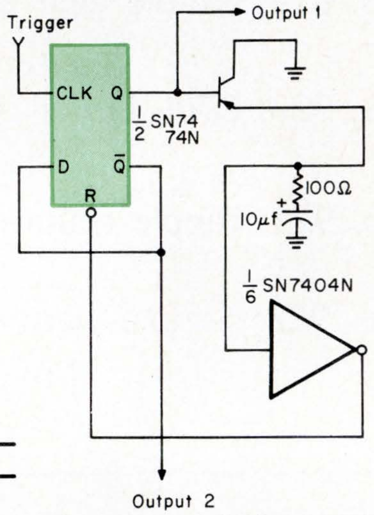
Special techniques are usually required to increase the duty cycle of one-shot circuits beyond 90%. This circuit uses a simple and inexpensive approach to achieve its high duty cycle. The example shown uses a Series 74 gate and flip-flop although you can use any DTL or TTL circuits.

The top circuit gives you short output pulses—those attainable with a 0.01 μF capacitor. If you need longer pulses, then the bottom circuit is recommended. This scheme replaces the diode with a transistor to decrease the amount of current discharged through the output transistor of the flip-flop.

Applying a 50 ns or longer trigger pulse to the circuit causes the Q side of the flip-flop to go high and charge the capacitor. When the voltage on the capacitor exceeds the threshold voltage of the gate, the gate output goes low and resets the flip-flop. The capacitor now discharges rapidly through the diode (or transistor) and the output transistor of the flip-flop. With the capacitor discharged, the output of the gate goes high again and the circuit is ready for the next pulse.







920 CTμL buffer as a digital line driver/receiver

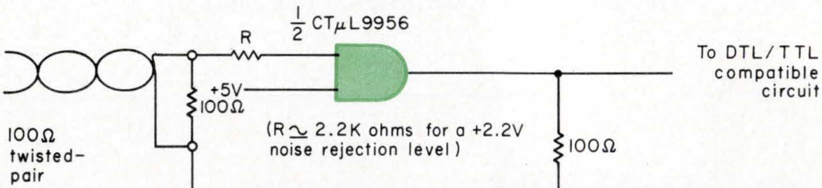
Raymond S. Lim

Computer Design Engineer, Sunnyvale, Calif.

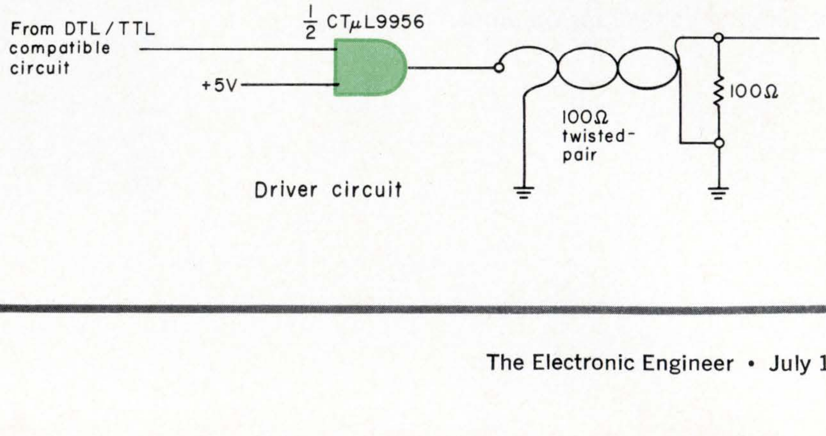
Here is a circuit that lets you use an inexpensive buffer as a digital, single-ended, party-line receiver or driver. Fairchild's CTμL 9956 is a dual 2-input power AND gate that provides high fanout capability.

The buffer circuit is particularly attractive in this application because (1) the input circuit does not inject current into the party line, (2) the output circuit can be OR-tied high which is a necessity for party-line operation, (3) you can raise the input noise rejection level with a resistor as shown, (4) the output is short circuit protected, and (5) you can drive a twisted-pair line for at least 100 feet.

CTμL Buffer as digital line receiver/driver

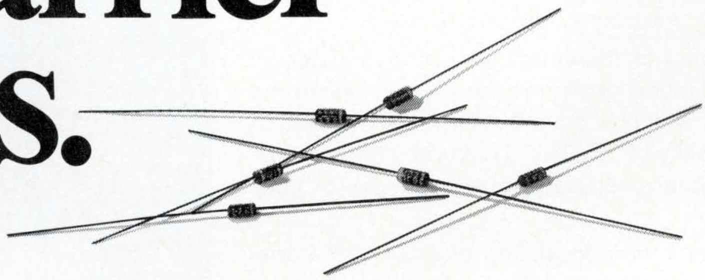


Receiver circuit



Driver circuit

Process more information faster and cheaper with HP hot carrier diodes.



Now you can think about circuit switching speed in terms of picoseconds instead of nanoseconds, for digital logic systems, data handling and peripheral equipment and other applications where you're designing circuits for mixing, clipping, clamping, A/D conversion, gating and sampling.

These low-cost hybrid Schottky diodes are fully passivated, have a 0.4 V threshold voltage, have 100 picosecond switching speed and 1.0 mV/degree C temperature coefficient. They'll withstand temperatures from −55° to 200° C and breakdown voltages up to 70 V. In fact, their near-ideal combination of forward voltage/current characteristics adds up to better-than-PN-junction performance at volume user prices. And they're newly EIA registered.

Check your HP sales office for prices, which are as low as 32¢ each in 100,000 quantities for the HP 5082-2800. Ask about specs and prices on the HP 5082-2810 and 2811, too.

.01008

HEWLETT hp PACKARD

SOLID STATE DEVICES

Circle 33 on Inquiry Card

Computerized Design For Better Printed Circuit Boards

Here's how to reduce both cost and lead time in converting a circuit design to production-ready printed circuit board artwork. At Electronic Graphics, Inc., we call it our photomask service.

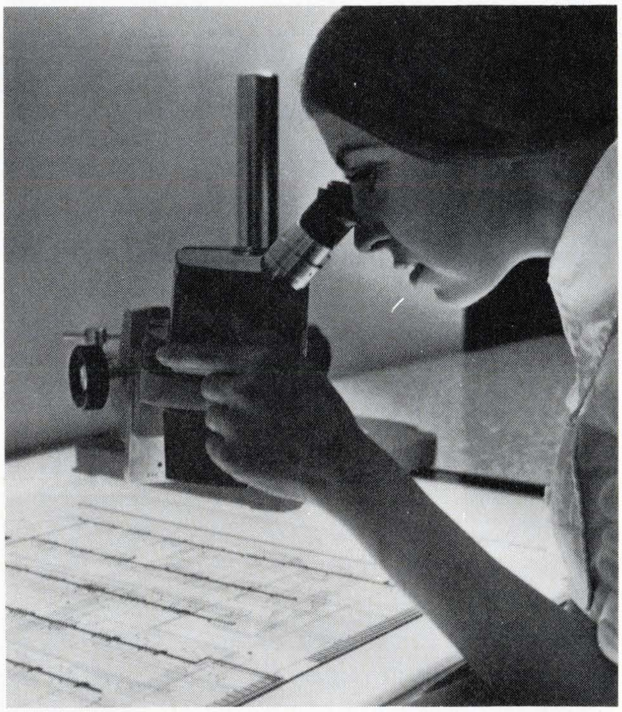
Using a computerized system we design single-, double- and multi-layer printed circuit board layouts and provide supporting engineering and assembly documentation. With this system we provide for you in one to four weeks photo masters and documentation that require as much as six months to produce using conventional manual layout techniques.

Electronic Graphics' photomask service utilizes a highly sophisticated software program which our engineers and programmers have developed. Operating through our IBM 360-44 computer, this program provides the logic required to design well-ordered PC layouts. The output of this computer system is input to a Seaco 1500A CRT artwork generator to create the photomask master negative. From this negative we process your photo master. It can be either negative or positive on either film or glass.

In addition to the latest computer and artwork generator systems, facilities at the Garland plant include: An auto-trol digitizer, extensive photo lab facilities, and precision microscope inspection equipment.

The photomask service gives you more than just automated artwork. It's a turnkey service that includes the following:

1. Computerized design of the printed circuit board layout. Placement of components and interconnection routing is in full compliance with your engineering specifications (e.g. component location, test points, circuit paths, etc.).
2. Automated translation of the computerized layout design into precision production photo masters by an electronic graphic generator, which is accurate to ± .001″ point to point, with repeatability of ± .0005″. (Accuracy of this magnitude results in higher yields on production runs of your circuit board.)
3. Engineering documentation consisting of a bill of material list, a point-to-point wire list, a component location list, and a drill plan showing hole locations.
4. Assembly drawings showing component location and orientation.
5. Production-ready numerical control tapes for any drill, router, or component insertion machine. (Available on request.)
6. An optional customer file storage service which facilitates rapid engineering changes and duplication of photo masters or documentation.



Investigate our service, facilities, and capabilities and you will find that Electronic Graphics, Inc. can do a better job of producing precision photo masters, deliver them faster, and provide you with measurable savings in both time and money.

electronic graphics, inc.

electronic graphics, inc.
2834 W. Kingsley Road • Garland, Texas

921 Ripple counter has fixed delay for any count

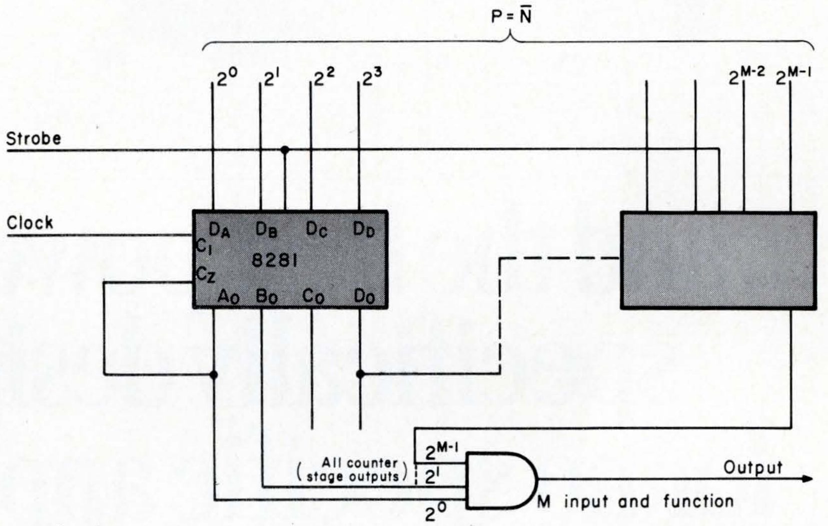
S.S. Golenski

Link Div., Singer Co., Binghamton, N.Y.

This idea lets you operate a binary ripple counter with a fixed propagation delay no matter what the count. The counter, such as the Signetics 8281 shown here, can be preset to any count from 0 to 2^M-1 (where M is the number of counter stages).

You get the fixed propagation delay by starting with the complement of the desired count and counting up to all 1's instead of starting at 0 and counting up to N. Since you sense the all 1's state for all values of N, the propagation delay is the same for any count.

For a recycling counter or frequency divider, you must reset the counter to the value P ($P=\overline{N}$) each time. The P input can be hardwired by connecting the inputs to V_{cc} and ground or varied under program control.



922 Simple word gate circuit

W. K. Lenhardt

Resalab Inc., Garland, Tex.

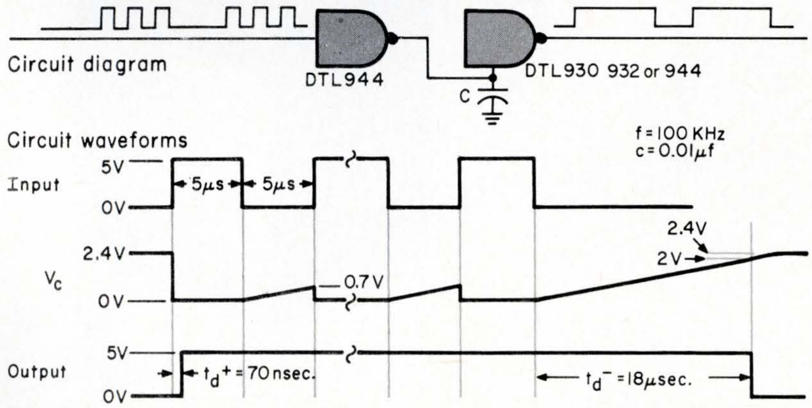
It is often desirable to have a word gate circuit in digital systems to identify the start and end of each word. This scheme combines a capacitor, and two DTL gates to give you a word gate.

The first pulse in the clock burst discharges *C* through the 944 driver. You must choose the capacitor such that each successive clock pulse does not allow the capacitor to charge to the gate threshold until after the last pulse in the burst. The voltage on the capacitor is $V \cong 5(1-\varepsilon^{-t/RC})$ for $0 < V < 2$ Since the threshold voltage of the gate is about 2 V

$$2=5(1-\varepsilon^{-t/RC})$$

$$t/RC=0.51$$

The maximum charging time for *C* is 1/2f where f is the frequency of the symmetrical clock burst.



Therefore

$$C_{min} = 1/2fR(0.51)$$

$$t_d = (0.51)RC$$

For a 932 or 944 gate, use $R=3.75$ kΩ

$$C_{min}=261/f \ (\mu\text{F})$$

$$t_d=C(\mu\text{F})/980 \ (\text{s})$$

For a 930 gate, use $R=2$kΩ

$$C_{min}=490/f \ (\mu\text{F})$$

$$t_d = C(\mu\text{F})/980 \ (\text{s})$$

When choosing *C*, pick a value at least twice as large as C_{min} since this is a threshold value. The waveforms shown are for a test circuit built with a 944 gate and using a clock rate of 100 kHz. Since C_{min} was 0.0026 μF, a 0.01 μF capacitor was used.

The best power supply
for driving 5 volt IC's
is one specifically designed
for driving 5 volt IC's.
We make it.
We call it our
5 volt IC series.

(Catchy, isn't it?)

acdc electronics inc.

Oceanside Industrial Center, Oceanside, California 92054, (714) 757-1880

The best power supply for
driving operational amplifiers
is one specifically built
to drive operational amplifiers.
We make it.
We call it our OA series.

(In case you missed the connection,
that's short for operational amplifier.)

acdc electronics inc.

Oceanside Industrial Center, Oceanside, California 92054, (714) 757-1880

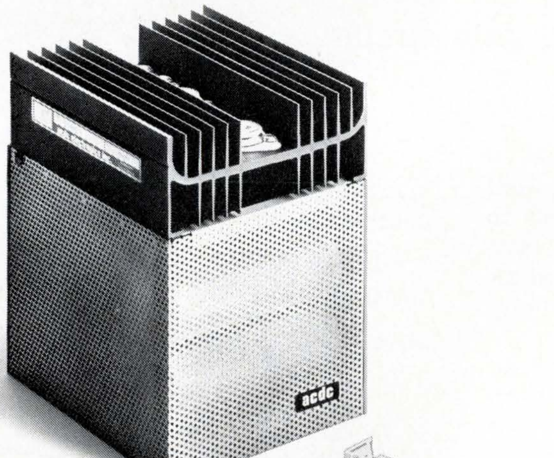
The best power supply
to tuck into impossible spaces
is the one specifically designed
to tuck into impossible spaces.
We make it.
We call it our Impossible Space
Power Supply.

(also known as the JR series)

acdc electronics inc.

Oceanside Industrial Center, Oceanside, California 92054, (714) 757-1880

...and the best power supply specifically designed for no specific application is our BX series.



If you're looking for power supplies but don't need the miniature size of our JR series . . . or the optimized characteristics of our IC series . . . or the dual output of our OA series . . .

There are over 175 models in the BX series, covering voltage ranges from 2 through 400 volts (0.01% regulation) with current ratings from 300 mA to 20 amps. 2 through 28 VDC supplies are off the shelf, however, you may have to wait a bit for ratings up to 400 VDC. Prices start as low as $66 with a nominal addition for overvoltage protection, and they all carry ACDC's "guaranteed forever" warranty.

But, if you're still looking, there are 178 models in our BC series (0.5% regulation), a complete line of dual output modules, digital programmables, wide range programmables, multiple output, digital readout and memory power supplies.

acdc electronics inc.

Oceanside Industrial Center, Oceanside, California 92054, (714) 757-1880

Circle 35 on Inquiry Card

Feature article abstracts

Published information is vital to your job.
To save time in finding this information,
we have abstracted the important technical features
from eight electronic engineering publications.
Should any of these articles interest you, contact the magazine—
names and addresses are listed below.
Reprints of articles with an asterisk are available free.
Save this section for future reference.

Charts and Nomographs

***Optoelectronics wall chart,** "The Electronic Engineer," Vol. 29, No. 7, July 1970, pp. 49-56. The multi-colored chart contains information about all of the optoelectronic devices currently in use, covers the frequency spectrum of the many materials, and serves as an application guide.

Predict intermodulation distortion, Harold B. Goldberg, Computone Systems, Inc., "Electronic Design," Vol. 18, No. 10, May 10, 1970, pp. 76-78. Third-order intermodulation distortion and cross-modulation are both caused by a third-order nonlinearity in the transfer characteristic of a device. This article shows how to find one if the other is known, either analytically, or with the aid of a simple nomograph.

Circuit Design

Streamline flow graphs for active circuits, Allston L. Jones, Philco-Ford, "EDN," Vol. 15, No. 10, May 15, 1970, pp. 47-50. In this brief article, Mr. Jones shows you how to simplify flow graphs so that they depict only that information necessary to solve the problem at hand, thus reducing algebraic manipulations and minimizing errors.

Toward high stability in active filters, Philip R. Geffe, Westinghouse Electric Corp., "IEEE Spectrum," Vol. 7, No. 5, May 1970, pp. 63-66. Recently, active filters have demonstrated lessened sensitivity and greater stability. The author reports on the research that has made active filters, in some cases, more stable than passive filters.

Communications

A common bit rate unifies three separate Japanese pcm systems into a national network, Y. Kurahashi, M. Ota and T. Sakashita, Nippon Telegraph and Telephone, "Electronics," Vol. 43, No. 11, May 25, 1970, pp. 86-92. A pulse-code modulation system has been placed in operation in Japan to accept signals from three sources and transmit each at a rate of 7.876 megabits per second. This system can operate over wires or by microwave.

Components

A stable, field-replaceable strapdown gyro-in a can, Alfred Rosenblatt, "Electronics," Vo. 43, No. 11, May 25, 1970, pp. 106-111. New gyros are packaged in small can sized plug-in, plug-out packages. These are designed to be strapped down to the body of the vehicle, rather than attached to the gimbal of an inertial guidance system.

