VOL. 16 NO.

Electronic Design 24

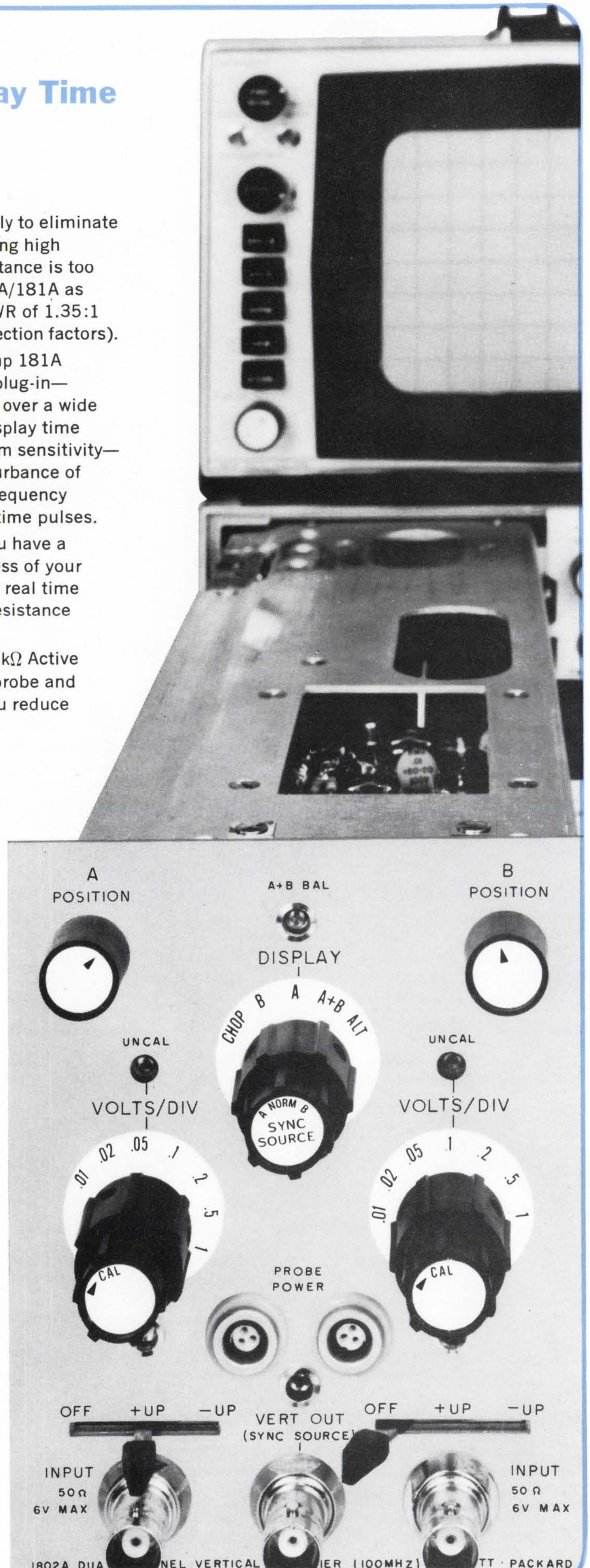
FOR ENGINEERS AND ENGINEERING MANAGERS

NOV. 21, 1968

LSI changes computer design. Economical memory-module size is shrinking, cycle times are being slashed. Future cost cuts may permit use of active read-only memory in central controls, lower field repair expense. For details on coming changes, on CAD, high-speed logic, and a vendor's point of view, turn to page C1

New hp 1802A 3.5 ns, 100 MHz Plug-In

Now...Stop, Store, Vary Display Time of 100 MHz Traces — Without Capacitive Distortion



The new hp 100 MHz, 3.5 ns plug-in is designed expressly to eliminate the effect of input capacitance—the big problem in making high frequency, real time measurements. Because the capacitance is too low to be measured, hp specifies the dual-channel 1802A/181A as having a low reflection (<0.13) and an extremely low SWR of 1.35:1 at 100 MHz, 10 mV/cm sensitivity (1.1:1 at all other deflection factors).

For the first time, you can use a real time scope—the hp 181A Variable Persistence and Storage Scope and the 1802A plug-in—to measure nanosecond rise times and high frequencies over a wide range of source impedances—and stop, store, or vary display time of your traces! You can observe your signal with 10 mV/cm sensitivity—without capacitive distortion and without capacitive disturbance of your circuit under test. You can capture and hold high frequency single shot phenomena—or look at low rep rate fast risetime pulses.

With the 50Ω impedance in the 181/1802A system, you have a near-perfect termination for your 50Ω systems—regardless of your signal frequencies. To cover 90% of your high frequency real time measurements, optional hp resistive dividers increase resistance 5, 10, 50 or 100X with **only** 0.7 pF capacitance.

For still more input resistance, the new hp 1123A 100 kΩ Active Probe has only 3.5 pF capacitance. Combine the active probe and its set of X10 or X100 matched resistive dividers and you reduce the capacitance of the active probe system to 3 pF.

Why all the fuss over providing the lowest possible capacitance for measuring nanosecond rise times and high frequencies?

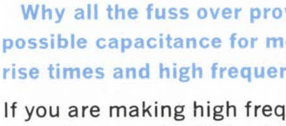
If you are making high frequency cw measurements, capacitance not only loads your circuit under test, it also causes phase shift.

If you're looking at pulses, capacitance attenuates rise time. Rise time displayed on an oscilloscope is basically the result of the relationship of source impedance—*and* the capacitance of the **signal sources,** the capacitance of the **probe,** and the capacitance of the **scope.**

Figure it out for yourself! Rise time is the square root of the sum of the squares of the rise times of your signal source, *and* probe, *and* scope. Or, use the new hp measurement error calculator.

Get the full story on the new hp 1802A—and your *free measurement error calculator*—from your nearest hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva.

Price: hp 180 (conventional display) Scope System with 100 MHz capability, $2500; hp 181A (variable persistence and storage) with 100 MHz,



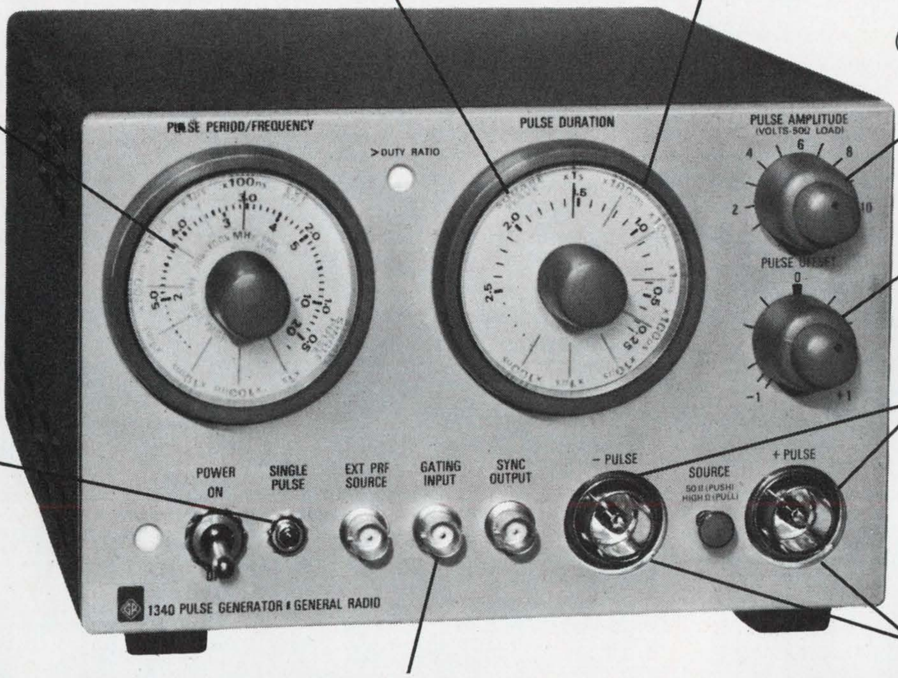
$3150; hp 1802A amplifier plug-in alone, $1200; hp 1123A Active Probe, $325.

088/8

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

This New Pulse Generator Speaks for Itself



And It SHOUTS its price: $395.

Need we say more?

For complete information, write General Radio Company, West Concord, Massachusetts 01781; telephone (617) 369-4400. In Europe: Postfach 124, CH8034 Zurich 34, Switzerland.

GENERAL RADIO

Systron-Donner worked till we could give you a line of DVM's clearly superior to any others on the market today. Take the tiny Model 9000 you see here:

We gave it a clean, modern design and pivoted the display so you can adjust it to be read without stooping and craning your neck.

We gave it a quick response input amplifier to eliminate hunting and enable it to track varying inputs. That means you don't have to wait while the digits flicker every time you tweak a pot.

We used the best conversion technique—dual slope integration—to give it 80 db noise rejection and maximum long-term accuracy.

We made it read current and resistance as well as voltage to broaden its utility.

We made it show polarity, decimal point and unit of measurement so just about anyone can use it without risk of error.

And we gave it a price tag you can afford: $395.

Little Model 9000 is but the smallest of an elegant new family that includes .01% DVM's and multimeters in easy-to-carry cases or flat Thin Line configurations that take only 1-3/4" of rack space.

We perfected the imperfect DVM —and gave it class too.

SYSTRON DONNER

888 Galindo Street, Concord, California 94520. Telephone (415) 682-6161

VOL. 16 NO.
Electronic Design 24
FOR ENGINEERS AND ENGINEERING MANAGERS
NOV. 21, 1968

NEWS

TECHNOLOGY

PRODUCTS

Departments

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If you don't know the μA709 has been replaced, we have a little surprise for you: The μA741.

The μA741 is the only monolithic operational amplifier that has frequency compensation built right on the chip. It's a pin-for-pin replacement for the μA709. An improvement in performance without an increase in price:

Differential Input Voltage	±30V min.
Offset Current	200nA max.
Offset Voltage	.5mW max.
Input Resistance	300k min.
Output Swing	±12V min.
Power Dissipation	5mW with ±5V supplies typ.
No latch-up when the common mode range is exceeded.	
Package	hermetic DIP
Order Number	U6E7741393
Price	$3.25 (100 up)

Starting October 9, 1967, Fairchild promised to introduce a new integrated circuit each week for 52 weeks. This is number **31.**

μA741 FREQUENCY COMPENSATED OPERATIONAL AMPLIFIER

The μA741 is a monolithic operational amplifier with built-in frequency compensation. It's the successor to the μA709 and a pin-for-pin replacement for it. Performance characteristics of the μA741 far exceed those of the μA709. But, the two devices are comparably priced.

The μA741 has a wide differential input voltage range of ±30V. There's no latch-up when the common mode range is exceeded. Offset current is 200nA and offset voltage is 5mV. Input resistance is 300k and output swing is ±12V. Minimum open loop gain is 50,000. Power dissipation is only 5mW with ±5V supplies. A 10k-ohm potentiometer is all you need to zero the input offset voltage. The adjustment range is ±25mV without degrading common mode or power supply rejection. And, there's no internal positive feedback to cause transfer function hysteresis.

You don't need stabilization components for closed loop operation because the μA741 has internal frequency compensation. (The compensation circuitry includes a 30pF MOS capacitor.) The amplifier can withstand indefinite short circuits to ground or supplies because the output stage is current limited.

The μA741's excellent stability and performance characteristics are the result of proven, monolithic high-yield processes used in the production of all Fairchild Second-Generation linear integrated circuits. It's actually the third Second-Generation linear IC we've introduced this year. (Other members of the family include the μA722 Programmable D/A-A/D Converter Current Source and the μA727 Temperature-Controlled Differential Preamp.)

You can use the μA741 any place the μA709 can be used. And, many places where the μA709 can't be used. The μA741 can function as an integrator, differentiator, summing amplifier, voltage follower or comparator in such applications as airborne fire control systems, process control systems, analog computers and ground support systems.

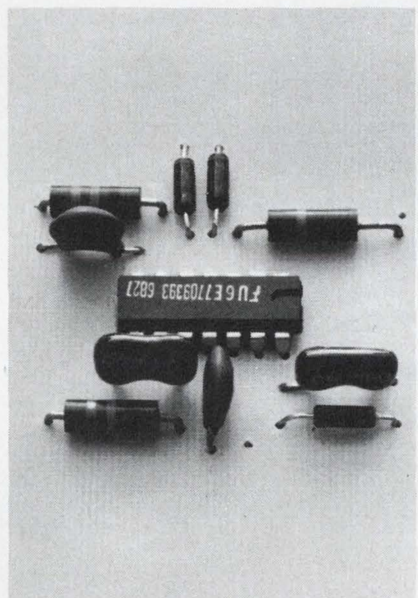
The new linear comes in a low-profile, 8-lead TO-99 package. It will operate over the entire temperature range from −55°C to +125°C. (It will soon be available in 0°C to +70°C DIP and TO-99 packages.) Your Fairchild distributor has it on his shelf now. We have it in volume quantities. Write for complete specs and applications information.

To order the μA741, ask for:
Part No. U5B7741312
Price: $22.50 ea. (1-24)
18.00 ea. (25-99)
15.00 ea. (100-999)

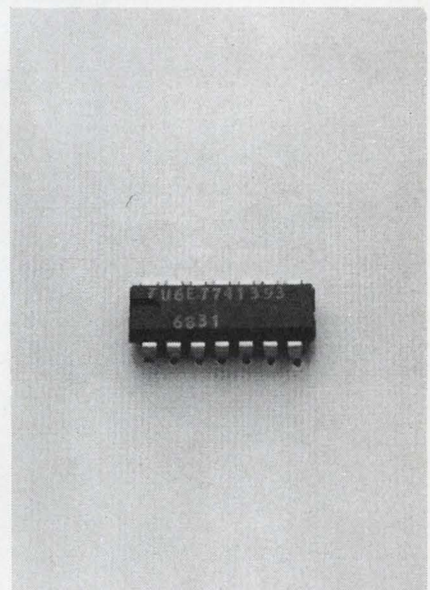
FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation — FAIRCHILD SEMICONDUCTOR — 313 Fairchild Drive, Mountain View, California 94040

The μA741 is a key member of Fairchild's family of Second Generation linear integrated circuits. Basic building blocks for virtually any linear application. New devices with better component matching, better specifications, increased chip size and higher complexities.

Other members of the family include the highly versatile μA723 Precision Voltage Regulator, μA727 Temperature-controlled Differential Preamp, μA733 Wide Band Differential Amplifier and the μA722 MSI Programmable D/A - A/D Converter Current Source. □ Compare our Second Generation Linears with any Linear ICs on the Market. You'll find there's a big difference between price/performance and price-per-product. □ Write for detailed specs on the entire linear family.



Unity gain amplifier built with μA709.



Unity gain amplifier built with μA741.

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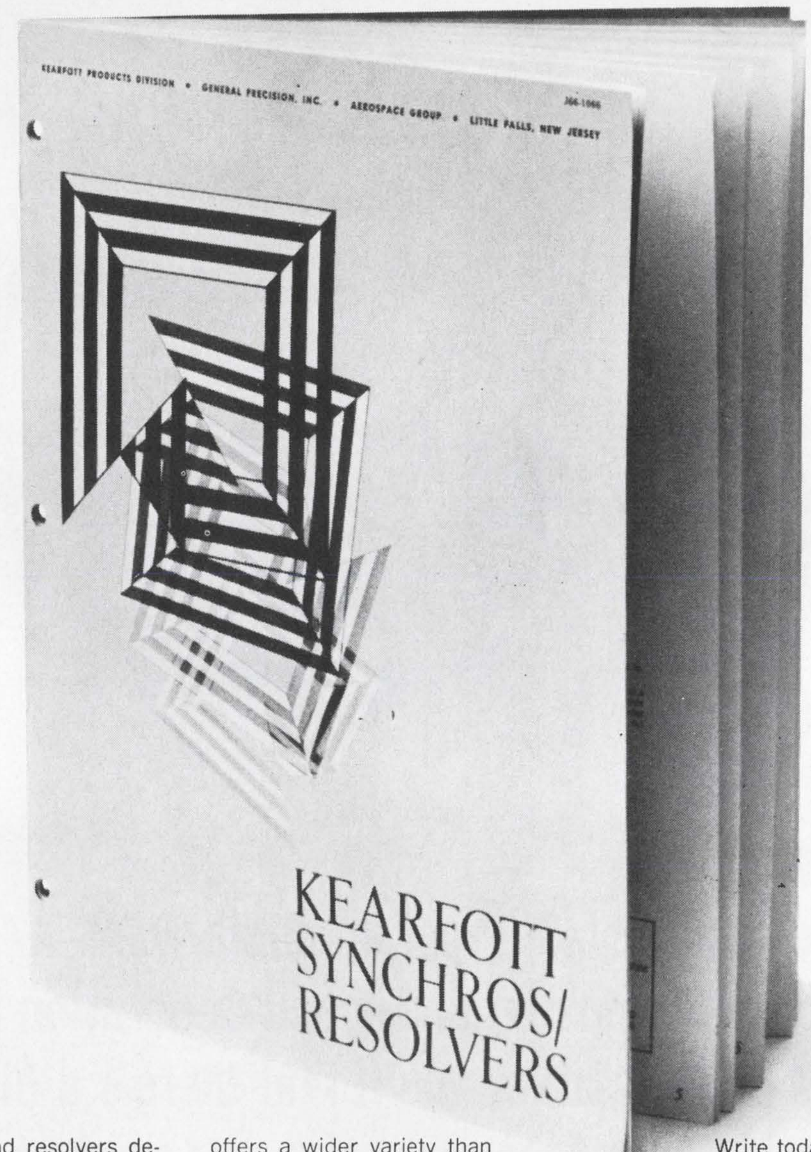
INFORMATION RETRIEVAL NUMBER 4

Resolve to get it.



Most of the synchros and resolvers described in this new 32-page brochure are standard only in the sense that they are readily available at competitive prices. Any of the "standard" units can be quickly modified to suit your particular needs, providing thousands of opportunities for *you* to resolve *your* problems.

These components reflect the highest order of precision in design, construction and performance and are backed by twenty years of Kearfott engineering and production experience.

We don't think you'll find anyone that offers a wider variety than we do. To emphasize the point, our catalog covers: Synchros, sizes 5 to 25; resolvers, sizes 5 to 28; winding compensated resolvers; resolver-amplifier combinations; multispeed units; transolvers; tandem synchros; custom-engineered units such as geared and gearhead synchros; rotary transformers; goniometers; phase shifters; etc.

Order the catalog. It's loaded with diagrams, dimensional data, electrical characteristics and application data. There's even a section on design basics.

Write today to: Kearfott Products Division, General Precision Systems Inc., Kearfott Group, 1150 McBride Ave., Little Falls, New Jersey 07424. Dept. 3-1450.

GENERAL PRECISION SYSTEMS INC.

KEARFOTT PRODUCTS DIVISION

A SUBSIDIARY OF THE SINGER COMPANY

INFORMATION RETRIEVAL NUMBER 5

Looking for Fast, High Volume AC and DC Calibration Capability?

Whenever and wherever you need precision, high volume calibration capability for your calibration laboratory, production line, maintenance testing shop — Hewlett-Packard has an instrument that specifically meets your requirements.

Two of these instruments—designed specifically to meet high accuracy and high volume calibration needs—are the hp 740B for DC and the hp 745A for AC. With either instrument, you press a button, turn a dial and you have an instant voltage reference!

High Resolution DC Calibration. The hp 740B DC Standard/Differential Voltmeter delivers output voltage to 1000 V with six digit resolution in discrete steps of 1 ppm of range. Accuracy of $\pm$(0.002% of setting +0.0004% of range) extends over 30 days.

As a differential voltmeter, the 740B measures voltage to 1000 Vdc with an input resistance of $>10^{10}\Omega$, independent of null condition. Accuracy is $\pm$(0.005% of reading +0.0004% of range $+1\mu$V).

The 740B is also a precision dc amplifier and high impedance voltmeter, and can be used to drive a recorder.

Fast, Accurate AC Calibration—Cut your ac calibration time in half with the state-of-the-art hp 745A AC Calibrator—an excellent choice for production line calibration and mainenance testing.

The 745A has a calibrated output voltage with $\pm$0.02% accuracy. It also has a six-digit readout, pushbutton ranging and a continuously adjustable frequency from 10 Hz to 110 kHz.

Eliminate tedious error calculations with the exclusive 745A direct reading percent error scale.

Get full specifications on these and other calibration instruments from your hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva. Price, 740B, $2350; 745A, $4500.

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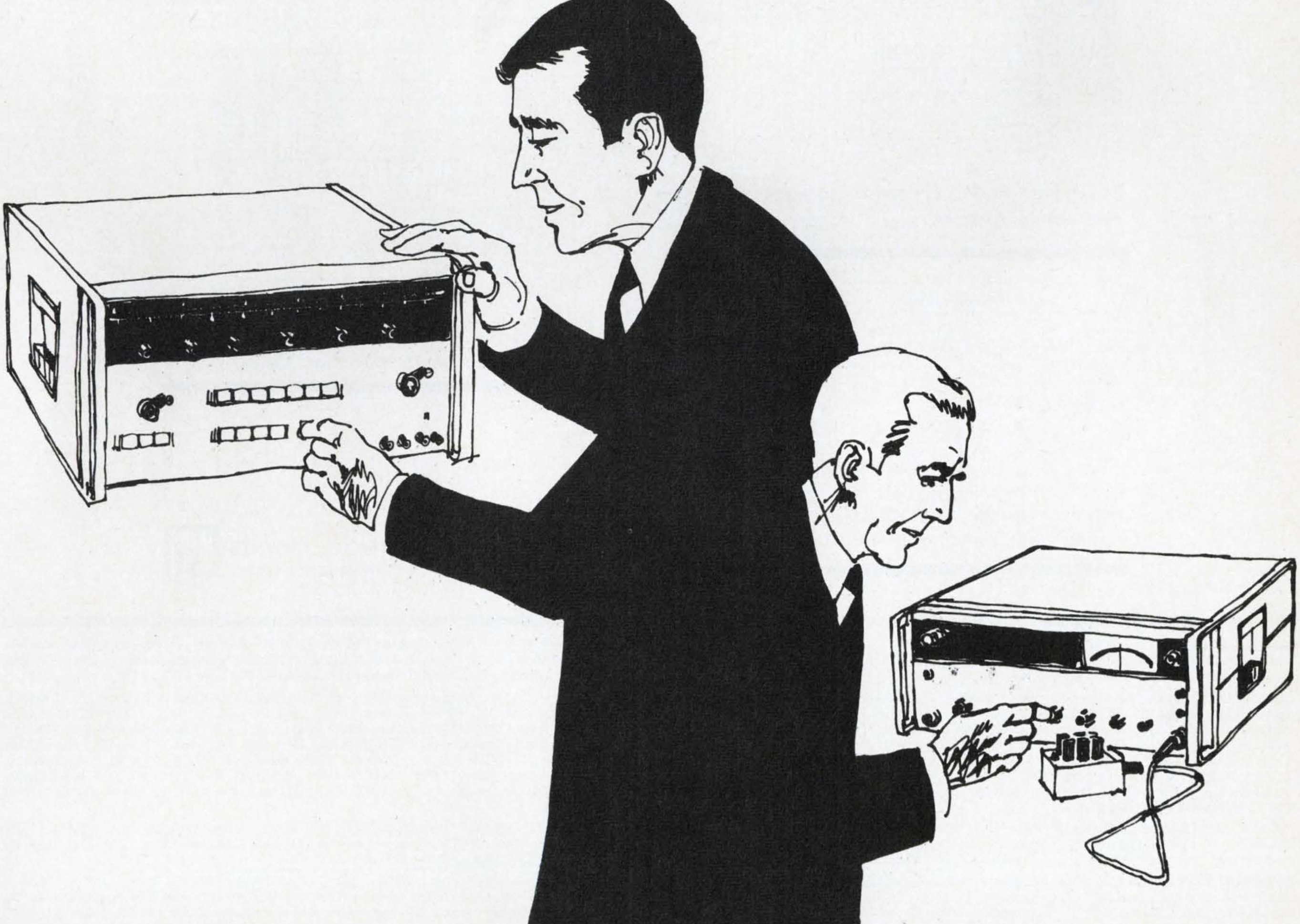
HEWLETT hp PACKARD

WORKING STANDARDS



INFORMATION RETRIEVAL NUMBER 6

Slowdown!

(and read about the world's fastest IC adder.)

Signetics announces a no-kidding leadership device: the 8260 Arithmetic Logic Element, latest addition to our DCL family.

The 8260, now available in volume, is a monolithic gate array incorporating four full adders structured in a look-ahead mode. The device may be used as four mutually independent Exclusive-NOR or AND gates by proper addressing of the inhibit lines. Here is a device which in typical application increases speed three to four times, greatly reduces package count and appreciably lowers over-all system costs.

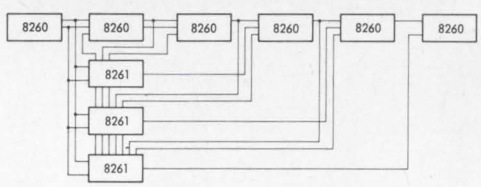
As a four-bit adder, the 8260 permits parallel addition of four sets of data and features simultaneous (look ahead) carry on each bit within the package. Extension of the look-ahead feature for 16 bits or more is facilitated by the 8261 Fast Carry Extender.

Access to the 8260 from previous stage(s) is provided through five OR-ed channels, and inhibition of carry-in-data and bit-to-bit carries is accomplished by a true (active high) logic level of C_{INH}.

The "carry-outs" available are: Internally Generated ($\overline{C}_G$); Propogated (C_P); and Ripple ($\overline{C}_R$). This gives the 8260 complete flexibility when used in Ripple Carry or Anticipated Carry Adder systems.

The 8260 is available now in 24-lead flat pak, −55° C to +125° C and 0° C to +75° C, and will soon be available in both full MIL and commercial DIPs.

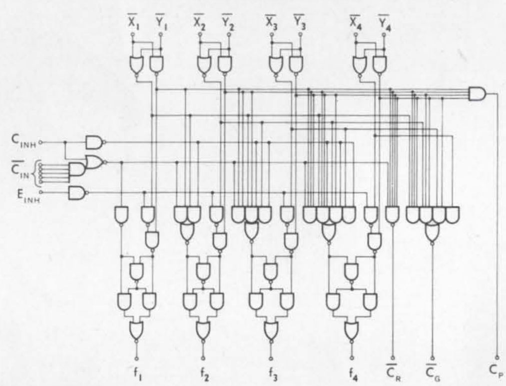
For complete information on the world's fastest adder write Signetics, 811 East Arques Avenue, Sunnyvale, California 94086. Fast!



24-bit Fast Adder System; 9 packages; minimum external connections.

No. of Bits	Package Count: 8260	8261	Quad 2-Input NAND Gates	Addition Time per Bit (ns)	Total Addition Time Input to Output (ns)
16	4	1	–	3.3	52
24	6	3	–	3.3	52
32	8	3	–	2.0	64
48	12	6	1	1.3	64
64	16	7	1	1.2	76

Increased speed and reduced package count far exceed what is attainable with any other IC family.



The 8260 Arithmetic Logic Element.

Signetics Integrated Circuits
A SUBSIDIARY OF CORNING GLASS WORKS

SIGNETICS SALES OFFICES: Wakefield, Massachusetts (617) 245-8200; Trumbull, Connecticut (230) 268-8010; Poughkeepsie, New York (914) 471-3292; Syracuse, New York (315) 469-1072; Fort Lee, New Jersey (201) 947-9870; Radnor, Pennsylvania (215) 687-2660; Silver Spring, Maryland (301) 946-6030; Clearwater, Florida (813) 726-3734; Winter Park, Florida (305) 671-5350; Dayton, Ohio (513) 433-4133; Minneapolis, Minnesota (612) 920-3256; Rolling Meadows, Illinois (312) 259-8300; Richardson, Texas (214) 231-6344; Garden Grove, California (714) 636-4260; Burbank, California (213) 846-1020; Redwood City, California (415) 369-0333.

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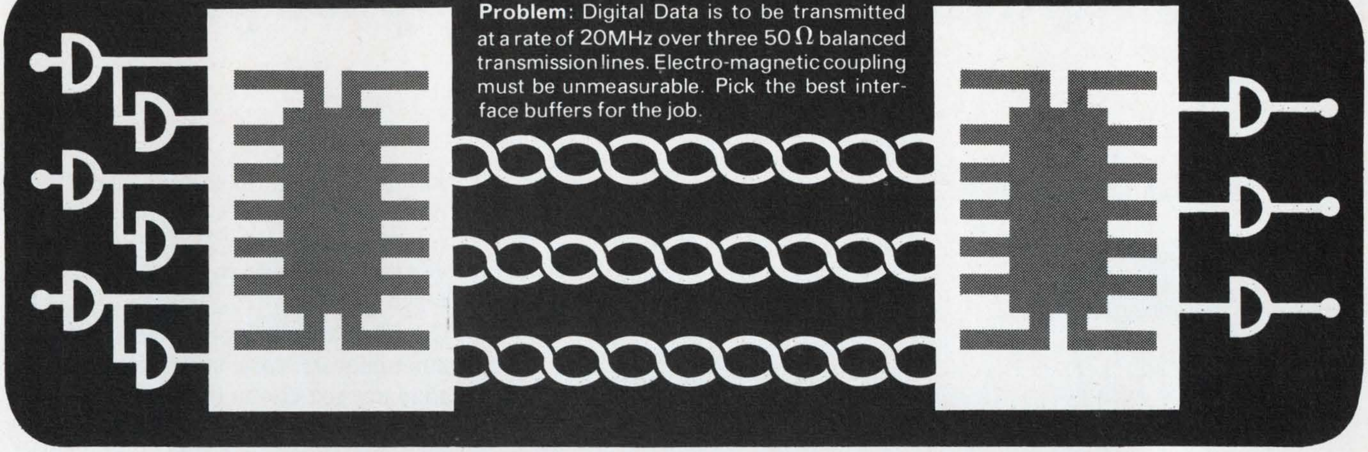
INTERNATIONAL SALES: France, Germany, Italy, Belgium, Holland, Luxemburg, Spain—**Sovcor Electronique,** 11, Chemin de Ronde, Le Vesinet, (S.-&-O.) France. United Kingdom, Ireland, Sweden, Denmark, Norway, Switzerland, Austria, Portugal—**Electrosil Ltd.,** Lakeside Estate, Colnbrook-By-Pass Slough, Buckinghamshire, Great Britain. Australia—**Corning,** 1202 Plaza Building, Australia Square, Sydney, N.S.W. 27-4318. Canada—**Corning Glass Works of Canada, Ltd.,** Leaside Plant, Ontario, Canada (416) 421-1500. Israel—**Talviton,** P.O. Box 3282, Tel-Aviv, Israel 236-666. Japan—**ASAHI Glass Co., Ltd.,** Corning Products Sales Dept. No 14, 2-Chome Marunouchi, Chiyoda-ku, Tokyo, Japan 211-0411.

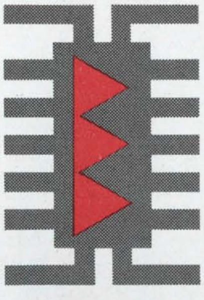
INFORMATION RETRIEVAL NUMBER 7

Pick the BEST IC for the job



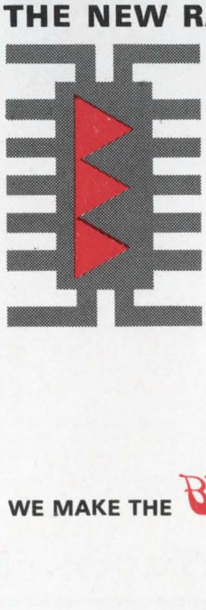
the BEST Solution:

THE NEW RA-245 LINE TRANSMITTER



The best IC to use at the sending end is Radiation's dielectrically isolated RA-245. This line transmitter converts digital voltage pulses to current pulses. The high speed CML circuits assure data transfer rates in excess of 30MHz. Power dissipation is a constant, independent of data rate. The balanced system virtually eliminates the adverse effects of line capacity. Electro-magnetic coupling and susceptibility is greatly reduced. RA-245 is available in both the TO-84 flatpack and the ceramic dual inline package. Three voltage-to-current converters are in each package. Power dissipation is negligible when converters are not being used. So use only one or all three. RA-245 is the Best IC for the job.

THE NEW RA-246 LINE RECEIVER



For best results, use Radiation's dielectrically isolated RA-246 at the receiving end. This 3-element buffer faithfully restores the current pulses to digital voltage pulses. The RA-246 current-to-voltage converter has built-in input terminations for balanced 50 Ω lines. Outputs from each element are suitable to drive all standard saturated logic circuits (such as DTL, TTL, etc.).

Like the RA-245, the RA-246 is available in both the TO-84 flatpack and the ceramic dual inline package. And you can use any or all of the converters. The Best IC for the job.

Contact your nearest Radiation sales office for further information. Ask how the RA-245 can be used as a level shifter. And how to use the RA-246 as a threshold detector. We will help you pick the Best IC for the job.

WE MAKE THE BEST IC FOR THE JOB

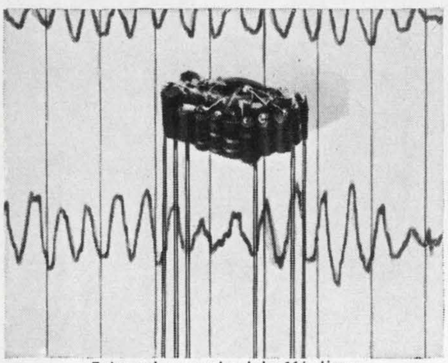
RADIATION
INCORPORATED
SUBSIDIARY OF HARRIS-INTERTYPE CORPORATION
MICROELECTRONICS DIVISION

RADIATION SALES OFFICES: P.O. Box 476, Lexington, Mass. 02173, (617) 682-1055 • 600 Old Country Road, Garden City, N.Y. 11530, (516) 747-3730 • 2600 Virginia Avenue N.W., Washington, D.C. 20037, (202) 337-4914 • 6151 W. Century Boulevard, Los Angeles, California 90045, (213) 670-5432 • P.O. Box 37, Melbourne, Florida 32901, (305) 727-5430 • International Sales: Marketing Department, P.O. Box 37, Melbourne, Florida 32901, (305) 727-5412

INFORMATION RETRIEVAL NUMBER 8

Propensity for density

or: C.I. capacitors cut another space problem down to size


Enlarged approximately 1½ times

When you convince more than 30 discrete components, including 10 electrolytic capacitors ranging from 0.01 to 2.2 mfd., to huddle together in a space somewhat smaller than 1/20 of a cubic inch, you've got yourself some pretty high-density packaging.

That's what engineers did at Signatron, Inc., Gardena, California, when they designed their miniature Model 2300-EEG differential amplifier — a potted, high-reliability unit designed primarily for use in their telemetry devices for physiological monitoring such as electro-encephalographs.

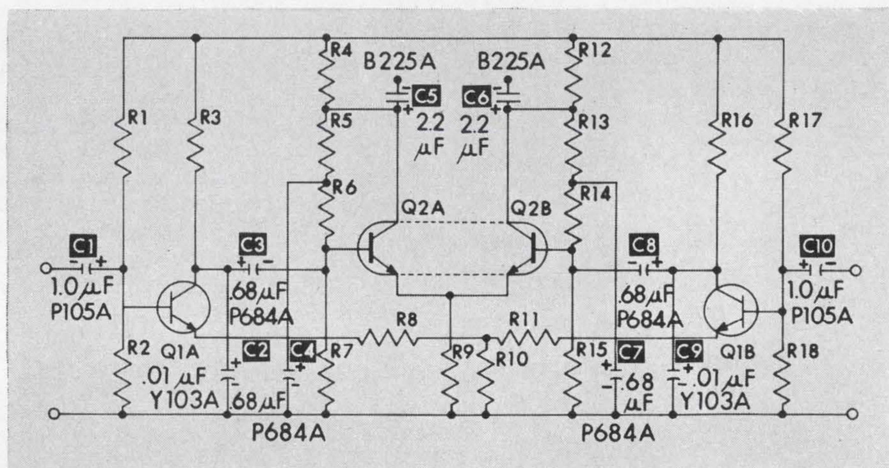
Of course they turned to Components, Inc. for the capacitors because, as everybody knows, C.I. makes the smallest, most dependable solid tantalum capacitors available . . . anywhere. Results: No capacitor failures, no leakage problems, excellent performance.

The Minitan® Cordwood Series used in this application were specifically designed for miniature equipment. They are available in five different case sizes from ⅛″ to ¼″ in length, with radial or axial leads, and capacitance values up to 47 mfd.

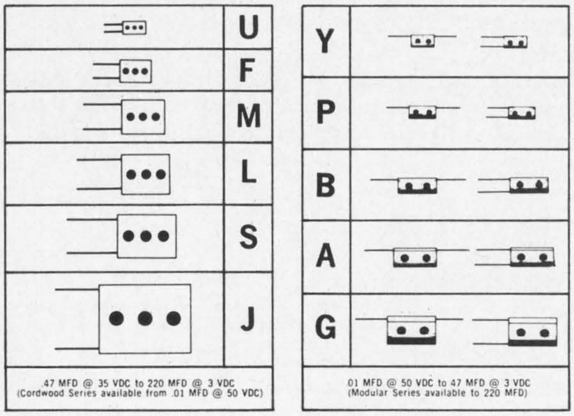
Performance is maximum, leakage is minimum, prices are optimum. Full reliability up to 125°C. Non-polar versions available in standard capacitance ratings.

C.I. . . . space race ace We offer more subminiature case styles and ratings than anyone else in the business. Samples, performance and reliability data, and application assistance are yours for the asking.

First in reliability . . . service . . . delivery. We prove it every day.



MINITAN MODULAR (Also available with axial leads) **MINITAN CORDWOOD**



(ACTUAL SIZE) (ACTUAL SIZE)

COMPONENTS, INC.
CAPACITOR PRODUCTS
BIDDEFORD, MAINE 04005 — TEL: (207) 284-5956 — TWX: 710-229-1559

INFORMATION RETRIEVAL NUMBER 9

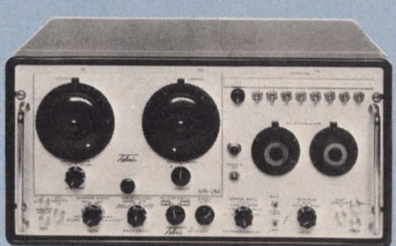
- SWEEP/SIGNAL GENERATORS
- BANDPASS FILTERS • LOWPASS FILTERS
- ATTENUATORS • COAXIAL SWITCHES
- RF DETECTORS • VSWR INSTRUMENTATION
- LOG AMP DETECTORS

telonic™

2003 Sweep/Signal Generator System

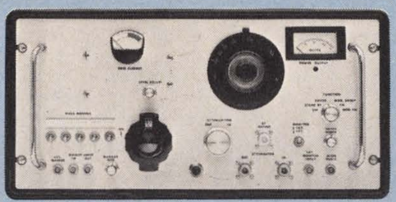
Totally modular in design — has 7 plug-in sweep oscillators — plus attenuators, frequency markers, rate modulation units, display processing and detector plug-ins—adapts quickly to any application — lowers instrument inventory — frequency range .02 Hz to 1500 MHz — sweep widths to 1500 MHz.

SM-2000 Sweep/Signal Generator



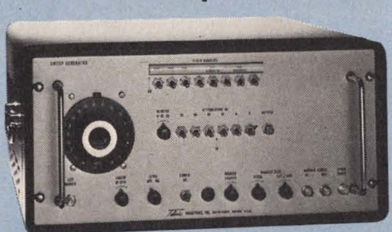
Has 21 plug-in oscillators available — quick adaptability to sweep or signal generating applications — covers 20 Hz to 3 GHz — broad selection of marker types — variable sweep rate — CW operation.

PD-B High Power Sweep Generators



Outputs to 40 watts — leveled swept output up to 8 watts — frequency coverage from 20 to 1000 MHz — sweep widths to 15%—sweep or CW modes — birdy frequency markers.

HD Series Sweep Generators



Four single chassis models — 20 kHz to 900 MHz — continuously variable sweep widths—birdy frequency marking — high stability, low VSWR — 50 or 75 ohm versions.

Attenuators — Rotary types — ranges to 109 dB — steps from .1 to 10 dB — Toggle Switch models—ranges to 102 dB — steps of .5 to 1 dB.

Coaxial Switches — Six models — 2 pole, 2 position — 4 pole, 2 position — single pole, 6 position — with or without DC switching — BNC, TNC, or N connectors.

RF Detectors — High sensitivity—low VSWR — flat response — wide range of frequency, 10 kHz to 3 GHz—VSWR less than 1.2:1.

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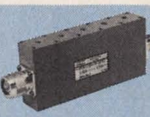
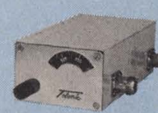


Cavity Bandpass Filters — Seven different series — sizes to **subminiature** — 2 to 6 sections — 20 MHz to 12,000 MHz.

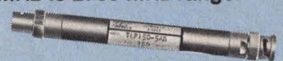
Interdigital Bandpass Filters — Frequency range 1000 MHz to 6000 MHz — 6 to 19 sections.

Combline Bandpass Filters — 1.4 to 10 GHz frequency range — two to eight sections — special 2.2-2.3 GHz telemetry version.



Tunable Bandpass Filters—Two series — full octave coverage — 48 to 4000 MHz.

Tubular Bandpass Filters—Available in four series — diameters from 1¼″ down to ¼″ — two to 12 sections — 20 MHz to 2700 MHz range.



Tubular Lowpass Filters — 20 MHz to 3000 MHz—two to 12 sections—five different series.

VSWR Instrumentation — Rho-Tector impedance bridges — Rho-Meter VSWR meter — simple, inexpensive, and fast VSWR measurement—swept or single point — VSWR to 3.0:1 — 5 MHz to 5000 MHz.

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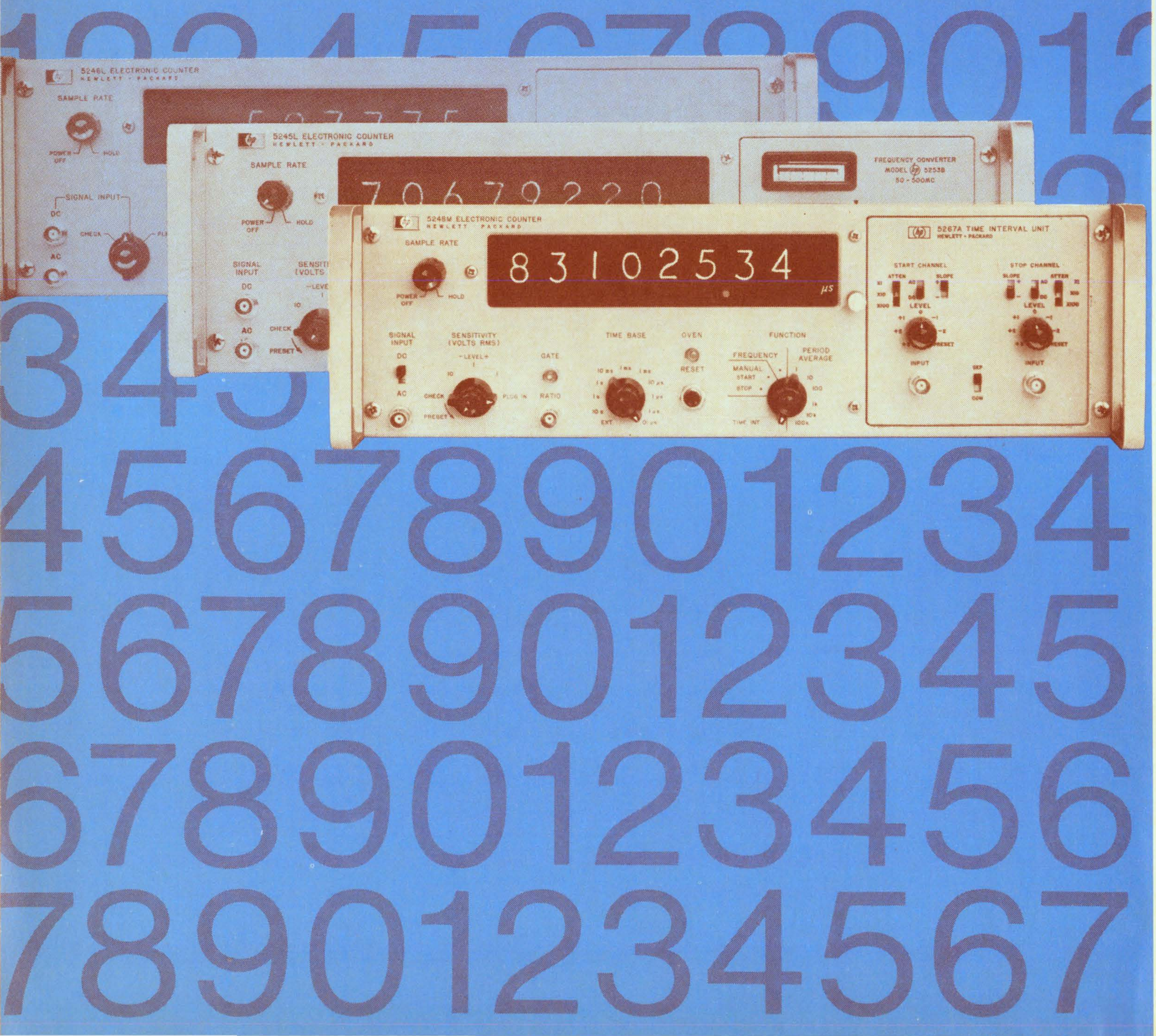
THE COUNTER REVOLUTION GOES ON AT HP



it's a family tradition

Ever since 1954. That's when the Hewlett-Packard 524A Electronic Counter first set the industry standard for quality and versatility. And since then the entire counter family has gotten into the act—consistently offering revolutionary values.

The tradition continues—giving you the ideal combination of accuracy, versatility and reliability . . . at the right price!

Look the current 5245 series family over. And join the Counter Revolution.

THE 5248L/M COUNTER. The newest, "jet set" member of the family, this high-speed counter extends your frequency range to 135 MHz and, with the 5267A plug-in, gives you time interval resolution to 10 ns. Has all the features of the 5245L and accepts all the plug-ins. ("M" version gives you rapid warm-up and even greater time base stability.) Great for high-speed applications such as wind-tunnel testing, computer switching, pulse delay, as well as general-purpose counting. Price: $2900. (5248M version, $3300.)

THE 5245L COUNTER. Patriarch of the family, this highly versatile precision instrument measures frequency from 0 to 50 MHz, period, multiple period average and frequency ratio. It has $<3 \times 10^{-9}$/day time-base aging rate *together* with excellent short-term stability of 2×10^{-10} rms (1 second averaging). Input impedance is high and constant at 1 megohm/25 pF on *all* input attenuator ranges, and dc input coupling is usable over the entire frequency range. Display storage and BCD output are *standard*, instead of extra-cost options. It accepts all HP plug-in accessories. Price: $2480.

THE 5245M COUNTER. The respected "uncle," this counter is nearly identical to the 5245L, except it has the most stable and spectrally pure time-base oscillator ever built into an off-the-shelf counter. Aging rate is 5×10^{-10}/day and short term stability is 5×10^{-11} rms (1 second averaging). With rapid warm-up, this cyrstal oscillator is an excellent secondary frequency standard, whose S/N ratio is typically >87 dB. Price: $2900.

THE M54-5245L COUNTER. The family "hero"—the military ruggedized version of the 5245L. Meets MIL STD-108D section on moisture-proof enclosures, and MIL specs for shock, vibration, humidity, temperature and electromagnetic compatibility. Still basically the 5245L. Price: $2850.

THE 5246L COUNTER. A stripped-down economy version of the 5245L, this "cousin" has a 6-digit readout and a time-base aging rate of <2 parts in 10^7/month. Options available are 8-digit readout, BCD output, and 5245L time base. It also uses all the 5245L plug-ins. Price: $1800.

THE 5247M COUNTER. This "cousin" is for rapid but accurate "hands-off" measurement of an extremely wide range of signals. It measures frequency only, directly to 135 MHz (to 18 GHz with a plug-in frequency extender), and accepts any input voltage between 100 mV and 10 V without trigger level adjustment. It's similar to the 5245M in ultra-stable, rapid warm-up characteristics. Price: $2950.

THE 5244L COUNTER. This member of the family is the "basic frame" counter. It doesn't accept plug-ins, but sports the frequency, ratio and period measurement versatility of the 5245L. Frequency range is to 50 MHz, with standard 7-digit readout and BCD output. Time-base aging rate is <2 parts in 10^7/month. Price: $1900.

And, of course, the "family appliances"—HP's extensive line of plug-ins and other accessories to make the 5245 family of electronic counters the most flexible line of counters available in the industry.

PLUG-INS TO USE WITH THESE COUNTERS:

5256A	Heterodyne Converter, 8 GHz to 18 GHz (and 1 to 200 MHz), $1950.
5255A	Heterodyne Converter, 3 GHz to 12.4 GHz (and 1 to 200 MHz), $1850.
5252A	Prescaler, DC to 350 MHz, $685.
5253B	Plug-in Converter, 50 to 512 MHz, $500.
5254B	Plug-in Converter, 0.2 to 3 GHz, $825.
5257A	Transfer Oscillator, 50 MHz to 18 GHz, $2100.
5258A	Prescaler, 1 to 200 MHz, 1 mV, $900.
5261A	Video Amplifier, 1 mV RMS, 10 Hz to 50 MHz, $325.
5262A	Time Interval Plug-in, 100 ns resolution, $250.
5264A	Preset Unit for normalized measurements, $650.
5265A	Digital Voltmeter, 6-digit presentation of 10, 100 and 1000V full scale, $625.
5267A	Time Interval Plug-in, 10 ns resolution, $400.

Nice thing about this family of counters: spare parts and service are available almost everywhere. So, join forces with the HP family, and revolutionize your own counting capabilities.

For complete information on any or all of these counters, call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

02824A

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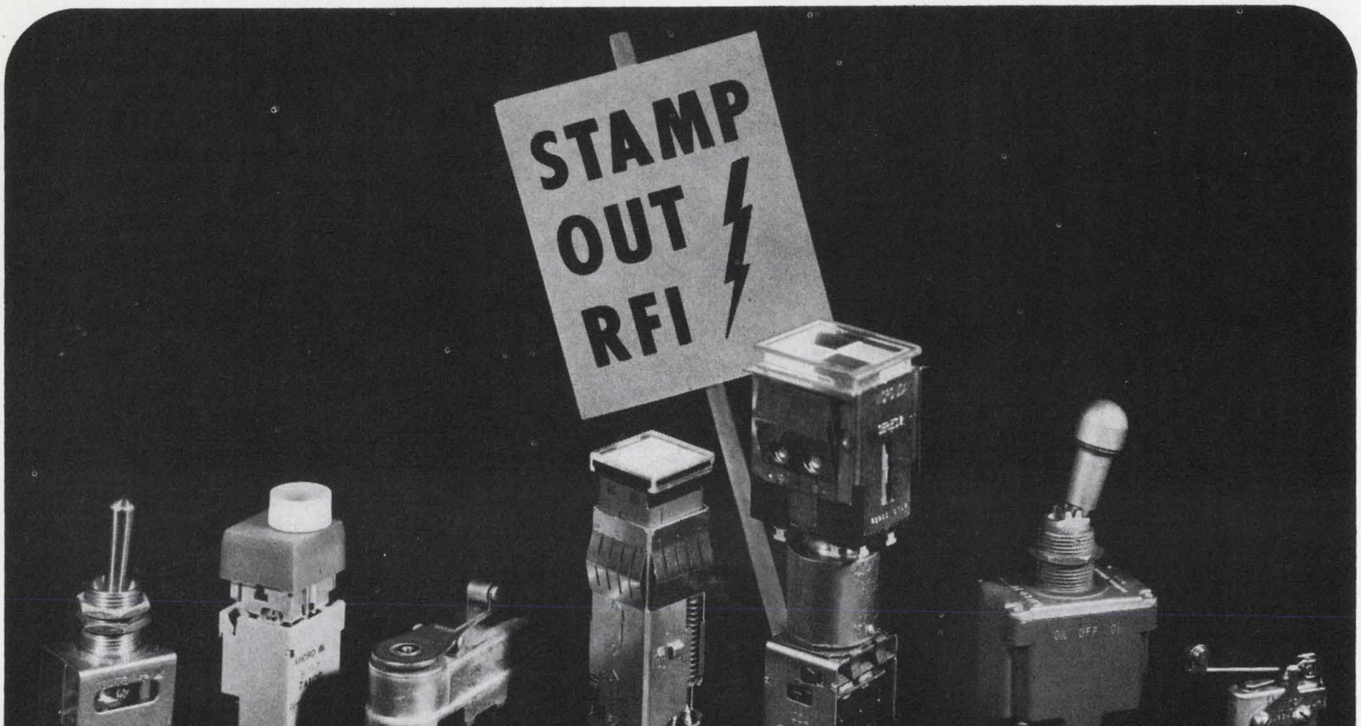
ELECTRONIC COUNTERS

INFORMATION RETRIEVAL NUMBER 11

The MICRO SWITCH RFIghters fight interference



For many years, MICRO SWITCH has been engaged in design work fighting radio and electromagnetic interference (RFI/EMI) between electronic equipment. Using Honeywell's RFI/EMI test facilities—the nation's most advanced—we have come up with answers unequalled elsewhere.

Many of these answers are available to you right off the shelf in a full line of stock switches that rate the nickname "RFIghters"! These RFIghter switches have all been designed to maintain panel integrity and help you meet RFI attenuation specifications such as MIL-STD-461, 462, and 463. In addition, we have developed a switch matrix which has been successfully tested to FED-STD-222.

Whether it's toggles you need, lighted pushbuttons, or basic snap-action switches, find out what MICRO SWITCH is doing to provide RFIghters that best maintain panel integrity.

Most RFI/EMI problems are unique and require special analysis for proper solution. For help in determining which switch will best improve shielding in your application, call a Branch Office.

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I have had a total of ___ years' experience.

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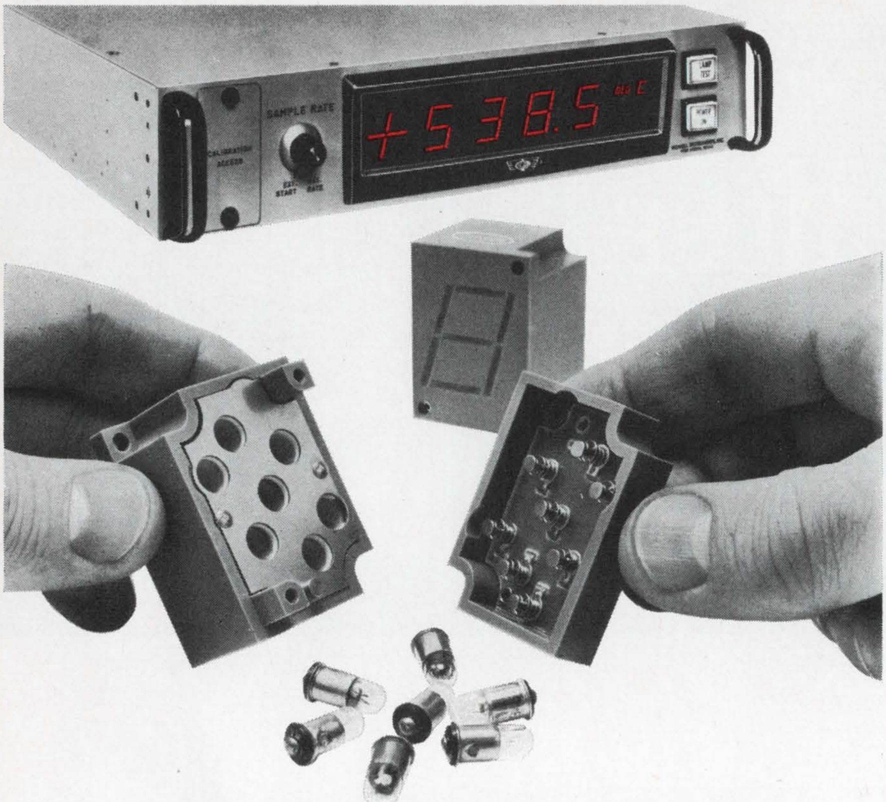

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Reliable because of simple module construction and long life lamps. Designed for use with neon or incandescent lamps to meet circuit voltage requirements. Easy-to-read from any viewing angle. 1" high characters are formed by unique patented light-gathering cells, and may be read from distances of 30 feet. Sharp contrast makes for easy viewing under high ambient lighting conditions.

Dialight Readout Features

1. Operate at low power.
2. 6V AC-DC, 10V AC-DC, 14-16V AC-DC, 24-28V AC-DC, 150-160V DC or 110-125V AC.
3. Non-glare viewing windows in a choice of colors.
4. Available with RFI-EMI suppression screen.
5. Available with universal BCD to 7 line translator driver.
6. Can be used with integrated circuit decoder devices now universally available.
7. Caption modules available; each can display 6 messages.

Send for catalog

Catalog-folder contains complete specifying and ordering data on numeric and caption modules, translator drivers, mounting accessories. Dialight Corporation, 60 Stewart Avenue, Brooklyn, New York 11237. Phone: (212) 497-7600.

DIALIGHT

INFORMATION RETRIEVAL NUMBER 14

DT-126

Designer's Datebook

JANUARY						
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23	24	25	26	27	28	

For further information on meetings, use Information Retrieval Card.

Jan. 21-23

Reliability Symposium (Chicago). Sponsor: J. E. Condon, Office of Reliability & Quality Assurance, NASA Hdqrs., Washington, D.C. 20006

CIRCLE NO. 401

Jan. 23-24

International Conference on Systems Sciences (Honolulu). Sponsor: IEEE; Univ. of Hawaii; F.F. Kuo, Dept. of EE, 2565 The Mall, Univ. of Hawaii, Honolulu, Hawaii 96822

CIRCLE NO. 403

Jan. 26-31

Winter Power Meeting (New York City). Sponsor: IEEE; J. W. Bean, American Electric Power Service Corp., 2 Broadway, New York, N.Y. 10004

CIRCLE NO. 404

Jan. 28-31

International Symposium on Information Theory (Ellenville, N.Y.). Sponsor: David Slepian, Dept. of Transportation, Washington, D.C. 20006

CIRCLE NO. 402

Feb. 10-11

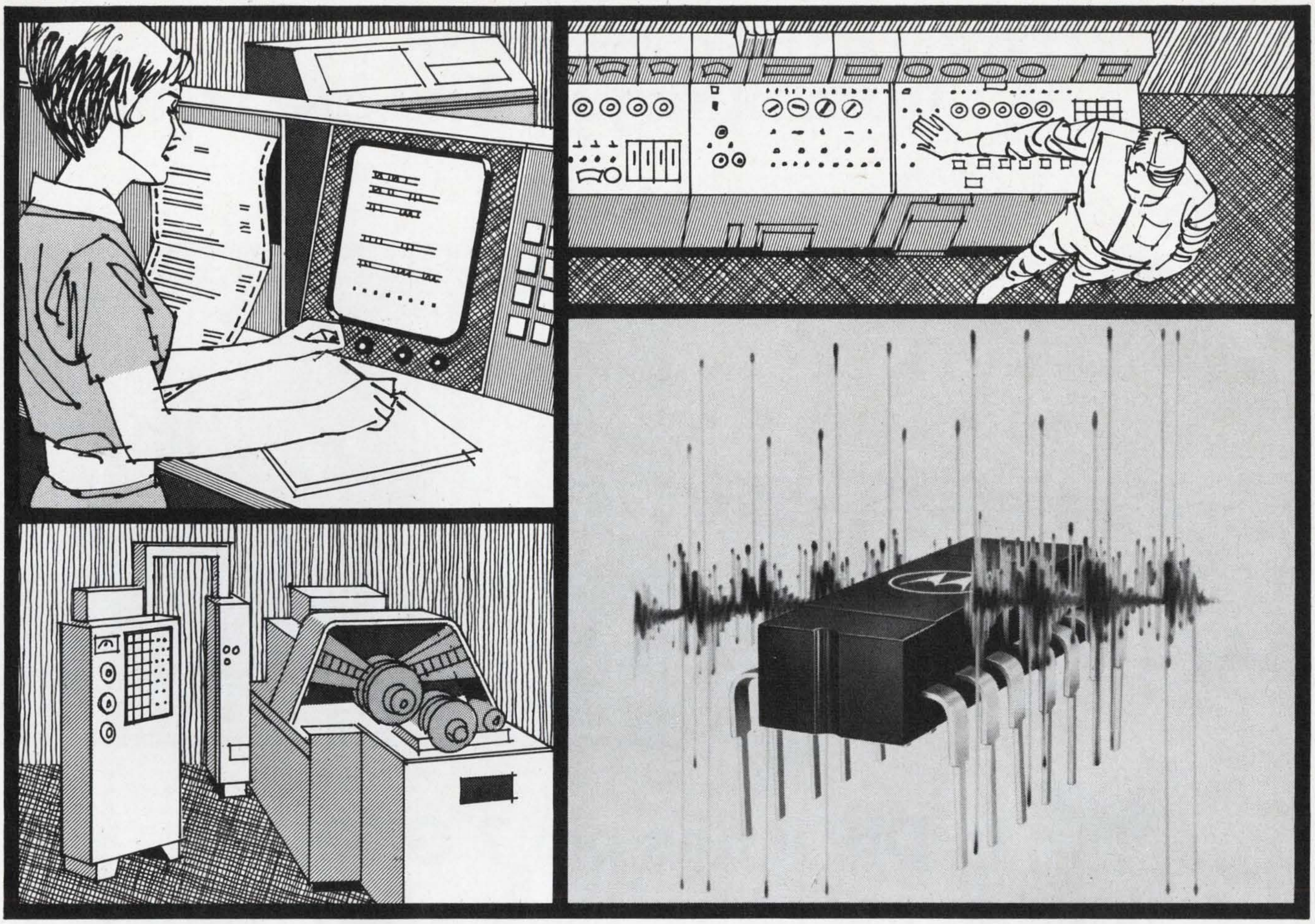
Transducer Conference (Washington, D.C.). Sponsor: IEEE; H. P. Kalmus, Harry Diamond Labs., Dept. of the Army, Washington, D.C. 20438

CIRCLE NO. 405

Feb. 19-21

Solid-State Circuits Conference (Philadelphia). Sponsor: IEEE; Univ. of Pennsylvania; L. Winner, 152 W. 42 St., New York, N.Y. 10036

CIRCLE NO. 406



If Noise Is Your I/C Problem... MHTL is The Economical Answer!

A recently-expanded line of integrated logic circuits that provides 6-volts (typ) noise immunity is now available in hermetically-sealed, dual in-line ceramic packages at the same price levels as previously-announced types in plastic.

It's called MHTL*—for Motorola high-threshold logic. And, because of the six new circuits in the line — bringing the total to ten — the designer has much greater latitude in high noise-immunity system implementation.

MHTL is an ideal family for use in numerical control, supervisory control and computer-peripheral equipment. It's also valuable for interfacing with discrete components. In addition, MHTL offers a voltage swing of 13 V, over a wide operating temperature range (—30° to +75°C), high fan-out and 30 mW power dissipation.

Here are the ten devices and functions:

TYPE	DESCRIPTION
GATES	
MC660P	Expandable Dual 4-Input Gate (active pullup)
MC661P	Expandable Dual 4-Input Gate (passive pullup)
MC670P	Triple 3-Input Gate (passive pullup)
MC671P	Triple 3-Input Gate (active pullup)
MC668P	Quad 2-Input Gate (passive pullup)
MC672P	Quad 2-Input Gate (active pullup)
DRIVER	
MC662P	Expandable Dual 4-Input Line Driver
FLIP-FLOPS	
MC663P	Dual J-K Flip-Flop
MC664P	Master-Slave R-S Flip-Flop
EXPANDER	
MC669P	Dual 4-Input Expander

Send for our new Perpetual Data Brochure which contains specifications, logic diagrams and operating characteristics for all ten MHTL circuits. We'll also send you two Application Notes to help you to better understand the use of these superior high-noise immunity circuits. ***DO IT TODAY!***

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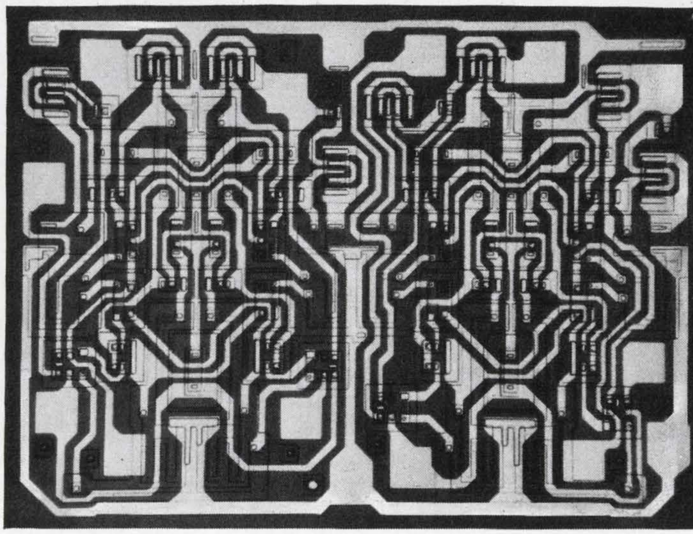
MOTOROLA *Integrated Circuits*

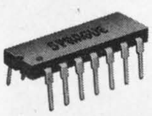
MOTOROLA SEMICONDUCTOR PRODUCTS INC. / P.O. BOX 20912 / PHOENIX, ARIZONA 85036

INFORMATION RETRIEVAL NUMBER 15

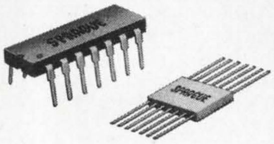
Here's a new digital IC from Sprague. The 54/74107A.



It's a single-chip replacement for the 5473/7473 dual JK m-s flip-flop.



In DIP it has pin 7 GND, just like the rest of the Series 54/74 family.



For existing designs, it's also offered in the "old" pinning in either DIP or flat pack.

SPECIFICATIONS
Dual JK m-s Flip-Flop

	DIP PIN 7 GND	DIP PIN 11 GND	TO-88 PIN 11 GND
0 to +70 C	USN-74107A	USN-7473A	USN-7473J
−55 to +125 C	USS-54107A	USS-5473A	USS-5473J
Clock freq.	15 MHz	15 MHz	15 MHz
P_{diss}	50 mW/ff	50 mW/ff	50 mW/ff
Fan Out	10	10	10

Choose 0 to +70 or -55 to +125 C temperature range. Choose "old" or new compatible pinning.

Choose Sprague for all Series 54/74.

And coming soon: Complex-Function circuits.

To request samples, call your Sprague representative. For further information, write to Technical Literature Service, 347 Marshall St., North Adams, Mass. 01247.

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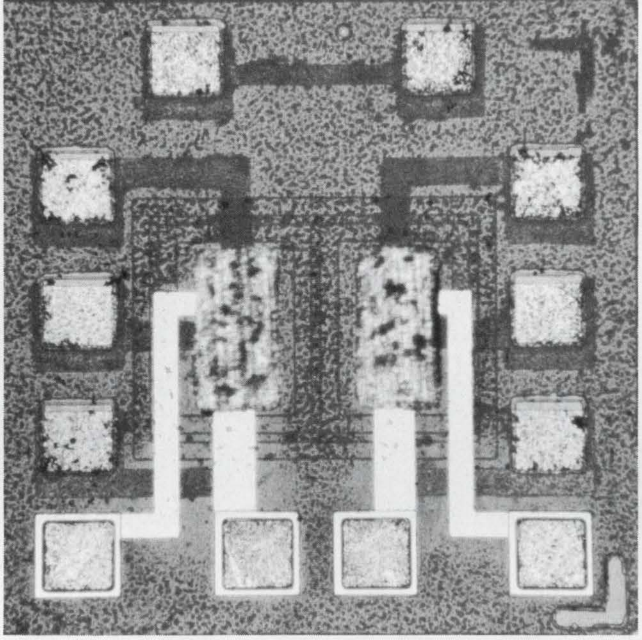
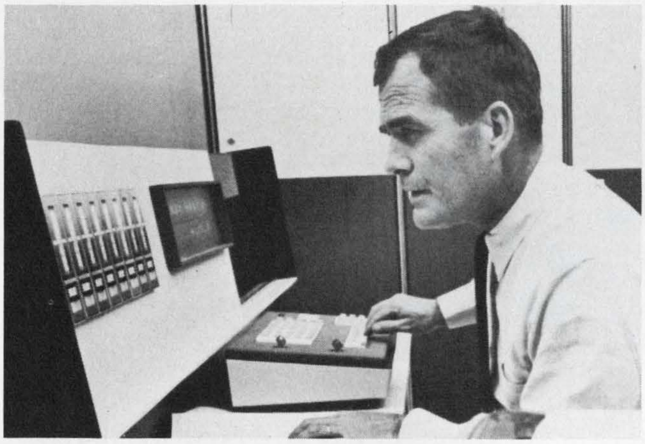
INFORMATION RETRIEVAL NUMBER 16

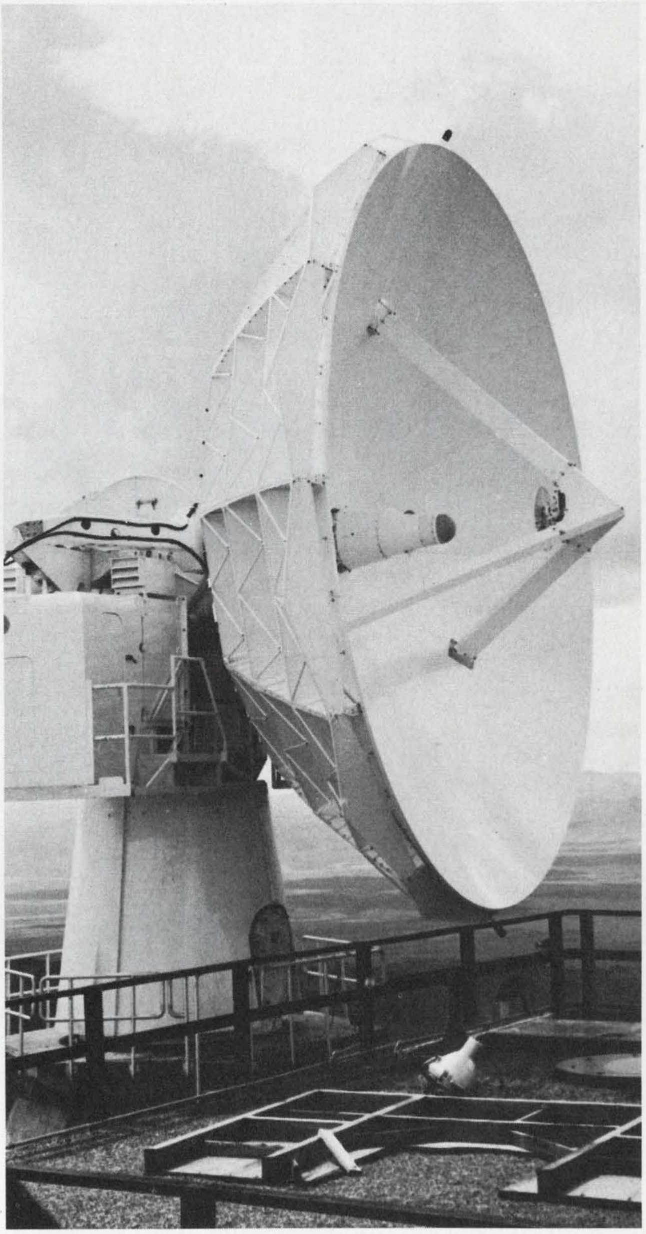
News



New process for monolithic pnps form radiation-resistant, mesa-isolated circuits. P. 25



Computer-operated systems are taking over in the industrial control field. P. 30



ICs are reducing the size of the electronic portion of a range radar by one-fifth. P. 32

Also in this section:

There's a new sweeping Sig Gen in the 100 kHz to 110 MHz league.

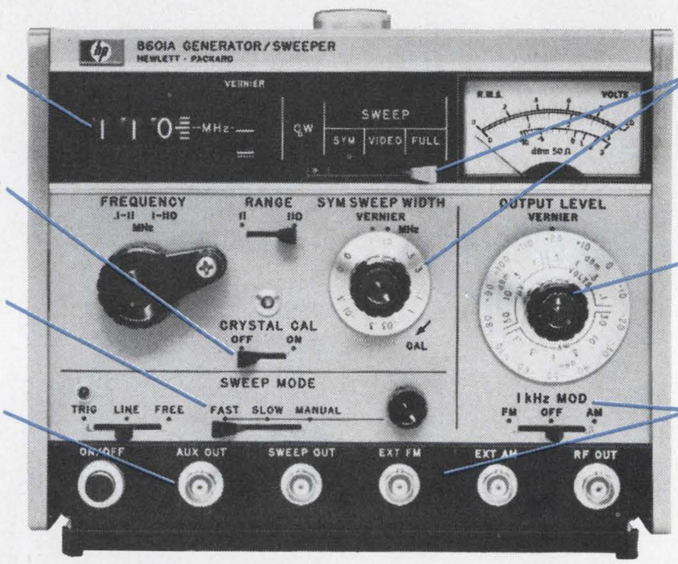
It's a powerful switch-hitter.

Digital frequency dialing accurate to 1% of frequency.

0.01% calibration check at 5 MHz intervals.

Sweep speeds and triggering versatility for all applications.

Monitor frequency to 110 MHz with low-cost 10 MHz counter—HP 5321.



3 sweep functions—full, video, symmetrical—go from broad to narrow sweep with the flick of a switch.

±1 dB output accuracy from 13 dBm to −110 dBm.

AM/FM modulation — internal, 30% AM and 75 kHz deviation FM.

Here's a combination signal generator/sweeper that'll go to bat for you in all types of lab and production work. Get 2-in-1 instrument performance in a small, lightweight package.

You can make fast, accurate swept measurements with the HP 8601A. With 0.5% sweep linearity and 1% frequency accuracy, it's so precise you don't even need markers. Flatness is ±0.25 dB over the full range from .1 to 110 MHz. It doubles as a signal generator with clean, calibrated output and modulation flexibility.

Put this All-Star to work for you—$1975. Call your HP field engineer for complete information, or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

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SWEEP SIGNAL GENERATORS

04810

News Scope

Electronics officials see expansion under Nixon

Electronics suppliers are looking for increased spending for military and space programs once the Administration of Richard M. Nixon takes over in Washington. But the infusion of new Government money will probably not be felt, they say, before fiscal 1971.

Throughout his campaign for the Presidency, Nixon stressed the need to outpace—not merely to match—the Soviet Union in military strength and space technology. In weapons procurement, he called for expanded R&D to rebuild the nation's arsenal and to guard against "possible breakthroughs by the huge Soviet research and development establishment." In space, he asserted on the eve of the election: "When I am elected, I shall see to it that America regains the lead in space—America will be No. 1 in space."

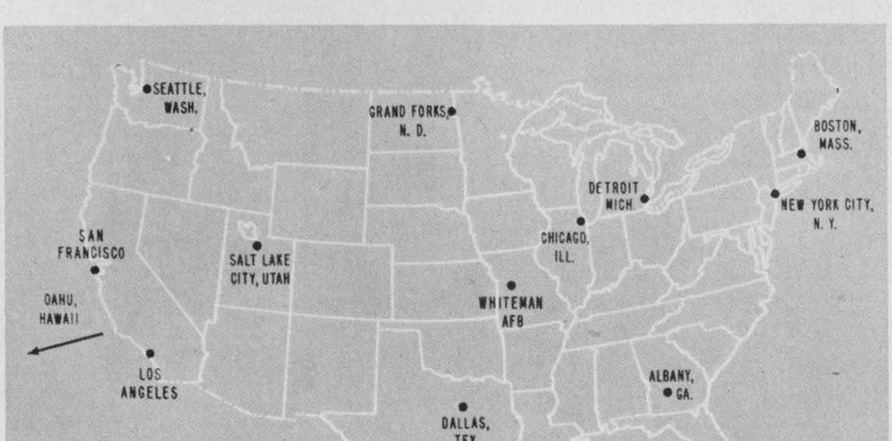
Citing such statements, officials in the electronics industry are looking for new opportunities to grow, but the budget for fiscal 1970 has already been drawn up in large part, they noted. No serious change is likely until fiscal 1971, they said.

Spending for civil electronics should expand, too, many in the industry believe. They recalled a statement by the President-elect that "scientific activity cannot be turned on and off like a faucet." Increased outlays for NASA, the National Science Foundation and the National Institutes of Health are expected, along with these developments:

- Increased support for electronic programs to help combat the increasing crime rate.
- The procurement of advanced systems, including data processing to improve the civil air transportation system.
- A vigorous R&D program to build up the U. S. maritime fleet.
- The development of a new source of cheap nuclear energy.
- Broadened support for a national oceanographic program.
- Expanded research to solve air and water pollution problems.

One effect of the impending Republican takeover is already evident in Washington. Thousands of non-Civil Service appointees in the Defense Dept. and other electronics-related agencies are seeking new employment. A massive exodus is expected to be in full swing by the end of the year.

"The Nixon broom is going to sweep the city clean," one industry professional observed the day after election. "I've already had two calls this morning from Defense Dept. officials trying to beat the rush."



Sentinel antiballistic missile system was endorsed by President-elect Nixon early in his campaign. First of 13 sites will protect Boston.

Video-taped technical sessions to hit the road?

A new way to make technical conference papers and panel discussions available to engineers who are unable to attend meetings was initiated at the 22nd annual Northeast Electronics meeting that was held in Boston.

A video tape was made of the session dealing with electric cars. The tape will be edited and reviewed by NEREM officials and then, if it is satisfactory, made available for distribution. William Stalfors, project manager at Sylvania Electronics Systems Div. and a member of the NEREM arrangements committee, is enthusiastic about the idea but says he does not yet know precisely how it can be implemented effectively and equitably.

Conceivably the service could be used to build up a traveling library of important technical information. The video tapes were made by Sylvania's Commercial Div. in Bedford, Mass.

Pioneer IX transmits finer, faster, farther

NASA's Pioneer IX satellite, which went into orbit around the sun on Nov. 8, is transmitting data two times faster, with fewer transmission errors, than its predecessors and can beam back its findings from distances that are 40 per cent greater. Credit for the improved performance is given to an experimental convolutional coder employed in its data system.

According to a NASA spokesman, an encoder uses the signals furnished to each on-board sensor to provide proper synchronization with the spacecraft's digital telemetry unit. Data from this unit are processed by an on-board data system into a coded data bit stream for transmission to the ground.

Launched to monitor the characteristics of the solar wind, interplanetary magnetic fields, cosmic rays and other phenomena that could affect the safety of the astronauts now scheduled to orbit the moon sometime between Dec. 21 and Dec. 26. In addition to the convolutional coder, Pioneer IX carries seven other experiments.

The Tetr-II (Test and Training) satellite that rode up with Pioneer IX and went into earth orbit, is also functioning well. Tetr-II is simulating an earth-orbiting Apollo spacecraft to train the ground-based communications and tracking crews and equipment.

Still making news is the Pioneer VI solar satellite, launched in 1965. For more than a week before the satellite passed behind the sun on Nov. 15, scientists at the Jet Propulsion Laboratory in Pasadena carefully examined the frequency of signals returned by a transponder in the satellite, for evidence of a spectral shift caused by the sun's gravitational field. If the shift matches that predicted by Einstein's general theory of relativity, scientists believe they may be able to obtain one more empirical corroboration of the theory. Unfortunately, increased solar activity during the crucial period prevented good reception.

Observers will, however, have another chance on Nov. 27 when the satellite emerges from behind the sun.

Electronics is leading U.S. industry in growth

During the past decade, the electronics manufacturing industries registered the fastest sales and growth rate of any industry in the U. S., the Dept. of Commerce report states.

In a report, "Growth Pace-Setters in American Industry,"—a comprehensive study of fifty-five industrial frontrunners from 1958 to 1968—the Federal agency sets the growth rate for all U. S. manufacturing industries at 65%; for the fifty-five leaders studied, the growth rate averaged out to 85%.

Leading the all-industry group, by far, is computer manufacturing, which registered a phenomenal 511% boost in sales during the decade. Computer industry sales grew from $1.1 billion in 1958 to an estimated $6.7 billion in 1968. The Commerce study attributes this $5.6 billion surge to "the information revolution" with its demand for more efficient record keeping and faster data processing."

Another electronics industry—makers of cathode ray picture tubes—came in second, registering a growth rate of 460%, with sales of $159 million in 1958 and $890 million this year.

In fourth position is the semiconductor manufacturing industry, with sales increasing from $250 million in 1958 to a total of $962 million in 1968.

Copies of the report are available for $1.50 each from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

$75 electronic watches predicted under pact

"Within five years electronic watches utilizing the highly accurate tuning-fork principle will be available for $75 and up, says Austin T. Graves, president of Gruen Industries, Inc.

The only tuning fork watch available today is the Accutron, which sells for $125 and up, made by Bulova Watch Co., the sole patent-holder for the tuning fork driving principle.

The cut in price is expected to come from a cross-licensing agreement Bulova made with Ebauche, S. A., a Swiss holding company. The agreement gives manufacturing rights to a number of Ebauche member companies, one of which is Gruen Industries, Inc.

The watches are expected to be cheaper because of the lower cost of skilled labor in Switzerland, the new competition and an expanded supply of watches.

"It will be a year away," Mr. Graves says, "but Swiss companies will be mass-producing watches that make use of the tuning-fork principle. Consequently these watches will be available at prices the consumer can afford."

Connector standards remain doubtful

Progress on connector standardization is clearly in the eye of the beholder, according to divergent views expressed at the 1968 Annual Connector Symposium held in Cherry Hill, N. J.

Speaking on the side of progress, the military cited evidence that standardization is advancing. The recently revised rf connector specification, MIL-C-39012A, calls for some designs to use hardware that is piecewise interchangeable. In addition, a forthcoming military standard will list preferred designs for each connector type. The military also indicated a renewed effort to consolidate all similar specifications, including those from different service branches.

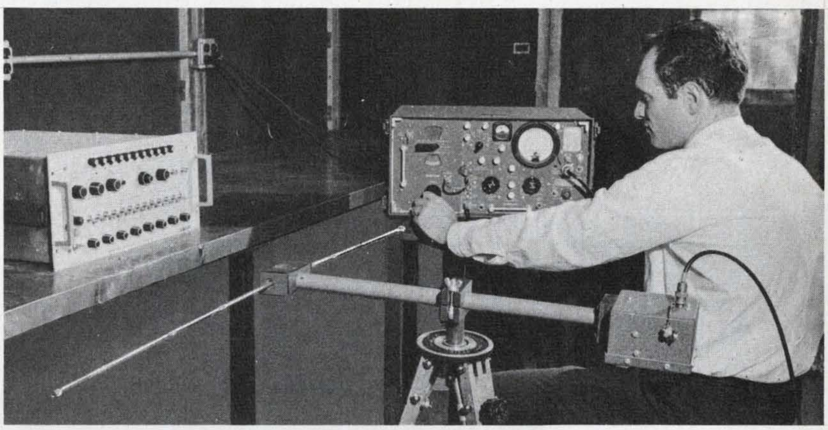
Manufacturers, however, do not agree with the military's concept of progress. They claim that the military actually hinders standardization by issuing too many specifications that cause too many design duplications, hence customer confusion. Other offenders, in the eyes of manufacturers, are users who are granted numerous design deviations by the military. This, say the manufacturers, delays standardization by encouraging the proliferation of new and needless connector designs.

Users, for the most part, agree with manufacturers—standardization is not really making progress. However, they blame both the manufacturers and the military. Manufacturers, the users say, prefer the certainty of a specialized market. The military, users go on to point out, issue many unnecessary specifications because of the competition between the various military agencies.

Clearly, the rate and extent of progress in standardization depends on the observer: who he is, how fast he would like it to go, and when he will consider it complete. Although the first forward steps have not satisfied an entire industry, they are a beginning.

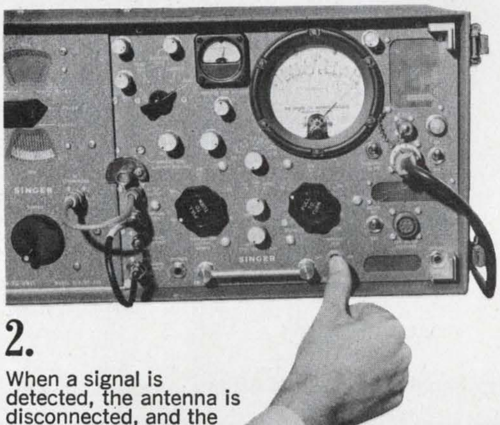
How to use the Singer Model NF-105 to make Noise and Field Intensity Measurements to meet the Tri-Service Specs

The Singer Model NF-105 has plug-in tuning units for specific bands of frequency. You can buy just the heads you need, add others as you need them. Rarely will contractual requirements for RFI testing make it necessary to purchase instrumentation that covers the entire spectrum — 14kHz to 1 GHz. This time-proven instrument, the most widely used in the world for RFI testing performs its measurements simply, accurately and quickly.



1.

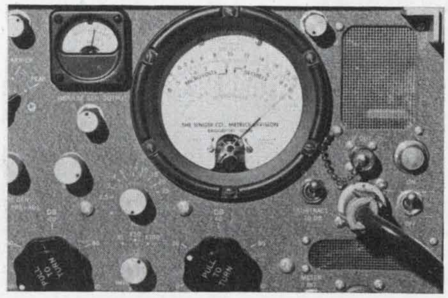
In this standard noise and field intensity measurement, a Singer dipole antenna is placed in front of the instrument under test. The operator first tunes through the frequency band on the Model NF-105 to determine quickly what signals — if any — the instrument under test is emitting.



2.

When a signal is detected, the antenna is disconnected, and the output from an internal impulse generator is connected to the receiver's antenna input. Depressing this push-button activates the generator for self-calibration of the receiver. The generator produces a broadband highly stable signal at a predetermined amplitude for calibration.

3. After the receiver has been calibrated, the operator re-connects the antenna to the antenna input jack and reads the result directly on the front panel meter. The meter is calibrated in dB above one microvolt. Calibrated internal attenuators extend the effective dynamic range of the meter to 100 dB.



4.

It is as easy and as fast as this to pull out the plug-in tuning units and put in others to cover additional frequency bands. Singer, which has been setting the standard for noise and field intensity measurements for 15 years, makes instrumentation of this type to cover the range of 20 Hz to 26.5 GHz. Singer also makes a complete line of accessory equipment, including a comprehensive set of antennas, probes, remote indicators and other equipment.