How to select rf connectors, Henry Pessah, RF Division of Amphenol, "EEE," Vol. 18, No. 5, May 1970, pp. 36-41. This article is a step in the right direction. First, it reassures the reader that he has plenty of company when he is bewildered by the task of having to select the "right" rf connector for his application. It also tells him the reasons (mostly historical) for the apparent anarchy in connector types, sizes and nomenclature. And it tells him where to start his selection (from the cable), and how to narrow it down by considering the voltage, mismatch and environmental characteristics. The article ends with a brief discussion of the objectives of Mil-C-39012 which, just as this article, was intended to bring a semblance of order in the rf connector field.

Computers and Peripherals

Use ECAP to design transistor models, Bruce Gladstone, Gulton Industries, "Electronic Design," Vol. 18, No. 10, May 10, 1970, pp. 92-96. Most of the easily available computer-aided design programs are limited in their ability to model transistor nonlinearities. The author suggests that a computer subroutine used in conjunction with ECAP provides good results. The method is iterative. Device operating points are chosen and the ECAP analysis provides new operating points which are used to obtain an improved set of model parameters. These are rerun until the operating points are proper. Two iterations are generally enough.

Magazine publishers and their addresses

Computer Design

Computer Design Publishing Corp.
Prof. Bldg., Baker Ave.
W. Concord, Mass. 01781

EDN

Cahners Publishing Company
270 St. Paul Street
Denver, Colo. 80206

EEE

Mactier Publishing Co.
820 Second Avenue
New York, N. Y. 10017

Electronic Design

Hayden Publishing Co.
850 Third Avenue
New York, N. Y. 10022

Electronic Products

United Technical Publications
645 Stewart Avenue
Garden City, N. Y. 11530

Electronics

McGraw-Hill, Inc.
330 W. 42nd Street
New York, N. Y. 10036

IEEE Spectrum

Institute of Electrical & Electronics Engineers
345 East 47th Street
New York, N. Y. 10017

The Electronic Engineer

Chilton Company
56th & Chestnut Streets
Philadelphia, Pa. 19139

*Reprints available free. Request them on your company letterhead.

ABSTRACTS

Minicomputers—building block for computer power, Norman S. Zimbel, Arthur D. Little, Inc. "EDN," Vol. 15, No. 9, May 1, 1970, pp. 35-40. This article is a general discussion of the many roles which a minicomputer can play. Mr. Zimbel shows the significance of the minicomputer as a low cost, rack sized, general-purpose worker. As such, the author tabulates some of its many applications in data communications, industrial management and process control, and laboratory measurement systems. For each application, Mr. Zimbel shows the minicomputer's functions and necessary characteristics.

Minicomputers—jack of all trades, Howard O. Painter, Jr., Digital Equipment Corp., "EDN," Vol. 15, No. 9, May 1, 1970, pp. 41-47. Besides discussing some of the many uses of the minicomputer in both the business and scientific communities, Mr. Painter points out that such machines are true, general-purpose computers; that their versatility is a function of the number and variety of input/output devices connected to the machine; and that, being optimized for cost, minicomputers do have limitations, usually in instruction-set sophistication, precision, memory size, and the number of usable peripherals.

Etching memories in batches, Donald O'Brien, Laboratory for Electronics, "Electronics," Vol. 43, No. 10 May 11, 1970, pp. 94-99. Memories are made by etching a pattern of conductors on a printed circuit board. Then, layers of permalloy, insulation and copper are deposited and etched. Through these successive steps, you arrive at an array of toroids with interwoven conductors, and hence, a memory plane.

Digital Design

Synchro-to-digital converters, Part 5, Adapted from ELECTRONIC ANALOG/DIGITAL CONVERSION, by Hermann Schmid, Van Nostrand Reinhold Co., 1970. "Electronic Design," Vol. 18, No. 10, May 10, 1970, pp. 98-103. Type VI and multispeed converters are treated. The author details one of several methods for implementing the Type VI converter. The differences from other types are that they are mathematically exact, the solution is generated by a sequence of fixed-magnitude rotations, and the output is the sum of fixed-magnitude rotation angles. The multispeed converters provide improved accuracy. Normally, the angular position of the shaft is known to about 3 minutes of arc at best. Multispeed converters do better and the most common is the two-speed system, consisting of coarse and fine circuits.

Digital sampling and recovery of analog signals, Bernard M. Gordon, Analogic Corp., "EEE," Vol. 18, No. 5, May 1970, pp. 65-75. The main merit of this article is that it relies on intuition and physical analogies to explain the concepts of sampled-data systems, rather than resorting to the heavy mathematical analysis so common in the literature on this subject. Yet we expect the article to be most useful to readers who have already been exposed to that kind of analysis, because it will help them visualize the concepts that usually get buried in the math. The author starts by explaining the physical components that form and the signals, disturbances and factors present in a hypothetical sampled data system applied to hi-fi sound. He then describes the characteristics of those components (particularly the filters), of the signals (both in the time and frequency domains), and of factors such as aliasing, and frequency folding. The article ends with an example, applying sample data techniques to the hypothetical hi-fi sound system mentioned above, and includes a simple glossary of terms used in sampled data.

Clock and control with TTL, Wendell Dennison, National Semiconductor Corp., "Electronic Design," Vol. 18, No. 10, May 10, 1970, pp. 82-88. A comprehensive set of schematics and parts list is given for constructing a 12 hour digital clock, which can serve as the nucleus of a digital timing and control system. It will display time in hours, minutes, and seconds, and costs about $180 to build. The input time base is 60 Hz line voltage.

Integrated Circuits

***Performance and convenience trade-offs for MOS read-only memories,** Dr. Robert J. Proebsting, Mostek Corp, "The Electronic Engineer," Vol. 29, No. 7, July 1970, pp. 64-67. One of the areas feeling the impact of MOS technology most heavily is that of the read-only memory. This article, the latest in a continuing course on MOS ICs, looks at some of the compromises made during the design of a read-only memory.

Technological advances in large-scale integration, Herschel T. Hochman and Dennis L. Hogan, Honeywell Inc., "IEEE Spectrum," Vol. 7, No. 5, May 1970, pp. 50-58. Offering advantages of reduced size and weight, improved performance, and most importantly, cost-saving potential, LSI has arrived and offers the promise of enormous growth. Using a digital correlator as an example, the authors describe techniques and problems in design and fabrication phases.

***Selection charts on IC operational amplifiers,** A. Boyle, L. Rothstein, and D. Wilkins, "The Electronic Engineer," Vol. 29, No. 7, July 1970, pp. 57-61. These comprehensive charts classify all commercial integrated circuit operational amplifiers, both monolithic and hybrid, by the following three parameters: slew rate, temperature sensitivity of input offset voltage, and input bias current. Each of these three parameters is plotted on a separate chart, against unit price of the op amps. The charts include 389 amplifiers (284 monolithic and 105 hybrid) and spell out the definitions for the three parameters chosen.

Miscellaneous

***Optoelectronics Course,** "The Electronic Engineer," Vol. 29, No.7, July 1970, pp. 39-46 The first part of the four-part course is comprised of two articles: "The basics," by L. C. Wetterau, Jr. and Dr. R. L. Williams, Texas Instruments. It describes what is optoelectronics, what makes it useful, and contains a simplified glossary of terms; "A new era," by J. C. Haenichen, Motorola, tells why optoelectronics is so useful, and predicts where and what the growth will be in the next five years.

Semiconductors

Remote control for color tv goes the all-electronic route, Wayne Evans, Carl Moeller and Edward Milbourn, RCA, "Electronics," Vol. 43, No. 11, May 25, 1970, pp. 102-104. Instead of motors for remote tuning of TV sets, MOSFETs are being used to do the various tuning functions electronically.

Seeing red, yellow and green in a semiconductor alphanumeric display, Allen Barnett and Fred Heumann, GE, "Electronics," Vol. 43, No. 10, May 11, 1970, pp. 88-93. In the near future you will be able to obtain solid state, alphanumeric displays in your choice of color. Infrared diodes made in monolithic arrays are coated with phosphor. When the diode emits IR, it causes the phosphor coating to glow, with the color determined by the phosphor material.

Gate-controlled switches may make it yet, Robert H. Cushman, N. Y. Regional Ed., "EDN," Vol. 15, No. 6, March 15, 1970, pp. 63-70. Gate-controlled switches (formerly known as gate-turn-off SCRs) are SCRs that you can turn OFF as well as ON. Mr. Cushman tells us that these switches are being readied by several semiconductor manufacturers for volume markets that should materialize this year; markets such as gasoline-engine ignition systems, computer print-hammer drivers, dc to variable-frequency-ac drivers for induction motors, and so forth. Such markets badly need what the gate-controlled switch offers them: the ability to switch hundreds of volts at hundreds of kilohertz, at high power levels. The bulk of the article describes gate-controlled switch theory and operation, and the advantages of these new semiconductors over conventional SCRs.

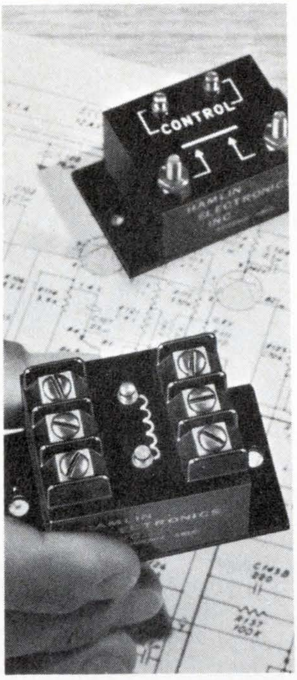
Gate-controlled switches may make it yet—Part 2, Robert H. Cushman, N. Y. Regional Ed., "EDN," Vol. 15, No. 8, April 15, 1970, pp. 37-43. Mr. Cushman concludes his description of gate-controlled switches (see "EDN," March 15, 1970 for Part 1), by showing that these semiconductors are useful in two types of circuits: those which would use transistors in a switching mode; and those which would use commutated SCRs. The author describes application of the new switch in power supplies, deflection circuits, induction-motor braking, and so forth.

Test and Measurement

Serial conversion knocks some stuff out of dvm's, Richard Van Saun and Frances Capell, John Fluke Mfg. Co., "Electronics," Vol. 43, No. 11, May 25, 1970, pp. 97-101. Large savings can result from using a recirculating remainder A/D converter designed by the authors. A dc signal is converted to digital with one counter, one bcd ladder and one decoder-driver, and some capacitors for storage.

Programmable calculators—the engineer's personalized computer—Part 2, Harry T. Howard, Tech. Ed., "EDN," Vol. 15, No. 10, May 15, 1970, pp. 35-45. The conventional calculator is a versatile tool, though not sophisticated enough for many engineering needs; but a full-size computer is expensive, and sometimes inconvenient, according to Mr. Howard. Thus, the programmable calculator seems to provide a happy compromise solution to many of the engineer's problems. To show this, Mr. Howard shows the results gathered from five users of such calculators, the problems they solved, and their comments on using these machines in their daily work routines.

20 MILLIWATTS KEEP YOU IN CONTROL WITH CONTROL-PAK.T.M.

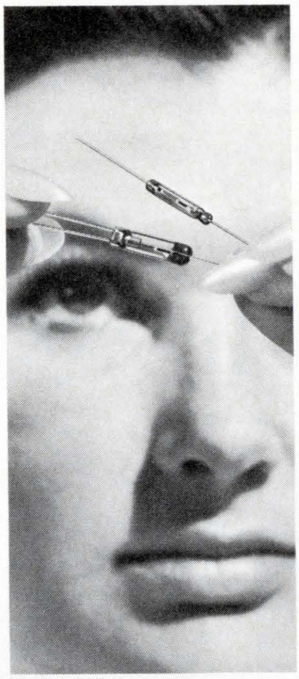


Solid state control handles up to 25 amps but can be controlled by I.C. logic input . . . without amplification. And it's fast—operates in a millisecond, releases within ½ cycle. No noise—electrical or acoustical. Zero switch-line for minimum EMI and RFI. It's completely encapsulated; immune to environment and shock-resistant. Controls all types of loads with reliable, arcless operation. Never needs maintenance. Write for catalog. Hamlin Electronics, Inc., 3066 West Clarendon, Phoenix, Arizona 85017. Or call, 602/277-4834.

HAMLIN
ELECTRONICS, INC.

Circle 36 on Inquiry Card

REED SWITCH SPEEDS WITH NO CONTACT BOUNCE.



¾ actual size.

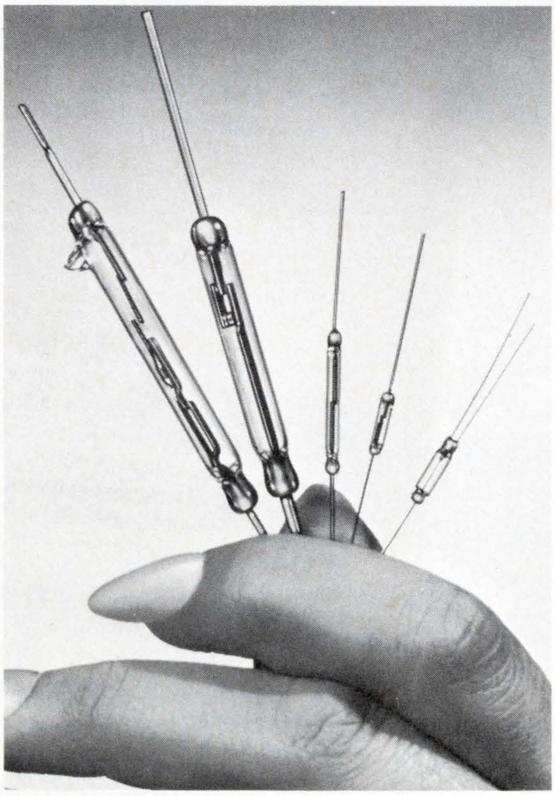
Hamlin's miniature, mercury-wetted switches offer all the advantages of high-speed, reed switches with the low contact resistance and high-power capacities of mercury switches. Precise, "on-off" actuation makes mercury-wetted switches ideal for applications where contact bounce cannot be tolerated. Available in form A (100 VDC) and form C (28 VDC). Useable length as low as .835." Write for catalog. Hamlin, Inc., Lake Mills, Wis. 53551. Or call 414/648-2361.

HAMLIN
INCORPORATED

Circle 37 on Inquiry Card

YOU PAY FOR RELIABILITY IN HAMLIN REED SWITCHES.

JUST ONCE.



The cost difference between a Hamlin reed switch and another of comparable rating is pennies—sometimes just mills. And it pays off. A switch failure may go unnoticed until it's too late. Then the cost of a malfunction is probably hundreds of times the cost of Hamlin reliability. Rhodium contacts, for example, precision assembly in white room conditions, the industry's most effective hermetic seal, rigid electrical inspection on a 100% basis—these are the things that will make you glad you specified Hamlin reed switches, even after 50 million safe, dependable closures. And you can choose from nearly 2,000 models, from 660 watt capacity down to a 3/10 watt, "grain of wheat" size. You get Hamlin reliability in every one and you pay for it only once. Write for free evaluation samples and catalog. Hamlin, Inc., Lake Mills, Wisconsin 53551. Or call 414/648-2361.

HAMLIN
INCORPORATED

Circle 38 on Inquiry Card

Complex waveforms piece by piece

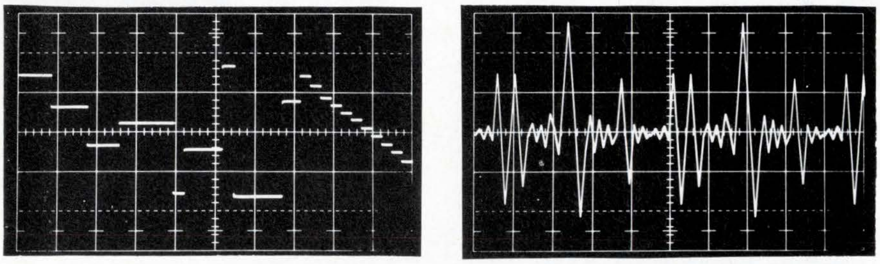
This unusual instrument lets you assemble your own waveforms. There are 40 pieces, or steps, available to synthesize any wave shape. And you can independently control each segment in amplitude, width, and slope.

Because of the great control over the segments, you can synthesize just about any waveform that you can imagine, from simple, low-distortion sinewaves to complex structures for cardiac stimulation, nerve and muscle potential simulation, transient and vibration testing, servo analysis, distortion studies, telemetry transmissions, word generation, and so forth.

The control arrangement gives you great flexibility in setting up a waveform. For instance, in the SLOPE mode, you can have all 40 segments variable in slope, or 20 variable slopes with 20 variable widths (i.e., 20 integrated increments variable in both slope and width). In the LEVEL mode, you have a choice between 40 variable step-heights, or 20 variable step-heights with 20 variable step-widths.

Time per step varies from 1 μs to 1 s in six decade ranges, and is continuously variable between decade settings. And in the VARIABLE STEP WIDTH mode, you can vary each of the 20 steps over a range of one to ten times the TIME/STEP setting. The 10/90% rise and fall times of each step are less than 100 ns (typically, about 60 ns), with less than 5% overshoot and ringing.

There are four TRIGGER modes: RUN; GATE; 1 STEP; and 1 CYCLE. In RUN, the instrument automatically recycles at the finish of the last step of a waveform. In GATE, the instrument free-runs as long as an external command signal (+2 V, DTL/TIL compatible) is applied or a panel push-button is depressed. In 1 STEP, you can advance the waveform one step at a time. And in 1 CYCLE, the instrument completes one waveform cycle (all steps) for each push-button signal.



Levels and slopes. These two illustrations give you some idea of what Exact's new waveform synthesizer can do. The trace at the left shows a digital waveform constructed with 20 steps, with the instrument in its 20-variable-step-width mode. On the other hand, the right-hand photo shows an analog waveform such as you may need to simulate speech, sonar, transient, or vibration signals. It was built with the instrument in its variable-slope mode, using all 40 segments.

The output impedance is 50 Ω, and the synthesizer can deliver 10 V pk-pk across a 50-Ω load, and a 60-dB attenuator controls the output level.