A brochure on the Model NF-105 is now available. For your copy, please circle the Readers Service Card or write on your letterhead.

EMPIRE SINGER INSTRUMENTATION The Singer Company, Metrics Div., 915 Pembroke Street, Bridgeport, Conn. 06608 (203) 366-3201

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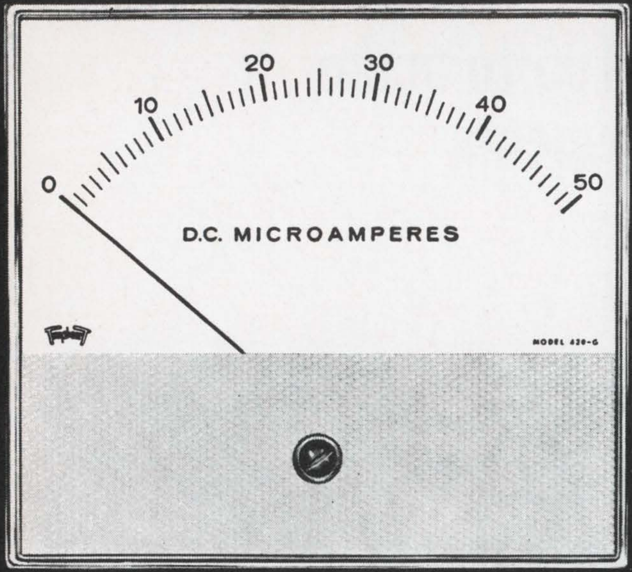
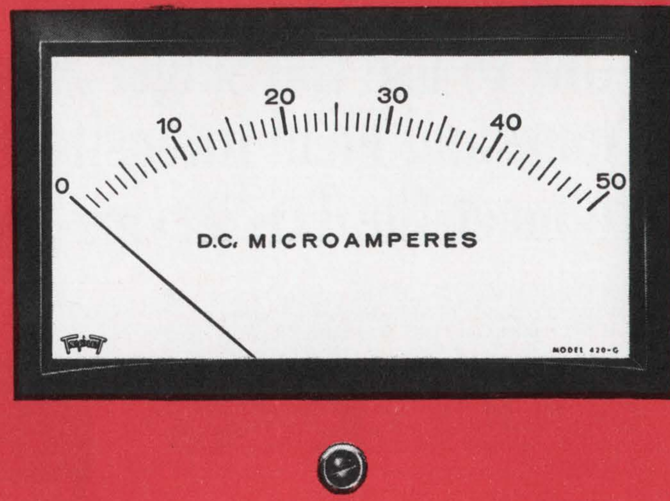
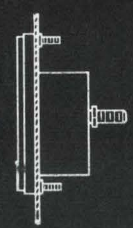
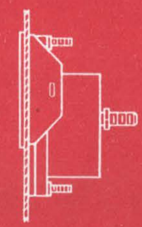




now you see it *now you don't*





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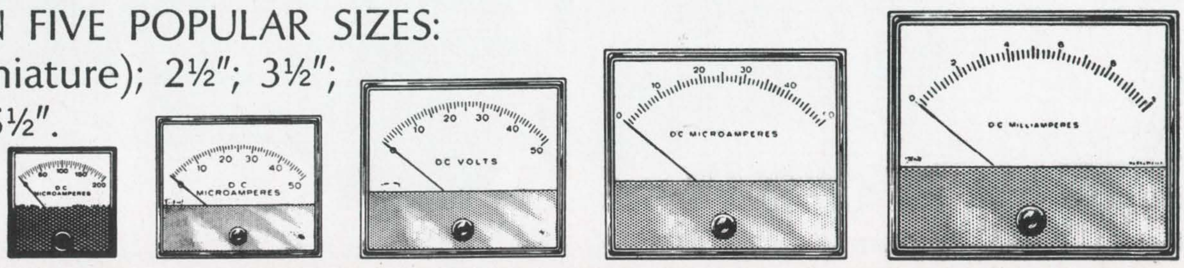


TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

New process upgrades monolithic pnps

Glass solder, back-lapping and mesa isolation are combined to improve the gain, stability and speed

Raymond D. Speer
Microelectronics Editor

A new approach to building both pnps and npns in one monolithic structure was announced at the Electron Devices Meeting in Washington, D. C.

In the process, developed at Fairchild Semiconductor's Research and Development Laboratory in Palo Alto, Calif., two separate wafers are prepared, one an optimized pnp and the other an optimized npn. The wafers are glass-soldered together to form a monolithic structure, and then the pnp wafer is lapped down, from its back surface, to about 20 microns' thickness. The pnp devices are then mesa-isolated, and metalization is added for interconnections.

"All processes," said David Oberlin, a member of the Fairchild technical staff, "are suitable for a production facility."

The high-quality pnp transistors made possible by this process can be used in push-pull output stages, level-shifters and positive current sources in op-amps. The low h_{fe} of the previous lateral and triple-diffused pnps, the slow speed of the substrate pnp, and the excessive processing of the multiple-epitaxial pnp are all avoided.

"The process is not limited to pnp and npn structures," Oberlin said. "The second wafer can be an MOS wafer, for instance, and the finished product a combination bipolar-MOS circuit."

The process can also be used to form mesa-isolated circuits for increased radiation-resistance. A dummy supporting structure is fused to an npn wafer, and the npn devices are back-lapped and mesa-isolated by etching. The devices are thus air-isolated; radiation-sensitive junction isolation is avoided. Oberlin said he had built satisfactory mesa-isolated 709 op-amps with this technique.

"This method of isolation is not nearly as expensive as dielectric isolation," he reported, "and the parasitic capacitance is lower."

The lower capacitance makes the circuits attractive for high-frequency applications.

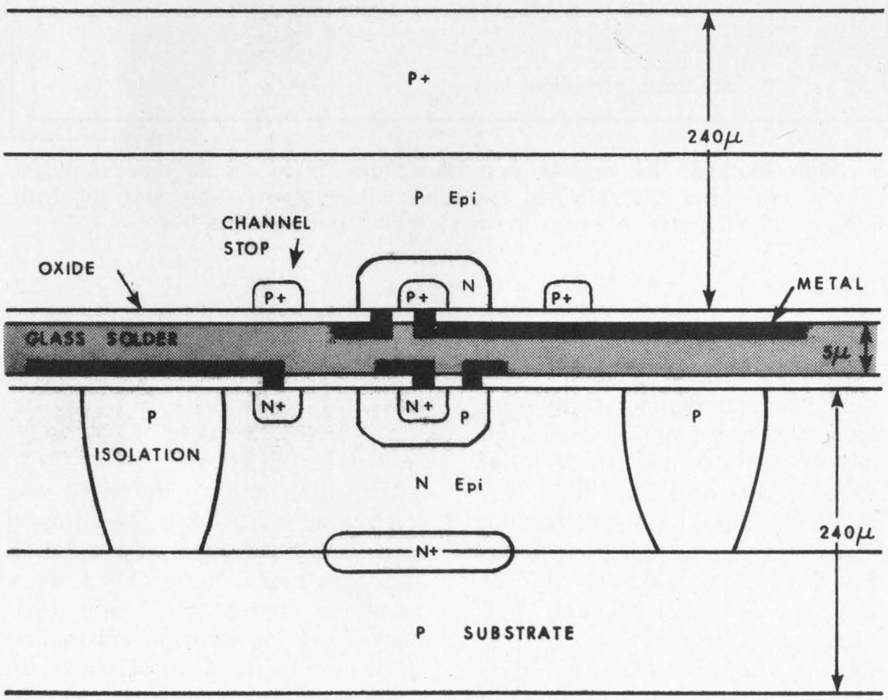
Solder-glass seal the key

The new process hinges on the ability to make the required glass-solder seal between the two wafers. After the optimized pnp and npn wafers have been processed separately, one is provided with a few aluminum bumps about 50 microns high, the other with matching etched pockets 50 microns deep. These are the alignment references. Then the glass solder is applied. The glass used must have a sodium content of less than 30 ppm to avoid contamination of the wafers, and it must have a low melting point—below 575°C, Oberlin said.

The application of the glass solder to the wafer is no simple task. The glass is pulverized, and a colloidal solution of the glass powder in an organic solvent is prepared. The powder is then centrifuged out of solution and onto the wafer. According to Oberlin, this results in a very uniform deposition at a well-controlled rate. The glass powder is deposited to a thickness of about 5 microns, and adheres well enough for careful handling. Foreign particles can be tolerated to a limited extent.

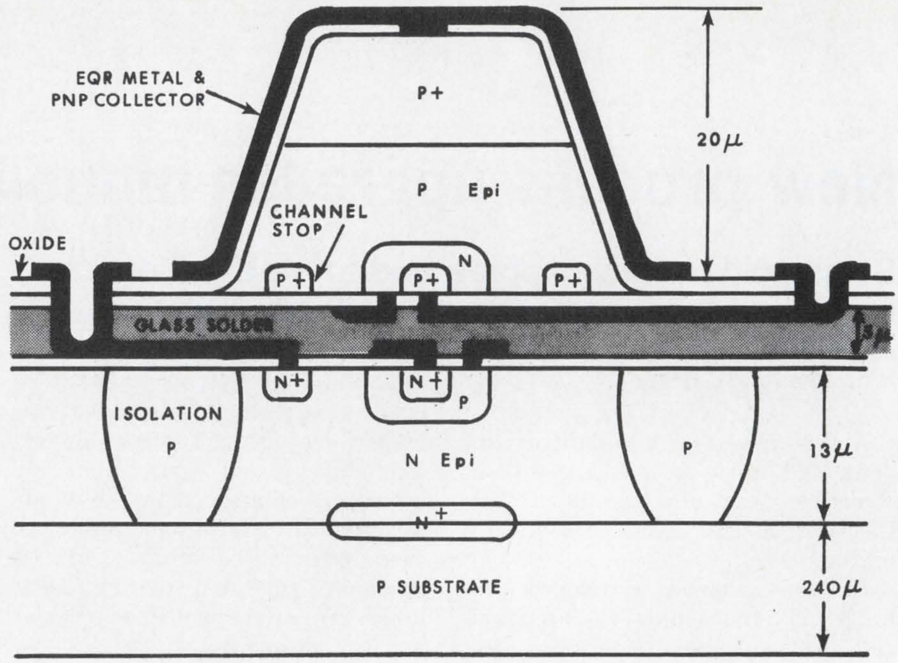
The prepared wafers, one of them glass-coated, can be mated by hand or by optical alignment in a production process. They are then bonded under pressure and elevated temperature (Fig. 1).

After bonding, the pnp wafer is lapped down to about 20 microns by a process that Oberlin described as "controllable and production-oriented." Enough p+ material is left to provide a buried layer. The

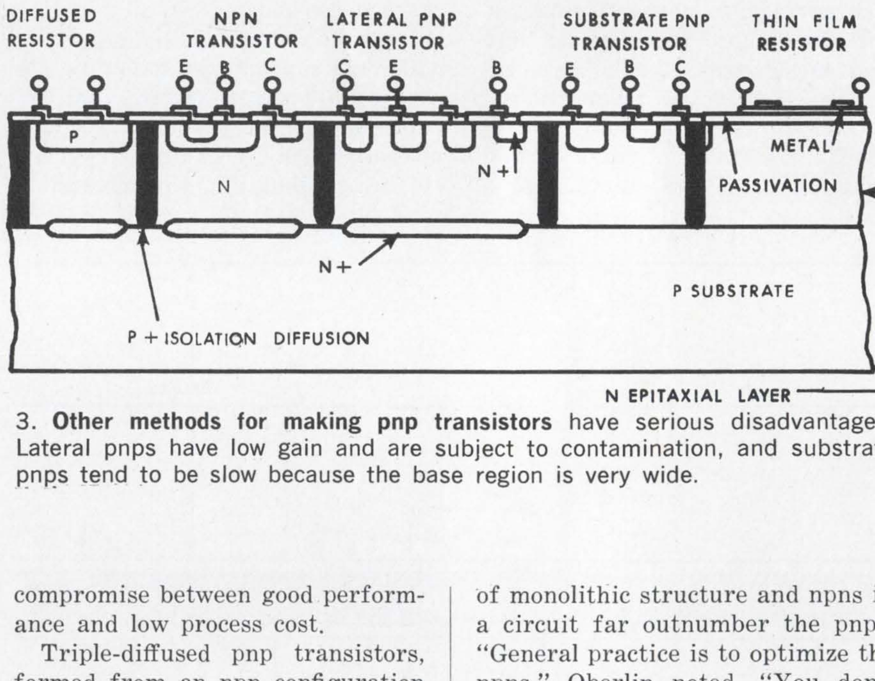


1. **Glass solder joins optimized npn and pnp wafers** face-to-face in a new monolithic process. The solder must be highly purified, and have a low melting point to avoid damage to the monolithic circuits.

(**pnps,** *continued*)
pnp devices are then mesa-isolated by suitable masking and etching. Metal interconnections are applied as a last step, with standard masking and etching techniques (Fig. 2). An equipotential ring is provided around the pnp to prevent channeling. Circuits are diced after processing, just as with ordinary monolithics.



2. **The pnp wafer is back-lapped** to a thickness of about 20 microns, and individual devices are mesa-isolated by standard masking and etching techniques. Interconnection metalization is applied by standard processes through the oxide layer and solder, to make contact to the original wafer metalization.



3. **Other methods for making pnp transistors** have serious disadvantages. Lateral pnps have low gain and are subject to contamination, and substrate pnps tend to be slow because the base region is very wide.

Alternatives are inferior

Other methods for making pnp and npn transistors in a monolithic structure are already in use, but each method has serious disadvantages. The lateral pnp (Fig. 3) is directly compatible with junction isolation techniques, and requires no additional processing steps. At the same time that the base regions of the npn devices are diffused, two closely-spaced p-type regions are diffused into an isolated n-type island. One of these regions is used as the emitter and the other as the collector of the lateral pnp. The n-type region between the two is the base. Current flows laterally —thus the name "lateral pnp."

The two p-type regions must not touch, of course. Because resolution is limited, the base-width must be quite large, and this reduces the gain of the transistor. In addition, the series resistances of the emitter and collector are higher than those of the npn transistors.

The lateral pnp is very surface-sensitive. The base region has a much larger exposed surface area than the vertical structure. Surface effects—notably fast recombination of carriers at the surface silicon-silicon dioxide system—result in low gain, and the greater exposed base area increases the chance of surface contamination. The gain, h_{fe}, is therefore low for a lateral transistor and subject to some instability due to surface impurities.

Substrate pnps a compromise

Substrate pnps are better than the lateral pnps because they do not have a large surface area. The wide base, however, makes it a slow transistor—f_T is quite low. Substrate pnps are considered a compromise between good performance and low process cost.

Triple-diffused pnp transistors, formed from an npn configuration by diffusing a p+ emitter into the original n+ emitter, have been proposed. This pnp configuration has a poor emitter efficiency, and thus low h_{fe}, and a collector-to-base breakdown of approximately 7 V. Steps taken to improve the efficiency and the breakdown voltage result in degradation of the npn transistors. This cannot be tolerated, since the npn transistor is regarded as the basic building block of monolithic structure and npns in a circuit far outnumber the pnps. "General practice is to optimize the npns," Oberlin noted. "You don't fuss with the pnps."

Also discussed by Fairchild was a proposal for a multiple-epitaxial structure, but too many processing steps are required for this to be a practical approach. Oberlin estimates that a multiple-epi monolithic would require at least 20 process steps, and perhaps 25. "If you do too many processing steps," says Oberlin, "you end up with silicon dust." ■■

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VOLTAGE: 50 to 500 VDC
TOLERANCE: down to 1%
TEMPERATURE RANGE:
−55°C to 150°C
Meets or exceeds
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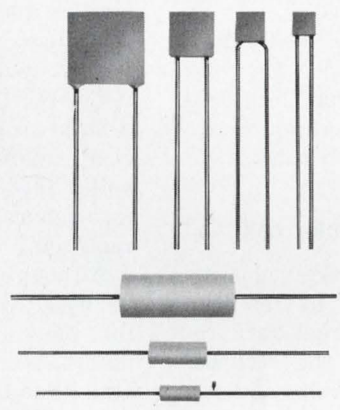

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TOLERANCE: down to 1%
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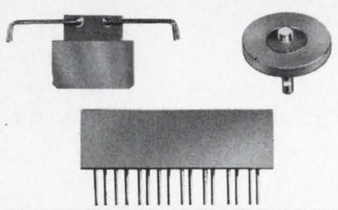

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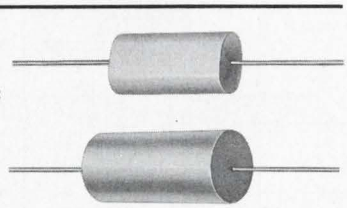
METALIZED MYLAR:
−55°C to 125°C
POLYCARBONATE:
METALIZED POLYCARBONATE
−55°C to 125°C



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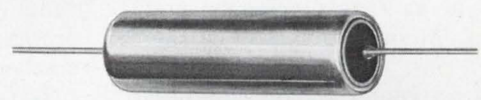

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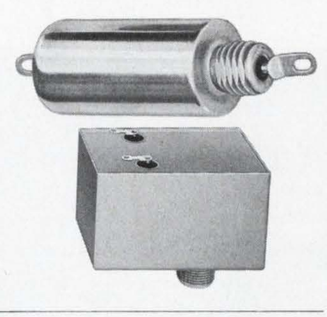


San Fernando Electric Manufacturing Company
1509 First Street, San Fernando, California
Tel. (213) 365-9411/TWX (213) 764-5963

INFORMATION RETRIEVAL NUMBER 20

Ceramic 'filter' generates color images

An unusual method of generating color images electronically may lead to a variety of new display devices.

Now under development at Sandia Laboratories, Albuquerque, N. M., the electro-optical system converts white light into colored light by applying electrical pulses to precise points on a thin plate of ferroelectric ceramic.

The voltages cause each of these tiny points or color cells to transmit a desired color of light, depending on the particular combination of pulses applied.

Essentially a solid-state color filter, the ceramic system—in its present state of development—appears to have two primary applications. According to Sandia, these are:

- As a rapidly changeable color display screen for computers and other electronic equipment.
- As a means of storing visual information; for example, as an erasable, reusable color slide.

While the color CRT displays now available for computer use are relatively bulky and complex, Sandia engineers say their new system requires little more than the x-y addressing equipment used in black-and-white conventional computer displays and graphical recorders. Each type of information is written on the display with a different voltage code, and different colors appear accordingly.

The new concept has been demonstrated by various laboratory models. But Sandia has not, as yet, built a complete display that incorporates the system.

The first prototype device now being fabricated includes 100 color cells in a pattern that measures 130 by 65 mils. The ceramic is two thousandths of an inch thick.

Two electrodes per color cell

Metallic electrodes are vapor deposited on each side of the lead zirconate-titanate ferroelectric ceramic plate to deliver the electrical pulses to each color cell—an area smaller than a pinhead, lying between two electrodes.

The ceramic with its pattern of electrodes is then sandwiched between two thin light polarizers. White light shining through the thin sandwich emerges as dots of light when pulses are applied to the various cells.

After the pulses have been applied, each color dot remains on the face of the unit until it is removed by a new sequence of pulses.

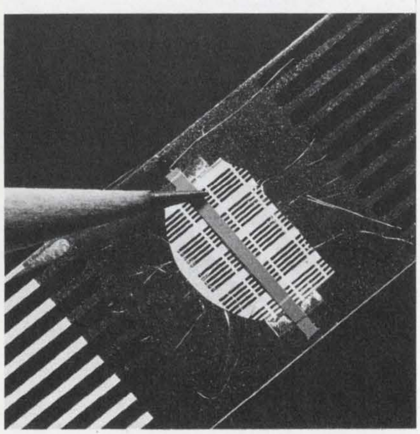
By applying extremely precise voltage pulses, the material is able to produce all first-order and second-order colors.

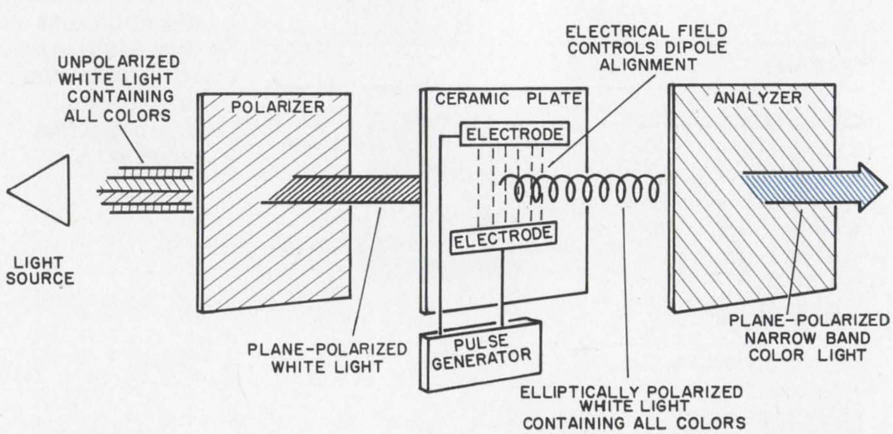
In a typical system, the electrical code might be: green equals +90 V; red equals +90 V −30 V; orange equals +90 V −30 V −30 V, and so on. Typical switching time is 100 millionths of a second per pulse; faster switching time is possible with higher voltages.

Color cells may be made in any desired size. As size increases, however, greater switching voltage—30 volts for each thousandth-of-an-inch-separation of electrodes—is required.

Although the new system can be used to produce color displays for more general use—for computers, aircraft instrument panels, etc.,—Sandia engineers agree that some problems remain to be solved. These problems, and their contemplated solutions, are:

- Weakness in producing a sharp blue. This might be corrected by using a blue-rich fluorescent tube.
- Inability to display black. This can be overcome by using a second ferroelectric ceramic plate to achieve a shutter effect.
- "Cross-talk" between color cells. This can be suppressed by chemically altering the ceramic; thus lower voltages per cell are obtained. ■■





Pencil points to tiny color cells in Sandia Laboratories' ceramic filter. Voltage is applied to the small electrodes via the metallic strip under the pencil tip and by gold wires extending from the larger electrodes. Illustration shows how polarized white light is converted into plane-polarized color light.

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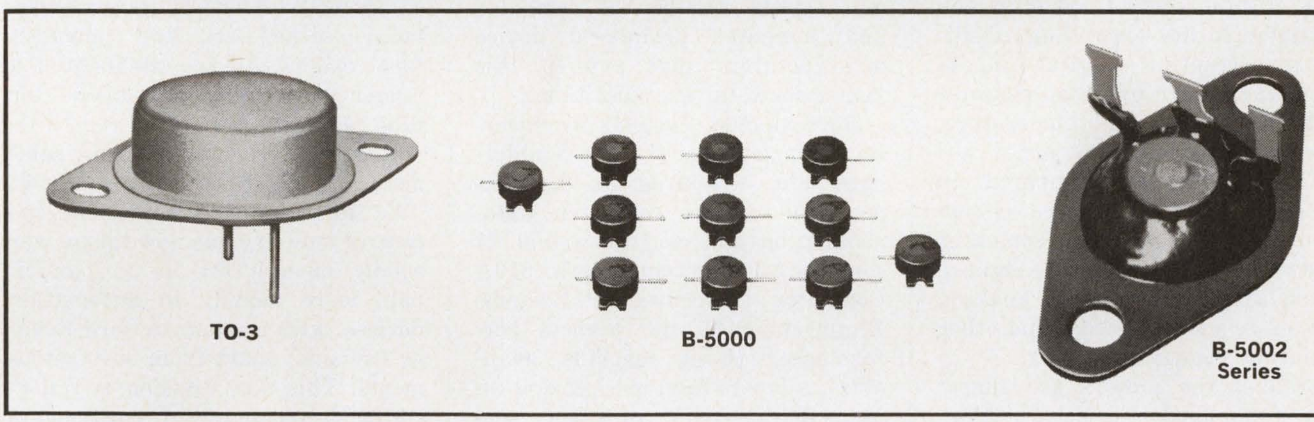

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INFORMATION RETRIEVAL NUMBER 21

Digital process control stars at exhibition

Versatile and more reliable systems are replacing old-line analog elements in industrial appications

Jim McDermott
East Coast Editor

Direct digital control systems, with their increased reliability and versatility, held the center stage at the 23rd annual Instrument Society of America Conference and Exhibition in New York.

More than 300 exhibitors, including some from Europe and Asia, joined in presenting a wide variety of measuring, analytical and controlling instruments. About half of the products displayed did not exist 10 years ago.

In digital control systems, the computer is the controlling intelligence, accepting digital inputs from analog sensors that measure such quantities as temperature, flow, velocity, humidity, etc.

These inputs are compared, in the computer, with desired system operating levels. The computer then sends out digital signals, which are reconverted to analogs, to operate valves, motors and other actuating elements.

Because the sensors are almost universally analog devices, analog-to-digital (and digital-to-analog) converters are usually incorporated in the control system. However, the trend now is to integrate these converters in the over-all sensor design. Among the examples displayed at the four-day instrument exhibition were a digital pressure indicator developed by Consolidated Controls Corp. of Bethel, Conn., and digital temperature readouts by Instrulab of Dayton, Ohio.

Peripheral devices abound

Recognition of the emergence of digital control was indicated by many papers presented at the conference on digital control systems and by the number of computer and computer peripheral device manufacturers that entered this year's show for the first time.

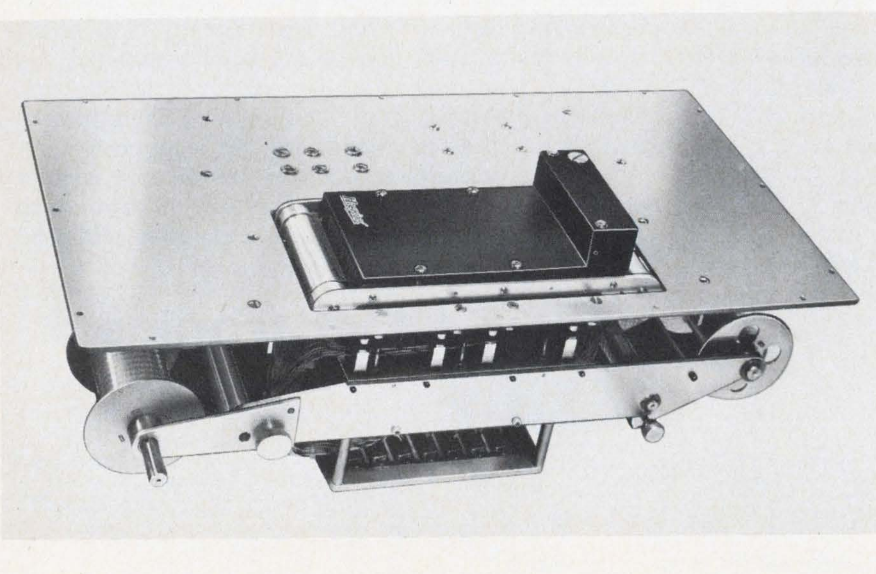
For example, Systems Engineering Laboratories of Fort Lauderdale, Fla., displayed its first expandable digital computer data-acquisition and control system. It consists of the company's 810A Computer (described by Systems Engineering as the highest performance, 16-bit machine available), a low-to-high-level analog input subsystem for converting sensor analog data to digital for the computer, and other peripheral equipment, including an operator control panel.

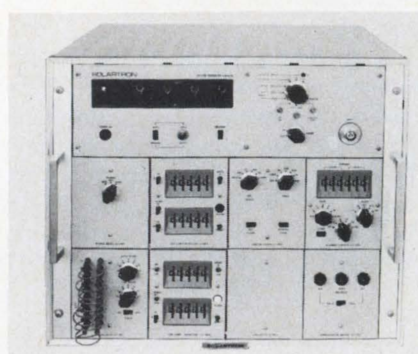
According to Kenneth G. Harpie, the company's vice president of operations, the rapidly expanding digital control market prompted it to enter the instrument society show for the first time.

Other digital-control computer exhibits included a Type 16 by Honeywell, Inc., Mass.; a Type 1800 by IBM, White Plains, N.Y.; a PDP-8/L by Digital Equipment Corp., Maynard, Mass.; and two low-level data-acquisition systems—one with a digital computer and one without—by Hewlett-Packard, Palo Alto, Calif.

For peripheral hardware, the Hickok Electrical Instrument Co., Cleveland, a new exhibitor, displayed several versions of its wire-contact, punched-card and punched-tape readers. All are offshoots of a reader originally developed for tube testing.

Robert Kerzman, Hickok sales manager, told ELECTRONIC DESIGN: "We feel that electronics in the control industry has now taken over solidly enough for us to participate more heavily in automation devices, with a separate Card Reader Division, apart from our instruments. This new division is tailored to development of components for controls in automatic warehousing, batch-mixing processes, data collection, and low-cost auto-





Left: Static tape reader by Hickok provides 540 contacts for each program step on the tape. **Above: Digital data logger** by Solartron has a capacity of 1000 channels. It responds to a signal of 2.5 microvolts.

mation, using the card as a memory."

Another entry in the contact card-reader field, exhibiting for the second year at the instrument show, was AMP, Inc. of Harrisburg, Pa. It displayed units that sense the standard 80-column card. For process and inventory control, or other applications where the data capacity of the full 80 columns is not needed, the company offered readers that sense only the first 22 columns of an 80-column card.

Displays stand out

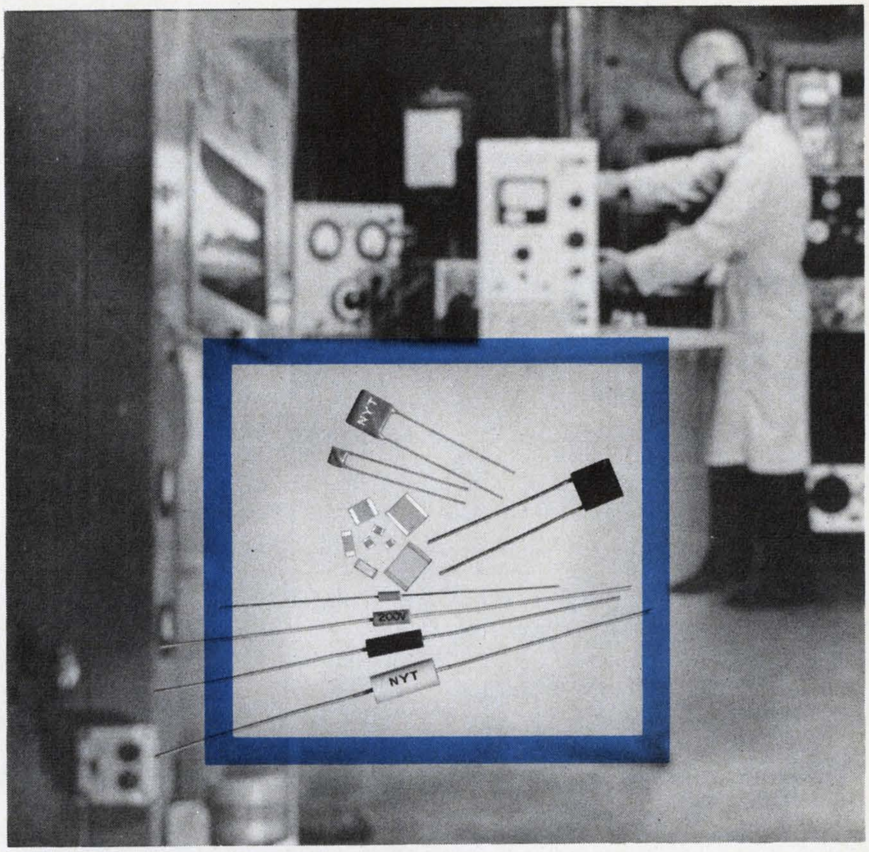
Emphasizing the digital trend, numerical displays blinked and glowed in a variety of forms and colors along the exhibit aisles. Some were incorporated in complete instruments, such as a digital data logger by Solartron of Farnborough, Hampshire, England. Other displays were readouts for sensors or for miniature panel meters. Several new panel voltmeters were shown, with both digital readouts and binary rear-panel outputs.

But interest in other lighted indicators and switches, data-line displays and elaborate display panels was also high. As Curtis Anderson, of Transistor Electronics Corp., Minneapolis, put it: "This show has been fantastic for us. We've exhibited here before, but never had a reception like this." The biggest demand from potential customers, he explained, was for smaller and more compact displays.

On the other hand, the increasing use of more complex process control systems is calling for new and larger colored displays.

Despite the glamour of computer-controlled systems, interest in the fundamentals of standard control instrumentation is still substantial.

Today's industrial control market shows strong growth, the exhibitors agreed. According to the Instrument Society of America, sales have doubled from an estimated $2.6 billion in 1958 to $5.2 billion this year. But the newest factor in the industry is the rapid growth of digital, computer data-acquisition and control systems, introduced only eight years ago. ■■



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INFORMATION RETRIEVAL NUMBER 22

ICs cut radar logic to one-tenth

Modular design, use of IC logic, and good packaging make custom-built radars easy

John F. Mason
Military/Aerospace Editor

Now in operation, on top of a 9200-foot-high mountain near Ely, Nev., is an example of how integrated circuits and good packaging can revolutionize the precise range radars that track high-flying, fast-moving objects in the atmosphere and in space.

Called Hair, for High Accuracy Instrumentation Radar, the system's electronic logic portion is approximately 10 times smaller and lighter than that in its transistorized predecessor, the AN/FPQ-6, and in the Q-6's transportable version, the TPQ-18. The electronic logic and displays make the new radar about one-fifth the size and weight of these forerunners. And, by changing a few modules, the new radar can be assembled in enough configurations to give the user a product that, for all practical purposes, is custom designed.

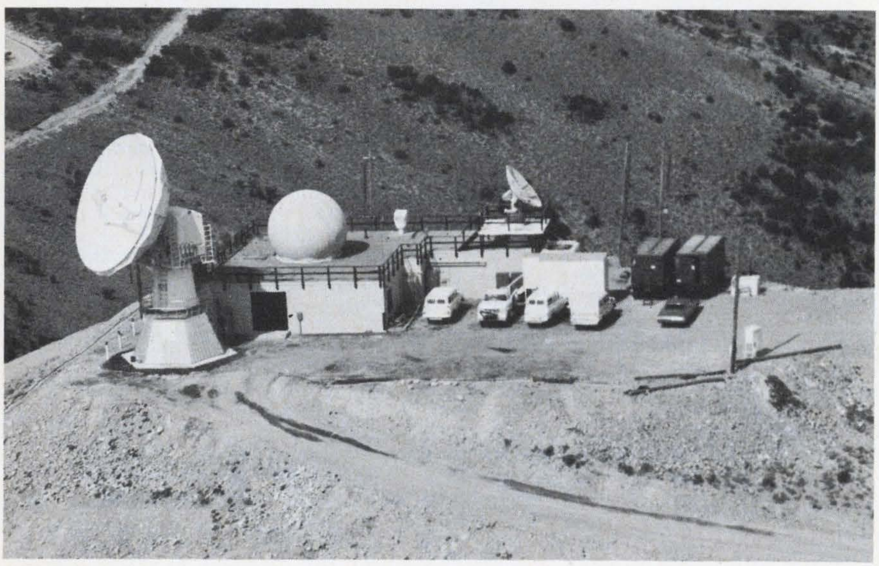
Built by the Radio Corp. of America's Missile and Surface Radar Div., at Moorestown, N. J., the radar was bought by the National Aeronautics and Space Administration to monitor tests at its Flight Research Range. The range extends from Ely to the Edwards Air Force Base range in California. In this area, NASA has tested the X-15 supersonic aircraft, the XB-70 and lifting bodies.

NASA's system is equipped with a 1-megawatt transmitter and the same 29-foot parabolic antenna and pedestal that are used on the FPQ-6. For other customers, the 3-MW transmitter used on the Q-6 is available, as are two other antennas with diameters of 12 feet and 16 feet.

The electronic portion, which RCA calls Capri—for Compact, All-Purpose Range Instrument—consists of a console that is 96 inches long and 72 inches high and weighs 4900 pounds; a transmitter/modulator that fits into a cabinet 80 inches high and 64 inches long, weighing 2800 pounds. A load center, which houses the power distribution equipment, is 70 inches high and 22 inches wide; it weighs 750 pounds.

Hair's computer is the Sigma 5, bought by NASA from Scientific Data Systems, Incorporated, El Segundo, California.

One example of Capri's compactness is the four-in-one duties of the console; besides providing the operator a working station, the console houses the system's range-tracking system, the radar receiver and the data-handling system. The TPQ-18 uses four shelters for these four functions.



Radar on mountain top near Ely, Nev., will track planes and spacecraft for NASA. ICs bring size down to a fraction of its predecessor.

Standard logic cuts cost

To simplify the construction and maintenance of Hair, basic building-block logic circuits were designed and used throughout the system. Wiring between logic elements is done by machine rather than by hand and is programed by a computer. Corrections were made by hand. The result, an RCA spokesman says, is higher reliability and cheaper production costs.

The C-band pulsed Hair is capable of tracking a six-inch sphere at a range of 100 nautical miles and of tracking a vehicle with a cooperative beacon transponder at 32,000 miles. The frequency range is from 5450 to 5825 MHz; pulse repetition frequency is 160 or 640 pulses per second; bandwidth is 1 to 6 Hz; and the receiver noise figure is 12 dB.

Building the radar to operate at 9200 feet above sea level caused several special problems in design.

The thin air at this altitude caused arcing and corona problems in the transmitter. "We had to move terminals farther apart when space permitted," an RCA engineer said. "We changed insulation and we changed the characteristics of the terminals from pointed to rounded configurations. When there was no room to separate components that were arcing we would, for example, in the case of a capacitor that was acting up, turn its terminals away from the terminal its was arcing to.

"We also had to replace the metal clamps on standard hollow wire-wound resistors with fiber glass clamps." ■■

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CIRCLE INFORMATION RETRIEVAL NUMBER 23 ►

TV camera offers resolution of 2200 lines

Use of a special vidicon tube has enabled engineers at General Electric's Space Systems Organization in Valley Forge, Pa., to develop a television camera for space work with a picture resolution of 2200 TV lines per inch. Other available TV space cameras provide a resolution of only 800 lines.

With improvements, GE engineers say, their camera should provide 10,000 lines.

The small, lightweight, real-time imaging system was developed for planetary exploration and earth-resources photography missions. The camera is being used at present in spacecraft training simulators, such as the one for the Apollo Lunar Module (LM). Present studies on the LM visual system indicate a need for 3500 TV lines at TV frame rates, so that potential hazards, such as small craters and rills on the lunar surface, can be portrayed to astronauts approaching for a landing.

GE's high resolution was obtained by using a Focus, Projection, Scan Vidicon in the camera and a high-resolution display tube in the monitor. The vidicon uses crossed electrostatic and electromagnetic fields.

The electrostatic fields are for beam forming and deflection, and a small magnet is used for focusing. Because large power-consuming electromagnetic beam-forming coils are not required, the vidicon is small and uses a minimum of power—29 watts for the camera and 40 for the display.

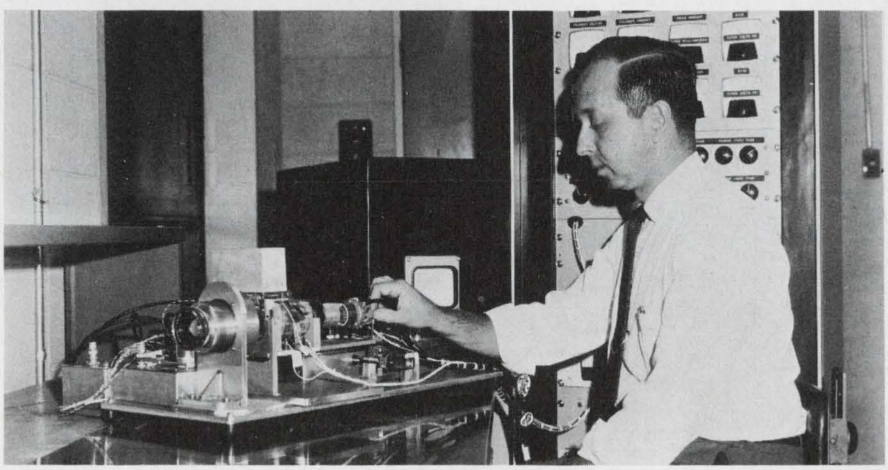
The camera's 30-Hz frame rate provides a flicker-free picture. This is a major improvement, GE engineers say, over slower frame-rate systems, which give astronauts in a simulator an unrealistic picture.

Because of the sensitivity and wide bandwidth of the preamps and amplifiers—features that were critical to the achievement of a new level of picture resolution—modular techniques were used to reduce electromagnetic interference.

Experiments were carried out on various amplifier designs before the prototype components were selected. A flat 60-MHz video bandwidth with a channel gain of 89 decibels was obtained. This gave a flicker-free 30 frames per second and the 2200 TV lines per inch.

The need for higher resolution at the same or higher frame rates will impose requirements for 100- and 300-MHz bandwidth amplifiers. These are under study at GE's laboratories in Valley Forge.

Other applications foreseen by the company for the new vidicon TV imaging system include closed-circuit TV for manned spacecraft operations; controls for remote manipulators; visual subsystems for aircraft training simulators; high-resolution neutron radiography; remote fabrication operations, such as controlling electron beam welding in large vacuum enclosures, and meteorology. ■■



GE's TV camera system, designed with a Focus, Projection, Scan Vidicon, has a resolution of 2200 TV lines per inch. The goal is 10,000 lines.

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U12	12	5.0	15.3 to 10.0	3.0	65.00
US24	24	1.5	26.2 to 20.2	2.5	35.00
U24	24	3.5 5.0	26.6 to 21.0 26.6 to 20.0	3.0 3.2	65.00
US28	28	1.0	30.6 to 25.5	2.0	35.00
U28	28	3.0 5.0	31.9 to 26.0 31.9 to 23.6	2.7 3.4	65.00

For your copy of the Acopian catalog listing all 62,000 models, write Acopian Corp., Easton, Pa. 18042 or call (215) 258-5441.

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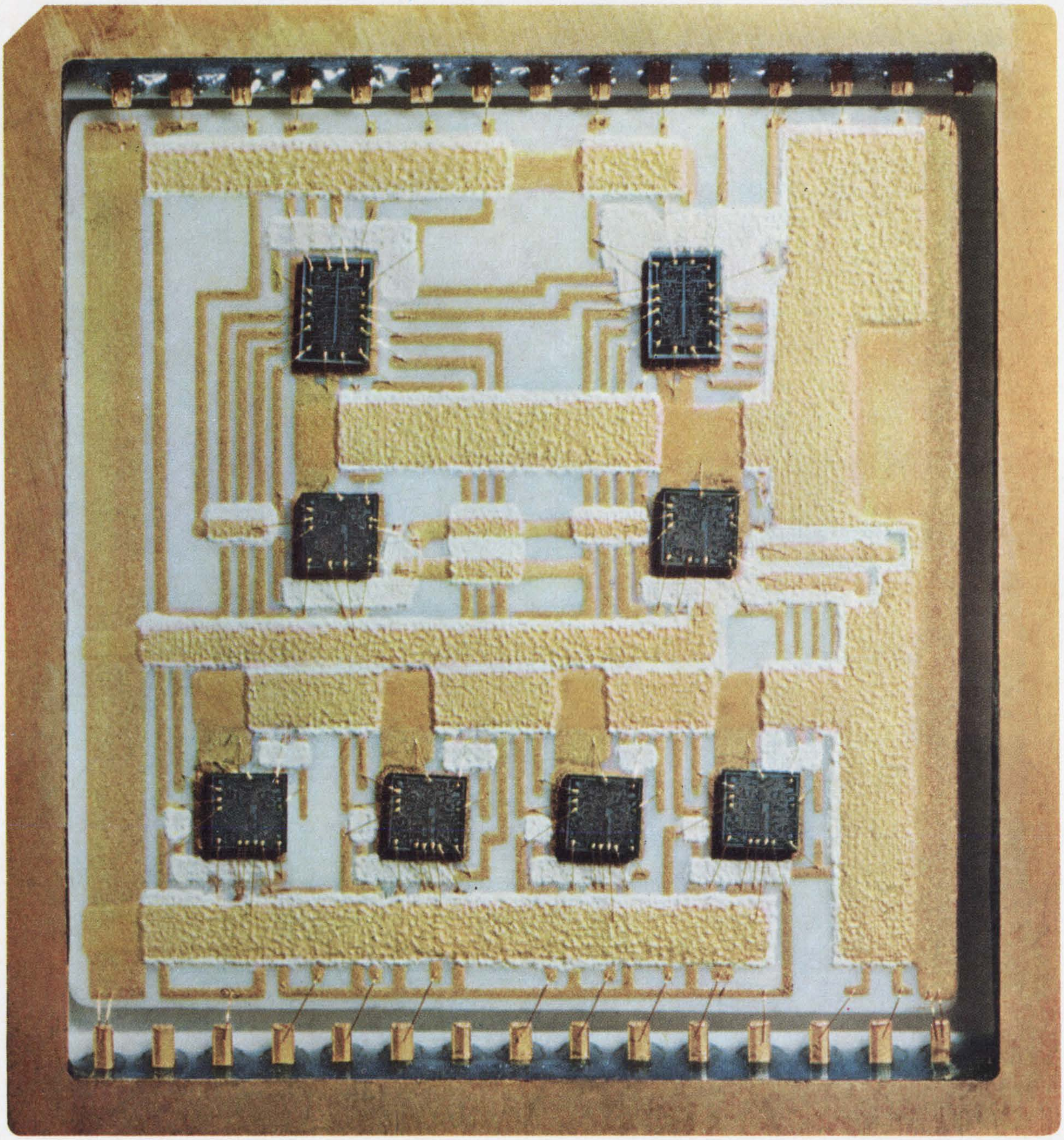
INFORMATION RETRIEVAL NUMBER 24

Fairchild can make more hybrids in



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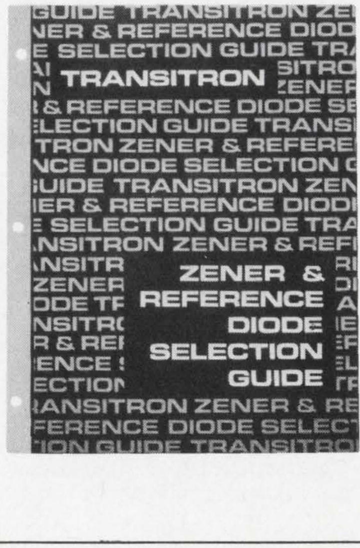

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μ-PAC logic module prices have been reduced. Again. It brings us close to our objective: to provide the most comprehensive and economical digital logic offering in the industry. First, take a look at some typical prices:

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DI-320	10, two input NAND gates	$25.00	$20.00	$2.00/gate
DN-320	6, three input NAND gates	21.00	16.00	2.66/gate
DF-320	8, three input NAND gates	New	20.00	2.50/gate
FF/320	8 basic flip-flops	New	31.00	3.87/flip-flop
FA/320	4 clocked flip-flops	31.75	25.00	6.25/flip-flop
BC-320	6 stage binary counter	46.50	38.00	6.33/stage
SR-321	8 stage shift register	New	54.00	6.75/stage
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COMPUTER CONTROL
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Army seeks hand-held radars

Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

Race continues for small Army radar

General Dynamics and RCA are continuing efforts to extend their marketing positions with the military for hand-held radar sets. Both exhibited 10-pound systems at the annual meeting in Washington of the Association of the U.S. Army. Top Army brass attended the meeting.

Neither radar set is newly developed, but both recently began field trials in Vietnam. The RCA AN/PPS-9 was developed by the company's Missile and Surface Radar Div. in 1966. Twenty of these sets have been purchased for testing by the Army Electronics Command at Ft. Monmouth, N. J., and over 100 have been purchased by all three military branches. The General Dynamics AN/PPS-10 was developed in the last three years with the help of funds from the Defense Dept.'s Advanced Research Projects Agency. Six sets have been delivered to the Army for testing of a total of 10 on order.

Both the RCA and General Dynamics sets are believed to operate at X-band (about 10 GHz). Both employ a flat-plate antenna array at the front of the sets. Remote control is possible by rf or hard-wire link.

The operating ranges are believed to be comparable. RCA claims over 1600 meters for personnel detection and as far as 10,000 meters against large vehicles. General Dynamics asserts that range limits are classified, but its PPS-10 range indicator shows a maximum of 3000 meters, and its personnel detection limit is believed equal to the RCA system.
The RCA radar set itself is smaller, weighing only 2-1/4 pounds, exclusive of the other accessories. General Dynamics achieved significant weight reduction by using thin rolled stainless steel legs in its tripod.

Test evaluations from Vietnam most probably will result in selection by the Army of a single supplier next year for what could amount to a total order of over 1000 radar sets.

The missile numbers game again

Just prior to the recent election and in answer to a "security gap" charge by Richard M. Nixon, Defense Secretary Clark M. Clifford held a press conference in which he asserted the "substantial military superiority" of the U.S. over the Soviet Union. To support his statement, he disclosed intelligence figures on the relative missile strength of the two nations. But the figures, on careful analysis, reveal a significant increase in Soviet strategic arms in the last year.

Just a year ago, former Defense Secretary Robert S. McNamara also presented comparative U.S.-Soviet strength figures. Thus, in comparing the McNamara numbers with the Clifford statistics, one can see that the Soviet military has increased its ICBM strength from 720 to 900, its submarine ballistic missiles from 30 to 80, and its total deliverable nuclear warhead capability from 1000 to 1200. It would appear that the weapons delivery capability ratio between the U. S. and Soviet Union has narrowed from 4:1 to 3.5:1. It is understood that these figures relate to the total warhead package atop a missile and do not take into account multiple warheads carried in a single vehicle. Nor do they relate to total nuclear megatonnage. It may be assumed that the U. S. enjoys some lead in the development of multiple independently targeted reentry vehicles but that the Soviet Union, with its larger lift capability, stockpiles larger warheads. When the new Administration assumes office it is expected to make an in-depth study of the nation's missile capabilities.

New Navy missile system on the way

The Navy has announced the award of three $6-million contracts to Boeing, General Dynamics and RCA for the contract-definition phase of the Advanced Surface Missile System. The heart of the system is electronic. It is intended to replace the existing Terrier-Tartar missiles now being used for air defense by surface ships.

The target acquisition and tracking radar is expected to be a phased-array that will provide nearly hemispheric simultaneous coverage. It is also believed that separate radar target illuminators will be employed for missile guidance and control. The missile itself, designed for use against supersonic missiles and aircraft, will home in on the illuminated target.

The program has suffered four years of delay due largely to budget problems and technology limitations associated with the phased-array radar. The present contracts should produce competitive system designs by late spring. Following their review a single contractor will be selected for the engineering development phase. The operational missile is scheduled to be ready for the new class of advanced guided missile destroyers known as the DX/DXGs, expected to be completed by 1974-75.

Electronics strengthens new Army tank

Two highly advanced electronic subsystems to be used in the Army's new Main Battle Tank (MBT-70) were shown for the first time publicly at the annual meeting of the Association of the U. S. Army. They are a fully automatic laser rangefinder and an automatic gun-stabilization system. The tank is under joint development by the United States and West Germany. It will be capable of firing both missiles and conventional munitions.

RCA has built and delivered 11 prototypes of the new laser rangefinder, which now will begin field testing. Its design concept is simple, making use of the transit time of a high intensity pulse to and from a target for accurate range determination. The calculation and input to the fire-control system is automatic and to date—after 1000 range test samples—over 95 per cent of range measurements have fallen within specified error limits, Army officials report.

The gun stabilizer, built by General Electric, is called an Optimum Ratio Stabilized Drive. The all-solid-state system is intended to compensate the gun carriage for violent motion while the tank is moving at high speed over rough terrain. Stabilization is achieved through the use of individual gyroscopes that sense any change in the yaw, pitch and roll axes. These provide an output designating the necessary direction and velocity change to power-control units. The latter apply the proper torque to neutralize the motion effects on the gun. The circuitry, according to GE engineers, permits continuous microsecond response in the stabilizing system.

Global Omega system approved

The Defense Dept. has given the Navy approval to increase its present four-station Omega navigational system network to eight stations, thus providing nearly complete global coverage. The existing four transmitter stations have been in use experimentally, to prove the value of long-range, very-low-frequency, hyperbolic-grid navigation. The complete system may be operational by the end of 1972.

The four new stations will be in the Western Pacific, Tasmanian Sea, Indian Ocean and lower South America. The Navy has indicated it will seek foreign participation in the completion of the Omega system, since the system inevitably will be used by the ships and aircraft of all nations.

Foxboro engineers select A-B hot molded potentiometers

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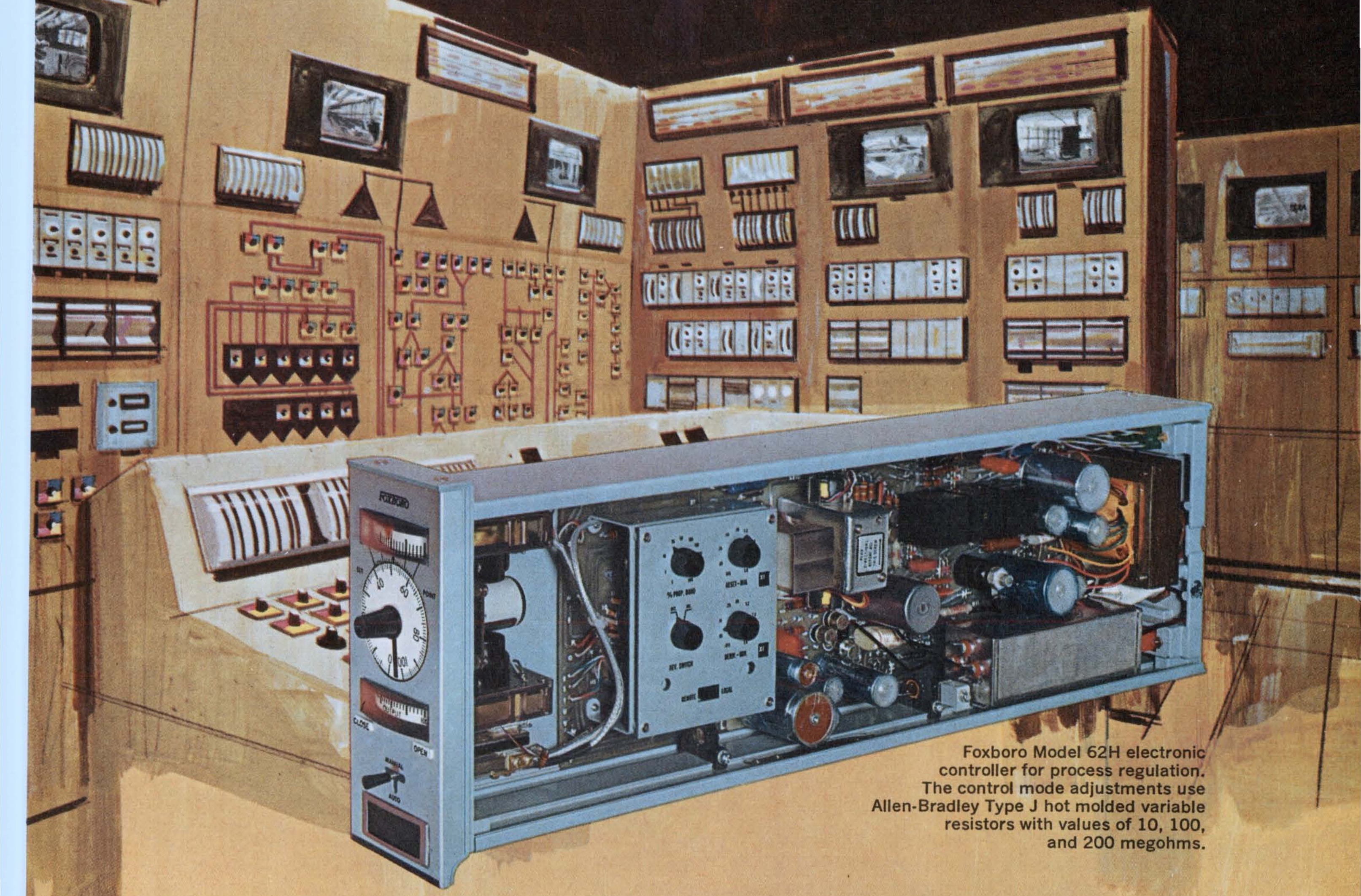
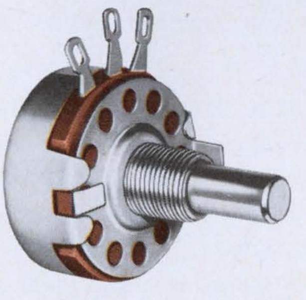


Foxboro Model 62H electronic controller for process regulation. The control mode adjustments use Allen-Bradley Type J hot molded variable resistors with values of 10, 100, and 200 megohms.



A-B Type J hot molded variable resistor rated 2.25 watts @ 70°C. Available in single, dual, and triple units. Standard total resistance values from 50 ohms to 5 megohms. Special resistance values and tapers can be supplied.

Widely used throughout the process industries, the Foxboro Model 62H Universal Controller is a highly dependable precision instrument. During the years of painstaking development, Allen-Bradley engineers worked closely with Foxboro to provide a potentiometer having unusually high resistance values, which would provide the precise performance required.

Allen-Bradley Type J potentiometers were the answer. They have a solid hot molded resistance track which is produced by an exclusive A-B molding technique that assures extremely long operating life. Accelerated tests—exceeding 100,000 revolutions—show very slight resistance change. Control is smooth at all times with adjustment approaching infinite resolution. There are none of the abrupt turn-to-turn resistance variations inherent in wirewound controls. Furthermore, Allen-Bradley Type J potentiometers are—for all practical purposes—noninductive, permitting their use throughout the frequency spectrum.

Whether your particular circuit design can be best satisfied with one of the millions of standard Type J variations or whether it calls for unusual resistance characteristics, it will pay you to look first to A-B Type J potentiometers. Their more than 25-year history of providing superior performance is your guarantee of complete satisfaction. For full details, please write for Technical Bulletin 5200: Allen-Bradley Co., 1344 South Second Street, Milwaukee, Wisconsin 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Avenue, New York, N. Y., U.S.A. 10017.

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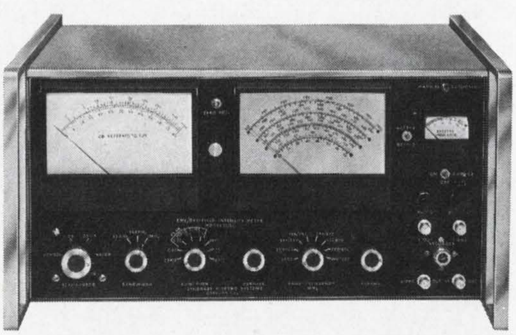

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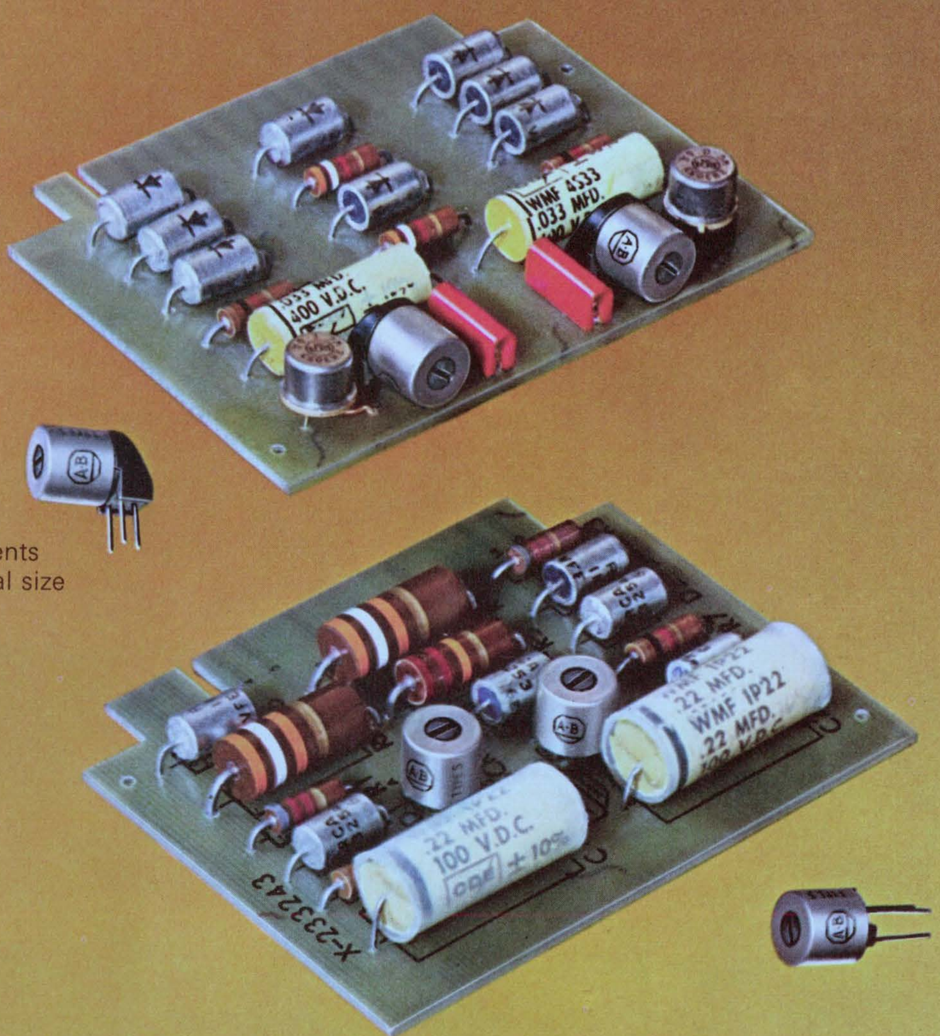

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Type S
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75-08-7E

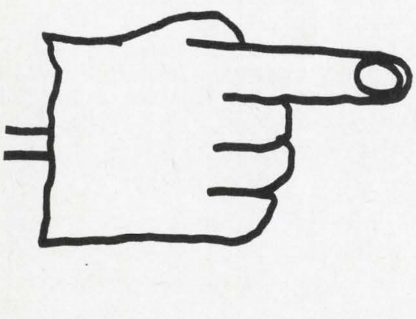
Computers to beget computers . . ?

Just where is LSI taking computer design? Without question, the incorporation of LSI into computers will demand that extensive changes be made in both electrical design and in physical construction. And these changes must be carefully planned. But LSI vendors feel that many computer men may be missing out, right now, by not going the large-scale way. Semiconductor manufacturers say they are ready to roll with extensive computer-aided design equipment—they say computers are ready to design computers. What LSI can really do is detailed in four articles edited by Microelectronics Editor Raymond D. Speer, which begin on page C4.

Getting checked out on one of General Electric's time-sharing computer centers: Managing Editor Robert Haavind (left) and Microelectronics Editor Raymond D. Speer.

The views of computer designers and LSI developers don't exactly match. Computer designers remain skeptical. The lack of agreement is spelled out in a news story by Managing Editor Robert Haavind on page C50 in which he reports what computer manufacturers around the country are actually saying about LSI. Military designers are trying some new computer organizational concepts to see if they can take fuller advantage of LSI, but commercial system designers are taking a longer, slower look. Should they design in self-checking, or even in self-correcting circuitry? If they do, how much and what will it mean in terms of circuit densities and thus cooling requirements? There are a lot of questions and few clear answers.

The day of MAC is here!



Pages C42, C43 and C77

INFORMATION RETRIEVAL NUMBER 32

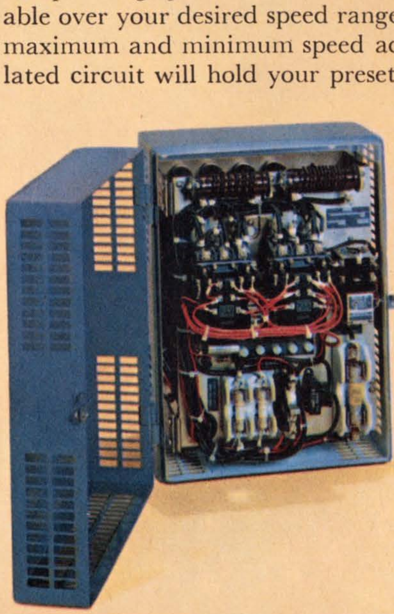
Allen-Bradley Bulletin 1313

new SCR TYPE regulated speed drive 1-5 H.P.

This newest Allen-Bradley regulated speed drive combines a NEMA re-rated integral horsepower motor, an easy-to-wire operator's control station, and a rugged controller matched to provide superior performance. Built to NEMA industrial standards, all three provide traditional high quality for trouble-free service. The SCRs for full wave conversion of the single phase supply are conservatively rated and amply protected. And there's a horsepower rated contactor.

Operating speed of the Bulletin 1313 is infinitely adjustable over your desired speed range, which is set by built-in maximum and minimum speed adjustments. And its regulated circuit will hold your preset speed within 2% of the motor base speed for load variations up to full rated load. The controller also features both timed acceleration, adjustable from 2.5 to 10 seconds, and current limiting, adjustable from 80% to 150% of motor full load current.

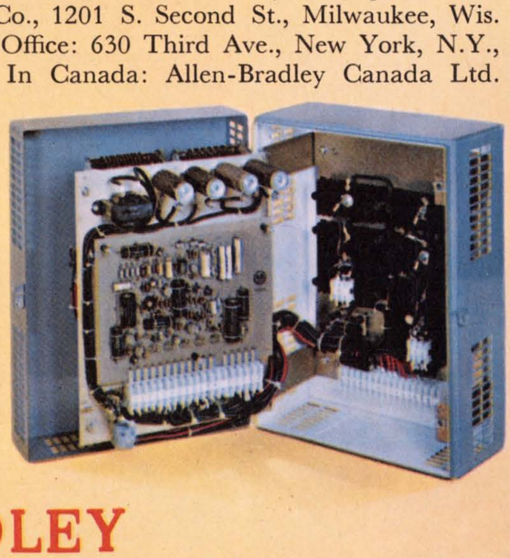
These new A-B packaged drives offer wide versatility with the many options available. There's dynamic braking, reversing with anti-plugging protection, jog at set or independently set speed, and speed indication, to mention a few. Please write to Henry G. Rosenkranz for complete details, or better still, let us know your requirements: Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017. In Canada: Allen-Bradley Canada Ltd.



Designed for ease of installation, inspection and maintenance

Vented NEMA Type 1 enclosure has knockouts at bottom. Deep cover opens for easy accessibility. White interior affords clear visibility. Controller can be removed from enclosure as a unit during wire pulling.

Hinged front panel swings out of the way for controller wiring and inspection. External wiring connects to fixed terminal blocks on the base of the controller.



ALLEN-BRADLEY
QUALITY MOTOR CONTROL

MC 6811

new 4 WAY INDUSTRIAL CERMETS

MODEL 3059

...with BOURNS Reliability Sealed in!

Actual Size

"4-way" means our new industrial Model 3059 is available in two printed circuit pin configurations of MIL-R-22097 (RJ-11 and RJ-12), as well as solder lugs and stranded insulated leads.

It was designed that way because as the newest member of the growing line of Bourns cermet potentiometers, it must — like every Bourns product — offer more by design and deliver more by performance.

The Model 3059 has a maximum temperature coefficient of 150 ppm/°C for all resistances; a power rating of 1.0 watt at 70°C, and an operating temperature range of −55 to +150°C. In addition, each unit is individually inspected for performance to guaranteed electrical and physical charcteristics.

Complete technical data on the new industrial cermet Model 3059 potentiometer is available from the factory or your local Bourns field representative.

SPECIFICATION TABLE

Standard Resistance Range	10 ohms to 1 megohm
Resistance Tolerance	±10%
Power Rating	1.0 watt
Operating Temperature Range	−55 to +150°C
Temperature Coefficient	±150 ppm/°C maximum.*
Seal	Mil-Spec immersion
Terminals	RJ-11 and RJ-12 Printed Circuit Pins, also Solder Lugs and Stranded Insulated Wires.

*100 ppm/°C available

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EDITORIAL

Users to phone companies: 'Thanks. Now about that 3-minute charge . . ?'

The future of the time-shared computer is becoming brighter and brighter. Consider the matter of using phone lines to link computers and customers. For years the designers of equipment have had to incorporate the phone company's exclusive Dataphone in their computer-network designs; no other interface between computer and common-carrier lines was permitted.

In its ruling in the Carterfone case last July, the Federal Communications Commission held that a privately installed connecting device could be used without telephone company approval. As a result of the ruling, data customers will soon be able to connect their terminals to the telephone network through inexpensive protective connectors. Because the connectors are now simpler, they rent for much less—about $2 a month. Because they're electrical, rather than acoustical, terminal design is simpler, too.

This is all to the good, so far as the computer designer is concerned. Wouldn't it be great if comparable reforms were instituted on behalf of users?

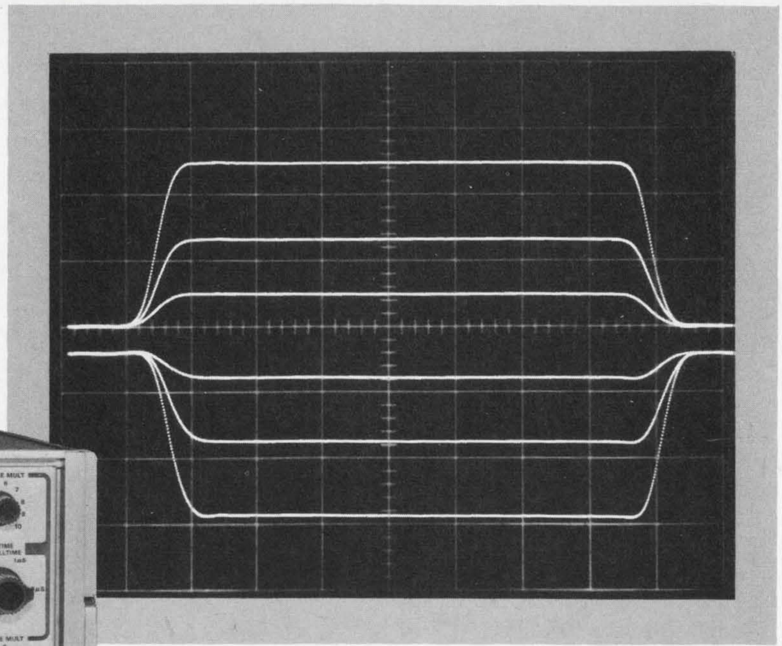
Consider the question of telephone tariffs. The price of every phone call is based on the assumption that the caller will be on the line for three minutes. But a computer that takes that long to deliver its information would be a very slow computer indeed. Why not tariffs for computer users based on the actual time that the phone line is used? The savings would be substantial.

And it's just such savings as these that are needed to make the time-shared computer a household tool. The growth of the American economy will depend in the near future on cheaper data communications. Managers of large and small companies will find the computer a vital aid in making decisions. Storekeepers—even housewives, in time—will come to rely on computer networks.

The Fall Joint Computer Conference in San Francisco is devoting a session (No. 7) to a full airing of the tariff and other computer-link problems. Should you be making your voice heard here?

A. Craig Reynolds, Jr.

Pulse Performance



Multiple exposure showing typical waveform aberrations for positive and negative polarities at various amplitude settings. Notice the constant risetime and falltime with amplitude changes. 20 ns/cm sweep time and 4 V/cm deflection factor.

- **REPETITION RATE 100 Hz to 10 MHz.**
- **VARIABLE RISE AND FALL TIME, 10 ns to 100 μs.**
- **±10 V into 50 Ω, with DC OFFSET.**

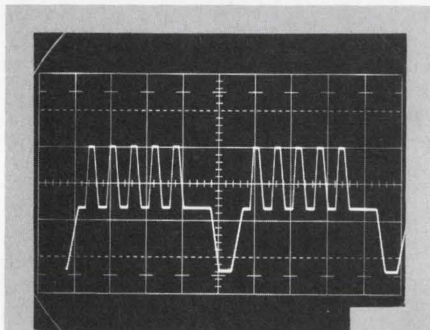
NEW TEKTRONIX TYPE 115 PULSE GENERATOR

This multi-purpose, solid-state generator produces exceptionally clean pulses with aberrations less than 3% P-P at ±10 V into 50 Ω. Pulse risetime, falltime, width, delay, period, amplitude and baseline offset are separately variable, permitting precise waveform simulation. Five operating modes offer a variety of output configurations — undelayed pulses, delayed pulses, paired pulses, burst of pulses and gated pulses. Risetimes and falltimes are continuously variable from 10 ns to 100 μs and periods variable from 100 ns to 10 ms. Pulse widths are variable from 50 ns to 500 μs with duty factors to 75% (50 ns minimum pulse separation). A continuously variable DC offset feature permits positioning pulse baseline through a range of +5 volts to −5 volts. Triggering is selectable, internally or externally. A manual pushbutton provides a means to produce a single undelayed pulse, delayed pulse, pulse pair, or burst of pulses.

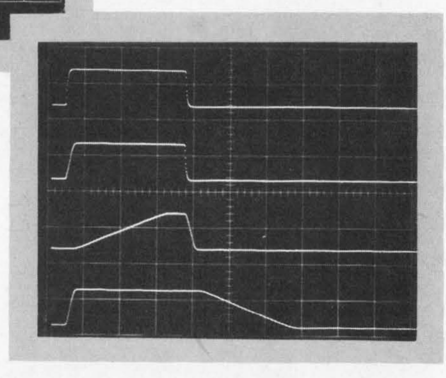
Your Tektronix Field Engineer will demonstrate the performance of the Type 115 in your application. Please call him, or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

TYPE 115 PULSE GENERATOR $825

U.S. Sales Price FOB Beaverton, Oregon



Single exposure showing combined outputs of two Type 115's. The burst of pulses on top of the positive pedestal was triggered by the + delayed trigger from the instrument generating the pedestal. 10 μs/cm sweep time and 2 V/cm deflection factor.



Multiple exposure showing variable risetime and falltime. 500 ns/cm sweep time and 10 V/cm deflection factor.

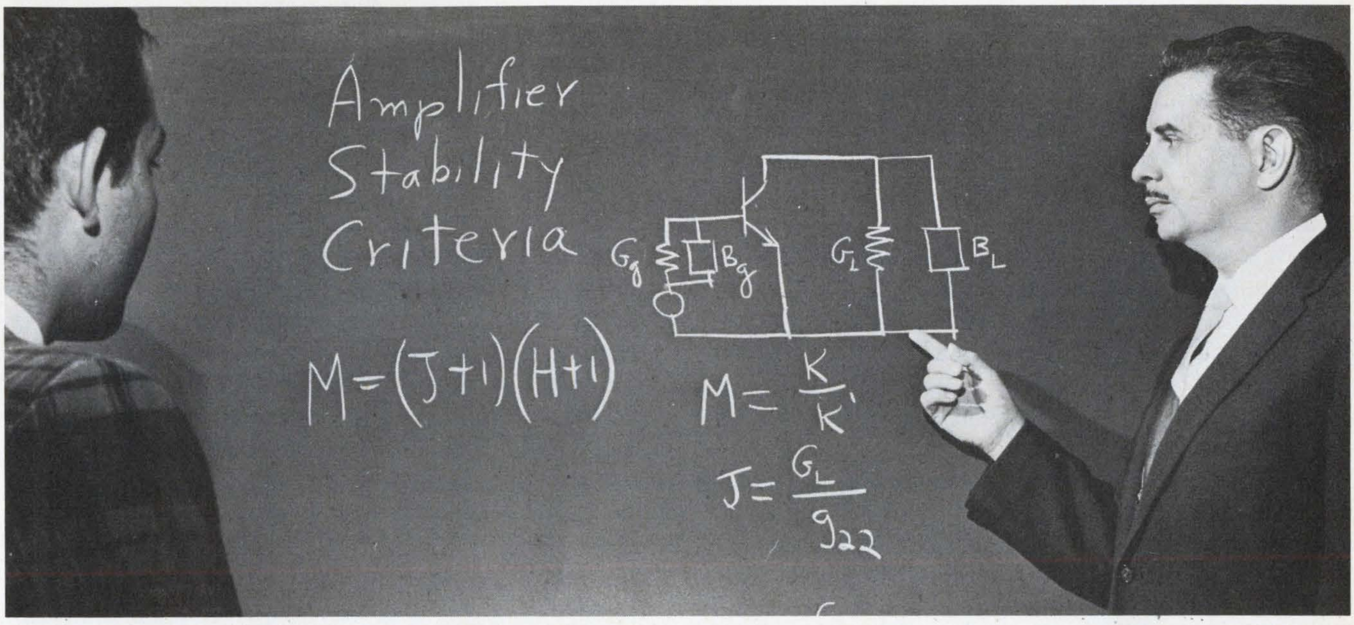
A detailed description of the Type 115 Pulse Generator is found in the August supplement to your Tektronix Catalog 27.

Tektronix, Inc.

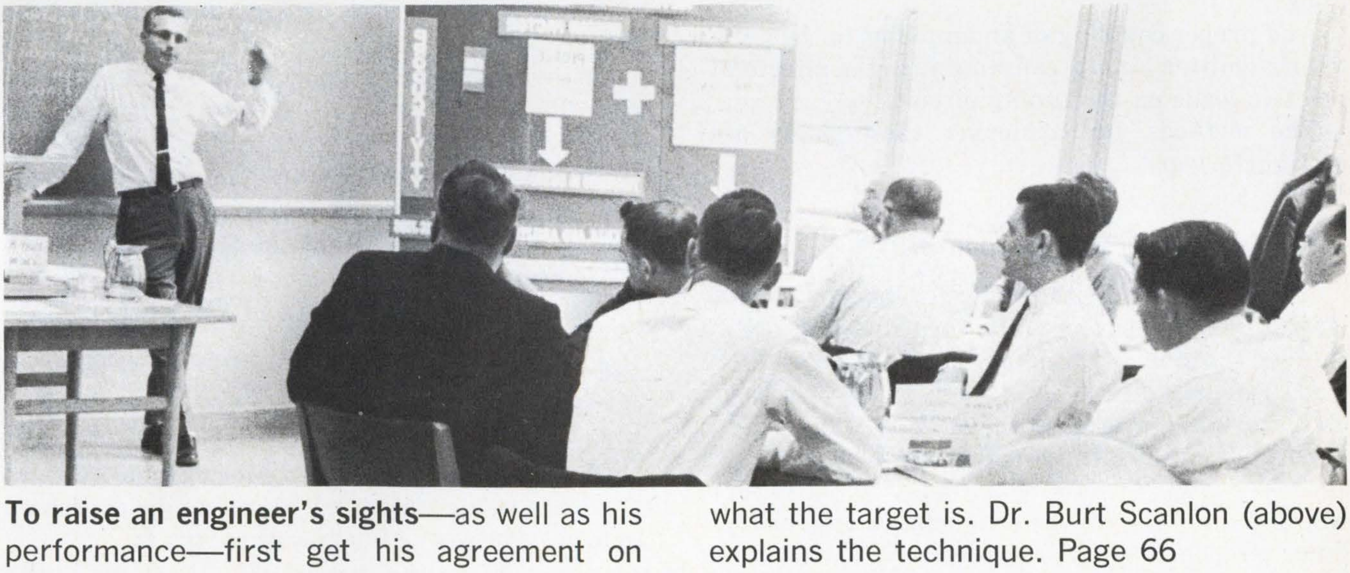
committed to progress in waveform measurement

INFORMATION RETRIEVAL NUMBER 35

Technology



You, too, can learn how to design oscillators with maximum drive capability and minimum frequency shift under reactive loading. Class begins on Page 50.



To raise an engineer's sights—as well as his performance—first get his agreement on what the target is. Dr. Burt Scanlon (above) explains the technique. Page 66

Also in this section:

Build digital comparators with off-the-shelf ICs. Page 56

FJCC special section including a report on LSI for computers. Page C1

Lower an oscillator's frequency drift

and maximize its driving capability with these new design procedures and a fresh look at amplifier stability

To produce an oscillator that can maintain power output over wide load variations, and that is as insensitive as possible to power supply changes, can offer a designer a real challenge.

Yet, by following a few principles for good design, he can come up with an oscillator that should be able to:

- Be loaded with the greatest possible shunt conductance before oscillations cease.
- Tolerate variations in supply voltage and transistor parameters with minimum frequency shifting.
- Exhibit the smallest possible frequency variation due to reactive loading.

The key to obtaining maximum power is to maximize the negative output conductance of the oscillator at the desired frequency of oscillation.

Freedom from changes in frequency due to fluctuations in transistor parameters is achieved by swamping the fluctuations out with more stable passive components. In a similar manner, voltage-sensitive parameters can be masked, eliminating much of the trouble caused by power-supply variations.

And proper coupling of an amplifier to the oscillator's emitter circuit can minimize the effects of reactive loads on the tuning circuit.

The methods for achieving these goals are straightforward.

Define an oscillator configuration

An active device with proper feedback will oscillate at the frequency at which the net admittance at the load terminals (including the admittance of the load) is equal to zero[1]. A block diagram of a basic oscillator configuration is shown in Fig. 1a.

The net output terminal admittance is

$$Y_T = G_T + jB_T, \quad (1)$$

where G_T and B_T are the conductance and susceptance components of Y_T, respectively. The load admittance, Y_L, and the oscillator output admittance, Y_o, are given by:

$$Y_L = G_L + jB_L \text{ and } Y_o = G_o + jB_o. \quad (2)$$

For Y_T to be equal to zero for any load, we must have

$$Y_L + Y_o = 0,$$

or

$$G_L = -G_o \text{ and } B_L = -B_o. \quad (3)$$

If the active device is a transistor, and a transformer is used as the basic feedback network, the circuit of Fig. 1b can be used to analyze the terminal conditions. In this figure the transformer is replaced with its standard model—a series resistance and reactance—both in series with the primary winding of a "lossless" (or ideal) transformer. The transistor is represented by a standard current-source model. In the subsequent discussion all symbols will be those defined in the figures.

The output admittance can now be written as

$$Y_o = G_o + jB_o = h_{22} - Y_n \quad (4)$$

and

$$Y_n = (h_{12} - N)\,(h_{21} + N)/(Z_F + h_{11}) = G_n + jB_n. \quad (5)$$

Since $Y_L + Y_o = 0$ at the frequency of oscillation, from Eqs. 4 and 5 it is clear that we can write

$$Y_L + h_{22} = Y_n = -N\,(h_{21} + N)/(Z_F + h_{11}), \quad (6)$$

where h_{12} has been neglected since it is small compared to N. (This is a reasonable approximation up to frequencies approaching the alpha cutoff of the transistor.)

To investigate the properties of Y_n, let:

$R_F + \text{Re}\,(h_{11}) = R$, $[X_F + \text{Im}\,(h_{11})]/R = \text{A}$, and $-h_{21} = r_2 + jX_2$.

Here (and hereafter) Re and Im stand for "real part of" and "imaginary part of," respectively.

The components of Y_n at the frequency of oscillation are:

$$G_n = G_L + \text{Re}\,(h_{22}) = N[AX_2 - (N - r_2)]/R\,(1 + A^2) \quad (7)$$

and

$$B_n = B_L + \text{Im}\,(h_{22}) = N[X_2 + A\,(N - r_2)]/R\,(1 + A^2). \quad (8)$$

If the oscillator uses the transistor in its common-base configuration, its alpha can be expressed in terms of real and imaginary parts as:

$$-h_{21} = \alpha = m - jn. \quad (9)$$

Then, substituting this expression into Eq. 7 and 8, we have:

$$G_n = [m - An - N]N/R\,(1 + \text{A}^2) \quad (10)$$

and

$$B_n = N[A\,(N - m) - n]/R\,(1 + A^2). \quad (11)$$

If G_n is now maximized with respect to N and A (using the standard maximization procedure—that

Robert R. Meola, Associate Professor of Electrical Engineering, Newark College of Engineering, Newark, N.J.

is, differentiating and putting the result equal to zero), the maximizing values are:

$$N_{max} = |\alpha|^2/2m, A_{max} = -n/m. \quad (12)$$

The corresponding maximum values of G_n and B_n are:

$$G_{n(max)} = |\alpha|^2/4R, B_{n(max)} = A_{max} G_{n(max)}. \quad (13)$$

If a given oscillator has its values of N and A at the maximizing values (N_{max} and A_{max}, respectively), the load it can drive is maximum and is given by $G_{n(max)}$ (conductance) and $B_{n(max)}$ (susceptance).

To make use of the above oscillator circuit, we must find a method of synthesizing the ideal transformer—that is, we really want to build a transformerless feedback network. One such network that is equivalent to an ideal transformer is shown in Fig. 2.

For each of the networks of Fig. 2, we can write a corresponding Y-parameter expression:

(a)	(b)
$Y_{11} = j\omega C_F$	$Y_{11} = j\omega (C_1 + C_2)$
$Y_{12} = Y_{21} = -j\omega N C_F$	$Y_{12} = Y_{21} = -j\omega C_2$
$Y_{22} = j(B_L + \omega N^2 C_F)$	$Y_{22} = j(\omega C_2 + B_3)$

Equating the corresponding Y parameters, we get:

$$C_1 = (1-N) C_F, C_2 = NC_F, B_3 = B_L + \omega C_F N (N-1). \quad (14)$$

Put the theory to work

All the previous analysis can now be summarized by a step-by-step oscillator design procedure (refer to Fig. 3). In Fig. 3 G_L denotes load plus the coil losses.

Step 1. Determine α, h_{ib} (which is the h_{11} we have been using), C_c (from the transistor data sheet).

Step 2. Choose R_F. The value chosen should be large enough to swamp out variations in h_{ib}. However, as R_F gets larger, $G_{n(max)}$ gets smaller. Thus the choice of R_F must be determined by a tradeoff between the needs for stability and drive capability in each particular application.

Step 3. Calculate $R = R_F + \text{Re}(h_{ib})$.

Step 4. Calculate $N_{max} = |\alpha|^2/2m$.

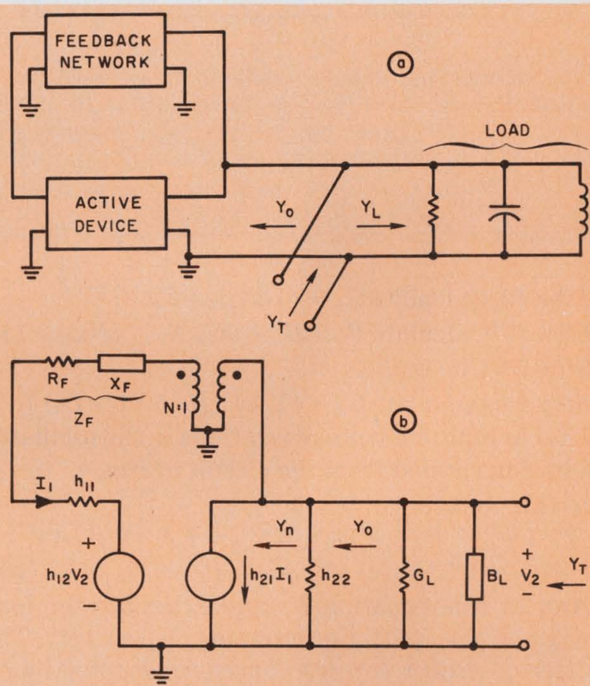
Step 5. Calculate $A_{max} = -n/m$.

Step 6. Calculate $G_{n(max)} = |\alpha|^2/4R$.

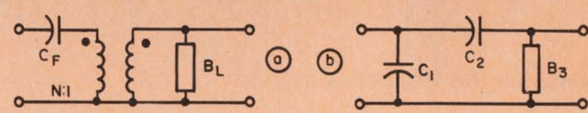
Step 7. Calculate $X_F = A_{max} R - \text{Im}(h_{ib})$,
note: $C_F = 1/\omega |X_F|$.

Step 8. Calculate $B_L = A_{max} G_{n(max)} - \text{Im}(h_{22})$.

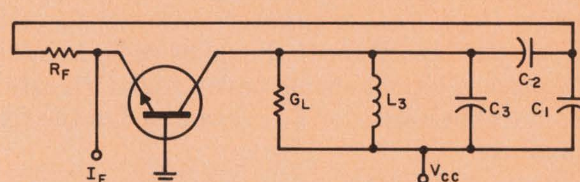
Step 9. Calculate $C_2 = N_{max} C_F$.



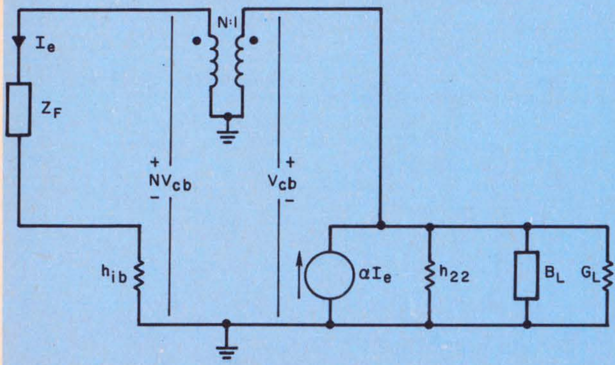
1. **Basic oscillator** block diagram (a) demonstrates the major elements. When the active device is a transistor and the feedback network is a transformer, the equivalent network is as shown in (b).



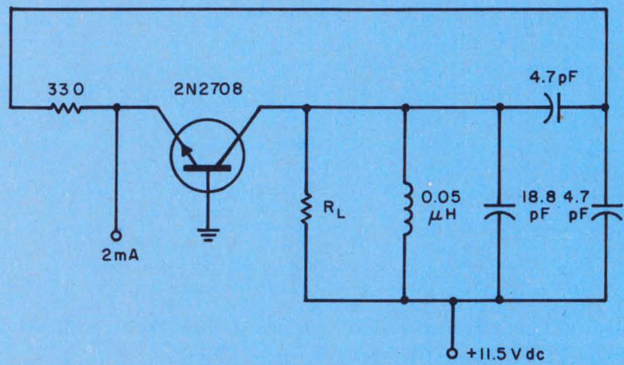
2. **An ideal transformer** (a), assumed as a feedback network in Fig. 1a, can be synthesized as a capacitor network (b) with a reactive element B_3.



3. **A complete generalized oscillator** is used to demonstrate the oscillator design procedure (see text).



4. **The current and voltage relations** in an oscillator required for its operation are determined with this equivalent circuit. Note that the feedback network is again shown as an ideal transformer.



5. **This 150 MHz oscillator** was designed, step-by-step, to illustrate the proposed design procedure. The 330-ohm emitter resistor is large enough to swamp changes in h_{ib} without sacrificing drive capability.

Step 10. Calculate $C_1 = (1 - N_{max})\ C_F$.

Step 11. Calculate $B_3 = B_L + \omega C_F N_{max}\ (N_{max} - 1)$.

Step 12. Choose L_3.

Step 13. Calculate $C_3 = (1/\omega)\ [B_3 + (1/\omega L_3)]$.

The current and voltage relations in the oscillator can be determined from the circuit of Fig. 4.

In this circuit:

$$Z_F + h_{ib} = R(1 + jA),\ NV_{cb} = I_e R\ (1 + jA),$$
$$|V_{cb}| = (|I_e| R/N)\ (1 + A^2)^{1/2},\ P_L = |V_{cb}|^2 G_L. \quad (15)$$

And in this equation P_L and I_e denote the load power and the emitter ac current, respectively. The emitter quiescent (or dc) current is denoted by I_E.

Using the maximizing values of G_L and A, we get:

$$|V_{cb}| = 2\ |I_e|\ R/|\alpha|,\ P_L = I_e^2 R. \quad (16)$$

For current-limited, class-A operation, $I_e = I_E/\sqrt{2}$, we have

$$|V_{cb}| = (\sqrt{2}/|\alpha|)\ I_E R,\ P_L = I_E^2 R/2. \quad (17)$$

Determine the frequency stability

The frequency stability of the oscillator can be evaluated best by noting that at the frequency of oscillation

$$B_L = B_n - \text{Im}\ (h_{22}).$$

Since Im $(h_{22}) = \omega C_c$ transistors with low C_c (collector output capacitance) should be used. In addition the tuned circuit should have a high C/L ratio. When the expression for B_n is examined in the following form

$$B_n = \frac{[X_F + \text{Im}(h_{ib})]\ (N - m) N - nN\ [R_F + \text{Re}(h_{ib})],}{|Z_F + h_{ib}|^2} \quad (18)$$

it can be seen that the effects of n can be minimized by using a transistor that has $f_T \gg f_{osc}$. Also, since h_{ib} varies approximately inversely with I_E the variation will be minimized if we make

$$X_F \gg \text{Im}\ (h_{ib}) \text{ and } R_F \gg \text{Re}\ (h_{ib}). \quad (19)$$

Noise modulation of the oscillator frequency will occur because of random variations in the net tuning capacitance.

Since $\omega_o = 1/\sqrt{LC}$, where L and C are a general inductance and capacitance, a change in C results in a change in ω_o (the oscillator radian frequency). Let $x = \Delta C/C$ and $y = \Delta\omega/\omega_o$ then $y = -(x/2)$ for small values of x. The changes in C that will take place in the oscillator will be primarily due to changes in the reflected capacitance, $C_n = B_n/\omega$, plus changes in the collector output capacitance, C_c. Since the reflected capacitance varies approximately directly with emitter current, an approximation of random I_E variations is necessary.

Assuming that I_E directly changes the reflected capacitance, C_n, (valid only if $Z_F = 0$), we can write

$$\frac{C_n}{C_n + \Delta C_n} = \frac{C_n}{C_n\ (1 + x_n)} = \frac{I_E}{I_E + \overline{I}_n} \quad (20)$$

where $\overline{I}_n$ = rms emitter $1/f$ noise current and $x_n = \Delta C_n/C_n$.

Then, solving for x_n we get

$$x_n = \overline{I}_n/I_E. \quad (21)$$

The presence of Z_F makes variations in B_n less than the variations in I_E.

The variations in C_c are due to changes in the collector voltage V_c. This capacitance variation depends upon the collector junction geometry. However, the following valid relation can be used:

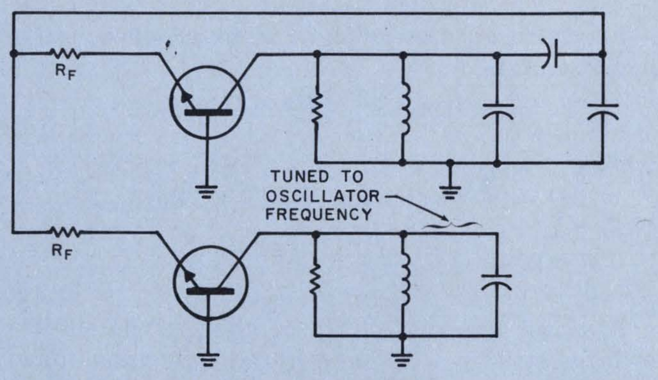
$$C_c = K/\sqrt{V_c}\ (K = \text{constant}). \quad (22)$$

We can now write the following final expressions for the oscillator output frequency:

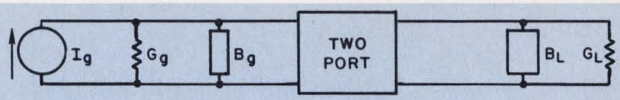
$$\omega_o = 1/\sqrt{LC} = 1/\sqrt{L(C_T + C_c)} = 1/\sqrt{L}\ \sqrt{C_T + (K/V_c^{1/2})},$$

where the capacitance has been separated into two components, the voltage-dependent C_c and the remainder, C_T.

Differentiating, we get:



6. **Frequency shifts due to loading** can be reduced by adding a coupling amplifier to the oscillator. The tank of the coupling amplifier is tuned to the oscillator. Biasing is omitted.



7. **Coupling amplifier stability** can be determined by using standard two-port network analysis.

Table. Oscillator parameters

Parameter	Computed	Measured	Units
f	150	158	MHz
V_{cb}	1.0	1.6	V,rms
P_L	0.7	1.0	mW
Δ f (noise)	1.0	1.0	Hz
%F / %V_c	0.006	0.004	

$$d\omega_o/dV_c = (\omega_o/4V_c)\ (C_c/C), \text{or}$$
$$(df_o/f_o)\,/\,(dV_c/V_c) = (\%\Delta f)\,/\,(\%\Delta V_c) = C_c/4C. \quad (23)$$

This last equation gives a measure of the sensitivity of the frequency to changes in supply voltage.

Designing a practical oscillator

Having established a detailed design procedure, we can now proceed with the practical oscillator design. A 2N2708 transistor will be used in the construction of a 150-MHz oscillator.

Here is the design sequence:

Step 1. 2N2708 parameters @ 150 MHz, $V_{cc} = 11.5\text{ V}, I_c = 2\text{ mA}$:
$h_{ib} = (23.9 + j37.3)$ ohms, $C_c = 1.5$ pF,
$\alpha = 0.952 - j0.202,\ m = 0.952,\ n = 0.202,$
$|\alpha| = 0.965.$

Step 2. Let $R_F = 330$ ohms (to swamp changes in h_{ib}).

Step 3. $R = R_F + \text{Re}\,(h_{ib}) = 354$ ohms.

Step 4. $N_{max} = |\alpha|^2/2m = 0.495.$

Step 5. $A_{max} = -n/m = -0.215$

Step 6. $G_{n(max)} = |\alpha|^2/4R = 0.00066$ mho, or
$R_{L(min)} = 1/G_{n(max)} = 1520$ ohms.

Step 7. $X_F = A_{max}R - \text{Im}\,(h_{ib}) = -113.3$ ohms, or
$C_F = 1/\omega\,|X_F| = 9.4$ pF.

Step 8. $B_L = A_{max}G_{n(max)} - \text{Im}\,(h_{22}) = -0.00155.$

Step 9. $C_2 = N_{max}C_F = 4.7$ pF.

Step 10. $C_1 = (1-N_{max})\,C_F = 4.7$ pF.

Step 11. $B_3 = B_L + \omega C_F N_{max}(N_{max}-1) = -0.00375.$

Step 12. Let $L_3 = 0.05\ \mu$H.

Step 13. $C_3 = [1/\omega]\,[B_3 + (1/\omega L_3)] = 18.8$ pF.

The oscillator is shown in Fig. 5, and its performance is summarized in the table.

Reduce loading effects

In the operation of the oscillator, power is extracted by inductive coupling to the tank coil. This type of coupling is not the most desirable, since the load will couple some reactance back into the tuning circuit. This will change the frequency of the oscillator. An alternate method is to couple an amplifier into the emitter circuit, as shown in Fig. 6.

In this scheme the amplifier circuit, with its swamping input resistor, does not directly affect the oscillator tuning circuit. This coupling method requires a redesign of the basic oscillator to account for the additional load in the emitter circuit. In this circuit the effective α is half of the transistor specified α (assuming identical transistors) for both the oscillator and the coupling amplifier. In addition R and A must be redefined as

$$R = [R_F + \text{Re}\,(h_{ib})\,]/2,\ A = \{X_F + [\text{Im}\,(h_{ib})\,]/2\}/R. \quad (23)$$

The modified design relations are then:

$$N_{max} = |\alpha|^2/4m,\ G_{n(max)} = |\alpha|^2/16R,$$
$$A_{max} = -n/m,\ X_F = A_{max}R - [\text{Im}\,(h_{ib})\,/2],$$
$$B_L = A_{max}G_{n(max)} - \text{Im}\,(h_{22}),\ C_2 = N_{max}C_F,$$
$$C_1 = (1-N_{max})\,C_F,\ B_3 = B_L + [N(N-1)\,/\,|X_F|\,],$$
$$C_3 = (1/\omega)\ [B_3 + (1/\omega L_3)\,].$$

Determine coupling amplifier stability

A stability analysis is now necessary to evaluate the performance of the amplifier to be coupled to the oscillator.

For a two-port network (see Fig. 7), the values of source and load conductances for maximum power gain are:

$$G_g = (1/2g_{22})\ \{\,[2g_{11}\,g_{22} - \text{Re}\,(Y_{12}Y_{21}]^2 - |\,Y_{12}\,Y_{21}\,|^2\}^{1/2}, \quad (24)$$
$$G_L = (1/2g_{11})\ \{\,[(2g_{11}\,g_{22} - \text{Re}\,(Y_{12}Y_{21}]^2 - |\,Y_{12}\,Y_{21}\,|^2\}^{1/2}, \quad (25)$$

where $g_{11} = \text{Re}\,(Y_{11})$,
$g_{22} = \text{Re}\,(Y_{22})$

and other symbols are illustrated in Fig. 7.

For positive G_g and G_L we have

$$[2 g_{11} g_{22} - \text{Re}(Y_{12} Y_{21})] > | Y_{12} Y_{21} |, \quad (26)$$

which is the basic device stability requirement. If this relation is rearranged we get the expression for the device stability as

$$C = | Y_{12} Y_{21} | / [2g_{11} g_{22} - \text{Re} | Y_{12} Y_{21} |] < 1. \quad (27)$$

This relation is Linvill's C factor (see ED 8, April 12, 1966, pp. 48-54).

If the source and load conductances are included in the basic stability statement, the following expression for the system stability results:

$$[2 (g_{11} + G_g) (g_{22} + G_L) - \text{Re} (Y_{12} Y_{21})] > | Y_{12} Y_{21} |. \quad (28)$$

This expression can be rearranged as follows:

$$(g_{22} G_g + g_{11} G_L + G_g G_L) > [(| Y_{12} Y_{21}/2 |) (1 + \cos\underline{/Y_{12}Y_{21}}) - g_{11}g_{22}]. \quad (29)$$

By inspection of this stability requirement we can see that if

$$G_L = | Y_{12}Y_{21}/2g_{11} | (1 + \cos\underline{/Y_{12}Y_{21}}) - g_{22} = G_{L(\min)}, \quad (30)$$

then any positive G_g will produce a stable amplifier.

Also, if

$$G_g = | Y_{12}Y_{21}/2g_{22} | (1 + \cos\underline{/Y_{12}Y_{21}}) - g_{11} = G_{g(\min)}, \quad (31)$$

then any positive G_L will produce a stable amplifier.

The basic system stability requirement (Eq. 28) can be rearranged to yield:

$$K = [2 (g_{11} + G_g) (g_{22} + G_L)]/| Y_{12} Y_{21} | [1 + \cos\underline{/Y_{12} Y_{21}}] > 1, \quad (32)$$

which is Stern's K factor.

If the value of K is greater than unity when $G_g = 0$ and $G_L = 0$, the amplifier will be stable for any positive G_g and G_L. The modified expression for the device stability becomes:

$$K' = [2g_{11}g_{22}/ | Y_{12}Y_{21} | (1 + \cos\underline{/Y_{12}Y_{21}})] > 1. \quad (33)$$

In a special case, when $G_g = G_{g(\min)}$ and $G_L = G_{L(\min)}$, the following interrelation exists:

$$K = 1/ K'. \quad (34)$$

The general statement for K (Eq. 32) can be rearranged as:

$$K = K' [1 + (G_L/g_{22}) + (G_g/g_{11}) + (G_gG_L/g_{11}g_{22})] \quad (35)$$

Then, letting

$$M = K/K', G_L/g_{22} = J, G_g/g_{11} = H, \quad (36)$$

we can write

$$G_{g(min)}/g_{11} = G_{L(min)}/g_{22} = J_{min} = H_{min} = (1-K')/K', \quad (37)$$

and, finally,

$$M = (J + 1) (H + 1). \quad (38)$$

Equation 38 gives a simple interrelation between the normalized source and load conductances for a given normalized stability factor.

A general relation for the power gain of an amplifier is:

$$G_p = | Y_{21} |^2 \text{Re} (Y_L) / | Y_{22} + Y_L |^2 \text{Re} \{ Y_{11} - [Y_{12} Y_{21}/ (Y_{22} + Y_L)] \}. \quad (39)$$

If the load is adjusted so that $B_L = -\text{Im} (Y_{22})$, Eq. 39 reduces to

$$G_p = [J/ (J + 1)] | Y_{21} |^2/ (J + 1) [g_{11}g_{22} - \text{Re}(Y_{12} Y_{21})]. \quad (40)$$

From Eq. 40 the value of J to produce unity power gain is:

$$J_1 = D + \sqrt{D^2 - 2D} \text{ at } G_p = 1, \quad (41)$$

where

$$D = [| Y_{21} |^2 + \text{Re} (Y_{12}Y_{21})]/2g_{11}g_{22}.$$

If $D \gg 1$,

$$J_1 \approx 2D = [| Y_{21} |^2 + \text{Re} (Y_{12} Y_{21})]/g_{11} g_{22} \approx | Y_{21} |^2/g_{11} g_{22}. \quad (42)$$

A simple figure of merit, combining the effects of large stability (K') and high load conductance at unity power gain, is:

$$F = J_1K'/2 = | Y_{21} | / | Y_{12}| (1 + \cos\underline{/Y_{21}Y_{12}}). \quad (43)$$

To demonstrate the effects of the addition of a coupling amplifier to the 150-MHz oscillator of Fig. 5, another oscillator was designed.

From the data sheet for the 2N2708 at 150 MHz, we have

$Y_{11} = 18.1 - j18.8$ millimhos,
$Y_{12} = -0.1 - j0.7 = 0.71 \underline{/-98.2^\circ}$ millimhos,
$Y_{21} = -15.1 + j20.6 = 25.5 \underline{/126.3^\circ}$ millimhos,
$Y_{22} = 0.1 + j1.4$ millimhos.

Using these values in Eqs. 23 through 43, we can redesign the oscillator with the coupling amplifier shown in Fig. 6. This amplifier sees an operating source of approximately 500 ohms or a conductance of 2 millimhos. For the 2N2708, this is a value of $H = 0.11$. Since $K' = 0.106$ at 150 MHz, a value of $M = 47$ is necessary to produce $K = 5$. This requires $J = 41$ or, for the 2N2708, $G_L = 4.1$ millimhos or $R_L = 240$ ohms.

The oscillator is modified by changing C_1 from 4.7 to 14.1 pF and C_3 from 18.8 to 17.5 pF. R_F, C_2 and L_3 are not changed. The amplifier collector resistor is 240 ohms. ■ ■

Reference:
1. D. F. Page, *Proceedings IRE*, June 1958, pp. 1271.

Acknowledgment:
The material for this article was compiled as a result of consulting work for Boonton Radio Co. (a division of Hewlett-Packard), Rockaway, N.J.

Test your retention

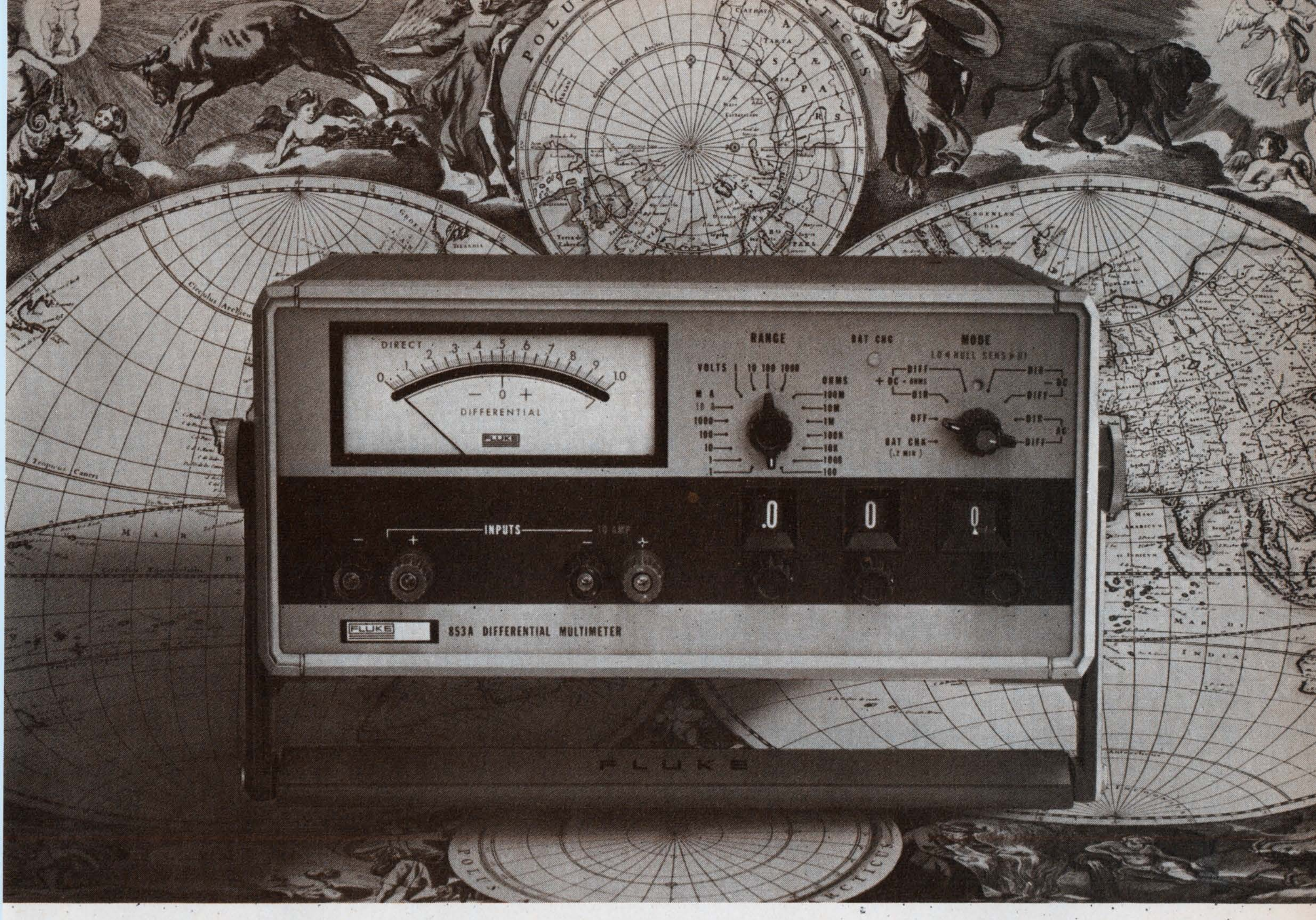
Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What is the purpose of a large emitter resistor?

2. What has the most effect on the collector output capacitance? How is it minimized?

3. In selecting a transistor for the oscillator, what relation is desired between f_T and the frequency of the oscillator?

4. What is the advantage of taking the output from the oscillator's emitter circuit?



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Here are more digital comparators

together with logical design data for building them with off-the-shelf ICs.

Part 2 of a two-part article

Logic design information for a variety of specific digital comparator types was presented in Part 1 of this article (ED 23, Nov. 7, 1968). Similar information for eight more comparator types is presented here in Figs. 10 through 17.

A. H. Frim and M. M. Miller, Radio Corporation of America, Defense Electronic Products, Aerospace Systems Div., Burlington, Mass.

Included for each comparator are a description of operation, logic diagram, truth table, Karnaugh map and typical timing waveforms. The actual ICs used in these designs are Fairchild Semiconductor Type 930 DTμL (diode-transistor micrologic) gate packages, which were described in detail in Part 1. The basic principles covered here, though, are easily applied to other types of ICs.

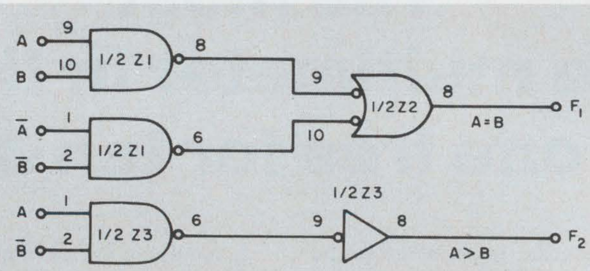
In the circuit descriptions, a designation such as Z2-1 means pin 1 of gate Z2.

10. A = B and A > B comparator (2-bit)

This comparator provides an output, F_1, when inputs A and B are equal, and another output, F_2, when A is greater than B. For example, if A and B are both HIGH, Z1-8 and Z2-9 will be LOW, so Z2-8 will be HIGH. And if A and B are both LOW, Z1-1 and Z1-2 will be HIGH. So Z1-6 will be LOW, again making Z2-8 HIGH. These are the conditions for A = B.

The condition for A > B occurs when A is HIGH and B is LOW. This makes Z3-6 LOW, so that Z3-8 is HIGH.

Logic diagram:



Truth table:

A = B

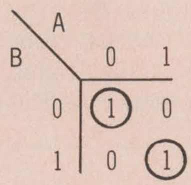
Inputs A	Inputs B	Output F_1
0	0	1
0	1	0
1	0	0
1	1	1

A > B

Inputs A	Inputs B	Output F_2
0	0	0
0	1	0
1	0	1
1	1	0

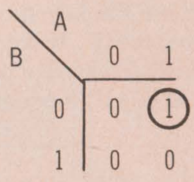
Karnaugh maps:

A = B



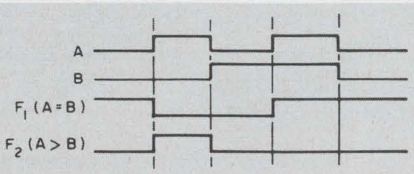
$F_1 = AB + \bar{A}\bar{B}$

A > B



$F_2 = A\bar{B}$

Timing diagram:

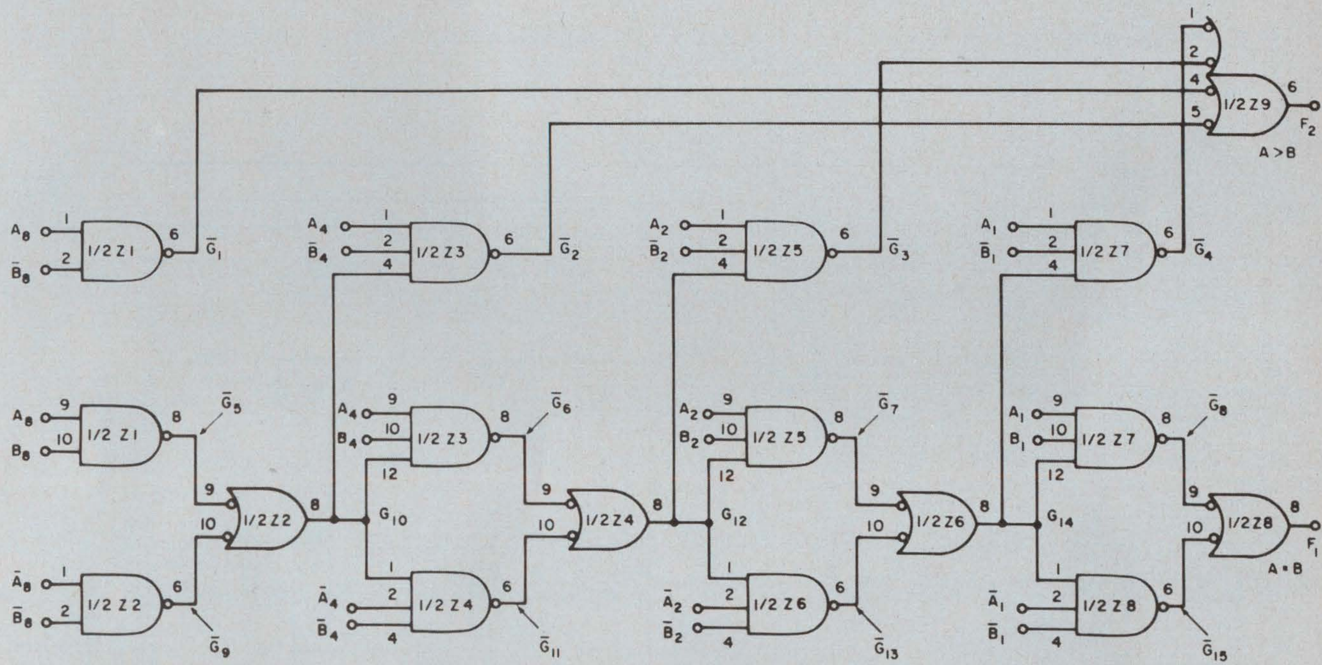


11. A = B and A > B comparator (8-bit)

This comparator compares two 4-bit numbers and produces one output, F_1, if they are equal and another output, F_2, if the A number is larger than the B number. For example, if the highest-order A bit (A_8) is HIGH and the highest-order B bit (B_8) is LOW, then Z1-6 will be LOW. This will cause Z9-6 to be high, thus indicating that A is greater than B.

If the A_8 and B_8 bits are equal, either Z1-8 or Z2-6 will be LOW, making Z2-8 HIGH. This HIGH output primes the second stages of gates, and the next lower-order bits are compared. Again, if the A bit is greater than the B bit, Z9-6 goes HIGH. And if these bits are equal, the next lower-order bits are compared, and so on. If all bits are equal, Z8-8 goes HIGH, indicating that A = B.

Logic diagram:



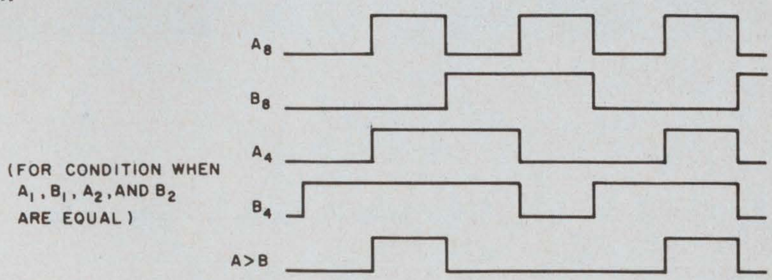
Logic equations:

A = B: $F_1 = (A_1 B_1 + \bar{A}_1 \bar{B}_1)(A_2 B_2 + \bar{A}_2 \bar{B}_2)(A_4 B_4 + \bar{A}_4 \bar{B}_4)(A_8 B_8 + \bar{A}_8 \bar{B}_8)$

A > B: $F_2 = (A_8 \bar{B}_8) + G_{10}(A_4 \bar{B}_4) + G_{12}(A_2 \bar{B}_2) + G_{14}(A_1 \bar{B}_1)$

where: $G_{10} = A_8 B_8 + \bar{A}_8 \bar{B}_8$ $G_{12} = G_{10}(A_4 B_4 + \bar{A}_4 \bar{B}_4)$ $G_{14} = G_{12}(A_2 B_2 + \bar{A}_2 \bar{B}_2)$

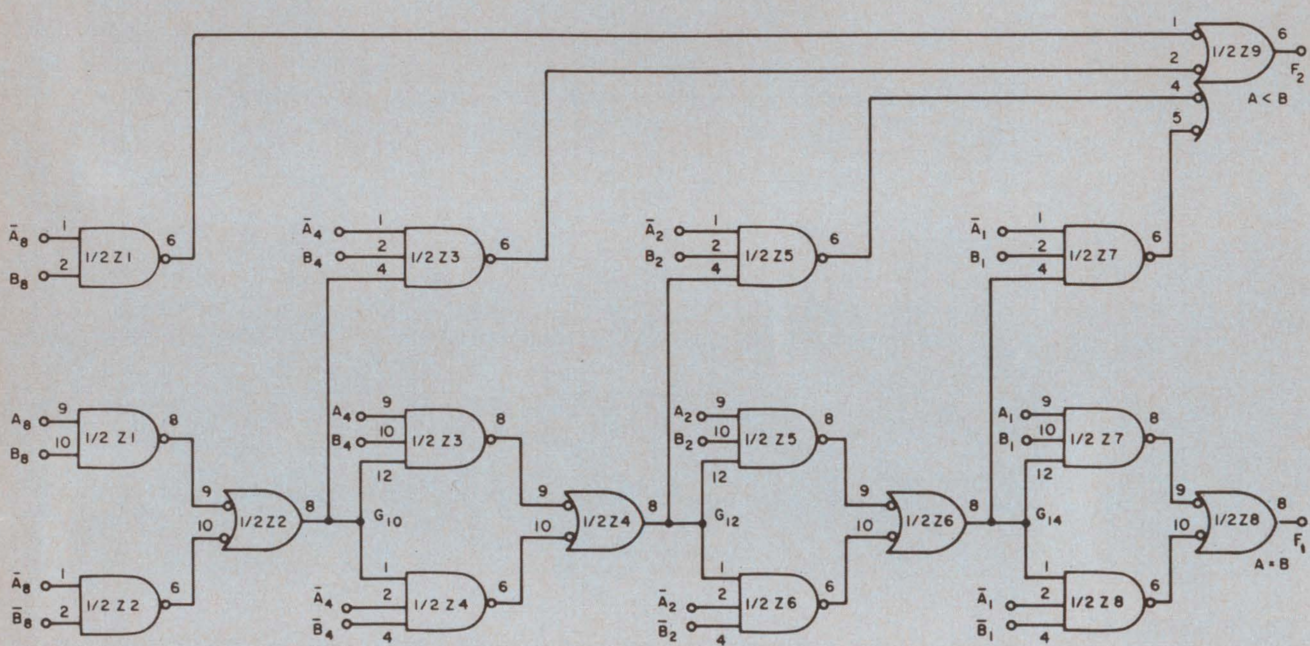
Timing diagram:



12. A = B and A < B comparator (8-bit)

This comparator is similar to the A ≧ B Comparator described in Fig. 11. The only difference is that the logic levels of the A and B inputs to the A < B gates are reversed.

Logic diagram:



Logic equations:

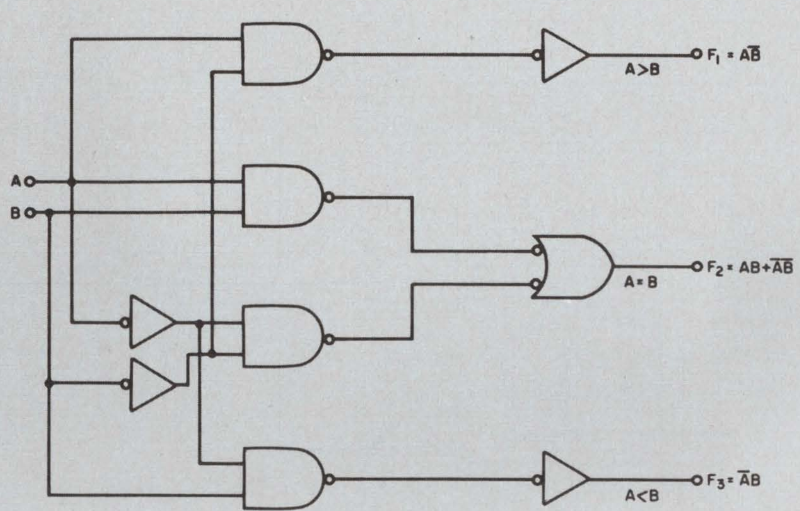
A = B: $F_1 = (A_1 B_1 + \bar{A}_1 \bar{B}_1)(A_2 B_2 + \bar{A}_2 \bar{B}_2)(A_4 B_4 + \bar{A}_4 \bar{B}_4)(A_8 B_8 + \bar{A}_8 \bar{B}_8)$

A < B: $F_2 = (\bar{A}_8 B_8) + G_{10}(\bar{A}_4 B_4) + G_{12}(\bar{A}_2 B_2) + G_{14}(\bar{A}_1 B_1)$

13. A = B, A > B, A < B comparator (2-bit)

This comparator provides three outputs: namely, A = B, A > B and A < B. The logic design is a combination of that of the individual A ≧ B and A ≶ B comparators (2-bit).

Logic diagram:



Truth table:

Inputs		Outputs		
A	B	A > B	A = B	A < B
0	0	0	1	0
0	1	0	0	1
1	0	1	0	0
1	1	0	1	0

Karnaugh maps:

A > B

B \ A	0	1
0	0	1
1	0	0

$F_1 = A\bar{B}$

A = B

B \ A	0	1
0	1	0
1	0	1

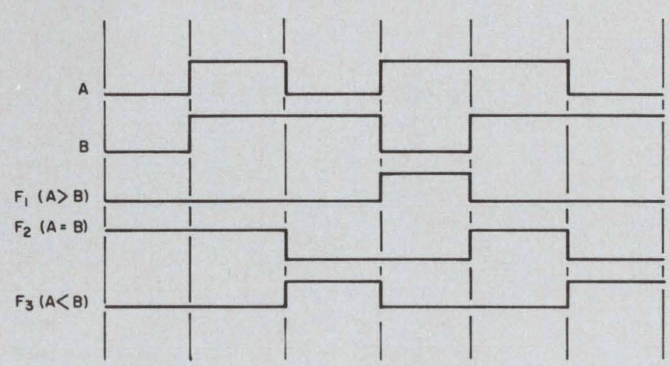
$F_2 = AB + \bar{A}\bar{B}$

A < B

B \ A	0	1
0	0	0
1	1	0

$F_3 = \bar{A}B$

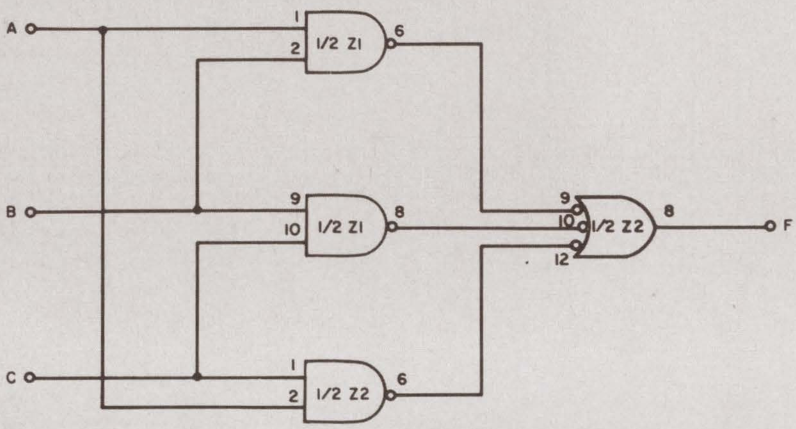
Timing diagram:



14. At least 2 out of 3 comparator

This comparator checks a three-bit input to determine if there are two or more HIGH's, in which case the comparator output is HIGH. Otherwise, the comparator output is LOW. For example, if inputs A and C are HIGH and B is LOW, then Z2-1 and Z2-2 will be HIGH and Z2-6 will be LOW. The converter output at Z2-8 will therefore be HIGH.

Logic diagram:



Truth table:

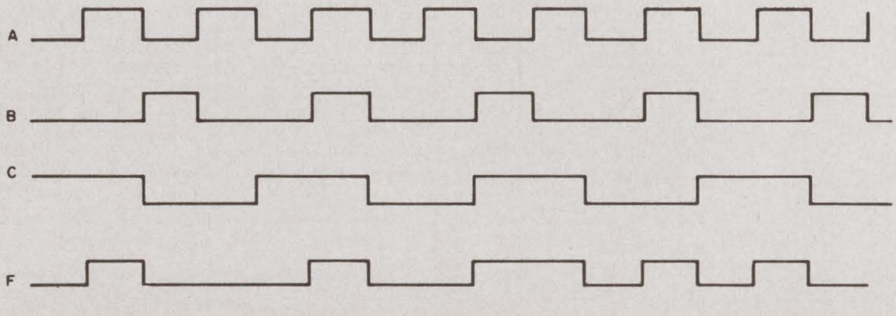
Inputs A	Inputs B	Inputs C	Output F
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Karnaugh map:

C \ AB	00	01	11	10
0	0	0	1	0
1	0	1	1	1

F = AC + BC + AB

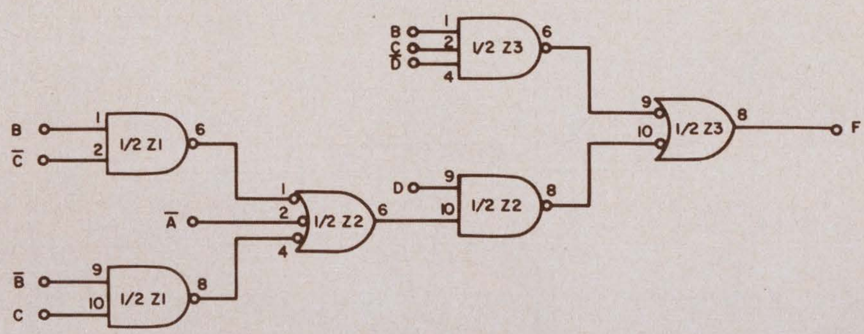
Timing diagram:



15. 2 out of 4 comparator (for BCD)

This comparator checks a four-bit binary coded decimal (BCD) input to determine if there are only two HIGH's. If so, the comparator output is HIGH. If there are none, one, three or four HIGH inputs, the comparator output is LOW.

Logic diagram:



Truth table:

Inputs A	B	C	D	Output F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	1

Karnaugh map:

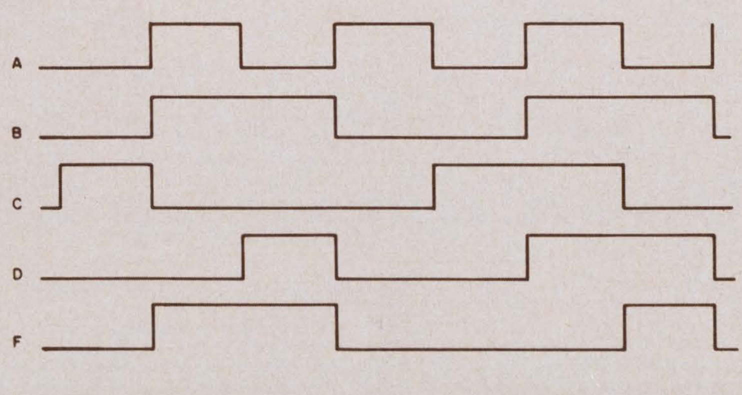
CD \ AB	00	01	11	10
00	0	0	X	0
01	0	1	X	1
11	1	0	X	X
10	0	1	X	X

$F = AD + BC\bar{D} + B\bar{C}D + \bar{B}CD$

$= D(A + B\bar{C} + \bar{B}C) + BC\bar{D}$

X = 10, 11, 12, 13, 14, 15 = (Don't care)

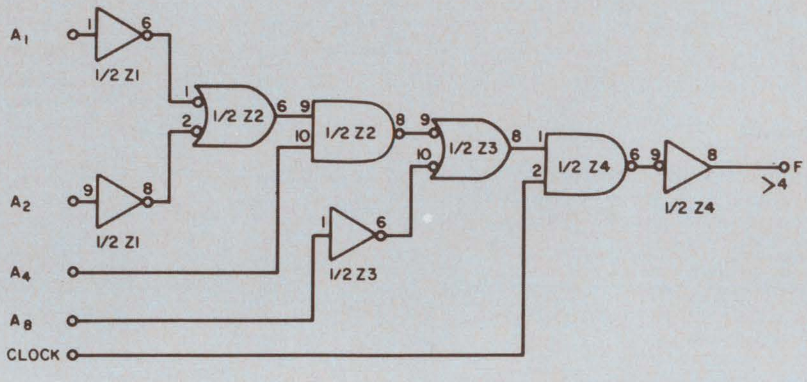
Timing diagram:



16. >4 comparator (strobed)

This comparator provides a logical HIGH output when the input is a binary number greater than four. For example, if the input is a binary five (0101), then Z1-1 and Z2-10 will be HIGH, and Z3-1 and Z1-9 will be LOW. As a result, Z2-9 and Z2-10 are both HIGH, causing Z4-1 to also be HIGH. A clock pulse on Z4-2 will then produce a HIGH output at Z4-8.

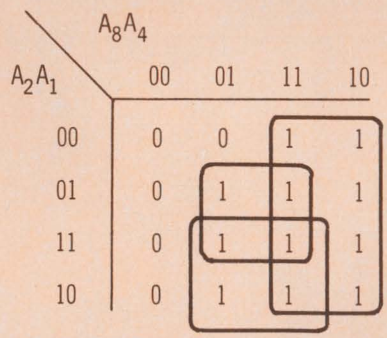
Logic diagram:



Truth table:

Inputs				Output
A_8	A_4	A_2	A_1	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	0
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
	•			•
	•			•
	•			•
1	1	1	1	1

Karnaugh map:

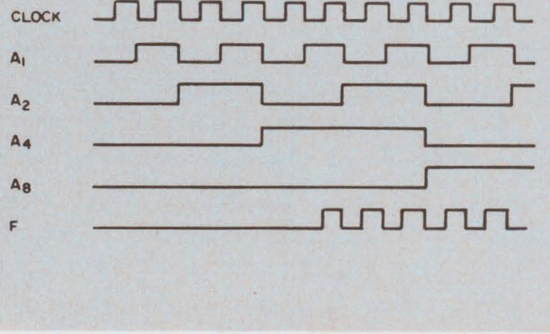


A_2A_1 \ A_8A_4	00	01	11	10
00	0	0	1	1
01	0	1	1	1
11	0	1	1	1
10	0	1	1	1

$$F = A_8 + A_4A_1 + A_4A_2$$

$$= A_8 + A_4(A_1 + A_2)$$

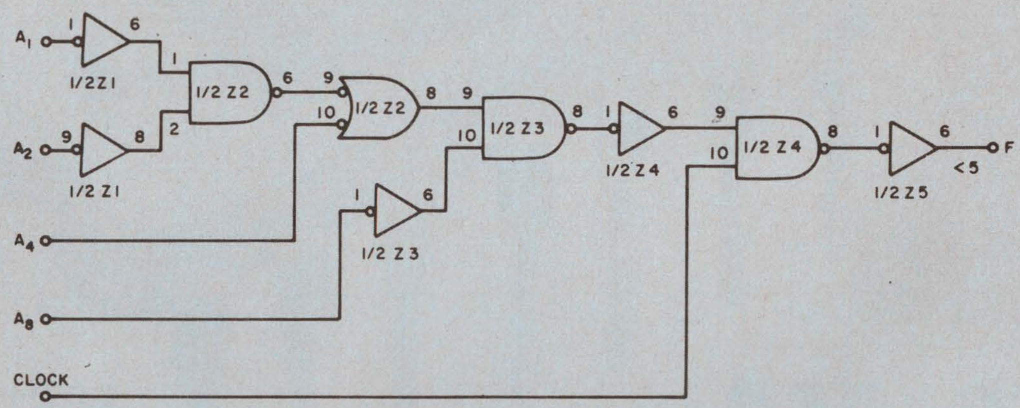
Timing diagram:



17. <5 comparator (strobed)

This comparator provides a logical HIGH output when the input is a binary number less than 5. For example, if the input is a binary three (0011), Z1-1 and Z1-9 will be HIGH, and Z2-10 and Z3-1 will be LOW. This will make pins 9 and 10 of Z3 HIGH, causing Z4-6 to also be HIGH. A clock pulse on Z4-10 will then produce a HIGH output at Z5-6.

Logic diagram:



Truth table:

Inputs				Output
A_8	A_4	A_2	A_1	F
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
	•			•
	•			•
	•			•
1	1	1	1	0

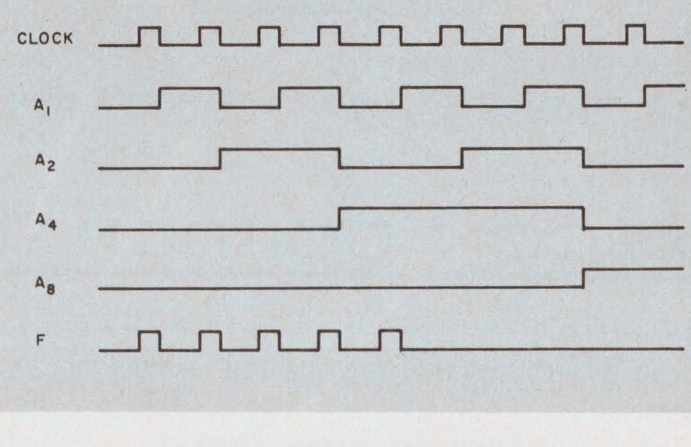
Karnaugh map:

A_2A_1 \ A_8A_4	00	01	11	10
00	1	1	0	0
01	1	0	0	0
11	1	0	0	0
10	1	0	0	0

$$F = \bar{A}_8\bar{A}_4 + \bar{A}_8\bar{A}_2\bar{A}_1$$

$$= \bar{A}_8(\bar{A}_4 + \bar{A}_2\bar{A}_1)$$

Timing diagram:



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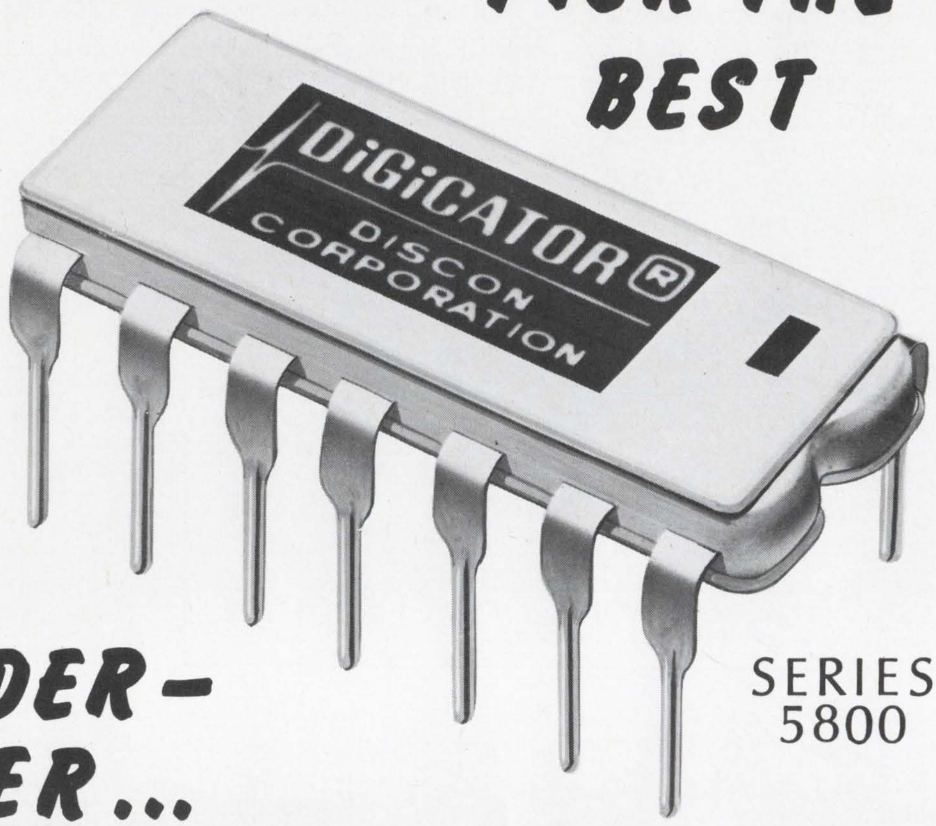

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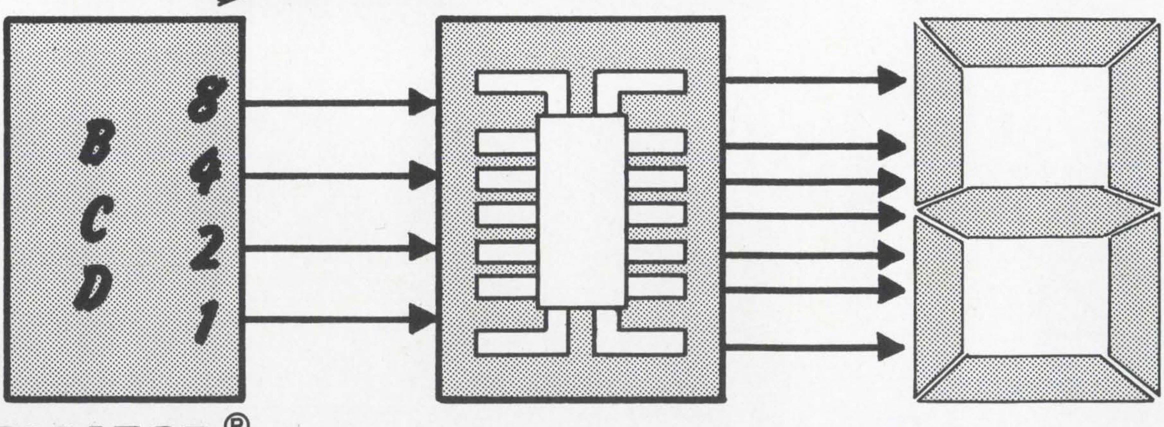

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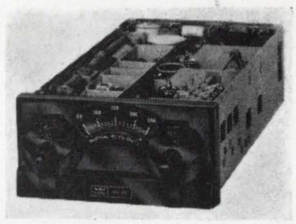

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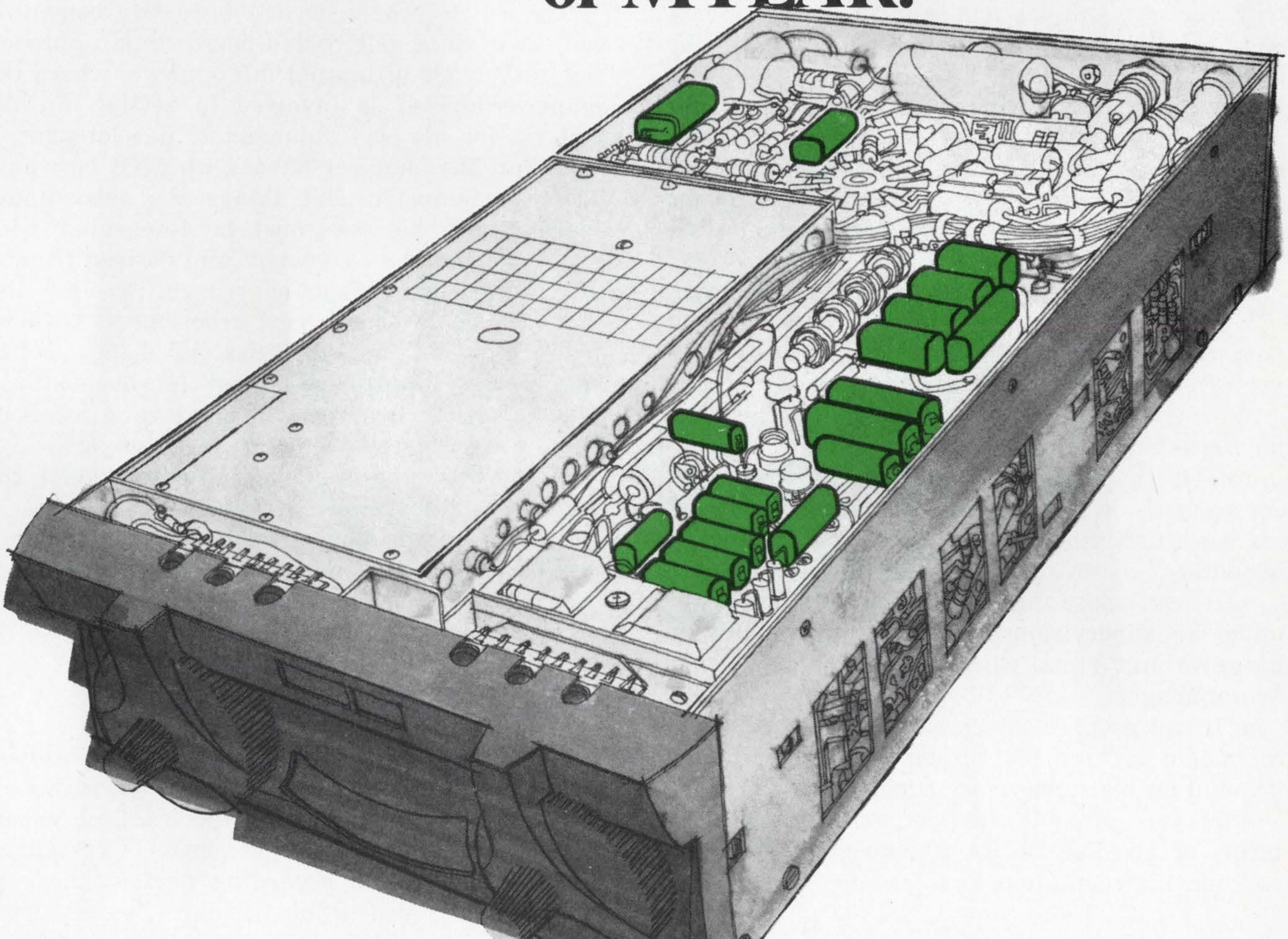

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INFORMATION RETRIEVAL NUMBER 38

How to upgrade job performance in the group you manage. Coach your men so that they, as well as you, look for top results in their work.

Most engineers have no trouble describing their jobs in a physical sense, in terms of the various activities they perform. But just ask the average engineer to describe his job in terms of *results expected*. Then compare his description with the views of his manager on the same subject. You'll gain a fresh understanding of the term "communications gap."

You'll also be putting your finger on a root cause of individual performance gaps—lack of mutual understanding and agreement between engineer and manager on the expected outcome of the work activities in which the engineer is involved.

Without such mutual understanding and agreement as a base, the success of even the most painstaking work a manager does to raise the performance of his staff will be limited.

With it, the manager can undertake a man-by-man coaching and development program for subordinates that will build his own stature in the company as it steps up the accomplishments of his work unit. Such a program can produce these benefits:

- It can close individual performance gaps under his supervision that reflect unfavorably on his work unit's total efficiency and his proficiency as a manager.
- It can prepare the employe reporting to him to handle greater job responsibilities, with less demand on his supervisory time.
- It can promote his employes' growth in terms of possible future advancement, thus enhancing his reputation as a leader.

Mutual agreement is the key

The key point in coaching and development is that there be mutual agreement on goals between manager and employe—an agreement that fosters commitment on the part of the employe. If he does not honestly commit himself in terms of the importance of performing certain activities as they relate to his job, in terms of agreeing to what factors his performance should be judged on, on how his performance will be measured in each area, and of what minimum standards he is to meet, it is very likely he will pour considerably more energy and effort into resisting the manager than into working with and for him.

The way to get the needed mutual agreement is not through a telling-and-persuading approach but rather one of mutual interchange, where the employe himself is involved in setting up the criteria for his performance and development.

So far, the manager has set up what he wants from the employe. But things the subordinate looks for in his job must be integrated with this to get mutual agreement and desired results. He wants such things as recognition, job importance, achievement, new experiences, freedom to work, growth opportunities and dollars. After the manager interprets desired improvements in his work performance to the employe in terms of these wants, a settlement can be made on:

- The work and major activities for which the employe is responsible.
- The factors upon which his performance will be judged, such as quality, schedule-meeting, cost, innovation, self-development, service to other people or departments, and so on.

How much to expect?

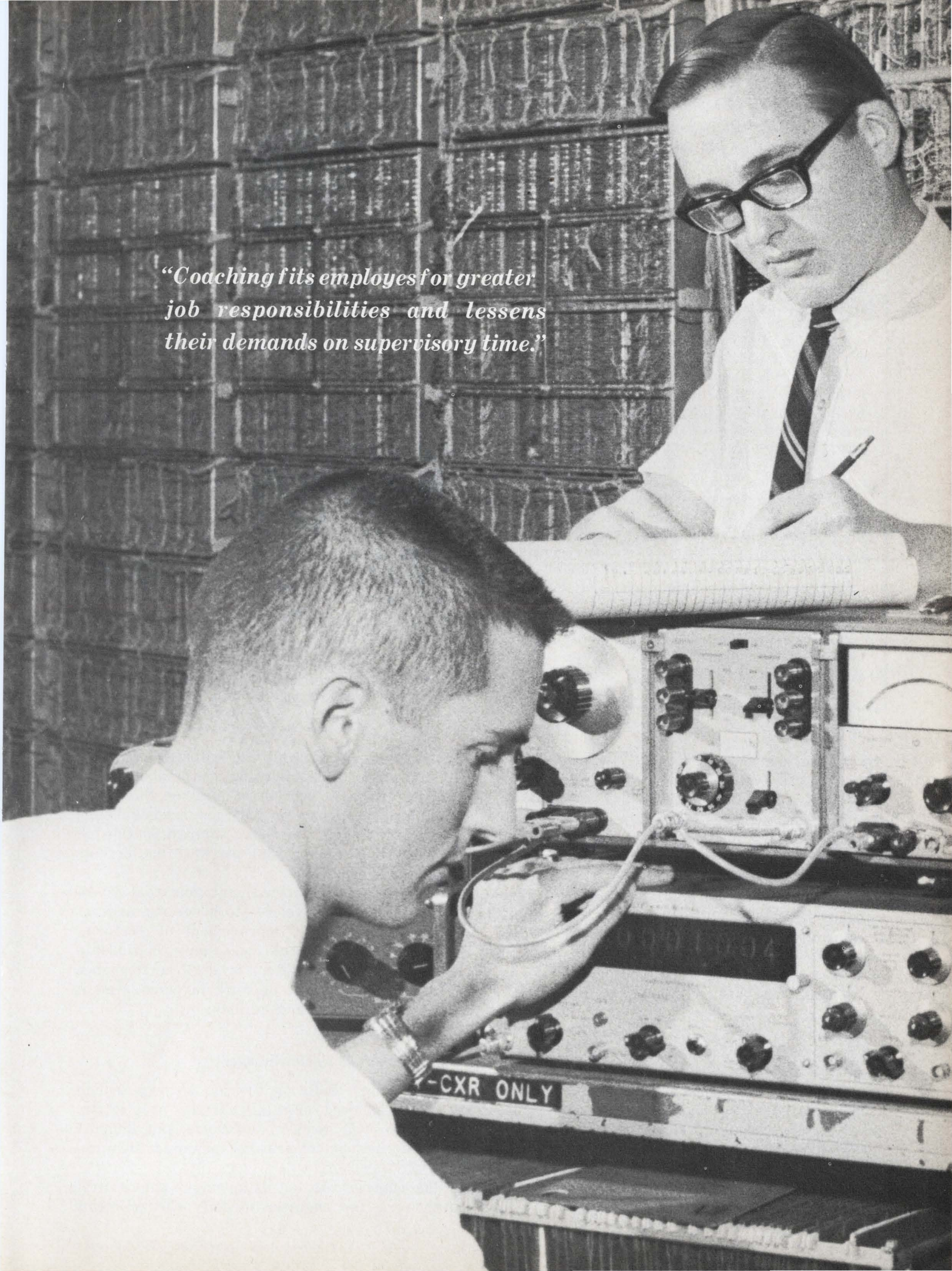
Setting the stage for a coaching atmosphere that will achieve maximum levels of performance on the part of subordinates involves, first, a performance analysis by the manager. Crystallization of information regarding performance expectations begins with his listing the names of all the people over whom he has direct supervision.

After this listing is complete, he must set up in his mind, as a second step, what would constitute a 100 per cent level of efficiency on each job. (If, with respect to a job in question, the man were performing at a 100 per cent level, what would he be accomplishing?) In the absence of existing measurable standards, judgments must be made.

The third step in performance analysis, is to rate each subordinate in terms of the 100 per cent standard for his job. Essentially, what is being

Dr. Burt Scanlon, Associate Professor, University of Wisconsin Management Institute, Madison, Wis.

"Coaching fits employes for greater job responsibilities and lessens their demands on supervisory time."



Goal-setting in action

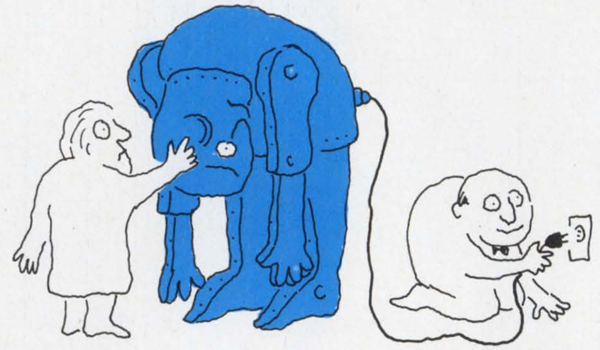
"Negotiation" of individual work goals between the manager and those who report to him is at the heart of General Electric Company's highly successful work planning and review meetings.

These man-manager meetings seek joint commitment to the individual's work goals and the means of meeting them, according to Marion S. Kellogg, the company's manager of individual development methods service. She notes, "Employes who help set their own goals have an extra incentive to reach them."

Centering of attention on goal-setting replaces a traditional pattern of dwelling on the need for improved performance in such meetings. Miss Kellogg explains that "Emphasis shifted to goal-setting after studies indicated that productivity more than doubled after an employe's effort was directed toward specific, measurable goals."

GE trains its managers in the skills of negotiating work goals with their employees, and managers strive in work planning and review meetings to get each employe's agreement to widen his skills and job knowledge in at least one area, thus preventing the employe's own development from being crowded out of the picture by emphasis on straight improvement of routine performance.

As the employe progresses, goals for his further progress are established. His development is continuous, and his interest in it gets little chance to lag.



The manager can help his engineer identify problems that are hindering his accomplishment.

Don't concentrate coaching only on those whose performance is below average.

done is to ask the question, "How well is the man doing?" Typical ratings will range all the way from a few in the upper 90s to a few in the 70s. The point of concern is not how well the man is doing in terms of what the manager thinks his potential might be, but rather how well he is doing in terms of what the job requires.

The rating is not an end in itself but rather a means to an end, improving performance. Ask the question, "Why this level of rating for this man?" You'll begin to spot the major areas of each man's performance that need improvement, as well as those areas where strength is being exhibited.

Following analysis of the man and his performance, set up performance improvement goals that present a challenge to him—an increase from a 75 per cent to an 85 per cent level in one area, from 80 per cent to 90 per cent in another, and so on. Goals must give him something to work for by stretching him and requiring some special effort. Those that are set too low will tend to result in apathy and disinterest on the job. A man easily becomes accustomed to putting forth half-way effort and achieving half-way results.

At the same time don't neglect the above-average performers to concentrate only on those who are at or below average. They, too, need challenge to prevent them from losing interest in the job because of the feeling that the work has become routine and repetitive.

The percentage improvement goal that is established should be related to a specific area of accountability where improvement of performance is sought; it should bear some relationship to the individual's present level of performance as well as to the type of work involved. And it must be reasonable and realistic.

The manager as a catalytic agent

Improving results on the job is very seldom a single-handed, do-it-all-yourself proposition. Engineers will require assistance and support from any number of sources, including their immediate superior.

The superior can act as an important catalyst in helping the engineer identify the problems

EMPLOYEE PERFORMANCE ANALYSIS
AND
IMPROVEMENT PLANNING CHART

I. EMPLOYEE'S NAME	II. HIS PRESENT EFFICIENCY LEVEL (IN TERMS OF 100%)	III. AREAS IN WHICH HE NEEDS IMPROVEMENT	IV. SPECIFIC IMPROVEMENT OBJECTIVES (BY AREA)	V. HIS OVERALL EFFICIENCY RISE SOUGHT (IN %)
1. Adleman, R.	85	Fails to adopt constructive criticism	work-in-progress reviews to prevent tangents	5
2. Lea, J.	70	New man: Does not organize time, X-check refs.	1. Re-schedule time 2. Require alt. ref. listings	15
GROSS TOTAL COLUMN II.	822	WORK GROUP EFFICIENCY GOAL ADD	GROSS TOTAL COLUMN V.	80
DIVIDED BY NO. OF NAMES	10		DIVIDED BY NO. OF NAMES	10
EQUALS THE PRESENT AVERAGE EFFICIENCY OF WORK GROUP (%)	82	equals 90%	EQUALS AVERAGE EFFICIENCY IMPROVEMENT SOUGHT (%)	8

A single form used to arrive at improvement objectives set for individuals and the entire work unit. It shows present efficiency ratings for both, efficiency goals for both, and sets out the plan for reaching goals.

Column I lists each employee in the work unit. Column II lists the present efficiency rating of each on the basis of 100 per cent. Column III lists areas for each individual's improvement. Column IV lists objectives of improvements to be made by each. Column V lists total improvement percentage expected of each man.

An additional column (not shown here) can show each man's strengths as an aid to the manager in arriving at a figure for the man's present efficiency level (Column II).

Total Column II and divide this total by the number of employees listed to arrive at the present average efficiency of the work unit. Total Column V and divide this total by the number of employees listed to get the work unit's average improvement objective. Add averages of Column II and Column V to determine the work unit's over-all efficiency goal.

and difficulties that are hindering his accomplishment in a particular area of job accountability. His emphasis, however, should be placed on listening, counseling and helping rather than on telling. We must begin with the assumption that because the man is closer to the job, he is in the best position to identify problems and difficulties that exist for him, as well as to suggest ideas about things that could be done about them. A telling approach very often elicits a defensive reaction rather than creating a climate where the man wants to improve.

In addition, if there is over-control in terms of detailing exactly how and when everything is to be done, the results actually achieved do not reflect the full efforts of the individual. Within broad limits he should be allowed to exercise his own initiative and ingenuity in determining how to achieve certain objectives.

The manager should not get bogged down in the detail of "how" but rather should concentrate on control in a broader sense. The confidence and trust he exhibits will usually be rewarded by successful performance. When mistakes do occur, they should be used to contribute to future growth and development. Emphasis should not be on the mistake itself, but rather on why it happened and what can be done to avoid it in the future.

Chances are good that performance improvement objectives will not be accomplished if the manager's appraisal dwells too heavily on the negative. People have a maximum tolerance for the amount of criticism they can accept, whether it be leveled at several areas of performance or just one or two.

The man undergoing coaching and development must receive feedback on his performance in all levels of his accountability. This enables him to gauge his own progress and make his own adjustments where needed—a process that frees the manager from the distasteful role of a policeman who watches performance, notes deviations and "issues tickets" when necessary.

Performance appraisal, as an essential part of the coaching and development activity, is not a once- or twice-a-year activity—not if it is to bring worthwhile results. ■■

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Typical Properties	HyCo 8B	HyCo 8H
Residual Induction (B_r) gauss	8500	7000
Coercive Force (H_c) oersteds	1600	1900
Energy Product (B_dH_d) max.	5.00×10^6	5.00×10^6
Peak Magnetizing Force—oersteds	6000	6000
Permeance Coefficient at (B_dH_d) max.	5.25	4.25

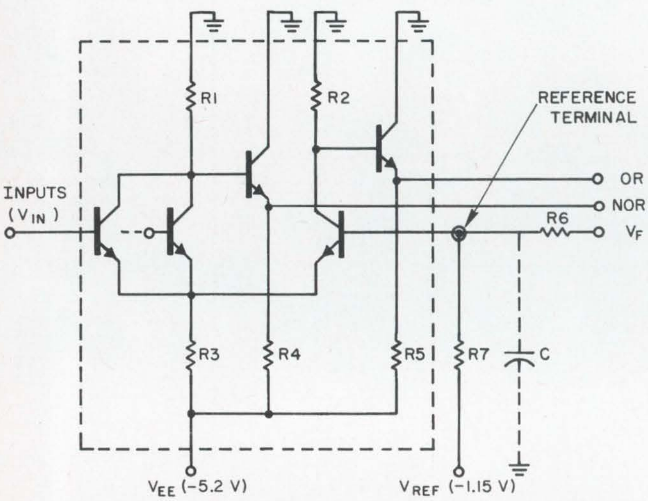
INDIANA GENERAL

Making Magnetics Work

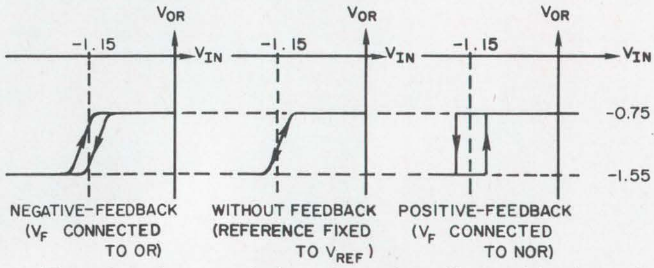
Delayed feedback improves ECL speed and noise immunity

Emitter-coupled logic (ECL), with emitter-follower level shifters at the outputs, is one of the most common high-speed integrated logic circuits. It can be made to operate even faster or with greater noise immunity by the addition of a simple delayed feedback loop.

As shown in Fig. 1, this can be done by adding a voltage divider, composed of R_6 and R_7, to the reference terminal. Then, when V_F is connected to the OR-output, an in-phase signal, delayed slightly from the input signal, is fed back to the reference terminal. The delay is several tenths to a few nanoseconds for high-speed ECL. If V_F is connected to the NOR-output, an out-of-phase signal, which is also delayed, is fed back. The capacitor, C, at the reference terminal adds an extra time delay to the reference signal. It can usually be omitted, though, because of the intrinsic delay between the input and output and the finite input capacitance at the reference terminal.



1. **Two resistors, R_6 and R_7,** are all that is needed to provide delayed feedback to the ECL circuit.



2. **Transfer characteristics** show the effect of both positive and negative delayed feedback on the ECL circuit.

The in-phase signal fed back to the reference terminal from the OR output effectively makes the threshold voltage of the circuit smaller, thus decreasing the propagation delay time. If high noise immunity is desired, delayed positive feedback, caused by an out-of-phase signal applied to the reference terminal from the NOR-output, can be used. However, this will also increase the propagation delay time slightly, because of the increased threshold voltage. Figure 2 shows the circuit transfer characteristics for both positive and negative feedback.

	Without feedback		With negative feedback[1]		Propagation delay time reduction
	Transition time[2]	Propagation time[3] delay	Transition time[2]	Propagation delay time[3]	
IC Circuit[1]	8.8 ns	6.7 ns	7.8 ns	5.0 ns	25.4%
IC Circuit[2]	4.4 ns	3.2 ns	4.2 ns	2.5 ns	21.9%
Discrete Circuit	2.1 ns	1.23 ns	1.9 ns	1.10 ns	10.5%

(1) $R_6 = 1.2\ k\Omega$, $R_7 = 2.4\ k\Omega$, C (External) = 0.
(2) Transition time = (rise time + fall time) /2.
(3) Propagation delay time = (delay time at rising edge + delay time at falling edge)/2; for fan-in = fan-out = 1 at NOR-output.

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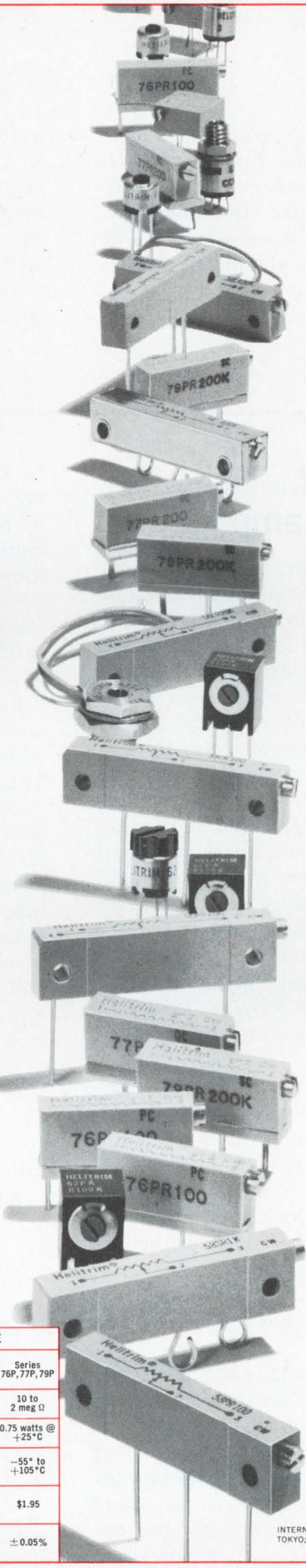

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INFORMATION RETRIEVAL NUMBER 40

The experimental results of propagation-delay and transition-time reductions for the delayed negative feedback case (V_F connected to OR) are shown in the table for integrated circuits and discrete components. As would be expected, the effect of feedback becomes less significant for the smaller transition time.

In cases where it is mandatory to exclude the reference voltage, V_{REF}, both external terminals of the voltage divider (V_F and V_{REF}) can be connected to the OR and NOR outputs to attain similar results. This, however, may cause some trouble due to the small difference in delay times at the OR and NOR outputs.

Akio Tojo, Researcher, Electromechanical Laboratory, Tokyo, Japan.

VOTE FOR 311

Infinite input impedance circuit uses one op amp

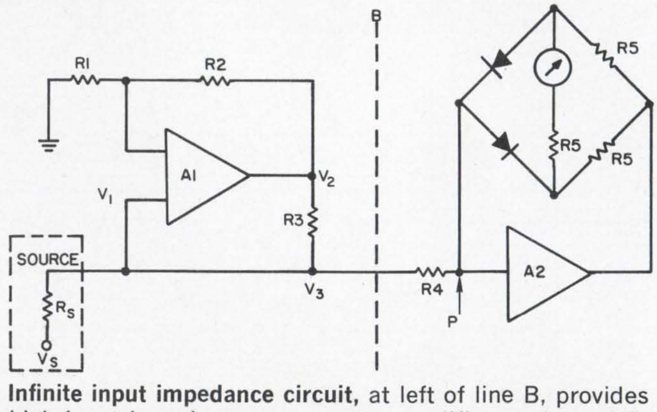
The conventional infinite input impedance circuit described in most operational-amplifier handbooks requires two operational amplifiers. With the circuit shown at the left of the illustration, the same thing can be accomplished with a single amplifier. With one amplifier used, instead of two in series, the delay of the feedback signal is only one-half as great. The error due to phase shift is, therefore smaller.

The circuit to the left of dotted line *B* in the illustration can provide a very high input impedance for any inverting operational-amplifier circuit that has a purely resistive input. In the circuit, V_S is the ac voltage to be measured, and R_S is the resistance of the source. V_1 is the voltage at the input of differential operational amplifier A_1. V_2 is equal to $(R_1 + R_2)\ V_1/R_1$, while point *P* is practically at ground potential, and $R_3/R_4 = R_2/R_1$. V_3 is the voltage produced by V_2 and the voltage divider R_3R_4. Thus, $V_3 = R_4V_2/\ (R_3 + R_4) = R_1V_2/(R_1 + R_2) = V_1$. V_3 therefore will provide the current drawn by amplifier A_1. No current is drawn from V_S, and $V_1 = V_S$. In actual practice, the ratio R_3/R_4 would be set to give a very high input impedance, rather than an infinite input impedance.

The circuit not only has a higher input impedance than a conventional voltage follower, but A_1 does not have to be a high gain or high input-impedance amplifier; therefore, error and frequency response can be the only consideration in selecting A_1.

In a conventional operational-amplifier voltage follower output voltage errors remain the same if the input voltage comes from a high- or a low-impedance source (except for current offset errors). These output errors are due to voltage offset, noise frequency response, and common mode error. If R_S in the illustration is a low value, the errors produced by A_1 will have little or no effect on V_3. This characteristic of the high-input-impedance circuit makes it especially applicable for use with voltmeters that use inverting operational amplifiers. If the voltage being measured (V_S) comes from a high-impedance source, the voltmeter circuit will draw very little current from the source. There will be errors in V_3 introduced by A_1, just as there would be errors in the output voltage of a conventional voltage follower. However, if the voltage being measured comes from a low-impedance source, V_1 will be practically equal to V_S. A_1 will introduce errors into V_2, but these will have little or no effect on V_3.

One application of the infinite input impedance circuit is shown to the right of dashed line *B* in the illustration. The circuit is an ac meter amplifier. A linear current meter in this circuit reads ac input voltage. If R_4 is 10 kilohms, and the three resistors labeled R_5 are 4.7 kilohms, the current through the meter is equal to $V_3/3R_4$ of $V_3/30$ mA. The circuit can also be used with operational amplifier circuits having two input resistors, such as the precision ac-to-dc converter and the precision absolute value circuit. The two input resistors of these circuits would be connected to V_3. The parallel resistance of these resistors divided by R_3 would be equal to R_1/R_2. The circuit can also be used for voltage-follower applications in analog computers.



Infinite input impedance circuit, at left of line B, provides high input impedance to ac meter amplifier at right of B.

Laboratory power. Popular price.

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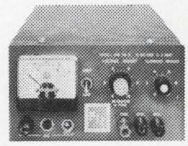

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SVC-20-15	0-20	0-15	*0.01% or 1mv	*0.01% or 1mv	3½ x 19 x 16⅝	470
SVC-20-30	0-20	0-30	*0.01% or 1mv	*0.01% or 1mv	5¼ x 19 x 16⅝	670
SVC-40-5 (Lab-Rak)	0-40	0-5	*0.01% or 1mv	*0.01% or 1mv	8 x 5 x 14	325
SVC-40-10	0-40	0-10	*0.01% or 1mv	*0.01% or 1mv	3½ x 19 x 16⅝	455
SVC-40-20	0-40	0-20	*0.01% or 1mv	*0.01% or 1mv	5¼ x 19 x 16⅝	650
SVC-60-3.5 (Lab-Rak)	0-60	0-3.5	*0.01% or 1mv	*0.01% or 1mv	8 x 5 x 14	345
SVC-60-7	0-60	0-7	*0.01% or 1mv	*0.01% or 1mv	3½ x 19 x 16⅝	575
SVC-60-14	0-60	0-14	*0.01% or 1mv	*0.01% or 1mv	5¼ x 19 x 16⅝	670
SVC-125-1.6 (Lab-Rak)	0-125	0-1.6	*0.01% or 1mv	*0.01% or 1mv	8 x 5 x 14	495
SVC-125-3.2	0-125	0-3.2	*0.01% or 1mv	*0.01% or 1mv	3½ x 19 x 16⅝	765
SVC-125-6.5	0-125	0-6.5	*0.01% or 1mv	*0.01% or 1mv	5¼ x 19 x 16⅝	1110

LVC Line

Model No.	Voltage	Current	Line (1)(3)	Load (2)(3)	Ripple	Size H x W x D	Price
LVC-10-2	0-10V	0-2A	.01%	±.01%	250 µv	4¾x4x12	$124
LVC-20-1	0-20V	0-1A	.01%	±.01%	250 µv	4¾x4x12	124
LVC-50-0.5	0-50V	0-0.5A	.01%	±.01%	250 µv	4¾x4x12	124
2LVC-10-2	Dual 0-10V	0-2A	.01%	±.01%	250 µv	4¾x8x12	248
	0-10V	0-4A					
	0-20V	0-2A					
2LVC-20-1	Dual 0-20V	0-1A	.01%	±.01%	250 µv	4¾x8x12	248
	0-20V	0-2A					
	0-40V	0-1A					
2LVC-50-0.5	Dual 0-50V	0-0.5A	.01%	±.01%	250 µv	4¾x8x12	248
	0-50V	0-1A					
	0-100V	0-0.5A					

(1) 105-125VAC (47-420 cps) (2) Measured NL-FL, FL-NL (3) or 2 mv whichever is greater.

RVC Line

Model No.	Volts	Amps	Load	Line	Dimensions H x W x D	Price
RVC-36-5	0-36	0-5	0.005% or 0.5mv	0.01% or 1.0 mv	3½ x 19 x 16⅝	$355
			1 ma/v change in output	1 ma		
RVC-36-15	0-36	0-15	0.01% or 1.0 mv	0.01% or 1.0 mv	5¼ x 19 x 16⅝	525
			3 ma/v change in output	3 ma		
RVC-36-25	0-36	0-25	0.01% or 1.0 mv	0.01% or 1.0 mv	7 x 19 x 16⅝	670
			5 ma/v change in output	5 ma		

RB Line

Model No.	Volts	Amps	Load	Line	Dimensions H x W x D	Price
RB-18-3-M	0-18	0-3	0.01% or 1 mv	0.01% or 1 mv	4½ x 8 x 14⅜	$225
			2 ma/V change in output	0.5 ma		
RB-36-2-M	0-36	0-2	0.01% or 1 mv	0.01% or 1 mv	4½ x 8 x 14⅜	225
			1 ma/V change in output	0.5 ma		
RB-50-1.5-M	0-50	0-1.5	0.01% or 1 mv	0.01% or 1 mv	4½ x 8 x 14⅜	245
			0.75 ma/V change in output	0.5 ma		

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358

Although a patent application has been made, the circuit may be manufactured and used by, or for, the government without compensation.

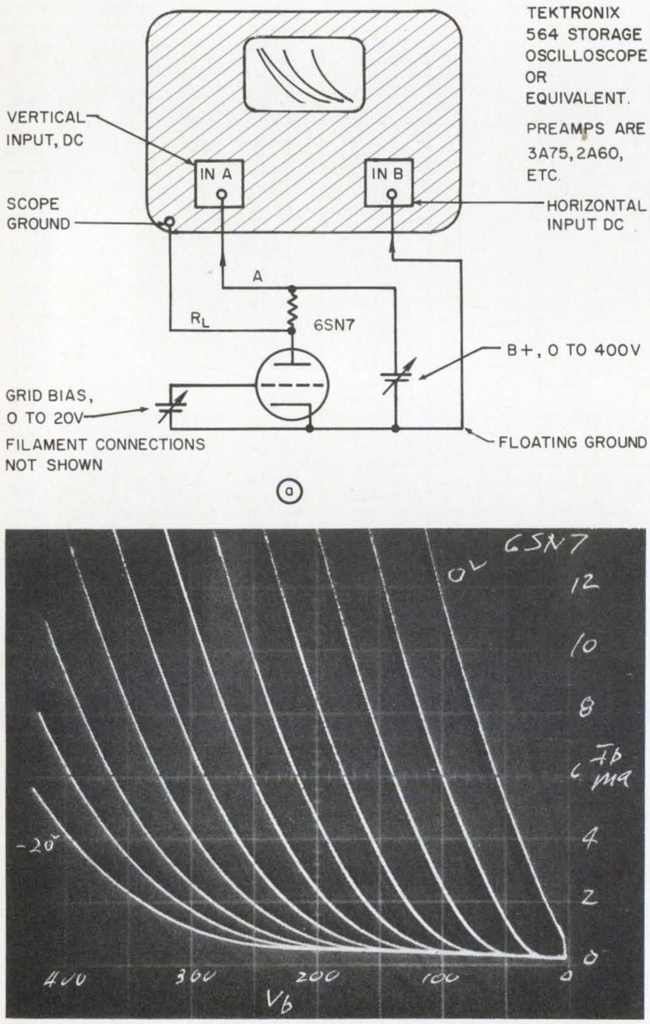
Walter Ellermeyer, Design Engineer, U. S. Navy Electronics Lab., San Diego, Calif.