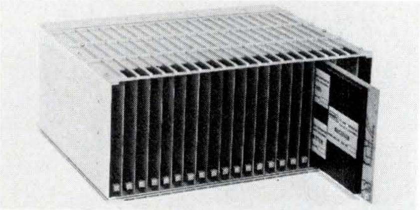
Two models of the instrument are available. Model 201 costs $1995, has the number of steps fixed at 40; Model 202, at $2495, includes a cycle length counter that lets you select any number of steps from zero to 40. The programmer section (the half-section of 40 knobs) of both models can be changed, as an option, to one with toggle switches, or multi-turn pots, or a card reader, and so forth. Exact Electronics, Inc., Box 160, Hillsboro, Ore. 97123. (503) 648-6661.

Circle 288 on Inquiry Card

Multiple data sets

A single chassis of this new series of modems hold up to 18, full-duplex, 300-baud modems and a power supply. The modems are Bell-compatible 103-types identical, from a system standpoint, to Bell 103A2 or 103E data sets.

Designed for timeshare and remote-terminal computer utilities, the data sets interface with the phone line through a Bell Data Access Arrangement for Automatic Originating and Answering Terminals (F58118).



The modems have a considerably lower cost than comparable leased units. For example, the VA300M can directly replace existing Bell equipment for less than one year's rental. And with this manufacturer's multiline dialer you save even more, because it eliminates the need for automatic dialers on every line. (The multiline dialer and dial multiplexer gives you automatic call origination over any line connected to the system.)

Built with active circuits, the new modems have a jitter-free phase-coherent transmitter, and an accurate, linear discriminator that performs well even at full data rates on poor connections. Active filters separate the two channels to prevent a strong, transmitted signal from interfering with weak-data-signal reception.

The VA300M multiple data sets are available in either answer-only or full originate/answer formats. For complete specifications, prices, and delivery information, contact The Vadic Corporation, 916 Commercial St., Palo Alto, Ca. 94303. (415) 321-6201.

Circle 289 on Inquiry Card

A significant advance in silicon rectifier power handling capacity

3 new series of silicon rectifiers from Tung-Sol permit designers to meet extremely high power requirements.

- **Reverse voltage ratings to 5000 Volts**
- **Average forward current to 500 Amperes**
- **Surge overload ratings up to 8500 Amperes**

Controlled avalanche characteristics provide transient handling capability that results in increased reliability.

All units feature ceramic-to-metal seals, mount in any position and are supplied in either polarity.

1511 SERIES

Max. av. forward current at 120° C—420 Amperes

Surge overload rating, 1 cycle—6000 Amperes

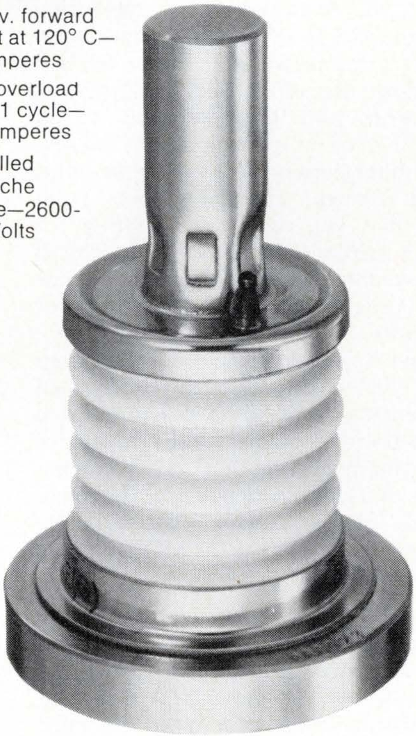
Controlled Avalanche Voltage—1250-3500 Volts

1621 SERIES

Max. av. forward current at 120° C—500 Amperes

Surge overload rating, 1 cycle—8500 Amperes

Controlled Avalanche Voltage—1100-2300 Volts



1611 SERIES

Max. av. forward current at 120° C—470 Amperes

Surge overload rating, 1 cycle—5200 Amperes

Controlled Avalanche Voltage—2600-5000 Volts

Write for technical data bulletins—
Tung-Sol Division, Wagner Electric Corporation
630 West Mt. Pleasant Ave., Livingston, N.J. 07039
Twx: 710-994-4865 • Phone: (201) 992-1100; (212) 732-5426

TUNG-SOL
High Power Silicon Rectifiers

Trademark TUNG-SOL Reg. U. S. Pat. Off. and Marcas Registradas

Circle 39 on Inquiry Card

High-speed DVM reads true rms values

Hewlett-Packard's Model 3480 is a 4-digit (5th digit is 50% overrange), multifunction DVM that attains a very short reading period—950 μs—through the use of the successive approximation, D/A conversion technique. With an external trigger, the instrument can reach a 1000-per-second reading rate for dc measurements.

Speed is indeed the major advantage of the successive approximation technique. But this technique also has a major disadvantage—a lack of noise rejection. To improve noise rejection, you must use filtering; and when you filter, speed drops.

The slowdown

For example, two of the three available plug-ins have filter-mode switches. With the filter out of the measuring circuit, the DVM's response time is indeed 1 ms to within 1 count of final reading. But in the first filter position, response time drops to 200 ms to within 1 count of final, and in the second filter position to 1 s (2 s for ohms measurement; and HP's specs point out that you may need filtering for quiet readings above 100 kΩ). This is unavoidable when you filter; it's a law of nature—you don't get anything for nothing.

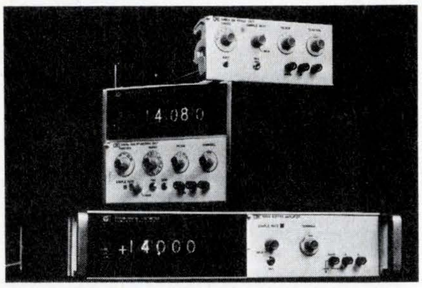
But if you don't need to filter, then the 3480 gives you a truly high-speed instrument suitable for automatic measuring systems. For resistance measurements, in fact, the combination of 1000 readings/s (on the lower ohms ranges), with six, full-scale ranges from 10 Ω to 10 MΩ is unique in a 4-digit DVM.

The rundown

The instrument consists of either the 3480A half- or the 3480B full-rack-width mainframe, combined with one of three available plug-ins: the 3481A buffer amplifier; the 3482A dc-range unit; and the 3484A multifunction unit.

Model 3481A buffer amplifier plug-in has a single, ±10 Vdc range for full-scale display, $>10^{10}-\Omega$ input impedance, and a true reading-rate of 1000/s (there is no filtering in this plug-in).

Model 3482A plug-in has five dc ranges from ±100 mV to ±1 kV, with manual, automatic, or remote range selection. Autorange time with the filter out is 4 ms/range-change. With the first filter in, this time is 200 ms; and with the second filter, 1 s. Final reading response-time is as mentioned earlier: 1 ms without the filter; 200 ms with one filter; 1 s with the other. Input impedance through the 10-V range is $>10^{10}$ Ω, and 10 MΩ on the 100- and 1000-V ranges.



Take your choice. Hewlett-Packard's new multifunction, 4-digit DVM uses the D/A conversion technique of successive approximation to reach a reading rate of 1000/s for dc measurements. In addition, it uses a proprietary thermopile to read true rms values that can include the dc component. Three plug-ins, two mainframe styles, and three options within the mainframe itself give Model 3480 a wide range of configurations.

It's in the cards

The third plug-in, Model 3484A, gives you the same dc capabilities as those of the 3482A. But in addition, this multifunction unit has plug-in option cards available for it. One card lets you measure resistance; the other, true rms levels.

Option 042—the ohms card—gives you six resistance ranges, from 100 Ω to 10 MΩ. The 1000-readings/s rate is usable to 100 kΩ; above this range, resistor noise may require you to filter, thus slowing down the reading rate. In the 1000-Ω through 1-MΩ ranges, 90-day accuracy is ±(0.02% of reading + 0.01% of range); the 100-Ω and 10-MΩ range accuracies are not quite as good. This is a two-wire system, and does not eliminate lead-length errors.

Option 043—the rms card—uses an HP-designed thermopile, and gives you five, true-rms ac ranges from 100 mV to 1 kV, and with crest factors of 7:1 at full scale, and 70:1 at 10% of full scale. Response times are 1 s to within 5 counts of final reading (ac coupled), and 15 s to within 5 counts of final reading (dc coupled).

Note that there are dc- and ac-coupled modes; the dc mode lets you measure rms values below 20 Hz, and down to dc. Or you can use a 10-μF external coupling capacitor to eliminate the dc component and measure ac components only, down to 1 Hz. (Input impedance is 2 MΩ.)

The 90-day accuracies are a function of the frequency and the coupling mode. For dc coupling: at dc, ±0.5% of range; 1 to 10 Hz, ±1% of reading; 10 to 20 Hz, ±(0.1% of reading + 0.05% of range). For ac coupling from 20 Hz to 1 MHz, the 90-day figure is ±(0.05% of reading + 0.05% of range).

Mainframe options

There are three options available in the mainframe itself. Option 002 gives you dc ratio measurements. The display is proportional to the ratio of the input voltage to an externally applied, 10-Vdc, reference voltage. Two ranges (10 V and 100 V) are available.

Both of the other two mainframe options give you measurement data outputs in digital form for printer and system applications. Option 003 gives you a non-isolated digital output; you can make floating measurements only if you can float all equipment connected to the data and input lines. Option 004, on the other hand, gives you an isolated digital output that lets you make floating measurements with no degradation in common- or normal-mode rejection characteristics.

[The three plug-ins—the 3481A, 3482A, and 3484A—include a non-isolated, remote-control capability. This means that you can make floating measurements only if you float the programming source itself. To get around this, there are isolated-remote-control options offered for the 3482A and 3484A. But to use them, you must also order mainframe Option 004.]

Pricing

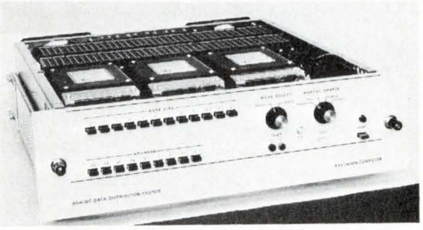
Because of the three plug-ins, the three mainframe options, and the two mainframe styles, the cost of a complete instrument will vary greatly depending on your needs. So let's say that you want a half-rack-width instrument with full ac, dc, and ohms capability. This means $800 for the 3480A mainframe, $900 for the 3484A multifunction unit, plus $200 for the Option 042 ohms converter, and $800 for the Option 043 rms converter. This totals to $2700.

But if you want to use this instrument in an automated measurement system, you may very well want Option 041, the isolated remote control, that goes for $200. But to use this option, you'll have to add Option 004, the isolated digital output, to the mainframe for $375. This adds another $575 to the previous cost, bringing it up to $3275. And so it goes. For more information, contact Inquiries Manager, Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

Circle 285 on Inquiry Card

ANALOG DATA DISTRIBUTOR

Resolution of 12 bits including sign.

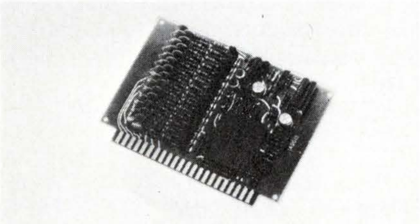


Model MDD1-06 accepts digital information from a computer along with channel address data, converts it into equivalent analog form and then distributes it to selected output holding amplifiers. System accuracy is 0.05% FS ±½ LSB and linearity is 0.03% FS ±½ LSB. Raytheon Computer, 2700 S. Fairview St., Santa Ana, Calif. 92704. (714) 546-7160.

Circle 286 on Inquiry Card

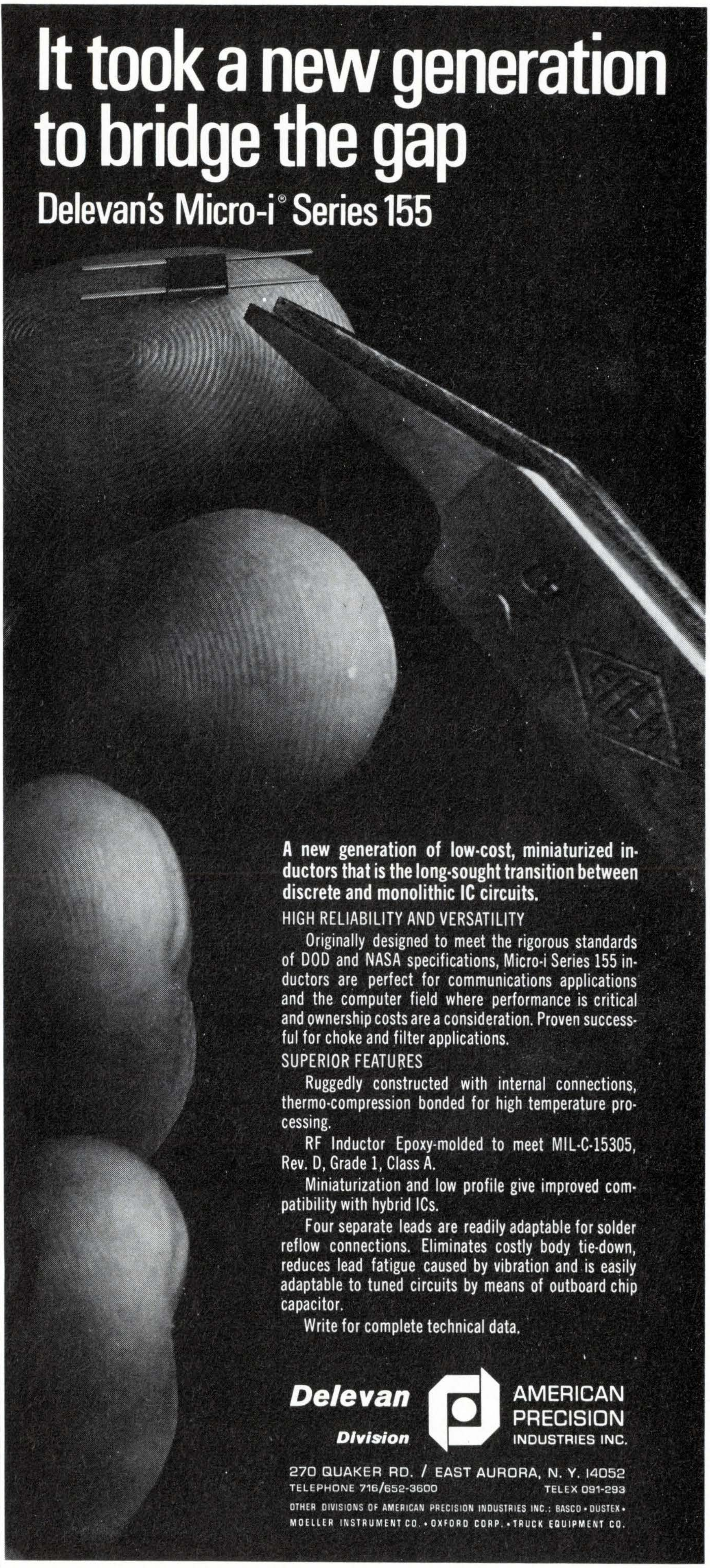
D/A CONVERTERS

With ±0.01% accuracy.



Seven new converters each provide a complete system element. All are available with bipolar or unipolar output. All that is needed to operate any unit in the DAC-A series is a ±15 V supply. All units are completely self-contained. Temperature coeff. is ±5 ppm/°C. They are TTL compatible. Phoenix Data Inc., 3017 W. Fairmount Ave., Phoenix, Ariz. 85017. (602) 277-4767.

Circle 287 on Inquiry Card



An analog-to-teletype coupler

There's been a lot said recently about multiplex couplers that link BCD-output measuring instruments to teletype terminals for computer entry (See "Controller/coupler interfaces with computer," **The Electronic Engineer**, June 1970, page 119.

But what do you do with a mass of analog information (from sensors, gauges, and so forth) when you want to process it automatically? Well, you could of course use a number of A/D converters to change such data into streams of parallel digital data that, in turn, feed one of the new multiplex couplers which output a serial data stream.

Or, you could use Beckman's Model 3108 Intercoupler. (For many data sources, you would also need a sequencer, such as a crossbar scanner.) The 3108 gives you a relatively inexpensive and direct way to digitize an analog signal and record the data on a teletype. And the TTY gives you not only hard copy, but also a punched paper tape record suitable for either direct or time-shared entry to a data processor.

Beckman's Intercoupler accepts analog input data and formats them into a serial digital data stream. The self-contained instrument is operable directly from its panel, or remotely through external contact closures to ground.

Control functions include initiation of data conversion and recording; recording of a two-digit sample number for each series of data conversions; selection of the number of readings per sample (1, 3, 10, or continuous); selection of the reading interval (1 to 100 s); and preparation of the paper tape leader.

The 3108 not only automatically turns on the teletype to record a sample, but also removes power from the TTY 6 seconds after each conversion cycle. This increases the life of the ASR 33 teletype which is designed for intermittent use only.

Analog input range of the Intercoupler is 0-100 mVdc standard, factory calibrated. However, optional multiplier and shunt resistors give you additional ranges of 0-1, 10, 100, and 1000 V, and dc current ranges of 0-10, 100 μA, 0-1, 10, and 100 mA. Overall accuracy is ±1% FS ±1 digit.

Common-mode rejection is >100 dB (max. common-mode voltage, 500 V peak); series-mode rejection is >38 dB at 60 Hz.

The digital data output is 0 to 1000 counts, +800 count overrange, −200 count underrange (2000-count span). Negative values are in a 9's- complement form. The output format gives you a data line that starts with a sample number followed by a series of up to ten data values. To record more than ten values, a new line is started.

Model 3108 Intercoupler costs $1595 (this is the price of the instrument alone, without a teletypewriter unit). For more information, contact Electronic Instruments Division, Beckman Instruments, Inc., 2400 Harbor Boulevard, Fullerton, Calif. 92634. (714) 871-4848.

Circle 241 on Inquiry Card

DISC MEMORIES

Have 16.7 average access time.

These systems are for fast-access files for everyday programs, and also for file storage and data collection. Model 1757 (for HP machines) holds 46,080 words; Model 1703 (for Varian's 620/i), 32,768 words. Both are plug-compatible, expandable, available in four capacities and start at $7500. Data Disc., Inc., 1275 California Ave., Palo Alto, Calif. 94304. (415) 326-7602.

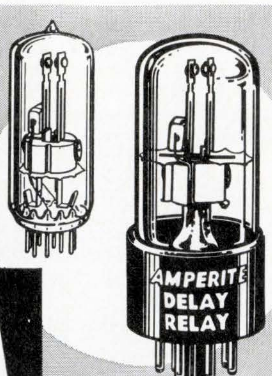
Circle 242 on Inquiry Card

BACK-COATED COMPUTER TAPE

Reduces errors and tape damage.

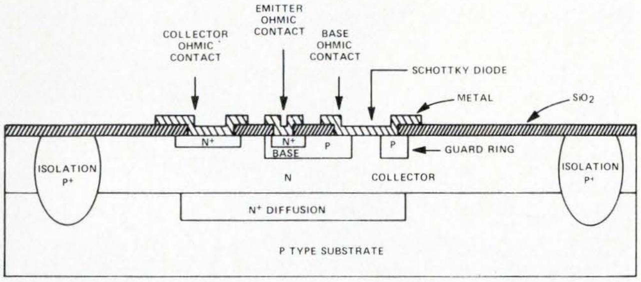
Astron tape is claimed to offer these advantages over conventional tapes: static buildup and backscratching, both of which result in errors, are eliminated; cinching and rewind offset, both of which result in tape damage, are reduced; and more consistent start/stop times with marginally performing drives. Memorex Corp., 1180 Shulman Ave., Santa Clara, Calif. 95050. (408) 247-1000.

Circle 243 on Inquiry Card



SCHOTTKY-CLAMPED TTL FAMILY

With 3 ns/gate typical propagation delay.

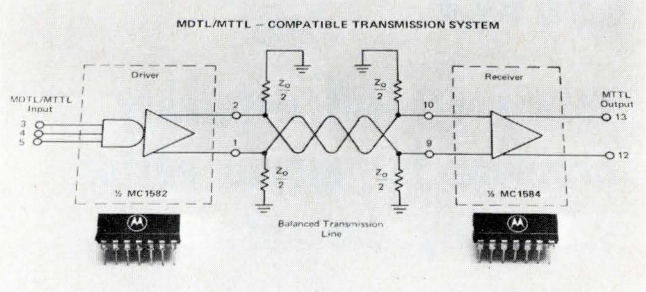


This family of TTL circuits, designated Series 54S/74S, uses Schottky diodes to clamp active transistors. This technique prevents saturation and allows extremely fast switching at low power. First units introduced are the SN74S00 quad 2-input positive NAND gate and the SN74S20 dual 4-input positive NAND gate. The third unit will be the SN74S112, a 100-MHz dual, negative edge-triggered J-K flip-flop. Schottky diode technology permits the individual circuit transistors to operate with an effective storage time of zero. Elimination of this storage time produces the high speed while retaining the low power consumption (20 mW/gate) of saturated logic. Prices (1-24 pcs) are SN74S00N, $3.90; SN74S20N, $3.90; SN74S112N, $10.51. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, M/S 308, Dallas, Tex. 75222.

Circle 255 on Inquiry Card

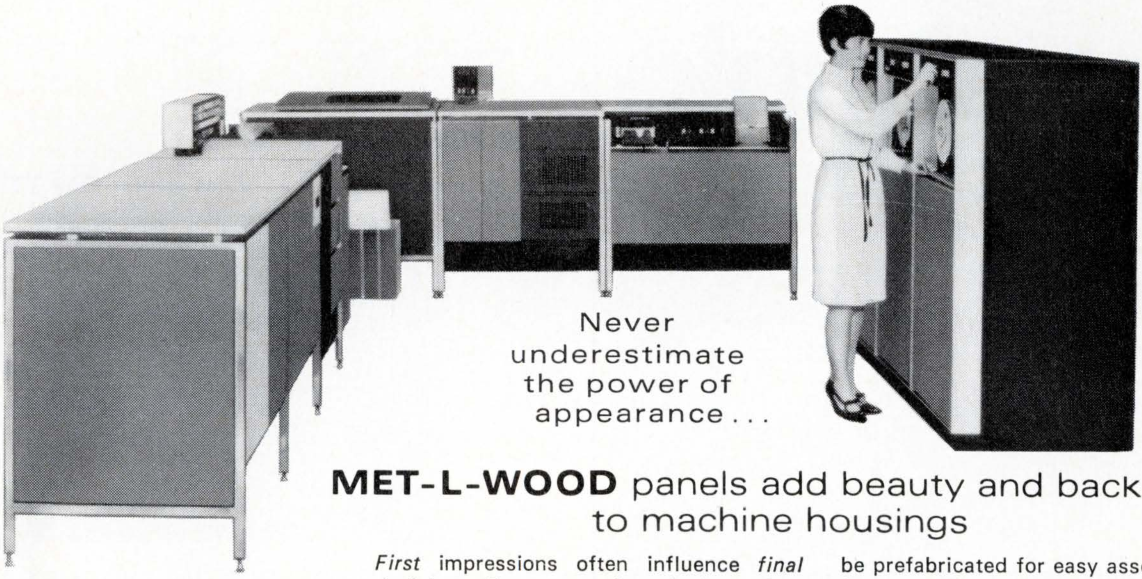
INTERFACE CIRCUIT FAMILY

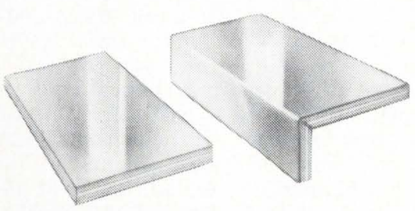
Five line driver/line receiver circuits.



These circuits will drive and receive digital data via coaxial or twisted-pair transmission lines. A driver and a receiver interface with all standard logic families and all five circuits are fully compatible with each other. The circuits are the MC1580L, a dual line driver/receiver (ECL, RTL); the MC1581L, a dual line receiver (ECL); the MC1582L, a dual line driver (DTL, TTL, RTL); the MC1583L, a dual saturated logic receiver with open collector (DTL, TTL, RTL) and the MC1584L, a dual DTL/TTL receiver with active pullup. All have the wide common-mode input and output voltage range, high impedance, and low propagation delay needed for digital transmission. Prices (100-999 pc lots) range from $7.50 to $8.75 ea. Motorola Semiconductor Products Inc., Technical Information Ctr., Box 20924, Phoenix Ariz. 85036.

Circle 256 on Inquiry Card





NEW MICROWORLD PRODUCTS

FOUR BIT BINARY FULL ADDER

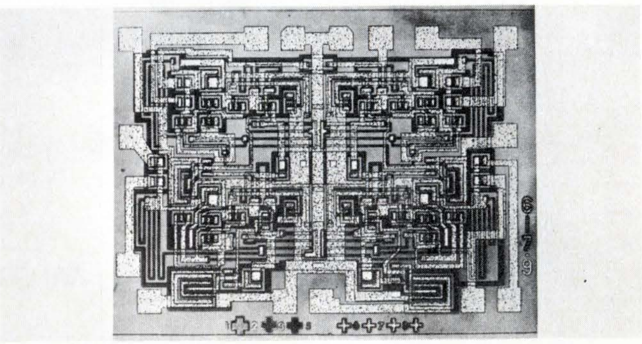
Called 2½ times faster than equivalent circuits.

The DM7283/8283 adds two 4-bit numbers, accepting carry at the input and propagating it to the output. The addition of each pair of bits occurs in parallel; but the limiting factor in adding long words is the ripple time of the adder— the time it takes the carry bit to propagate through each stage in series. This device incorporates internal carry look-ahead circuitry that cuts ripple time to 12 ns. It accepts four A and four B inputs plus the carry input, and has four Σ outputs plus the carry output. The full temp. version comes in a hermetic DIP while the industrial version is in a silicone DIP. Prices (1-24 pcs) are DM7283 (−55 to +125°C) $26.64; DM8283 (0 to +70°C) $11.82. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. (408) 732-5000.

Circle 244 on Inquiry Card

HIGH THRESHOLD LOGIC LINE

With dc noise immunity 15 times greater than TTL.

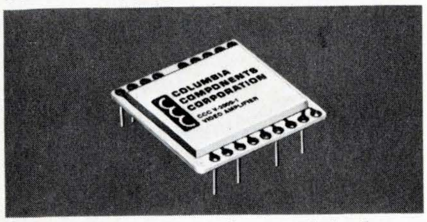


These devices, the SG393, SG394 and SG395, are high threshold logic (HTL) circuits that perform NAND gate functions. The SG393 is a quad two-input NAND gate and SG394 and SG395 are dual four-input NAND gates. The 395 has an open collector output and you can use it for driving relay coils and other electromechanical configurations. The noise immunity feature is particularly useful when logic elements must operate near electromagnetic switching equipment containing relays or solenoids. The devices are available in a hermetically sealed, metal-lid 14-lead DIP. In quantities from 100 to 999, prices are: SG393, $3.05 ea.; SG394, $2.75 ea.; SG395, $3.20 ea., with immediate delivery. Sylvania Electric Products Inc., 70 Empire Dr., West Seneca, N.Y. 14224.

Circle 245 on Inquiry Card

D/A CONVERTERS

Can drive 50 Ω cable.

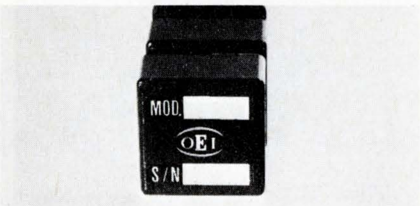


Each D-3000 series module has a high slew rate output amplifier, ladder network, internal voltage reference and high speed switching circuits. The series includes units with accuracies of 8 or 10 bits binary or 12 bits BCD. The output, 100 mA at +5 V, is short-circuit proof. Columbia Components Corp., 60 Madison Ave., Hempstead, N.Y. 11550. (516) 483-8200.

Circle 246 on Inquiry Card

ANALOG MULTIPLIER

With bandwidth of dc to 30 MHz.

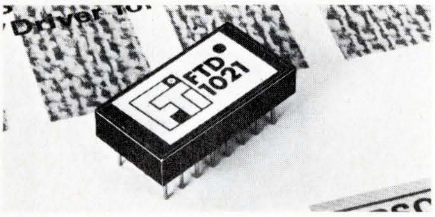


Model 5822 is a four-quadrant analog multiplier that gives you a 3% maximum untrimmed error and 73 dB null rejection at 5 MHz. The device is packaged in a 1 in. square by 0.5 in. high module. The price is $87 ea. (1-2) and $79 ea. (3-9) with immediate delivery. Optical Electronics, Inc., Box 11140, Tucson, Ariz. 85706. (602) 624-8358.

Circle 247 on Inquiry Card

DECODER/DRIVER

Cold cathode displays.

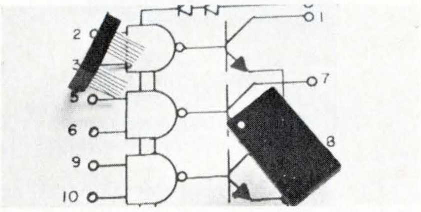


The FTD-1021 decodes BCD inputs to drive 7-segment cold cathode displays. Each output has a 100 V standoff rating at 2 μA standoff current. In the on state, each output can sink 20 mA continuously, with 50 mA surge currents, $10.50 in 100 quantities. Fabri-Tek Micro-Systems, Inc., 1150 N.W. 70th St., Ft. Lauderdale, Fla. 33309. (305) 933-9351.

Circle 248 on Inquiry Card

QUAD POWER DRIVER

In a dual-in-line package.

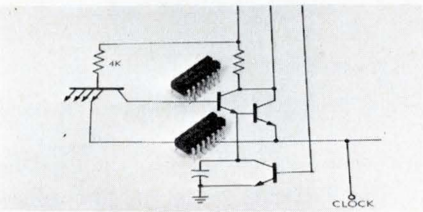


The MN304 is a quad, two input non-inverting power gate with four transistor output stages. The unit has an output voltage rating of 50 V and output current of 200 mA/output stage. Operating range is 0 to 70°C. Available from stock, the unit price is $13.50. Micro Networks Corp., 5 Barbara Lane, Worcester, Mass. 01604. (617) 756-4635.

Circle 249 on Inquiry Card

J-K FLIP-FLOPS

High speed TTL.



Type US74H571A is an AND-OR input J-K flip-flop and the US74H572A is an AND input J-K flip-flop. These 50 MHz devices feature a typical power dissipation of 60 mW. Both units are specified for 0 to 70°C operation and come in the 14-lead plastic DIP. $3.15 (100 to 999 pcs). Sprague Electric Co., North Adams, Mass. 01247. (413) 664-4411.

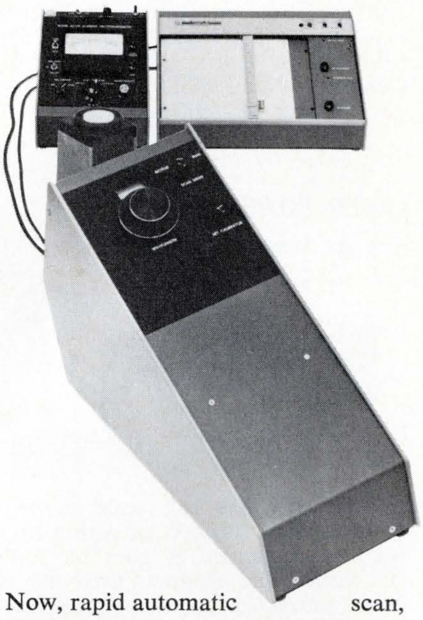
Circle 250 on Inquiry Card

DOUBLE BALANCED MIXER

Mounts in 0.08 in^3.

Model DBM-500PC has an rf and LO input frequency of 2 to 500 MHz and an i-f which operates from dc to 500 MHz. You can use the unit as a mixer, balanced modulator, rf switch and phase detector. Prices range from $12 to $24, with delivery from stock to 30 days. Elcom Systems Inc., 151 W. Industry Court, Deer Park, N.Y. 11729. (516) 667-5800.

Circle 251 on Inquiry Card



LOW COST DVM

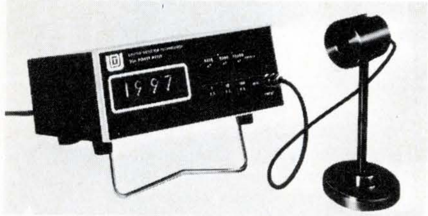
With 10 μV resolution.

Model 7005 features a 5½-digit readout with ±0.005% accuracy. The standard unit provides a resolution of 0.001% (10 μV) or you can increase it to 1 μV with a plug-in card ($225 option). DC measurements can be made up to 5 samples/s. $1295. Systron Donner Corp., 888 Galindo St., Concord, Calif. 94520.

Circle 257 on Inquiry Card

LASER POWER METER

Has six ranges.



This unit has full scale readouts from 1μW to 100 mW or with a beam splitter attachment it goes to 100W full scale. The readout gives the incident power for any three preselected laser lines from 2000 Å thru 1.15 μm and white light without calibration curves. Price under $1000. United Detector Technology, 1732 21st St., Santa Monica, Calif. 90406.

Circle 258 on Inquiry Card

DATA LOGGER

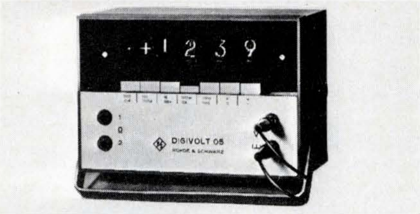
For unattended data acquisition.

Model 1202 consists of a digital voltmeter, a scanner, a digital clock and digital printer. The clock initiates the scan/record cycles at time intervals of 1, 5, 10, 30, or 60 min. In the standard system, the unit accepts 10 inputs, but you can expand it to a max. capacity of 100 points. $3650. United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403.

Circle 259 on Inquiry Card

DIGITAL MULTIMETER

Three digits plus overrange.

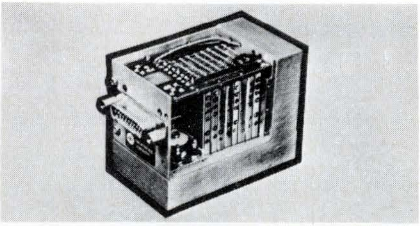


The UGWD measures dc and ac voltages from 100 μV to 1000 V and resistances from 1Ω to 15MΩ. It is an integrating voltmeter that uses the dual slope technique and it has a true integrating time of 300 ns and a sampling rate of 3 measurements/s. $750. Rohde & Schwarz, 111 Lexington Ave., Passaic, N.J. 07055.

Circle 260 on Inquiry Card

TIME REFERENCE GENERATOR

With selectable time code format.

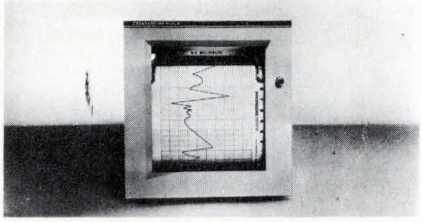


The TR-1000 gives you two tone-modulated and one unmodulated serial word with accumulated time information as well as eight sq. wave reference tones ranging from 250 Hz to 1 MHz. Construction and low power dissipation make the unit suitable for remote and severe environment applications. ESL Inc., 495 Java Dr., Sunnyvale, Calif. 94086.

Circle 261 on Inquiry Card

RECORDING GALVANOMETER

With 1 mV sensitivity.

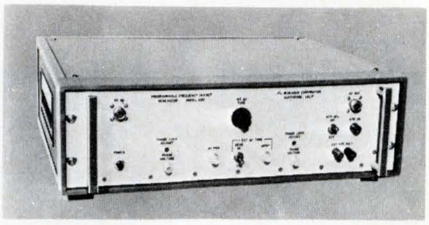


Available in six case configurations, this unit has 0.5 s full scale response, potentiometric input impedance, source impedances to 10,000 Ω, sensitivity to 1 mV, and accuracy of 1%. It comes in any of the manufacturer's three direct writing styles. Esterline Angus, div. of Esterline Corp., Box 24000, Indianapolis, Ind. 46224. (317) 632-6501.

Circle 262 on Inquiry Card

FREQUENCY TRANSLATOR

With bandwidth of 9.5 ±0.150 GHz.

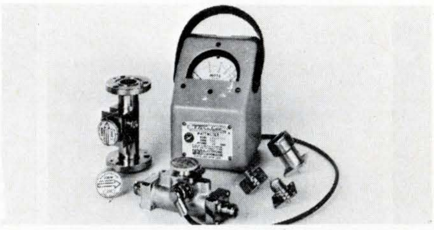


Model 6011 is available in L, S, C, X or Ku-band and preserves a-m and fm modulation characteristics of the input signal. Key technical characteristics include up to 1000 MHz rf bandwidth, 20 MHz fm bandwidth, and ±500 kHz freq. offset range. ITL Research Corp., 8955 Quartz Ave., Northridge, Calif. 91324.