VOTE FOR 312

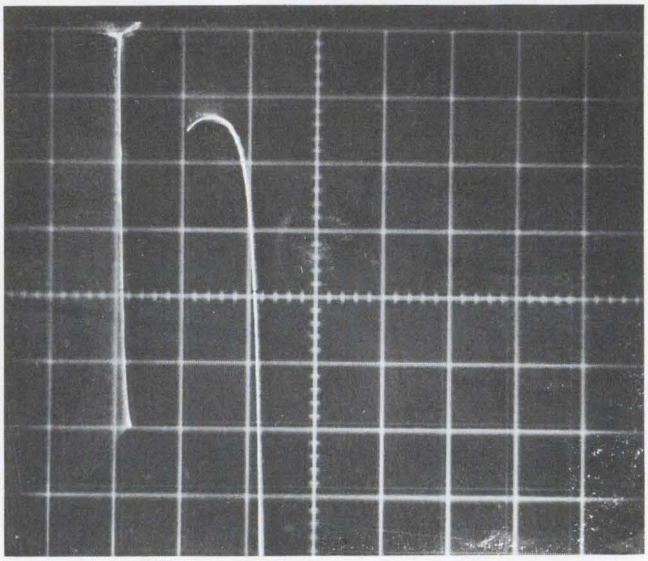
Storage scope displays characteristic curves

The approximate characteristic curves of such active devices as tubes, transistors, field-effect transistors and diodes can be displayed on a storage oscilloscope that has both x- and y-deflection preamplifiers available for inputs.

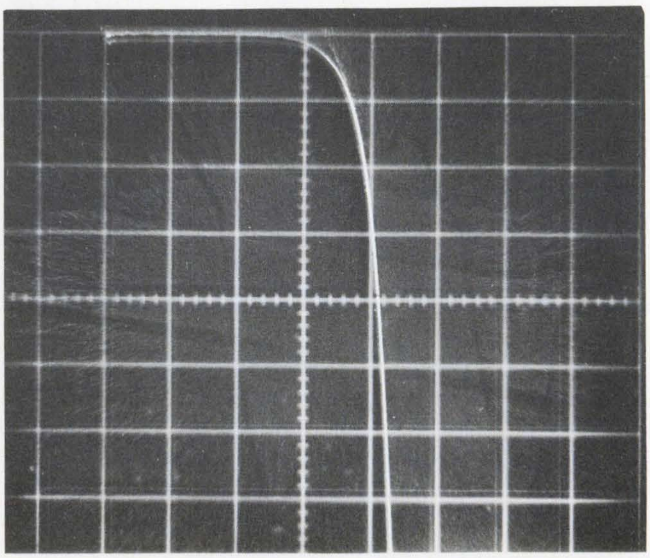
To illustrate this display method, assume that it is desired to display the characteristics of a 6SN7 tube. A pictorial presentation of the method is shown in Fig. 1 (top) and the resulting curves in Fig. 1 (bottom). In this particular instance plate current is displayed on the vertical axis, and plate voltage on the horizontal axis. Initial calibration of both axes is required, and, in the photograph, the calibration is horizontal, 50 V/cm; vertical, 2 mA/cm. Once the calibration is performed, all that is necessary to trace the curves is to set the scope on store, set the required grid voltage, and vary the B+ supply from 0 to 400 V.



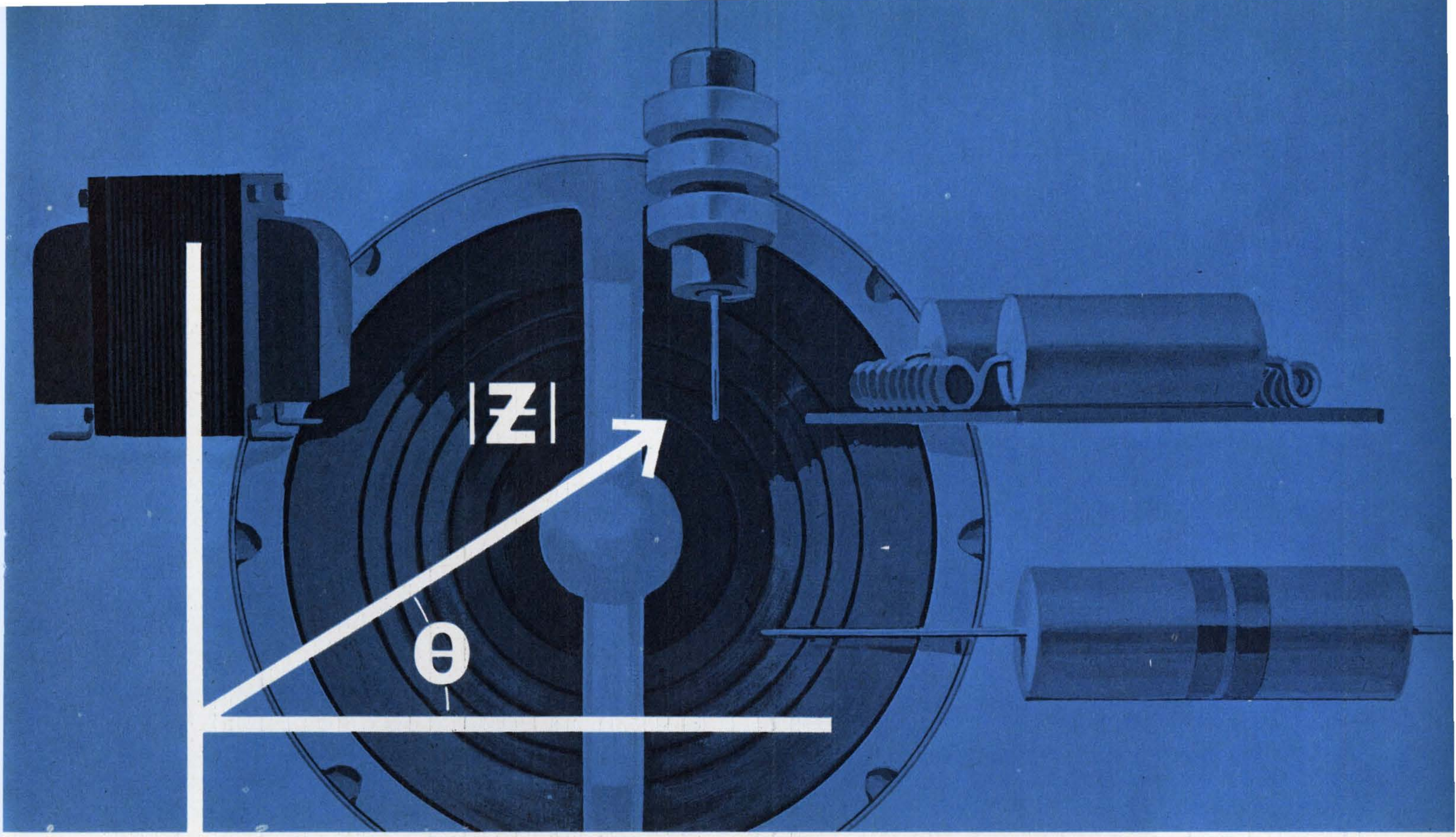
1. **Plate voltage serves as scope ground** in this arrangement (top) for displaying characteristic curves on a storage scope. The resulting curves (bottom) are then produced by varying the B+ voltage.



2. **Tunnel diode characteristic curve** was produced with the following calibration: horizontal axis, 0.2 V/cm; vertical axis, 0.5 mA/cm.



3. **Zener diode characteristic curve** was produced with the following calibration: horizontal axis, 1 V/cm; vertical axis, 1 mA/cm.



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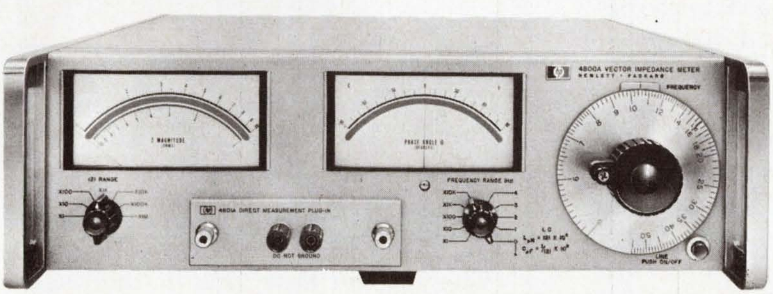
Application Note 86 describes many applications of the 4800A Vector Impedance Meter (5 Hz to 500 kHz) and the 4815A RF Vector Impedance Meter which operates in the 500 kHz to 108 MHz range. For your copy and complete specifications, contact your local Hewlett-Packard field engineer or write: Hewlett-Packard, Rockaway Division, Green Pond Road, Rockaway, N. J. 07866.

Pertinent Specifications:

Frequency Range: 5 Hz to 500 kHz, continuous.
Impedance Range: 1 ohm to 10 megohms.
Phase Range: 0 to ±90°.
Price: $1650.



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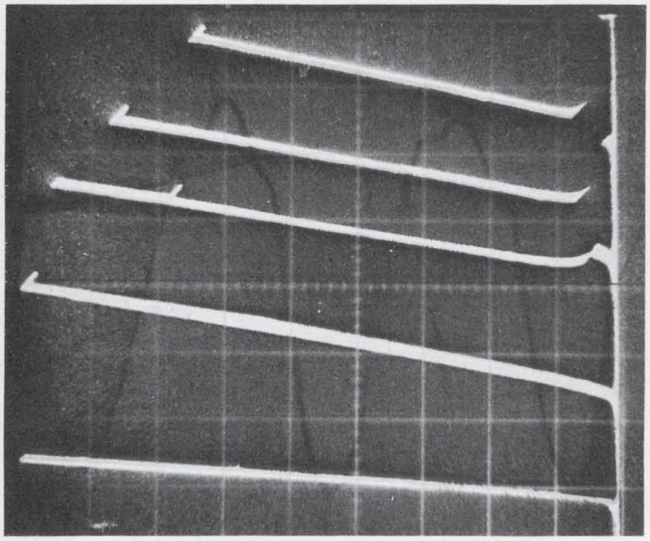
IMPEDANCE INSTRUMENTS



4. **Transistor characteristic curve** was produced with the following calibration: horizontal axis, 2 V/cm; vertical axis, 1 mA/cm. Base current is 10 μA per step.

The technique, shown here for a tube, is equally applicable to semiconductor devices. Curves produced for tunnel diodes, zener diodes and transistors are shown in Figs. 2, 3 and 4.

Ronald Tolmei, Graduate Student, University of Vermont, College of Technology, Burlington, Vt.

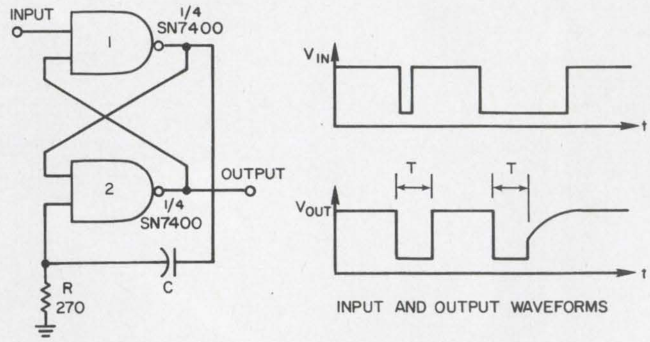
VOTE FOR 313

Simple one-shot circuit uses half a quad gate module

A simple and inexpensive one-shot can be made with half of a TTL quad, 2-input gate module (see diagram).

The output of the circuit is normally high. When a negative-going transition occurs at the input, the output of gate 1 goes high. Due to the low output impedance of a TTL gate, 3 volts (nominally) are dropped across the 270-ohm resistor and applied to the input of gate 2, the other input of which also goes high. Gate 2 turns on for a period, T, which is the time required for the voltage across the resistor to decay to the threshold voltage of the gate.

If the negative-going pulse applied to the input is shorter than the output pulse duration T, the output pulse terminates with a regenerative flip back to the quiescent state, resulting in a fast rise time. When the input pulse is longer than T, the pulse terminates with a slow-rising trailing edge (see waveforms).



Output pulse duration of the one-shot circuit is controlled by the value of capacitor C.

The output pulse duration should be controlled by choosing a suitable value for capacitor C, rather than selecting a different resistor value. The resistor value is determined according to the following criteria: It must be large enough to drop sufficient voltage when gate 1 turns off and the output voltage is initially divided between the resistor and the gate output impedance. Conversely, it must be small enough so that the voltage across it can decay to a value lower than the gate threshold voltage, while sinking the input current of the gate. It should be noted that once the circuit has flipped back to its quiescent state and the input is high, the noise immunity is not impaired by the resistor. This is because the second input of gate 2 is pulled down by gate 1.

With $R = 270$ ohms and $C = 0.1\ \mu$F, a pulse duration of approximately 4 μs was obtained. With the same resistor and a 12 μF tantalum capacitor —with the positive lead connected to the output of gate 1 the pulse duration was approximately 4 ms. In both cases, the rise and fall times of the output pulse—with an input pulse shorter than T—were less than 20 ns.

Reuven Peri, Senior Research Engineer, Moore Associates Division, The Rucker Co., San Carlos, Calif.

VOTE FOR 314

IFD Winner for August 15, 1968
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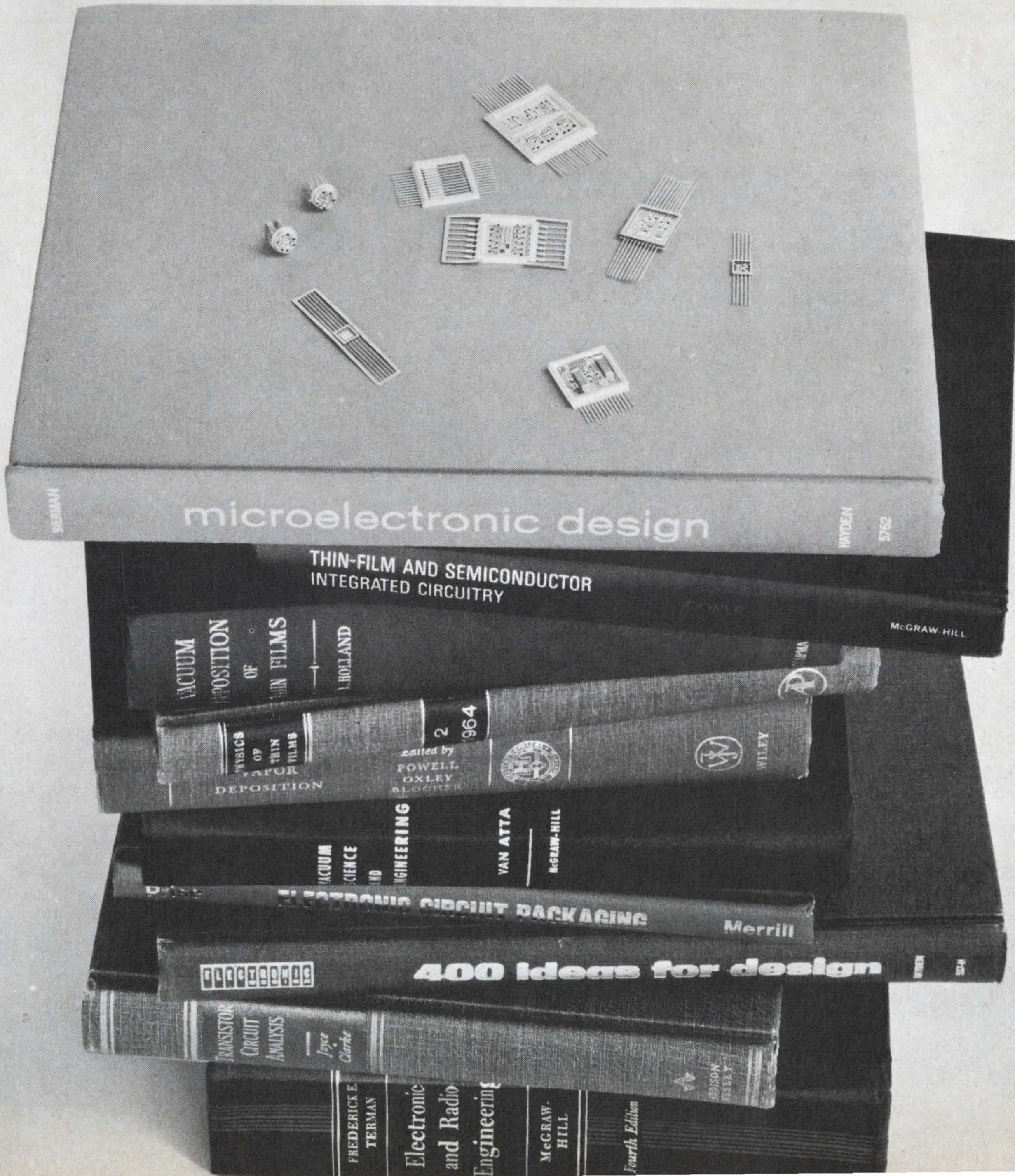

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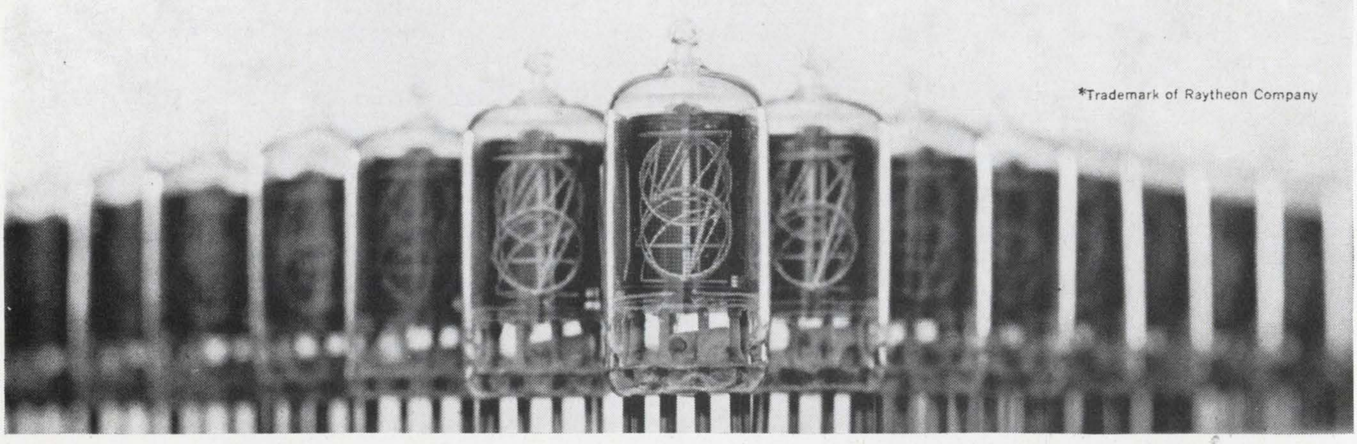

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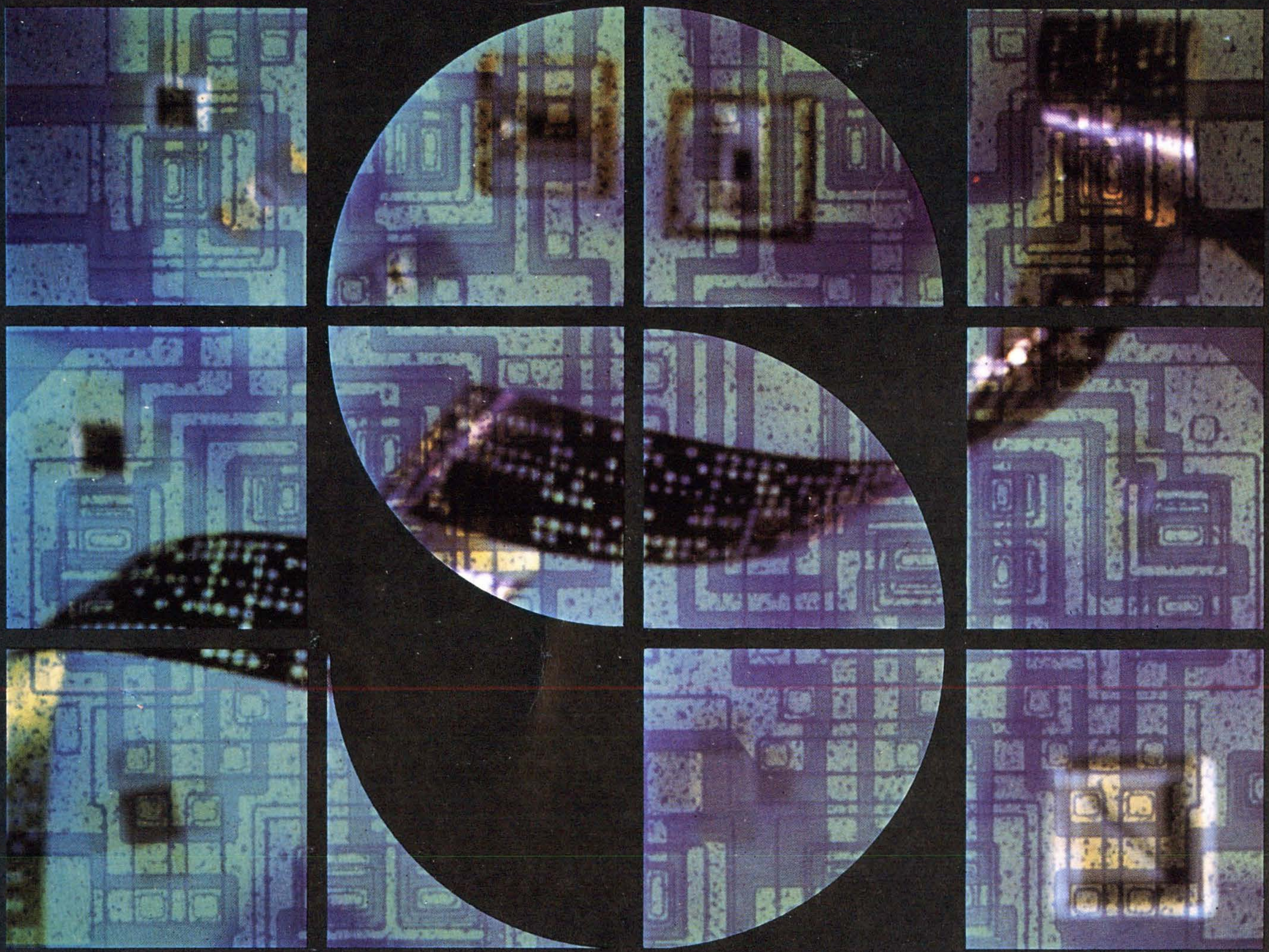
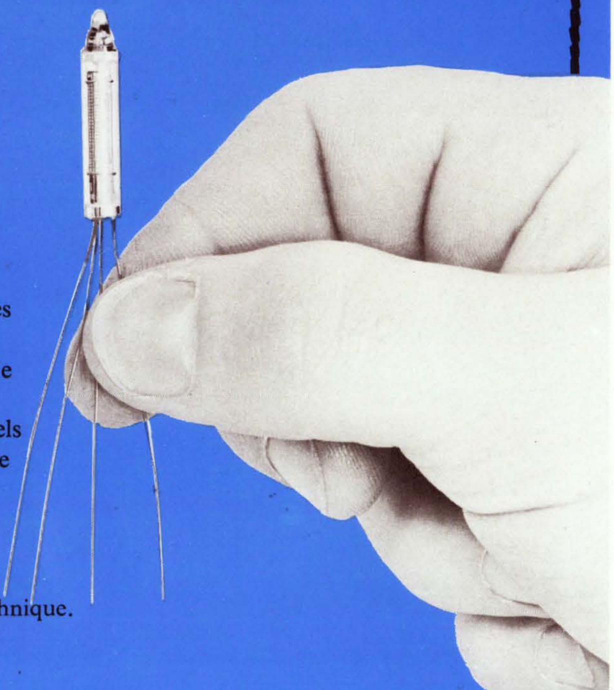
An Electronic Design Special Report



AND COMPUTER DESIGN

edited by Raymond Daniel Speer

The tube that made most computer indicator system designs obsolete!



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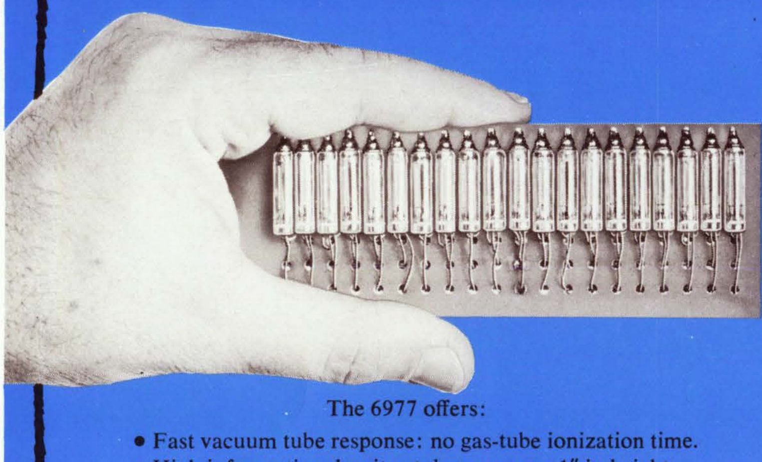

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TOMORROW'S THINKING IN TODAY'S PRODUCTS

LSI and Computer Design

LSI offers impressive advantages to the computer designer. He can save in connector wiring and system packaging costs, increase the speed of his system, reduce the parts count and increase the reliability. Yet designers are extremely cautious about LSI. Why?

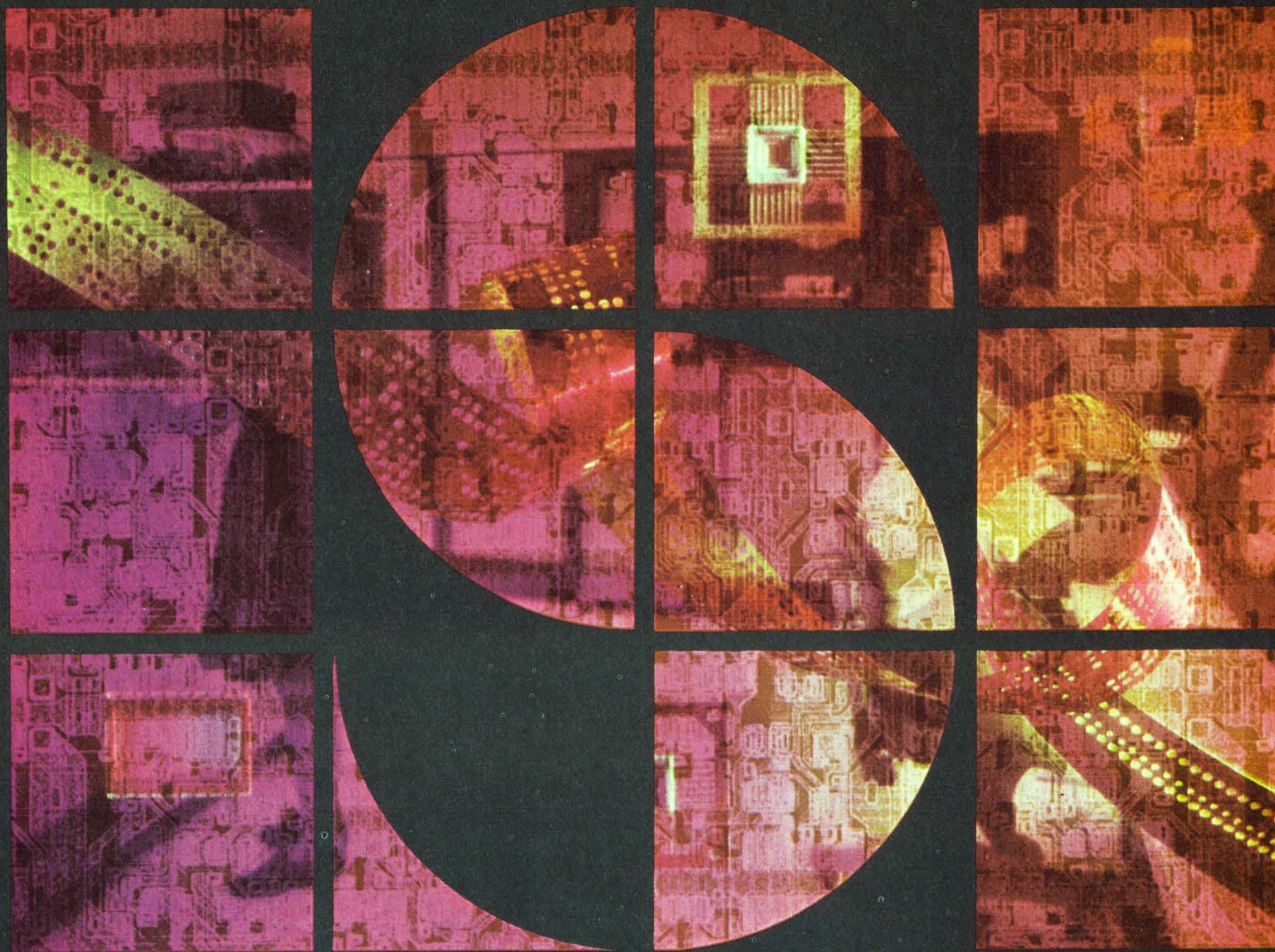
There are many reasons. Possible savings in hardware are often ignored in cost comparisons, and the higher apparent cost-per-gate for LSI circuits discourages buyers. Potential users are also very reluctant to relinquish control of their designs. They feel that too many design details will be buried in a computer at a distant vendor's plant. They have little confidence that their LSI purchase will work on the first run-through, and they fear the possibility of expensive redesign. Even if their circuit works, the burn-in yields may be very low—and they'll be faced with real testing problems in system checkout.

Many of these arguments against LSI have a familiar ring. They were used against ICs. LSI components will be accepted and used, it is widely believed, when users acquire confidence in the technology and the vendors. For a good look at what vendors see in the future, and what they offer now, turn the page. For a discussion of the problems faced by the computer manufacturers turn to page C50.

1968 Fall Joint Computer Conference

Data links—common-carrier toll lines between computers—are growing in importance. Printers, cathode-ray display devices, teletype units and computer-output typewriters all demand high-quality transmission facilities. But the cost to the user remains high, perhaps unnecessarily so.

The Federal Communications Commission is investigating restrictive practices and high tariffs in the transmission of data over phone lines. The inquiry has already resulted in a proposal for tariff changes and a relaxation of interface restrictions. You can now attach your own equipment to the telephone lines through a low-cost coupling unit that is available from the telephone company. Details of the inquiry will be discussed by FCC consultants at Session 7 of the computer conference. Turn to page C36 for a review of this and other sessions of interest. For a look at some of the products to be displayed, check page C66.



LSI memories change computer design

Active memories are fast—but expensive. Because their manufacturing costs run higher than those for core memories—\$1 per bit against 10 cents—they have been used only where a need for speed justified their cost.

They also have this disadvantage: The data stored in certain active memories are volatile—if power fails, all data are lost. For those applications in which the stored data must not be lost, such volatility is a significant drawback.

But if you can live with this shortcoming, take heart. Large-scale integration is going to bring the costs down. Applications for active memory will multiply, especially in special-problem areas where their great superiority in speed is critical. The market in these areas includes small computers, terminals, displays and similar applications. Total sales should hit \$50 million by 1975.

This special-application market will provide financial support for further research and development. Reliability will improve, and LSI active memories will be used in main-frames, perhaps as soon as 1972.

Already, use of active memories is forcing changes in memory system design. Let's consider some of the changes, and their consequences for design:

Memory-module sizes will be much smaller. The economical module size for active memory is now an order of magnitude smaller than that for magnetic memory. And while on the order of 4096 ferrite cores must be strung at one time to make core memory economical, active memory can be built in 256-bit units.

Smaller modules simplify failure diagnosis and field repair. At the same time maintenance and spare parts' costs are reduced. And only a one-part inventory need be stocked for the entire main-frame memory.

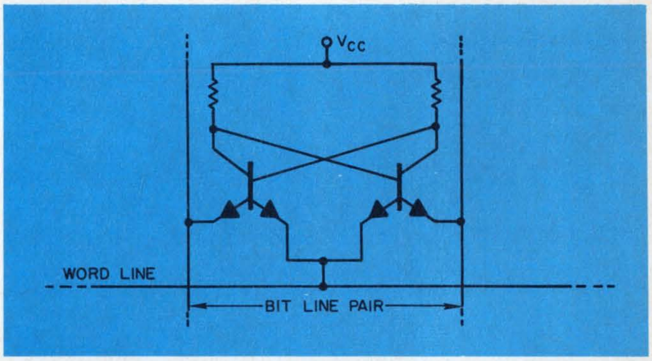
Small modules will allow the construction of memories of varying capacities and dimensions with a minimum of design, tooling and other expense. These small memories will be distributed about the processing system to optimize the electrical access time of the data stored. The basic module corresponds to the memory page size used in computers with page address relocatability.[1] This leads to automatic page-fault location and data rerouting; the defective page can be bypassed by the executive routine until it can be replaced.

Active main-frame memories provide the only reasonable possibility for an improvement in central-processor speeds. The improvement is by a factor of five to ten over current systems. Ferrite-core, flat-film magnetic and plated-wire magnetic memories are either too slow or too expensive.

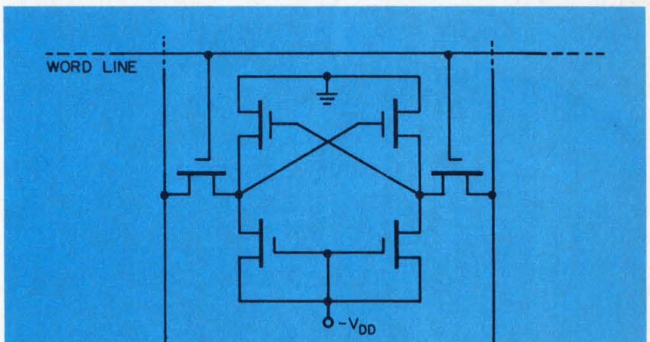
The availability of semiconductor read-only memories, at costs below 0.1 cent per bit and with 20-to-50-ns performance, will allow a major change to be made in the design of central computer-control sections. Currently the control section is a formless mass of logic that interconnects the time-sequence generator, instruction-decoder and temporary-storage elements. The code translation it performs can be done easily by a uniform read-only memory array. Such memories will simplify and reduce the cost of field changes in computing systems and will, therefore, replace the bulk of the random logic used for control of the arithmetic section of the processor.

The possibility of obtaining large-scale, content-addressable memory at a reasonable price will allow research into extremely powerful computing systems. This may open the door to a whole new industrial revolution in computer design and application.

Active memories made their debut in large-scale data processors. An IC register array re-

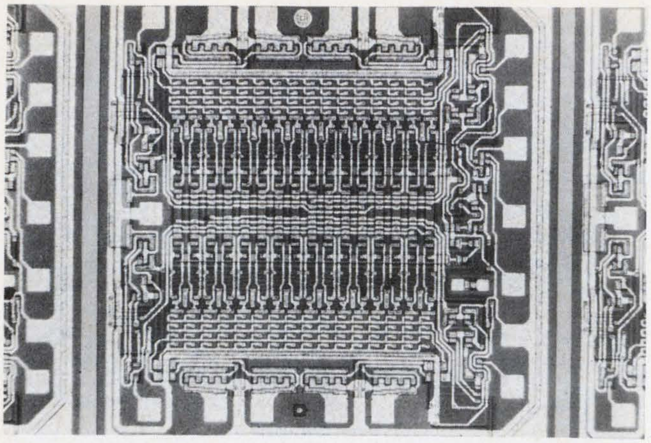


1. **The multiple-emitter bipolar latch circuit** is the basic storage element in all successful active memories. This latch circuit is the "ferrite core" of active memories.

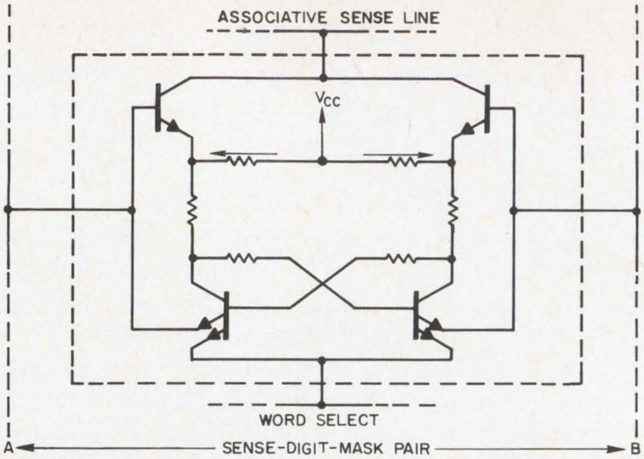


2. **The MOS cross-coupled flip-flop** is the basic storage element for MOS memories. The transistors have higher thresholds and lower intrinsic gain than bipolar devices; voltage swings must therefore be larger. The result is slower operation.

Wally Raisanen, Manager, MOS and Memory Products, Motorola Semiconductor Products Inc., Phoenix, Ariz.



3. **A 128-bit read-only memory,** the Motorola XC170, is for use in display code conversion, peripheral equipment and in general-purpose logic applications—for example, as an 8-channel data router.



4. **An IC associative cell** provides data storage, bit selection and association. The association feature is used in machines that modify their computing process, according to a program, as the computation progresses.

placed a high-speed, thin-film, scratch-pad memory in the UNIVAC 1108. A more sophisticated design for scratch-pad memory was then used in the I/O control of the arithmetic of the SDS Sigma series.[2] Honeywell's new 4200-8200 computers use up to 16,000 bits of active memory, and recent experimental aerospace computers use active memory for volatile scratch-pad and microinstruction decoders.[3] The IBM 360 Model 85 contains high-speed semiconductor associative memory.[4]

Motivating all of these applications has been the desire for higher speeds. To better understand these speed advantages, let's look at how they are gained by memory technology.

The storage array: The cost of active memories is dominated by the cost of manufacturing the storage array. For random-access memories, the basic requirements for the storage array are low standby power, high switching speed and, of course, low manufacturing expense. For economy in sense-digit and word-driver circuits, low parasitic capacitance and low leakage currents are required. The multiple-emitter bipolar latch circuit (Fig. 1) fulfills all requirements, with the exception of low power dissipation. Typical power dissipation is 2 to 10 mW. The MOS cross-coupled flip-flop (Fig. 2), on the other hand, fulfills all requirements except that of high speed. Consequently each design finds favor, depending on the ultimate application of the memory system.

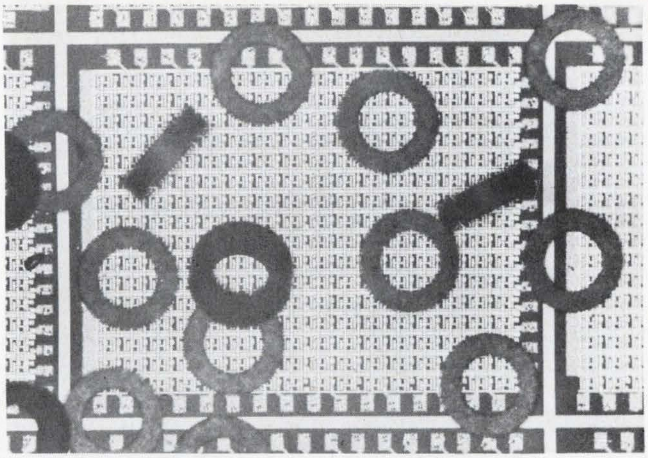
The bipolar storage array will ultimately cost two or three times more to manufacture than the MOS array. Bipolar wafer processing is more complex than MOS processing, and the bipolar array has a sensitivity to crystal faults and diffusion damage not found in the MOS circuit. Because the sense circuits and word decoders exert a dominant influence on cycle time of the active memory, the lower speed of the MOS array does not prove to be a significant disadvantage. But for the future, speed must be better than 50 ns, and the bipolar storage array will probably be preferred.

Complementary MOS ICs will allow construction of storage cells that dissipate only nanowatts of standby power. The increased complexity of the complementary MOS manufacturing process presently restricts application of this type of storage array to areas in which extremely low power is required, and high cost per bit is not a limiting factor. The complementary MOS device also suffers from susceptibility to losses in yield, through crystal damage, and this increases the ultimate manufacturing cost of this type of storage array.

Sense and Drive Circuits: Leakage in bipolar storage arrays and stray capacitance in MOS storage arrays limit the dimension of the basic modules, in the bit direction, to less than 128 storage locations. In the word direction, the larger bias current of the bipolar array suggests a limitation of 128 or less. For the MOS array, however, if bipolar word drivers are used, up to 512 bit-locations can be driven at a reasonable speed and power dissipation.

The total power dissipation of the active memory is its outstanding limitation with regard to system use. This difficulty may be circumvented by switching the power-supply voltages on the unaccessed portions of the storage array.[5] Dissipation in the word-drive circuitry and decoders, in the sense amplifiers and in the digit amplifiers may be reduced in a similar manner. Clever control-circuit design will achieve these features without complicating the application of memory to the computing system.

Read-Only Memory Storage Arrays: Bipolar and MOS read-only memories, with zero standby



5. **Standard 20-mil ferrite cores neatly encircle six active-memory storage cells.** Storage area is 10 times smaller in the active memory. Wires are shorter and speed is increased by roughly a factor of 3.

power, have been designed and are now commercially available. For the present, the bipolar read-only memory designs are restricted in their application to small, high-speed arrays.[6] Figure 3 shows a 128-bit read-only memory that contains all of the circuitry required for decoding 4 bits to 16 locations, for storage of 128 bits, for buffering the sensed data to logic, and for selection of one to four 16-word groups.

Advanced bipolar designs will soon allow economical construction of read-only memory arrays of 16,000 bits and upward. These will find use as microprogram translaters in high-speed computers (Fig. 4). Low-performance, low-cost arrays are now available. Their main application area is character-pattern generation for CRT displays.

Current prices are less than a cent per bit for 1024-bit and 2048-bit chip designs. The ultimate manufacturing cost of both bipolar and MOS read-only memory arrays of this size will probably fall to less than a tenth of a cent per bit. Certainly the most significant disadvantage of the semiconductor read-only memory is the long turnaround time associated with storing a new data pattern; this is because IC processing masks must be modified. High-speed, computer-controlled drafting machines can be used to generate the masks in less than a day, but ordering, specifying data, assembling the components, testing and shipping will probably keep turn-around times at longer than two weeks.

Content-Addressable Memories: Content-addressable, or associative, memories have been discussed in the technical literature for about 10 years, but their cost severely restricts their application. No economically feasible cell design has yet appeared. The IBM Model 360-85 application is a good example of a high-cost, high-speed associative memory. Although simpler associative storage cells have been developed, they await applications of sufficiently high volume to warrant their manufacture.

In the 1980's very large associative memories may allow the construction of computers that will generalize and process data in ways that can be modified on the basis of the results of previous processing. This activity may lead to computer systems that will give the appearance of intelligence and creative ability. The associative cell (Fig. 5) can now be constructed in moderate quantities for roughly 25 cents a bit. Given volume application and sufficient time to develop the technology, it appears that the ultimate cost will be not more than two or three times that of a more conventional storage array.

Optimum-Cost Module Design: The cost of the storage-array chip—the most expensive part of the active memory—must be as low as possible. With present technology, optimum module size appears to be in the neighborhood of 256 bits a chip, with a size approximating a tenth of an inch square.[7]

Since this storage size is uneconomical in terms of packaging efficiency, it is necessary to assemble a number of such chips into the first-level repairable subassembly. Usually 16 or more are interconnected into a basic storage plane, which may be organized either as a bit-plane or as a linear-select array of about 64 words by 64 bits. Surrounding the storage array is a group of IC chips that comprise the word decoders and drivers, the sense amplifiers and the digit drivers. Control circuitry for timing the memory, strobing the power supplies and electrically reconfiguring the word length may be required.

Typically, IC chips are uniformly distributed about a ceramic or metal heat sink and are interconnected by a thin- or thick-film conductor network. The conductors are connected to the active circuitry by either thermo compression or ultrasonically bonded flying-wire jumpers. This interconnection method, however, has serious disadvantages: The reliability of the flying leads is poor, so they degrade the over-all system reliability, and the cost of manually placing thousands of flying-leads far exceeds that of all other assembly costs.

For these reasons, beam-lead structures have been developed for connecting the IC dice to the interconnection wiring.[8] Beam leads are jumpers that are 2 to 4 mils wide, 0.5 mil thick and 8 to 24 mils long. They are formed during the manufacturing of the IC or the interconnect structure, and are a continuous extension of the metalization to which they are attached. The free end is bonded to the mating part as microassembly proceeds.

In advanced manufacturing systems, up to 14 of these free ends are bonded with a single tool stroke. This type of structure provides the ultimate in bond reliability, and the process can be automated to reduce assembly costs.

In the more desirable system designs, this interconnected array of IC chips forms a subassembly, which is the first repair level of a memory system. It appears that chip-failure rates as low as 0.001 per cent in one thousand hours can be obtained with such designs. This corresponds to a mean time before failure of one year for a million-bit semiconductor memory comprised of an array of modules.

Thermal System Design: In a 4096-bit basic bipolar module, the power dissipation will be 8 to 10 watts (for an MOS module not using power switching, it will be less than a watt). Ten watts of power dissipation can be easily handled with a conventional forced-air cooling system, if a physical volume of 8 cubic inches is allowed for each module and a metallic heat radiator with 32 square inches of surface area is employed to transfer heat to the air stream.

For more compact system designs, more sophisticated means of cooling are required. Successful designs employ metallic or ceramic conduction of heat from the IC chips to a metallic card cage, which has coolant channels that carry freon—or an equivalent cooling agent—as part of its wall structure. By using such a structure, the designer can pack 4096 bits into as little as two cubic inches without sacrificing ease of repair.

Main-Frame IC Memory: For industrial computers of the 1970's, cycle times of 200 ns or less will be required in the main frame. The only reasonable contenders are extremely small ferrite-core (Fig. 6), flat-film magnetic, plated-wire magnetic and LSI active memories.

Active memories can easily be designed to cycle in the 75-to-200-ns range at a power dissipation comparable to that of other technologies and at substantially less cost per bit.

The cost of manufacturing of flat-film magnetic memories has not been reduced sufficiently to allow their use in the main-frame application. Similarly the high cost of manufacturing ferrite cores that have an internal diameter of 6 mils, as well as the cost of stringing such small-core memories, will preclude their use.[9] Present developments do not hold promise for reducing the cycle time of low-cost, plated-wire memories much below 400 ns.

As the technology progresses, the minimum-cost point for segmentation of large memories into basic modules will rise. In the late 1970's the optimum-cost module will consist of approximately 64,000 bits. At that time a 100-million-bit memory will have a mean time to failure in the neighborhood of one year. It will be sold for less than 3 cents a bit. The read or write cycle time will be below 200 ns; for higher power-dissipation designs, it could be below 100 ns. Such a memory can be contained in a 3-by-3-by-4-foot cube, which would be cooled by both conduction and liquid-transfer means.

The internal regularity of interconnection of the classical random-access memory, the uniformity of application in data processors, and the similarity of the various memory system organizations all lead to great economies in LSI manufacture. LSI has made active memories possible, and the cost and speed performance inherent in LSI memory designs will provide the technical base for the next generation of high speed digital data processors. ■■

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Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What is the predicted active-memory market for 1975?

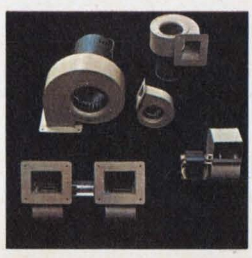
2. How soon will LSI active memory be applied to main frames?

3. What are five expected changes in memory-system design that will result from wide use of active memory?

4. The ultimate manufacturing cost of both bipolar and MOS read-only memories is expected to be very low. How low?

Moving air is easy... controlling it takes an expert

Clearing a path in traffic is seldom a problem for the trucker who has mastered the dock-wallopers whistle. Ear-splitting in its audibility, that shrill, sharp blast says "Move it Mac" with an authority few mortals would care to dispute. It figures. Anyone capable of channeling air with such finesse has little trouble communicating with even the most literal-minded audience. Take Torrington's team of engineers. When it comes to controlling the movement of air, they're experts at making themselves understood. The language they talk is pure Crossflo(TM), centrifugal, vane—or tube—axial. Got a big or small air flow problem requiring straight interpretation? We've got the specialists to help you. The Torrington Manufacturing Company.



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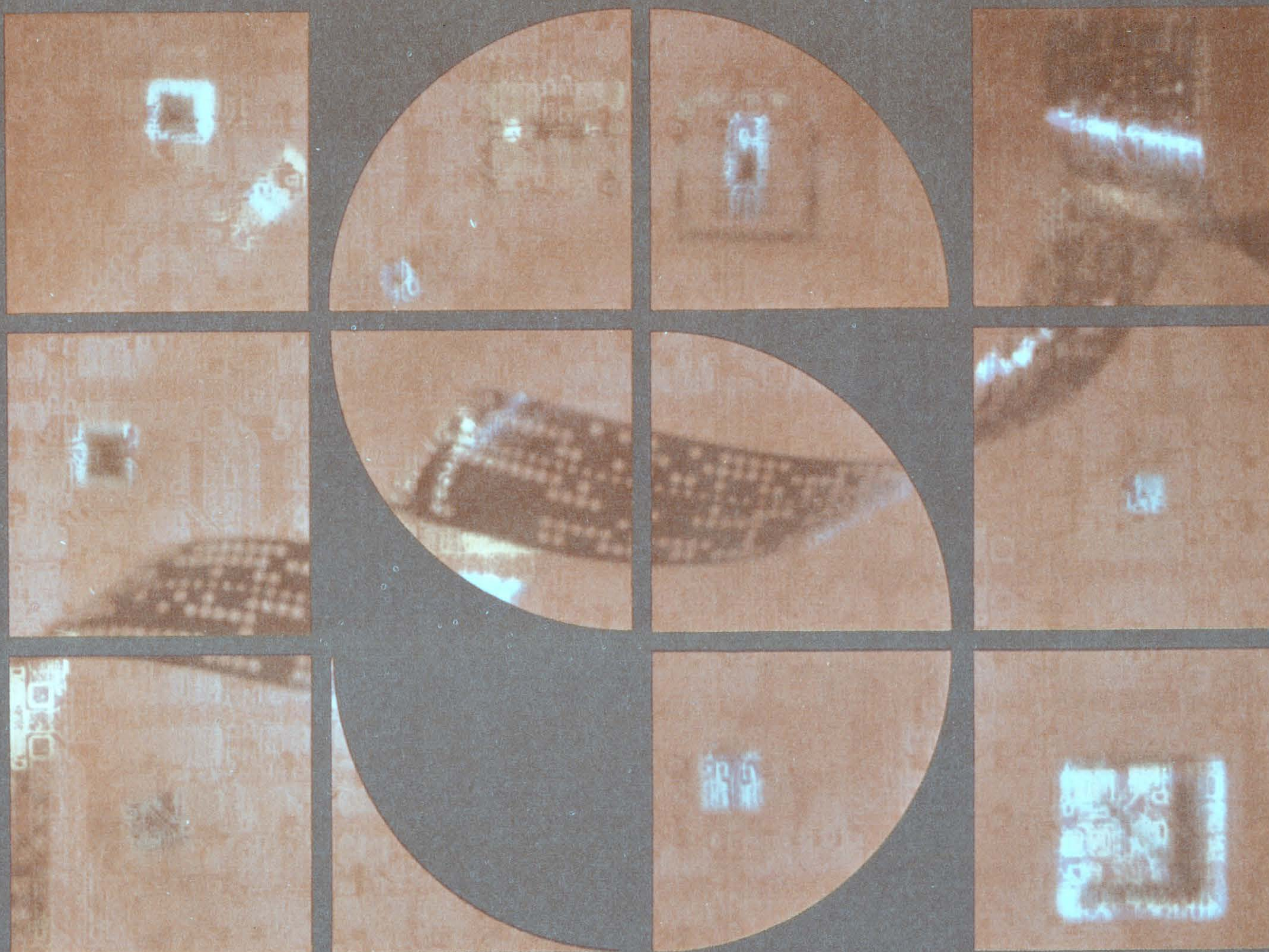


Computer-aids speed discretionary wiring

It's very difficult to make an LSI wafer on which all circuits work. Process problems, impurities and crystal defects cause a number of faulty circuits on each wafer. If the circuits are to be connected into a functional array by a fixed wiring arrangement, a single defective circuit can cause a whole wafer to be rejected.

But if all of the circuits on the wafer are tested, and only the good ones are used in the complex logic function, a number of reject circuits can be tolerated. This is discretionary wiring. The result—a considerable reduction in the wafer-reject rate.

There is one major drawback—a unique metalization pattern may be required for each wafer, even though the final logic functions are identical. The savings resulting from reduced reject rate could easily be lost in the added design costs. For the discretionary approach to be economical, a means for quickly generating low-cost wiring designs and a high-speed low-cost mask generation system must be available. Computer aided design makes it all possible.

Design automation speeds delivery

In Texas Instruments' bipolar discretionary LSI, three layers of metal interconnection pattern are added to the wafer (Fig. 1). The first level connects resistors, diodes and transistors to form logic gates and flip-flops. The second and third layers correspond to the interconnections found between discrete ICs on a printed-wiring board.

The initial processing of an LSI wafer is very siimlar to that of a standard IC. After the circuit processing, however, and before adding the metallization, the entire wafer is tested to determine which gates and which flip-flops are good. The test results are used as input data to a series of computer programs called the discretionary wiring system (Fig. 2). This system generates the mask design required to avoid bad circuits.[1]

The design procedure (Fig. 3) begins with receipt of a logic diagram. The logic diagram is transformed into data which can be used by the computer to define the logic diagram. A program called the LSI data-checker is used to check the consistency in the logic diagram as well as to transpose the computer-generated logic listing by device into a listing by node. This program provides diagnostic messages if errors or inconsistencies are detected in the data. The logic data checker has detected errors in over 75% of the logic functions received.

If test patterns are received, the logic-data description can be used as the input to a simulation program, and the test patterns can be used to check the simulated logic. This procedure assures the accuracy of the computer form of logic diagram, and is more accurate than a simple check of the logic diagram.

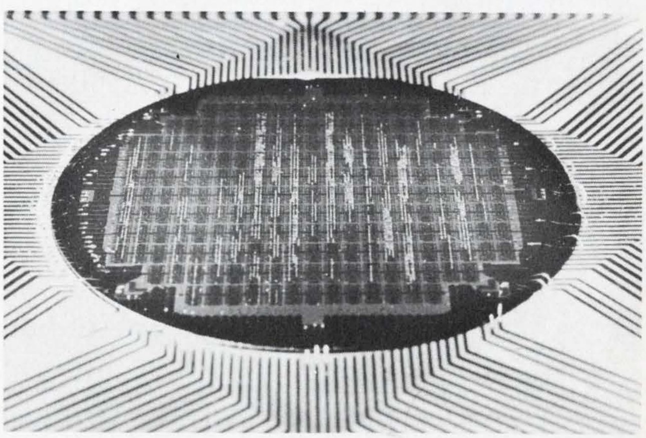
After checking the correctness of the logic diagram, the test-sequence-generation program is used by an engineer to develop a set of tests for the slice. If no test patterns are available, a set of tests is generated using a test-generation program.

The logic-data checking program generates a map of the register positions—in the computer driving the tester—and the connector pins on the LSI slice. This register-to-pin assignment is combined with the test patterns and used to make the magentic tape, which is the input for the test system. Finally, the logic-function data is used as an input to the discretionary-wiring system, to create the masks corresponding to that logic function.

The main purpose of the design-automation software is to rapidly produce an accurate mask for manufacturing the custom arrays. Both the data checker and simulator are necessary as a check on the logic function. The test-generation program is necessary to achieve the short cycle-time needed for custom arrays.

The logic-data checker applies consistency tests to the logic-function description, as well as displaying it in several ways. Basically, the logic-data checker constitutes the primary source of machine-compatible logic-function data for a particular custom logic function. Consider the following example: a simple two-gate circuit.

Here, the output of a four-input NAND gate is connected to a two-input NAND gate, whose output goes to the connector (Fig. 4a). Each gate and signal line is given a name. At TI the signal-line name is called a *signature;* the term *node* is also used. To put the data into the software for



1. **A discretionary-wired LSI wafer** is an array of logic circuits that are connected after testing to form the desired complex logic function. The interconnection pattern is different for each wafer, and uses only the good circuits.

John Hanne, Manager, Design Automation, Components Group, Texas Instruments Inc., Dallas, Tex.

LSI, a coding sheet must be created (Fig. 4b).

The connector has been given the name CONN. The type is given as CN, so that the computer recognizes it as a connector. The pins are numbered 3 through 7 and 9. All connector-pin numbers are input as three-integer digits with preceding zeros when necessary. Finally, for each connector-pin, the signature name is shown.

Gate ALPHA, which is a four-input NAND gate, is recognized by the computer from the 4G description, and its pins are A0 for the output through A4 for the inputs. Of course, pins A1 through A4 are logically symmetric.

Finally, gate BETA has its gate type (a two-pin input gate) shown, and its pins and signatures as well. Although there are conventions for the connector and the device names as well as for their pin names, the conventions are mnemonic, and the data is easily interpreted by the operator.

The first output obtained is a device list (Fig. 4c). The difference between the device list and the input data is that inconsistencies relating to a device are listed right in with the data. If no errors are mentioned, each of the devices can be checked against the logic diagram, to verify that they were input correctly.

The errors commonly occurring in the device data are: improper pin names; not using the output of a NAND gate; not using the clock of a flip-flop; trying to put two signatures on one pin; not using the input on a NAND gate; failing to use one of the outputs on a flip-flop, and violating the power and ground conventions of the slice.

An alternate method of checking the logic-diagram is the node list (Fig. 4d). If any inconsistencies occur, relating to the nodes, these are listed with the node data. Some of the errors commonly found in the node listing include overloaded signals; signals with no source or no connector pin, and signals with too high a current requirement as the connector pin.

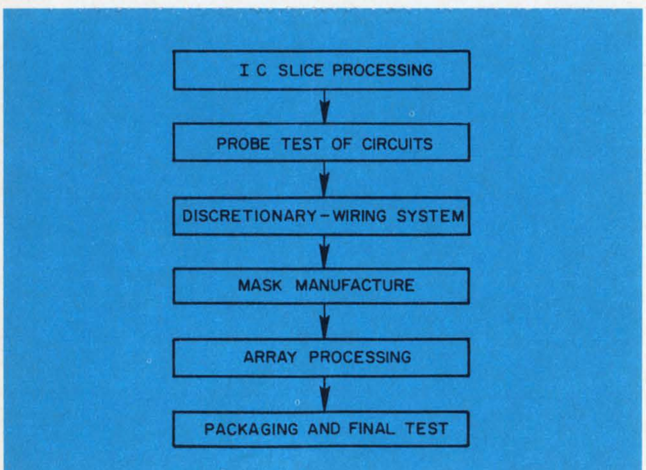
A listing of the device, as it appears on the connector, is given in the connector list (Fig. 4e). Pins 1 and 2 are ground, and pin 8 is for power. The remaining pins show the available name. The loading shown in Fig. 4e is an ideal or required loading as well as the signature loading; an output is capable of driving 10 inputs.

The summary page shows the complexity of the slice and several parameters relating to the slice as well as a clear cut statement of whether the program does or does not construe the logic data to be acceptable (Fig. 4f).

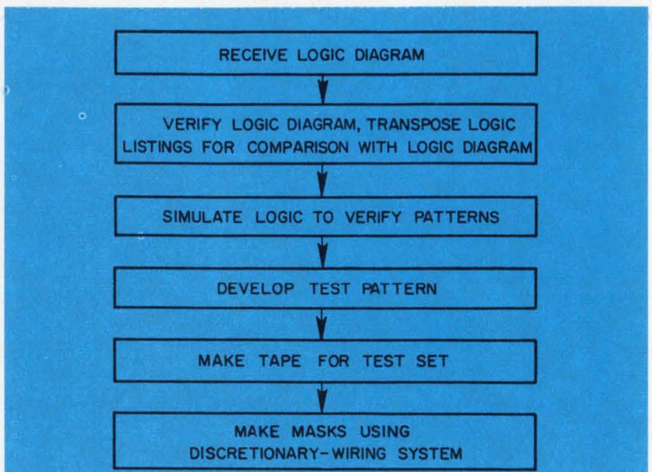
Finally, the assignment from the register position of the test computer to the LSI connector pins is shown in the register-to-pin assignment (Fig. 4g). Although this example is simple, the assignment is usually fairly complex. This assignment is punched on cards and used in making test tape formats for testing the LSI chip. Specific details of all the checks run in the logic data checker have been widely published.[2]

By checking and rejecting the initial logic diagram, this program has prevented unnecessary manufacturing expense on over 75% of the diagrams reviewed. Although the initial computer inputs had been corrected until they corresponded to the logic diagram, the logic diagram in these cases was still unacceptable.

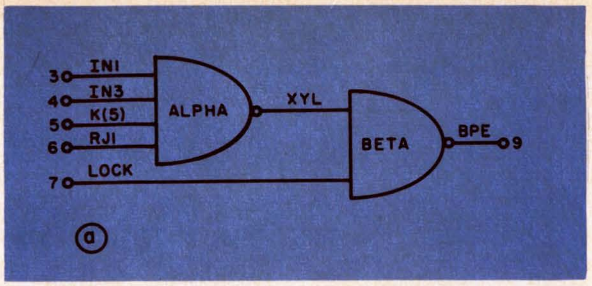
This is not surprising when you realize that it is fairly common for an engineer to assign the responsibility of sketching a logic diagram to a technician, who then has a draftsman draw up the final engineering drawing. Errors are bound to occur. The purpose of the logic-data checker is to catch these errors by data checking. The program diagnostics are sufficiently clear that a



2. **The discretionary-wiring process is highly automated.** Probe-test data and data describing the desired logic are fed to computers which generate a suitable wiring pattern and cut the required metallization masks.



3. **Logic diagrams are carefully checked or simulated by computer** before any further work is done. Over 75% of the diagrams received to date contained errors which were found by the computer.



(b)

HEADER		
CONN	CN 003	IN1
CONN	CN 004	IN3
CONN	CN 005	K(5)
CONN	CN 006	RJ1
CONN	CN 007	LOCK
CONN	CN 009	BPE
ALPHA	4G A0	XYL
ALPHA	4G A1	IN1
ALPHA	4G A2	IN3
ALPHA	4G A3	K(5)
ALPHA	4G A4	RJ1
BETA	2G A0	BPE
BETA	2G A1	XYL
BETA	2G A2	LOCK

(c)

DEVICE NAME	PIN NAME	SIGNATURE	DEVICE TYPE	EQUAT NUMBER		LOAD
CONN	003	IN1	CN		......	0
CONN	004	IN3	CN		......	0
CONN	005	K(5)	CN		......	0
CONN	006	RJ1	CN		......	0
CONN	007	LOCK	CN		......	0
CONN	009	BPE	CN		......	0
ALPHA	A0	XYL	4G		......	10
ALPHA	A1	IN1	4G		......	-1
ALPHA	A2	IN3	4G		......	-1
ALPHA	A3	K(5)	4G		......	-1
ALPHA	A4	RJ1	4G		......	-1
BETA	A0	BPE	2G		......	10
BETA	A1	XYL	2G		......	-1
BETA	A2	LOCK	2G		......	-1

(d)

SIGNATURE	DEVICE NAME	DEVICE TYPE	PIN NAME	LOAD	EQN NUMBER
BPE	BETA	2G	A0	10	
BPE	CONN	CN	009	**	
				10	
IN1	ALPHA	4G	A1	-1	
IN1	CONN	CN	003	**	
				-1	
IN3	ALPHA	4G	A2	-1	
IN3	CONN	CN	004	**	
				-1	
K(5)	ALPHA	4G	A3	-1	
K(5)	CONN	CN	005	**	
				-1	
LOCK	BETA	2G	A2	-1	
LOCK	CONN	CN	007	**	
				-1	
RJ1	ALPHA	4G	A4	-1	
RJ1	CONN	CN	006	**	
				-1	
XYL	ALPHA	4G	A0	10	
XYL	BETA	2G	A1	-1	
				9	

CONNECTOR DATA

(e)

IEC PIN	SIGNAL TYPE	SIGNAL CLASS	LOAD	SIGNATURE
1	2	GROUND		
2	2	GROUND		
3	1	INPUT	-1	IN1
4	1	INPUT	-1	IN3
5	1	INPUT	-1	K(5)
6	1	INPUT	-1	RJ1
7	1	INPUT	-1	LOCK
8	3	POWER		
9	10	OUTPUT	10	BPE

```
        ** SUMMARY **

1. COMPLEXITY

              1        2G
              1        4G

              2 EQUIVALENT GATE COMPLEXITY

           .020 WATTS POWER DISSIPATION

              7 SIGNATURES USED NOT COUNTING THE 0 THAT WERE IGNORED

             14 PINS USED INCLUDING    6 ON THE CONNECTOR

              5 INPUT CONNECTOR PINS

              1 OUTPUT CONNECTOR PINS

2. ACCEPTABILITY

             ** .. ** CONGRATULATIONS ** .. **

             YOUR DATA HAS BEEN A PLEASURE TO DIGEST

             THIS IS ACCEPTABLE FOR DISCRETIONARY WIRING
```

(f)

PERFORMANCE BOARD DATA

INPUT REGISTER	PERFORMANCE BOARD		CONNECTOR PIN NUMBER	SIGNATURE	LOAD
IA01	141	144	3	IN1	-1
IA02	143	146	4	IN3	-1
IA03	145	148	5	K(5)	-1
IA04	147	4	6	RJ1	-1
IA05	149	6	7	LOCK	-1
IA06					
IA07					

(g)

4. **A two-gate circuit illustrates the use of design automation software.** A code sheet identifying gates and signal times is prepared (b), and a device list (c) or node list readout (d) is obtained. Any inconsistencies are listed with the data. A listing of the device as it appears on the connector can be obtained as a connector list readout (e). A summary page shows complexity and indicates acceptability of the logic data (f). Finally, assignment from register position of the test computer to LSI connector pins is shown (g).

non-technical secretary can input the data, comprehend the comments, and correct the input using the program and a logic diagram.

Computers generate the wire routing

The discretionary-wiring system defines a mask on magnetic tape, the mask design being based on the logic-function and the slice-probe data (Fig. 5). The magnetic tape is then transported to the mask-generation system.

The probe-processing program takes data from the probe-test equipment (Fig. 6). This program verifies that there are enough good devices on the slice to make the requested logic function. The devices whose outputs go to the connector are then assigned to guarantee that the specified noise-immunity is not exceeded. Following this step, a procedure is initiated to remove all of the unnecessary devices on the slice.

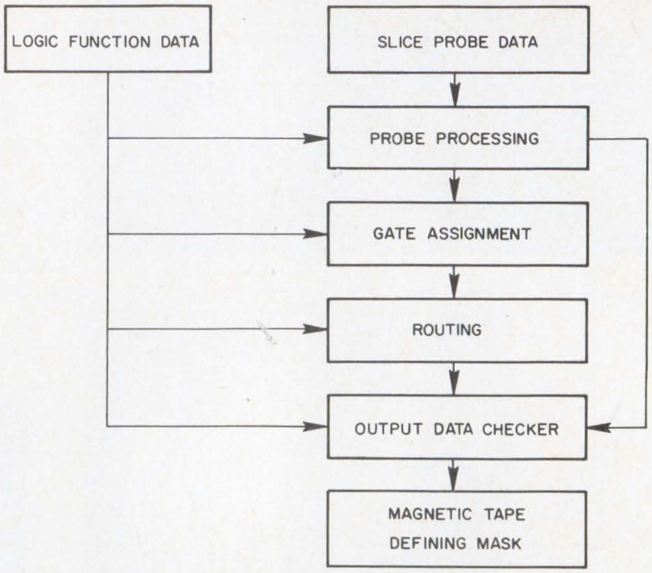
The gate-assignment program assigns the remaining gates from the logic function to the good gates which remain on the slice. The main goal is to minimize the amount of wire necessary for routing.

The actual routing is done next. This program is allowed to interchange symmetrical pins, such as inputs on the same NAND gate, to route the slice. As with any routing system, this system has specified density levels for a fixed geometry, which it is not capable of exceeding at any time. Where a mask is needed with a complexity greater than the routing system is capable of running automatically, it is necessary that an operator complete the routing.

The output-data checker checks any routing created solely by the program, or modified by an operator, to verify that the routing itself corresponds to the good devices on the slice and the requested logic function. The output-data checker generates a magnetic tape which is transported to the multilevel-interconnection generator (Fig. 8) and used for defining the mask. The checker can also generate a recovery tape including the current routing, the good-data, and the logic function data so that the routing may be modified and rechecked by the output-data checker. This program is a valuable aid in case of extreme complexity or changes in the routing system.

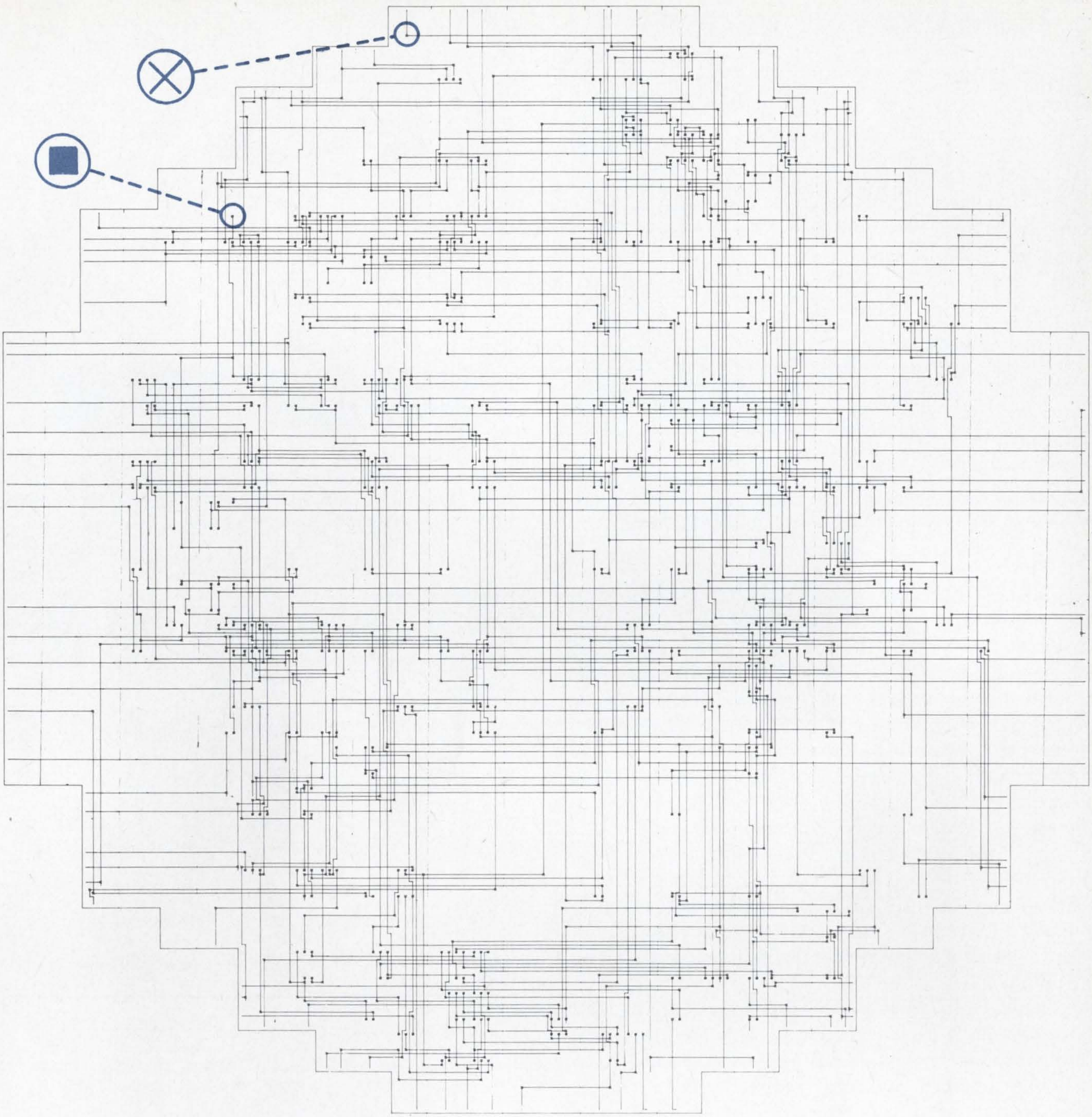
A routing for an LSI slice completed by the program without manual intervention is shown in Fig. 7. The little squares correspond to openings which connect to the first level metal on the gates and the flip-flops. Most of the vertical lines correspond to the second level of metal (the first discretionary level). The Xs correspond to openings between this and the third level of metal. Most of the lines running horizontally are on the third level of metal. The lines which appear to go nowhere simply meet a fixed pattern for the connector, or for power distribution.

The automated test-generation system produces a dc functional-test sequence which verifies the logic function. In the case of an LSI array, there are approximately 75 input leads and 75 output leads. The simple-array test-set (SATS) used at TI can handle 96 inputs and 96 outputs (Fig. 9). If there are 25 flip-flops on the device, and 75 input leads, then there are 2^{100} possible patterns to test the machine for all inputs in all states.



5. **Four main programs are used** to transform wafer-probe and logic-function data to mask data. They check that there are enough good devices on the chip and assign these devices to the logic diagram, route the interconnections, and then check the routing.

6. **The automatic probe-test equipment** rapidly and accurately determines which circuits on a slice are good and which are defective. The data are fed to a probe processing program.

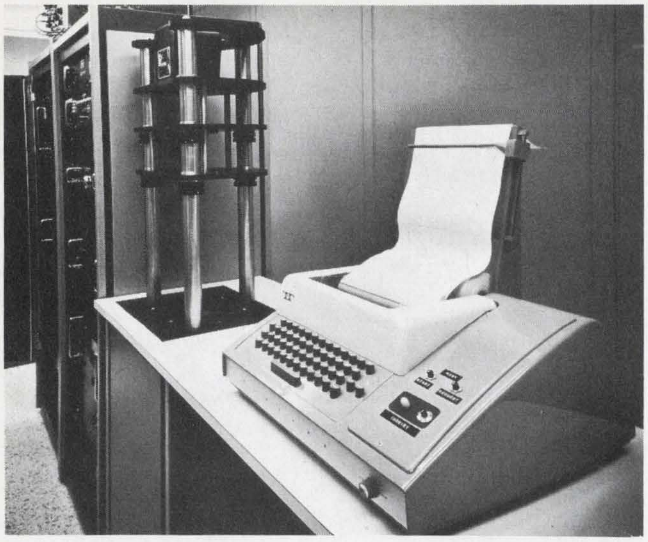


7. **This computer-generated routing map** shows the pattern to be applied as the second and third levels of metal. Tiny "Xs" mark crossovers between the second level of metal and the lines which run horizontally. The "■"s mark connections to the first level metal on the gates and flip-flops.

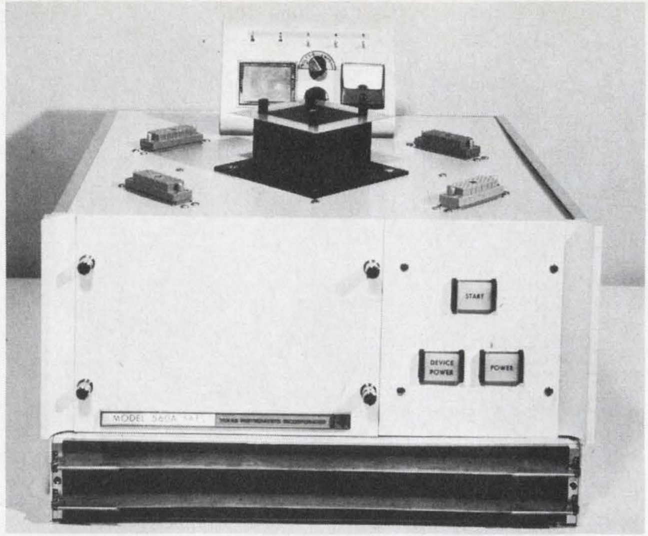
This number of patterns (roughly 10^{30}) is beyond any testing capability—at mHz test rates, complete testing would take human lifetimes.

Since it is impossible to completely test an LSI array, a series of patterns are defined which are sufficiently complete to give a high degree of confidence that the device functions as intended. In the case of bipolar discretionary LSI, the flip-flops and the gates have been individually tested prior to adding the interconnecting metal to form the logic function. This greatly reduces the need for verifying that the logic elements are right. Thus, the testing becomes a system-level problem of whether the logic function is correct.

To handle a large number of designs on a very fast turnaround basis with a high degree of accuracy, it is necessary to have the aid of a high-speed digital computer in generating and evaluating the tests for a given set of logic. It is necessary to make sure that the expense of generating the tests is not so great as to prohibit meeting the required market prices on the products.



8. **The interconnection generator creates a mask pattern** by exposing a film with a high-speed cathode-ray tube. Loss of resolution from beam overshoot is avoided by blanking the beam as the trace is moved.



9. **The simple-array test set (SATS)** can handle 96 inputs and 96 outputs. The test patterns are generated by a large general-purpose computer and transmitted to the test system on magnetic tape.

With a discretionary slice of 200 gates, and an average of 3 pins per gate, there are approximately 600 pins on the slice. Each of these pins is assumed by the test sequence generation program either to be operating or to be stuck at either one or at zero. The single-failure hypothesis is assumed for the generation of the tests; that is, that only one failure occurs. Thus, there are approximately 1200 different logic-functions which are considered (the good logic, the 600 resulting from tying each pin to power, and the 600 from tying each pin to the ground). The system is simulated until patterns are found which differentiate the good logic functions from those resulting from the insertion of any of the faults.

The general model of the logic for an LSI array results from the use of NAND gates and flip-flops as the basic units in the array. It is possible to place different memory elements into the test simulation program, but at additional effort.

All of the tests for a recent airborne LSI computer have been developed by using the test-generation scheme and then having an engineer find the remaining failures by isolating them using manually generated patterns. Of the total number of faults in the entire 7000-gate system, more than 90 per cent were found by the computer.

The event-simulation system used at Texas Instruments is capable of simulating a single system of 10,000 gates. It can also build up systems with a higher number of gates from smaller duplicated units. For systems where this build-up occurs, it is possible to use more gates than normally fit in core by representing the duplicated logic only once. ■■

Acknowledgment:

The assistance of the Discretionary Wiring Section, the Simulation Section and the Test Section, and of the Technology Customer Center, is gratefully acknowledged.

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2. J. R. Hanne and R. M. Jennings, "User Assurances in LSI Discretionary Routing," *Digest of Technical Papers 1968 Computer Group Conference*, p. 27.

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. Why does the discretionary wiring approach require the extensive use of computer aids?

2. The LSI logic-data checker tests customer logic diagrams. About what percentage of diagrams received have contained errors?

3. Why is it impossible to completely check most LSI arrays?

4. What is the purpose of the event-simulation system?

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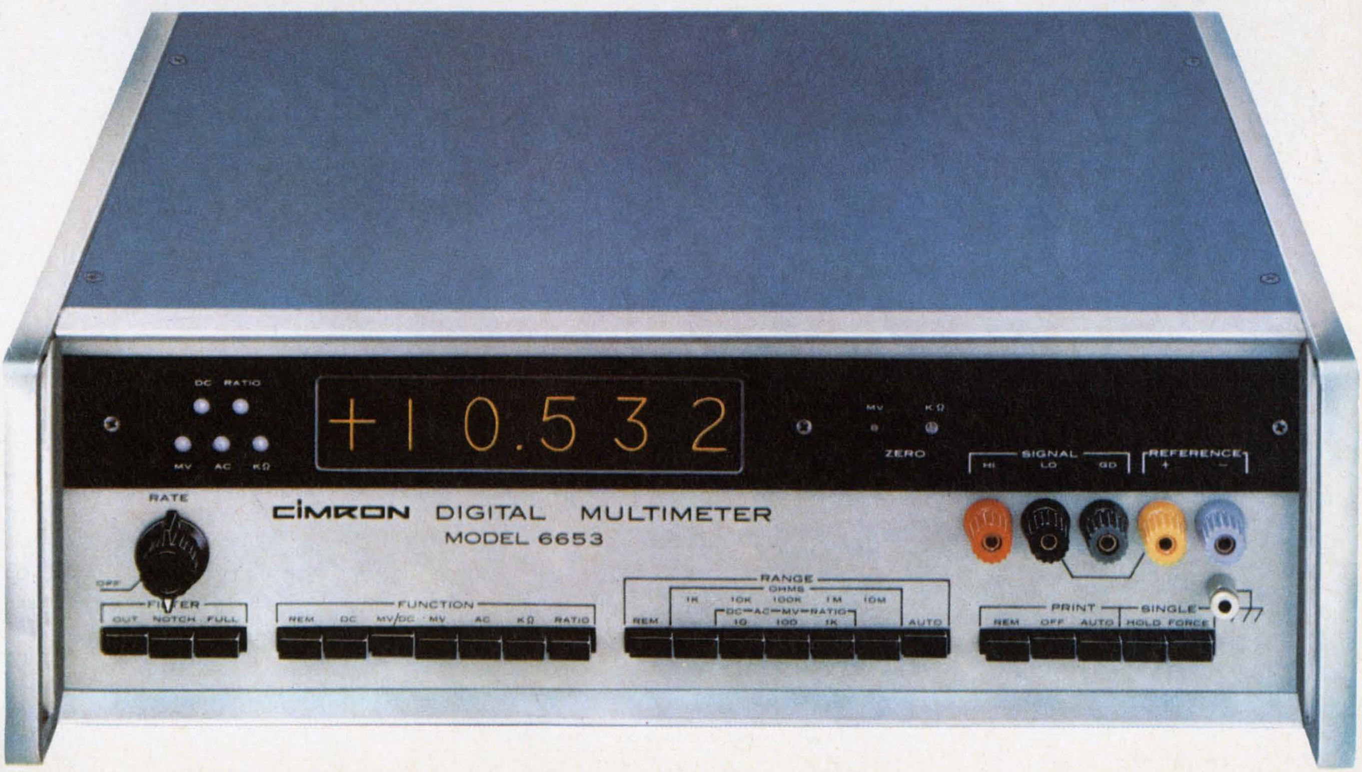

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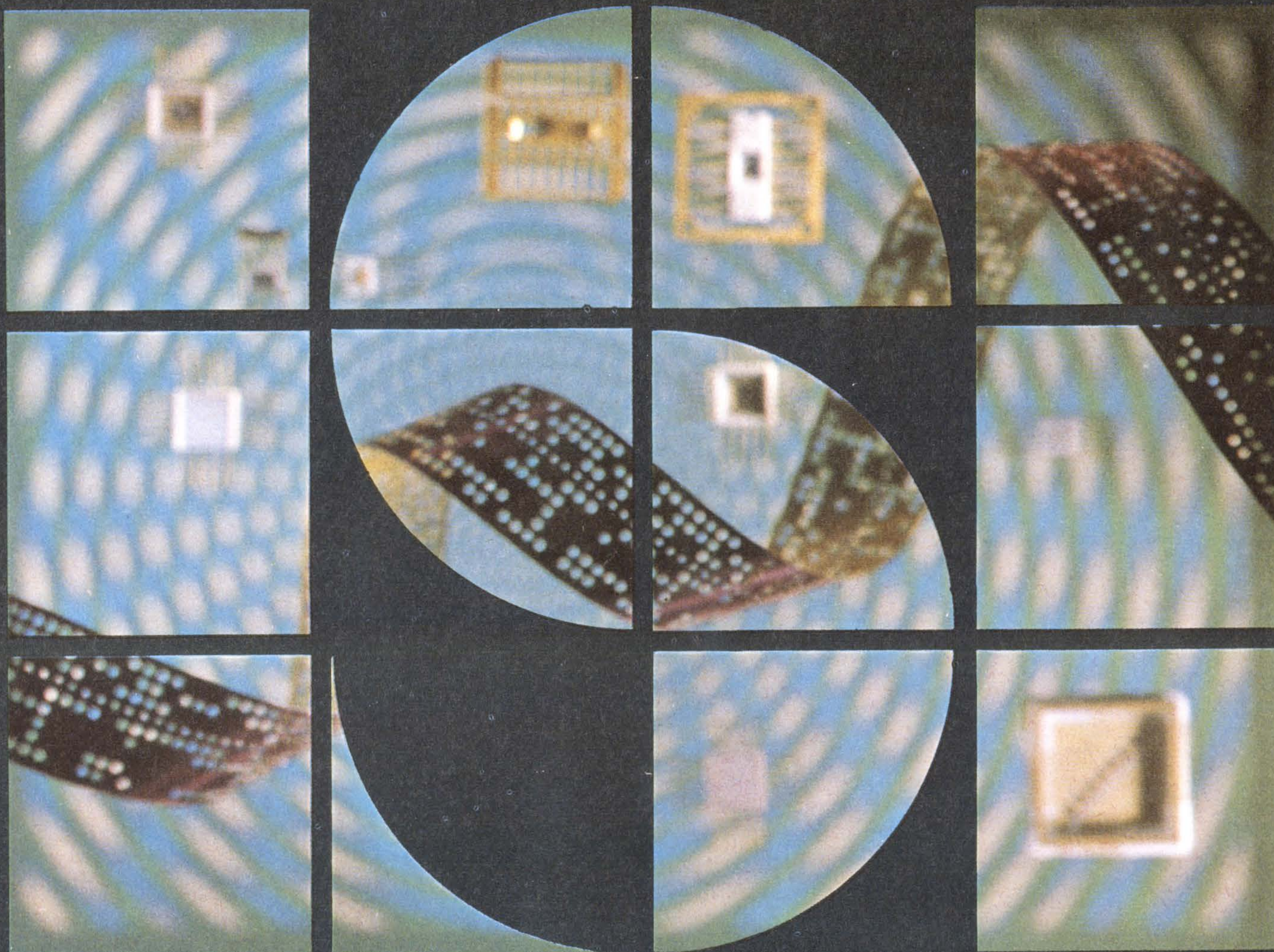


LSI offers high logic speeds

Computer logic speed has been boosted by six orders of magnitude in the last 20 years, but it still isn't high enough. Pattern recognition, signature analysis, terrain radar and similar applications all demand logic speeds of a nanosecond or less. The search for faster circuits goes on.