Circle 263 on Inquiry Card

DIRECTIONAL RF WATTMETER

Full scales from 1 W to 10 kW.

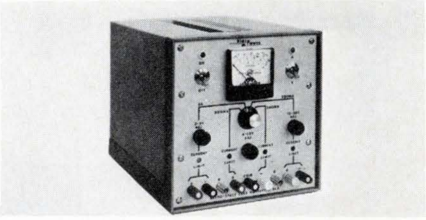


This Thruline^{R} coaxial wattmeter is an insertion type instrument for measuring forward and reflected cw power in ⅞ in. EIA and in rf cable transmission lines. It measures rf power flow with an accuracy of ±5% in discrete frequency bands from 0.45 MHz to 2.3 GHz. Bird Electronic Corp., 30303 Aurora Rd., Cleveland, Ohio 44139. (216) 248-1200.

Circle 264 on Inquiry Card

LAB POWER SUPPLY

For linear and digital circuits.



Model 401 has four power supplies in one cabinet. The logic section furnishes 3-5 Vdc at 3 A with overvoltage protection. The linear section has dual tracking dc outputs of 0.5 A, adjustable from 6-18 V. The MOS/relay section provides 0.5 A, from 15-28 V. $295. Astro-Space Laboratories, Inc., 110 Wynn Dr., N.W., Huntsville, Ala. 35806.

Circle 265 on Inquiry Card

DIGITAL SIGNAL GENERATOR

Gives you RZ or NRZ format.

The DG-7 operates from 1 Hz to 35 MHz with its own internal oscillator. The unit provides a serial data stream 16 bits long, plus a parallel pulse stream. Output signals feature ±4 V offset and 10 V signal amplitude with 5 ns rise and fall times. Because it has variable clock width plus amplitude and offset control, you can use the DG-7 as both a pulse generator and data generator. The instrument is completely self-sufficient, no additional signal sources or amplifiers are required. Four modes of operation give you a continuous or programmable data stream. Price of the instrument is $990 with delivery from stock to two weeks. Tau-Tron Inc., 685 Lawrence St., Lowell, Mass. 01852. (617) 458-6871.

Circle 266 on Inquiry Card

NEW LAB INSTRUMENTS

DIGITAL EVENT COUNTER

Counts to 1999 at rates up to 1 MHz.

You can use this unit, the Type 320 counter, to replace mechanical and other less versatile and adaptable counters in process control and other applications. Among its advantages are noiseless operation, a high operating speed, solid-state reliability with no moving parts, and buffered BCD output for compatibility with computer-controlled systems. The device features a self-contained ac power supply and you can panel mount it. Input requirements are any 2-V pulse with a rise time between 20 and 30 ns. A plus plus 2-V signal level change resets the counter to zero. In quantities of 1-9, price is $149. Digilin Inc., 6533 San Fernando Rd., Glendale, Calif. 91201. (213) 246-8161.

Circle 252 on Inquiry Card

INTEGRATED CIRCUIT CARD TESTER

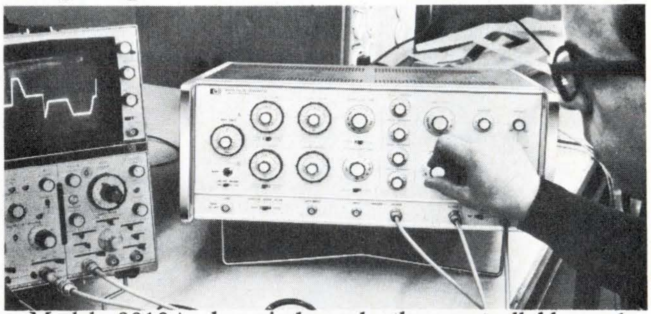
For go/no-go and qualitative testing.

You can adapt the model ICT-100 to test all digital circuit card families. The unit attains this high degree of flexibility by using a card reader and standard IBM punched cards for programming. In addition, the instrument has a universal test connector that you can adapt for most connector configurations. The unit will do high speed dynamic testing at 1 MHz and will also perform a low speed dynamic test at 60 Hz. It includes programmable supply voltages and circuit loads and you can use it on the bench or rack mount it. General Dynamics, Electronics Division, Dynatronics Operation. Box 2566, Orlando, Fla. 32802. (305) 838-6161.

Circle 253 on Inquiry Card

COMPLEX WAVEFORM GENERATOR

Two pulse generators with a common output.

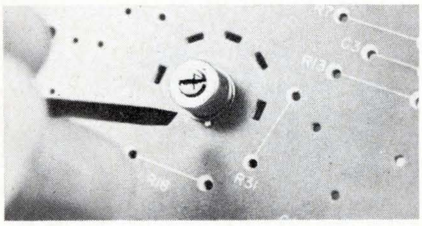


Model 8010A has independently controllable pulse shaping controls (width, amplitude, risetime, falltime, offset) for each channel. Combining the two outputs gives you an infinite variety of complex waveforms or each channel's output can be supplied separately. Individual control of rise and fall transition times lets you generate ramps, trapezoids, and triangles as well as rectangular waveforms. Or you can use the instrument to simulate intricate electrical waveforms like those found in bioelectronics, TV signals, nuclear physics, and so on. Price is $1925. Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

Circle 254 on Inquiry Card

ROTARY SWITCH

In a transistor can.

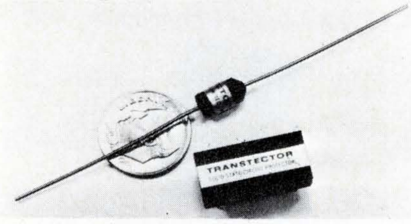


First of a projected line of switches in transistor cans, the TO-5 rotary switch is for circuit selection on PCS. The screwdriver-actuated switch is SP7T 8-pos., one position off. It has a positive detent action holding the switch in each position, contacts plated with 30 μin. of gold over 30 nickel, and easy assembly. Chicago Switch, Inc. 2035 W. Wabansia Ave., Chicago, Ill. 60647. (312) 489-5500.

Circle 267 on Inquiry Card

CROWBAR CIRCUITS

Protect against transients.

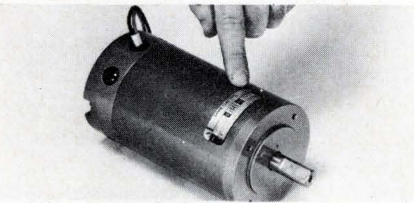


This line of hybrid SCR crowbar circuits protects transistors, ICS and multilayer circuit boards from overvoltage transients. Transtector Circuit Protectors™ have operating current levels of up to 10 A. They can be ordered with std. overvoltage trip points ranging from 5 to 200 Vdc. Standby power loss runs <1 mW/V. Transtector Systems, 1161 Monterey Pass, Monterey Park, Calif. 91754.

Circle 268 on Inquiry Card

PM SERVO MOTORS

Come in four sizes.

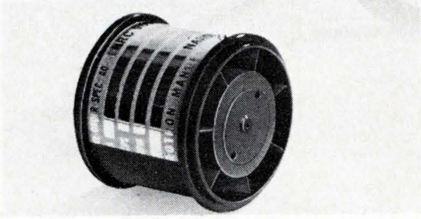


New line of dc permanent magnet servo motors is for computers, business machines, machine tools, and similar applications. They come in 2.5, 3.3, 4.0, and 6.0 in. diameters and with many shaft configurations. Units can be supplied in 18 std. armature windings for 6 to 120 Vdc service. Speed of the motor line ranges to 6000 rpm (no load) with stall torque ratings of 75 to 1600 oz-in. AMETEK/Lamb Electric, 629 Lake St., Kent, Ohio 44240. (216) 673-3451.

Circle 269 on Inquiry Card

COMPACT FAN

For use in microelectronic devices.

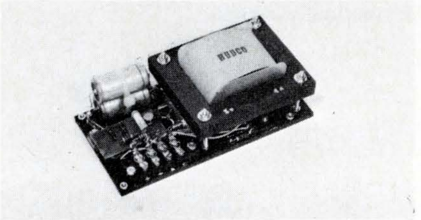


Nanos® is a compact (1 in. in dia. by 1 in. long), hf fan that provides up to 7.5 cfm free delivery. It withstands 100 g shock in any direction, operates from −55° to +100°C, and may be mounted in any attitude. Airflow is reversible by turning the fan end-for-end. Power requirement is 26 Vac, 400 Hz, 1 ϕ. Rotron Inc., Hasbrouck Lane, Woodstock, N.Y. 12498. (914) 679-2401.

Circle 270 on Inquiry Card

POWER SUPPLY

Only 1¾ x 6¼ x 3⅛ in.

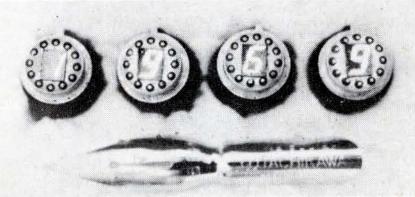


Miniaturization is achieved in the Model HM5-4 without switching techniques; thus there is no switching noise and/or spikes in the dc output. The 5 V unit is rated at 4 A at 71°C. It works from 105 to 125 V, 50 to 500 Hz. Regulation is ±0.25% for line and load changes. Ripple is 4 mV rms max. Response time is 50 μs max. $48 (100 to 499). Hudco, 2740 S. La Cienega Blvd., Los Angeles, Calif. 90034.

Cricle 271 on Inquiry Card

PHOTODIODE

Integrated 8 and 16-segment units.

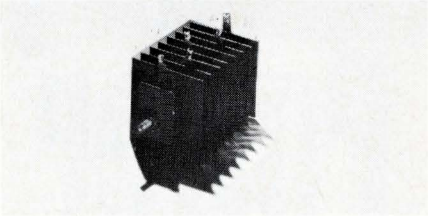


These photodiodes provide bright readouts, fast response to switching, low power consumption and long life. An 8-segment display about the size of a thumbtack can produce figures from zero to nine and a stop sign in bright red. The 16-segment diode can produce the complete alphabet. Large crystals of arsenic phosphate gallium (GaAs P) are used in a monolithic integrated structure. Hitachi, America Ltd., 437 Madison Ave., New York, N.Y. 10022. (212) 758-5420.

Circle 272 on Inquiry Card

RECTIFIER COMPONENTS

Selenium plates and hardware.

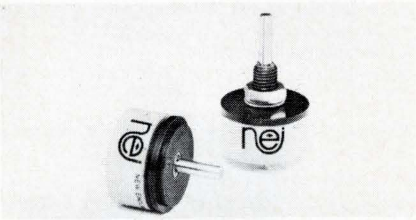


You can use these units to build custom rectifiers. The plates are rated at either 30 PIV, 25 V rms (style PT), or 36 PIV, 30 V rms (style PU), and range from 0.5 A capability to 173 A in 24 sizes from 1 in.^{2} to 8 x 16 in. Plates are stacked for the required voltage and circuit configuration. Siemens Corp., Components Div., 186 Wood Ave. So., Iselin, N.J. 08830. (201) 494-1000.

Circle 273 on Inquiry Card

INDUSTRIAL POTS

Long life—25 million revolutions.

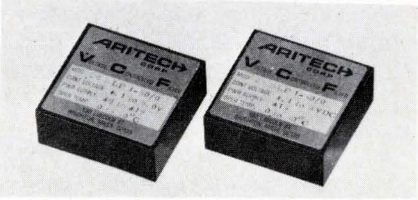


Standard models come in both servo and bushing designs with a ⅞ in. dia. and a choice of a ⅛ or ¼ in. dia. shaft. All have infinite resolution, resistance ranges from 1 k Ω to 10 k Ω, and linearities from 1 to 0.25%. Power rating is 1 W at 70° C, derated to 0 at 125°C. $4.99 (100 units). New England Instrument Co., Kendall Lane, Natick, Mass. 01760. (617) 873-9711.

Circle 274 on Inquiry Card

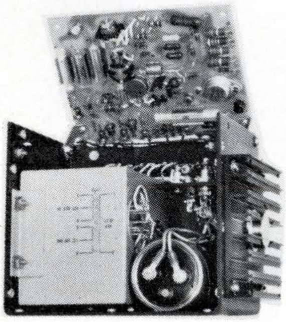
MATCHED FILTERS

For multichannel systems.



These filters are for dual or multichannel systems for simultaneous processing of signals or for multiple channel recording. They come in the range from 0.1 Hz to 100 kHz. Matched fixed filters are being produced to within ±1° in phase and ±¼ dB in amp. Voltage Controlled Filters (VCF's) track to within 2° and ±½ dB over a 50:1 freq. range. < $100 (in quan.), Aritech Corp., 130 Lincoln St., Brighton, Mass. 02135. (617) 254-2990.

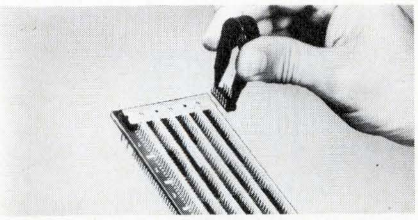
Circle 275 on Inquiry Card



NEW PRODUCTS

DIL PACKAGING SYSTEM

Eliminates packaging problems.

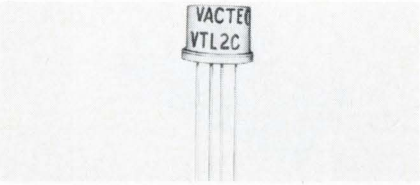


DIP-PAC is a pluggable DIL packaging system with contacting fingers that permit the DIP to be inverted and plugged into the system. DIP-PAC provides an integrated ground and voltage plane on the wiring side connected to dummy pins or specified DIP locations. Tail side of the system is arranged for automatic wiring. It comes in std. sizes of 30, 60, 90, 120, 150 and 180 DIP positions. Elfab, Box 34555, Dallas, Tex. 75234. (214) 239-7181.

Circle 276 on Inquiry Card

LED PHOTON ISOLATORS

Hermetically sealed.

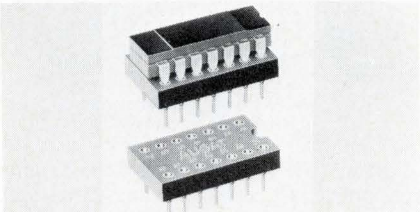


Vactrols combine a ss light source (light emitting diode) with a photoresistor to provide I/O isolation. Four types of photoconductors are available in combination with the LED. VTL2C series Vactrols, when operated within their ratings, provide virtually unlimited life because there are no filaments to burn out. As low as $4.20 ea. (1000 quan.). Vactec Inc., 2423 Northline Industrial Blvd., Maryland Heights, Mo. 63043.

Circle 277 on Inquiry Card

DIL SOCKETS

With machined four leaf contacts.

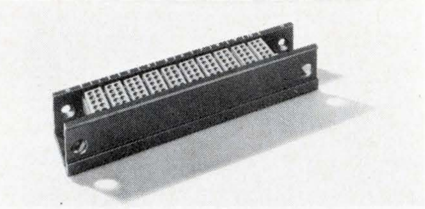


Low profile body of these 14 and 16 contact DIL sockets is made of glass filled nylon. Machined contacts are beryllium copper, gold over nickel plated. Sleeves are brass, gold over nickel plated. Body dimensions are 0.450 in. max. x 0.750 in. max. x 0.180 in. max. $0.78 to $1.41. Augat Inc., 33 Perry Ave., Attleboro, Mass. 02703. (617) 222-2202.

Circle 278 on Inquiry Card

TERMINAL JUNCTION SYSTEM

Designed to Mil-T-81714.

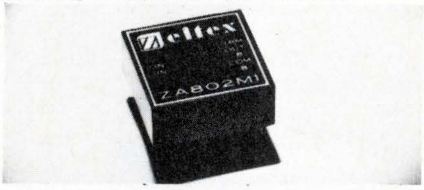


The Mil-T-81714 terminal junction system includes feedback and feedthru modules and tracks. It offers max. pin-to-socket conductivity and a one piece contact/busbar construction. The system's modules and splices use the company's "Ulti-mate" socket contact to insure greater peripheral pin-to-socket area in contact than normal pins and sockets. Appleton Electronics Div., Appleton Electric Co., 1701 Wellington Ave., Chicago, Ill. 60657. (312) 281-6400.

Circle 279 on Inquiry Card

FET OP AMP

In a 1.0 x 1.0 x 0.4 in. module.

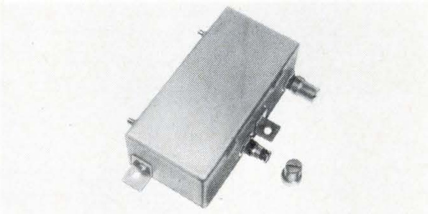


Model ZA802M1 features 15 pA (max.) input current; 100,000:1 CMR and 4 MHz (unity gain) freq. It has a max. input voltage drift of 50 μV/°C (−25° to 85°C). Price/performance ratio make it attractive for use in current-to-voltage conversion, integration, buffering, sample/hold operations, and differential amplification. $26 (1-9). Zeltex, Inc., 1000 Chalomar Rd., Concord, Calif. 94520. (415) 686-6660.

Circle 280 on Inquiry Card

VHF PRESELECTOR

With a 15 W capability.

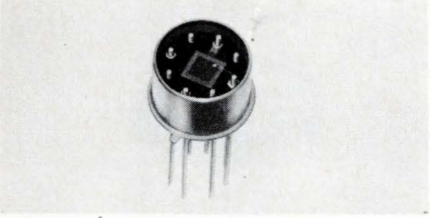


Model 2510-1 tunable preselector tunes the 116-150 MHz band and has 15 W capability. Two screwdriver controls tune it to any vhf freq. Loss is 4 dB max. and rejection at ±2 MHz is 30 dB min. It has minature connectors and brackets for systems mounting. $95.00. Microwave Filter Co., Inc., 135 W. Manlius St., East Syracuse, N.Y. 13057.

Circle 281 on Inquiry Card

PHOTODIODE/OP AMP

Low-noise unit.



Model 682 combines a silicon photodiode and a high-gain, low-noise op amp in one TO-5 package. The built-in amplifier, optimized for photodiode input, eliminates pick-up noise between detector and amplifier. During operation, the reverse-biased photodiode acts as a current source. This current develops a voltage across a built-in 40 kΩ feedback resistor. Since amplifier input is at a virtual ground, amplifier output voltage is equal to the photocurrent times the feedback resistor. $79.50 ea. (1-9) Electro-Nuclear Laboratories, Inc., 115 Independence Dr., Menlo Park, Calif. 94025. (415) 322-8451.