A prime requirement is small size—and large scale integration meets this requirement hands down! LSI logic elements are extremely small. Interconnection can be done at the chip level. And 1-ns arrays of 50 or 100 gates are now entirely feasible.

High-speed circuits are obtained by keeping device size small and by keeping voltage swings low. Circuits are kept physically small to reduce lead capacitance and lead inductance—all of which contribute to propagation delay. Low signal swings reduce the amount of current that must be fed to parasitic capacitances, thus reducing power dissipation.

But high speed and high complexity do pose some problems. LSI circuit yields are dependent on device area. As area increases, yield decreases; an economic upper limit to chip size—about 150 mils square for high speed logic—presently exists. The exact limit depends, of course, on the particular process used and the degree of process control achieved.

Normal dissipation in LSI subnanosecond logic elements is about 50 milliwatts per gate, and this power must be conducted out of the chip. In LSI chips, power density becomes very high. One hundred gates at 50 mW generate 5 W of heat on a surface roughly 150 mils square. Given a package and a heat sink scheme, the thermal limitations of the chip (which can normally stand only 150°C) dictate the maximum acceptable power level.

One of the most difficult problems is keeping the supply-voltage drops at reasonable levels as the complexity on the die is increased. The metal interconnect film must be kept very thin, to avoid resolution problems in photoetching. For a given circuit and process, there is a minimum attainable ohms-per-square. For a given maximum tolerable voltage-drop, the percentage of the die area required for supply-runs increases as the complexity and supply-current increase. A 100-gate subnanosecond array using present technology would require about 1 ampere of power-supply current (and would dissipate about 5 W). If the worst-case V_{CC} drop were limited to 50 mV on a 0.025-ohms-per-square metal layer, the V_{CC} metal would require at least one-half the die area.

In spite of the problems, subnanosecond operation is possible. Research at Motorola has recently yielded 10-W IC gates with propagation delays of 0.5 to 1.0 ns.[1] (The devices use emitter widths of 1.0 to 2.0 microns.) These results indicate that speed-power products of 5 to 10 picojoules are possible. The research has also shown that all possible circuit configurations, emitter-coupled logic (ECL) is most suitable for high speed LSI (Fig. 1).

Robert M. Frazier, Manager, Digital ICs and Systems R&D, and **Michael Lee,** Group Leader, Nonsaturated Logic Circuits and Systems R&D, Motorola Semiconductor Products Inc., Phoenix, Ariz.

Subnanosecond operation with ECL

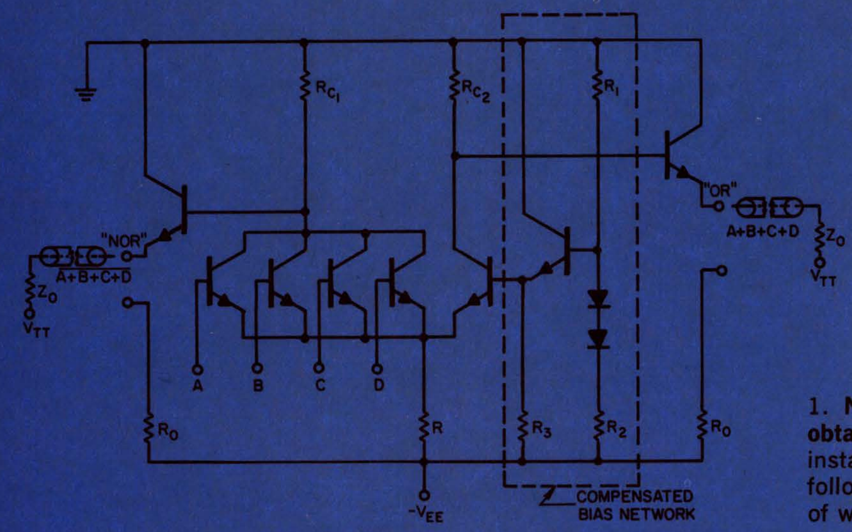
In addition to offering the highest speed for a given technology, the ECL circuit has speed-power, circuit-density and power-density advantages over circuit configurations. The advantages result mainly from the lower total resistance requirements for a given circuit power level, and from lower emitter and signal currents for a given circuit power level and fanout capability.[2]

Signal paths in an ECL gate pass through emitter followers and grounded-base stages, both of which are inherently fast. And because the output impedance of the gate is low and the input impedance high, deteriorating effects of parasitics and load capacitances are minimized. Moreover, since the output impedance can be made as low as 5 ohms, the ECL circuit is capable of driving terminated coaxial cables or striplines of 50 ohms or larger. One does this by returning the termination resistance at the far end of the transmission line to a voltage somewhat lower than a logical "0." Finally, reflections caused by discontinuities along the transmission line are inverted by virtue of the low output impedance.

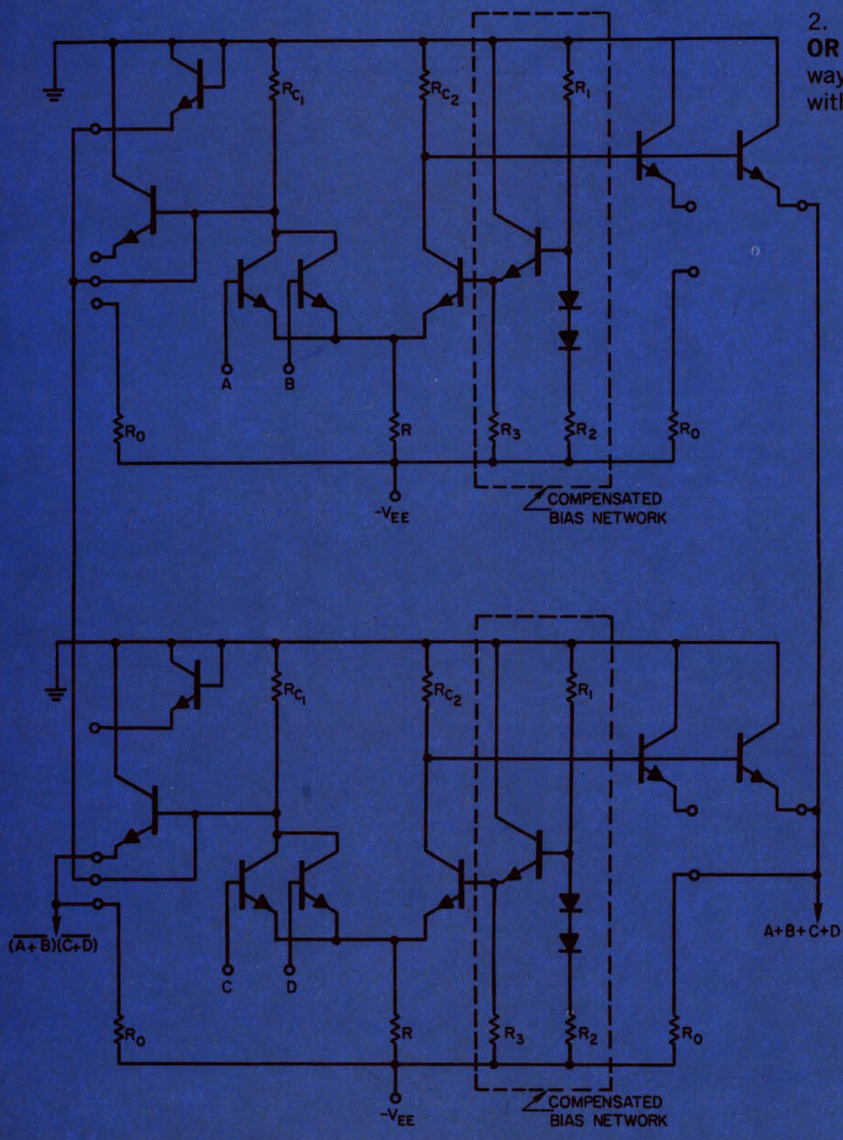
The ECL configuration also allows simple wired-OR and wired-AND connections, by addition of emitter-follower output and collector-clamp transistors, as shown in Fig. 2. With the wired-AND connection, the following extra logic combinations can be obtained: $(A+B)\ (C+D)$, $(A+B)\ (\overline{C+D})$, $(\overline{A+B})\ (C+D)$, $\overline{(A+B)\ (C+D)}$. With the wired-OR connection, the additional logic combinations are: $A+B+C+D$, $A+B+\overline{C+D}$, $\overline{A+B}+C+D$, $\overline{A+B}+\overline{C+D}$.

In place of the common-emitter resistor, a constant-current generator or another current switch can be inserted, resulting in the double-level ECL circuit shown in Fig. 3. With such an arrangement, series-parallel logic may be performed. This is particularly useful for clocking purposes, since an independent gate input can be added without adding gate delay. In practice R_E is also replaced by a current source to prevent logic-level dependency on V_{EE}.

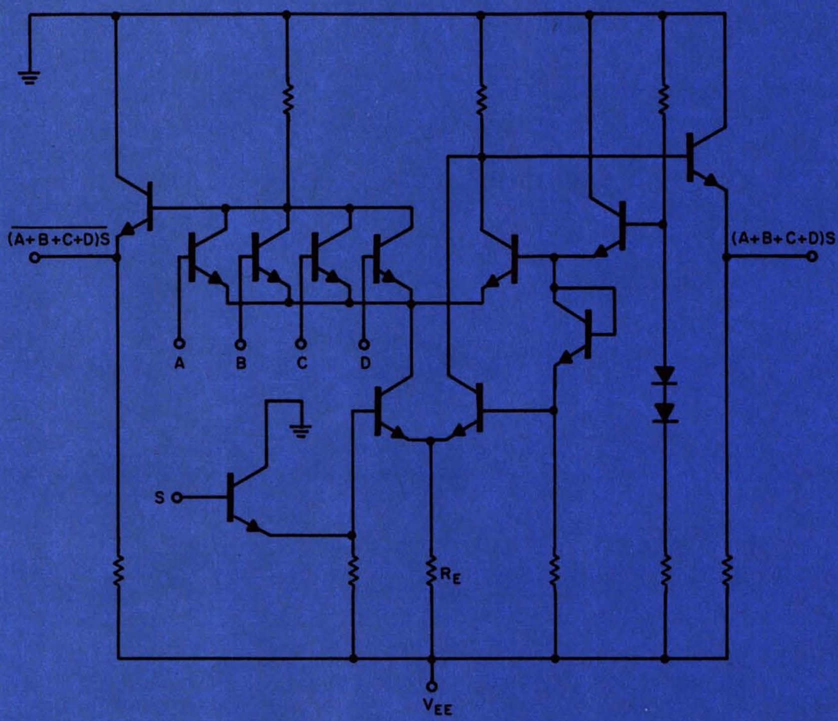
With a standard 5-V supply, up to three levels of gating can be accommodated when a current source is used in place of R_E. Figure 4 shows a nanosecond full-adder ELC circuit that makes use of three-level series gating.



1. **Nonsaturated logic circuits are used to obtain high speeds.** This ECL gate, for instance, has signal paths through emitter followers and grounded-base stages, both of which are inherently fast.

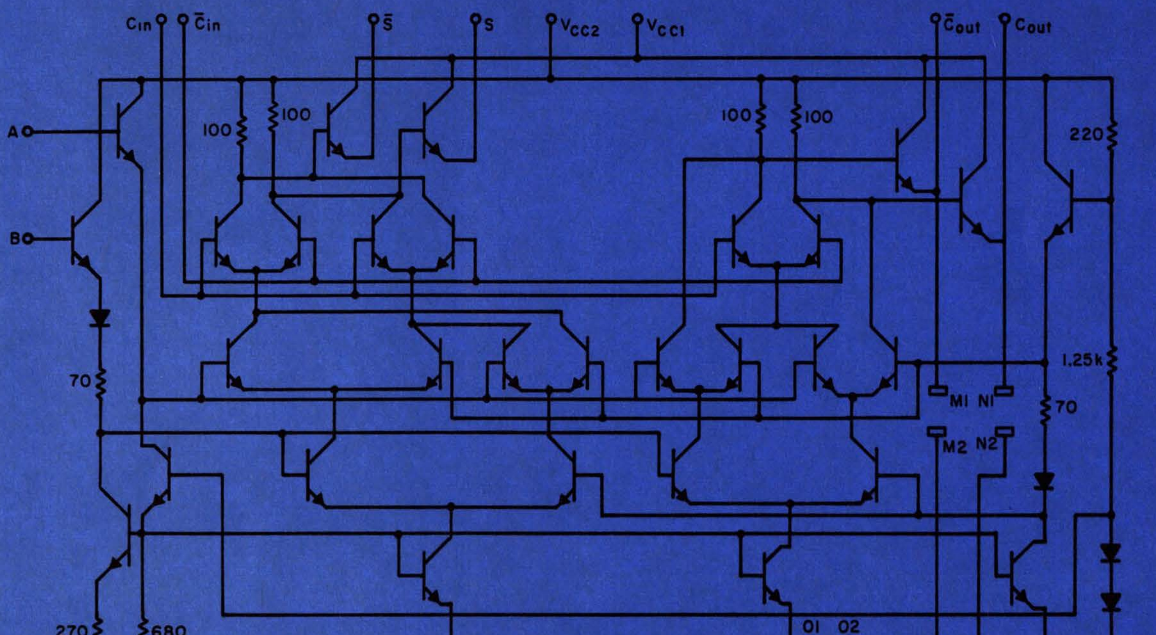


2. **The ECL configuration allows WIRED-OR and WIRED-AND connections.** In this way extra logic gating can be performed without adding delay.



3. **In the double-level ECL gate** the S input allows series-gating or ANDing of the basic OR and NOR outputs.

4. **This ECL full adder** is a subgroup of 56 components using three-level series gating. The three-level ECL gating scheme allows double series-gating or two-input ANDing of the basic OR and NOR gates.

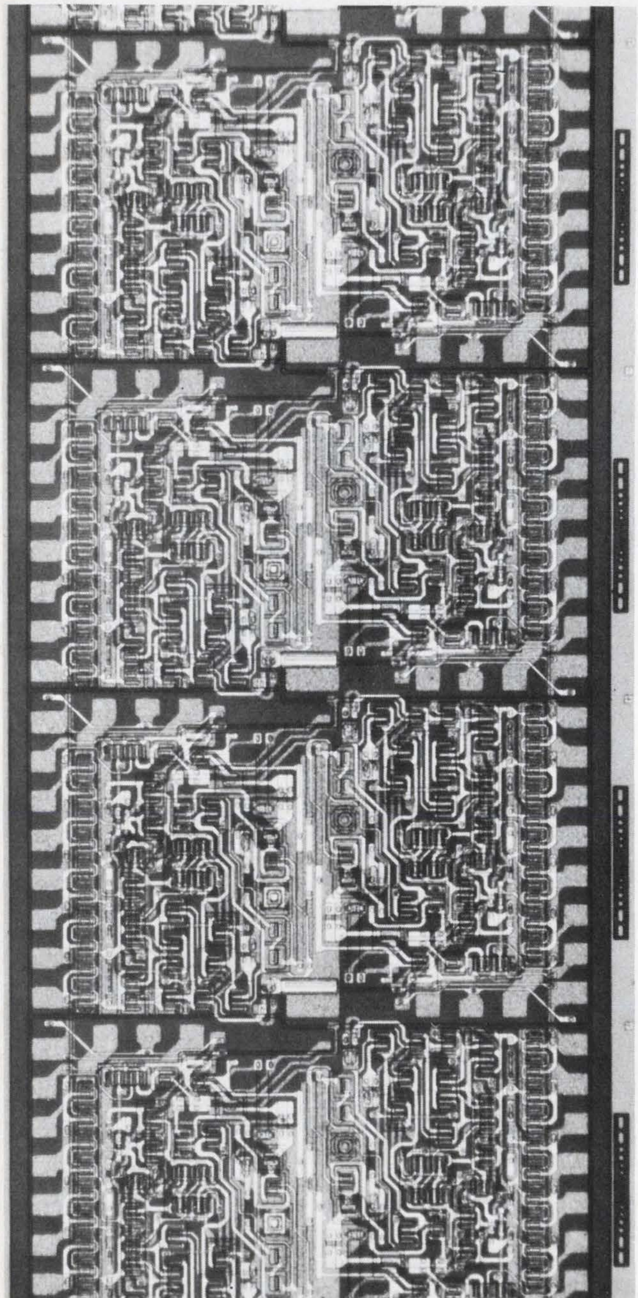


When the basic ECL circuit configuration is combined with selective use of wired gating and series gating, high system speeds and low system speed-power products can be obtained.

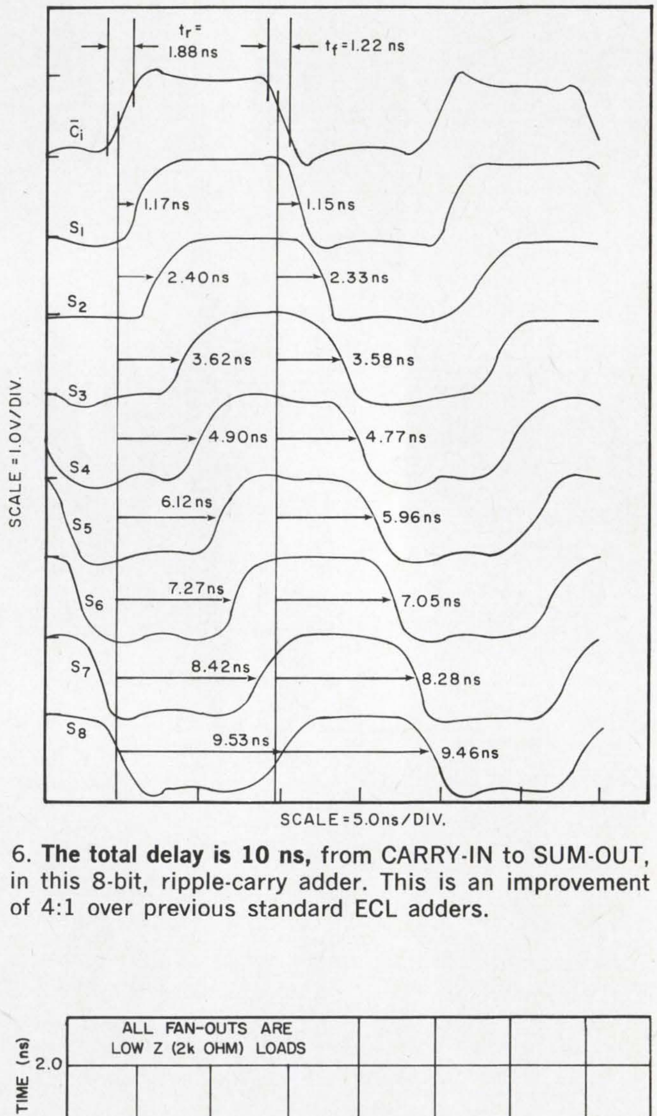
Figure 5 shows a photomicrograph of an 8-bit ns full-adder, which is one of the most complex high-speed logic functions fabricated to date. The 8-bit adder is equivalent to 88 logic gates, and it has three layers of metalization. It employs a total of 448 components. The die is 46.3-by-110.1 mils. The effective average component area, therefore, is roughly 11.4 square mils per component.

The per-stage delay from CARRY-IN to SUM-OUT is approximately 1.2 ns. Connected as an 8-bit ripple-carry adder, total delay from CARRY-IN to SUM-OUT of the 8-bit is approximately 10 ns (Fig. 6).

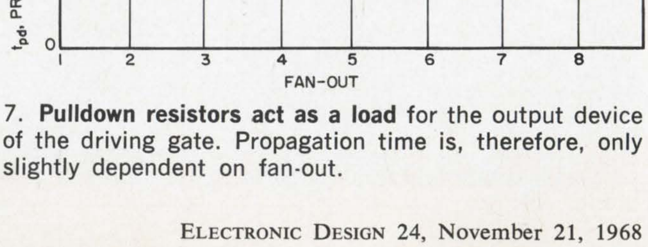
The adder is composed of four subgroups, each consisting of dual full-adders. The basic full adder is a subgroup of 56 components, interconnected with series-gating techniques to produce the full-adder function with a minimum propagation delay. Both the SUM and $\overline{\text{SUM}}$ are available for each bit. Either may be made available at the



5. **This 8-bit nanosecond full adder** (four circuits are shown) is one of the most complex high-speed circuits built to date. Its complexity is equivalent to 88 logic gates, or 448 components, on a 46.3-by-110.1 mil chip.



6. **The total delay is 10 ns,** from CARRY-IN to SUM-OUT, in this 8-bit, ripple-carry adder. This is an improvement of 4:1 over previous standard ECL adders.



7. **Pulldown resistors act as a load** for the output device of the driving gate. Propagation time is, therefore, only slightly dependent on fan-out.

outputs. Initially, however, only the SUM will be used.

The first layer of metalization intraconnects a majority of the components within each dual full-adder assembly. The exceptions are a few critical crossovers that must be made in the second layer to eliminate voltage distribution and routing interference problems. The second layer completes the dual full-adders. The addition of the third layer interconnects all of the logic of the dual devices into one complete 8-bit full-adder. This third layer also performs the over-all power distribution function.

The adder requires 28 pins for input and output functions and is packaged in a 32-pin stud-mounted ceramic flat-pack. With adequate heat-sinking, the stud-mounted packages can provide relatively constant junction-temperature distribution between multiple 8-bit adder packages.

Motorola now offers three circuits in their MECL III line that are capable of subnanosecond speeds. The circuits include a dual 4-gate, dual 2-gate and a flip-flop. The gate circuits can drive terminated 50-ohm lines with 1.1 ns propagation delays, and provide subnanosecond rise, fall, and delay times with lighter loading.

Tricks for improved operation

In the design of circuits for minimum propagation delay, it was necessary to employ a separate V_{CC} line for the output devices. This separation prevents current transients—caused by unbalanced loading of the output devices—from being coupled back into the gate by way of common connections to a V_{CC} node. For best results in characterization and in system performance, these terminals are connected to a good ground-plane close to the package. The connection for the bias driver and input circuit is designated V_{CC2} and is connected via pin 14. The output device supply is labeled V_{CC1} and is connected to pin 1.

An input-pulldown resistor (R_p) is associated with each input family. This resistor circumvents the "floating base" problem of emitter-coupled logic families by providing a sink for I_{CBO} leakage currents and for signals that would normally be coupled to a floating base through C_{ob}. The pull-down resistor value for the high-input impedance circuits is about 50 kilohms.

Planned circuits will employ 2-kilohm pull-down resistors. The resistors will not only serve as pulldowns for floating bases, but will also act as loads for the output devices of the driving gates. Figure 7 shows the effect of loading a gate (in this case, one with no output load resistor) with a fan-out of gates having low input-impedance load resistors (2-kilohm). Note that the curve is relatively flat. A well-designed printed circuit with tight spacing between packages (0.625 in. between centers) would be a candidate for such loading techniques.

The emitter-follower output devices are designed to drive a 50-ohm transmission line terminated to —2.0 V. This is an equivalent output load-current of 22 mA. When terminated with a 510-ohm resistor to V_{EE}, the emitter-follower output current is 8.5 mA. To complement the gate elements, a storage element capable of shifting and counting with very low propagation delay was required. An all-logic D flip-flop was selected, designed with two layers of metal to provide a more economical device with reduced chip size. It not only offers high speed but also simplifies system application, since its operation is not dependent on clock rise time.

A more exact title for this flip-flop is "one phase D." It's a master-slave flip-flop with an information (or data) input to the master. The master is updated while the clock is at low level, and data are transferred to the slave on a positive excursion of the clock. Direct set and reset inputs are provided for presetting or parallel data entry. These set and reset inputs are provided with a "look ahead" capability, since both master and slave sections are changed simultaneously by the direct inputs. ■■

References:

1. WPAFC Contract AF 33(615)-5205, "Advanced Integration Techniques For Low Power 100-200 MHz Digital Processing," April 1968.

2. C. D. Phillips, et. al., "Complex Monolithic Arrays: Some Aspects of Design and Fabrication," *IEEE Journ. of Solid-State Circuits*, December, 1967, p. 156.

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What basic problem does LSI solve for high speed logic?

2. Name three problems associated with building LSI logic.

3. How fast are presently available high-speed logic elements?

4. Give three reasons why ECL logic is the best configuration for high-speed operation.

5. Why does Motorola use separate V_{CC} lines in its high-speed logic? Why does it provide pulldown resistors?

Must the vendor bear development costs?

LSI development hasn't been easy. For several years, vendors have been investing hard work and hard cash. They took the risk—and developed the technology. Now they look for a return on their investment.

But in spite of the widely accepted benefits of LSI (reduced parts count, simpler system packaging, less miscellaneous hardware, faster speed, higher reliability) aerospace users are only now beginning, hesitantly, to back LSI development. The computer community is skeptical, and consumer-electronics users are notable by their absence.

LSI vendors, heavily committed, are concerned. When are the users, who stand to benefit from LSI, going to accept the products, put in their orders and help support the development?

Customers' reticence can no longer be attributed to high cost. The cost of standard MSI is lower than that for conventional ICs, on a per-gate basis. Custom LSI arrays, of course, with functions designed for a specific customer, may have a higher per-gate cost. In any case, per-gate cost comparisons are unfair. Savings on board design, assembly, and interconnection must be taken into account. The only fair way to compare costs is to weigh all aspects of system cost, for all alternatives—from conception to production. A fair comparison may show that LSI is now the most economical way to go.

But some designers hesitate to even consider LSI, much less weigh the cost. These designers do not have confidence in the LSI products, are nervous about the design procedures and costs, and are worried about protection of their proprietary designs. They shouldn't be.

The technology is feasible

The products work. The technical feasibility of LSI, from a processing point of view, has been established beyond doubt. Actual products are available in a variety of forms.

Fairchild, for instance, has announced 11 products in its 9300 series of TTL MSI functions. These range in complexity from about 30 gates to over 100 gates on chips varying in size from approximately 65 by 65-mil to 140 by 140-mil. All are in production, and some have reached high-volume levels with satisfactory yields.

A typical bipolar product is the 9328 chip, a TTL dual 8-bit register. This device contains approximately 105 gate-equivalents (318 components) on an 85 by 112-mil chip.

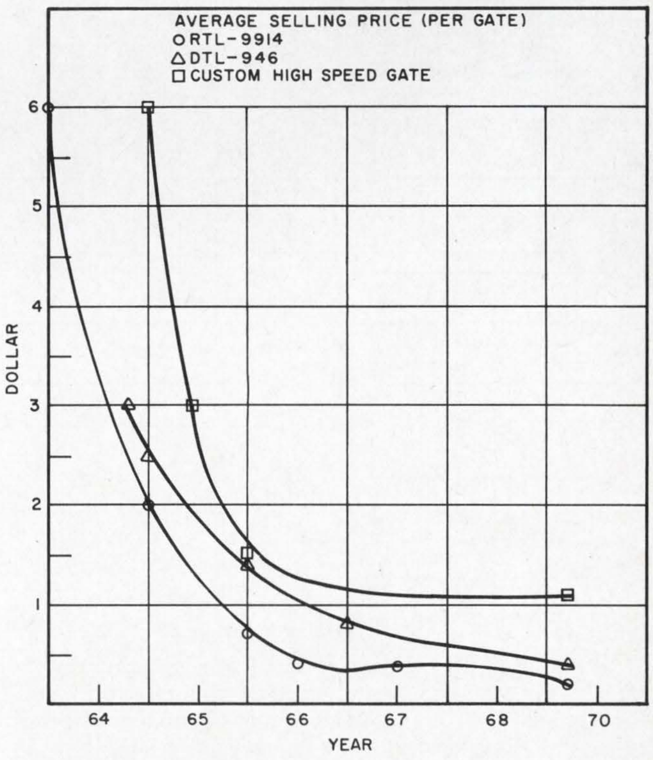
The two static-shift registers have common reset, and both common and independent shifting operation. Either of the clock inputs can be used to inhibit the shifting operation by maintaining the input HIGH. Each register can receive serial data from either of two sources, each of which is selected by means of a single-line input select terminal. The capability for making chips with complexities of 100 to 200 gates has been adequately demonstrated by a number of vendors (see photos).

Robert M. Walker, Supervising Engineer, Custom Arrays, Fairchild Semiconductor, Mountain View, Calif.

Putting a thousand or more gates on a package is, of course, another problem. Multichip packaging is a possible solution, and one Fairchild developmental package employs facedown bonding of 20 LSI chips. If we assume there will be 100 gates or more on each chip, the potential for placing several thousand gates in a single package is evident. Multichip packages may have a strong impact on the evolution of LSI.

Assuming that an economic, repairable, multichip assembly technique will be developed—and semiconductor memories may force this to occur—custom subsystems of several thousand gates can be assembled. For bipolar systems, most of the logic will then be selected from an existing inventory of standard MSI functional chips and interconnected with a few custom chips and a custom-designed multilayer ceramic substrate. This will be the next step in LSI. There will be no need to butt through the monolithic yield-area stone wall. But what of design procedures and design costs?

The LSI vendor is presently faced with two main problems: He must offer a custom design capability, and his turnaround time must be short—as short as a few weeks. And his final



1. **The average selling price of ICs has dropped drastically.** LSI vendors are being forced to introduce their products at prices that are competitive with the less complex ICs.

Fairchild's computer-aided design program provides for checking and exercising the customers' logic, automatic generating of functional test sequences and automatic analysis of customers' test programs. Cell assignment and interconnection and mask generation are done only after thorough checking of the logic design.

product must be low in cost, of course, if it is to compete with existing products (Fig. 1).

If system engineers are correct in assuming that LSI will lead to a proliferation of unique parts, someone will have to build an awful lot of custom components. And custom work poses its own problems.

Custom LSI means low product volume

Uniqueness of parts is going to lower production volumes. If a complex part is used only once per system, then for most customers the total production order for a custom array will be for a few hundred or a few thousand parts. The allowable engineering fee must be low—roughly equal to the cost of engineering and laying out a printed-circuit function. Clearly, no one can amortize a $50,000 engineering charge over a thousand parts—unless, of course, some groovy benefit of LSI (smaller size, better reliability, lower power, or more speed) is of special value to the user.

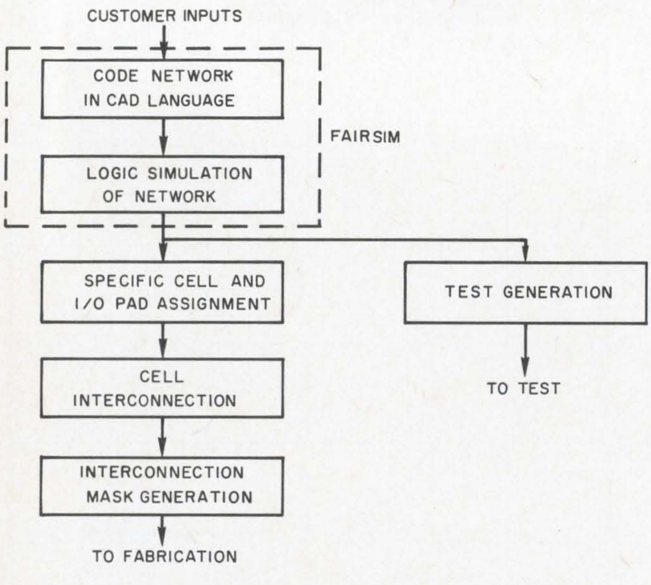
While such advantages may be quite significant in certain aerospace and defense applications, they tend to evoke somnolent reactions from consumer-electronics system houses. Comments on speed cause an occasional flicker of an eyelid among these buyers, but unless the improvement is by an order of magnitude, the flicker is followed by a yawn. Consumer-electronics will be hard to sell on custom LSI, unless production orders are quite large.

Custom turnaround time must be as short as four weeks. LSI products will not be used as replacement parts for printed-circuit boards; they must be designed into the next generation equipment. Errors in logic design are inevitable, and last-minute system changes must be possible. Some way must be found to provide fast service on custom circuit redesign. It appears that four weeks (from receipt of a customer's logic diagram to shipment of a small lot) is the longest turnaround time that the customer will tolerate, if custom LSI is to be significant in new system designs.

So this is what the vendor is faced with—a large-scale logic design that must be turned into hardware in only four weeks. How can he do it?

With computer aids.

Thus semiconductor manufacturers have put a great deal of effort into development of computer programs for LSI design (see photo above).



2. **In the Fairchild computer-aided design program** the customers' logic equations or diagrams are first converted to a CAD compatible format, then simulated to verify the basic design and the network coding. The arrangement of cells in the array is made to simplify the cell interconnection, and the required masks are computer-generated. An optimum sequence of tests is then produced to fully test the custom circuit.

Computer aids speed design

A fully integrated computer-aided design capability is now available (Fig. 2). This system, and a special approach to custom LSI (called Micromatix™) enables Fairchild to meet the primary LSI requirements of custom design and fast turnaround. Computer aids check the logic of a customer design by simulation, and generate an optimum series of tests for the finished custom circuit.

A program called *FAIRSIM* provides the computer simulation of the customer's digital design. It uses a look-ahead simulation technique similar to that described by Ulrich[1]. *FAIRSIM* takes advantage of the fact that only a small percentage of the elements in a digital system change state during any short period of time. It provides simulation of an element if, and only, if one of the inputs to the element changes state.

In order to sequence the transmission of signals, the concept of logical delay is used. Each logic element has two specified delay times associated with it. These delays are a measure of the time required between a change in an element's input and the corresponding change in its output.

Sixty-four areas of memory are reserved for a "time wheel," that corresponds to the logic delay range of 0 to 63. The program scans each position of the time wheel and, upon encountering an entry, is directed to a list of logic elements whose delays have timed out and whose outputs are ready to change.

The program then performs the following tasks: (a) it transmits the new output along the fan-out net as inputs to other logic elements; (b) it then simulates all affected elements to determine if their outputs will change state; (c) if they will change state, it places the proper flag in the time wheel at the time slot their output is due to change (for example, after their delay). The scanning of the time-wheel elements then resumes. The time wheel also updates total elapsed system time before recycling. The output of *FAIRSIM* is a listing of requested logic element outputs, either 1, 0 or undefined.

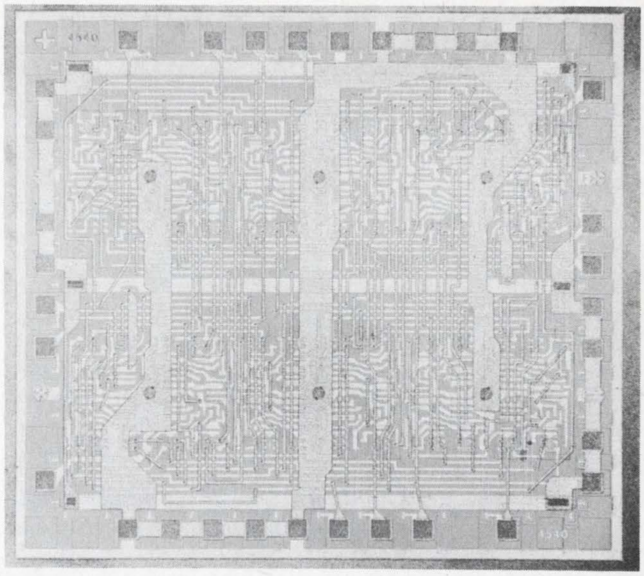
One powerful feature of *FAIRSIM* is the *MACRO* network-description capability. A new logic element may be defined in terms of existing logic elements, and then called up as part of a larger system. In this fashion, users may build up their own library of commonly used designs. The network description and performance test which is prepared for *FAIRSIM* may be used as input to other Fairchild CAD programs, such as interconnection routing and test generation.

The testing of complex arrays represents a formidable problem because of the difficulty in testing complex logic networks without access to intermediate cells (basic logic functions), and because the cost of testing represents a large share of the price of a finished package.

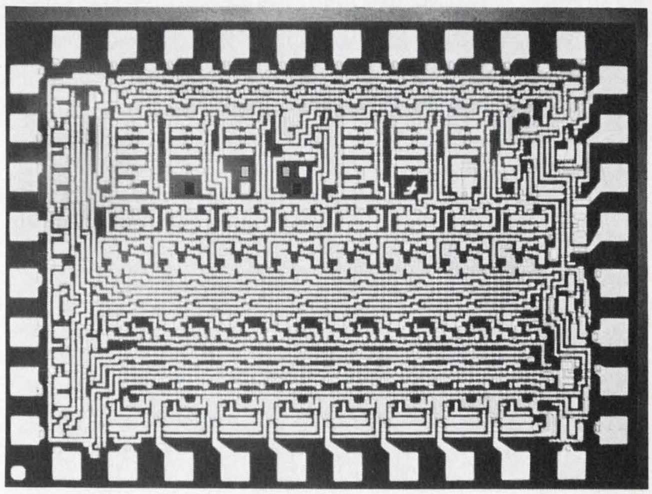
The number and types of tests performed depend upon the logic design, the required confidence level and the eventual environment. Potential failure modes must be analyzed. Worst-case dc measurements are required for inputs and outputs, to assure that interfaces with other devices achieve the desired margins. The number of such tests is proportional to the number of pins and will, in general, be small in comparison to functional tests.

Functional tests verify the transfer function, truth table, or state diagram of the device, and check internal devices. The number of functional tests required has been debated heavily in the industry, and the spectre of 2^{N+M} possible input combinations for an array with N inputs and M states is often used to arouse an appreciation for the upper bound on numbers of tests. Fortunately, *it is extremely unlikely that a useful complex logic function will even approach this limit* since partitioning, redundancies, and non-independence of variables greatly reduce the input sequence requirements.

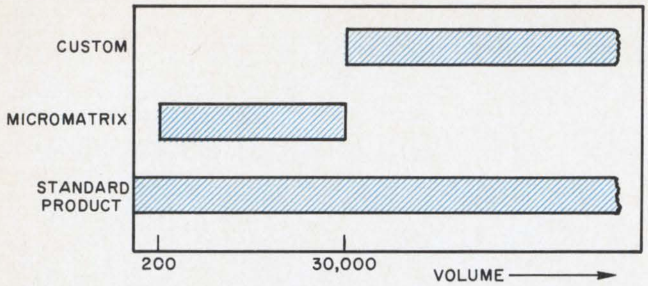
The computer-aided design program used for acceptance functional testing is known as *FAIRTEST*. This program performs three functions. It analyzes the *FAIRSIM* performance test and generates a list of untested array elements. At this point, more tests may be written in *FAIRSIM* to test the array more completely, or automatic test generation may be selected. The



A four-bit carry-look-ahead arithmetic unit, implemented with the 4700 array, performs any of eight parallel functions on two 4-bit operands. The functions include ADD, SUBTRACT, $A \cdot B$, $A \cdot \overline{B}$, $A+B$, $A+\overline{B}$, $A \oplus B$, and $A+\overline{B}$. In the subtract mode, the circuit can function as a 4-bit comparator, providing $A<B$, $A=B$, or $A>B$.



This eight-bit MOS accumulator contains 200 gates, or about 600 individual components. It is capable of processing eight bits at once, in an area of 86-by-116 mils. The unit combines on one chip an input register, an adder-subtractor, an accumulator register and an output buffer.



3. **Medium volume complex circuits** are often not standard products and are not required in sufficient volume to justify custom design. A special approach, which allows a limited amount of customization, is required for this market area.

second function of *FAIRTEST*, automatic test generation, is performed using sophisticated algorithms to select optimum test sequences. These additional tests are then combined with the performance test to form the final functional acceptance test. The third function of *FAIRTEST* is automatic formating of test sequences to the appropriate tester format.

All of these computer aids, now in use at Fairchild, have been designed to complement their custom LSI program. MOS LSI is presently automated from Boolean logic description to automatic mask generation including cell assignment and placement.

Custom LSI at low volume

The semiconductor industry has historically provided two approaches to customers, where new products are concerned. The customer has bought standard circuits specifically designed to meet the majority of his needs, or he has paid the necessary custom development costs. Fairchild developed their Micromatrix™ in attempt to bridge the gap between these two approaches (Fig. 3). The Micromatrix is intended to serve the custom market for volumes ranging from very low to the economic crossover point for pure custom design.

A Micromatrix array is a two-dimensional matrix of multi-gate building blocks or cells. Each cell contains a set of components (diode clusters, inverters, etc.) that may be individually specialized by cell intraconnections to become one of a variety of fundamental logic building blocks (NAND gate, flip-flop, etc). By means of a two-layer metalization process, the cells may be interconnected to form a complex subsystem logic function in a manner analogous to the interconnection of conventional ICs on a double-sided printed-circuit board.

The major incentive for the development of complex custom arrays is based on economic considerations, rather than upon any dramatic new advance in size or performance.

Although arrays can be shown to be economically attractive on a per-wired-gate cost basis, the true economic impact cannot be appreciated unless viewed from a total systems concept. Substantial savings will be felt in engineering documentation, in-plant inventories, and in field maintenance procedures. It will soon be practical to throw away, rather than to repair, a malfunctioning subsystem.

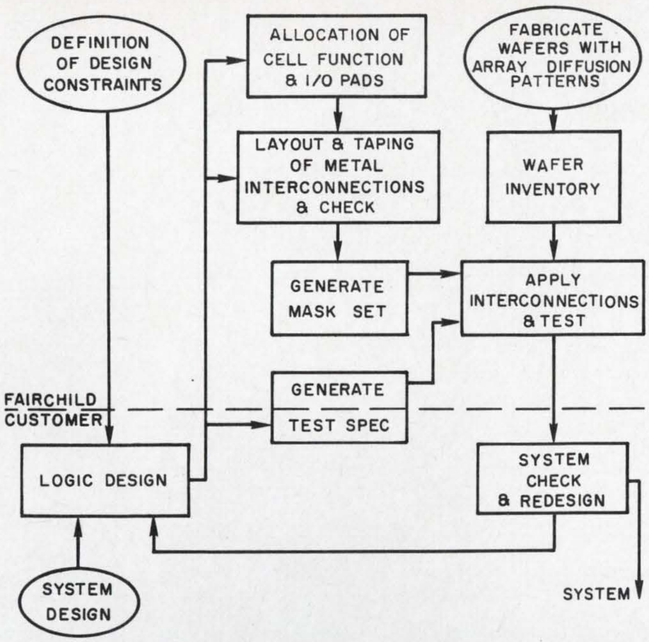
The major difference between Micromatrix and custom design is in the trade-off between engineering and manufacturing costs. In general, a given function can be custom-designed to use a smaller chip size, or to use a simpler manufacturing process than the equivalent function in Micromatrix. Both affect yields and thus manufacturing costs. At low volumes, the engineering cost heavily influences total unit cost. At high volumes, the manufacturing cost predominates.

It will not always be possible or practical to use all of the components in an array, in implementing a subsystem. Experience indicates that 80 per cent usage is a practical guide for evaluating the efficiency of the system logic partitioning. A complex custom circuit, on the other hand, is usually an optimally arranged group of components designed for a specific application.

Since it is impossible to define—much less implement—an optimum over-all design, the problem becomes one of choosing a set of compromises satisfactory to the largest possible number of users. Such a generalized approach will not satisfy all applications. A complete custom design will be justified in those circumstances where some parameters (power, speed, area efficiency, etc.) must be optimized; where cost is either a secondary consideration, or where total parts volume can justify the added expense of a fully customized design.

The Micromatrix approach to LSI is distinguished from the discretionary wiring approach in that no testing is performed at the cell level. Testing is done only after fabrication is complete. Elimination of area-consuming test pads permits an array to be fabricated on a state-of-the-art chip size, ensuring reasonable yield. And only one set of masks is required per custom design.

Basic wafers, completely fabricated up to metalization, will be stocked in plant inventory; from which wafers will be drawn for all custom arrays fabricated from this product family. This will lead quickly to high-volume wafer manufacturing, which is a requisite for low costs. In addition to eliminating the custom engineering design lead time that is normally required for wafer processing and for evaluation, the high-volume approach provides for greatly reduced in-process inventories of many different wafer types and leads to greater process uniformity, more thoroughly characterized devices, and a



4. **No single interface definition will satisfy all customers** or applications, but it is important that identification of vendors' and customers' responsibilities be as clear-cut as possible.

larger volume of data upon which reliability and failure-mode predictions can be made.

Interconnection masks can be designed and fabricated much more quickly than a complete set of diffusion-plus-interconnection masks; thus the Micromatrix approach is assured of a faster turnaround time than a full custom approach. The use of two-layer metal and highly systematic layout procedures greatly simplify design.

Large scale integration has projected the semiconductor manufacturer into the business of subsystem fabrication; where he once interfaced mainly with circuit and component engineers, he must now communicate with system engineers, logic designers, and packaging engineers as well. The systems builder must become more aware of the limitations of the process technology.

As the technology evolves and becomes more sophisticated, it appears that a means must be found to merge the vendor and the systems builder into a coherent design team. This is a very difficult problem, and a great deal of cut-and-try experimentation will be required during the coming years to develop common languages, information formats, document controls, and all other implements needed to bridge the user-manufacturer interface. No single interface definition can be made that will satisfy all customers or all applications. Nevertheless, the first interface definition should be chosen so as to make the identification of responsibilites as clear-cut as possible. Fairchild proposes an interface (Fig. 4) which we believe to be workable. This interface consists of the following:

1. *Fairchild defines specifications for cell family* (design manual).

2. *Customer analyzes system requirements* and selects the appropriate array type. It may be that a design already exists in Fairchild's library of custom designs that will perform the desired function. Basic decisions such as MOS or bipolar, number of cells, etc., are made at this point.

3. Using a design kit, *the Customer can breadboard his design* using discrete Micromatrix quarter-cells.

4. *Customer supplies logic specifications* of desired subsystem logic functions (within constraints imposed by design manual).

5. *Fairchild generates specialized mask sets* from logic specifications using the following procedures:

a) Make matrix cell-position logic-assignment with proper correspondence to logic specification requirements.

b) Lay out cell interconnections.

c) Three specialization masks (1st layer metal, 2nd layer metal, and dielectric) are generated by standard reduction and stepping techniques and applied to stock wafers that contain the basic array diffusions.

6. *Fairchild tests (to its own and/or customer specifications) and delivers finished units.*

The interface described above is by no means "frozen" and is subject to negotiation. As Fairchild and user learn to communicate more adequately, the interface will tend to drift in the direction of placing more and more control of the design parameters in the hands of the user. ■■

References:

1. E. G. Ulrich, "Time-Sequenced Logical Simulation Based on Circuit Delay and Selective Tracing of Active Network Paths," ACM 20th National Conference *Proceedings,* 1965.

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What are five advantages of LSI that the consumer-electronics user can expect to enjoy?

2. What solution is advised for putting a thousand or more gates in a package?

3. What are two characteristics of the custom LSI business?

4. What is the longest turnaround time that a custom LSI buyer can be expected to tolerate?

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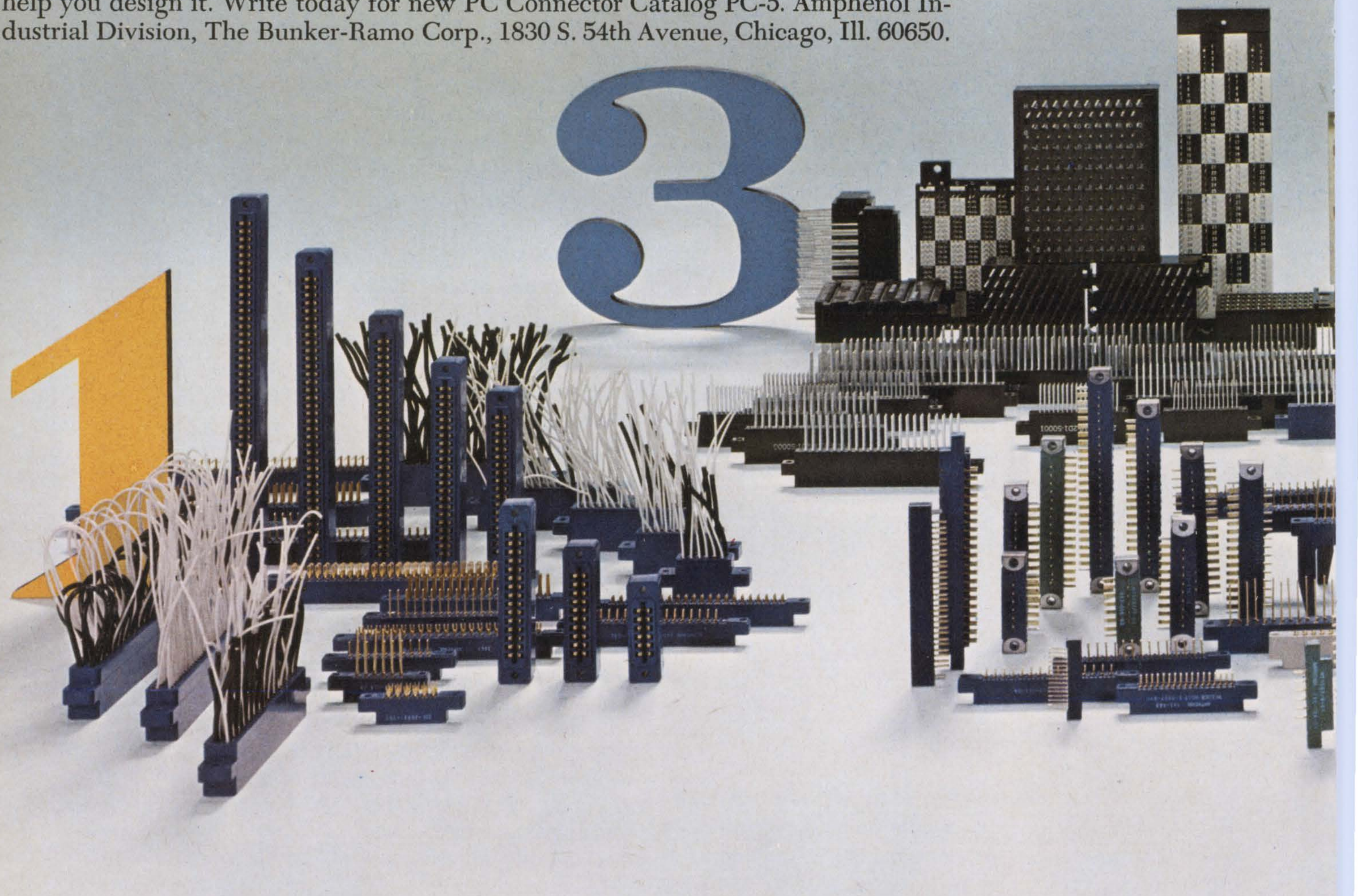

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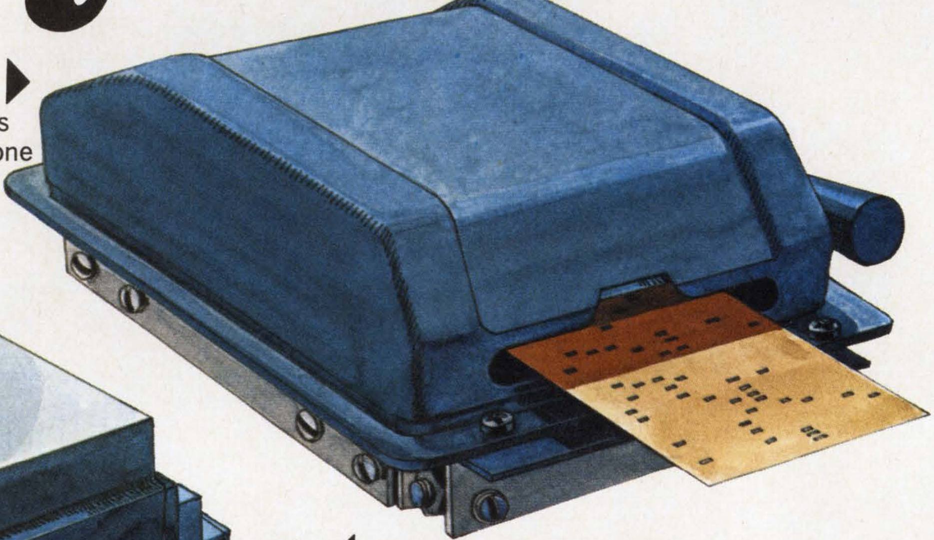
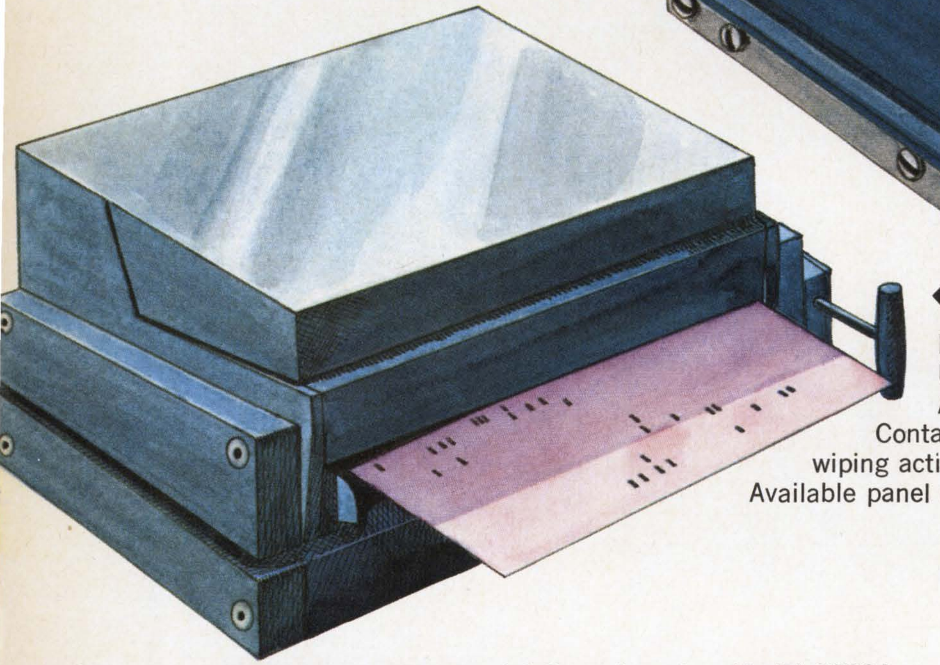
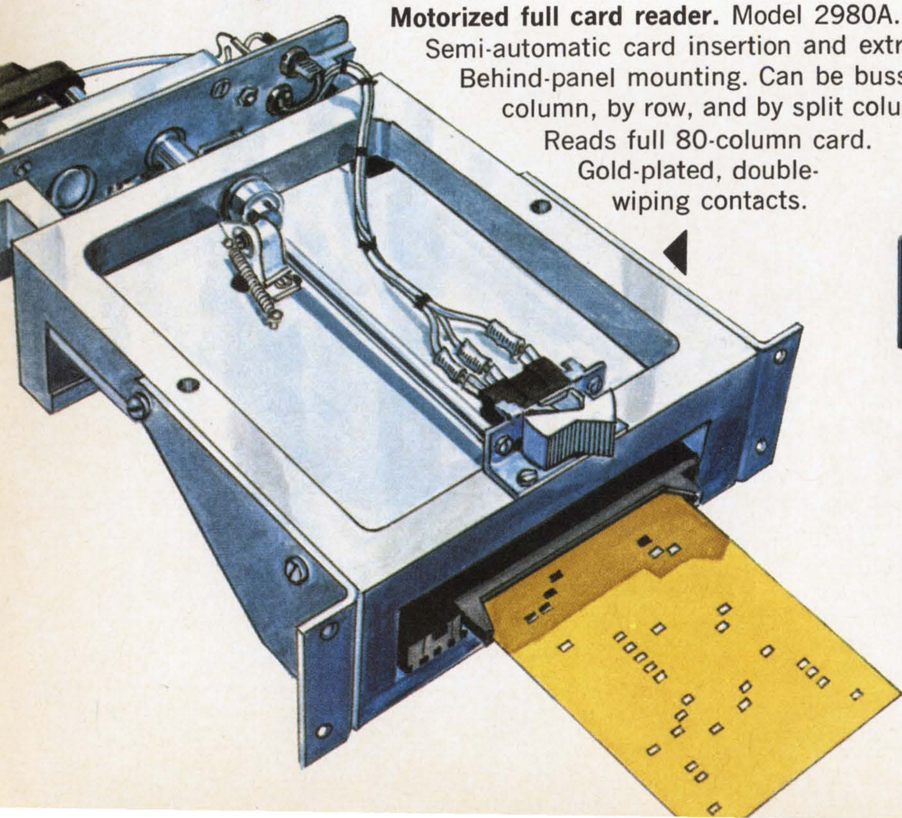
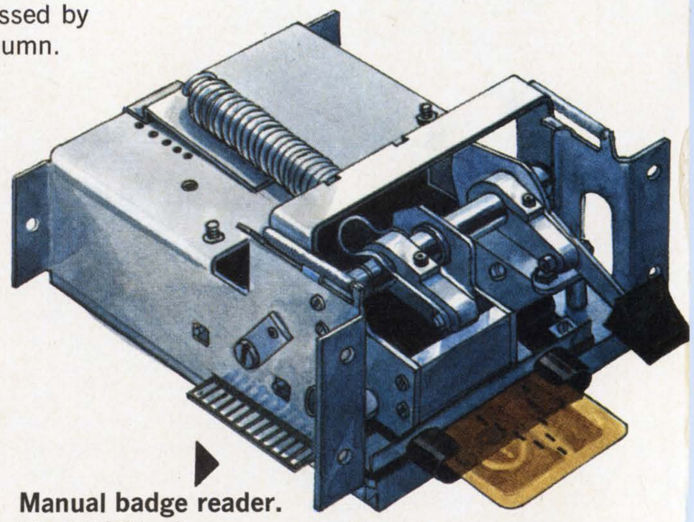




Desktop card reader. Model 1040. Up to 960 switches, 80-column format. Available in matrix or isolated outputs. Contact rating of 0.25 amp DC. Double-wiping action cleans contacts at each use. Available panel mounted.

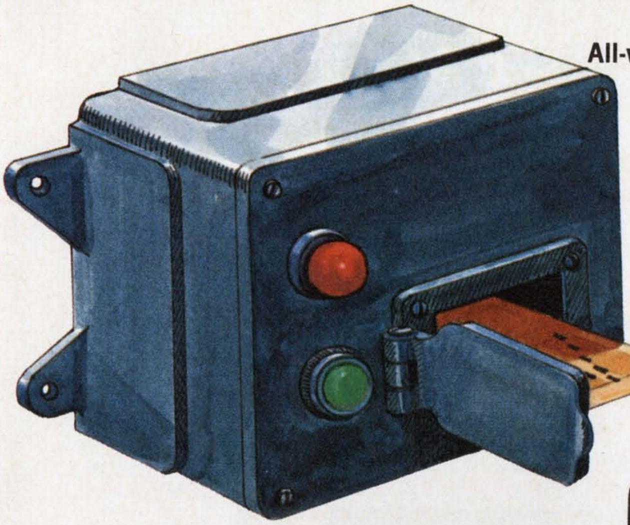
Motorized full card reader. Model 2980A. Semi-automatic card insertion and extraction. Behind-panel mounting. Can be bussed by column, by row, and by split column. Reads full 80-column card. Gold-plated, double-wiping contacts.





Manual badge reader. Model 361. Cross-matrix or individual outputs. Takes 15-, 20- or 22-column badge up to 0.040″ thick. One-hand operation. Up to 264 switches. Designed for one million cycles.

formation:



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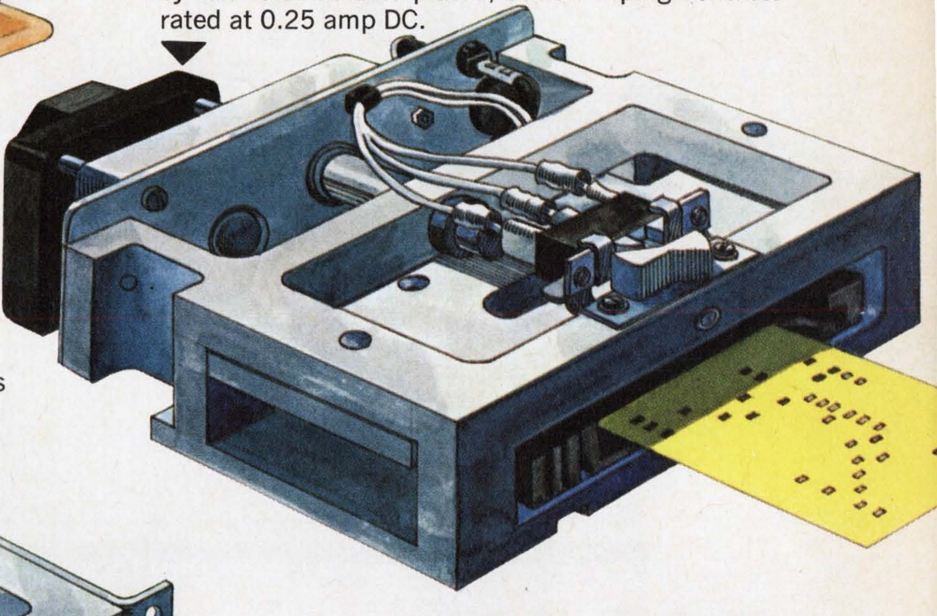
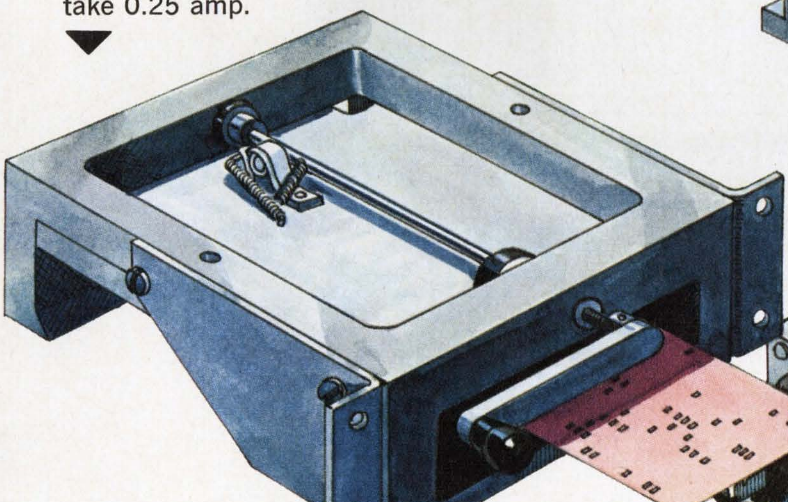
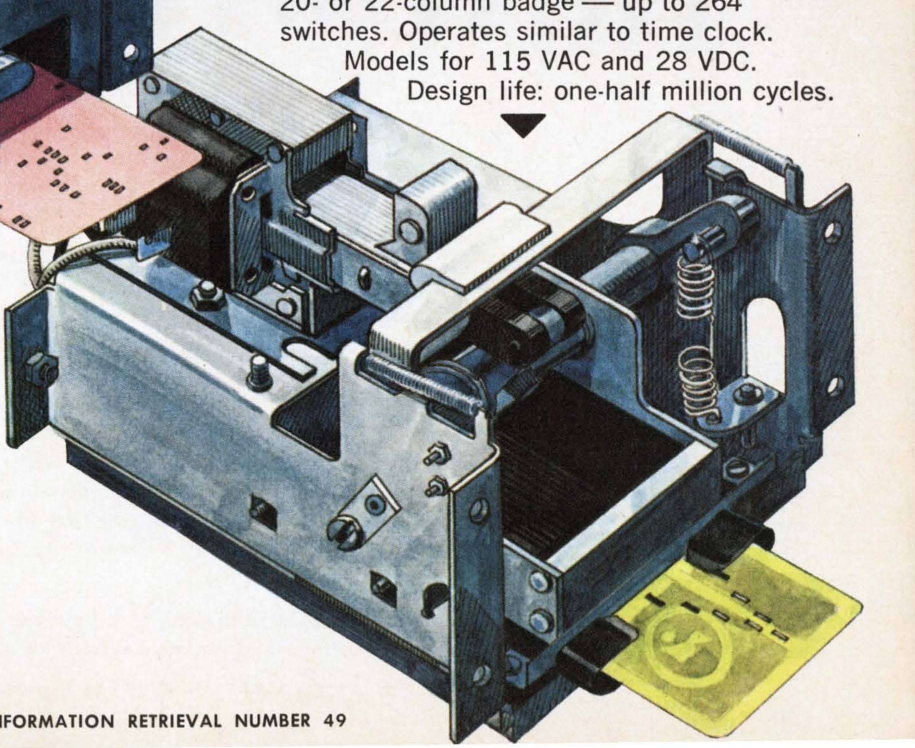
Low-cost industrial reader. Model 2900A. Motor-operated or manual model 2901A. Up to 264 switches, 80-column format. Bussed by row, by half-column or by full column. Gold-plated, double-wiping contacts rated at 0.25 amp DC.



Behind-panel reader. Model 2981A. Industrial full 80-column card reader. Complete alphanumeric coding and 160 six-bit word capability with only 160 diodes. Can be bussed by column, by split column, or by row. Gold-plated contacts take 0.25 amp.



Solenoid badge reader. Model 360. Reads 15-, 20- or 22-column badge — up to 264 switches. Operates similar to time clock. Models for 115 VAC and 28 VDC. Design life: one-half million cycles.



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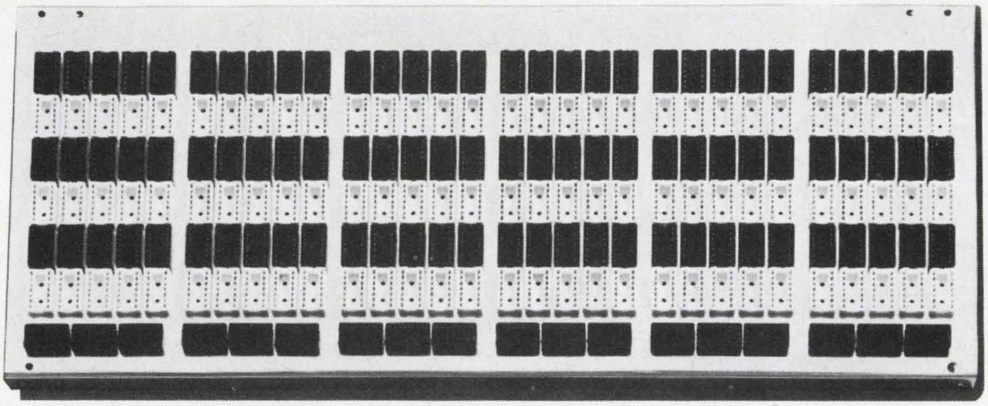

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MOS BRIEF 3

MOS ANALOG FUNCTION GENERATOR

Complex analog functions, like that in Figure 1, can be digitally generated as fast as 125,000 analog levels a second. The generator fits on a small printed-circuit board, because the function is stored as binary bits in an MOS read-only memory and is read out through an integrated-circuit digital-to-analog converter. In the past, slow and bulky electromechanical equipments, such as photoelectric mask scanners and machined-cam followers, were used to generate signals as unusual as these.

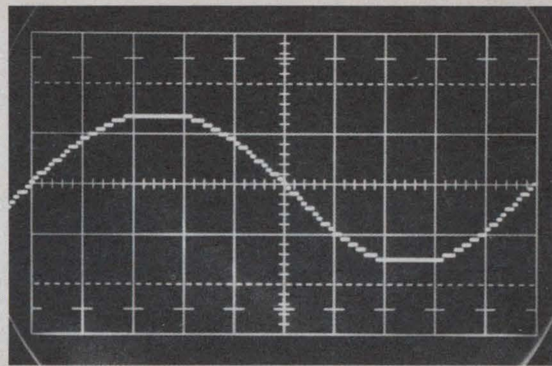
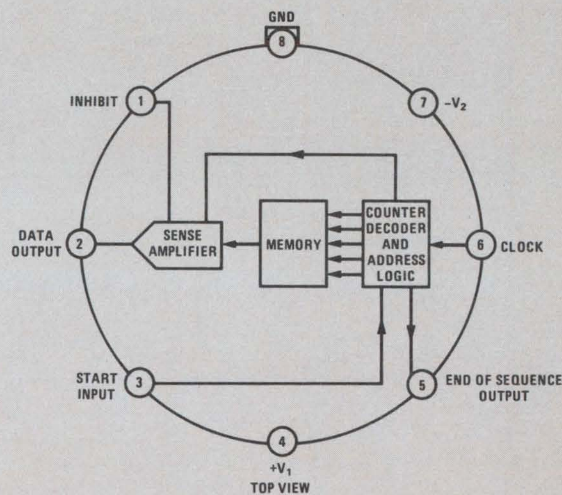


FIGURE 1. Typical Scope Trace Produced by MOS Memory.

The initial application of the MOS generator is drawing special test patterns on a CRT screen. An operator can compare the generated function with the signal produced by systems or transducers excited by programmed test stimuli. This substitutes a quick go-no-go curve-matching test for a laborious measuring and plotting procedure. It takes little imagination to see many non-display applications. Coders and decoders for secure communications, analog computers and simulators, and automatic control of processes are a few probabilities.



NOTE: Pin 4 connected to case

FIGURE 2. MM520 Read-only Memory and Character Generator Contains 256 Bits of Storage, Addressing and Control Logic in a Single Chip of Silicon.

The memory circuits are 256-bit MM520's, which are frequently used as character generators (Figure 2). Programmed metallization masks are used to store code words during chip manufacture. Connections are made or not made at each storage node in the chip, depending on whether the code calls for a binary "1" or "0" at that node.

Figure 3 represents the operating model that produced the scope photos in Figure 1. Coding of the analog levels is somewhat like pulse-code modulation. The number, N, of bits in each binary-coded word determines the waveform resolution:

$$\% \text{ Resolution at full scale} = 100/2^N$$

For the model, 6-1/4 percent was ample, so each word is four bits long and each MM520 thus stores 64 distinct, quantized levels.

The bits are read out serially when a logic "1" signal triggers the start input of the first MM520. The end-of-sequence pulse from the first MM520 triggers the next, and so on through the string. Flip-flops A and B (MM583 JK binaries) generate the trigger pulse and also divide the clock by four, so that the MM508 serial-in/parallel-out register will separate the serial bit stream into the four-bit code words.

Four more MM583 flip-flops and four MM580 dual NOR gates operate as buffered registers to hold the four bits of each word and drive the A/D converter. The converter is a four-rung resistor ladder and an MM551 multiplexer used as a series switch. Errors in the analog output are detected and nulled in the ladder via the feedback loop of the LM201 operational amplifier. Full-scale voltage adjustment is provided in the feedback loop by potentiometer R1. All analog levels appearing at the output are equally spaced in time, since the system is synchronous.

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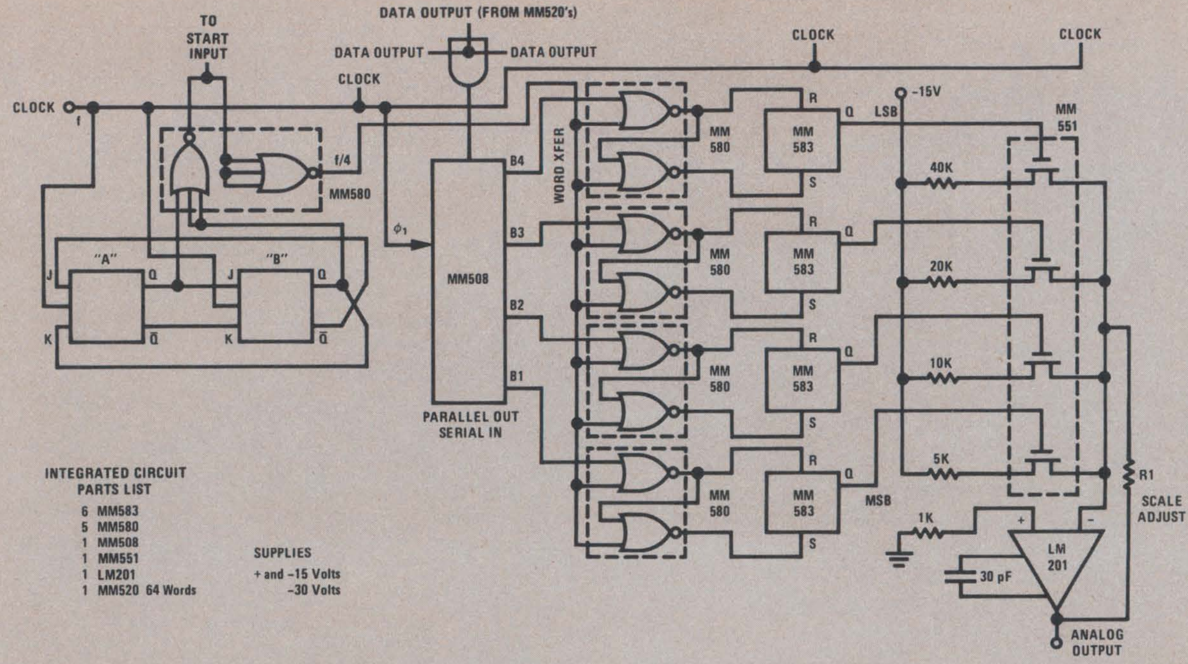

FIGURE 3. Working Model of Analog Function Generator Uses Four Bits in Each Digital Word to Define Analog Levels. Any Number of MM520's Could Be Used.

If greater resolution than 6-1/4 percent is desired, the words can be made longer, of course, by merely extending the clock divider and converter logic circuits. One operational amplifier will still suffice. In fact, this portion of the system can easily be time-shared by several function generators if a programmed selector switch is added. Or the operator can change functions by manual switching or plug-in replacement of the MM520 strings.

Some applications require a periodic function—for example, a complex sine wave. The auxiliary circuit in Figure 4 makes it unnecessary to store both positive and negative halves of the function. In the working model, the ripple counter produces a sign-reversal pulse at 64-word intervals. Delivered to the MM550 analog switch, the pulse periodically connects the function-generator output to the positive or negative side of the operational amplifier. Here again, the number of circuits used can easily be changed to fit the function-generation requirement.

Stored code words can also be used to divide an oscilloscope's sweep into regular angular increments, or to produce other special traces that may be required in analysis work. Since the words are digital, they can also be used to compute automatically the sine, tangent or other mathematical functions of the analog signals that are displayed.

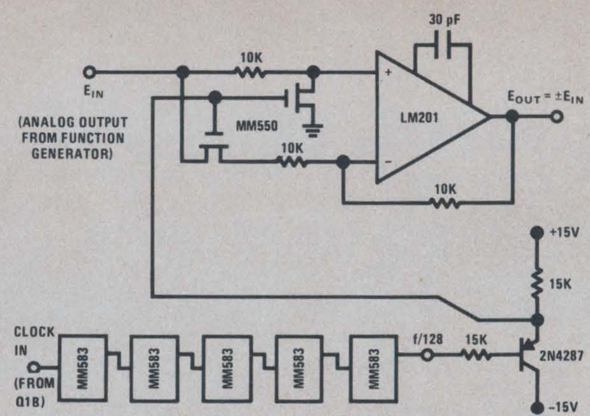

FIGURE 4. Analog Inverter Reverses Polarity of Periodic Functions.

Complete data sheets and additional applications information on all the MOS devices are available upon request.

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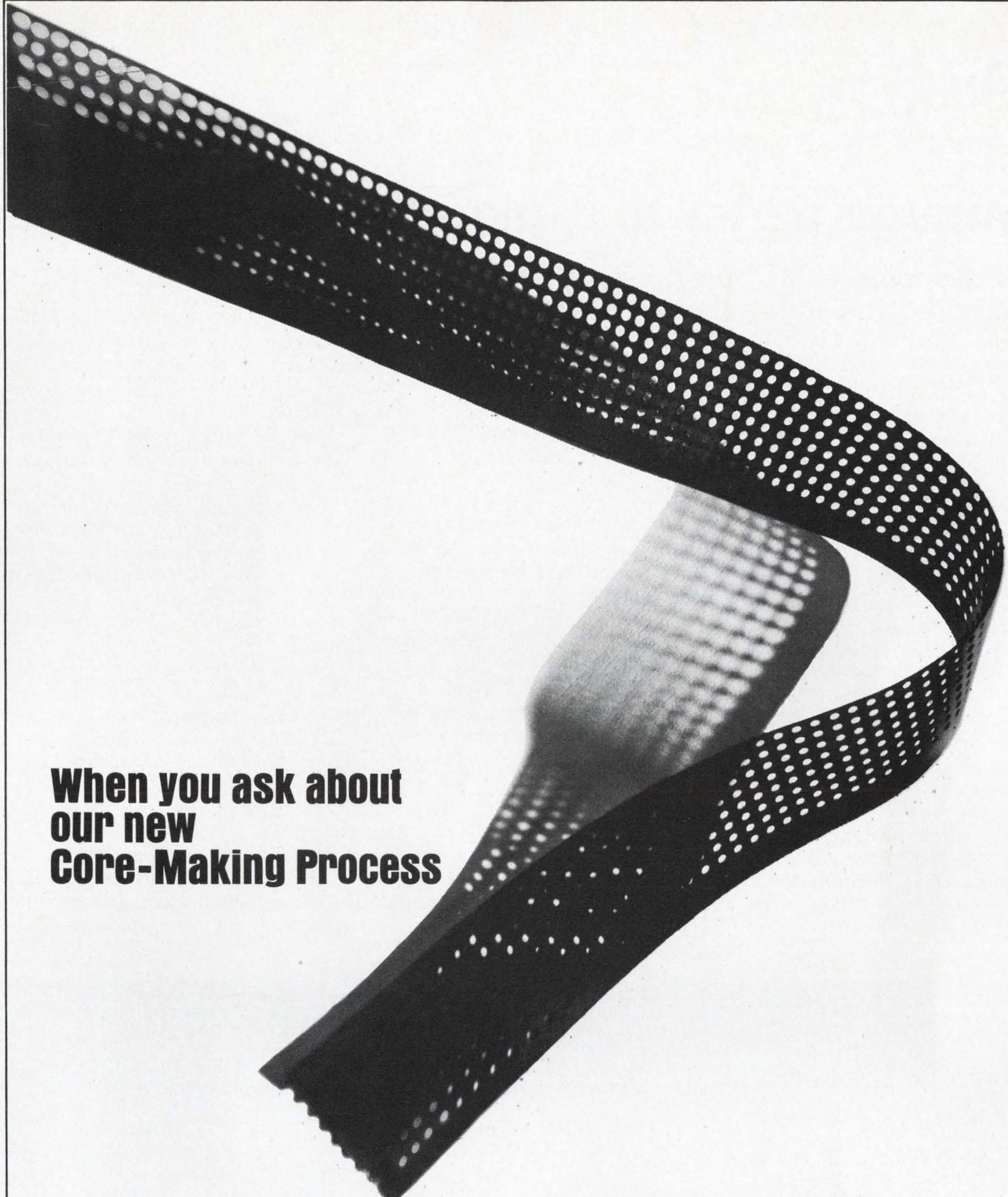

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Computer parley to explore new design goals

Sharp rise foreseen in '70s in use of phone lines to transmit digital data on a time-shared basis

A. Craig Reynolds, Jr.,
Technical Editor

By the end of the 1970s, the American Telephone & Telegraph Co. estimates 50 per cent of its phone traffic will consist of digital data transmissions. This trend, along with Federal Communications Commission steps to liberalize consumer use of the phone lines, is opening new opportunities for time-sharing computer design.

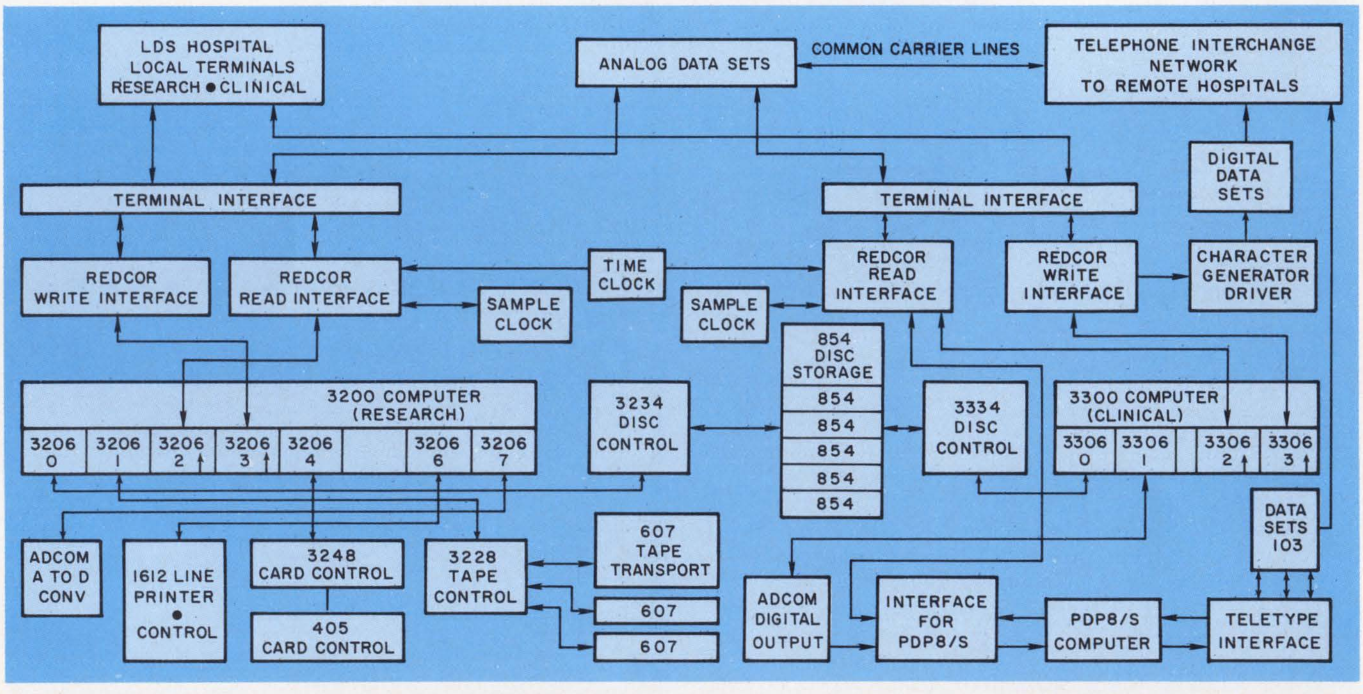
The impact and the challenge of data communications will be subjects of major concern at the Fall Joint Computer Conference, which is being held Dec. 9-11 at the Civic Center in San Francisco.

Panelists at Session 7 of the conference are prepared to look closely at an FCC inquiry now under way into the "interdependence of computers and communications." Before the inquiry, and before last summer's decision in the now noted Carterfone case, computer designers were obliged to interface with the voice-band transmission network either through Dataphone subsets, rented by the telephone company, or through acoustic coupling. The first alternative was costly, since the rental fee could run as high as $80 a month per unit, while the second was both expensive to design and subject to errors caused by local noise interference.

Last July the FCC ruled in the Carterfone case that phone company prohibitions against the attachment of customer-provided devices were too broad to be valid. The ruling made the Carterfone, a privately installed device that connects message toll telephone facilities with two-way mobile radio systems, a legitimate phone attachment that could be used without phone company approval. And since then the FCC has been examining the 1934 Communications Act with a view to liberalizing the use of phone lines for digital data communications.

The benefits to computer designers are being felt already. Interfacing is now allowed through the use of a small protective circuit that the phone company rents for only $2 a month. Engineers no longer need work with Dataphone subset characteristics and can be more selective in their computer network designs.

Recently the tariffs charged for use of Telpak, an AT&T name for wideband combinations that are available to satisfy specific user requirements and to provide broad bandwidth channels in the microwave communications systems, were the subject of controversy. This resulted from an FCC ruling that the tariffs were excessive. Telpak was withdrawn until the sub-



1. **The over-all system organization** of the Utah biomedical computer controlled system uses voice-grade transmission lines for data communications. The remote terminals may be as far as 50 miles from the central computers, which are at the Latter Day Saints Hospital in Salt Lake City.

mission by AT&T of lower rates and their acceptance by the FCC. The combinations are now available again to digital data communications systems users.

The speakers at Session 7, all of whom have active roles in the FCC inquiry, are:

Louis Feldner, consultant, Data Communications, Palo Alto, Calif., the chairman of the session.

Prof. Manley Irwin and Prof. Michael Duggan of the Whittemore School of Business and Economics, University of New Hampshire.

Bernard Strassburg, Chief, Common Carrier Bureau, FCC, Washington, D.C.

Paul Rogers, general counsel, National Association of Regulatory Utility Commissioners, Washington, D.C.

Rep. John Dingell (D-Mich.), chairman, Subcommittee on Regulatory and Enforcement Agencies.

Communications in medical work

Use of common-carrier toll message facilities is increasing rapidly in medical practice. This is particularly true in electrocordiographic diagnosis and in monitoring patients in intensive-care wards. The trend is being discussed at Session 25.

An experimental installation at the Presbyterian Hospital in Los Angeles will be described by David Stewart of the University of Southern California School of Medicine and a staff member at the hospital. The installation uses an IBM 1710 to provide diagnostic services. Experience gained in the past year in monitoring over 500 patients is being incorporated in a new system that will use a Scientific Data Systems Sigma 5 computer.

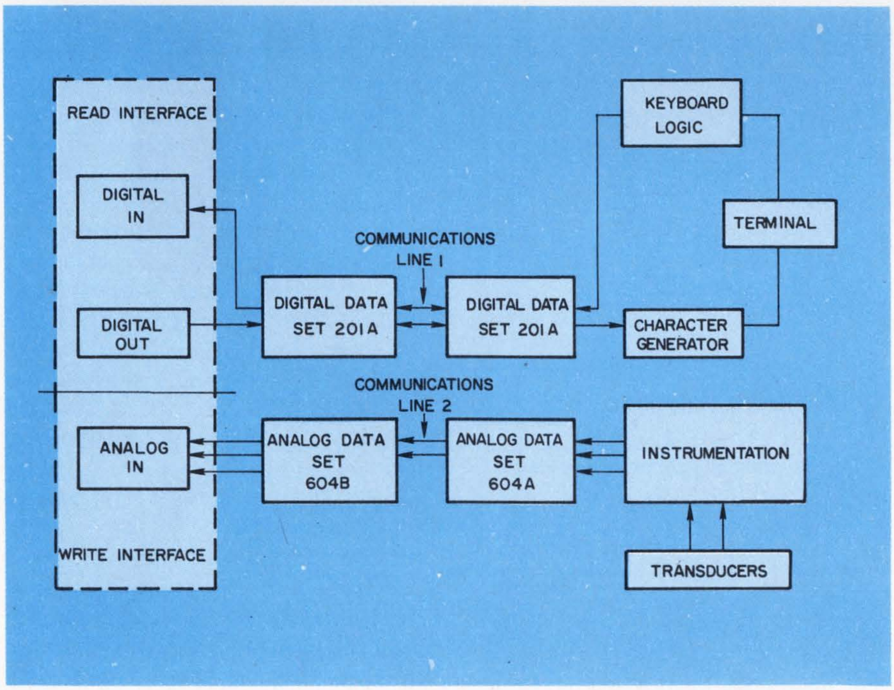
The 1710 is limited to real-time operation. It services only two patients at a time, but it can monitor 11 functions of primary biological importance, such as blood pressure, pulse rate and respiratory activity.

Expansion of the system by incorporating the Sigma 5 will permit operation in a time-shared mode and will greatly increase both the number of patients to be monitored and the amount of peripheral equipment that can be connected to the central facility. The extension of the network to service the greater Los Angeles area, using communications over voice-grade lines, is envisioned.

Reed Gardner of the Latter Day Saints Hospital, Salt Lake City, will describe the engineering of a far more extensive system in use in Utah. It services six medical areas at distances ranging from a few miles to 50 miles from two central computers at the Latter Day Saints Hospital. Voice-grade, common-carrier lines are used for data interchange between the terminals and the central computers. Since the lines used are on the dial network, interfacing is accomplished with Bell System Dataphone subsets. The 201-A subset is used for digital data communication and the 604-B for analog information transmission. Twenty remote terminals are in use. In addition a six-bed intensive-care ward for patients who have had open heart surgery is continuously monitored on a programed basis.

The central computers being used are the Control Data Corp. 3200 for research applications and the company's 3300 for clinical functions and medical diagnosis. Communication speed between the terminals and the computers for patient diagnosis averages less than two minutes.

The system is protected against failure through use of the 3200 as hardware backup for the 3300. Extension of the system to other areas in Utah is planned. (Fig. 1 shows the over-all systems organization, and Fig. 2 the details of the interfacing equipment and the terminal units.)



2. **Both digital and analog information must be exchanged** between the remote terminals and the central computers. Bell System Data Phone subsets are used to interface with the toll-message voice communications network.

Telecommunications also used

In many applications the slow-speed telecommunications network can be used for communication between remote terminals and central computers instead of the more expensive voice-grade lines. Different design consideration are involved because of the narrower bandwidths available, as compared with voice-grade lines and Telpak options.

Local storage at the terminal units must be provided for display regeneration in order to relieve the central processor from controlling this function, which is costly in computer time. Programs must be constructed and implemented in hardware to provide control functions and to interface with the central unit on a time-shared basis. Interaction between the terminals and the computer must be provided through keyboard inputs, function-control panels and the use of a light pen interacting with the display unit to correct programs and to change the configuration of graphic displays of circuits or other systems as desired by the designer.

International Business Machines has developed and constructed one of the most complete units for utilization of the telecommunications systems. The terminal unit has been designated the IBM 1150/2250 Stand Aline/Remote Graphic System. It will be discussed in detail by Michael Rapkin, IBM, Kingston, N.Y. (Session 23). Because of the number and complexity of the functions that are performed, the 1150/2250 is essentially a small computer with graphic display plus interaction capabilities with the central computer. The unit may be aptly termed a satellite computer. The central processing unit is a System/360 computer with time-sharing capabilities.

A graphic subroutine package has been prepared for the programmer. It can service scientific, engineering and commercial applications. This is important, for it greatly simplifies the problem in using the telecommunications network in combination with the central computer.

Bulk memory devices are needed

Efficient use of remote terminals that have communication facilities for data transfer to central computer installations operating in a time-shared mode requires the development of much larger and more compact units than present ones. These are needed to solve the programing requirement for time-shared operation. The cost per bit must also be significantly lowered to permit the use of larger memories on an economical basis.

Dr. William Gross of the Ampex Corp., Redwood City, Calif., states in Session 43 that at least three orders of magnitude improvement over existing memories is required. This will be a long-range program, he says. Programing is extremely difficult with bulk memories because of the need for additional addresses and decision branching logic. The solution is still in the laboratory stage.

Gross says that "even existing prototypes are unsatisfactory and that manufacture of production units is virtually impossible." However, Ampex has constructed and successfully tested a bulk memory that satisfies the storage capacities required at a lowered bit cost. The requirement of compactness is not satisfied, since bulky multiple tape transports are used.

The development and operation of the Ampex system will be discussed by Sidney Damron, Jerry Miller, Erik Salbu and Manfred Wildman, all of Ampex, and by Joseph Lucas of the U.S. Dept. of Defense.

Ampex uses video recording techniques to achieve high bit density. Recording is in blocks of 10^6 bits in a section of 2-inch tape that is 0.9 inch long. Transverse scan is employed to achieve an effective tape speed of 800 inches per second in the write mode. Longitudinal addressing is employed to locate a desired block, and the contents of the block are scanned to read the required data message. Redundant recording is used to achieve a demonstrated accuracy of 1 in 10^{10} bits. However the unit still suffers from many of the deficiencies of tape units when rapid random access is required, since access time to a required item is determined not only by selection of the required transport unit but, on the average, requires a search time that is one half the time required to search the selected tape.

The remote terminal unit used in the Utah network. Note the compactness of the unit and the simplicity of the controls.

Frank Risko of Bryant Computer Products, Walled Lake, Mich., has a different viewpoint that he will express in the same session. "Improved magnetic memories will be developed for use in systems to be built in the early 1970s," Risko agrees. "The rapid random access available from disk storage makes it an attractive starting point for device improvement."

However, he points out the limitations of magnetic devices and predicts they will be replaced by new and different techniques. In his opinion, the development of photochromic optical materials that will be capable of much higher bit densities, and will be erasable in addition to performing read and write functions can lead to satisfaction of the large bulk of memory requirements. Much research is being done in this area, and Risko says that optical memories using photochromic properties will be in use in the late 1970s.

Lasers produce high bit density

Another approach to optical techniques has been taken by Keith McFarland of the Precision Instrument Co., Palo Alto, Calif. He is using laser recording on a sputter-deposited metallic film, placed on a plastic tape base, to build read-only memories. He employs a laser with an output beam controlled by passing it through a Pockels cell, a unit that changes the polarization of the laser light output by 90° upon application of an electric field of the proper magnitude to the cell. A Glan prism, which transmits light of one polarization but rejects that of others, furnishes the shutter action required to form a bit "one" or to suppress the light output for the bit "zero." An argon continuous-wave laser is the light source. The energy of the laser beam evaporates the metallic film to record the "one" bit. The size is 5 microns, and the total time for recording a bit is 250 nanoseconds. The density is 2

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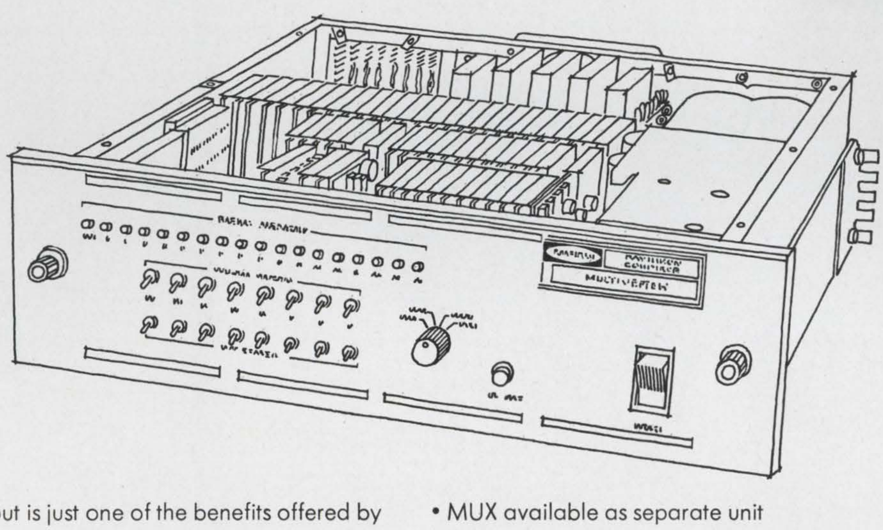

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to 5 × 10^9 bits recorded on a tape strip 4-3/4 inches wide and 31.4 inches long. The record and read rates are 5 megabits per second. Approximately 12,000 tracks are recorded on the tape. The device provides permanent storage, which restricts its use to applications where erase and rewrite are not required. It is now in the engineering model stage of development, but it is expected to become a production unit within the next two years. It has both military and commercial applications where read-only memories are required.

Such memories can be employed for storing permanent subroutines and for information retrieval.

IBM is pursuing conventional photo-optical recording with high-quality silver-halide film as the storage medium. The system will be described by Dale Gustlein and Don Prentice of IBM, San Jose, Calif. The IBM 1360 Photo-Digital Storage System is capable of storing 2.38 × 10^{12} data bits on line to the main processor. It is in limited production, and two systems have been installed and are operable.

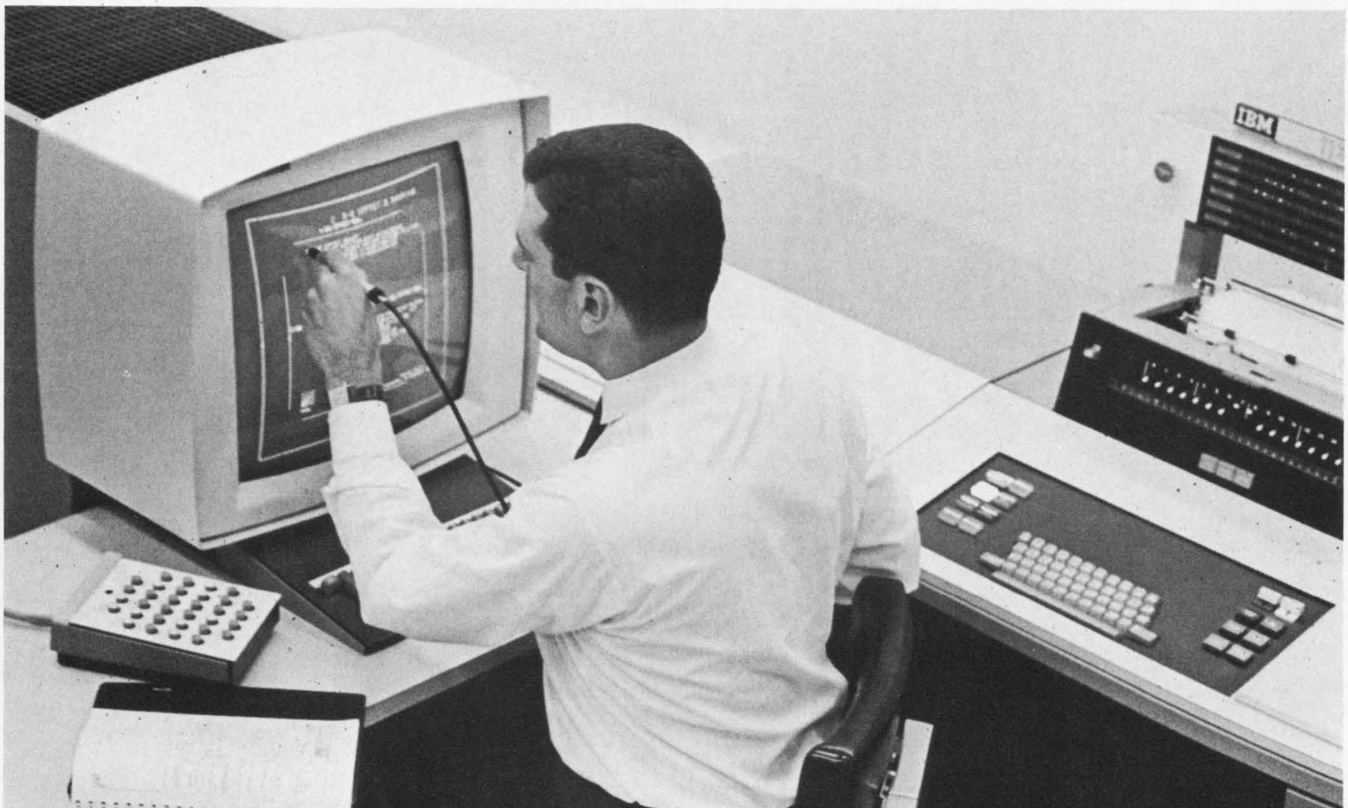
Large-scale integration has uses

Large-scale integration will become very important because of the high density of functions that can be obtained in very compact packages and the consequent reduction in cost per function where mass production of the units is feasible. Its future is still controversial, however, according to Dr. James Angell of Stanford University. Dr. Angell has organized Session 28 to demonstrate the pros and cons, as well as to discuss existing LSI elements.

Cedric O'Donnell and Robert Booker of Autonetics, Inc., Anaheim, Calif., will lead the arguments in favor of LSI. Autonetics has built a complete computer, the D-200, using eight different chip types and a total of 24 chips. The LSI chips are metal-oxide-semiconductors (MOS), and, as a consequence, the computer is relatively slow. The add time is 8 microseconds and multiplication 108 microseconds for 24-bit numbers. The clock rate is 250 kHz. The unit was built to prove feasibility rather than to demonstrate high-speed capabilities.

Dr. Lester Spandorfer of Sperry Rand, Blue Bell, Pa., is pessimistic about the use of LSI in the near future. He argues that "there is no clear economic advantage or improvement in design over present techniques" and that "it will not be until the late 70s that there may be a speed advantage in using LSI for memory, but no advantage will occur in the logic sections of computers." MOS is unsatisfactory because of its slowness, he notes. Bipolar transistor circuitry is, in his opinion, the only way to take advantage of LSI.

Donald Calhoun, of Hughes Aircraft Co., Culver City, Calif., will demonstrate an existing LSI array of four-bit multiplier units on a one-inch-square ceramic substrate. The operating speed of the units is 25 MHz, considerably higher than that available from MOS units. Gated full address, NAND gates and NOR gates have also been built with the same techniques. Here speed advantages do appear. The LSI units will be used in further development work. ■■



An operator is using the IBM 1150/2250 Stand Alone/ Remote System. A program correction is being made by interaction between the light pen and the display unit. The correction is transmitted to the central processor.

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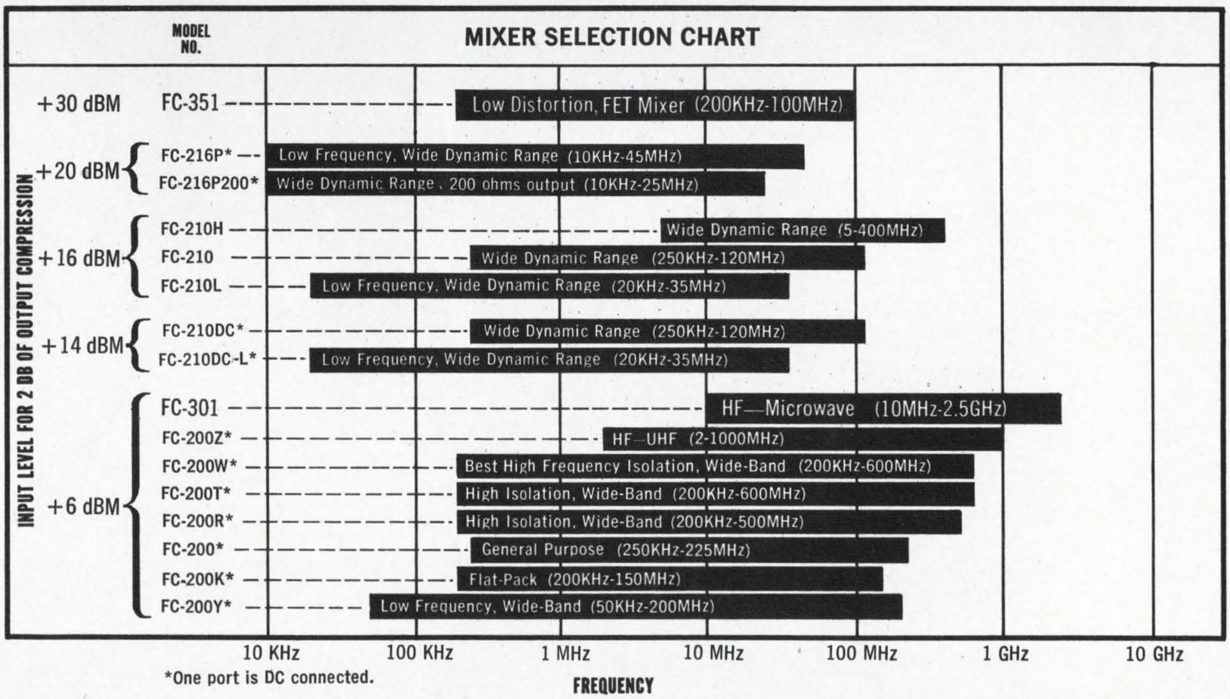

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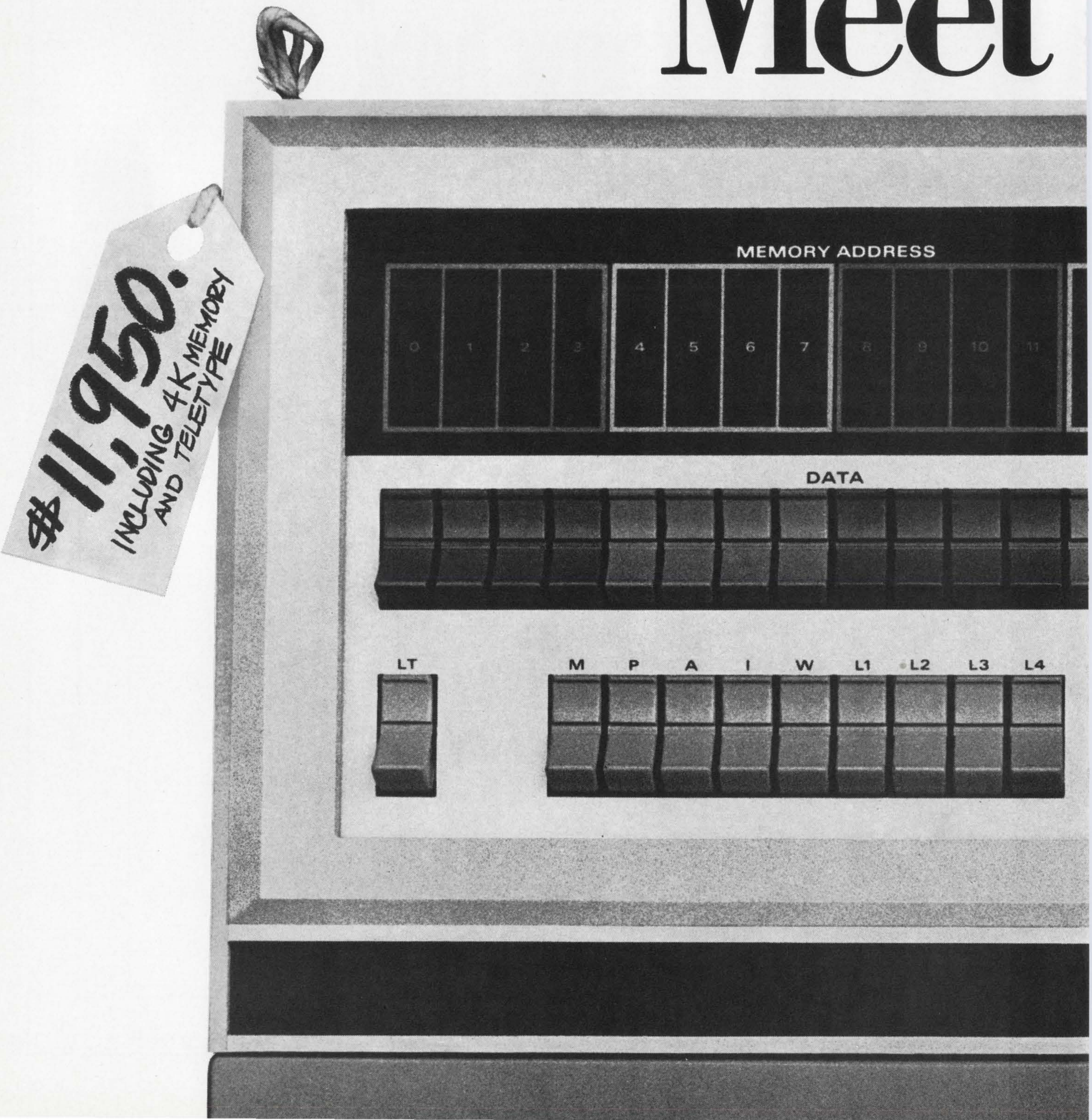

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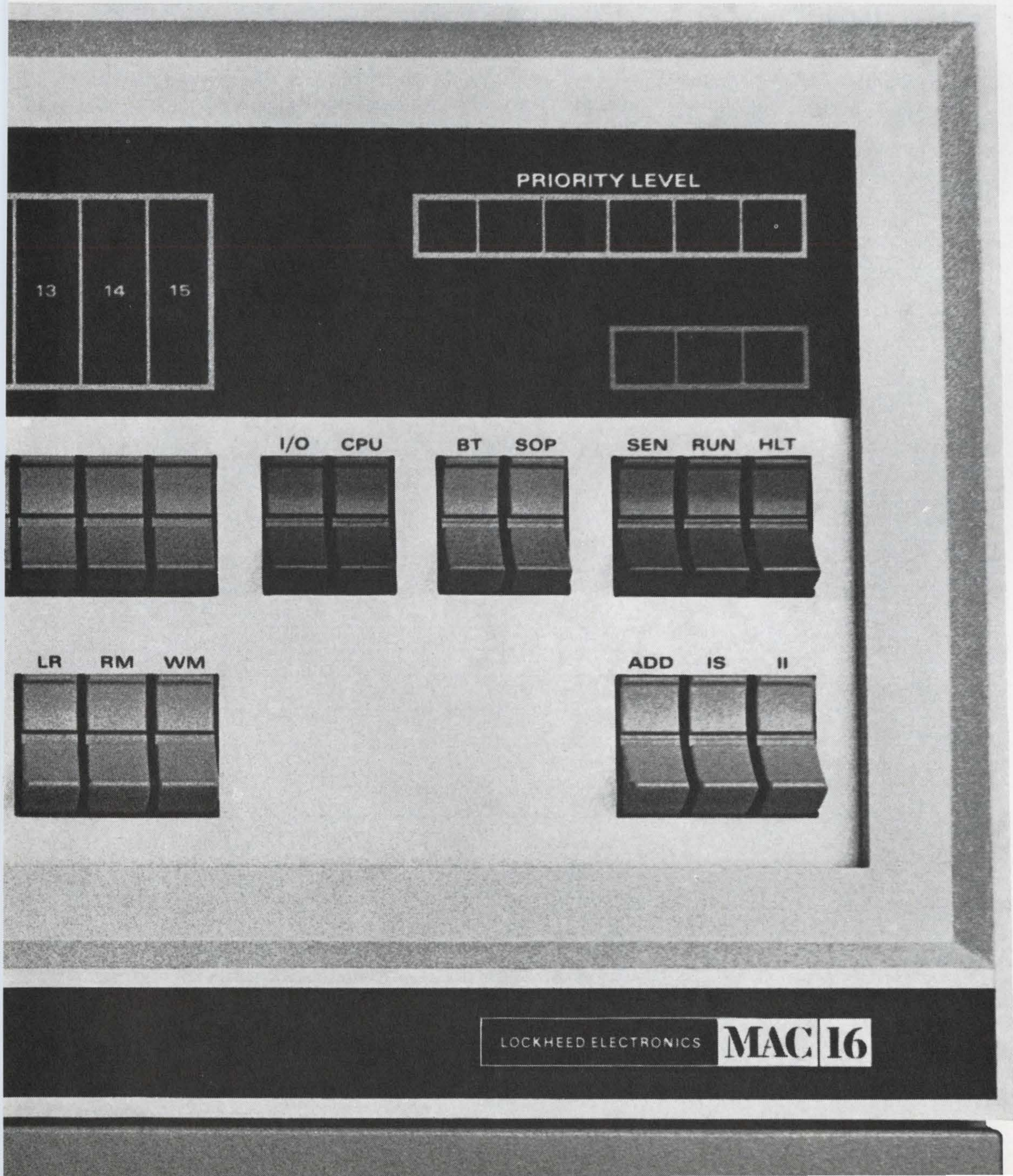

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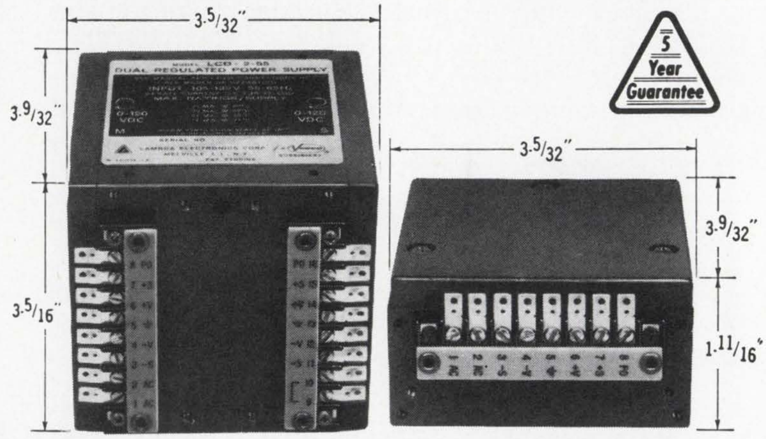

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		40°C	50°C	60°C	71°C	
LCD-2-11	0-7 VDC 0-7 VDC	300ma 300ma	240ma 240ma	175ma 175ma	115ma 115ma	$155
LCD-2-12	0-18 VDC 0-7 VDC	160ma 300ma	130ma 240ma	100ma 175ma	65ma 115ma	155
LCD-2-13	0-32 VDC 0-7 VDC	120ma 300ma	95ma 240ma	70ma 175ma	45ma 115ma	155
LCD-2-22	0-18 VDC 0-18 VDC	160ma 160ma	130ma 130ma	100ma 100ma	65ma 65ma	155
LCD-2-23	0-32 VDC 0-18 VDC	120ma 160ma	95ma 130ma	70ma 100ma	45ma 65ma	155
LCD-2-33	0-32 VDC 0-32 VDC	120ma 120ma	95ma 95ma	70ma 70ma	45ma 45ma	155
LCD-2-44	0-60 VDC 0-60 VDC	65ma 65ma	52ma 52ma	37ma 37ma	23ma 23ma	170
LCD-2-55	0-120 VDC 0-120 VDC	30ma 30ma	30ma 30ma	22ma 22ma	14ma 14ma	170

LCS-2 SINGLE OUTPUT MODELS

3 5/32" x 3 9/32" x 3 5/16"

Model	VOLTAGE RANGE	MAXIMUM CURRENT (MA) AT AMBIENT TEMPERATURE (1)				Price (2)
		40°C	50°C	60°C	71°C	
LCS-2-01	0-7 VDC	550ma	455ma	350ma	240ma	$90
LCS-2-02	0-18 VDC	330ma	275ma	210ma	140ma	90
LCS-2-03	0-32 VDC	240ma	205ma	155ma	95ma	90
LCS-2-04	0-60 VDC	145ma	115ma	87ma	57ma	100
LCS-2-05	0-120 VDC	50ma	50ma	45ma	30ma	100

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LCS-1 SINGLE OUTPUT MODELS

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Model	VOLTAGE RANGE	MAXIMUM CURRENT (MA) AT AMBIENT TEMPERATURE (1)				Price (2)
		40°C	50°C	60°C	71°C	
LCS-1-01	0-7 VDC	200ma	200ma	150ma	100ma	$85
LCS-1-02	0-18 VDC	95ma	95ma	95ma	80ma	85
LCS-1-03	0-32 VDC	65ma	65ma	65ma	40ma	85
LCS-1-04	0-60 VDC	35ma	35ma	35ma	25ma	95
LCS-1-05	0-120 VDC	12ma	12ma	12ma	12ma	95

NOTES:
(1) For operation at other than 57-63 Hz, consult factory for ratings and specifications.
(2) All prices FOB Melville, N. Y. All prices and specifications subject to change without notice.

OVERVOLTAGE PROTECTION

FOR USE WITH	Model	VOLT ADJ. RANGE	Price (2)
LCD-2-11, LCD 2-12, LCD-2-22, LCS-2-01, LCS-2-02, LCS-1-01, LCS-1-02	LC-OV-10	3-24 VDC	$20
LCD-2-13, LCD-2-23, LCD-2-33, LCS-2-03, LCS-1-03,	LC-OV-11	3-47 VDC	20
LCD-2-44, LCS-2-04 LCS-1-04	LC-OV-12	3-70 VDC	25

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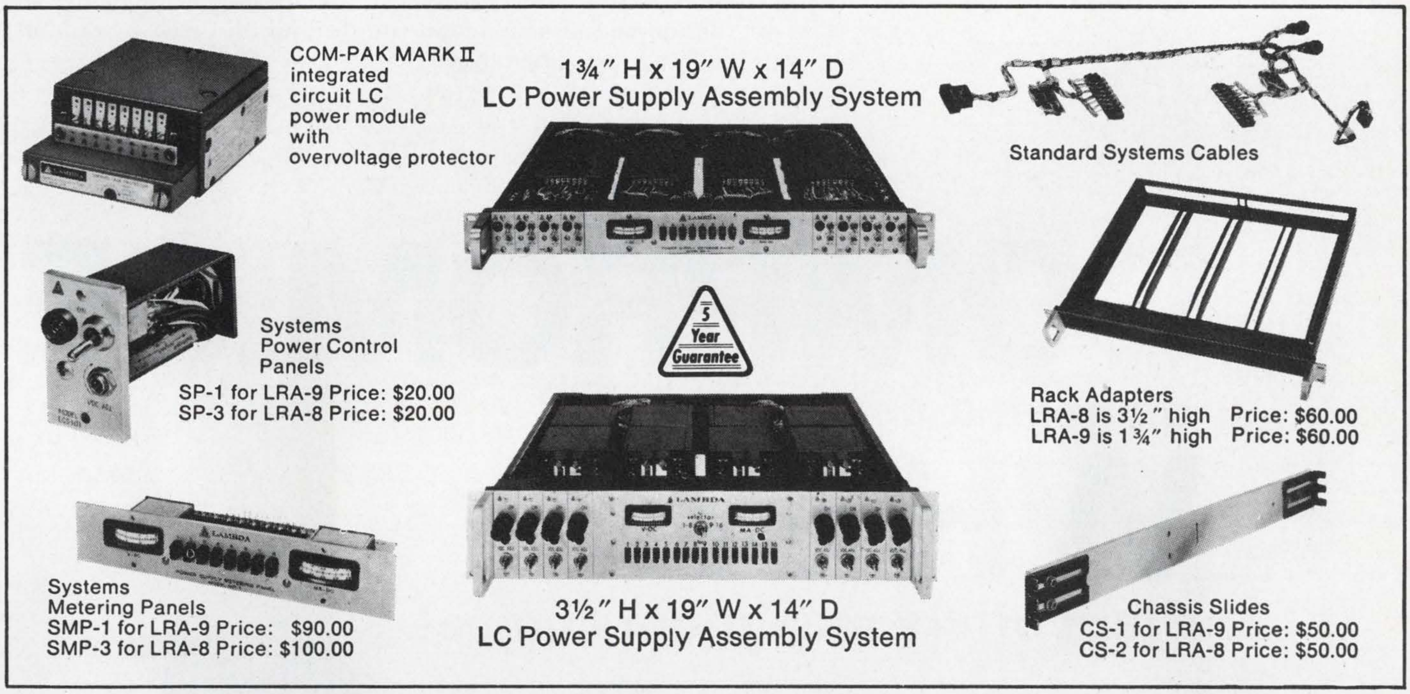

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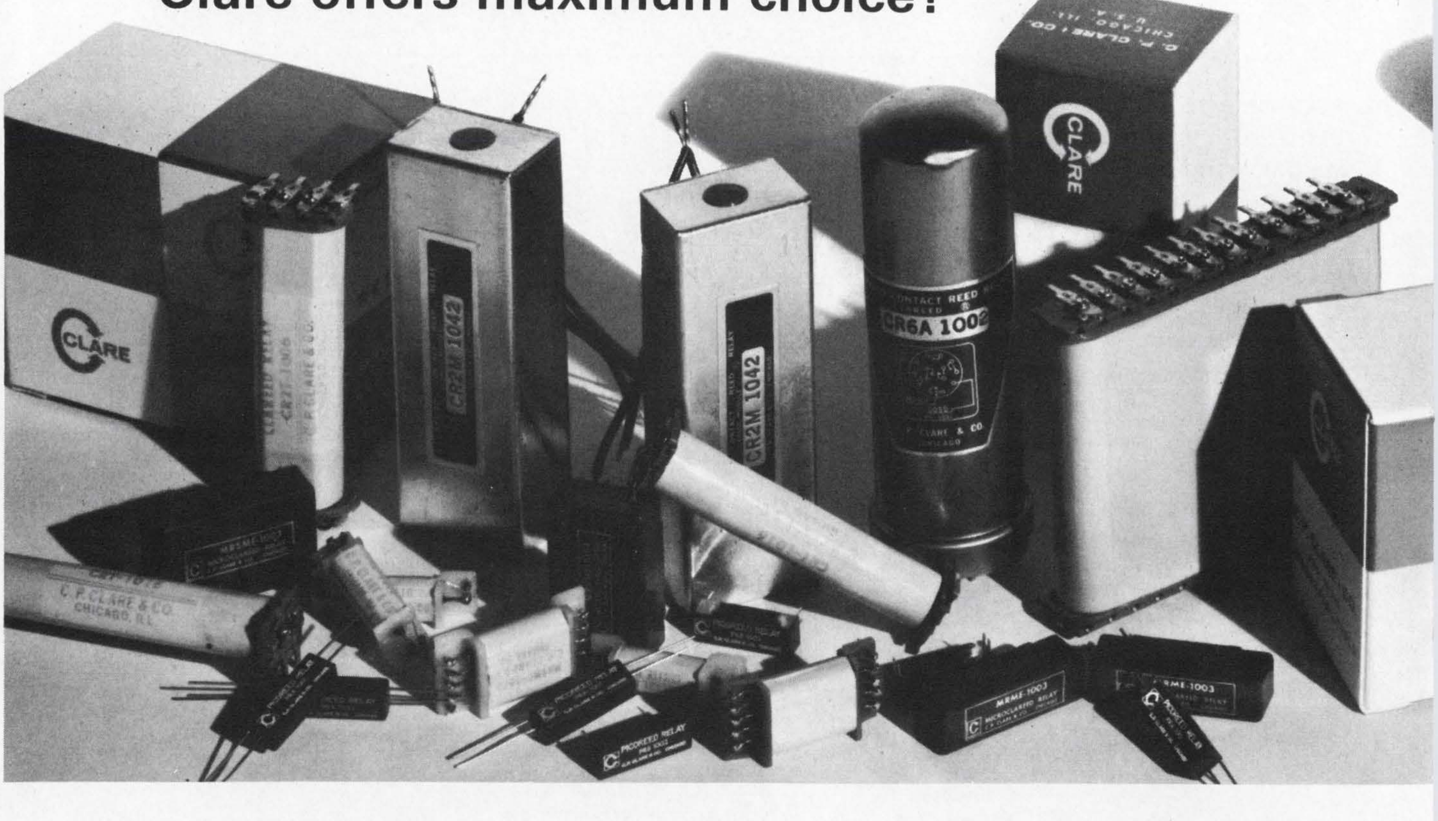

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SWITCH RATINGS	Identical	Identical
SWITCHES ALSO AVAILABLE WITH WIRE-WRAP TERMINALS?	YES	NO
RELAMPING CONVENIENCE	No tools required for relamping.	Tool required to relamp some units.
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LSI: Computer makers proceed with caution

Most believe wide use is 5-7 years away except for military-aerospace applications

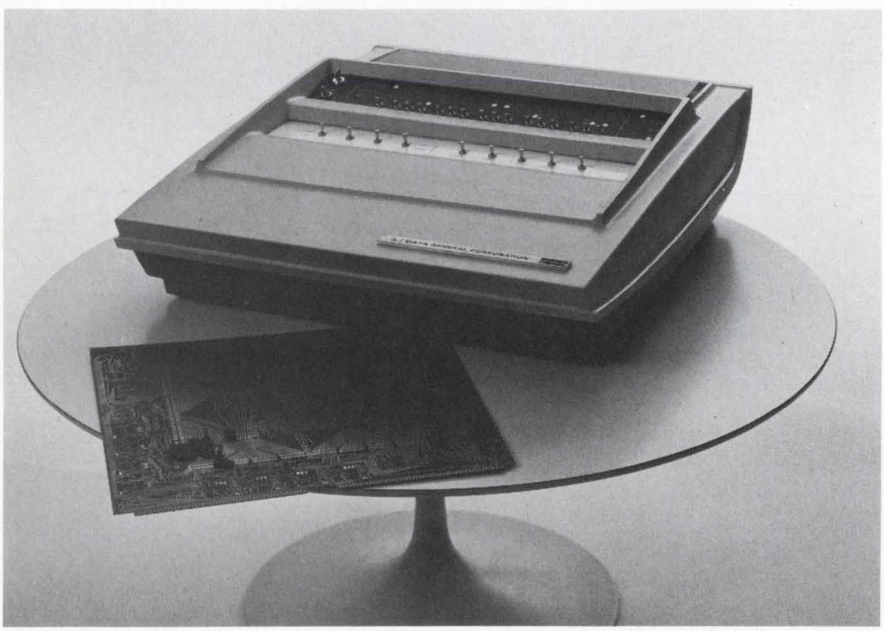
Robert Haavind
Managing Editor

Large Scale Integration (LSI) will some day permit low-cost batch fabrication of large segments of computer circuitry. But that day, according to most designers in the commercial computer field, is some time off.

This arm's length approach to LSI today is coupled with growing excitement over its effects on the computer field some years hence. Each person contacted in a wide swing through the computer community—university researchers, consultants, software specialists, and company managers as well as both military and commercial designers—has strong views on the eventual impact of LSI. But most see it as at least five years off. While there is wide agreement that LSI will contribute to the generally expected computer boom, predictions as to its particular effects and results vary widely.

The military computer scene offers a sharp contrast. The accent here is on now. Aerospace designers, for example, are exploring many possible avenues to LSI computers, both in-house and with multiple vendors.

"LSI is a necessity to meet specifications required in several of the systems for the 1970s," one aerospace engineering manager explained. Thus some of the most advanced development work, such as that of Litton's block-oriented computer, to be described later, is found in the aerospace field. But despite the "wait-and-see" attitude of commercial computer companies, their designers are evolving their own concepts to take optimum advantage of LSI when it does arrive. Most of their schemes are aimed at clever uses of scratch-pad or read-only memories. Some see registers and arithmetic units nested within fast memory modules. In one case, to be detailed later, a designer foresees a complete computer being built of standard LSI memory elements that will serve as logic, stored program and arithmetic units.



MSI arrives in the Data General Nova computer, which features four accumulators—two used as index registers, in a $6050 basic machine with 1024 16-bit words of storage. Read-only memory modules are also offered by Data General, to users who provide a paper tape of a debugged program.

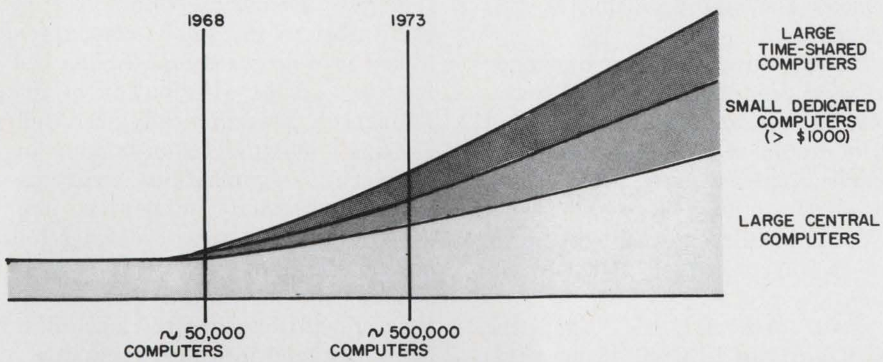
Some developers of the LSI technology that is already commercially available are piqued by lack of strong support from computer engineers. They believe that despite all the general talk on the subject, too many computer engineers are not fully aware of the powerful computer-aided design approaches that already exist.

The growing importance of medium-scale integration (MSI) is granted even by those who are most vocal in opposing LSI for the near future. MSI is now beginning to be defined as functions of such complexity that standard devices are possible—counters, shift registers, or code converters—while LSI is defined as constituting devices of higher complexity that require unique layout with computer assistance.

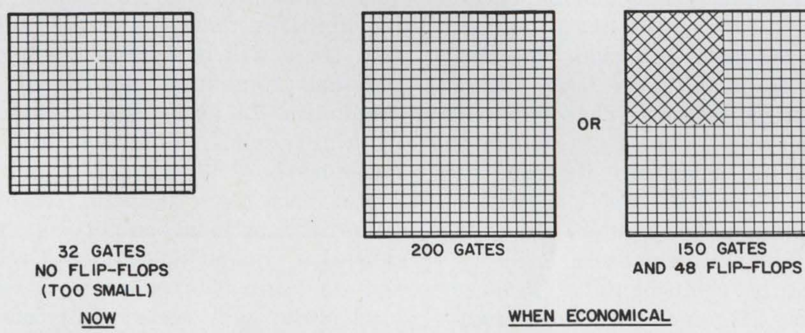
Many designers are now finding that the standard block of 40-to-100 gate complexity can offer savings, just as the flip-flop and the gate on a chip did in the early days of integrated circuits. The standard block frees the designer. It allows him to put more effort on other aspects of his total system design, which may prove to be of greater value to the user.

MSI offers definite advantages right now, particularly in the small memory and computer arithmetic areas, according to J. E. McAteer, director of development, and Dennis White, manager of computer development, for Varian Data Machines, Inc., Irvine, Calif. But they see LSI at least five to seven years off. The company makes small computers that are particularly designed for process control and communications.

"If LSI makes the same sort of economic gain over ICs as ICs did over transistors, it will come," McAteer commented.



1. **Expansion of the computer industry** as seen by a small computer manufacturer. By 1973, according to Burton Yale, vice-president, General Automation, the industry will be moving toward a hierarchy of worker, supervisor and management computers.



2. **Today's LSI technology still falls short** of the complexity range in which it offers real economic advantages, according to Charles King, computer-aided design specialist for Computer Usage Development Corp., Palo Alto, Calif. He feels LSI will catch on with reasonable yields at the 200-gate level.

But he and White both see a number of reasons why this goal is still years away. They do not feel that aids to logic design have been sufficiently developed for LSI. Computer-aided design looked attractive at first, White said, but many who were originally interested are now backing off: It requires extensive coordination, and this becomes cumbersome when the design process is accomplished in a distant vendor's plant. Also, rapid development cycles are needed. And changes are a way of life in computer design. Even IBM has found bugs in systems after they were out in the field. Coping with such difficulties becomes extremely expensive after a design has been committed to mask-making.

The cost factor is cited again and again, with most observers feeling that an LSI design would end up costing over twice as much per gate-equivalent as an MSI or conventional IC design. Since the larger the array of circuitry becomes, the more unique the array tends to be, few observers feel that LSI prices can come down soon.

Because of this "parts number" problem, Linder C. Hobbs, president of Hobbs Associates, Corona Del Mar, Calif., believes—along with many others—that the economic factor will force greater and greater standardization in the design of certain computer functions. He points out that the semiconductor makers—by varying the interconnection of standard arrays of devices—have worked out a number of schemes to allow some flexibility to the computer engineer.

One technique is the discretionary wiring approach, in which an array of circuits is fabricated and individual circuits are tested. Then the computer, which has stored the desired logic equations, generates an interconnection pattern that will produce the desired logic functions, using only the good circuits and skipping the bad ones. This is the direction Texas Instruments, Inc. is following. The difficulty here is that a separate mask must be made for *each* chip, based on the test results; this is expensive unless low-cost ways can be found to make masks by computer.

An alternate approach, that taken by Fairchild Semiconductor, assumes that all circuits are good. Here, an interconnection mask is prepared that can be used on all the chips that are to produce the desired logic functions. This method requires a high resultant yield to be successful.

The yield-curve battle

This yield problem was cited by Richard Drew, director of marketing for Computer Automation, Inc., Newport Beach, Calif., as a major reason why LSI is still years off. Drew, formerly a west coast representative for TI, said that process engineers are fighting an exponential probability curve for yield as chip complexity rises. LSI is asymptotically approaching the limits on the yield curves, he says. According to Drew, his company's experience with infant mortality on burn-in tests for MSI chips—quad-latches and quad-adders—bears out this situation. With simple ICs, burn-in usually eliminated one device out of perhaps 54 on a card. This rate rose significantly with MSI devices. If such a card were converted to a single LSI device, then burn-in would eliminate just about every one of the devices.

Because of the expense involved in catching any problems after an LSI design is commited to masks, both Drew and David Methvin, president of Computer Automation, felt that the first use might be a straightforward conversion of a small, well-proven machine, like the PDP-8 or a similar computer.

Hobbs agrees that LSI will have

its earliest impact on small computers, whose low prices might allow production volumes to become large enough to support the development of unique, complex LSI chips. Another favorable area to which he believes LSI will gravitate is peripheral units, such as communications terminals, where much storage and logic now handled in central processing units (CPU) will be handled.

Managers of companies making large computer systems are less enthused over the prospects for LSI than small computer makers. Max Palevsky, president of Scientific Data Systems, commented that, for the scientific machines his company makes, the cost of the hardware represented only a small part of the total system cost. Even a 40 per cent reduction in central processor hardware cost would therefore do little to bring down total system cost. At an IEEE Computer Group meeting where Palevsky made his comments, it was also pointed out that LSI might be suitable for arithmetic units because of their regularity, but not for control circuitry, which has a unique and non-repetitive structure in each computer. This will make such portions of the computer economically difficult to translate into LSI.

LSI must provide stronger incentives to the machine designer before he will accept it, according to James Thornton, vice president and senior consultant to Control Data Corp., Minneapolis. Thornton, a designer of the CDC 6600, a very large scientific computer, sees several problems facing the integrated circuit manufacturers interested in successfully introducing LSI.

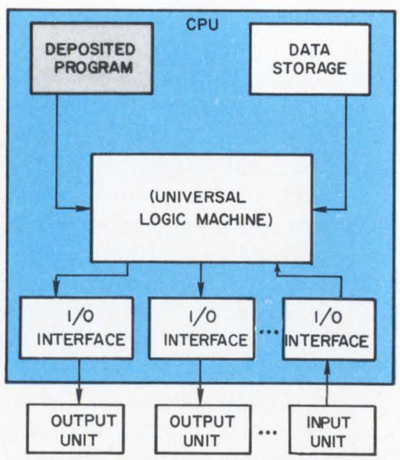
One problem is dollars-and-cents. With prices for ICs and MSI getting lower, it is hard to see how these can be beat with LSI and still pay off heavy development costs. Reliability is already pretty high on small computers, but this is one advantage that LSI might offer designers of the large machines.

Performance improvements definitely could excite computer designers, Thornton says. But both conventional ICs and discrete devices beat today's LSI for circuit speed. Increased speed requires higher current. This can create serious thermal problems at LSI densities.

Self-checking and redundancy are also needed to make LSI maintenance reasonable. Incorporating them would require about a 100:1 density increase over today's LSI, the Minnesotan believes.

Scratchpad memories is one area where Thornton feels that LSI advantages are worthwhile.

Some observers feel that the availability of LSI will bring a tremendous increase in growth to the computer industry. Burton Yale, vice president of General Automation, Inc., Orange, Calif., foresees the computer industry splitting into three paths. One branch will be the centralized computer area, the mainstay of today's market. But two more branches will rise. One will be the large time-sharing computing systems. The other will be the small, dedicated computers —that is, machines designed to perform specific functions within a hierarchy of computers. Many of these small computers will be bought as components of a large system. He envisions these computers as being sold for hundreds of dollars, whereas small computers sell today for a few thousand dollars. He also sees this growth becoming so great that perhaps as many as 500,000 total computers will be sold by 1973.



3. **Extreme standardization due to the economics of LSI** is foreseen by Larry Gosshorn, president of General Automation. All portions of the computer might first be purchased as large, off-the-shelf LSI chips. The user might then produce his proprietary program in the form of a read-only memory.

Larry Gosshorn, president of General Automation, refers to this proliferation of small computers linked into larger computers as being part of the distribution of intelligence, geographically as well as functionally. Decision-making in all large organizations will be speeded up and handled at the lowest possible levels. Yale sees today's computer industry, which can be broken into business, scientific and process control machines, being changed into new groupings: worker computers, supervisor computers and management computers. Hobbs agrees: "You won't have a large central computer in Kansas City or somewhere sending data back and forth to stupid terminals. The communications costs will be too high for that. It's more likely that there will be local computers, regional computers and central computers. In each case, as much work as possible will be done at the lower levels."

He feels there is little reason, from a functional standpoint, to centralize computing, but good reason to centralize storage. Many local units will occasionally need access to a large central data base. Also, some actions taken at local terminals will require this central data base to be changed. He cites airline reservations and nationwide credit-reference systems as two examples.

LSI developers fight back

This tendency of commercial computer companies to foresee great tomorrows for LSI, but to show little interest in today, raises hackles on some LSI developers. Fairchild, for example, is already in production on LSI devices. Robert Schreiner, who heads this effort, feels that many of the views of computer designers are based on inaccurate conceptions of just what can be accomplished today.

Schreiner admits that years ago he wrote a memo at General Electric Co., where he was a computer designer, in which he stated that integrated circuits were impractical. He recalls:

"I had all kinds of groovy reasons—like all the changes we'd have

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to make, and we wouldn't be able to make them because they're in a chip that we wouldn't have any control over, and the fact that you'd turn the circuit design responsibility over to the vendor."

He feels that right now there is the same sort of resistance to the new concept of LSI. Yet he sees it as a simple economic situation that will force LSI to catch on.

"Fundamentally what we're claiming," he says, "is that we can make printed wiring on a chip cheaper than you can make it on a PC board."

Schreiner points out that a straight cost-per-gate comparison is an extremely unfair way to analyze pricing, because the computer handles all the board placement problems and wiring design.

Schreiner sees the complexity level of LSI as rising rapidly, through a sophisticated multi-chip capability.

"A package we're working on now has 18 LSI-type chips in it, all facedown bonded. These chips are all big enough to have 100 gates-worth of logic."

Market factors forcing LSI

A designer who agrees that LSI will come soon is Robert Bond, applications analyst for Hewlett-Packard's Data Products Div., Palo Alto, Calif. Bond says that MSI and IC prices can come down only so far. Also, the semiconductor manufacturers know that computer manufacturers are working on their own IC processes. So they will keep moving, both to keep ahead of the technology and to keep their prices moving down. The computer manufacturers, at the same time, can not overlook the possibility that competitors will come out with LSI machines.

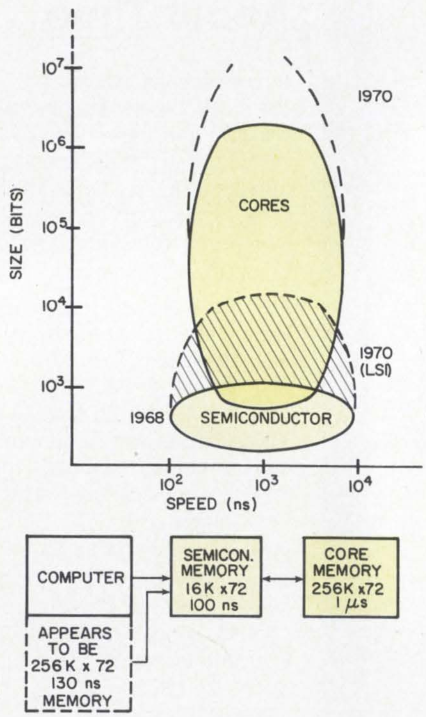
Bond does not expect there will be a large movement into the fourth generation of computers, as there was for the third. Rather, he feels, that new LSI machines will appear gradually. He does not expect IBM to lead the way.

Bond sees a proliferation of small computers and of real-time input-output devices. He reasons that there is far too much useless input and output with today's computer system.

A manager, for example, who wants certain types of information from his system, must have his request go through several levels of systems people and programmers before he gets back his data. As a result he simply doesn't ask for the information in the first place. Once the manager has a terminal in his office, however, Bond sees him querying the computer and getting his data back immediately.

He sees BASIC as the first of a whole series of reactive terminal languages. He feels that this sort of interaction with the system will accomplish much more for the user, and more quickly and simply, than FORTRAN or similar languages could do: It will also cut down on programing cost. He sees the whole emphasis in the fourth generation being given to eliminating the programmer.

Many observers agree that much of what is now handled in programing will be transferred to circuitry. This is a natural result of the growing discrepancy between hardware costs (getting steadily lower) and software costs (getting steadily higher).



4. **Increasing needs for mass storage** and lower cost/bit, will keep the core-memory market growing despite increasing competition from faster semiconductor memories, predicts Tom Gilligan, manager of engineering for the commercial division of Electronic Memories, Hawthorne, Calif. Smaller semiconductor memories will be coupled with large core stores to simulate large, fast memories, as shown below.

Richard Bloch, vice-president of corporate development for Auerbach Corp., Philadelphia, sees the possibility of a much more modular concept in future computer generations. Instead of designing a general system to do everything for everybody, there will be groups of standard modules that can be assembled into a system. Some of these modules will be dedicated modules tailored to one particular large group of users—bankers, insurance companies, and so on. The dedicated modules might have substantial portions of the programs wired in.

In this way, a single instruction, for example, might cause an inquiry to be matched across a large data base, with only desired data being drawn from storage.

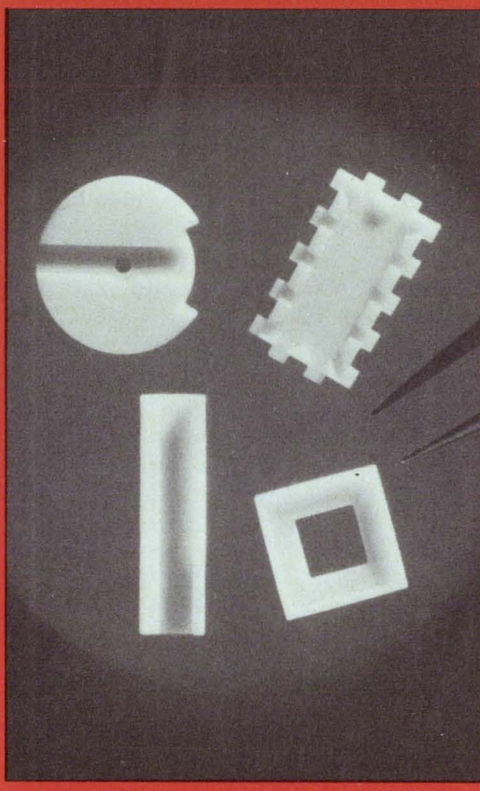
Each system, then, can be tailor-made for each user by combining groups of these standard modules. Through experience, or as needs change, the user can have his system modified through modular interchange. Such a series of machines might involve some 1000 to 2000 modules over-all, of which 50-100 may constitute a particular machine of the series, Bloch believes.

Bloch predicts that there will be a proliferation of what he calls small "para-computers," which will better serve great segments of the user community than can today's large, all-purpose computer centrals. He sees this trend going so far that the modular sections will be stocked by large systems installation houses, and buyers will simply specify the desired configuration.

Computers to run computers

Another area in which LSI might have significant effect is machine efficiency, according to Gerald Estrin, head of the computer department at the University of California, Los Angeles. His group at UCLA is investigating a number of techniques that, when combined, might allow a comput-

increase ic yield



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er's efficiency to be monitored in real-time and its mode of operation varied to improve performance.

This program started with an analysis of instruction sets; the purpose was to find the average frequency of their use. Results obtained allowed a more intelligent allocation of memory.

Sensors are now under development to find out how often certain registers and other pieces of hardware are used in performing particular programs. Such sensors might be external to the machine, or be built right into the system. Both types are being used by UCLA. These data are then analyzed to develop more efficient programs.

Eventually this sort of analysis might be done with a control computer that operates in a feedback loop, allowing programs to be modified while the problem is running; thus optimizing system efficiency.

The analysis of instruction sets was similarly undertaken by Litton Data Systems, Van Nuys, Calif., in preparing their move into LSI computer design for the military.

Needs of 1970s analyzed

Mat Ginosar, manager, LSI projects, said that Litton started by defining customer needs for the 1970s and analyzing the languages to be available in that time period. A statistical study of instruction frequency was performed; out of this a smaller repertoire of more powerful instructions was developed. The instructions were chosen to use up to 50 per cent less of main-memory capacity, Ginosar said, because in future systems more data must be handled, and programs will be more complex. Some functions, such as square root for a hypothetical example, are handled by microprograming rather than in software. Usually fast read-only or scratch-pad memories are used for this, although, in some cases, logic circuitry might be used.

Litton prefers MOS wherever great speed is not required, because three to five times the complexity per package can be achieved. The company is working with four outside vendors on LSI, in addition to developing its own approaches.

One of these in-house programs is a block-oriented computer, which is a highly parallel processor that is somewhat similar to the Solomon computer concept developed at Westinghouse some years back. This computer was described by Dr. William Mow, project manager in the digital computer lab. of Litton's Guidance and Control Systems Div., Woodland Hills, Calif. Many similar arithmetic units (AUs) can be separated into groups to operate on a continuous incoming instruction stream. For example, nineteen of these AUs can be connected to generate sine and cosine values of an angle continuously. This is done by using series approximations and summing the elements of the series.

The Dinary algorithm is used to perform arithmetic in the block-oriented computer. This permits operations to proceed on the most-significant bits first. For example, if an $A \times B \times C$ operation is being performed, the product of the most significant bits of $A \times B$ will be multiplied by the most-significant bit of C before the lower order bits of A and B have been multiplied together. Each AU can proceed independently while the others are still being filled.

Each sub-minor iteration takes 4 μs; but the machine goes through a total of 32 bits in each minor cycle, which takes 128 μs. This means that a 32-bit multiplication takes 32 x 128 μs, or 4.096 ms. But the time for one multiplication, for 10 or for 100, is the same: 4.096 ms. The same times hold for multiple additions, square roots, divisions, subtractions, incrementations or decrementations.

Each arithmetic unit has three input lines connected to address registers. These registers can select up to 120 different AUs for data to come from, so that each AU can be connected to up to 360 others. There is also a control register that tells the AU what function it will perform. Four modes are possible: dinary, buffer, multiply-divide, or input-output.

The connection of these AUs is problem-oriented, but the structure can be varied by selection, using the address registers.

No discretionary wiring is used. Instead devices on a wafer are tested; the good ones are then bonded together. This saves a second layer of metalization at the circuit level that might cause many additional failures due to pinholes, Dr. Mow says. One wafer might contain 36 AUs and six processor controls. If one AU and one processor control is working, the wafer is usable.

He showed a wafer with 36,000 MOS transistors on it, and explained that one with 144,000 transistors was now in development for the block-oriented computer. The wafers will be square—a little over an inch on a side—to remain compatible with a memory wafer that is most efficiently fabricated in square form.

The all-memory computer

Since fast, low-cost memory wafers will probably be the earliest result of LSI, it might someday be efficient to build an entire computer from memory, Walter Edwards, vice-president of Decade Computer, Huntington Beach, Calif., believes. The program and even the logic can be stored in read-only and scratch-pad memories, he explained.

"I could structure the logic so that my flow diagram would represent addresses in the store, and the control terms would represent read-onlys. Edwards pointed out that a memory can be viewed as a large array of AND-OR gates, where particular words are selected by putting a ONE on a particular line, or another line, etc. Assuming speeds for these memories reach the 5-to-10 MHz range, he believes that such a machine might be built so that it would use 5 to 10 cycles per instruction. One memory would store all the possible actions of a register. The flow diagram would then select particular operations that are stored as memory.

To accomplish such a design a user might buy standard arrays and then somehow scribe his desired patterns of ONEs and ZEROs onto it.

One thing is certain in the computer field: No one is ignoring LSI. ■■

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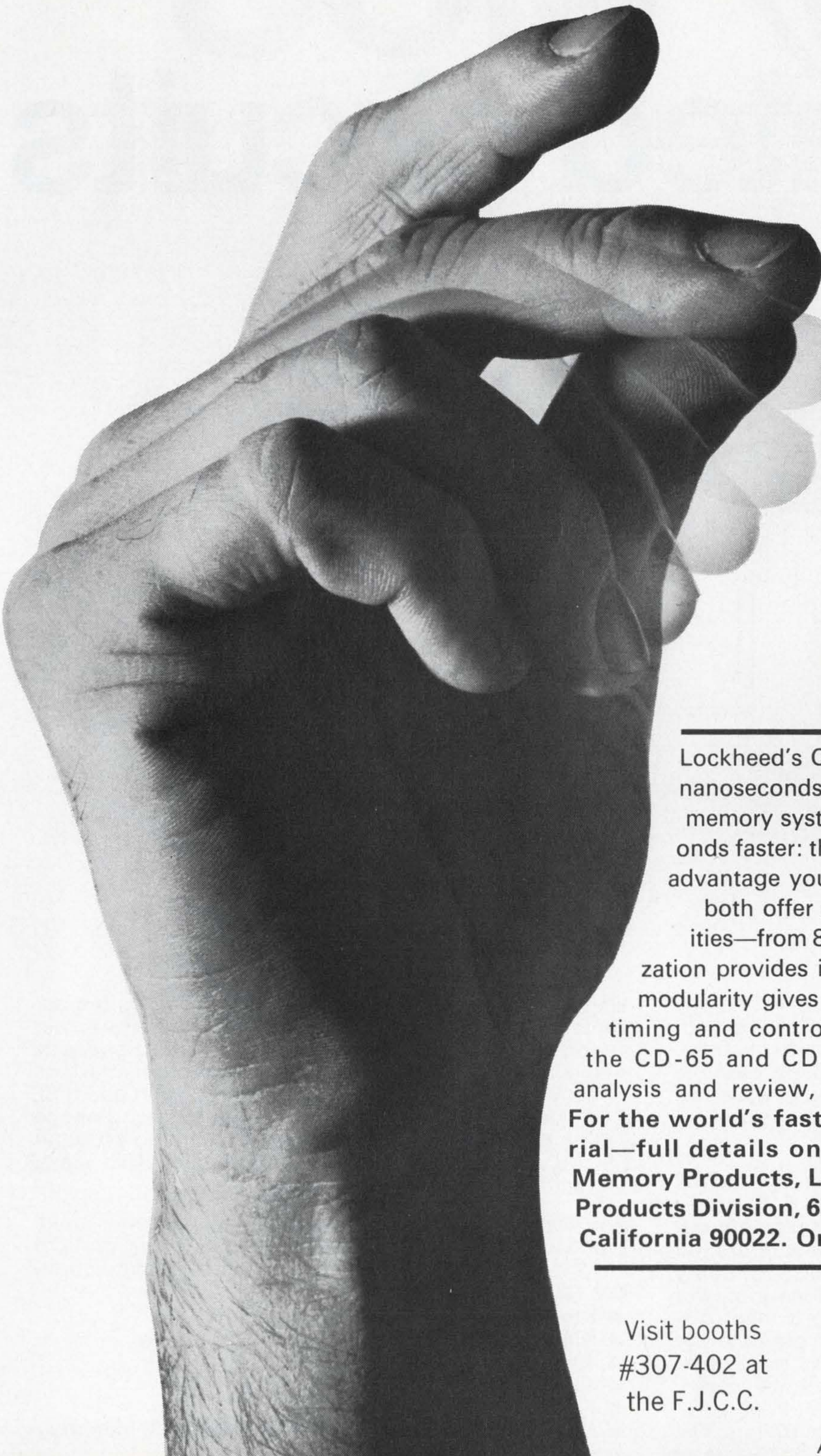

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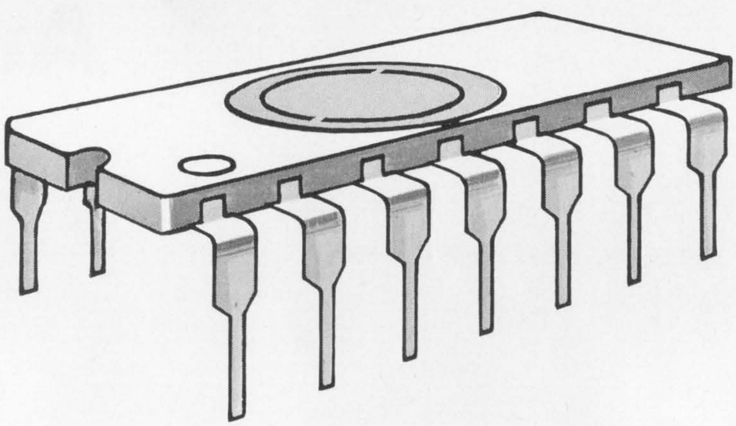

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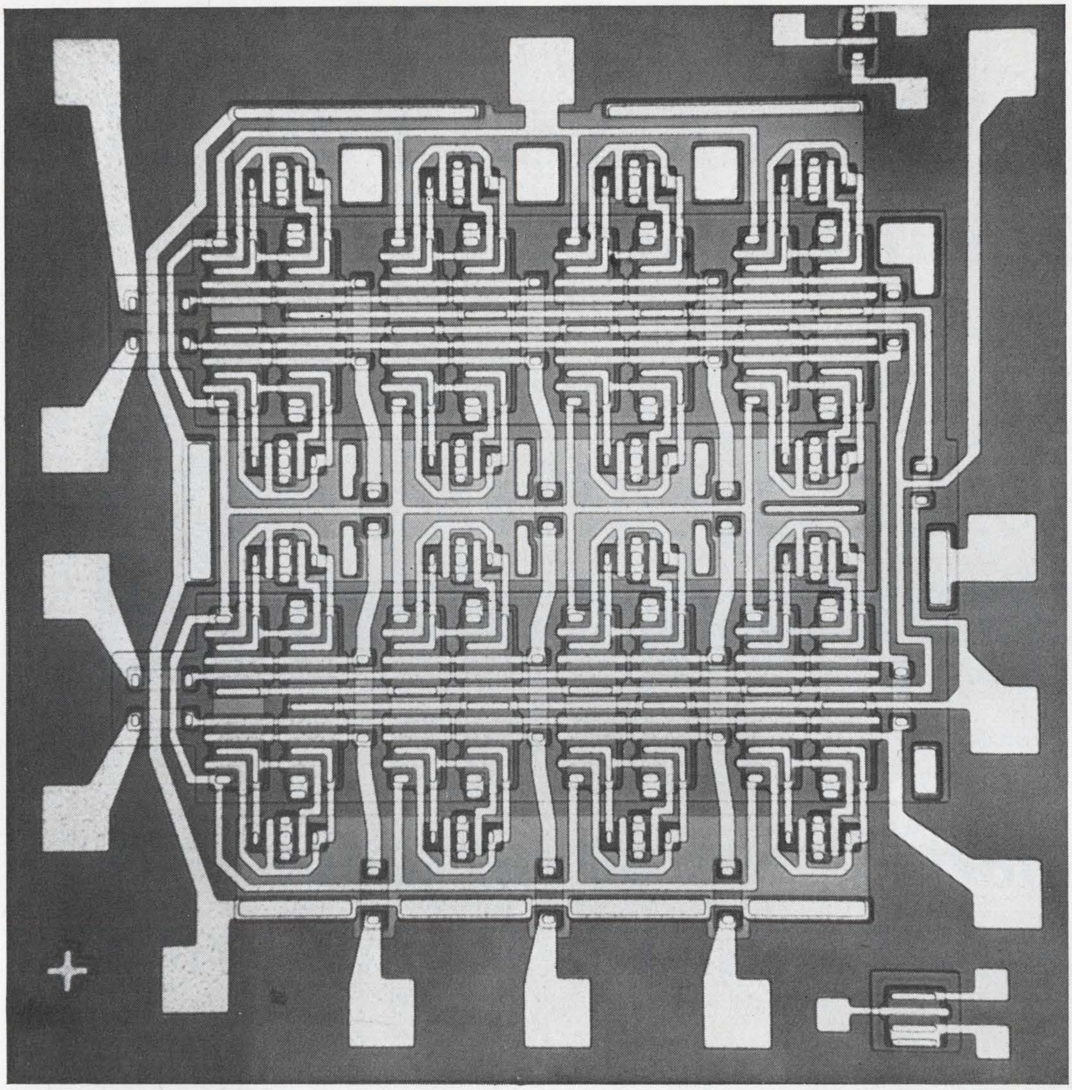

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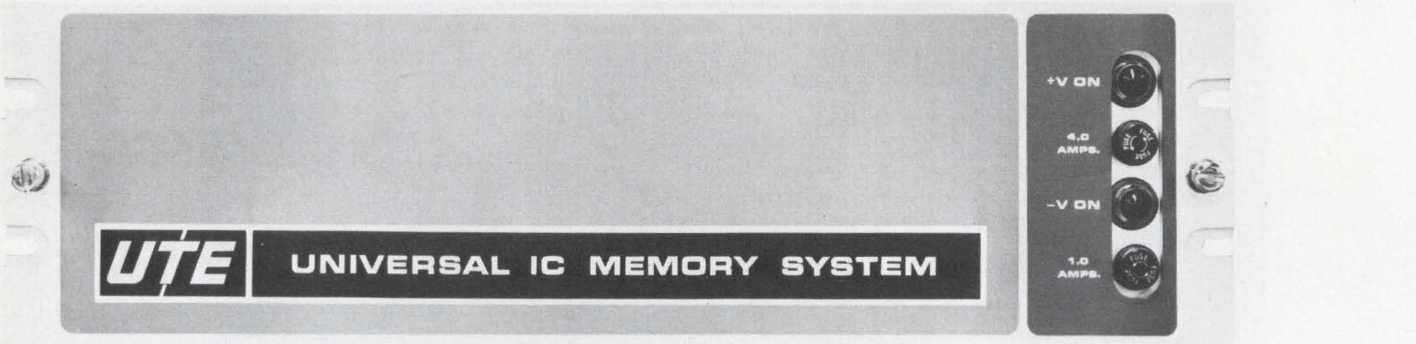

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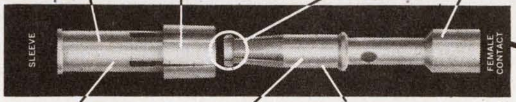

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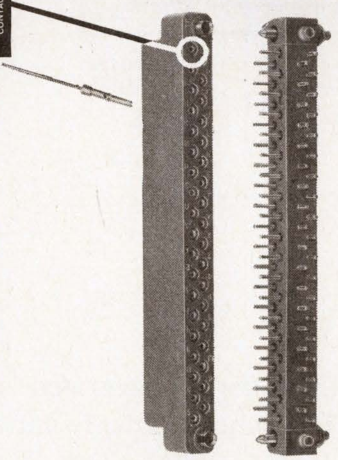

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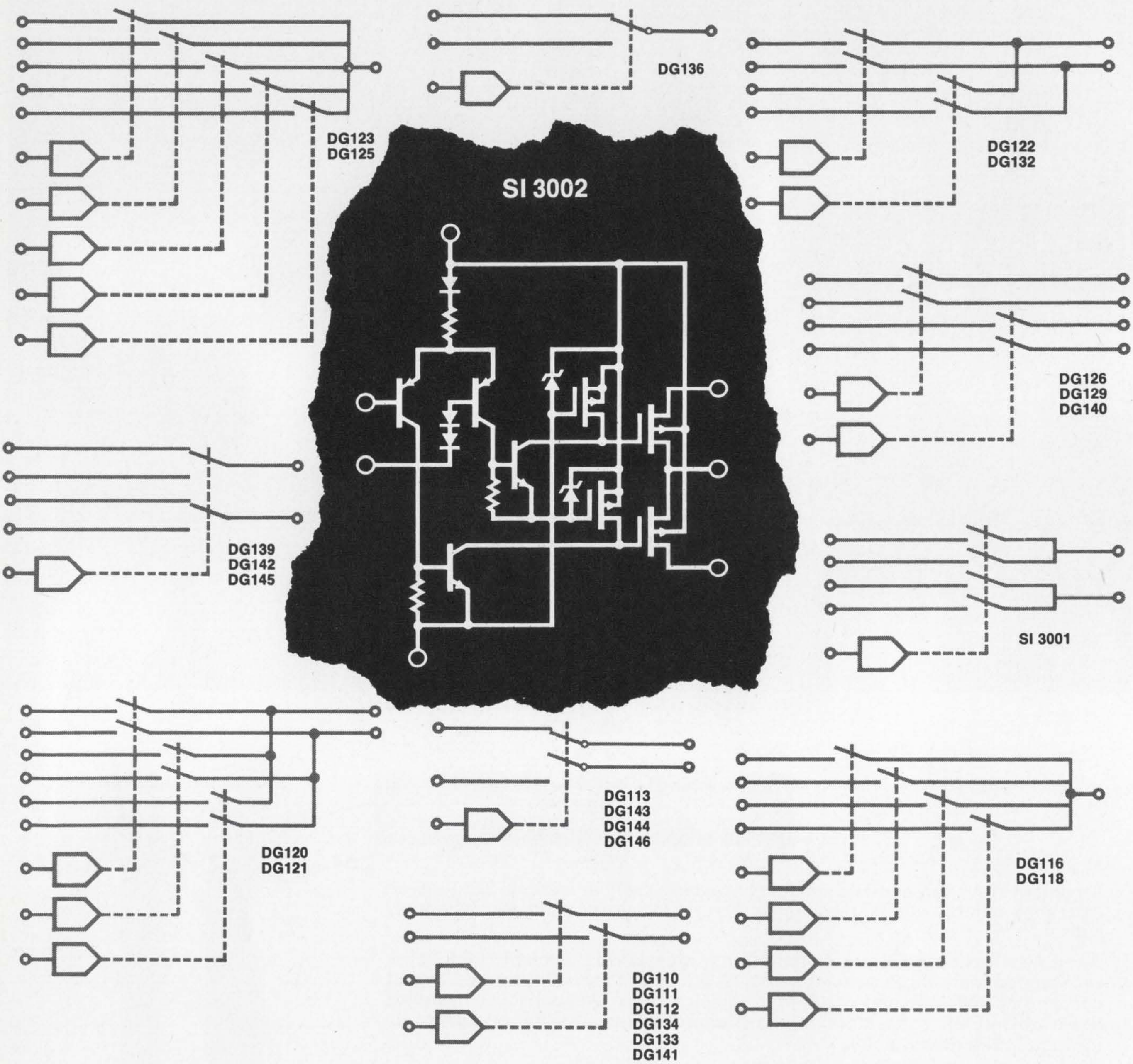

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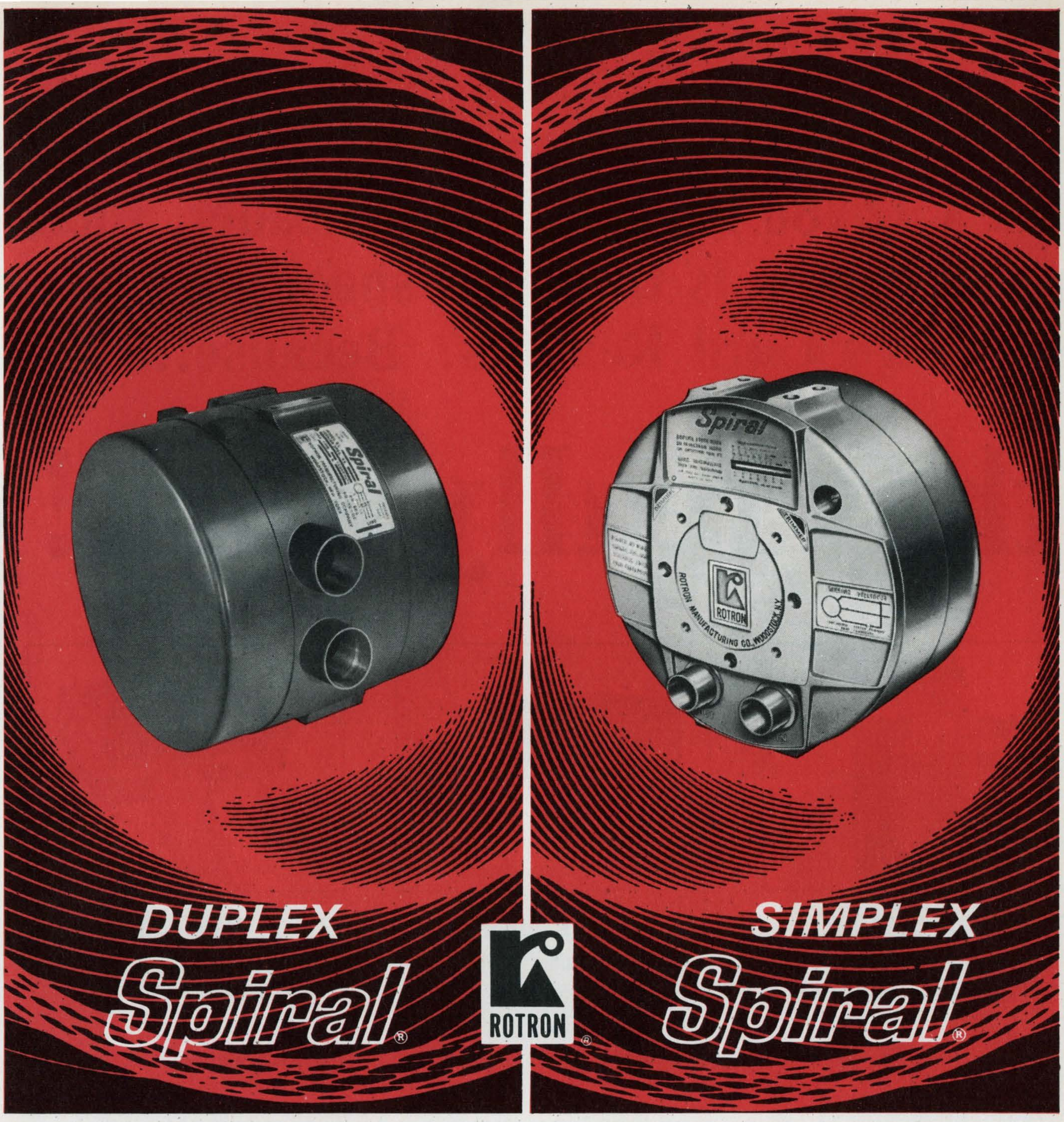

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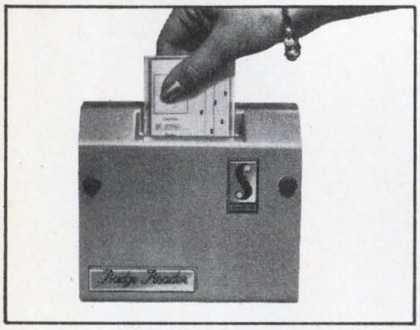
Rotron Spirals are revolutionary air movers that have become standards in the process control and computer industries as: vacuum source for tape slack control . . . pressure source for tape air bearings . . . vacuum / pressure source for card handling and paper sorting equipments. Spirals are the choice—their brushless motor design offers unparalleled reliability, unusually long-life and eliminates costly equipment down-time.

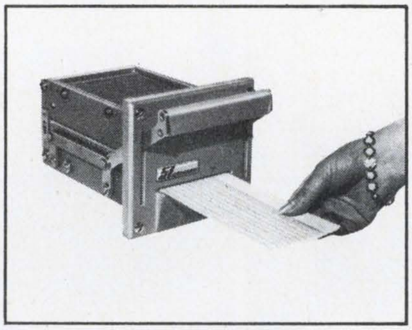
ROTRON® **ROTRON mfg. co., inc.**
WOODSTOCK, NEW YORK • 914-679-2401
West Coast: Rotron / Pacific, Burbank, Calif.
Canada: Aerovox Canada Ltd., Hamilton, Ont.
Rotron Europa N.V. Breda, The Netherlands

INFORMATION RETRIEVAL NUMBER 68

Outside of the fact that Sealectro makes a 10x10 Badge Reader, 12x51 Tab Reader, and a 12x80 Punched Card Reader, what other reason is there for specifying Sealectro Card Readers? Because...

they really work!





10 x 10 BADGE READER

- **For Personnel Identification**
- **For Process & Production Control**

At last, a Badge Reader that works the way you want it to – exclusive Sealectro contact design features positive mechanical sensing of punched holes for maximum reliability. Completely self-contained and ready-to-use, the Sealectro Badge Reader accepts standard IBM and Friden badge cards.

Visual readout immediately indicates if card is inserted correctly. Contacts do not actuate until authorized card is properly inserted. When card is completely inserted, solenoid-operated contacts sense hole pattern and read. Read function is automatically held until feedback from system releases contacts and card is automatically ejected. Electrically, the Badge Reader may be bussed in either direction, or all 100 points can be discretely fed and readout.

12 x 51 TAB READER

- **For Data Acquisition**
- **Production Control**
- **Terminal Operations**

Accepts and reads standard IBM column cards with read area limited to 51 columns providing 612 bits of information. Ideal for terminal operations in data processing systems not requiring full 960 point readout.

Absolutely fool-proof. Correct orientation and positioning of card electrically interlocks operating handle eliminating faulty readouts. When card is properly inserted and handle pulled down to read position, unit commences operation. When reading is completed, pull handle up and card is automatically ejected. Tab Reader features exclusive Sealectro contact design for positive mechanical sensing of punched holes and maximum reliability.

12x80 STATIC CARD READER

- **For Peripheral Equipment in Data Processing Systems**

The 12x80 Sealectrocard™ Reader reads all 960 points on a standard IBM card simultaneously. Punched holes are sensed mechanically with all contacts away from dust, lint and dirt Unit features double contact wiping surface and positive mechanical lockout if card is improperly inserted or incorrectly oriented. Contacts are field replaceable and each 12-hole row is registered independently from adjacent rows.

All 960 switch points have discrete input and output terminations. With versatility exceeding any other card reader, units can be ordered with bussed inputs and discrete outputs, or with terminal panels providing fanned connections.

Interested in complete technical information and prices? Call 914-698-5600 today.

SEALECTRO ®

PROGRAMMING DEVICES DIVISION

SEALECTRO CORPORATION

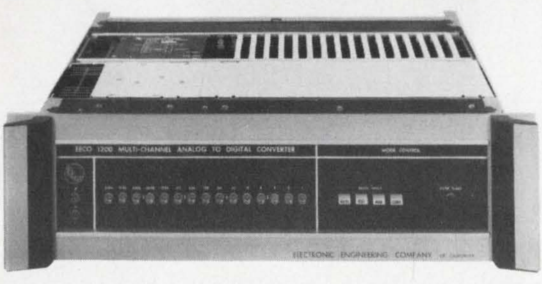
HOYT STREET • MAMARONECK • NEW YORK
PHONE: 914 698-5600 TWX 710-566-1110
Sealectro Ltd., Portsmouth, Hants, England

INFORMATION RETRIEVAL NUMBER 69

INFORMATION RETRIEVAL NUMBER 70 ►

EECO's new Model 1200 Analog-to-Digital Converter...

... 250,000 conversions/second, 15-bit binary resolution



Chassis model also available with computer interface circuitry to your specification.

Use the new EECO Model 1200 high-speed Analog-to-Digital Converter for direct input to a computer for "on-time" data processing, analysis of rapidly varying analog information, or for transient analysis by memory loading at a 250,000 word/second rate and reading out at slower speeds.

Features include:

- **Integral 4-channel multiplexer** option.
- **Complete digital isolation** and **shielded enclosure** to minimize noise pickup.
- **Parallel output,** or **serial output** at 10 MHz-bit rate.
- **Conversion by successive approximation** in parallel groups.
- **Continuous protection** against input signal transients.
- **Modular design**—unit measures only 5″H x 5″W x 17″D, with **integral power supplies.**

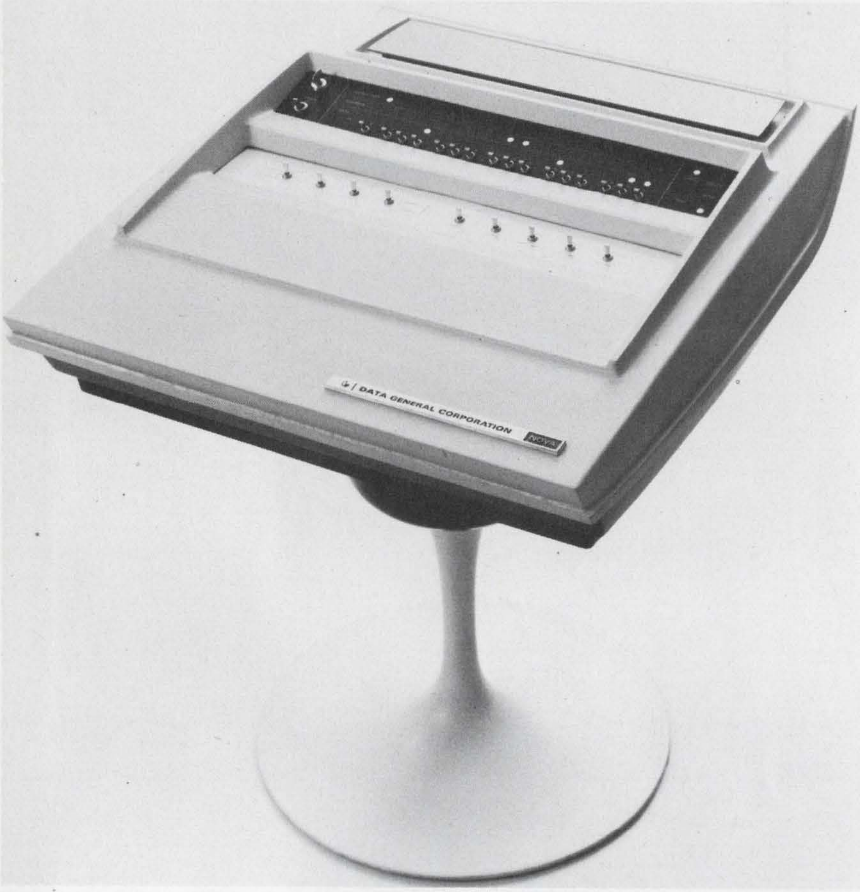
Prices start at $6,000. For complete specifications and prices, send today for the EECO Model 1200 ADC data sheet.