Circle 282 on Inquiry Card

CHIP THERMISTORS

With large negative TCs.

This line of miniature, solderable, chip thermistors with large negative TC is for use in temp. sensing and control applications. They are also used for temp. compensation or stabilization of circuit elements, components and modules. Available in sizes as small as 0.050 in. Four resistivities (at 25°C) offered are: Type A, 1000 Ω cm (Alpha is −4.4%/°C), Type B, 40 Ω cm (Alpha is −3.4%/°C), Type C, 175 Ω cm (Alpha is −3.8%/°C), and Type D, 2000 Ω cm (Alpha is −4.7%/°C). The Carborundum Co., Electronics Plant, Niagara Falls, N.Y. 14302. (716) 278-2521.

Circle 283 on Inquiry Card

INSULATING VARNISH

Low-cost, Class "H" (180°C) type.

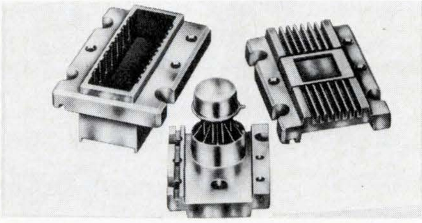
B-515, is a flexible dipping and baking polyester varnish that is suited for coating motor, coil, and transformer windings and all electrical insulating applications requiring Class "H" temp. resistance. Actual curved electrode tests conducted according to Mil-I-24092 have established a thermal rating of 188°C on the basis of present electrical industry criterion of 40,000 h. Thermal rating at 25,000 h, however, is 194°C, much higher than the 180°C rating needed to qualify under Class "H." Available in 1 gal. cans, 5 gal. pails, and 55 gal. drums. Westinghouse Electric Corp., Ind. Plastics Div., Chemical Products Plant, Manor, Pa. 15665.

Circle 284 on Inquiry Card

NEW PRODUCTS

CONDUCTIVE CARRIERS

For MOS ICs.

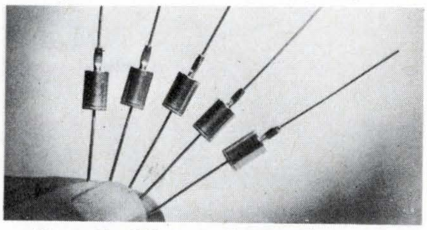


These aluminum plated conductive carriers preclude the possibility of charges of static electricity building up during handling and shipping and ruining std. MOS ICs. A conductive plating over the entire carrier surface maintains all leads shorted so that no voltage differential can exist between them. The new carriers are available in TO, flat-pack, DIL types. $0.03 to $0.25. Barnes Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050. (215) 622-1525.

Circle 230 on Inquiry Card

VOLTAGE SUPPRESSORS

Dissipate 1500 W of pk power.

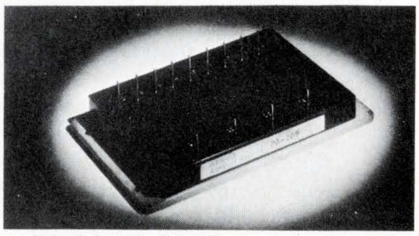


TransZorb® transient voltage suppressors come in voltages from 6.8 to 200 V (JEDEC types 1N5629 through 1N5665A). All dissipate 1500 W of pk. power for 1 ms with instantaneous clamping capability. They can actually dissipate over 10,000 W of pk. power for up to 10 µs. From $3.25 ea. (100-piece quan.). General Semiconductor Industries, Inc., 230 W. Fifth St., Tempe, Ariz. 85281. (602) 966-7263.

Circle 231 on Inquiry Card

HIGH POWER OP AMP

Drives dc torque and servo motors.

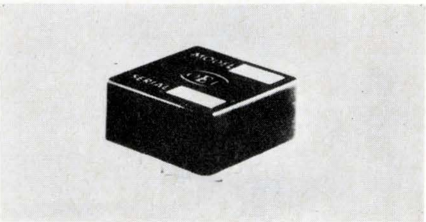


Model PA-209 has a single ended output of ±15 A at ±20 V and built-in current limiting. It also has internal diss. capability to over 300 W and high open loop gain of 300,000. $145 (100 lot quan.). Torque Systems Inc., Box 167, 225 Crescent St., Waltham, Mass. 02154. (617) 891-0230.

Circle 232 on Inquiry Card

H-F OP AMP

Dissipates 90 mW.

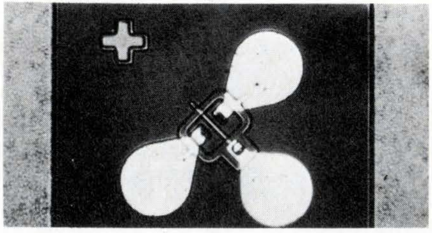


Model 9428 lets you build hf analog systems operating from limited power (battery) sources. Heat build up in large complex analog systems is no longer a problem with the low power 9428. It features: ±500 V/s slewing rate, 80 dB min. open loop gain, 100 MHz closed loop BW, 70 ns settling time to 0.1% residual error and ±10% V at ±30 mA output current capability. $76 (1-2). Optical Electronics, Inc., Box 11140, Tucson, Ariz. 85706. (602) 624-8358.

Circle 233 on Inquiry Card

DIFFERENTIAL FET PAIRS

Feature very low gate current.



These matched, dual, n-channel FETs also have low differential drift. Types 2N5902 through 2N5905 have an I_G of 3 pA max.; the 2N5906-09, 1 pA max. The 2N5902 and 2N5906 have 5 mV offset max., with 5 µV/°C differential drift. In TO-78 cans, the FETs cost $7.05 to $22.50, 100-pc. lots. As chips, CDNTO1, $4.35/pair, 100-pc. lots. Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, Calif. 95054. (408) 246-8000.

Circle 234 on Inquiry Card

DUAL POWER SUPPLIES

Choice of output combinations.

ET Series miniaturized dual output supplies mount on PC boards. Outputs are isolated and may be independently connected in either polarity. All combinations of output voltages from 1 through 28 V, at currents up to 250 mA, are available in 406 std. models. From $58 to $78. Acopian Corp., Easton, Pa. 18042. (215) 258-5441.

Circle 235 on Inquiry Card

REVERSE FEED-THRU

Installs in only 0.200 in. centers.

Part No. 002-3007, new Press-Fit® reverse feed-thru has a Teflon bushing only 0.0150 in. in dia. Its tubular brass, solder plated turret lug has a slot in its upper section. This slot holds wire which is brought through the 0.030 in. dia. thru-hole, from the bottom of the chassis. Rated for 5.5 A cont. duty. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543.

Circle 236 on Inquiry Card

DRY REED RELAY

With low thermal drift.

Thermal offsets are < 2.5 V at 100% duty cycle in the Milliscan relay. It has 1 in. PC board mounting centers and an overall height of 0.500 in. Models are available in 6, 12, and 24 V nom. operation with switching capacity of SPST, DPST, and 3PST. $2/circuit in quan. James Electronics Inc., 4050 N. Rockwell, Chicago, Ill. 60618. (312) 463-6500.

Circle 239 on Inquiry Card

DC POWER AMPLIFIER

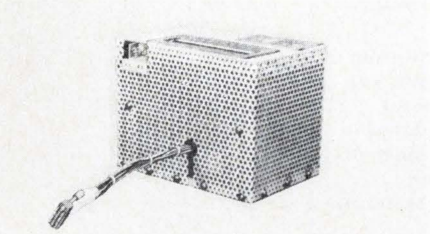
Rated at 200 W.

Model PA-3, is rated at 200 W with a max. output of ±24 Vdc and ±8 A. It is especially useful in applications requiring precise control of high currents. It features current limiting, full power output from dc to 5 kHz and a low drift differential input stage. Prices start at $244 (100 lot quan.). Control Systems Research, Inc., 1811 Main St., Pittsburgh, Pa. 15215. (412) 781-1887.

Circle 240 on Inquiry Card

POWER SUPPLY

Independent operation.

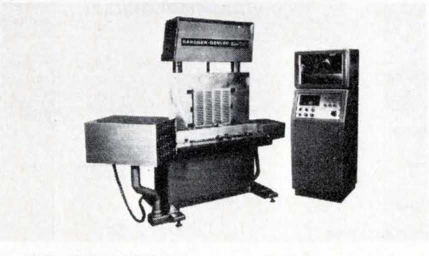


This supply's operation is relatively independent of input voltage, polarity, or frequency. No changes or adjustments are needed for it to function on positive or negative 22 to 32 Vdc; 115 or 230 Vac ±10% at 50 to 420 Hz. The unit shown provides five independent 1-v outputs (+25, −12, −3.2, −6, and −12 Vdc) each regulated to $< 1\%$ with 36 W at 95°C with a TC of $< 0.007\%$ from −54 to +95°C. Capitron Div., AMP Inc., 155 Park St., Elizabethtown, Pa. 17022. (717) 564-0101.

Circle 237 on Inquiry Card

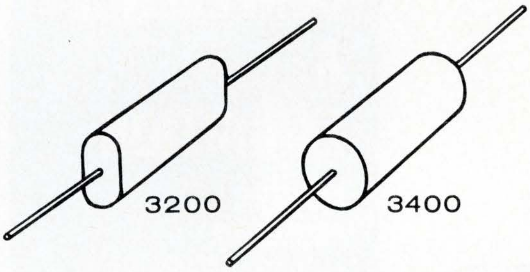
TERMINAL LOCATOR

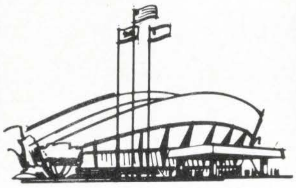
For semi-automatic wire wrapping.



Model 15YN is a useful companion to the fully automatic Wire-Wrap® machine, answering the needs of those whose wire terminating requirements are 1,000,000 wires/yr. It is well suited for handling twisted pair wires and those wire gauges that are not normally wrapped on the automatic machine. Standard equipment includes terminal locator capable of wiring an area 24 x 36 in., lighted wire bin (32 tubes), and a SS numerical control. Gardner-Denver Co., Gardner Expressway, Quincy, Ill.

Circle 238 on Inquiry Card





**NOW,
A FIRST-OF-A-KIND
CONFERENCE
DEVOTED
SOLELY
TO THE ENGINEERS
WHO DESIGN,
BUILD AND
TEST
COMPUTERS**

COMPUTER DESIGNER'S CONFERENCE & EXHIBITION

**ANAHEIM,
CALIFORNIA
JANUARY 19, 20, 21,
1971**

RESERVE YOUR BOOTH SPACE NOW

to sell this concentrated audience of specifiers for the COMPUTER COMPONENTS you make.

Electronic Engineer Magazine
is an Associate Sponsor
of the
Computer Designer's Conference.

The Computer Designer's Conference and Exhibition *IS DIFFERENT* from all other computer shows for it will concentrate ONLY on the design, engineering, and construction aspects of computers — *not on their applications!* This Conference will bring together, for the first time, engineers from diverse areas of computer design for a fruitful exchange of ideas and an examination of the latest developments in components and techniques. This will be accomplished with:

- **a 300-booth exhibition of the components, support and peripheral equipment employed in the design and construction of computer equipment and systems.**
- **a wide ranging Technical Program that will spotlight current design techniques for all types of computer systems.**

Are your products used for designing, building and testing equipment in the following or related areas?

Analog, digital and hybrid computer systems
Magnetic, semiconductor, optical or electro-mechanical memory sub-systems
Logic modules
Analog-to-digital and digital-to-analog converters
Modulators and demodulators
Data communications systems
Information display devices
Electromechanical readers, punches, and printers
Analog and digital multiplexers
Peripheral equipment or accessories
Data acquisition systems
Digital logic circuit test systems
Time-sharing systems and terminals
Digital signal processing

. . . then the Computer Designer's Conference can help you achieve rapid and deep penetration of the COMPUTER OEM MARKET.

THIS IS A SELLING SHOW *in which everything is done to help you sell your products!* Organized and directed by Industrial & Scientific Conference Management, Inc., producers of the famed NEPCON and INTER/NEPCON conferences, it will incorporate the same careful planning and intensive promotion to attract the specialists in your field—the multi-billion dollar computer equipment market.

CALL OR WRITE NOW
FOR FULL DETAILS
AND APPLICATION
FORMS TO
INDUSTRIAL &
SCIENTIFIC CONFERENCE
MANAGEMENT, INC.

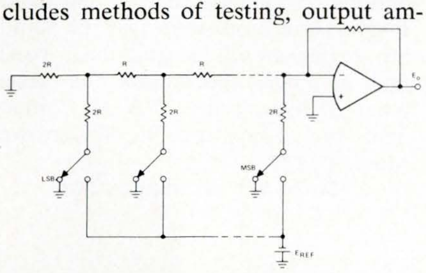
Specialists in Technical and Scientific Conferences

222 W. ADAMS ST.
CHICAGO, ILL. 60606
PHONE:
(312) 263-4866

LITERATURE

D/A converter handbook

Various techniques of performing D/A conversion are discussed in this 88-page handbook. An extensive coverage of applications information includes methods of testing, output amplifier selection and bipolar operation. You'll find schematics and graphs throughout the entire book supplementing the discussions. Hybrid Systems Corp., 95 Terrace Hall Ave., Burlington, Mass. 01803.



Circle 361 on Inquiry Card

Circuit applications

"A comparison of Thyristor Three-Phase Controlled Rectifiers" is the title of an application note discussing the advantages, disadvantages and differences in performance of two basic thyristor circuits. The 12-page note compares the three-phase full-wave full converter with the three-phase full-wave semiconverter circuit. Circuit diagrams and curve traces of circuit responses supplement the discussions of rectification characteristics, delay angles vs system response, gate firing circuit considerations and requirements, double pulsing and inductance loads. Westinghouse Electric Corp., Box 868, Pittsburgh, Pa. 15230.

Circle 362 on Inquiry Card

Industrial computer

The SPC-16 16-bit computer is another member of GA's compatible family of fourth-generation industrial automation equipment. This 24-page brochure provides details on reliability, industrial applications, software, organization and instruction repertoire. One of its distinctive features is that it accommodates real-time dedicated control applications in the foreground while performing background batch processing. And you'll read how the SPC-16 can be incorporated into various systems. General Automation Inc., 1402 E. Chestnut Ave., Santa Ana, Calif. 92701.

Circle 363 on Inquiry Card

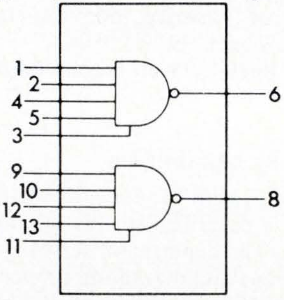
Photoelectrics

A 16-page catalog is designed to help you with the selection and application of photoelectric controls for industrial automation and materials handling. Products include edge guide scanners, light sources and sensors, amplifiers and time delay modules. Drawings illustrate applications and are accompanied by explanations of the functions of the photoelectric sensors and the associated timers and controls. Warner Electric Brake & Clutch Co., 449 Gardner St., Beloit, Wis. 53511.

Circle 364 on Inquiry Card

ICs and transistors

Two catalogs, "Transistor Planar Selector" and "Integrated Circuits Planar Selector," discuss the main groups of the company's product lines and then provide the characteristics of the various devices within each group. Connection diagrams and package outline drawings supplement the information on IC devices, and, of course, comparable information is provided for transistors. Societá Generale Semiconduttori S.p.A., c/o Varadyne Inc., 1805 Colorado Ave., Santa Monica, Calif. 90404.



Circle 365 on Inquiry Card

IC supplement

Some 25 new MSI and SSI circuit functions have been added to TI's 54/74 TTL line since their basic TTL catalog was published. The 196-page supplement contains complete data sheets on the new circuits and lists of all their TTL ICs by function and type number. A cross-reference shows nearest equivalents to competitive devices. And if you're interested in applications, you'll find a section listing available application information. Texas Instruments Inc., Box 5012, M/S 308, Dallas, Tex. 75222.

Circle 366 on Inquiry Card

Transistor design idea

"New design idea #23" tells you about a programmable unijunction transistor for use in pulse and timing circuits, SCR trigger circuits, relaxation oscillators, sensing circuits and threshold detectors. The 6-page note provides schematics for various applications and tells you the advantages of using the PUT in each. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172.

Circle 367 on Inquiry Card

Computerized design

Photomasks and documentation for PC boards are discussed in this 4-page brochure on computerized design. The service is fully described and the details of their photomask process are outlined for you. The discussion of their service and capabilities include photos of their facilities. Electronic Graphics Inc., 2834 W. Kingsley Rd., Garland, Tex. 75040.

Circle 368 on Inquiry Card

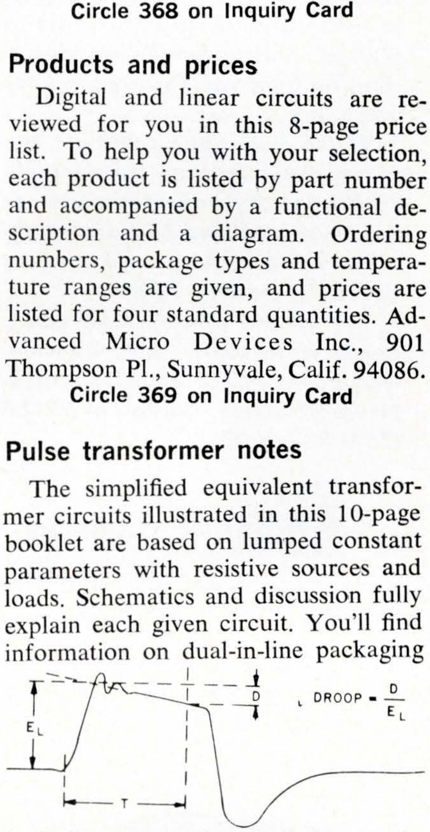
Products and prices

Digital and linear circuits are reviewed for you in this 8-page price list. To help you with your selection, each product is listed by part number and accompanied by a functional description and a diagram. Ordering numbers, package types and temperature ranges are given, and prices are listed for four standard quantities. Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086.

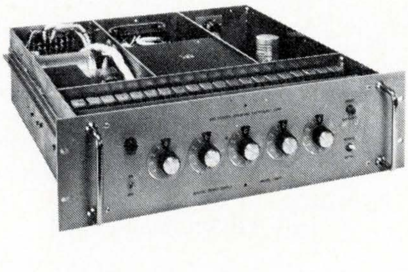
Circle 369 on Inquiry Card

Pulse transformer notes

The simplified equivalent transformer circuits illustrated in this 10-page booklet are based on lumped constant parameters with resistive sources and loads. Schematics and discussion fully explain each given circuit. You'll find information on dual-in-line packaging including specs, electrical characteristics and applications. At the end of the booklet you'll find a chart of conversion factors, constants and units. Technitrol Inc., Components Div., 3825 Whittaker Ave., Philadelphia, Pa. 19124.



Circle 370 on Inquiry Card



LITERATURE

Digital memory modules

The use of glass digital memory modules in high-speed buffers for computer terminals and other data transmission systems is discussed in a 4-page application note. Several forms of addressing are covered—continuous data input, non-synchronous and synchronous random word rates, and parallel channel operation. And you'll find diagrams to illustrate the memory functions in a variety of systems. Corning Glass Works, Corning, N.Y. 14830.

Circle 371 on Inquiry Card

Instruction manual

Ten pages of fact-filled instructions outline techniques for high-yield production of cermet circuits. The manual deals with Firon™ conductors and discusses thick-film theory, printers, viscosity effects, conductor-resistor interface, etc. Another seven pages of charts illustrate such factors as viscosity and temperature, load life, resistivity and stability. Electro Materials Corp. of America, 605 Center Ave., Mamaroneck, N. Y. 15043.

Circle 372 on Inquiry Card

System capabilities

The System Products Department of XDS is described in this 16-page brochure. The department serves as an applications and marketing support activity for their 900 Series digital modules and analog/digital instruments. The booklet provides a summary of their products and services, more specifically their IC logic modules, automated wiring services, minicomputer and peripheral equipment. Xerox Data Systems, 701 S. Aviation Blvd., El Segundo, Calif. 90245.

Circle 373 on Inquiry Card

Amplifier applications

Correct input connection practices are described for you in this 12-page application note. You'll find definitions for common terms, a discussion on the function of the guard shield, and typical input circuit illustrations for thermocouples and bridge transducers. And there's a set of rules included to help you with correct input connections. Neff Instrument Corp., 1088 E. Hamilton Rd., Duarte, Calif. 91010.

Circle 374 on Inquiry Card

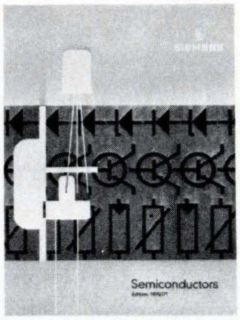
Subminiature switches

More than just a catalog of a complete product line, this 12-page booklet contains complete hardware, panel layout and mounting information, and a cross index system which makes it easy to locate the list of peripheral options available for a particular switch. And more than just the standard toggle switch is described; you'll find complete information on seven other configurations. C & K Components Inc., 103 Morse St., Watertown, Mass. 02172.

Circle 375 on Inquiry Card

Semiconductors

Charts, diagrams and complete specs on both standard and industrial semiconductors make up this 32-page catalog. Germanium and silicon diodes, NTC resistors, and germanium and silicon transistors are covered within the standard types section. And among the industrial types you'll find silicon charge storage varactors, magneto resistors and Hall effect devices. Siemens Corp., Components Div., 186 Wood Ave. South, Iselin, N.J. 08830.



Circle 376 on Inquiry Card

Buyer's guide

Manufacturers of electronic components plus their industrial distributors and/or sales representatives are listed for you in this buyer's guide. You'll find more than 500 manufacturers listed alphabetically, and their distribution outlets listed geographically. One big advantage of this guide is that you can locate components (semiconductors, capacitors, resistors, connectors, etc.) for immediate delivery, and you have the names of authorized representatives should you need technical information. Electronic Distributor Tek Publishing Co. Inc., 155 E. State St., Westport, Conn. 06880.

Circle 377 on Inquiry Card

Cable design

To help you make better connections, this 24-page circuit cable design guide offers you help with packaging and cable design through graphic examples of good high-density, low-volume interconnection and cable configurations. You'll find help with special fabrication techniques, electrostatic shielding, and soldering methods. Charts list characteristics of copper, laminates and dielectrics. Teledyne Electro-Mechanisms, 29 Crown St., Nashua, N.H. 03060.

Circle 378 on Inquiry Card

Popular op-amps

Twelve of the most widely used operational amplifiers are discussed in a 6-page catalog. The amps are divided into 6 groups: low cost, FET input, ultra-low-drift chopperless types, fast settling, high stability chopper stabilized, and femtoampere resolution varactor bridge electrometer types. Specs and application suggestions are included for each. Analog Devices Inc., 221 Fifth St., Cambridge, Mass. 02142.

Circle 379 on Inquiry Card

Data systems

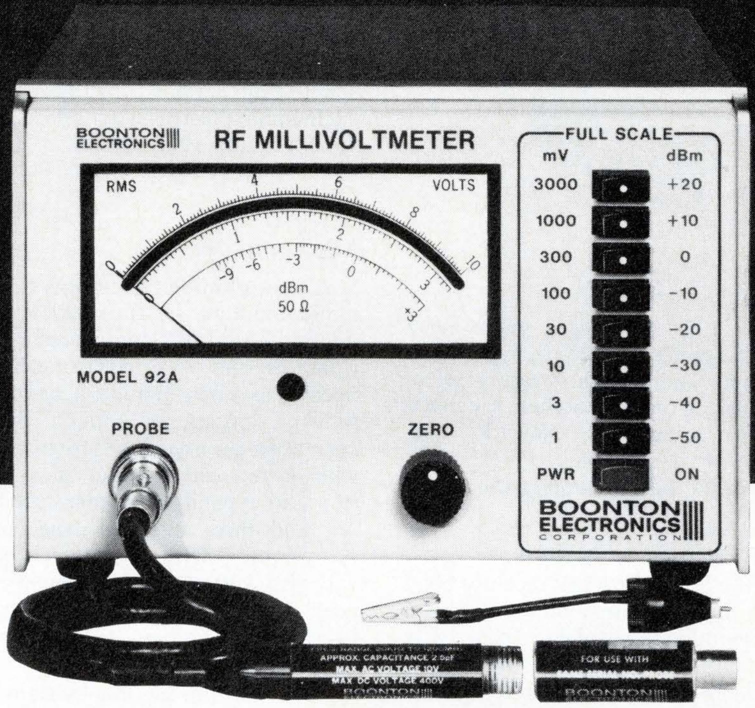
"How to Make Measurements Automatically" explains the advantages of digital data acquisition systems and how they can automatically measure temperature, pressure, force, strain and other physical parameters. The 16-page brochure provides a detailed system description and lists the considerations involved in selecting the components of an automatic-measurement system. Vidar Corp., 77 Ortega Ave., Mountain View, Calif. 94040.

Circle 380 on Inquiry Card

Relay catalog

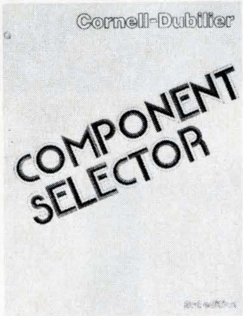
A 24-page manual/catalog tells you about a complete line of general-purpose relays. As it's meant to simplify your relay specification, it includes facts, photos and dimensional drawings for all the relays. All types are included from heavy-duty power types to miniature plug-in relays, and all are specifically engineered for PC board applications. Guardian Electric Manufacturing Co., 1550 W. Carroll Ave., Chicago, Ill. 60607.

Circle 381 on Inquiry Card



Component selector

Here is a catalog designed to guide the user to the proper selection of a standard stock design to meet given requirements. Capacitor reference data provides detailed background on capacitor standardization and rating selection. The 120-page guide also includes application charts, type selector charts and standard rating selector tables. Cornell-Dubilier Electronics, 150 Avenue L, Newark, N.J. 07101.



Circle 382 on Inquiry Card

Computer data reduction

A 19-page section has recently been added to the Semiconductor Strain Gage Handbook available from BLH Electronics. Section VIII, titled Computer Data Reduction, describes problems in reduction of data from semiconductor gages, specifies availability and applicability of timesharing computers for data reduction, offers guidelines for computer programs to perform analysis, and describes 5 programs which are applicable to strain data reduction and transducer compensation. Copies of Section VIII, as well as the previously published sections are available from BLH Electronics Inc., 42 Fourth Ave., Waltham, Mass. 02154.

Circle 383 on Inquiry Card

Mini manual

Reference material for Honeywell's time-sharing customers is contained in a 40-page manual. Library programs describing the 1648 system commands and the languages FORTRAN, BASIC, SOLVE, and TEACH are discussed in addition to the EDITOR language being described. The catalog groups programs by application areas —management sciences, engineering, educational, games and demonstrations, information, and advanced uses. Honeywell, Information Services Div., Minneapolis, Minn.

Circle 384 on Inquiry Card

Circuit breakers

Technical data on a line of molded-case hydraulic magnetic breakers used in panelboards is covered in an updated technical data sheet. Bulletin 3412 is organized for quick selection of general-purpose breakers in current ratings from 0.01 to 100 amps (ac and dc). One-, two- and three-pole breakers are listed with model numbers identifying circuit modifications. Heineman Electric Co., 250 Magnetic Dr., Trenton, N.J. 08602.

Circle 385 on Inquiry Card

Minicomputer

A new addition to the field of 16-bit minicomputers is the 620/f, introduced with a full complement of peripherals and supporting software. Special features include a basic cycle time of 750 ns, an optional braided-core ROM, an expanded instruction set with a reduced number of program steps, an expandable planar core memory and three different types of I/O operations. This 16-page brochure will give you all the information you need on this new computer from Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. 92664.

Circle 386 on Inquiry Card

High performance ICs

OEM users can now create high performance ICs. A 6-page brochure details how and why a linear IC user should test incoming ICs, outlines a company's facilities to do so, and presents the advantages of using such a testing service. The various implications of IC testing are also discussed in the catalog. Nova Devices, Inc., 829 Woburn St., Wilmington, Mass. 01887.

Circle 387 on Inquiry Card

D/A converters

Two D/A converters whose 15-bit resolution represents the industry's highest resolution in a modular D/A converter are described in a 4-page data sheet. Specs for both converter versions are provided, the pros and cons of speed vs accuracy are discussed, and pin connections and physical dimensions are listed. Also covered are examples of input coding options and an explanation of how to select a converter with the correct output voltage range. Analog Devices, 221 Fifth St., Cambridge, Mass. 02142.

Circle 388 on Inquiry Card

Thumbwheel switches

When you open this 48-page catalog the first thing you'll find is a brief background on the company. If you're not familiar with thumbwheel switches, you'll read on to the general information provided. This is followed by a section on the basic dimensions and features of each switch series. Then detailed data and specs are given. After a section featuring problem solving applications, you'll find a complete price list for all models. Special sections include truth tables, switch codes, and one showing the many modifications and special features available. Digitran Co., 855 S. Arroyo Pkwy., Pasadena, Calif. 91105.

Circle 389 on Inquiry Card

Instrumentation systems

Along with a 24-page condensed catalog of DCS instrumentation systems, you'll receive a reprint of an article on basic PCM techniques, "Basics of Pulse Code Modulation Telemetry." The catalog gives you information on the equipment for PCM instrumentation systems (as well as for analog, digital and hybrid systems), and the article describes the processes involved in a typical PCM telemetry system. Data-Control Systems Inc., Commerce Dr., Danbury, Conn. 06810.

Circle 390 on Inquiry Card

Rf connectors

All major rf connector classifications are covered in a 161-page catalog. There's a part number cross-reference table (MFG/MIL and MIL/MFG) plus cable data and assembly instructions. You'll find that the catalog is fully illustrated and complete with part numbers, dimensions and engineering data for each connector type within a series. Bendix, Microwave Devices Div., Hurricane Rd., Franklin, Ind. 46131.

Circle 391 on Inquiry Card

NASA LITERATURE

One of the outgrowths of NASA space programs has been the publications issued by the NASA Office of Technology Utilization. Their charter calls for "The rapid dissemination of information . . . on technical development . . . which appear to be useful for general industrial application." Listed below are some of the publications with appropriate symbols to indicate where they can be obtained. (* means inquiries and/or requests should be addressed to the Technology Utilization Division, Code UT, NASA, Washington, D.C. 20546; ** means requests should be addressed to the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151; *** means requests should be addressed to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.)

Improved storage

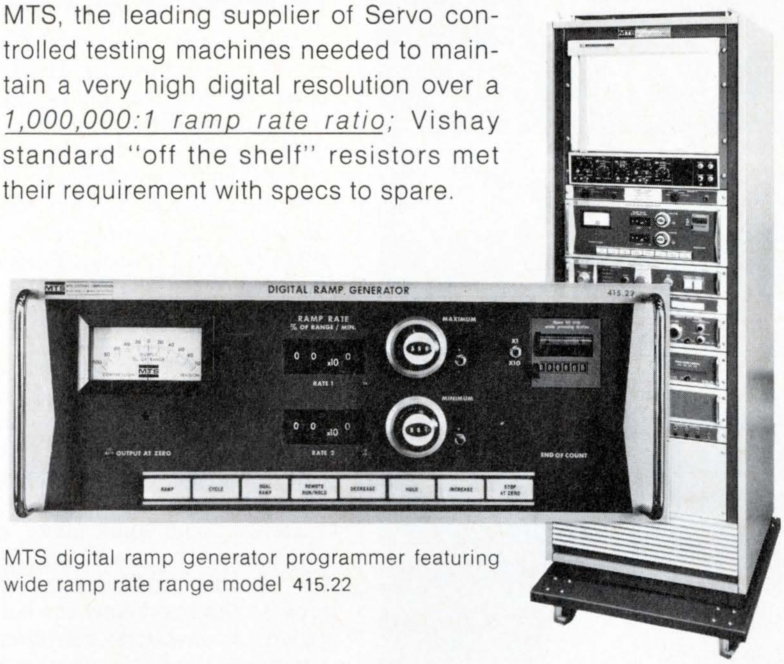
Brief 70-10074* describes a simple solid state charge-discharge device that should find applications in memory systems and in high-resolution arrays for light-responsive image sensing. The device, which can be fabricated without the use of diffusion techniques, offers high yields in multiple arrays. Essentially, the storage device is a semiconductor and a metal plate, with a high resistivity insulator sandwiched between the two components. A positive voltage applied to the sandwich charges the semiconductor surface. After the charging voltage is removed, the surface retains its charge until discharge is effected by exposure to light or a voltage pulse of opposite polarity.

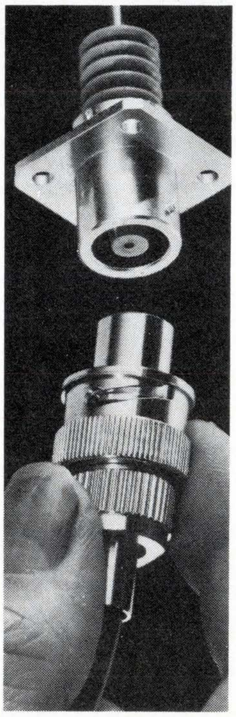
Micropower logic circuits

This report offers low power circuits built and tested at the NASA Lewis Research Center. These circuits exhibit many desirable features, including nearly ideal waveforms and power transfer efficiencies that are virtually independent of operating conditions within their design range. NASA SP-5022 is 15 pages and priced at 75¢.***

Circuits

This report, "Selected Electronic Circuitry," presents a selection of circuits chosen for reliability, simplicity, fail-safe characteristics, and the ability to withstand environmental extremes. Among the circuit categories in NASA SP-5046 are amplifiers, oscillators, multivibrators, power supplies, wave shaping, temperature compensation, control, specialized computer, and miscellaneous. The booklet is 102 pages and priced at 70¢.***





WELCOME

This column welcomes new companies or new divisions in the electronics industry.

Power supplies being produced

Despite the competitiveness of the power supply business, Hi-G, Inc., located in Windsor Locks, Conn., recently decided to try their hand at it, utilizing their capabilities with printed circuits and transformers. The result was an in-house division for the development and production of power supplies. The Electronic Products Div., financed by its "parent," has help from engineering and production groups within the framework of the organization, in producing transformers, printed circuit boards and integrated circuits. (It's kind of like "one from column A and two from column B," with the result being a reliable power supply.)

Design and application engineers experienced in producing equipment for specific customer requirements provide the know-how for such applications as inverters, converters, computer data terminals, printers, memory circuits, and various other products.

An IC hybrid timing module is presently being offered by the new Electronic Products Division. Unique to the module is the IC timer circuit which evolved from Hi-G's in-house thick-film manufacturing technology. Specs include output of 1 A at +25°C, 10% timing tolerance over the input voltage range of 18 to 31 Vdc, with delay times of 50 ms to 60 s. The unit is operable over the temperature range of −55°C to +85°C (with hopes of expanding it to +125°C to meet Mil specs 5272 and 5400).

Asked about competition, a spokesman for the Electronic Products Division stated, "We are the only power supply manufacturer who presently offers a guarantee of satisfactory performance in the system on all custom-designed power supplies. Ours not only meet the basic specs of the customer, we also help him prepare the specs to fit his needs. This, we feel, is a unique feature of our service."

Circle 395 on Inquiry Card

Experience is the best teacher

In most cases experience plus equipment is an unbeatable combination for success. This is the theory behind Micro Arrays Corp., located at 160 School House Rd., Souderton, Pa. Manufacturing MOS and bipolar IC masks, the company was formed as a subsidiary (in financial name only) of National Information Systems Corp. by former employees of United Aircraft's Electronic Components Division. Nick Florimonte, president of Micro Arrays, previously served as division manager for United Aircraft's mask-making operations.. The new firm's vice president, James Hewitt, was Mr. Florimonte's assistant at UA.

Offering a full functioning facility that utilizes the latest state-of-the-art equipment, Micro Arrays manufactures photo masks for high-frequency MOS ICs and diodes to whatever specs the customer chooses. Representative product offerings include Nikon wide-sealed lenses that cover a 240-mil chip at 10x and a 500-mil chip at 5x. They have also developed the ability to step and repeat arrays over a 3½ in. area with a repeatability better than 10 µin. Maintaining line width tolerances to within 10 µin. with a minimum line width of 1 micron is another capability of the new company.

Because Micro Arrays has a small work force at present, there is a slight backlog problem. There are plans, however, to increase the number of employees.