Coming soon—a new ADC/Multiplexer with more than 100 input channels, 15-bit resolution, 200,000 words per second. Send for details.

INSTRUMENTS DIVISION

ELECTRONIC ENGINEERING COMPANY OF CALIFORNIA

1601 EAST CHESTNUT AVENUE · SANTA ANA, CALIFORNIA 92701 · (714) 547-5501



Small-scale digital computer gets accumulators via MSI

Data General Corp., 275B Cox St., Hudson, Mass. Phone: (617) 562-7358. P&A: from $6050; Jan., 1969.

Using the inherent advantages of medium-scale integration, a small-scale general-purpose computer for the first time offers the additional flexibility of multi-accumulator organization. The type of machine organization is the same as that used in such large-scale computers as the IBM 360.

With over half of its circuitry in the form of MSI devices, the Nova computer boasts four accumulators. Two of these may be used as index registers to perform arithmetic and logical operations within the computer's arithmetic unit without accessing memory.

Nova's memory, which is expandable to a total of 32k words, is available in modules of 1024 to 4096 words with 16-bit lengths. The memory can be supplied as a random-access core or as a read-only unit compatible with the core.

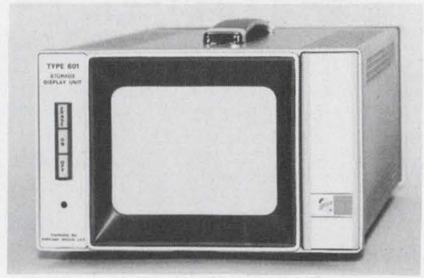
The memory arrangement allows the user to write his program with the core, using the full software of the system. When he has debugged his program, he can send a paper-tape version of it to Data General, the manufacturer of Nova. The company will hard wire a read-only memory based on the tape.

Nova is contained in a 5-1/4-in.-high package that can be mounted on a stand or in a conventional 19-in. rack. This package can accommodate seven 15-by-15-in. circuit boards. Nova's central processor requires two boards, while each memory module occupies one.

The new computer is available with a full line of options and peripheral equipment. These include: a Teletype, a high-speed paper-tape punch and reader, an incremental plotter, a printer, a real-time clock, and Dataphone interfaces.

Booth No. 105 *Circle No. 250*

CRT storage displays stop flicker and fade



Tektronix, Inc., P.O. Box 500, Beaverton, Ore. Phone: (503) 644-0161. P&A: $1050 or $2500; 45 days.

Designed for displaying information readout from digital computers and other data systems, two new storage display units use bistable CRTs to provide non-flickering, non-fading, presentations of alphanumeric and graphic information without being refreshed. Both units' operating functions are remotely programmable at a rear-panel connector by a contact closure to ground. A manual control on the front panel provides the erase function. Full-scale deflection factor is 1 V.

Type 601 is a 5-in. unit that stores information at the rate of 100,000 dots per second and has an erase time of 200 ms. In an 8-by-10-cm display area, it provides a resolution of 100 stored line pairs along the vertical axis and 125 stored line pairs along the horizontal axis. The 601 is 5-1/4-in. high by 8-1/2-in. wide by 17-3/8-in. deep. It weighs 17-1/2 lb.

Type 611 is an 11-in. unit that has a dot settling time of 3.5 μs/cm plus 5 μs, and a dot writing time of 20 μs. In a 16.3-by-21-in. display area, it provides a resolution of 400 stored line pairs along the vertical axis and 300 stored line pairs along the horizontal axis.

In addition, the 611 unit features a write-through function that permits the operator to position the writing beam to any point on the display area without storing new information or destroying previously stored information. The unit measures 11-7/8-in. high by 11-5/8-in. wide by 22-3/8-in. deep. Its weight is 50 lb.

Booth No. 214 *Circle No. 251*

WHO EVER HEARD OF A TRIMMER WITH NO CRACKS IN ITS CARCASS?

Nobody ever heard of a *seamless cermet* trimmer until Spectrol developed its new Model 53! But now, just look at some of the state-of-the-art design advancements and high-quality performance specifications we've packed into this tiny trimmer which *sells for less than $1 in quantity!*

For under a buck, you can have a unit that offers...

- sealed, seamless, co-molded all plastic external housing (no "glue" used for sealing or potting) to guard against leakage, moisture and voltage breakdown.
- only four joints in its entire construction (2 terminals, wiper-to-element and rotor-to-slip ring).
- pins molded in a unitized header providing a terminal pull-strength in excess of 2 lbs.
- cermet element for essentially "infinite" resolution over a wide 10 ohm to 1 megohm resistance range.
- power rating of ½ watt @ 85°C.
- dielectric withstanding voltage of 1,000 VAC at sea level.
- stop strength better than 10 oz.-in.
- operational temperature range of −65°C to +125°C, plus the withstanding of acceleration to 50 G's, vibration of 30 G's to 2,000 cps and shock of 100 G's @ 11 ms.

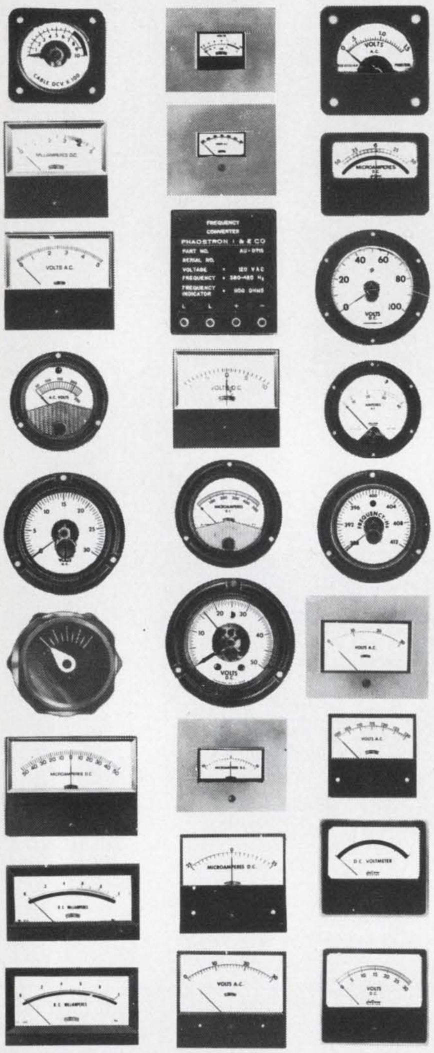
ACTUAL SIZE

For full specs, circle the reader service card. And for immediate delivery, contact your local Spectrol distributor. Compare the Model 53 with any competitive unit. Spec for spec, you can't buy a better "pot" for the money!

Spectrol Electronics Corporation
A subsidiary of Carrier Corporation
17070 East Gale Avenue
City of Industry, Calif. 91745
Phone: (213) 964-6565 • TWX: (910) 584-1314

Spectrol

PHAOSTRON CAPABILITIES IN DEPTH



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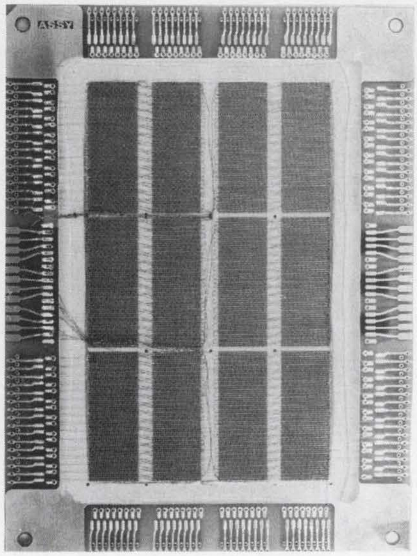
PHAOSTRON INSTRUMENT & ELECTRONIC COMPANY
151 Pasadena Avenue
South Pasadena, California 91030 Area code (213) 255-1471

"indicating instruments of integrity"

Representatives in all major cities. Call or write for detailed information and brochures.

INFORMATION RETRIEVAL NUMBER 72

Three-wire 3-D memory cycles in only 750 ns



Core Memories, Inc., Subsidiary of Data Products Corp., 2525 Charleston Rd., Mountain View, Calif. Phone: (213) 837-4491. P&A: 4¢ to 7¢/bit; Jan. 1969.

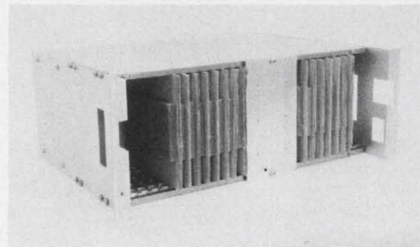
By eliminating the fourth winding required for conventional coincident-current organization, a three-wire 3-D memory system is able to cut cost per bit and operate in shorter cycle times. STORE/33 uses a single winding to sense, during the read portion of the memory cycle, and to inhibit, during the write portion.

The three-wire technique not only reduces the assembly cost of magnetic planes, but also allows the use of IC inhibit driver electronics. Employing integrated circuitry enhances reliability, reduces power consumption and enables compact packaging.

In addition, the magnetic planes can be assembled using cores with diameters as small as 18 mils. Because of the fast switching time of small cores, an increase in over-all system switching-speed can be realized.

Using 18-mil cores, which switch in less than 200 ns, results in an over-all system cycle time of 750 ns or less. Using 22-mil cores, the memory cycles in 900 ns.

Although 3-D memory systems are slower than 2-D ones, they provide an extra dimension of information that is invaluable. Offering this additional depth at faster rates than previous 3-D systems, STORE/33 is expected to capture the market of 2-1/2-D memories with word sizes of 4096 to 16,384.



Standard 19-in. rack accommodates modular card nests of three-wire 3-D memory system.

Providing word capaciites of 4k, 8k, or 16k (42 bits each word) the new memory system consists of: a pluggable magnetic stack containing diode/transformer word line decoders and line termination resistors; PC modules containing the memory current source, drive and data circuits, and timing controls; power supplies, and an optional exerciser panel.

The magnetic stack and PC modules are housed in one or more card nests that are 7 in. high and that fit in a standard 19-in. rack. Power supplies are mounted either behind or above the card nests.

Booth No. 1209 Circle No. 272

Automatic test system evaluates ferrite cores

E-H Research Labs, Inc., 515 11th St., P.O. Box 1289, Oakland, Calif. Phone: (415) 834-3030. Availability: 90 to 120 days.

Providing complete core-handling and testing capability in a single-bay rack, model 8321 automatic test system grades ferrite memory cores by comparing measurements against preset limits. The test routine is generated by a digital programmer providing 16-bit times and digital repeat subroutines. Program functions are set by inserting a program pin in the appropriate drive and analysis channel at the desired bit time.

Booth No. 2002 Circle No. 273

FAST RESPONSE — MINIATURE

D/A BINARY LADDER NETWORKS

Five Standard Values
Full Scale Accuracy ±½ LSB
4 to 8 Bits — 10 to 35 Volts

Mepco Binary Ladder Networks provide high accuracy, high speed conversion to within ±½ LSB (least significant bit) over the full military temperature range. Networks are available as precut, stabilized factory stock in five standard resistance values. Final switch compensation in accordance with customer specification assures perfect mating with switching circuitry.

Used in conjunction with a flip-flop register, a buffer amplifier, a ladder switch and a precise reference supply voltage, the Mepco binary ladder provides digital to analog conversion to an accuracy within ½ the least significant bit.

May also be used with a comparator and a control gate to provide analog to digital conversion.

The low profile, small size, modified dual in-line package assures close-spaced board sandwiching, and compatability with automatic insertion equipment. Standard DIP mounting pins furnish standoffs for ultrasonic board cleaning, and provide extra leads for increased vibration and shock resistance.

Write or call for Data Sheet — or talk to any MEPCO representative.

MEPCO

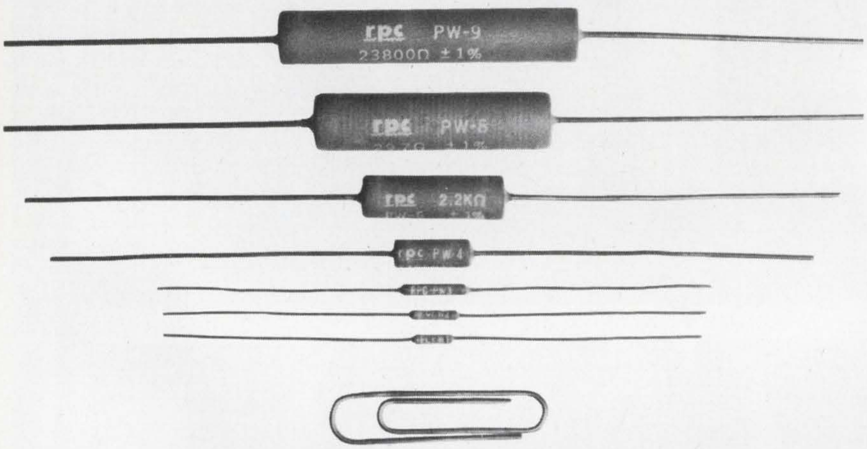
MANUFACTURERS OF PRECISION ELECTRONIC DEVICES

MEPCO, INC.
Columbia Road
Morristown, N. J. 07960
Telephone: (201) 539-2000 TWX: 710-986-7437

D/A Binary Ladder Networks - one of a series of MEPCO network modules.

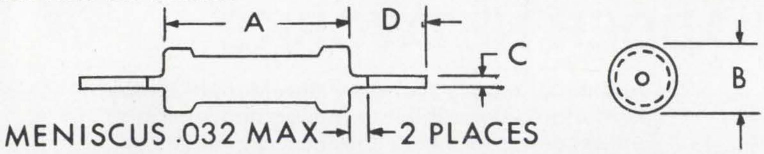
INFORMATION RETRIEVAL NUMBER 73

Resistors so precise we call them pre/sistors TM*



9 styles/±20ppm/°C T.C./Temperature −65°C to +275°C Standard tolerances ±.1% to ±10%/Extended range/Small size/Uniformly wound elements/High thermal conductivity core/All welded end cap construction/solvent resistant/moisture resistant/Up to +275°C operating temperature/High stability/MIL spec performance/High reliability/Life test/Burn-in/Solderable-weldable leads/Lot traceability/Environmental testing/Designed to customer requirements.

RPC Resistors, Type PW Precision Power Resistors designed and manufactured to the highest quality standards are now available for applications requiring precision and stability at reasonable prices. When ordering, state quantity, RPC type, resistance value and tolerance.



RPC Type	DIMENSIONS A*	B**	C±.003	D±⅛	*** Watts	Volts	Current	Res. Range	Mil-R-26 Equiv.
PW1	.230	.080	.020	1.50	1.5	145	2.24A	.3-5.75K	RW81
PW2	.292	.080	.020	1.50	2.25	232	2.74	.3- 8K	
PW3	.401	.095	.020	1.50	2.5	335	2.88	.3-15.5K	RW70
PW4	.480	.198	.032	2.00	4	547	2.83	.5-41.5K	RW69
PW5	.792	.165	.032	2.00	5	865	3.16	.5- 67K	
PW6	.855	.290	.040	2.0	6.5	1095	2.55	1- 145K	
PW7	.980	.290	.040	2.0	7.5	1710	2.74	1- 180K	RW67
PW8	1.386	.352	.040	2.0	10	2385	3.16	1- 320K	RW55
PW9	1.808	.352	.040	2.0	12.5	3150	3.54	1- 430K	RW68

*Tolerances: ±.031 on PW1 thru PW3; ±.062 on PW4 thru PW9.
**Tolerances: ±.015 on PW1 thru PW3; ±.031 on PW4 thru PW9.
***Derate to zero at +275°C.

... because we cared first!*

RPC Resistance Products Co.

914 SOUTH 13th STREET HARRISBURG, PA. 17104
PHONE (717) 236-5081

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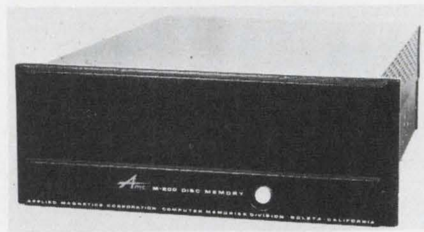
INFORMATION RETRIEVAL NUMBER 74

FJCC PRODUCTS

Small computers get disc memory



Applied Magnetics Corp., 75 Robin Hill Rd., Goleta, Calif. Phone: (805) 964-4881. P&A: $5600; 90 days.

Designed for small computers, model M-200 disc memory is a fast access, head per track mass memory. The unit is available in four capacities that range from 426,000 to 3,408,000 bits; average access time is 8.7 ms. The number of data tracks varies from 16 to 128 with 26,624 bits per track. Three timing tracks provide a bit clock, a sector and an origin pulse.

Booth No. 208 Circle No. 260

Computer I/O terminal has fast data rate

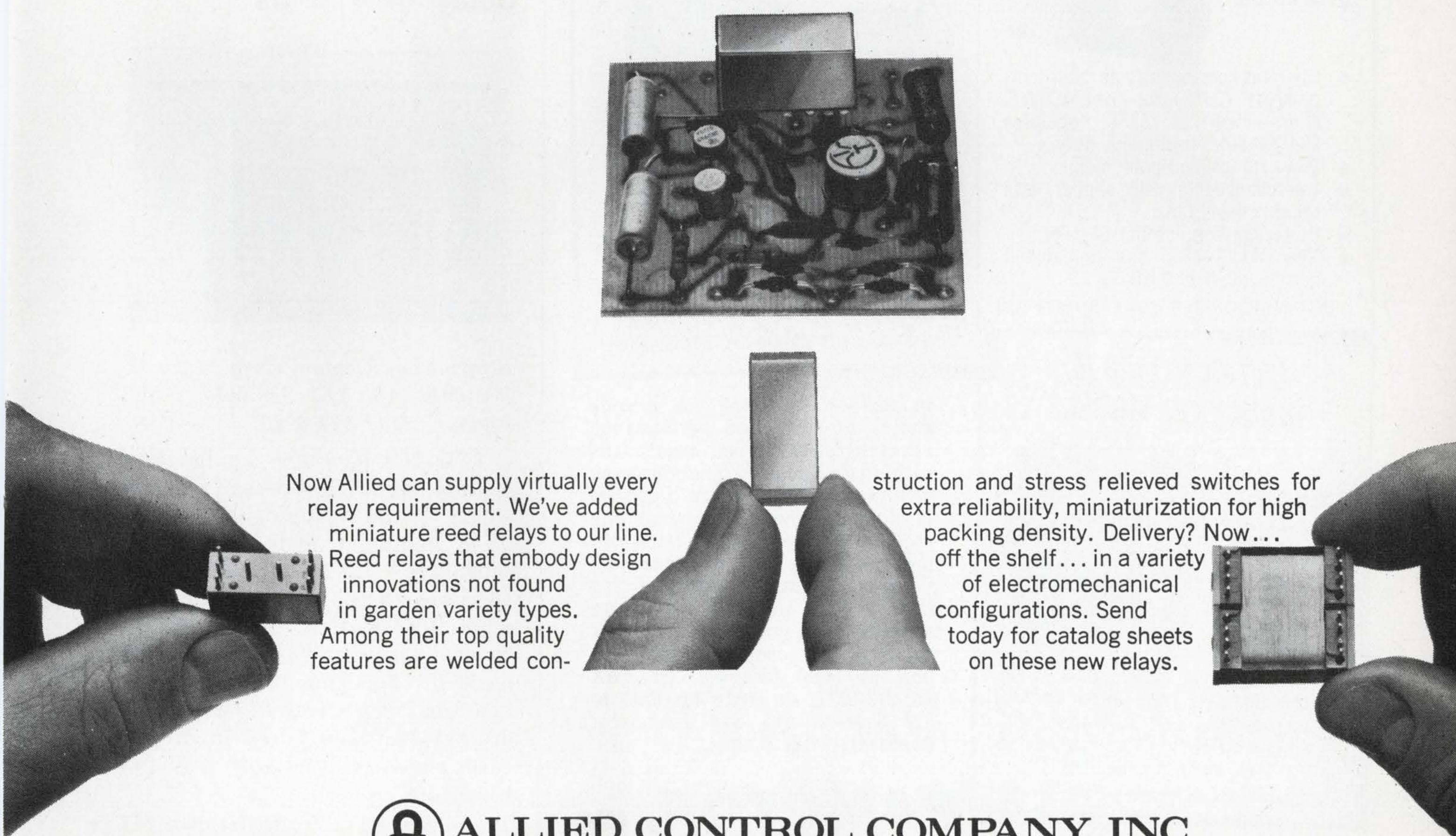
Friden, Inc., Div. of The Singer Co., 2350 Washington Ave., San Leandro, Calif. Phone: (415) 357-6800. Price: $3200.

Providing on-line access to time-shared computer systems, a keyboard/printer data communications terminal is a self-contained portable unit operating at 12.2 characters per second. Model 7100 features integrated-circuit logic for maximum reliability and minimum downtime. An automatic color ribbon shift allows the operator to print in red and the computer's response to print in black.

Booth No. 1707 Circle No. 261

Allied Control announces a new addition to the family...

Miniature Reed Relays.

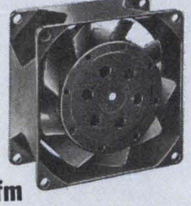


Now Allied can supply virtually every relay requirement. We've added miniature reed relays to our line. Reed relays that embody design innovations not found in garden variety types. Among their top quality features are welded construction and stress relieved switches for extra reliability, miniaturization for high packing density. Delivery? Now... off the shelf... in a variety of electromechanical configurations. Send today for catalog sheets on these new relays.

ALLIED CONTROL COMPANY, INC.
2 EAST END AVENUE, NEW YORK 10021

Keep your equipment cool. Here are a few of our 23 all-metal fans that will do the job...economically.

COMPACT MODEL 8500



1/8″ thinner than other 3 1/8″ fans . . . 45 cfm

- Unmatched noise level of 28.8 dB
- Ideal for tight dimensional applications where performance and cost are prime considerations.
- Only 3 1/8″ x 3 1/8″ x 1 1/2″ deep.
- Standard mounting dimensions for EIA 3 1/2″ rack panels.
- UL recognition number E41168.

INFORMATION RETRIEVAL NUMBER 231

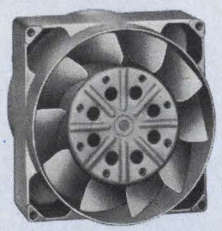
LOW-NOISE 4 1/2″ MODEL 4500

115 cfm with less than 37.5 dB SIL

- Operates continuously at room temperature (25°C) for over 100,000 hours—even at 55°C, operates 20,000 hours, continuous duty.
- Powerful shaded-pole motor.
- Interchangeable with similar, less reliable 4 1/2″ fans.
- UL recognition number E41168.
- New Model 4800 has unmatched noise level of 17.9 dB SIL.

INFORMATION RETRIEVAL NUMBER 232

ULTRA-RELIABLE INDUCTION MODELS

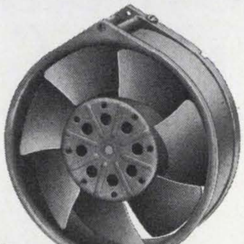


8 models available with ratings from 130 to 65 cfm

- Models 1000A, 1110, 1300, 2000, 2050, 2110 are 4 7/16″ square x 1 31/32″. Models 3000 and 3050 are 3 15/32″ square x 1 31/32″.
- UL recognition number E41168.

INFORMATION RETRIEVAL NUMBER 233

6″ MODEL 7500

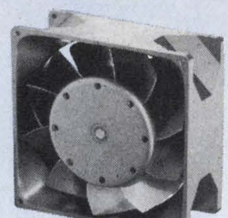


Use one to replace two or more fans where maximum total air movement is required with extremely low noise level

- Moves up to a whopping 265 cfm
- Ideal for cooling large electronic enclosures with excessive resistance to air flow.
- With new aerodynamic design of pressure type blades, sustains delivery as high as 225 cfm at .2 inches of water back pressure.
- Low noise 40.5 dB SIL at 265 cfm.
- UL recognition number E41168.

INFORMATION RETRIEVAL NUMBER 234

LOW-COST MODEL 2500



high air delivery at higher back pressures

- 4 1/2″ fan moves 115 cfm.
- Standard mounting dimensions.
- 50-60Hz operation at 117 or 230 VAC.
- UL recognition number E41168.

INFORMATION RETRIEVAL NUMBER 235

In addition to giving you a wide choice of sizes and performance characteristics in all-metal fans with shaded-pole or induction type motors, we can give you a special fan to solve your particular cooling problem. We can deliver fans with low, low noise levels, economical "bracket" models, and ball bearing fans for 85°C ambient temperature operation. Extend the life of your equipment . . . cool it and call us now at (415) 863-5440. Or TWX 910-372-6127. Or write for data to 312 Seventh St., San Francisco, California 94103.

PAMOTOR, INC.

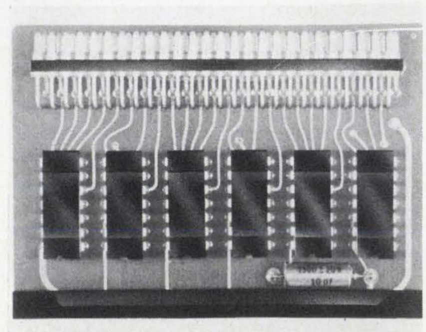
Digital data modem transmits 2400 bits/s

Lenkurt Electric Co., Inc., 1105 County Rd., San Carlos, Calif. Phone: (415) 591-8461.

Particularly suited for one-way or two-way data communications between computers, model 26C data set transmits digital signals at speeds as high as 2400 bits per second. Operating over standard 3-kHz voice channels, the compact unit automatically detects errors without redundancy. With a signal-to-noise ratio of 13 dB, the average error rate is only one bit per 100,000 bits.

Booth No. 412 *Circle No. 262*

TTL IC cards delay only 8 ns



Information Control Corp., 1320 E. Franklin Ave., El Segundo, Calif. Phone: (213) 322-6930.

TTL ICs for logic applications operate at high speeds from a single power supply with high noise immunity and high fanout capability. The T-100 modules are additions to the Abacus I-100 line from Information Control Corp. Typical propagation delays for the basic flip-flop and gate are 15 ns and 8 ns, respectively. The modules are supplied on a 2-by-3-in. circuit card, which is fitted with a 52-pin connector.

Booth No. K4 *Circle No. 263*

Zeners from the Power House.

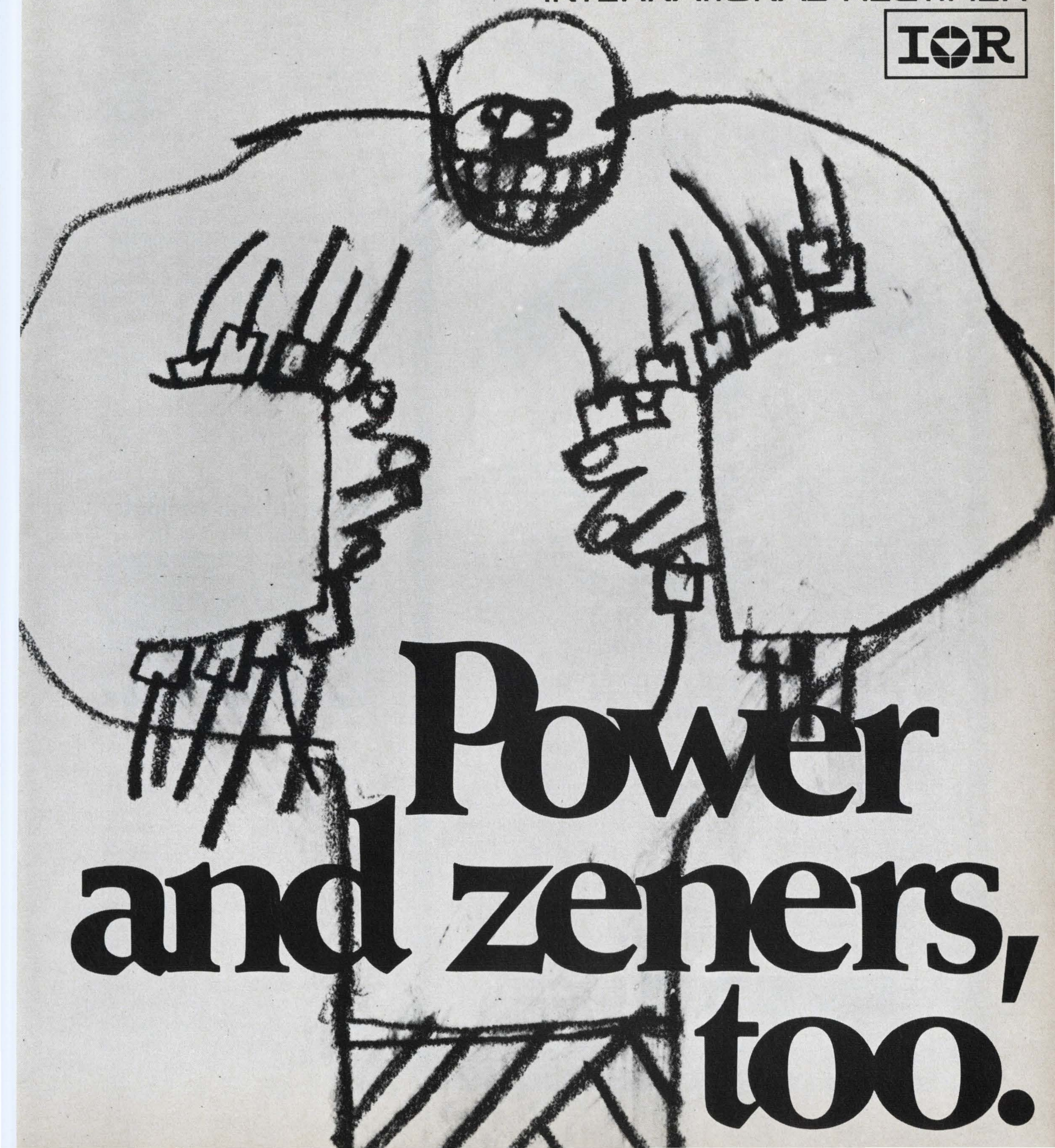
We're known as the Power House, mainly for our power rectifiers, SCRs and triacs. But we have another line working hand in glove with our power components: International Rectifier zener diodes, featuring the industry's only lifetime guarantee!

Our silicon zener regulators range from 150 mW to 50 W, from 2.0 V to 200 V. Our temperature compensated voltage references provide standard voltages from 5.9 V to 49.6 V, at standard temperature coefficients from ±0.01%/°C to ±0.0005%/°C.

Check our zeners and voltage references. They're stocked in depth at our distributors and covered in detail in our Short Form Catalog. Write for it now from the Power House, 233 Kansas St., El Segundo, California 90245.

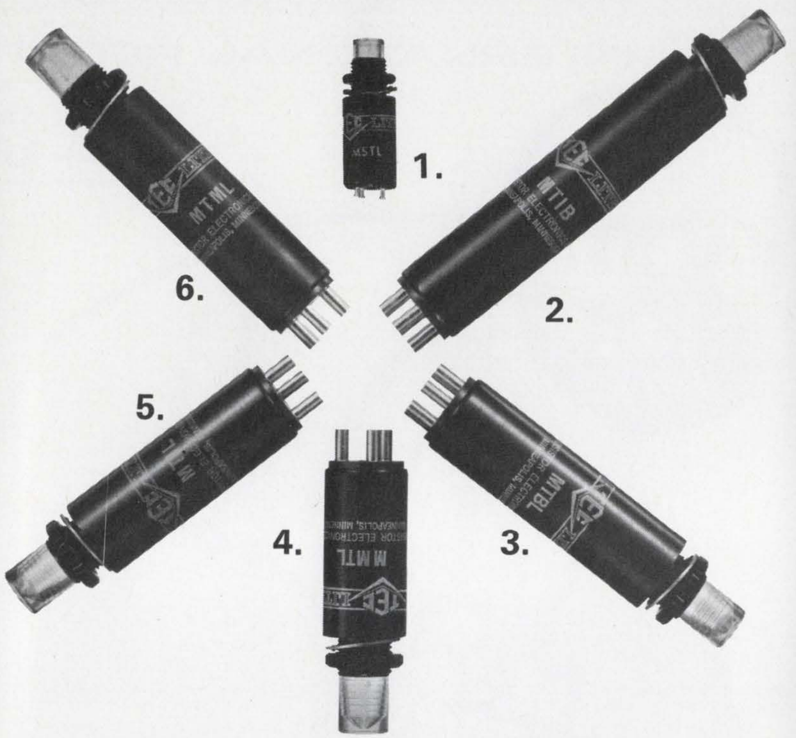
INTERNATIONAL RECTIFIER

IOR



Power and zeners, too.

Transistor Controlled INDICATORS/SWITCHES



1. MSTL Series
Extra small .360" dia. body. Neon or incandescent lamp controlled from low level I-C signals. As low as $6.75.*

2. MTIB Series
Offers integral, isolated switch with MTIL functions. As low as $5.10.*

3. MTBL Series
Adds integral, isolated switch to MMTL Series. As low as $4.25.*

4. MMTL Series
Controls neon lamp from signals as small as 1 volt. Price: As low as $5.35.*

5. MTIL Series
Replaceable incandescent lamp controlled by signals as low as .5 ma. As low as $4.15.*

*in 500 quantity

6. MTML Series
Turns on with a 2 μsec pulse. Remains on until cleared. Integral switch available. As low as $8.75.*

Complete range . . . operate directly from typical integrated circuit logic levels

Solid-state circuitry within the device uses low level outputs of your I-C system. Transistor control means high voltages and currents for lamps are confined to indicator and panel area. Lamp control logic is inside indicator. Mount on 19/32" centers except MSTL Series which mount on ⅜" centers. Wide range of terminals available. Also available for discrete component circuitry.

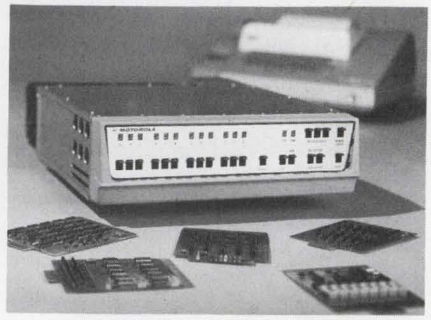
TEC has designed thousands of *special* display and control devices to be compatible with customer's logic levels. For information about TEC's complete line of INDICATOR/SWITCHES • READOUTS • DISPLAY PANELS • DATA ENTRY KEYBOARDS • CRT DISPLAY TERMINALS, call (612) 941-1100 or write:

TEC LITE®
Transistor Electronics Corporation

Box 6191 • Minneapolis, Minnesota 55424

INFORMATION RETRIEVAL NUMBER 77

Small-scale processor operates in real time

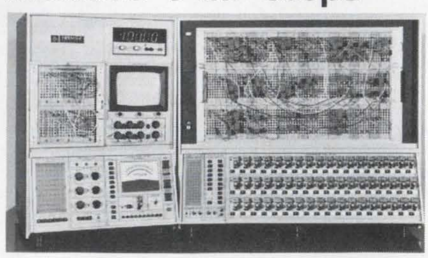


Instrumentation and Controls, Inc., Motorola, 3102 N. 56th St., Phoenix. Phone: (602) 959-1000. Price: $8400.

Designed to provide unusual versatility in real-time situations, a small-scale, digital data processor comes with a line of interface modules. Only one 8-bit word of memory is required to specify an instruction. The machine has a magnetic core memory with a capacity of 4098 8-bit words that is expandable to 16,000 words, in increments of 4098 words.

Booth No. 1409   Circle No. 258

Analog/hybrid computer includes 9-in. scope



Nissei Sangyo Co., Ltd., 501 5th Ave., New York City. Phone: (212) 986-5275. Price: $5000.

Capable of 3-mode repetitive operation, model 505 100-V analog/hybrid computer provides wide operational flexibility. A built-in electronically scaled 9-in. oscilloscope eliminates parallax. The unit can be expanded to 124 operational amplifiers. The desk-top computer is designed to be easily integrated into any hybrid system and features 90 servo-set potentiometers. The entire console is temperature stabilized and has a color-coded patchboard and shielded patchcords.

Booth No. K7   Circle No. 259


We call it INCONECT®. Our new Molex modular system that provides five ways of interconnecting electrical-electronic printed circuit assemblies: Two ways to connect circuit boards to chassis, three ways to interconnect printed circuit boards. It's a giant step forward in helping speed production and assembly techniques in the area of printed circuits. Unique flexibility enables you to tailor connector components to your specific product needs. Easily. Simplifies assembly, testing, servicing and model change requirements. It's another example of the Molex creative approach to circuitry problems. One that demonstrates just how reliable and economical printed circuit connections can really be. But see for yourself. Write for details. Or you can make connections by calling (312) 969-4550.
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This is just part of the broadest, most complete line of rectangular rack and panel connectors made.

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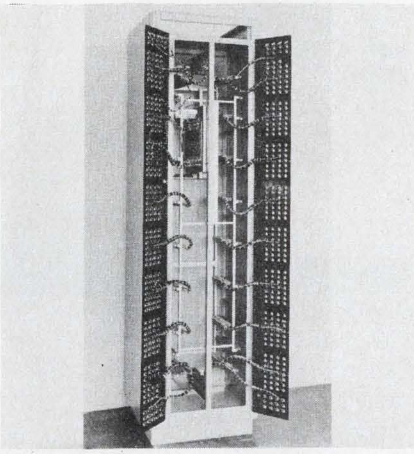
And they're available in quantity right now from your nearby ITT Cannon factory authorized distributor. If he doesn't have exactly what you need, he can get it for you. ITT Cannon Electric, 3208 Humboldt St., Los Angeles, California 90031. A division of International Telephone and Telegraph Corporation.

CANNON ITT

Delay line system has 500 inputs

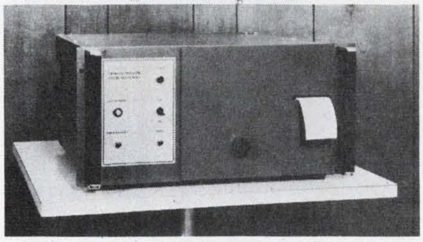


Tyco Labs, Inc., 200 Michael Dr., Syosset, N.Y. Phone: (212) 759-1800.

Designated type 420, a multitapped delay line system with 500 inputs and a single output is used for correlation studies. Total delay is 35,000 μs with a tolerance of ±1 μs. Tap separation is 70 μs with a tolerance of ± 1 μs. Nominal input and output pulse width is 1 μs.

Booth No. 207 *Circle No. 270*

Asynchronous printer writes 40 lines/s

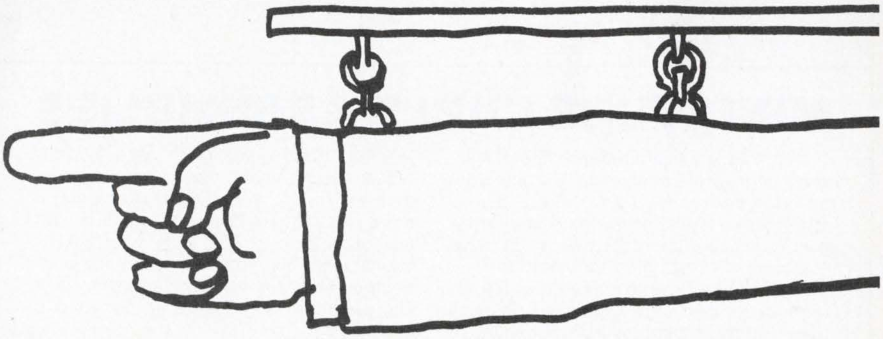


Litton Industries, Litton Datalog Div., 343 Sansome St., San Francisco. Phone: (415) 397-2813.

This asynchronous digital printer is capable of printing 40 lines per second and has a 16-column capacity. The MC 2400 utilizes a 12 or 15 character set, a hammer module design and a minimum of moving parts. Three models print at speeds of 20, 30, or 40 lines per second. The printer accepts four-line coded data input. Entry is bit and column parallel. An 8-4-2-1 BCD code is standard, and zero suppression is available for any number of columns.

Booth No. 2006 *Circle No. 271*

Back up for MAC.



Pages 44, C42, and C43

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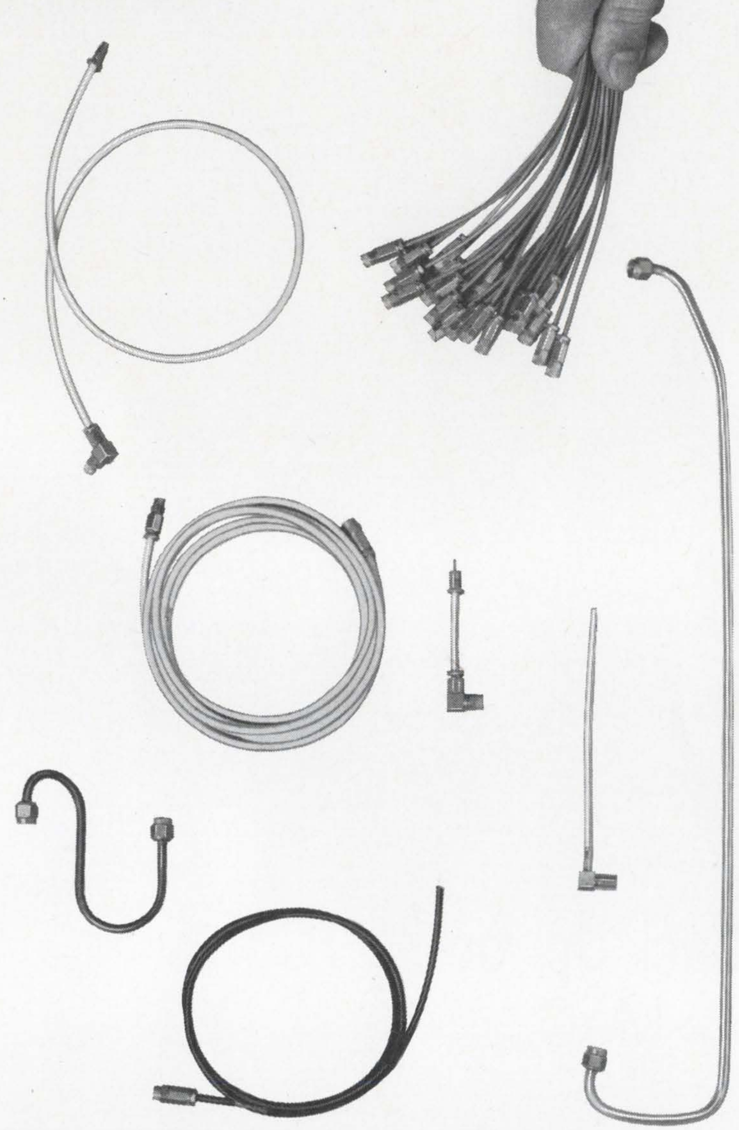

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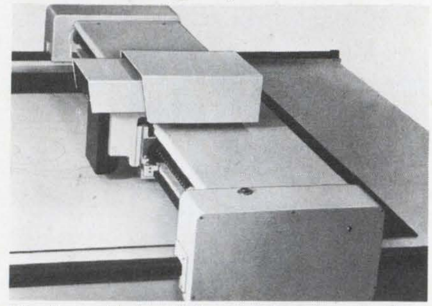
PHELPS DODGE ELECTRONIC PRODUCTS CORPORATION

INFORMATION RETRIEVAL NUMBER 81

Automatic digitizer converts graphic data

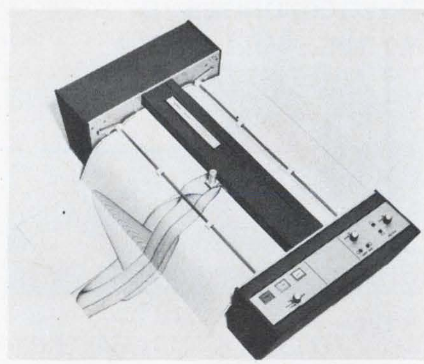


Gerber Scientific Instrument Co., P.O. Box 305, Hartford, Conn. Phone: (203) 644-1551. P&A: $50,000; 6 months.

Designed as a complement to Gerber's graphical display systems (series 2000), an automatic digitizer implements fast, complete conversion from graphic to digital data. The digitizer consists of a line follower which uses ICs, a digitizing program, and an operator's console containing a TV monitor and a control panel.

Booth No. 901 *Circle No. 264*

Digital plotter uses Z-fold paper



Houston Instrument, Div. of Bausch & Lomb Inc., 4950 Terminal Ave., Bellaire, Tex. Phone: (713) 667-7403. Price: $5500.

A 22-in. wide digital plotter uses Z-fold chart paper whose plotting surface area measures a full 22 by 144 in. Tearing at appropriate perforations affords the user standard A, B, C, and D size drawings. The DP-3 drive motors have two mounting positions that enable the user to change from 0.010 in. to 0.005-in. step size. Plotting rate is 300 increments per second.

Booth No. 1903 *Circle No. 265*

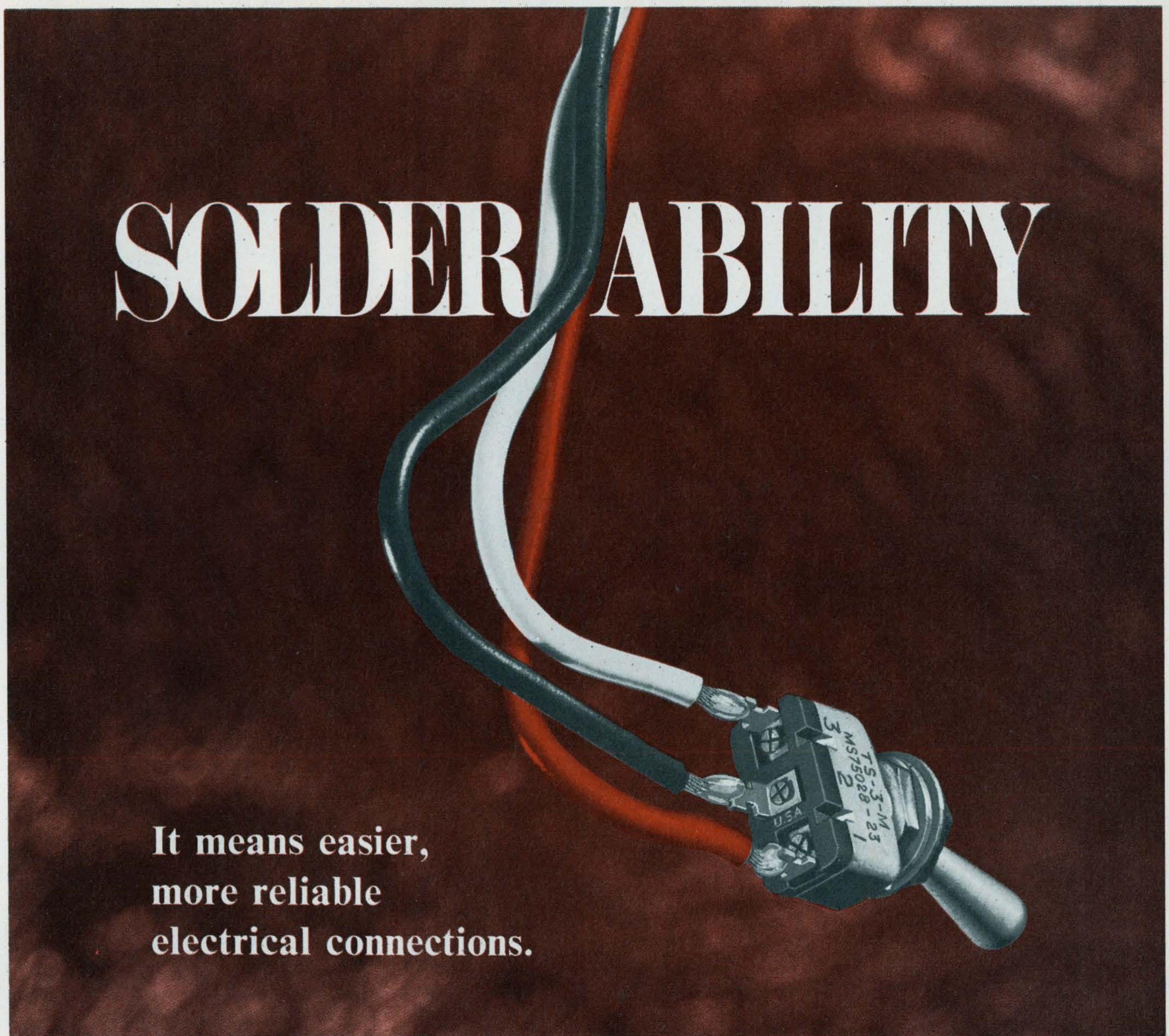
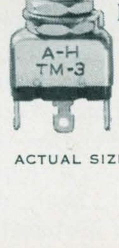


PHOTO TWICE SIZE

Oversized, gold-plated terminals make soldering these Arrow-Hart subminiature switches a snap.

You also get exceptional versatility of installation, because these are combination solder, quick-connect and single-turret terminals.



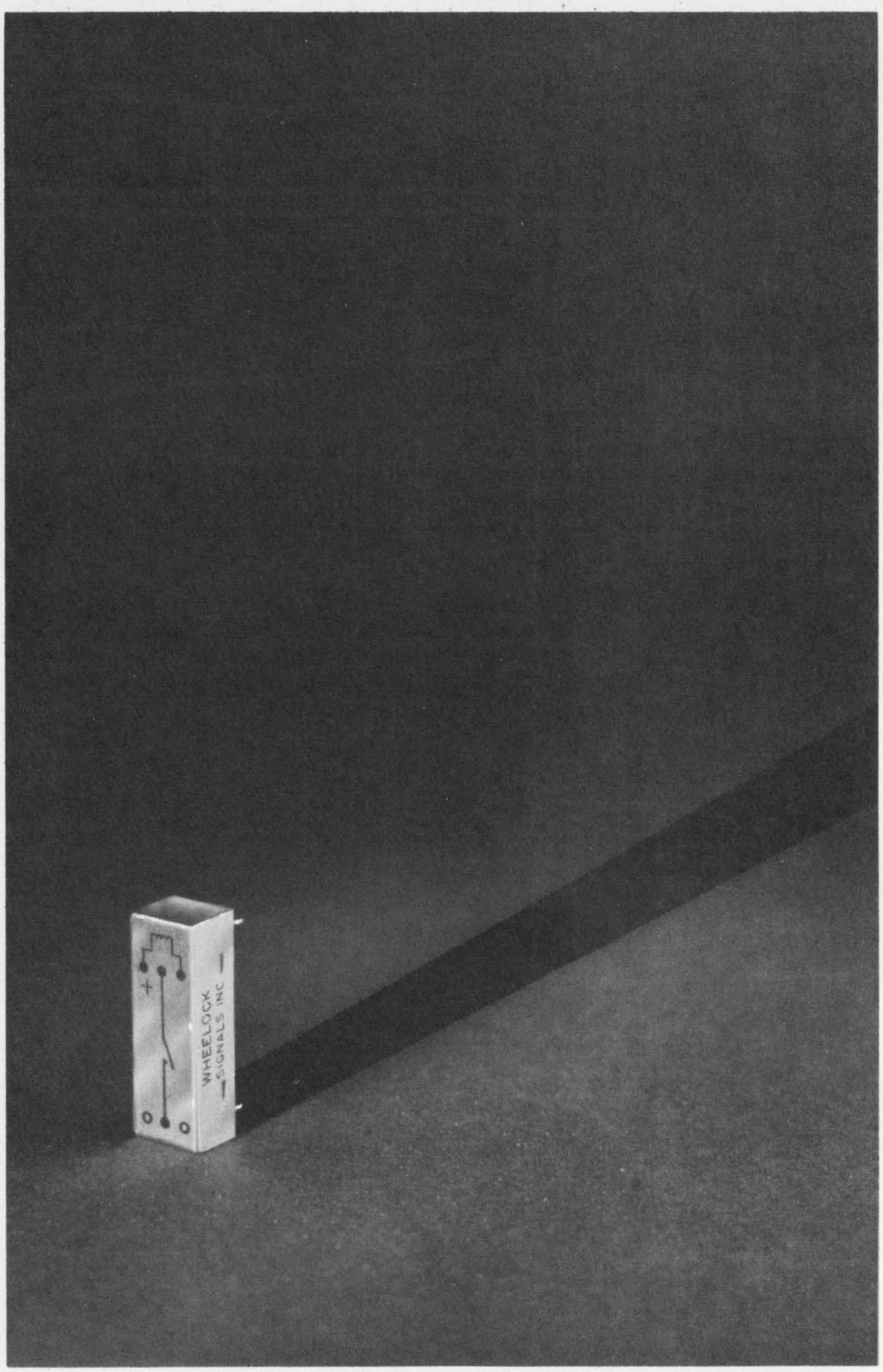
ACTUAL SIZE

Movable contacts are rhodium plated for long mechanical life. Stationary contacts are gold-plated silver for long shelf life and superior performance on low-energy circuits. Contacts are rated 5 amps at 125 volts AC and 29 volts DC. For design versatility, you get a wide choice of bat and ball levers, including seven colored types. Two or three position. Maintained or momentary contacts. Arrow-Hart subminiature switches are available to meet MIL-S-3950-C, MS-75028 and MS75029 specifications.

It all adds up to the performance, versatility, and installation ease you need for all types of instrumentation and other applications that call for maximum capability in minimum panel space. Write for complete technical information on subminiature toggle and push button switches. Arrow-Hart, Inc., 103 Hawthorn Street, Hartford, Connecticut 06106.

Arrow Hart ARROW-HART, INC., HARTFORD, CONN.

INFORMATION RETRIEVAL NUMBER 82



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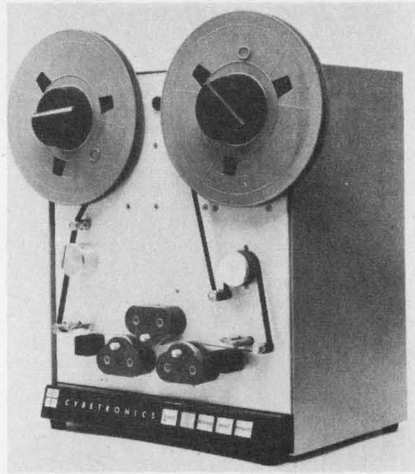
93

INFORMATION RETRIEVAL NUMBER 83

Magnetic tape cleaner runs automatically

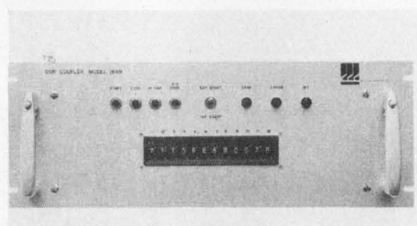


Kybe Corp., 132 Calvary St., Waltham, Mass. Phone: (617) 899-0012.

A dual-process, automatic magnetic tape cleaner provides a low-pressure cycle for newer types of tapes and a high-performance process for tapes with high concentrations of imbedded particles. Continuous tension is provided throughout the rewind cycle.

Booth No. 809 *Circle No. 266*

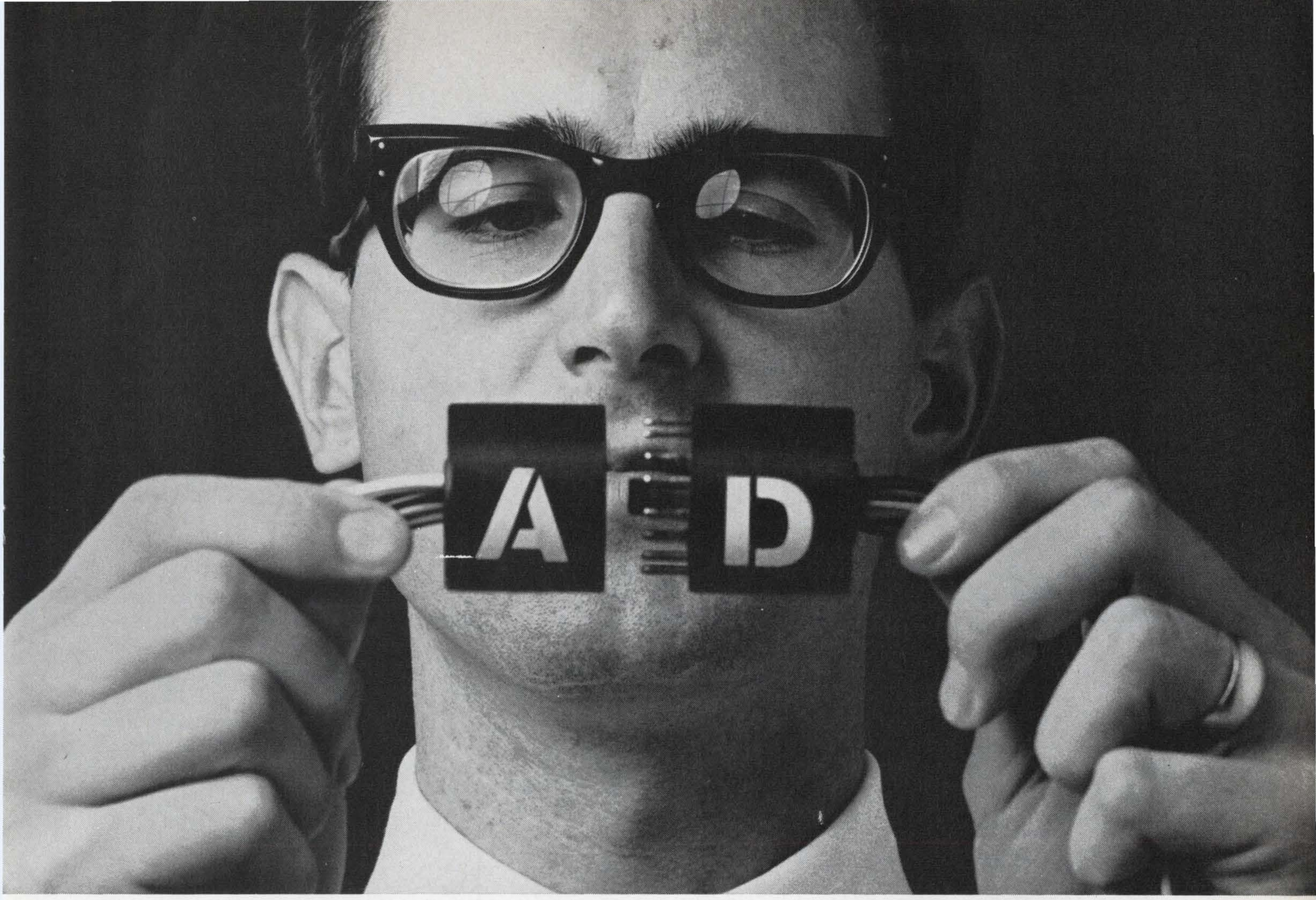
Recorder coupler interfaces counters



Digi-Data Corp., 4315 Baltimore Ave., Bladensburg, Md. Phone: (301) 277-9378.

Model 1649 coupler provides an interface between the Digi-Data incremental recorder and such digital output devices as counters and voltmeters. This coupler is designed for writing on tape compatible with the IBM 360. Tapes can be written in binary, EBCDIC or packed decimal. Controls within the coupler allow the user to select word and record length. Twelve characters of fixed data can be entered by front-panel switches.

Booth No. 1601 *Circle No. 267*



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Analog engineers design analog instruments for analog engineers. Digital engineers aren't usually analog engineers. This leads to problems.

Because we're involved with both D and A, we developed a group of instruments everyone can understand and use.

Before they were put on the market, our systems engineers demanded that analog signals get in and out of digital equipment with blinding speed and stunning accuracy. As a result, here are bold statements about our new line: **Our new instruments are: A.** As fast and more accurate than . . . **B.** Faster and more accurate than . . . **C.** Almost as fast and just as accurate as anyone else's. Whether **A, B,** or **C** applies depends on the instrument you choose.

Here are some of the new ways to get from analog to digital and back again.

Multi-channel digitizers

64 channel high-level multiplexers with sample and hold amp, plus a 15-bit A-D converter in the same chassis. Accuracy: 0.01%. The MD51 has a sample and conversion time of 10 μsec for $8,250 plus $200 for each eight channels. If you can spare another 20 μsec, you'll save $3,050 with the MD41.

Single channel digitizers

15-bit, high-level A-D converters with built-in sample and hold amps. Accuracy is $\pm$0.01%. The AD51 has a throughput word rate of 100 KHz for $5,400. The AD41, though it only costs $4,000, isn't a slowpoke. Throughput is 33 KHz.

Digital to analog conversion

The DA40 is a 10-bit, 16 channel D-A converter. If you need more channels, up to 16 DA40's can be ganged together for 256 analog outputs. Each includes address decode and channel controls, plus a power supply. $375 per channel.

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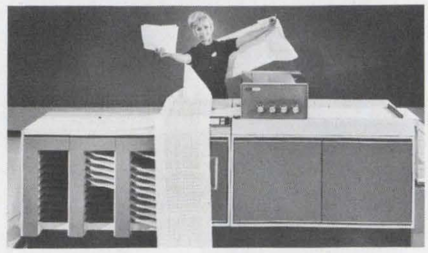
Duplicating machine speeds printout copy

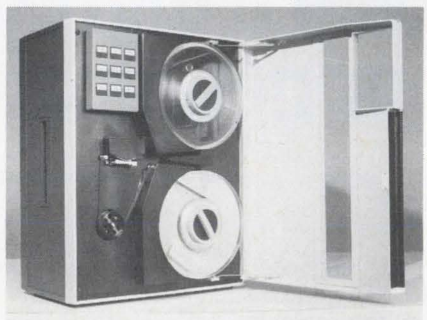


Xerox Corp., Midtown Tower, Rochester, N.Y. Phone: (716) 546-4500.

To help break the information bottleneck in computer output, a duplicating device automatically copies data directly from a computer printer, reduces page size at the same time, and then collates the completed copies. This computer-forms printer can accept 15-by-11-in. continuous fan-fold forms that come from data processing equipment. Within one half hour, it can print them out as collated sets on regular 8-1/2-by-11-in. pages for final binding.

Booth No. 210 *Circle No. 268*

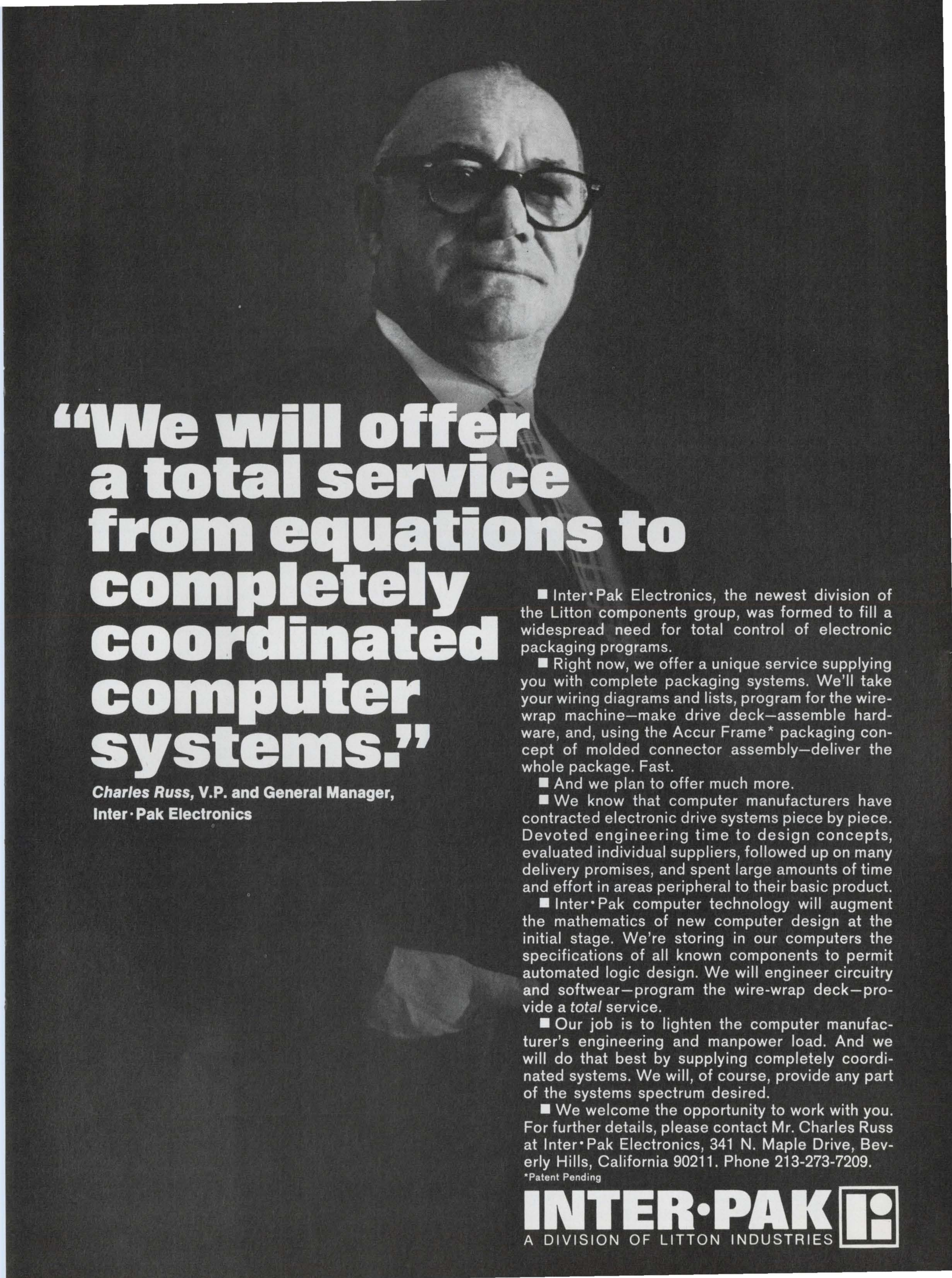
Tape memory system cuts user cost by 20%



Ampex Corporation, 401 Broadway, Redwood City, Calif. Phone: (415) 367-4151. Price: $3500.

A complete IBM-compatible tape memory system is priced 20 to 40 per cent lower than previous complete systems of its size and performance. The system allows computer manufacturers to purchase complete tape memories more economically than by building their own. Complete at its price, the TM-Z operates in both 7 and 9 track modes. It offers tape speeds up to 24 in. per second and packing densities up to 800 bits per inch.

Booth No. C-1 *Circle No. 269*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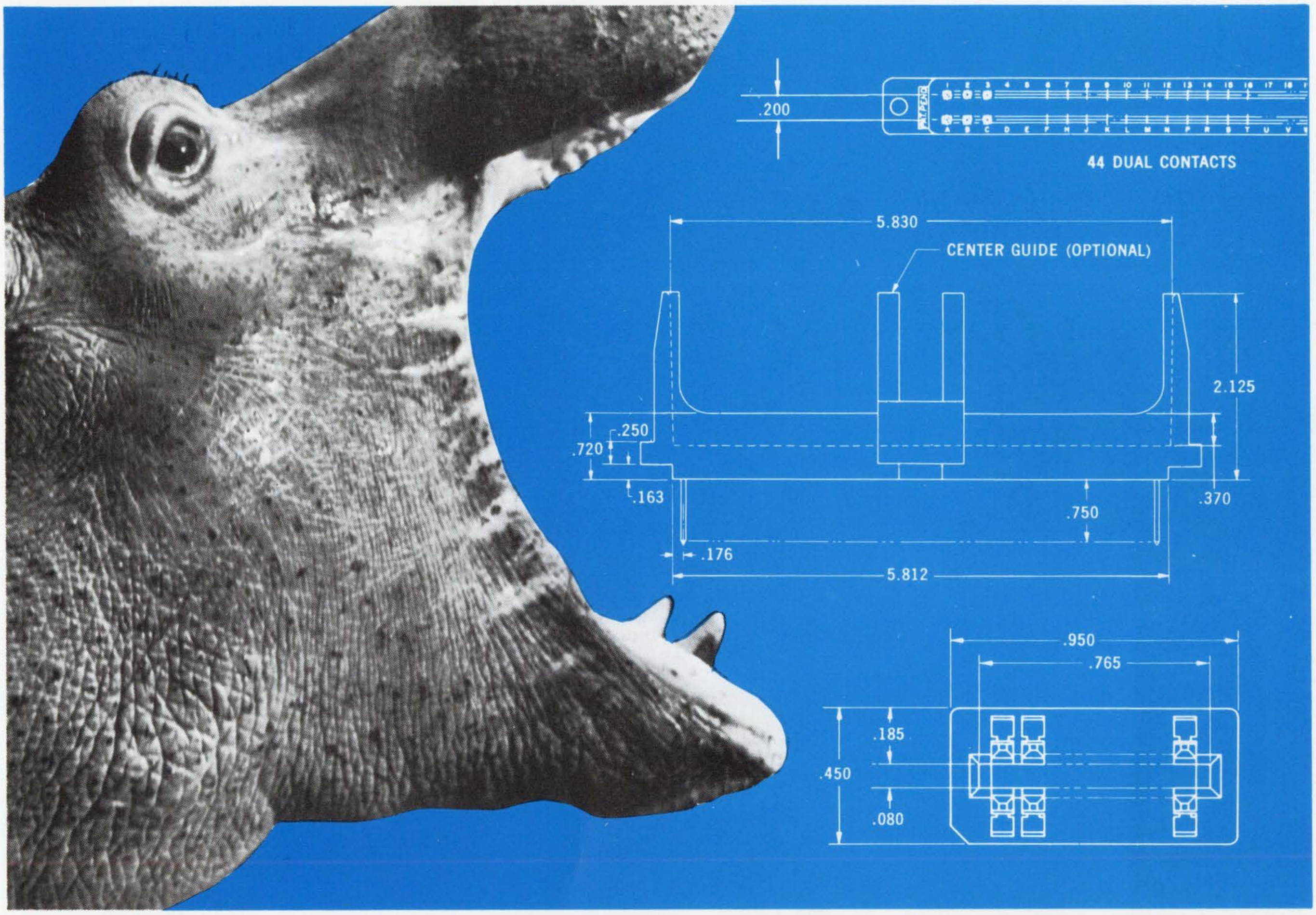
Advertisers' Index

(Covering pages C1 thru C88)



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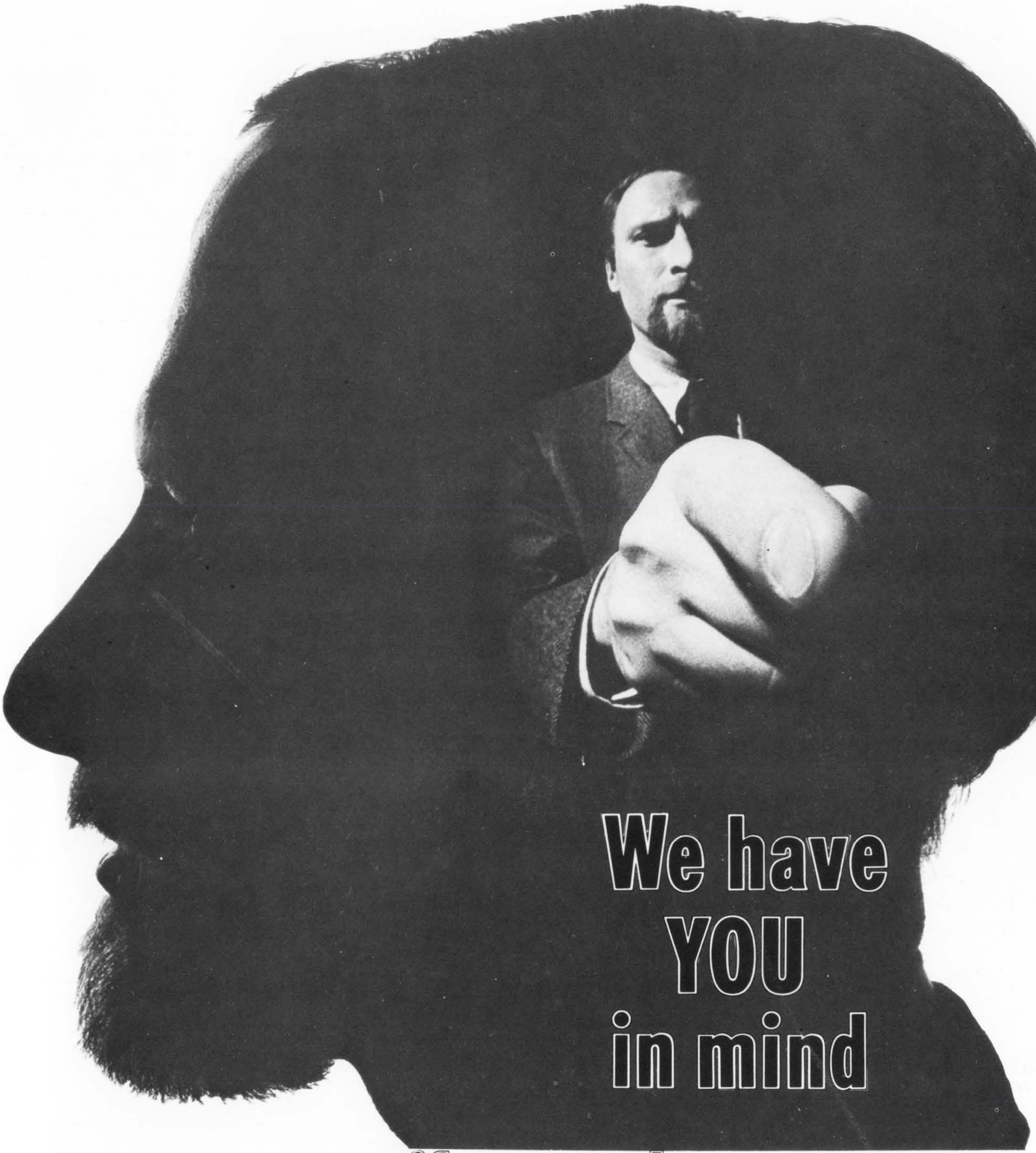

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Age	**U.S. Citizen** ☐ Yes ☐ No	**Security Clearance**		

Prime Experience	Secondary Experience

Desired Salary	**Availability Date**

Employment History – present and previous employers

Company			
City, State			
Dates	to	to	to
Title			
Specialty			

Education – indicate major if degree is not self-explanatory

Degree			
College			
City, State			
Dates	to	to	to

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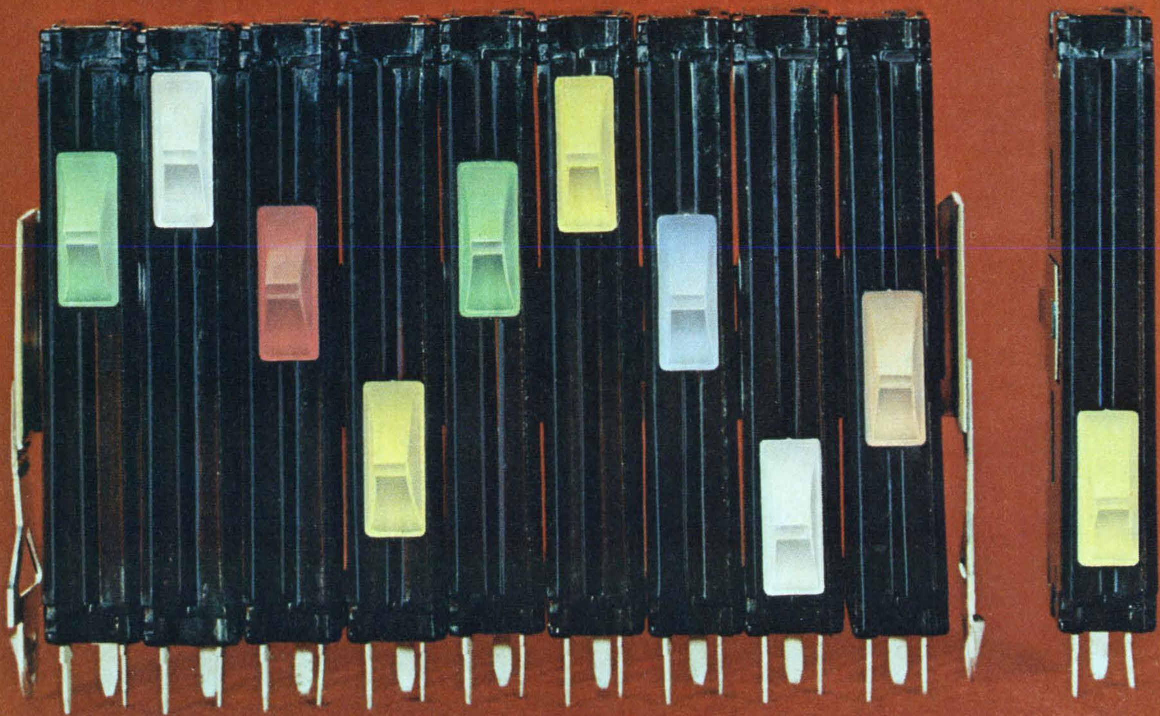
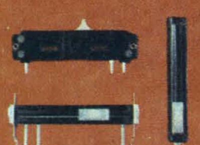
The Straight Line



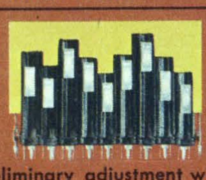
Covered under Patent No. 3,362,004 and others pending.

Functional new concept in Potentiometer design



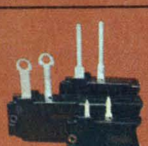
Horizontal, vertical or side mounting available.

Multiple units lock and actuate with single knob.



Preliminary adjustment with template possible.

Needs only 1/3 mounting area of standard control.



Standard solder lug, wire-wrap or printed circuit terminals supplied.

Forward or rear facing twist-tab mountings. Snap-in mounts also available.

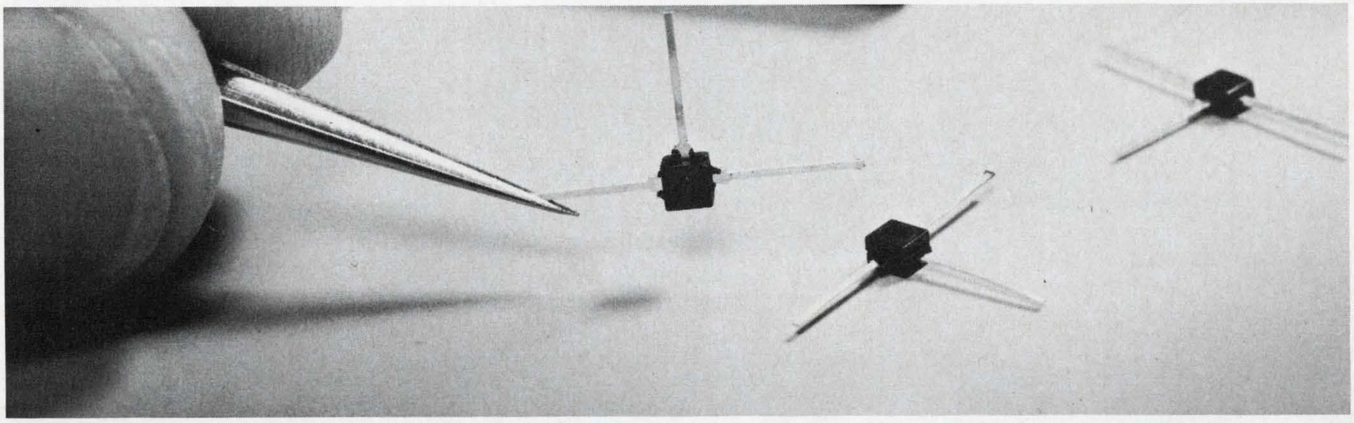
Variable resistors have been going in circles for years. Now Stackpole straightens them out. Using linear motion, Stackpole engineers created a potentiometer that conserves circuit board and panel space and offers a host of design advantages. Stackpole calls it SLIDE-TROL®. You'll call it ingenious! Utter simplicity, yet with all the quality and features of devices costing much more. SLIDE-TROL® is available in values of 40 ohms to 15 meg. ohms and since the element is rectangular and provides more area to dissipate heat, higher wattage ratings are possible. Phenolic housings eliminate shock hazards. Low noise and low contact resistance are assured by a patented 9-point movable spring contact. Only imagination limits the applications for SLIDE-TROL®. If you're looking for performance, economy and appeal in variable resistors, get the facts on SLIDE-TROL®. Write for samples and brochure:

Stackpole Components Co., P.O. Box 14466
Raleigh, N. Carolina 27610. PH: 919-828-6201
TWX: 510-928-0520

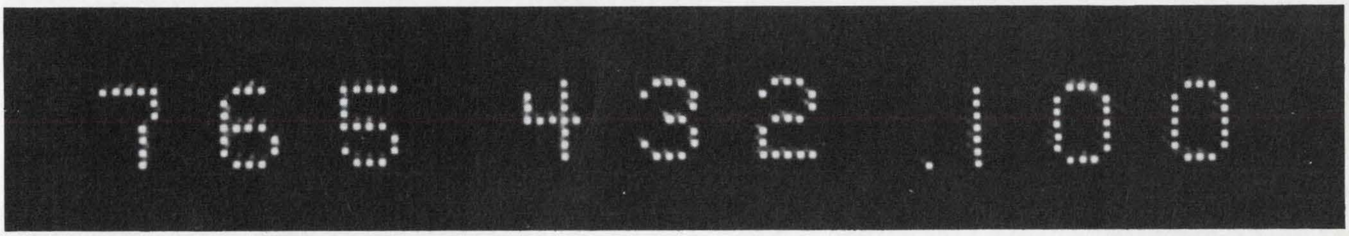
STACKPOLE®
COMPONENTS COMPANY

Also a leading producer of quality slide, rocker and rotary switches.

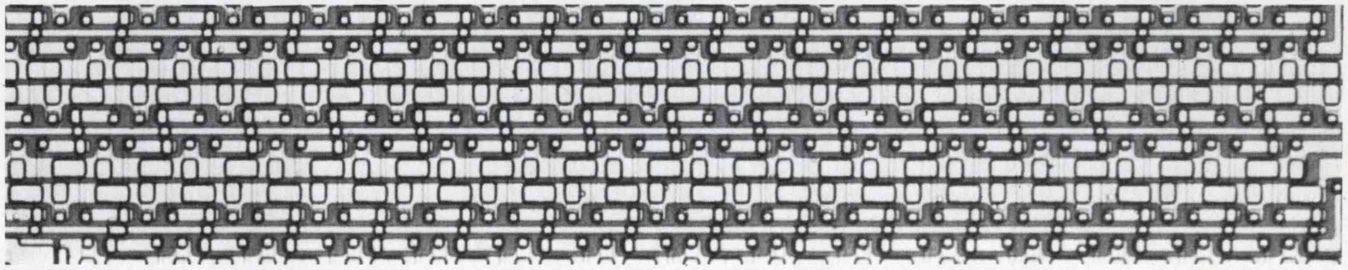
Products



Miniature silicon transistors feature a plastic spider-type package that occupies only 18% of the volume of a TO-46 metal can. Rated dissipation is 225 mW continuous. Page 120



Solid-state indicators display an array of bright red dots in numeral form. The thin, sealed modules contain light-emitting diodes and an LSI monolithic decoder. Page 94



LSI MOS shift registers, in both dynamic and static models, minimize interfacing problems. They drive bipolar circuits directly and are compatible with each other. Page 121

Also in this section:

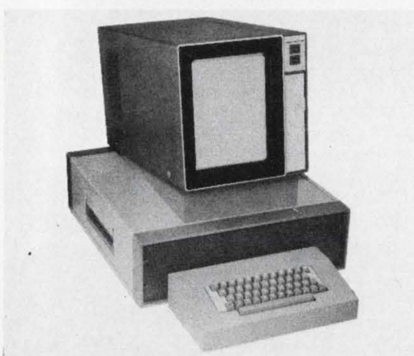
Computer terminal sends acoustic data

Anderson Jacobson, Inc., 2235 Mora Dr., Mountain View, Calif. Phone: (415) 968-2400. P&A: $1773; 2 wks.

Designed for users of time-sharing, model ADT 233 acoustic data terminal uses integrated circuits to provide high sensitivity to weak data signals in the presence of noise originating in the telephone line or in the room. The coupler and a teleprinter have been packaged together to provide a self-contained terminal.

Booth No. 501 *Circle No. 252*

CRT display terminals include curve generator



Computek, Inc., 905 Main St., Cambridge, Mass. Phone: (617) 864-2095. Price: $12,000.

Designed with both alphanumeric and graphic capabilities, series 400 display terminals contain a unique generator that allows curves to be drawn directly, rather than having them approximated by straight line segments. The systems include a storage-type CRT, an alphanumeric input keyboard, curve and vector generators for graphics, a character generator for alphanumerics, and interfacing for standard data sets.

Booth No. 508 *Circle No. 253*

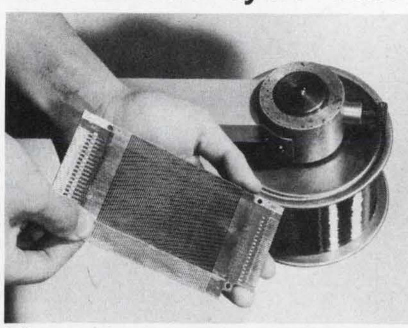
IC digital computer accepts 100 commands

Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. Phone: (714) 833-2400. Price: from $12,500.

Data 620/i, a system-oriented computer using monolithic IC construction, features nine hardware registers, six addressing modes and over 100 basic commands. Its processor can be supplied with memories whose capacities range from 4096 to 32,768 words of 16 or 18 bits. Requiring only 350 W of power, the unit weighs less than 70 lb and fits a 10-1/2-by-19-by-24-in. relay rack.

Booth No. G *Circle No. 274*

Plated-wire memories have 200-ns cycle time

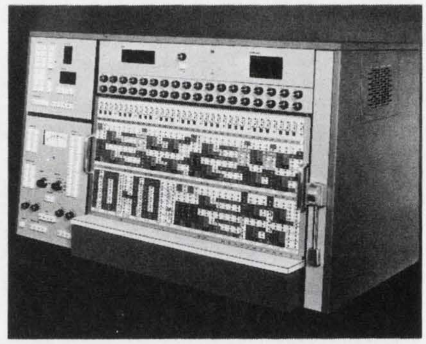


Electronic Memories, 12621 Chadron Ave., Hawthorne, Calif. Phone: (213) 772-5201.

Plated-wire memory planes boast a cycling speed of 200 ns or less, and a storage capacity of 64 36-bit words in both the bipolar and unipolar modes. The wire used for the memories is made of beryllium-copper alloy that is electroplated with a proprietary coating. These wires are inserted into plastic tunnel structures containing copper straps used as word conductors.