Circle 396 on Inquiry Card

Advertisers—July 1970

**No liability is assumed for errors or omissions.
This Index is published for a convenience.**

ACOPIAN CORP. 69
Mort Barish Assoc., Inc.
ACDC ELECTRONICS 76
Rose Assoc.
ADAMS & WESTLAKE CO. 18
Scofield, Braselton & Williams, Inc.
AMF, INC., POTTER & BRUMFIELD DIV. 23
Grant, Wright & Baker, Inc.
AMPERITE CO. 84
H. J. Gold Co.

BECKMAN INSTRUMENTS, INC. HELIPOT DIV. 70
N. W. Ayer/Jorgensen/MacDonald, Inc.
BELDEN CORP. 6, 7
Fensholt Adv., Inc.
BOONTON ELECTRONICS 99
The Creative Group, Inc.
BUNKER-RAMO CORP. AMPHENOL INDUSTRIAL DIV. 27
Marsteller, Inc.
BUSSCO ENGINEERING, INC. 48
T. F. Murray & Assoc., Inc.
BUSSMAN MFG. DIV. 2
Henderson Adv. Co.

CHRONO-LOG CORP. 90
Mort Barish Assoc., Inc.
COMPUTER DESIGNER'S CONFERENCE 96
Industrial & Scientific Conference Management, Inc.
COMPUTER PRDTS., INC. 94
Art After Six
COORS PORCELAIN ....Inside Back Cover
Buchen Adv., Inc.
COUCH ORDNANCE 86
Culver Adv., Inc.
CTS CORP. 16
Reincke, Meyer & Finn
CUSTOM ELECTRONICS 93
Laux Adv., Inc.

DELEVAN, DIV. API 83
Stahlka, Faller & Klenk, Inc.

ELCO CORP. 11
Schaefer Advertising Inc.
ELECTRONIC ARRAYS, INC. 62
Hal Lawrence, Inc.
ELECTRONIC GRAPHICS, INC. 74
The Hal Mayer Co.
ERA TRANSPAC CORP. 92
Josephson, Cuffari & Co.

FAIRCHILD MICROWAVES & OPTOELECTRONICS 42
Tom Jones Adv.
FAIRCHILD SEMICONDUCTOR 20, 21
Chiat/Day, Inc.
FERROXCUBE CORP. 13
W. H. Schneider, Inc.

GAMMA SCIENTIFIC, INC. 87
Guerin, Johnstone, Gage, Inc.
GARDNER-DENVER CO. 24, 25
Buchen Adv., Inc.
GRIES REPRODUCER CO. 86
Harold Marshall Adv. Co., Inc.

HAMLIN, INC. 79
Franklin/Mautner/Adv.

HEWLETT-PACKARD ASSOC. 73
Lennen & Newell/Pacific
HEWLETT-PACKARD, COLORADO SPRINGS Inside Front Cover, 68
Tallant/Yates Adv., Inc.

HOULE MFG. CO. 102

LEACH CORP. 16A, 16B
Chiat/Day, Inc.

MATHESON GAS PRDTS., DIV. WILL ROSS, INC. 19
Cooper, Strock, Scannell
MET-L-WOOD CORP. 85
Drew & Carr, Inc.
MILLER-STEPHENSON 89
Michel-Cather, Inc.
MOHAWK DATA SCIENCES CORP. 28, 29
The Lampert Agency, Inc.

NATVAR CORP. 89
Sanger-Funnell, Inc.
NON-LINEAR SYSTEMS, INC. 35
Ivy Assoc., Inc.
NORTON ASSOC., INC. 102
J. J. Coppo Co., Inc.

POTTER & BRUMFIELD, DIV. AMF, INC. 23
Grant, Wright & Baker, Inc.
THE POTTER CO. 95
Gordon Marks & Co., Inc.

RAYTHEON SEMICONDUCTOR 36, 37
Tycer Assoc.
RCA ELECTRONIC COMPONENTS LINEAR INTEGRATED CIRCUITS...Back Cover
Al Paul Lefton Co., Inc.
ROWE INDUSTRIES 102
Carr-Eyster Assoc., Inc.

SCHWEBER ELECTRONICS 47
Herman & Assoc., Inc.
SPRAGUE ELECTRIC CO. 1
The Harry P. Bridge Co.
SRC DIV./MOXON, INC. 98
Durel Adv.
SWITCHCRAFT, INC. 4
Buti-Roberts Adv.
SYLVANIA PARTS DIV. 15
Doyle Dane Bernbach, Inc.

TELEDYNE RELAYS 5
S. Michelson Adv.
TELEDYNE SEMICONDUCTOR 38
Monda, Smith & Co.
TEMPIL CORP. 22
Black-Russell-Morris
TEXAS INSTRUMENTS, INC., COMPONENTS GROUP 49-56
Albert Frank-Guenther Law, Inc.
TRW INSTRUMENTS 26
Fuller & Smith & Ross, Inc
TUNG-SOL, DIV. WAGNER ELECTRIC CORP. 81
Winius-Brandon Co.

VISHAY RESISTOR PRDTS. 101
Larwin Adv.

WATKINS-JOHNSON CO. 8
William C. Estler

THE
ELECTRONIC
ENGINEER

DISTRICT SALES MANAGERS

EDWARD G. SHAUD
BALA-CYNWYD, (Pa.) 19004
One Decker Square
(Area Code 215) SHerwood 8-2000

JOSEPH DRUCKER
NEW YORK 10017—100 East 42nd St.
(Area Code 212) OXford 7-3400

JOHN W. BERNHARDT
CHICAGO 60606—120 S. Riverside Plaza
(Area Code 312) 782-1400

G. T. ALFANO
NEEDHAM HEIGHTS, MASS. 02194—
570 Hillside Ave.
(Area Code 617) 444-0010

TERRENCE D. BUCKLEY
THOMAS R. BORIS
LOS ANGELES 90005 3727 W. Sixth St. #202
(Area Code 213) DUnkirk 7-1271

RALPH PETERSEN
LOS ALTOS (San Francisco) 94022
199 First St., Room 335
(Area Code 415) 941-6655

RICHARD DUTE
CLEVELAND 44114—601 Rockwell Ave.
(Area Code 216) SUperior 1-2860

NEWTON B. COLLINSON
ATLANTA 30309—1776 Peachtree St. N.W.
(Area Code 404) 872-4723

HAROLD E. MOTT
WAYNE L. LOVING
DALLAS 75206—Meadows Bldg.
Expressway at Milton
(Area Code 214) EMerson 3-6426

BRENT GILBERT
Houston 77027
4151 Southwest Freeway
Suite 735
(Area Code 713) 621-7550

INTERNATIONAL BUSINESS OFFICES

London, S W 1 .... Max F Holsinger
67 68 Jermyn St , St James's Dir European Sales
TRA 6318 9 Roy V C Hall, A Berg
Cables WHIP LONDON S W 1

Manchester 22 .... D I Goulden
Haletop, Wythenshawe Civic Centre MERcury 3293

4 Dusseldorf-Rath ... E Hillerbrand, R Schomburg,
Eitelstrasse 32 W Heckelmann
Dusseldorf 632031
Cables WHIP DUSSELDORF

Paris, 8e .... S Brown-Joussard
70 Rue de Ponthieu ELYsees 65-77
Cables UIIP PARIS 16e

Tokyo .... C T Sakaguchi
Room 814, Togin Bldg Marunouchi
CPO Box No 1572 Tel 211-3506-3509
Cables CLARENCESAKA TOKYO

BUSINESS STAFF

K. ROBERT BRINK
Publisher
STEPHEN A. FARKAS
Sales/Service Director
DENNIS J. PERKINS
Promotion Manager
MARK R. WERTH
Marketing Services Manager
JOHN E. JAENISCH
Advertising Sales Manager
PAT KAUFFMAN
Production Manager
WILLIAM M. COFFEY
Circulation Director
JAMES F. NAGY
Circulation Manager
JOSEPH P. BABCOCK
Reader Service Manager
JOHN H. KOFRON
Chilton Research Services
C. R. WILHIDE
Washington Vice-President

Index to Product Information

Listed below are all products and new literature that appear in this issue, along with the page number they appear on and their Reader Service Numbers (RSN). For more information, see the appropriate page and circle the corresponding number on the reader service card.

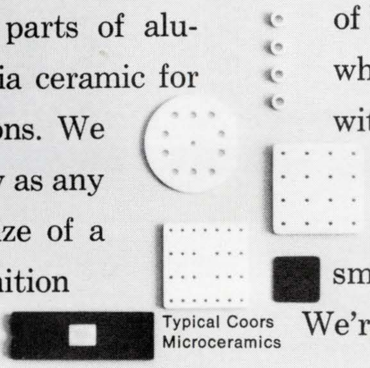
THE WHAT, WHY, WHEN, HOW AND WHOM OF COORS MICROCERAMICS

Q. WHAT ARE COORS MICROCERAMICS ANYWAY?

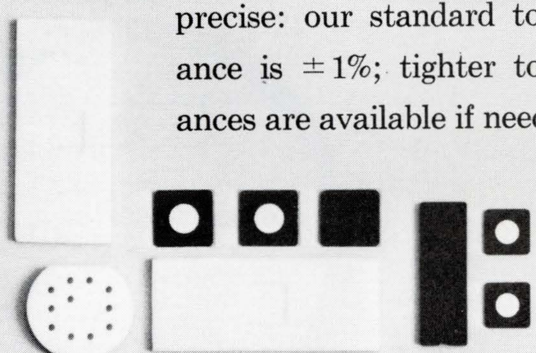
Dime

BB

A. Glad you asked. They are small, precise parts of alumina or beryllia ceramic for microelectronic applications. We define small rather loosely as any part between, say, the size of a dime and a BB. The definition of precise is more precise: our standard tolerance is ±1%; tighter tolerances are available if needed.



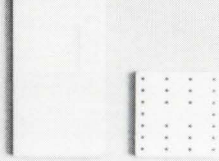
Typical Coors Microceramics



More Microceramics

Q. WHY SHOULD I USE COORS MICROCERAMICS?

A. (1) Because you can be sure they will be manufactured exactly to your specifications and not modified to suit our production capabilities; (2) Because you can be sure they will be of uniformly high quality; (3) Because of (1) and (2) your yields will improve and your unit costs will be lower.



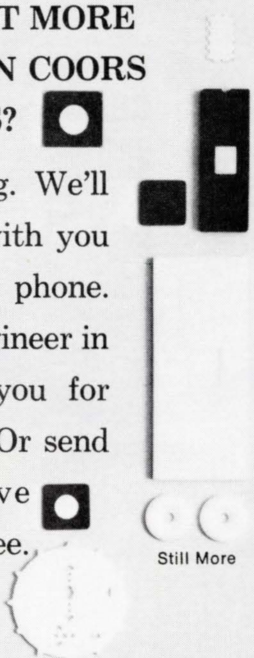
And Others

Q. WHEN SHOULD I USE COORS MICROCERAMICS?

A. When you want ceramic components of highest quality and reliability. Also when you need a ceramic producer with dependable, high-volume production capacity—or one that can turn out prototype and small-run quantities economically. We're geared to do both.

Q. HOW CAN I GET MORE INFORMATION ON COORS MICROCERAMICS?

A. Simply by asking. We'll be glad to counsel with you anytime by letter or phone. Or have our sales engineer in your area contact you for personal assistance. Or send you an informative data pack. Or all three.



Still More

Q. WHOM SHOULD I ASK?

A. Who else?

Coors Porcelain Company • 600 Ninth Street
Golden, Colorado 80401 • (303) 279-6565

Coors/CERAMICS

the tough stuff

CP-137

Circle 3 on Inquiry Card

RCA Linear IC Arrays: performance, dependability, and versatility in application.

Here are ten important answers to some of your most pressing circuit design problems. These monolithic, active-device arrays combine the attributes of integrated circuits with the design flexibility and accessibility of discrete devices.

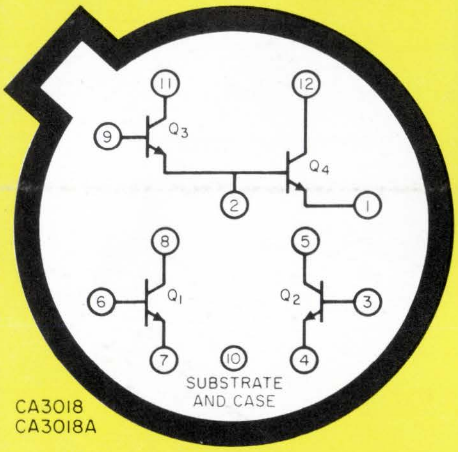
In this series of transistor and diode arrays, you get the economy and availability of mature devices. But you are in no way locked into a circuit configuration which may not meet the requirements of your application.

RCA IC Arrays offer four, five or six transistors in three package styles; six diodes in bridge configuration or as an array of independent diodes.

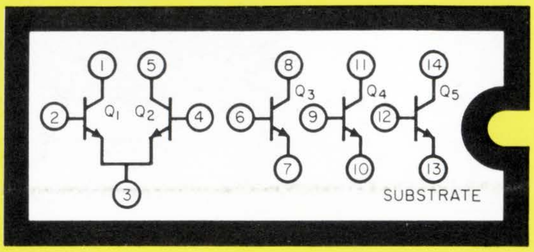
For new design freedom, for excellent device matching and temperature tracking, for significant savings—look into these RCA IC Arrays.

For further information, see your local RCA Representative or your RCA Distributor. For a copy of RCA's Integrated Circuit Product Guide (or a specific technical bulletin by File No.) write RCA, Commercial Engineering, Section 59G/CA37, Harrison, New Jersey 07029. International: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

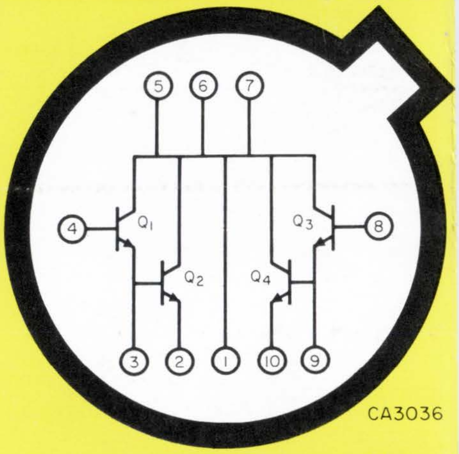
Circle 4 on Inquiry Card



CA3018
CA3018A

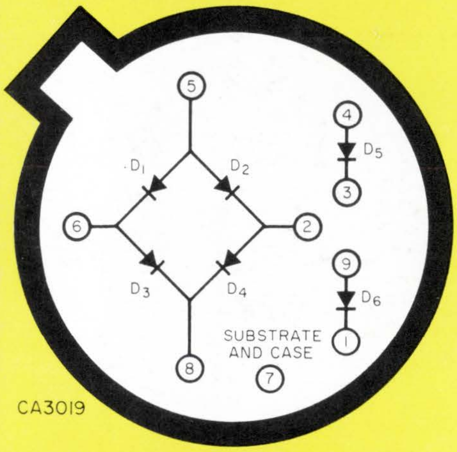


CA3045 CA3046

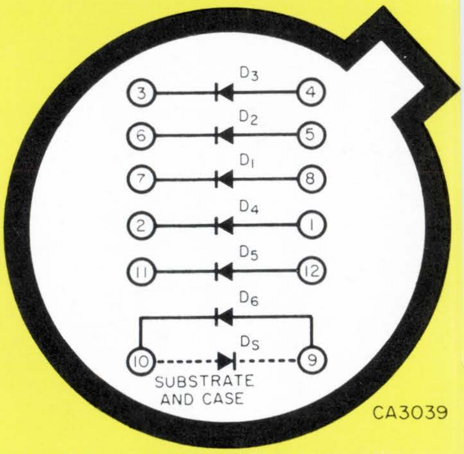


CA3036

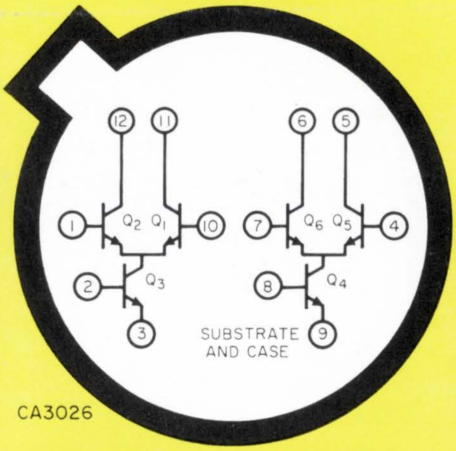
Device Type	Package	Description	Technical Bulletin File No.	Price (1000-unit level)
CA3018	12-lead TO-5	Two isolated transistors and Darlington-connected transistor pair	338	$ .98
CA3018A	12-lead TO-5	Premium version of CA3018 (performance controlled)	338	1.35
CA3019	10-lead TO-5	One diode-quad, two isolated diodes	236	.98
CA3026	12-lead TO-5	Dual differential amplifier	388	1.25
CA3036	10-lead TO-5	Dual Darlington array	275	.89
CA3039	12-lead TO-5	Six matched diodes	343	.98
CA3045	14-lead DIL ceramic	Differential amplifier and three isolated transistors	341	1.50
CA3046	14-lead DIL plastic	Differential amplifier and three isolated transistors	341	.98
CA3049	12-lead TO-5	Dual independent differential RF/IF amplifiers	378	1.95
CA3054	14-lead DIL plastic	Dual independent differential amplifiers	388	1.25



CA3019

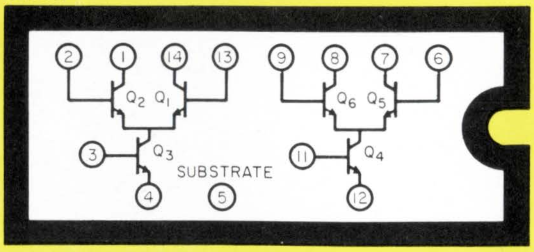


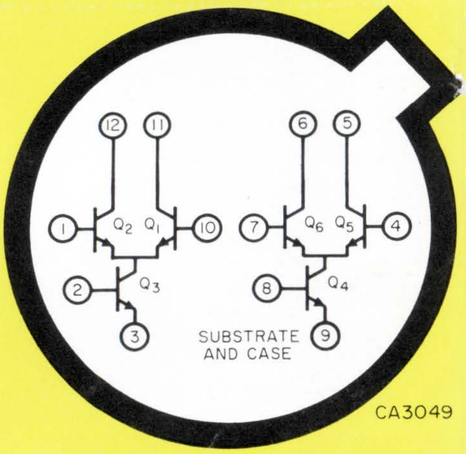
CA3039



CA3026

CA3054





CA3049

RCA
Integrated Circuits