Booth No. 1501 *Circle No. 275*

Desk-top computer is analog/hybrid



Electronic Associates, Inc., West Long Branch, N.J. Phone: (201) 229-1100.

The 380 analog/hybrid is a 10-V desk-top system for R&D and industrial applications. The basic 380 computer is an analog machine with expandable control logic for hybrid interface. In expanded format, it can be used in modern hybrid techniques in which the dynamics of physical systems too complex for simplified analytical models are studied.

Booth No. N *Circle No. 254*

Computer system stores 16K bytes

National Cash Register Co., Dayton, Ohio. Phone: (513) 449-6831.

Century 100, the base member of a compatible computer family, includes: a central processor with a storage capacity of 16,384 characters that is expandable to 32,738 characters; an integrated dual-spindle disc unit with a storage capacity of over 8.4 million characters; a printer with speeds ranging from 450 to 900 lines per minute; and a 1000-character-per-second punched-paper-tape reader, or a 300-card-per-minute punched-card reader.

Booth No. D405 *Circle No. 255*

Anaconda Magnet Wire leads to better electronic products

Designers and production engineers are drawn to Anaconda Magnet Wire.

Because they want to maintain reliability and component performance.

And have wire that's solderable.

And wire that shows low electrical losses at high frequencies.

And wire that's windable—meeting space factor requirements.

No wonder, then, designers specify these Anaconda Magnet Wires:

Anacryl solderable acrylic-type wire. Class 105.

Plain enamel wire features oleoresinous insulation. Class 105.

Analac has a solderable, polyurethane insulation. Class 105.

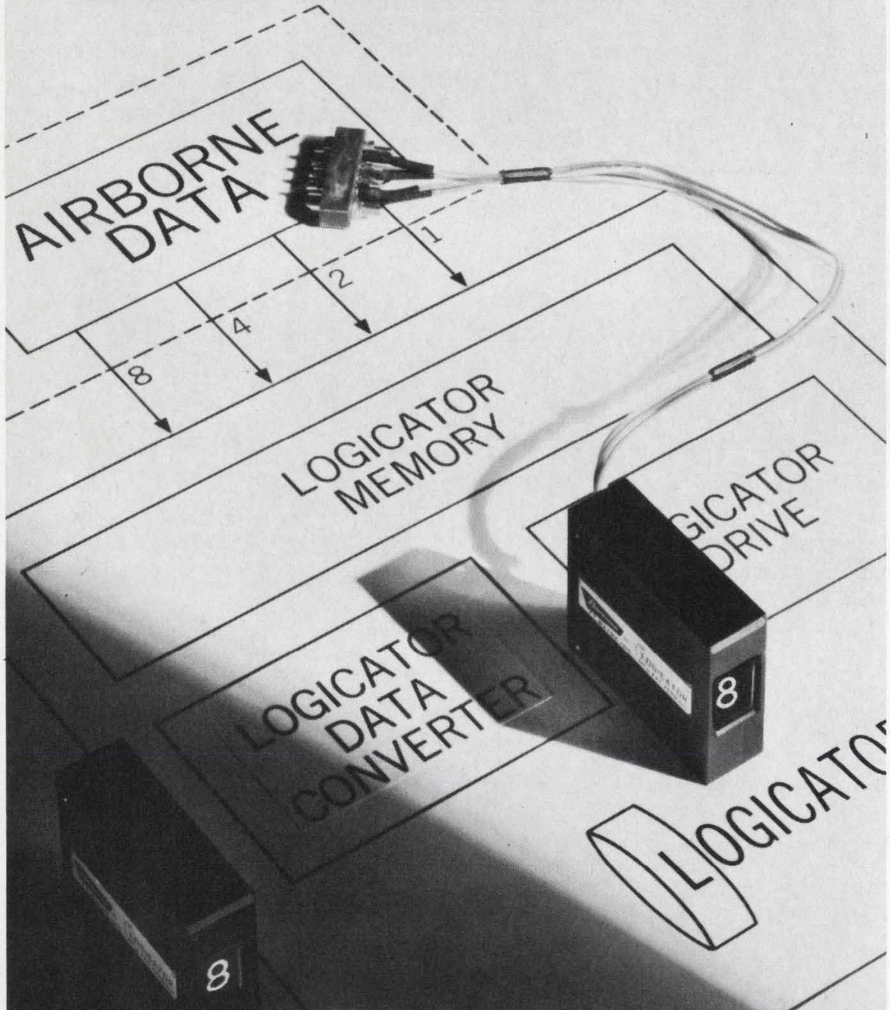
Nylac is polyurethane-insulated, nylon-overcoated, solderable-type magnet wire. Class 130.

Ask the man from Anaconda about Magnet Wire.

Or write to the Anaconda Wire and Cable Company, 605 Third Avenue, New York, New York 10016.

Don't be dazzled by competitive claims; LOGICATOR is the *only* computer logic indicator with constant readability under all ambient light conditions. This modular display unit combines the advantages of a printed drum with an exclusive *back-lighting* feature . . . ideal for airborne instrumentation display . . . less than 1 watt of logic power required. LOGICATOR provides direct readout of any digital computer level voltages, eliminating the need for mechanical drives, servos, and D-A converters. Modular design allows assembly of multi-digit displays of any number of 10 or 12-position drums. Units are designed to be compatible with the requirements of Mil-E-5400, Class 2. Additional features such as 1 million cycle minimum life expectancy, fast response time, time-sharing capability, and inherent magnetic memory, clearly indicate LOGICATOR's superiority. Isn't it logical that you should make a B-line* to Bowmar?

Gloom or glare, LOGICATOR® stands out when others fade out.



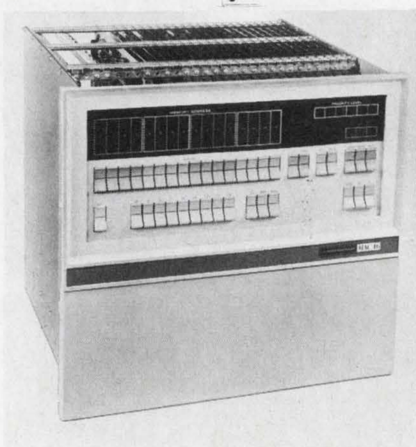
The shortest distance between computer and display is the Bowmar B-line*

*Call (219) 747-3121 for engineering assistance

BOWMAR INSTRUMENT CORPORATION
8000 BLUFFTON ROAD □ FORT WAYNE, INDIANA 46809

INFORMATION RETRIEVAL NUMBER 97

16-bit computer adds in 2 μs



Lockheed Electronics Co., Data Products Div., 6201 E. Randolph St., Los Angeles. Phone: (213) 722-6810. P&A: from $11,950; March, 1969.

The first of a new family of computers, the MAC 16 is a 16-bit parallel-word unit featuring a 2-μs add time and a 4096-word core memory, expandable to 65K words. The basic computer includes a programed data channel that services up to 255 devices with four priority interrupt levels. This priority system automatically stores the machine state upon interrupt and can be expanded to a total of 64 levels.

Booth No. 401 *Circle No. 276*

Plug-in adapters interface data set

Tuck Electronics, 235 Market St., New Cumberland, Pa. Phone: (717) 232-3431. P&A: $445 to $478; stock.

Making interface changes with the proper plug-in adapter, a universal data set is capable of operating on dial-up lines, acoustical couplers, magnetic couplers, and dedicated or private leased lines. Fully compatible with the Bell 103 series, model 1067 performs in either the originate or reply modes. It is used to provide full interface between most data terminals and a voice-grade line at data rates up to 300 baud.

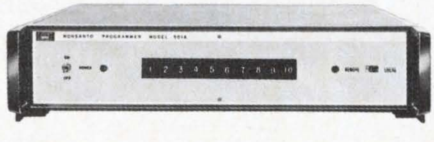
CIRCLE NO. 277

INFORMATION RETRIEVAL NUMBER 98 ►

Universal; extended range
7 nanosecond pulse resolution
Full 50 MHz counting
Programmability, BCD output...

all for only $1185.

MODEL 501A DIGITAL PROGRAMMER



Our new model 110A offers you a broader range of operational advantages than any other counter/timer in its price range.

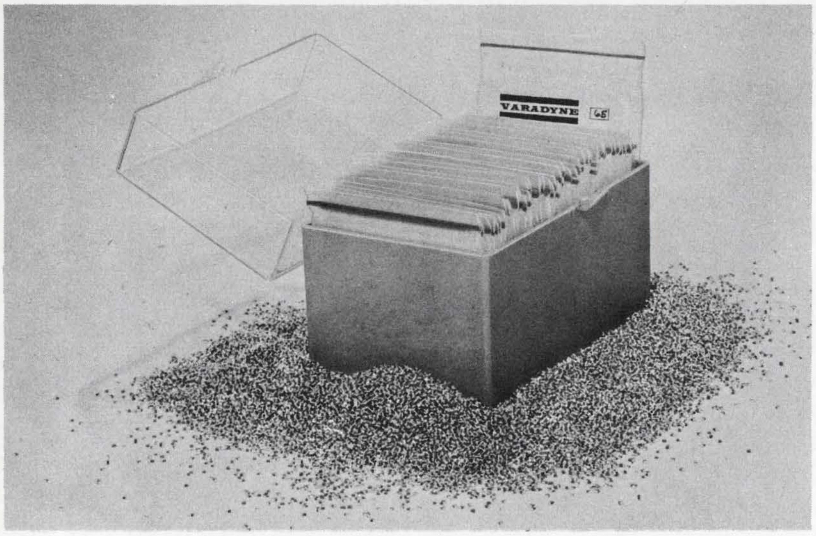
Front-panel functions are tailor-made for programming with our Model 501A Programmer (shown at right) or can be readily selected by virtually any contact-closure or logic-level source.

The extended frequency range, dc to 50 MHz, of the Model 110A together with such advantages as: provision for use of an external time base; internal time base, marker, and gate outputs; the inherent reliability of our "4th generation" integrated circuit design, plus our usual 2-year warranty all combine to assure you the versatility, the reliability, and integrity of performance you have come to expect from Monsanto. The price is only $1185.00, FOB West Caldwell, N. J. Eighth digit optional.

For a demonstration, or for full technical details, call your local Monsanto Field Engineer or contact us directly at Monsanto Company, Electronic Instruments, West Caldwell, New Jersey 07006, (201) 228-3800.

Monsanto

HYBRID CHIP KITS



- VARADYNE'S CAPACITOR CHIP KIT contains all standard RETMA values from 1pf to .015 μf (50 values), 10 chips per value, ±10% tolerance.

- VARADYNE'S THICK FILM CHIP RESISTOR KIT contains all standard RETMA values from 10 ohms to 2 megohms (65 values), 10 chips per value, ±10% tolerance.

- $162.50 per KIT

Write for complete and comprehensive data sheets..

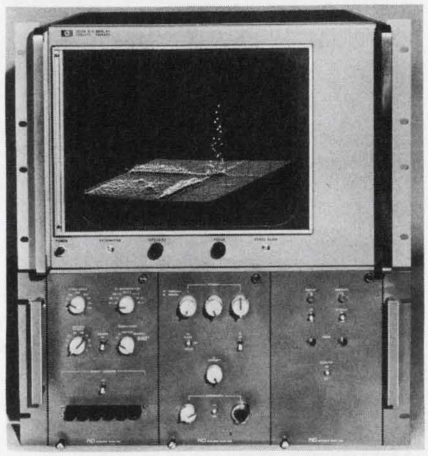
VARADYNE, INC. 1805 Colorado Ave. • Santa Monica, California 90404

VARADYNE

Tel. (213) 394-0271, (213) 870-9094 TWX (910) 343-6856

INFORMATION RETRIEVAL NUMBER 99

Storage/display system shows three dimensions



Nuclear Data Inc., 100 W. Golf Rd., P.O. Box 451, Palatine, Ill. Phone: (312) 529-4600.

Designed for use in programmable data acquisition and display systems, series 50/50 storage/display units allow data to be presented in three dimensions or in only two. Displayed data can be expanded, divided, intensified, and manipulated in a variety of ways without destroying any of the information. Able to store 24 binary bits, the unit presents a continuous, flickerless display on a 14-in. screen.

CIRCLE NO. 278

Serial impact printer has moving printwheel

Litton Industries, Automated Business Machines Div., 600 Washington Ave., Carlstadt, N. J. Phone: (201) 935-2200.

Model 630 serial impact printer features a moving printwheel that allows faster, more efficient operation. It also has electronically controlled stepping motors that reduce the number of moving parts for high reliability and long life. In addition, its positive detent assures smudge-free copy. The printer can be ordered with tractor feed or split platen. A companion keyboard is also available.

CIRCLE NO. 279

INFORMATION RETRIEVAL NUMBER 100 ▶

THE ORIGINAL MINIATURE 4PDT POTTER & BRUMFIELD KH RELAY WAS BORN IN 1960

LOOK HOW THE FAMILY HAS GROWN!

We designed the original relay of this type. We've made more, by far, than anyone else. And we make more variations than anyone, too!

When your circuit calls for a 4PDT relay to switch from low level to 3 amperes, specify a KH from P&B and get these advantages:

- **Exceptional long life** . . . up to 100 million mechanical operations DC (50 million AC).
- **Small size** . . . only slightly larger than one cubic inch.
- **Wide choice of mountings,** enclosures, terminals, sockets and contact materials.

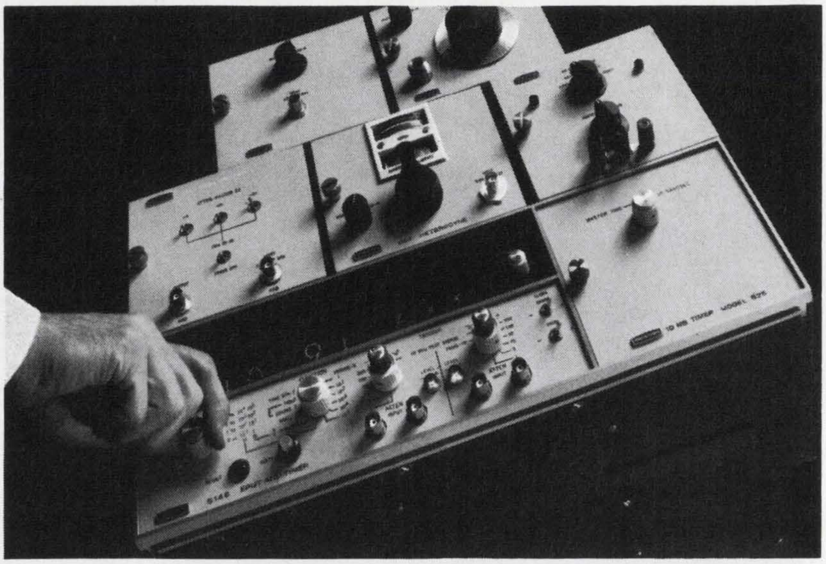
Underwriters' Laboratories list this relay (KHU Series) under their Component Recognition Program. The KHX Series is U/L recognized for opposite polarity ratings.

Partial list of variations of original KHP Series:

KHS	Hermetically sealed KHP.
KHC	KHP relay with printed circuit terminals.
KHU	U/L rated for 1/10 HP, 3 amperes @ 120V AC; 3 amperes @ 28V DC resistive.
KHF	Same U/L recognition as KHU Series but with printed circuit terminals.
KHX	U/L recognized for opposite polarity ratings.
KHE	Same U/L recognition as KHX Series but with printed circuit terminals.

Let us show you the most complete family of miniature four pole relays available anywhere. Let us tell you about our vast production capacity. Talk with your local P&B sales engineer today or call Potter & Brumfield Division of American Machine & Foundry Company, Princeton, Indiana. 812-385-5251.

AMF | POTTER & BRUMFIELD



THE Dependables FROM Beckman

Can your present counter
(without the use of additional test equipment)

- *show* your operator when he makes mistakes?
- determine the zero crossover of a symmetrical wave form, either ac or dc coupled and with or without a dc bias?
- *see* if there is an input signal?
- display the *correct* attenuator setting?
- make timing measurements with 10 ns resolution?
- measure the pulse width of a single wave form?
- measure the separation between pulses?
- perform two-channel timing measurements without the aid of a plug-in?
- be used as an error expander with a resolution of 1 part in 10^{10}?
- be *spared* for less than $100.00?
- give you reliability—MTBF above 60,000 hours?

BECKMAN'S Model 6148 can . . . DEPENDABLY! . . . in addition to making all the conventional frequency, period, multiple period, ratio, time interval, scaling measurements.

For complete information on what the Model 6148 can do for you, contact your local Beckman office, sales representative or the factory direct.

The Electronic Instruments Division develops and manufactures precision electronic measurement and test instrumentation for science and industry. Major product lines include: electronic counters, IC testers, oscillographic recorders, panel meters, system components, signal sources, time standards, and data acquisition systems.

Beckman INSTRUMENTS, INC.
ELECTRONIC INSTRUMENTS DIVISION
RICHMOND, CALIFORNIA • 94804

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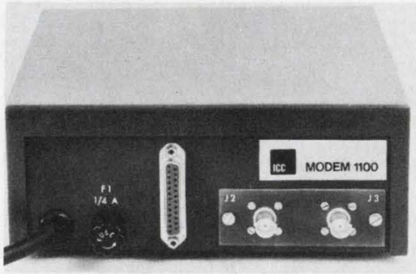
INFORMATION RETRIEVAL NUMBER 102

Communications modem transmits 10^6 bit/s



Milgo Electronic Corp., 7620 N.W. 36th Ave., Miami, Fla. Phone: (305) 691-1220.

Handling information at high speeds, modem 1100 is a new data set that permits computer communication over transmission channels at rates of 9600 to 1,000,000 bits per second. One of the primary applications foreseen for the ultrafast modem is the moving of large amounts of data in computer installations that operate in a concentrated area. This includes the computer time-sharing industry.

Booth No. 212 *Circle No. 280*

Programed controller follows 140 commands

Computer Automation, Inc., 895 W. 16th St., Newport Beach, Calif. Phone: (714) 642-9630. Price: $11,900.

A programed digital controller with a 4096-word, 16-bit 8-μs memory accepts over 140 basic instructions. Model 816 features multilevel indirect addressing, hardware index register, immediate instructions, conditional jumps, parallel processing, block input and output, and three priority interrupts. It has a parallel DTL interface and is available with many standard peripherals including teletype, magnetic and paper tape, disc, and modems.

Circle No. 281

The logic of precious metal cladding

The logic of precious metal cladding is simply this—it puts metals like silver and gold into a form that a manufacturing company can afford to use.

Just why would a company want to use silver and gold in its products? Because of their unique properties—exceptional electrical and thermal conductivity, corrosion-resistance, stability in the most extreme environments. In many cases they're simply the only metals that will do the job.

Designers are finding an answer to the cost problem in Handy & Harman's "Bimets," precious metal alloys metallurgically bonded to base metals and supplied as wire and strip. Bimets conserve precious metals in a logical way—by confining them to areas where they are functionally needed.

Look at some typical examples. Silver-clad copper wire replaces solid silver for diode leads. Slip ring assemblies are made of 50% coin silver clad to brass, instead of solid coin silver. Electrical relay bars are made of a Bimet—

a strip of silver clad to copper—instead of solid silver.

Bimets conserve precious metals. But they can do a lot more. The "one-piece" Bimet can often be stamped or formed directly into a finished part, sharply reducing the manufacturing costs inherent in fabricated-and-assembled components.

And because they're tailored composites, combining the properties of two or more metals, they frequently solve problems that can't be solved by monolithic metals.

If your company uses precious metals (or wishes it could afford to), Handy & Harman's cladding capabilities are worth exploring. If you'd like some easy reading on the subject, ask for our informative new booklet, "The Logic of Precious Metal Cladding." It has ideas that will stimulate your imagination.

HANDY & HARMAN

850 THIRD AVENUE, NEW YORK, N.Y. 10022
100 Years of Leadership in Precious Metals

INFORMATION RETRIEVAL NUMBER 103

"The Infraredder" SSL lamps!

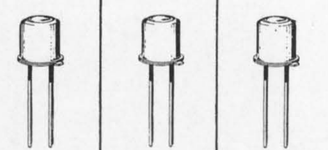
new from General Electric

If you're looking for SSL lamps with more infrared power output, look no further. Here are the SSL-5's, three new gallium arsenide solid state lamps with up to 7½ times the infrared output of our SSL-4.

Use them in readers, counters, controls and other photoelectric applications. They'll fit in anywhere you need a tiny infrared source capable of withstanding shock and vibration as specified in MIL STD-750.

Order your calibrated samples today. You'll soon discover how you can save space, improve performance and reduce maintenance costs in your product.

For more information on all GE infrared SSL lamps, ask for free technical bulletin 3-8268.



SSL-5A	SSL-5B	SSL-5C
POWER OUTPUT AT 100 MA		
.6mw	1.5mw	2.3mw

Please send me ____________
GE SSL-5A lamp(s) at $9.10 each.

Please send me ____________
GE SSL-5B lamp(s) at $14.56 each.

Please send me ____________
GE SSL-5C lamp(s) at $18.20 each.

Name ____________

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Address ____________

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To:
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Miniature Lamp Department
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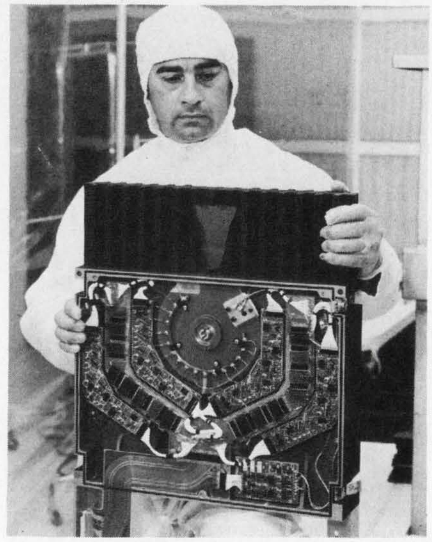
Cleveland, Ohio 44112
Attn: J. D. McMullin

MINIATURE LAMP DEPARTMENT

GENERAL ELECTRIC

INFORMATION RETRIEVAL NUMBER 101

Megabit disc memory uses modular technique



Computer Peripherals Corp., 10457 Roselle St., San Diego, Calif. Phone: (714) 453-1960. P&A: 0.05 to 0.1¢/bit; Jan., 1969.

Intended for such real-time applications as program swapping, time sharing, and message switching, DSU-8100 fast-access disc storage system features 25- and 50-megabit storage modules that can be randomly combined to provide memories with 25-million to multibillion bit capacities. Only one disc drive is required to serve as many as four storage modules.

Booth No. 503. *Circle No. 282*

Intra-frame jumper uses flat cable

Rogers Corp., Rogers, Conn. Phone: (203) 527-0726.

A computer intra-frame jumper utilizes a mass-terminated flat cable in place of conventional twisted wires. The new jumper provides controlled impedance for signal transmission between computer rack connectors. Hardboard cable termination allows use of a conventional PC-board connector. Adhesive bonding between cable and hardboard prevents strain on solder joints, thus eliminating the need for separate strain relief.

Circle No. 283

Don't let the good looks of Honeywell's MS Taut-Band Meter fool you.

What you see is a combination of functional advantages.

Modern curve.

The concave cover gives the meter a very contemporary look, alright.

But besides: By curving the cover, we minimized glare and shadows. That makes the meter easy to read.

Clean face.

We uncluttered the face by leaving out all the extraneous data. We made the scale longer. We printed the numbers above the scale.

Very stylish.

But also very easy to read.

More window.

We made the sides of the cover out of crystal-clear Plexiglas, just like the front of the cover. That makes the whole meter sparkle.

It also brightens the dial by letting more light in.

The specs.

As for the insides of the meter, the Honeywell taut-band mechanism is completely frictionless, so it responds to even the slightest inputs. Hysteresis-free, so its repeatability is near perfect.

Honeywell Series MS Taut-Band Meters come in 20 standard colors. In 33 standard ranges. And 3 sizes (1½", 2½" and 3½").

The price.

This is the taut-band meter that costs even less than a pivot-and-jewel meter.

So if you like it, there's nothing to keep you from having it.

(We'd like to send you a catalog. Write Honeywell Precision Meter Division, Manchester, New Hampshire 03105.)

The Classy Meter from Honeywell

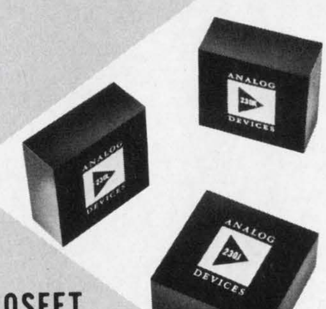
It takes all kinds of meters to make the Honeywell line.

INFORMATION RETRIEVAL NUMBER 104

0.5μV/°C

$67

(100 LOT)



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DEVICES

This ad is for the man who already knows that $67 is a fantastically low price for a chopper stabilized op amp.

Model	J	K	L	Units
E_{os}	0.5	0.25	0.1	μV/°C
I_{bias}	1	0.5	0.5	pA/°C
Price	$67.	$82.	$105.	(100 Lot)

Make us prove it...the reader service card will bring comprehensive data sheets, or better yet, request a sample on your letterhead or business card. No obligation to buy, of course.

INFORMATION RETRIEVAL NUMBER 105

Solid-state numeric displays operate from 5-V IC levels

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 321-8510. P&A: $50/numeral; Nov. 1969.

Displaying any numeral in an array of bright red dots, solid-state numeric indicators operate directly from IC-compatible voltage levels (5 V dc) with a total power consumption of only 0.5 W. Packaged as flat, sealed units, the new modules use gallium-arsenide-phosphide light-emitting diodes for the display, and a large-scale monolithic IC for decoding. All modules include a decimal point.

Numerals are produced by selectively energizing 27 electroluminescent diodes arrayed within a 5 × 7 matrix that is compatible with ASCII requirements. The diodes are supported by a dielectric substrate, along with the electrical interconnections to the LSI chip. This assembly is then placed in a metal case and sealed with a glass cover.

The display, which has a brightness of 50 ft L with 5 V applied, produces numerals that are 0.25-in. high. Brightness can be varied by simply lowering applied voltage. Since all numerals are produced in the same plane, the new indicators present no parallax problems.

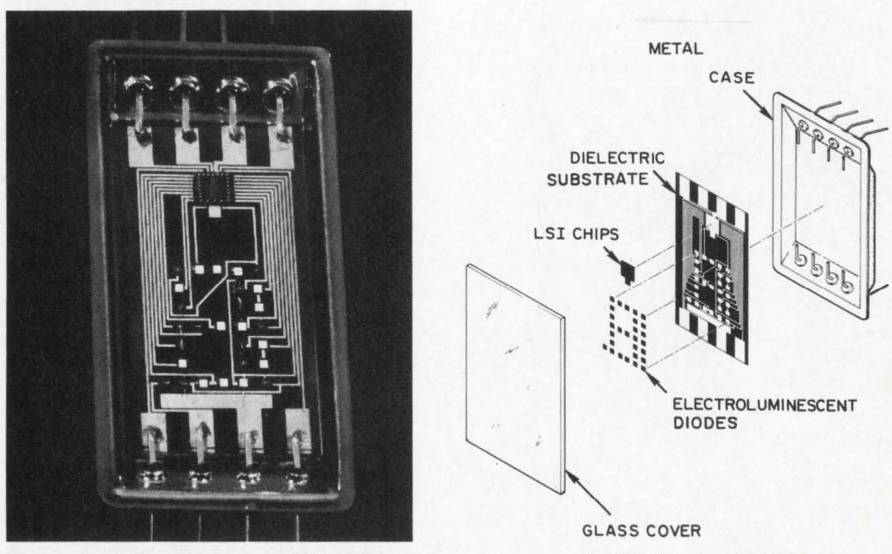
Two versions are available: one displays a single numeral set, the other displays three in a row on 0.4-in. centers. Both versions have eight connections per numeral set: one connection feeds the IC decoder; another supplies the diodes; four others connect to the 8-4-2-1 BCD data-input source, and the last activates the decimal point.

The light-emitting diodes represent a technological advance in growing materials. Hewlett-Packard, the supplier, has developed the capability of growing gallium-arsenide-phosphide wafers up to 2 in. in diameter, while holding the phosphor-arsenic ratio within 1% and holding thickness within 1 micron.

Only 27 positions of the 35 available in the matrix are occupied by light-emitting diodes. The 35 can be used to form alphanumerics (now in the development stage).

Since certain combinations of positions always occur together, only 18 diode-driving signals are necessary. These 18 unique diode combinations eliminate the possibility of undetected misreadings should a single diode or a diode set fail.

CIRCLE NO. 284

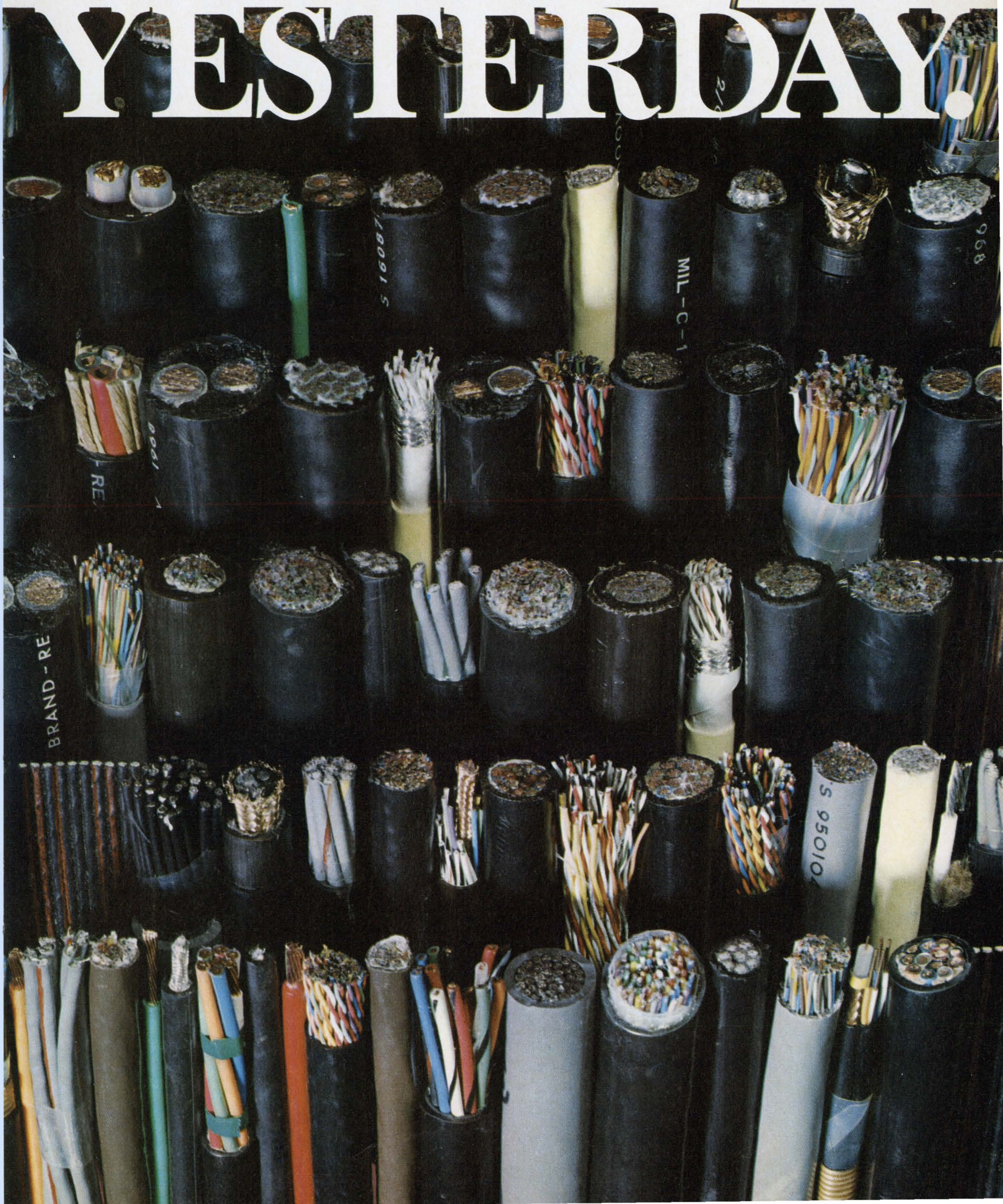


Numeric indicators go solid state with an array of 27 light-emitting diodes and an LSI decoder chip. Exploded view shows thin modular construction.

Last year Brand-Rex came up with over 3,000 new wire and cable constructions to solve unique problems. Today we're creating hundreds of new designs for use tomorrow. You can be sure we didn't become the industry's largest supplier by living in the past. Brand-Rex Division, American Enka Corporation, Willimantic, Conn. 06226. Phone 203 423-7771.

Make wire the easiest part of your next design by making connections now with

BRAND-REX



25 winners in our collection of op art

nobody, but nobody makes more discrete op amps than Philbrick/Nexus

Philbrick/Nexus is avant-garde in operational amplifiers. Covers the spectrum of op amp capabilities — from mini-cost to maxi-performance. Standard products, as well as mixed products, match your needs economically. Use them. They'll color *you* bright. Op art masterpieces like these are but a few of the total Philbrick/Nexus exhibit:

Economy Grade

SQ-10A — MINI-PRICED, but a top performer in general purpose applications. Only $10.50 each in hundred quantities.

QFT-5 — LOWEST PRICED FET. General-purpose performance, low leakage. Only $15 each by the hundred.

1009 — LOW COST, HIGH PERFORMANCE FET. Input impedance 10^{12} ohms. Input bias current 5 pA. Priced at $20.50 each in quantities of 100.

General Purpose

CIA-2 — LOW PROFILE, HIGH PERFORMANCE. Thick-film hybrid, 80,000 gain, $\pm 5\mu V/°C$ input voltage offset.

SQ16 — HIGH PERFORMANCE. Gain 150,000, ±5mA guaranteed minimum output at ±11 volts. Low noise, 1μV rms broadband.

Q102A — ULTRA-HIGH PERFORMANCE. Gain 200,000, $\pm 2\mu V/°C$ input voltage offset typical at −25 to +85°C. Internally trimmed to 0.5mV max.

QFT-2 — TOP-GRADE PERFORMER. Gain 200,000, slew rate 10V/μsec, 10 pA input bias current.

Q103A — HIGH INPUT IMPEDANCE, LOW BIAS CURRENT. Input voltage offset $\pm 2\mu V/°C$. Only $25.50 each by the hundred.

High Reliability

Q10A — ALL-PURPOSE TOP-GRADE. −55°C to 100°C operating temperature range.

P65A — PREMIUM GRADE. Wide application usage, proven performance, low broadband noise 1μV.

CDA-3A — PROVEN PERFORMANCE. Input bias current 1nA, differential input resistance 2 megohms.

Q25AH — WIDEBAND FET HYBRID. 600,000 hours of operation with no failures. Small size TO-8 package, hermetically sealed.

Wide Band

PP45U — 100 MHz BANDWIDTH. Slew rate 200V/μsec. Excellent for broadband inverter applications.

1016 — FAST, HIGH POWER. fp>1 MHz. Full output of ±10V, ±100 mA to 1 MHz. CMRR 100,000. E_{os} T.C. is $10\mu V/°C$. A_o at 750,000.

1011 — LOW PROFILE, FAST SETTLING TIME FET. 15 MHz bandwidth, slew rate 70V/μsec. Delivers ±11.5V output. Settles in 1.5 μsec to .01%, 0.4 inches high max.

Universal

ESL-1 — WIDE SUPPLY VOLTAGE RANGE, ±8 to ±16V. CMRR 1,000,000:1, common mode input resistance 1.5 G ohms.

USL-1C — HIGH STABILITY. Wide range of supply voltages from ±8 to ±26V. Input voltage offset $\pm 1\mu V/°C$. Low drift.

High Voltage

MLF-100 — ±100 VOLT OUTPUT at 10mA. FET input amplifier. Short circuit protected.

Micro-Power / Low Voltage

Q-200A — BATTERY OPERATED. ±50μA quiescent drain. Ideal for OEM battery operated and airborne instrumentation.

1402 — MICROCIRCUIT FET HYBRID. Bias current 5pA. Input impedance 10^{12} ohms. Output ±14V, ±5mA. Supply voltage from ±4 to ±24V. Quiescent current ±0.5mA. In TO-8 case, hermetically sealed.

High Performance

1003 — LOW-NOISE FET. 3,000,000:1 CMRR $\pm 1\mu V/°C$ input offset voltage +10°C to +60°C. Uses hermetically sealed active components.

1700 — LONG-TERM STABILITY. Input voltage offset $\pm 0.15\mu V/°C$. Full output to 1.2 MHz. Gain 10^9. Long-term stability .2μV per day.

1018 — ULTRA-LOW DRIFT. Gain 1.5 meg E_{os} $0.5\mu V/°C$ and I_{bias} .02nA/°C.

Monolithic IC's

S-52 — LOW, LOW COST IC. Easy to stabilize. Dual in-line package. $5 each in quantity.

T-52 — A REAL BUY. Same as S-52, but in TO-5 package. Same low price.

Your Best-Of-Show selection brings with it, at no extra cost and available nowhere else — unequalled integrity resulting from superb artistry in things analog. For other op amp prize winners, too numerous to mention, contact your Philbrick/Nexus sales representative for complete specifications, prices and applications assistance. Or write, Philbrick/Nexus Research, 46 Allied Drive at Route 128, Dedham, Massachusetts 02026.

PHILBRICK / NEXUS RESEARCH

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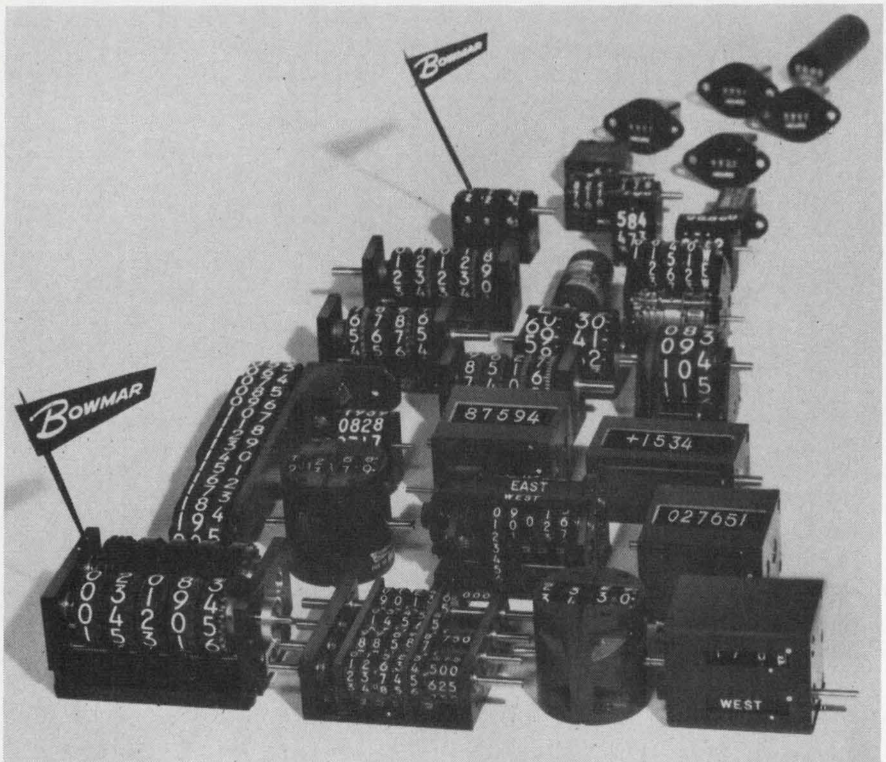
INFORMATION RETRIEVAL NUMBER 107



In the name of design freedom

...join Bowmar's counter revolution!

While others have been trumpeting the merits of standards, we've spent the past 18 years quietly meeting the mechanical counter needs of the world's 100 toughest customers. Now, with thousands of field-proven configurations in our B-line™ design library, we can't stay quiet any longer.

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Be a counter-revolutionary! Strike a blow for design freedom by adding Bowmar to your qualified bidder list.

The shortest distance between output and display is the Bowmar B-line*

* Call (219) 747-3121 for engineering assistance

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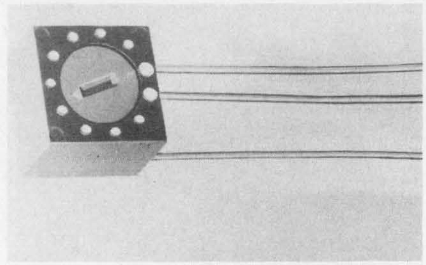
INFORMATION RETRIEVAL NUMBER 108

PC trimmer pot shows wiper position

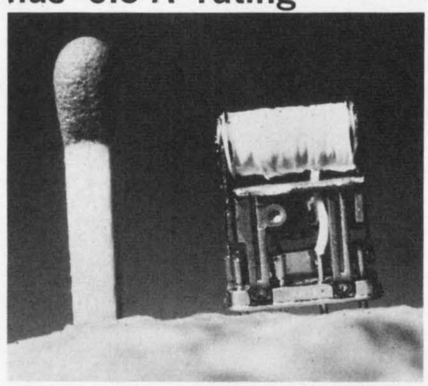


Maurey Instrument Corp., 4555 West 60th St., Chicago. Phone: (312) 581-4555. Price: $2.50.

A miniature wirewound PC potentiometer, only 1/4 by 1/4 by 3/16-in. deep, has a pointer indicating the exact position of its wiper on the winding. It has a glass-filled diallyl phthalate housing and beryllium-copper gold-plated leads, on tenth-grid spacing. All connections are welded. The unit is available with up to 10-kΩ resistance.

CIRCLE NO. 285

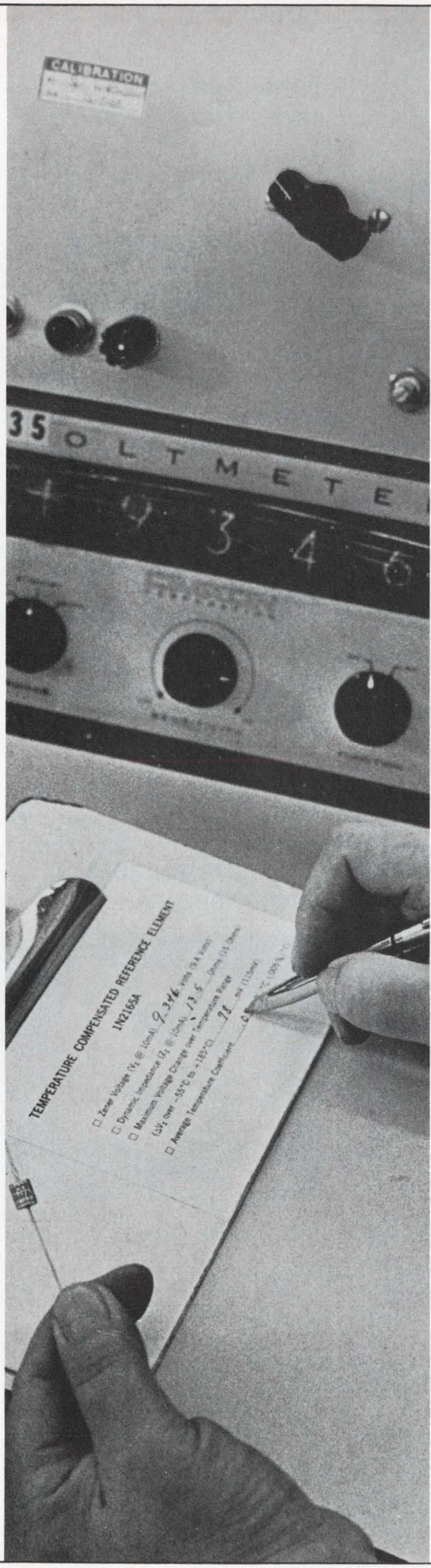
Crystal-can relay has 0.5-A rating

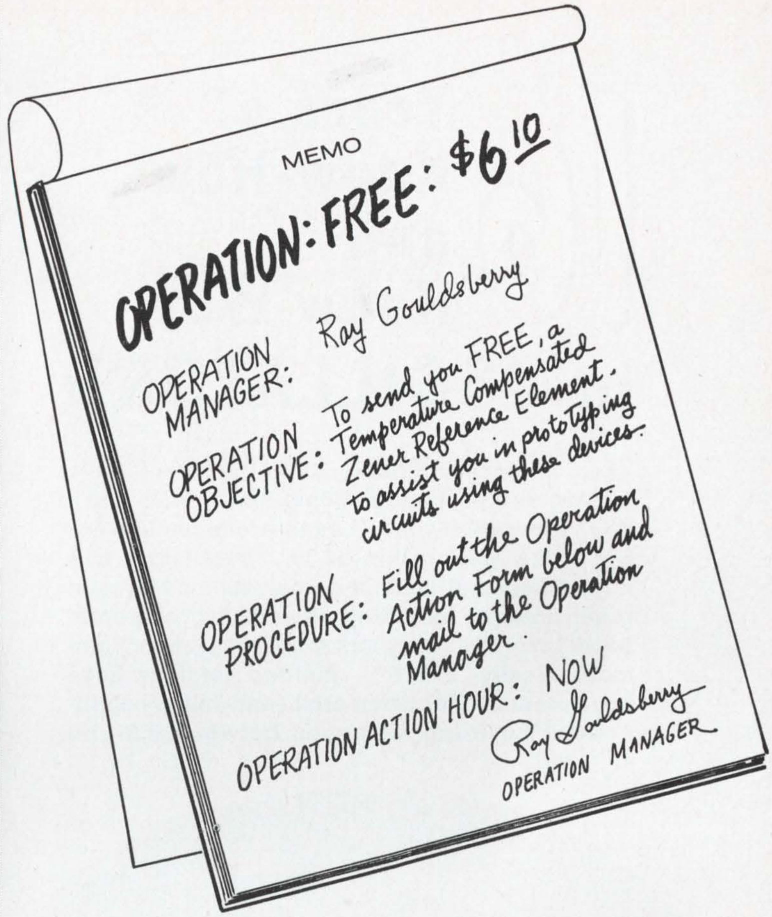


Hi-Spec Electronics Corp., 1000 Lawrence Dr., Newbury Park, Calif. Phone: (805) 498-6671. P&A: $10; 10 to 12 wks.

Style GD relay is a high-performance, 0.5-A unit that has a coil sensitivity of 100 mW and is packaged in a 1/7-size crystal can. Weighing only 0.1 oz and measuring 1/2-in. high by 0.4-in. wide by 0.2-in. thick, the device is built to perform dry circuit or low level switching functions. It performs in a temperature range of −65 to +125° C and withstands vibration of 30 g at 10 to 2000 Hz.

CIRCLE NO. 286





This high quality device selling for $6.10 has these standard specifications:

Zener Voltage (V_Z): 9.4 Volts ±2%
Maximum Dynamic Impedance (Z_Z): 15 Ohms
Maximum Voltage Change Over Temperature Range (ΔV_Z over −55°C to +185°C): 115 mV
Average Temperature Coefficient: .005%/°C

It will be sent to you free attached to card on which all critical parameters of your device have been recorded for you.

Operation Action Form

In what project will this device be used? ____________

If this is a production project what quantity of Zener Reference Elements do you anticipate using? ____________

Name: ____________ Position: ____________

Company: ____________ M/S: ____________

Street: ____________

City: ____________ State: ____________ Zip: ____________

Phone: ____________ Ext: ____________

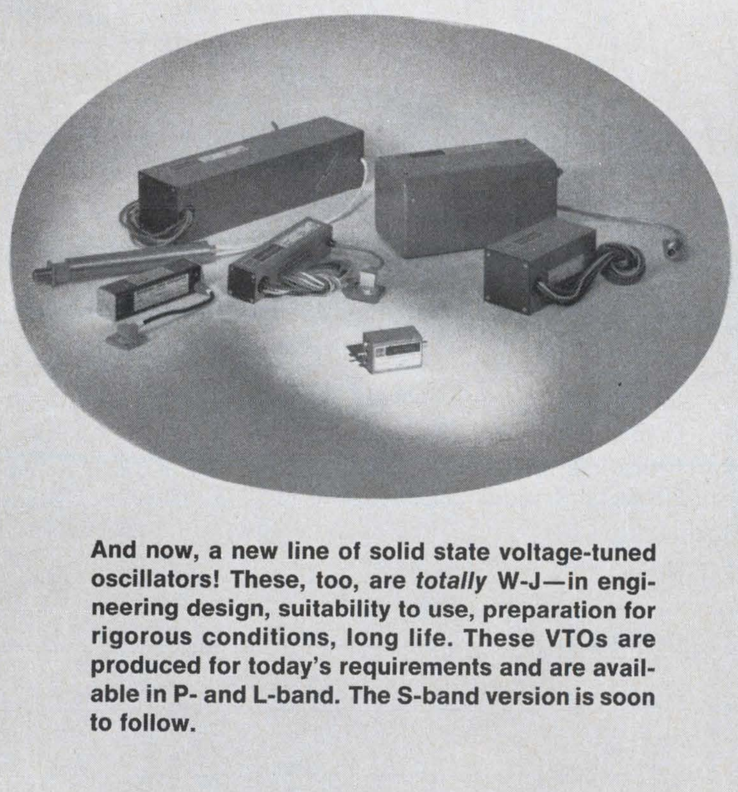
COMPONENTS, INC.
SEMCOR DIVISION

3540 W. OSBORN RD. / PHOENIX, ARIZONA 85019
PHONE 602-272-7671 / TWX 910-951-1381

INFORMATION RETRIEVAL NUMBER 109

16 Years of Know-How and Know-Why in OSCILLATORS

W-J's engineering authority in backward-wave oscillators has been building since 1952, when W-J's Stewart Division began producing BWOs. Each new generation of W-J oscillators has anticipated and matched sophisticated system requirements, including severe environmental conditions. Over the years standard, compact and magnetically- and RFI-shielded versions have been produced for commercial and military applications covering all bands between 0.5 and 40 GHz.



And now, a new line of solid state voltage-tuned oscillators! These, too, are *totally* W-J—in engineering design, suitability to use, preparation for rigorous conditions, long life. These VTOs are produced for today's requirements and are available in P- and L-band. The S-band version is soon to follow.

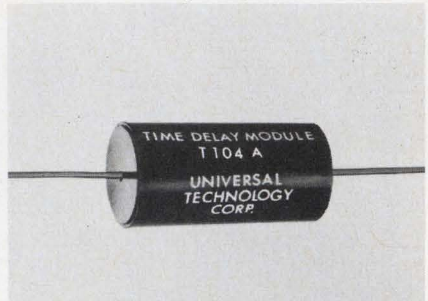
WATKINS-JOHNSON

Information in more detail available from representative in your area or from Applications Engineering . . .

3333 HILLVIEW AVENUE
STANFORD INDUSTRIAL PARK
PALO ALTO, CALIFORNIA 94304

INFORMATION RETRIEVAL NUMBER 110

Time-delay module saves relay space

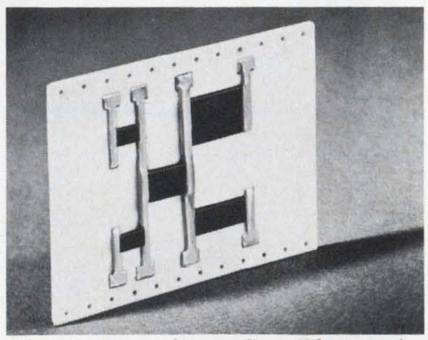


Universal Technology Corp., 107 New St., Pittston, Pa. Phone: (717) 654-7385. P&A: $6.50 to $8; stock.

Series T electronic time-delay modules completely separate the timing circuit from the relay. Conventional time-delay relays combine timing circuit and relay in one package. If a relay already exists in the timing circuit, it makes no contribution. With the Series T module, the circuit designer can add time delay to his circuitry without the space required for an unnecessary relay.

CIRCLE NO. 287

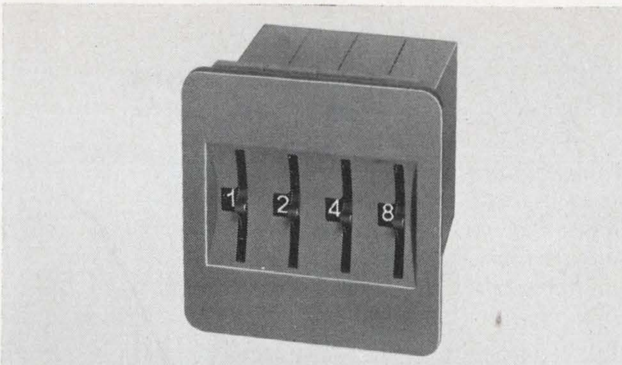
Chip thermistors have negative TC



The Carborundum Co., Electronics Plant, Niagara Falls, N.Y. Phone: (716) 278-2521.

Miniature solderable chip thermistors with a large negative temperature-coefficient solve temperature-stability problems in thick-and thin-film hybrid microcircuits. They can also be used in temperature sensing and in control applications. Manufactured by a tape process, the units are available in sizes as small as 0.05 in.^{2} with resistivities from 40 to 2000 Ω-cm.

CIRCLE NO. 288



Thumbwheel Switches For Industrial Control

These panel-mounted thumbwheel switches offer you convenient control devices for presetting digital information. A visual indication of the setting is provided by easily-read characters on each thumbwheel.

You can use these switches for binary decimal coding or decoding, or for straight decimal circuitry. They are available for special functions, and the use of four independent contact wipers and built-in diode gates make them readily adaptable to individual circuit requirements. The thumbwheel switches can be used in single pole, double pole and four pole switch applications.

For mounting, standard facades are available to accommodate from 1 to 9 switches on 1/2" centers. Send for technical data now.

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Timing & Stepper Motors • Electromechanical & Electronic Timing Devices & Systems

INFORMATION RETRIEVAL NUMBER 126

Turn yourself on with FREE KNOB SAMPLES from Kurz-Kasch

Any knob will turn the equipment on. Kurz-Kasch design-oriented instrument knobs turn on the engineer, the designer, the user. 21 families, 347 stock knobs in a variety of thermosetting materials and colors brighten the products of 3,000 OEM's. You can be 3,001. Write for free catalog and samples!

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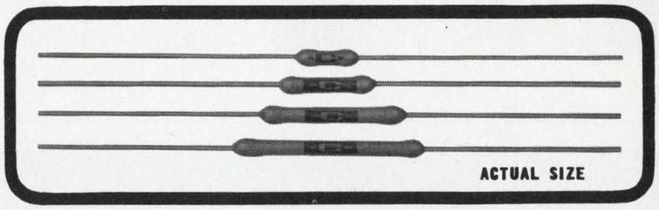
INFORMATION RETRIEVAL NUMBER 127

MINIATURE MEGOHM RESISTORS



T.C. Absolute: 80 PPM/°C*
T.C. Tracking: to 5 PPM/°C on special order.

Applications include high voltage dividers, high resistance networks, precision RC timing circuits, etc. We specialize in network sets with matched characteristics. Facilities available to perform Hi Rel screening.

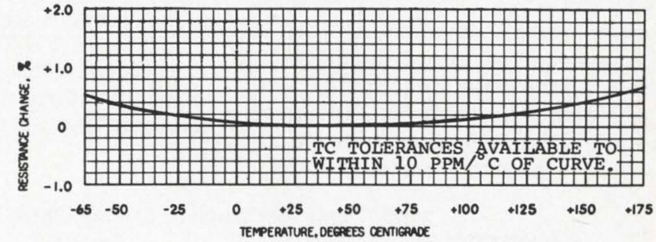
Model No.	Watt-age	Max. Voltage	Dielect Str'gth	Resistance Min.	Resistance Max.	Dimensions Length	Dimensions Dia.	Dimensions Lead Dia.
MG 650	.5	600	750	500 K	5 meg	.313 ±.020	.094 ±.015	.025 ±.002
MG 660	.6	1000	750	1 meg	10 meg	.500 ±.030	.094 ±.015	.025 ±.002
MG 680	.8	1500	750	1 meg	15 meg	.750 ±.030	.094 ±.015	.025 ±.002
MG 710	1.0	2000	750	1 meg	20 meg	1.000 ±.040	.094 ±.015	.025 ±.002
MG 721	2.0	2500	1000	1 meg	30 meg	1.000 ±.050	.240 ±.030	.040 ±.002
MG 750	3.0	3000	1000	3 meg	150 meg	2.125 ±.060	.315 ±.030	.040 ±.002
MG 780	5.0	4000	1000	4 meg	220 meg	3.125 ±.060	.315 ±.030	.040 ±.002

***Temperature Coefficient:** 80 ppm/°C referenced to 25°C, ΔR taken at —15°C and +105°C. **Maximum operating temperature:** 225°C. **Resistance Tolerance:** ±1% (tolerances to .2% on special order). **Insulation Resistance:** 100 megohms, minimum. **Overvoltage:** 1.5 times working voltage for 5 seconds, R shift .8% max. **Thermal Shock:** MIL-STD-202, method 107, cond. C, R shift .5% max. **Moisture Resistance:** MIL-STD-202, method 106, R shift .8% max. **Loadlife:** 1000 hours at rated power, R shift .8% max. **Encapsulation:** Silicone Conformal. **Leadwire:** Gold Plated Dumet 1½" long ±⅛".

MICRONOX ™ Resistance Films

Micronox resistance films are produced exclusively by Caddock Electronics. They are composed of complex oxides fired in air at temperatures above 1400°F. The resulting films are relatively insensitive to high ambient temperatures and thermal shock. Films show negligible effect from moisture.

This totally new approach to precision resistors and networks opens new design possibilities because of the wide resistance range, precise temperature characteristics, and high temperature and power capability. Temperature coefficient can be accurately reproduced (within ±10 ppm/°C of curve if required). The typical curve shown below will vary slightly with resistivity of the film and configuration of the substrate.

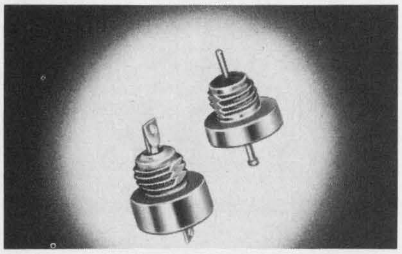


CADDOCK ELECTRONICS

3127 Chicago Avenue, Riverside, California 92507 • Telephone: (714) 683-5361

INFORMATION RETRIEVAL NUMBER 128

Button-size filters have broadband specs

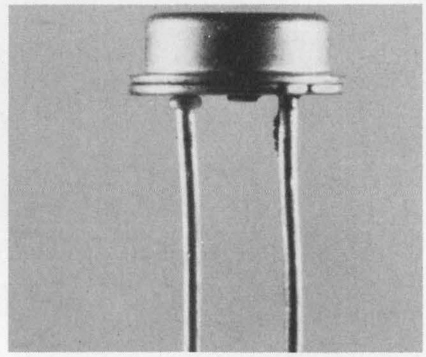


Gulton Industries Inc., Metuchen, N. J. Phone: (201) 548-2800.

Said to be one-fifth the size of the smallest comparable filters available today, a new line of broadband low-pass filters reduce size without sacrificing performance. An epoxy version measures only 0.287-in. long, while a hermetically sealed version is 0.357-in. long (excluding terminals).

CIRCLE NO. 289

Thermal sensors gauge low levels

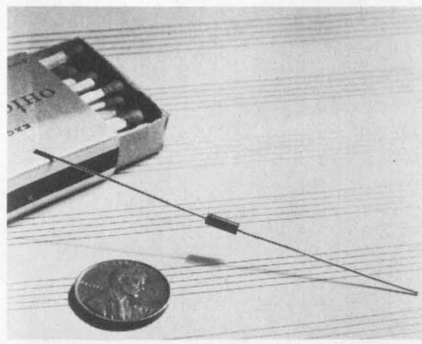


Lake Shore Cryotronics, Inc., P.O. Box 214, Hamburg, N.Y. Phone: (716) 833-4285.

TG-100 solid-state Cryo-Sensors achieve measurement accuracies of 0.005°K over the 4° to 400°K temperature range, and 0.010°K from 1 to 4° K. Stability of 3 μV in 1.5 V is gained by techniques previously unavailable with gallium arsenide. A platinum-encapsulated version offers a magneto-resistive error of less than 3% in magnetic fields to 50 kG.

CIRCLE NO. 290

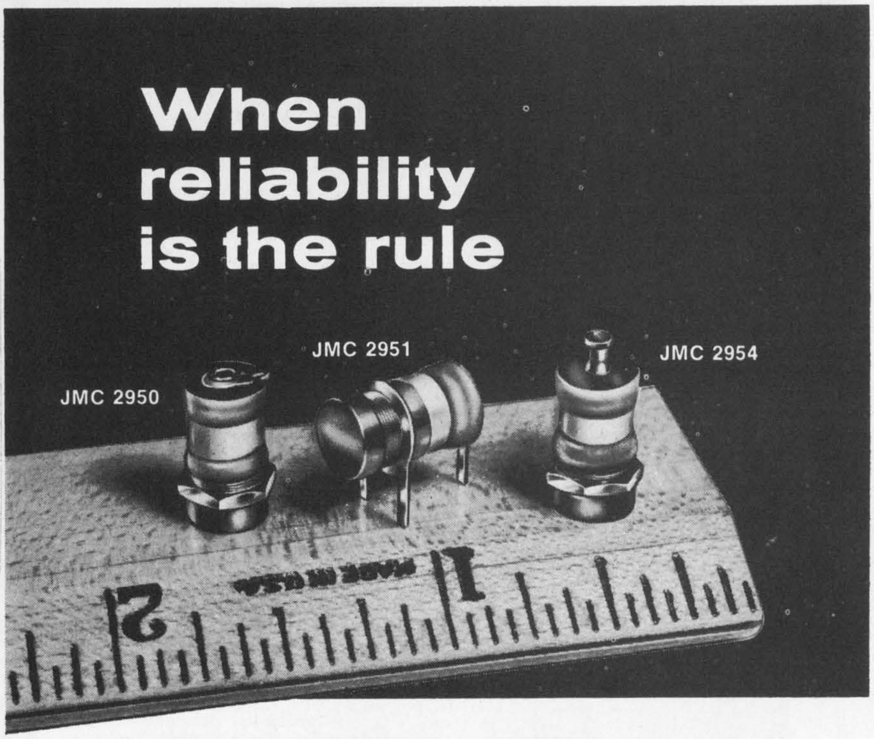
Thick-film resistors provide up to 20 M Ω



Mepco, Inc., Columbia Road, Morristown, N. J. Phone: (201) 539-2000.

Designed for high-impedance circuits such as resistor networks, operational amplifiers and FET configurations, miniature thick-film resistors cover the resistance range of 499 kΩ to 20 MΩ. Rated at 200 V max, GE10 resistors measure only 0.265-in. long and 0.095 in. in diameter. They are available with tolerances of ±1% or ±2%, and temperature coefficients of ±150 or ±200 ppm/°C.

CIRCLE NO. 291



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HIGH Q, HIGH FREQUENCY VARIABLE AIR CAPACITORS

This versatile series provides, in miniature size, exceptionally high Q, superior ruggedness for protection against shock and vibration, -55° to +125°C operating temperature range, protection against fungus, salt spray and humidity . . . plus all the other construction and performance features that have made Johanson capacitors the industry standard for excellence.

Specifications

Capacitance Range: 0.8 — 10.0 pF
Dielectric Withstanding Voltage: Rating 250 VDC breakdown >500 VDC
Insulation Resistance: >10^6, megohms @ 500 VDC
Q: >2000 @ 100 mc
Temperature Coefficient: 0 ± 20 ppm/°C
Rotational Life: >800 revolutions

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INFORMATION RETRIEVAL NUMBER 112

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Reliability? Fusite is the *only* sealer that formulates, smelts, and preforms technical glasses. This means a greater in-depth capability to solve your problem, design the part, build the dies, smelt the glass, make and assemble it to your specs. At less cost than you could do it yourself. Want proof? Send us your latest design for hermetic terminals, glass preforms, or glass-ceramic substrates or lids. Challenge our experience with low temperature solder glasses as coatings and preforms. We'll send you a similar part for inspection. Plus a cost estimate for prototype quantities—or production in millions.

For solutions to all your sealing glass problems, call Fusite in Cincinnati. Or, if your interests are overseas, call one of these plants: Fusite N.V., Konigweg 16, Almelo, Holland; Fusite-Japan, Gotemba, Japan; Terminal Products, Hormigueros, Puerto Rico; or, Fusite GmbH, Dieselstrasse 5, Karlsruhe, West Germany. Fusite Corporation, 6000 Fernview Ave., Cincinnati, Ohio 45212... phone (513) 731-2020.

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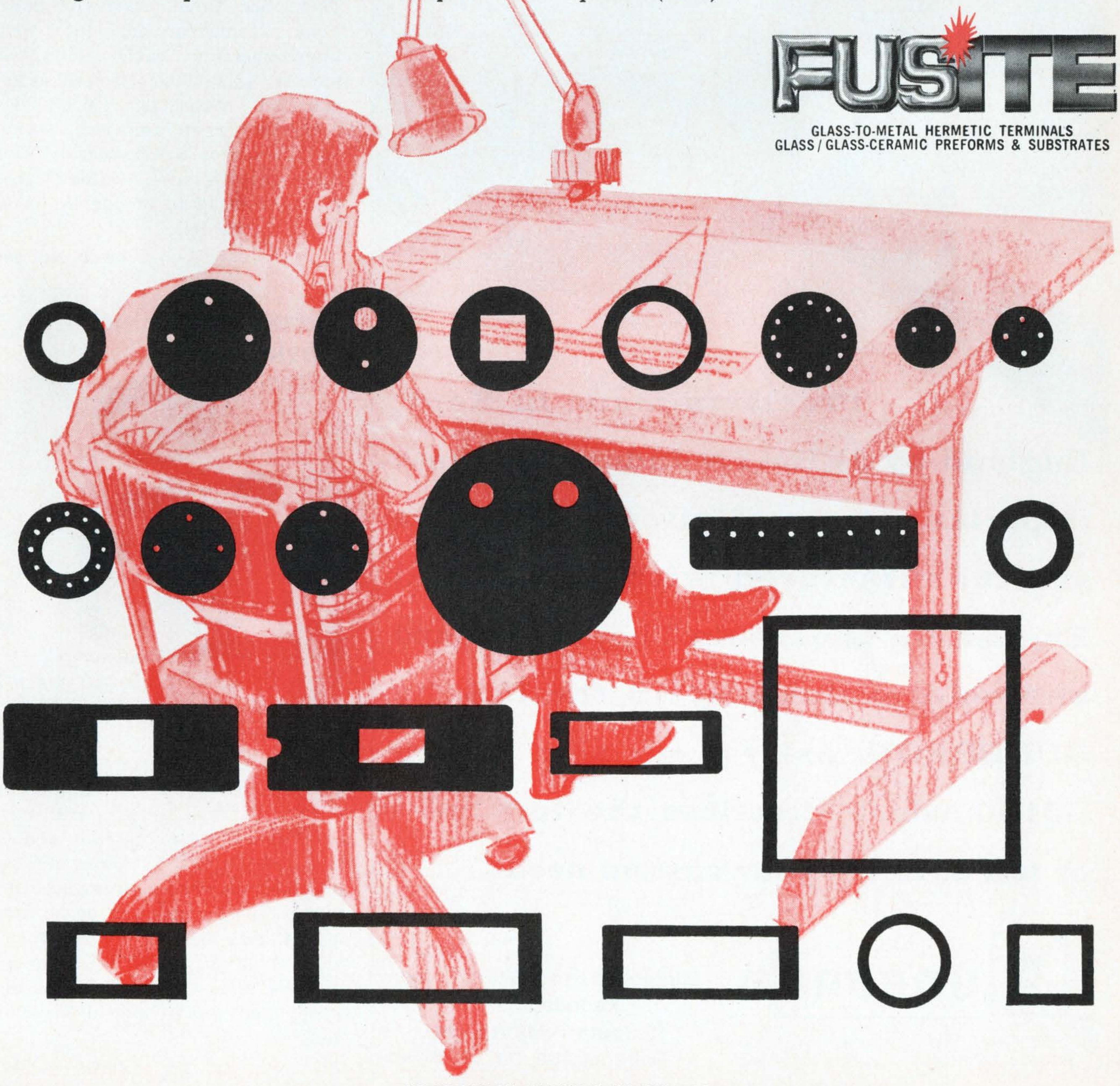


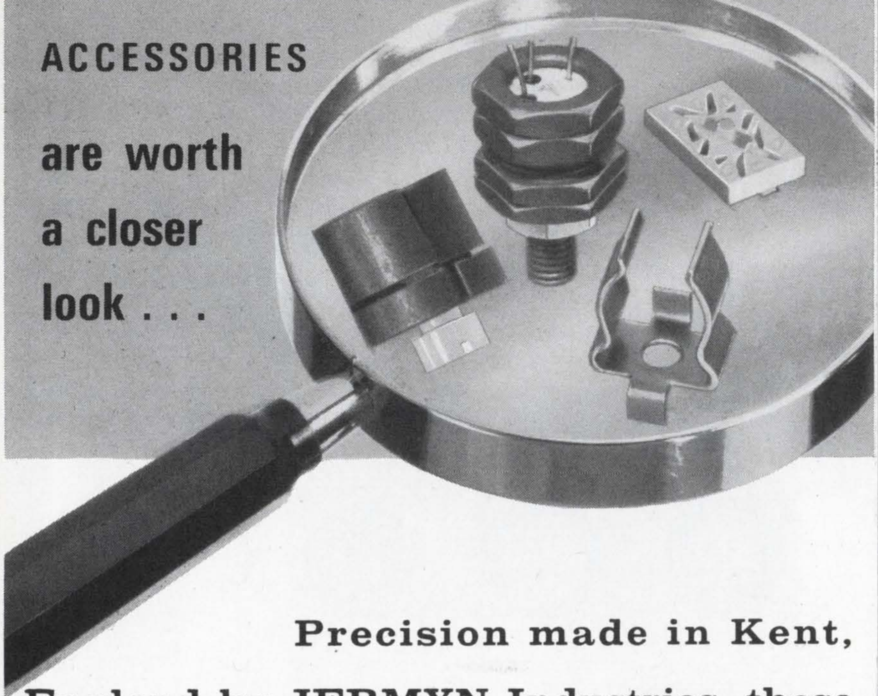
INFORMATION RETRIEVAL NUMBER 113

If you're concerned with Transistor Pads and Clips— Heat Sinks and Adapters . . .

JERMYN

ACCESSORIES

are worth a closer look . . .



Precision made in Kent, England by JERMYN Industries, these important items of circuit hardware are manufactured with traditional English craftsmanship. They are stocked and sold exclusively in the U.S. by GUDEBROD. Ask for our new Catalog GJ100 which describes the full line— or tell us about your custom needs.

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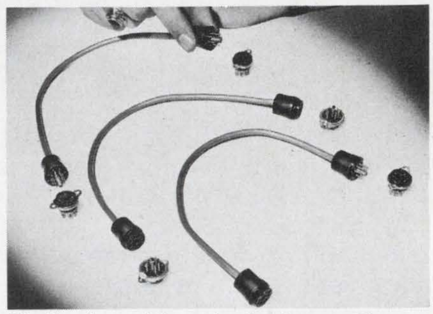
Electronics Division

Gudebrod Bros. Silk Co., Inc.
Founded 1870
12 South Twelfth Street
Philadelphia, Pa. 19107

INFORMATION RETRIEVAL NUMBER 114

Connector assemblies breadboard cables

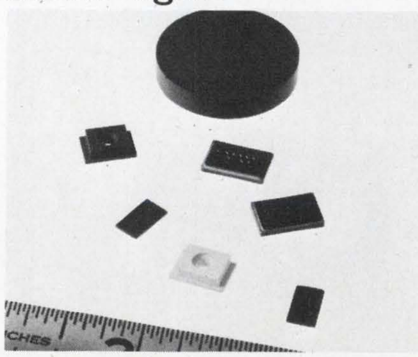


Methode Manufacturing Corp., 1700 Hicks Rd., Rolling Meadows, Ill. Phone: (312) 392-3500.

A new packaged kit concept provides connector-and-socket cable assemblies for immediate use. There are three basic configurations: connector-connector with interconnecting cable and two sockets (MP-5000); socket-socket and two connectors (MS-5000); connector-socket and one socket and connector (MPS-5000). Five cable lengths are available that range from 12 to 36 inches, in 6-inch increments.

CIRCLE NO. 292

Alumina ceramic blocks light

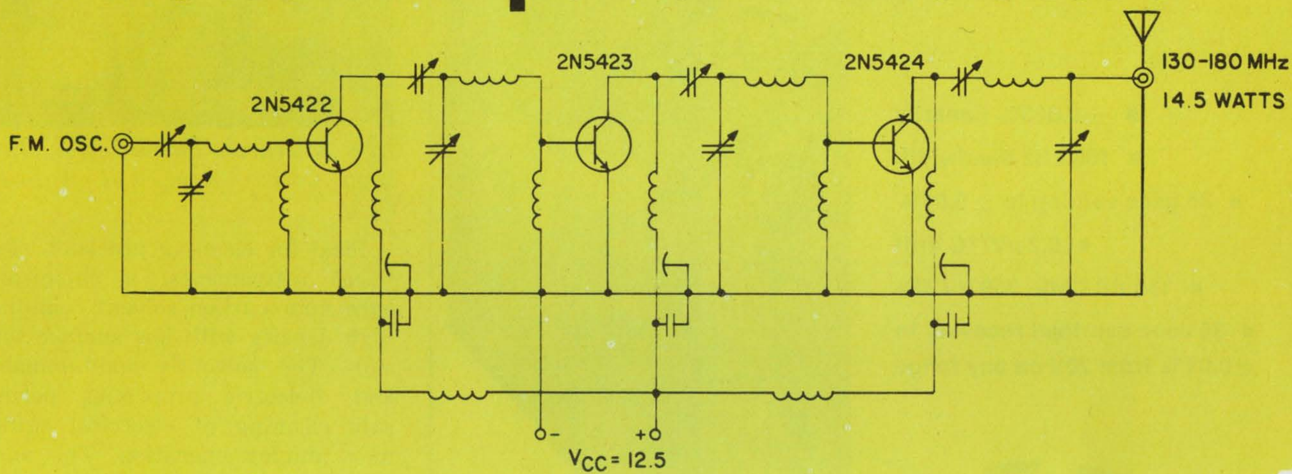


Basic Ceramics Inc., 221 Seventh Ave., Hawthorne, N.J. Phone: (216) 696-0330.

In relatively thin cross-sections, a high-alumina black ceramic is an opaque barrier to light transmission. Readily pressed into shapes and metalized by conventional molybdenum/manganese techniques, the ceramic can be used as a packaging material for silicon devices such as transistors, diodes and ICs. It is also useful as a substrate material in hybrid flip-chip designs.

CIRCLE NO. 293

The simplest way to design 12V VHF circuits like this is to get the data sheet on ITT's new RF power transistors



The sheet contains 18 performance plots, the industry's most complete set of large signal data, including large signal input and output impedance vs. frequency and large signal input and output impedance vs. power.

The 2N5421, 2, 3, and 4 have 1, 2, 5, or 13 watts output respectively at 175 MHz. VSWR performance is specified and each transistor is 100% tested for power output before shipment. If you're designing VHF mobile transmitters, make circuit optimization easier. See your ITT distributor or write for the industry's most comprehensive VHF transistor specification sheet.

ITT Semiconductors is a division of International Telephone and Telegraph Corporation, 3301 Electronics Way, West Palm Beach, Florida

Please send me a free copy of the industry's most complete spec sheet on VHF power transistors.

NAME ______________________ TITLE __________

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805 EAST CERRITOS AVENUE
ANAHEIM, CALIFORNIA 92805
(714) 776-6400

INFORMATION RETRIEVAL NUMBER 116

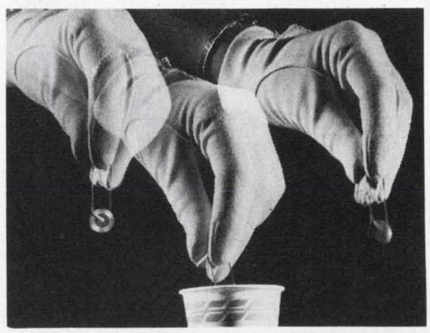
Fluorocarbon solvent cleans on contact

LPS Research Laboratories, Inc., 2050 Cotner Ave., Los Angeles, Calif.

Ideal for cleaning precision electrical instruments, a chemically pure fluorocarbon solvent combines high density with low surface tension. The solvent's nonflammable and dielectric properties permit safe cleaning of electrical equipment during operation. The antistatic cleaner is compatible with electric insulation, elastomers, and all metals.

CIRCLE NO. 294

Epoxy coating powder fuses at 125°C



Dexter Corp., Hysol Div., 211 Franklin St., Olean, N.Y. Phone: (716) 372-6300.

HYSOL DK9, an epoxy coating powder, will fuse to substrates preheated to 125°C, or can be applied to parts at room temperature, for subsequent heat cure. The material can be applied by dipping the heated part in a cup of the powder. It can also be applied successfully by spray, electrostatic deposition, flow coat and aerated bed methods. The powder is designed specifically for coating heat-sensitive components.

CIRCLE NO. 295

Our main claim to fame is the design and application service we provide on every mercury relay we sell. If we don't have the relay you need, we help you develop a new one. And that's not all! Adlake has the most complete line of mercury-wetted and displacement relays in the business. Contact ratings from 100 VA to 100 amperes. Operating speeds from 1 millisecond to 150 milliseconds. Consistent contact resistance—even under adverse environmental conditions. Time delay relays from one-half second to 30 minutes, all of them tamper-proof. Load relays with an exclusive anti-spinout feature. Relays equipped with epoxy coils that are guaranteed for life. Plus many other special features. We also have a line of dry reed relays. So call us. We'll put you in touch with an engineer who specializes in the type of relay best suited to your needs—mercury-wetted, displacement or dry reed. We can help you solve your circuit design problem creatively, whatever the application.

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INFORMATION RETRIEVAL NUMBER 117

Electronic Design... sells design engineers and engineering managers—the men who specify.

NO OTHER PUBLICATION PROVIDES AS MUCH EVIDENCE OF READERSHIP Take a close look at the readership of Electronic Design and you find a market that can exert an overwhelming influence on your sales. The reason? These readers are, exclusively, design engineers or engineering managers responsible for the specification of electronic products. In the ever expanding complex of electronics, these men must specify everything needed to test and manufacture their products. These products could well be your own. These men are your primary target for advertising that leads to sales action. And the magazine they prefer, proved in over 93% of independent readership studies, is Electronic Design. No other publication provides as much evidence of readership.

NUMBER OF INDEPENDENT READERSHIP STUDIES AS REPORTED TO AIA, 1968 (Released in 1966-67. Question 32)

ELECTRONIC DESIGN	18
ELECTRONICS	4
ELECTRONIC NEWS	None
EDN	None
ELECTRONIC PRODUCTS	None

SEND FOR "THEY SPEAK FOR THEMSELVES"—A RECAP OF 72 INDEPENDENT MEDIA STUDIES CONDUCTED BY ELECTRONICS MANUFACTURERS OVER THEIR OWN LISTS. ELECTRONIC DESIGN HAS WON 67 OUT OF 72 STUDIES!

Subscribers numbered 62,915 in June '68. Add the readers who receive pass-along copies, and the total audience for Electronic Design swells to more than 194,773 engineers and engineering managers.* Among subscriptions, 21,449 reached engineering management and 41,466 reached engineers.

NOTE: By December, 1968, subscribers will exceed 69,000!

*An analysis of Electronic Design readers by Systemetrix, Inc.

NO OTHER PUBLICATION PROVIDES AS MUCH EVIDENCE OF EDITORIAL QUALITY The magazine and its editors have won more awards in the last two years than all other electronic publications combined.

Jesse H. Neal Award/1967 Jesse H. Neal Award/1966
Industrial Marketing Award/1966
Society of Publication Designers—Magazine Design Award/Illustration—4 color/1966
Society of Publication Designers—Magazine Design Award/Cover—Black & White/1966

Editorially, Electronic Design is balanced in the following three categories:

News (perspective) The engineer is kept abreast of important events and major changes in the industry. "News Scope" and "Washington Report" plus design-oriented news consisting of industry-wide surveys that place vital areas into proper perspective, tell what's new, and give the engineer guidance on the type of design activity in the future. (17% of editorial.)

Technology (How To) Articles consist of solutions to design problems. They show "how to" design, save costs, evaluate, test, specify, and apply new technology. (55% of editorial.)

Products (With What) Electronic Design publishes more new product information than any other book in the field. All material is carefully selected and edited to give the designer maximum benefit. Major sections are used to guide this selection procedure—for example, components, power supplies, etc. (28% of editorial.)

ELECTRONIC DESIGN PRODUCES MORE THAN ONE MILLION INQUIRIES ANNUALLY!

Electronic Design produced more than 1,200,000 inquiries in 1967—far more than any other publication in this field. Your Electronic Design representative has independent proof that direct applications are made from inquiries. Ask him to show you the facts from our All-Inquiry issues.

NO OTHER PUBLICATION OFFERS AS MANY PROOFS OF READERSHIP AND EFFECTIVENESS Electronic Design stands ready at all times to cooperate in any reasonable way to measure readership and advertising effectiveness. Call your Electronic Design representative, he will be happy to tell you of the many ways our Research Department can be put to work for you.

SERVICES FOR MARKETERS Utilize material developed by the Marketing Services Department of Electronic Design. It includes: A Profile of Engineering and Engineering Management—Men Who Specify • Semiconductor Directory Reference Issue Survey • Brand Recognition Study • Reader Recall and Readership Studies • Buying Authority Studies (measure advertising impact, product applications, supplier preference, and actual purchase for such products as FETs, Panel Meters, Monolithic Integrated Circuits, Operational Amplifiers, Precision Test Instruments, etc.) • Inquiry and Application Studies • AIA Form • Reprint Service.

1969 SCHEDULING GUIDE (Effective December 2, 1968)

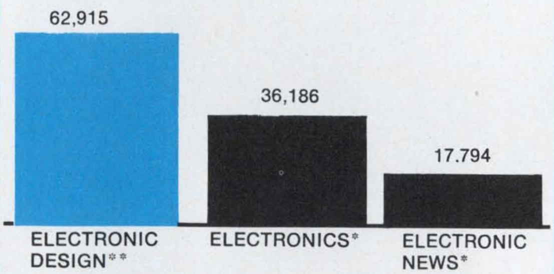
Issue No.	Publ. Date	Closing Date	Special Issues	Reader Recall
1	Jan. 4	Dec. 2	(All ads in issue included in Top 10 Contest)	X
2	Jan. 18	Dec. 16		X
3	Feb. 1	Dec. 30		X
4	Feb. 15	Jan. 13		X
5	March 1	Jan. 27		X
6	March 15	Feb. 10	IEEE	
7	April 1	Feb. 24		X
8	April 12	March 10		
9	April 26	March 24	Spring Computer Report	
10	May 10	April 7		X
11	May 24	April 21		
12	June 7	May 5		X
13	June 21	May 19		X

Issue No.	Publ. Date	Closing Date	Special Issues	Reader Recall
14	July 5	June 2		X
15	July 19	June 16		X
16	Aug. 2	June 30		
17	Aug. 16	July 14	WESCON	
18	Sept. 1	July 28		X
19	Sept. 13	Aug. 11		
20	Sept. 27	Aug. 25		
21	Oct. 11	Sept. 8		X
22	Oct. 25	Sept. 22		
23	Nov. 8	Oct. 6		X
24	Nov. 22	Oct. 20	Fall Computer Report	
25	Dec. 6	Nov. 3		X
26	Dec. 20	Nov. 17		X

DATA-SELL UNITS SPEED SELLING! Send for information about Electronic Design's exciting new TELL-ALL technique called "DATA-SELL." See how advertisers take advantage of the tremendous self-service buying potential in this industry to telescope the selling process. DATA-SELL discounts range up to 75%!

NEW 48 HOUR FAST CLOSE FOR RECRUITMENT ADVERTISERS Now your recruitment ad can be accepted up to 48 hours prior to Electronic Design's mailing date. (Full page, b&w only.) Ask for details.

ELECTRONIC DESIGN PROVIDES BY FAR THE LARGEST NUMBER OF ENGINEERS AND ENGINEERING MANAGER SUBSCRIBERS IN THE E.O.E.M.



E.O.E.M. ENGINEERS AND ENGINEERING MANAGERS

*As reflected in ABC Publisher's Statement, 6/30/68
**As reflected in BPA Publisher's Statement, 6/68

NUMEROUS JOB FUNCTIONS The average Electronic Design subscriber is involved in six or more of the following activities.

ACTIVITY	PERCENT	ACTIVITY	PERCENT
Research and Development	71.7	Reliability Analysis	27.5
Circuit Design	70.3	Standards	25.1
Test and Measurement	69.6	Value Engineering	24.9
Systems Design	69.5	Environmental Factors	24.8
Material Selection	50.1	Human Factors	24.4
Packaging	45.3	RFI Control	23.8
Production	34.6	Quality Control	22.6
		Styling	18.2

Source: A Profile of Engineers and Engineering Management—Page 6.

AREAS OF BUYING INFLUENCE-COMPONENTS The Electronic Design subscriber specifies, buys, and approves components that run from antennas to zener diodes. The average subscriber has a direct and active buying influence in more than twelve different categories of components.

COMPONENTS RECOMMENDED, SPECIFIED, OR APPROVED FOR PURCHASE

	%		%
Antennas, Transmission Lines	29.2	Microwave Components	23.7
Capacitors	62.9	Printed Circuits, Modules	48.9
Coils	44.5	Relays	49.6
Connectors	62.8	Resistors, Fixed	62.8
Cores, Ferrites	33.8	Rotating Devices (Motors, Gyros, etc.)	36.8
Crystals	38.9	Switches	56.5
Delay Lines	23.5	Terminals	43.1
Diodes, Solid State	68.7	Transducers	34.4
Fans, Blowers	35.5	Transformers, Chokes	52.1
Fasteners	26.8	Transistors	68.0
Filters	40.7	Tubes	36.7
Hardware	45.5	Variable Resistors, Potentiometers	56.2
Materials, Chemicals	22.8	Wire, Cable	46.3
Metals, Alloys	21.7	Other	1.5
Meters, Panel Type	38.7		
Microcircuits	48.5		

Source: A Profile of Engineers and Engineering Management—Page 10.

AREAS OF BUYING INFLUENCE — TEST EQUIPMENT AND APPARATUS The Electronic Design subscriber's specifying, buying and approving authority is exerted in all major areas of equipment. The average subscriber has a direct and active buying influence in more than seven different categories of equipment.

EQUIPMENT RECOMMENDED, SPECIFIED, OR APPROVED FOR PURCHASE

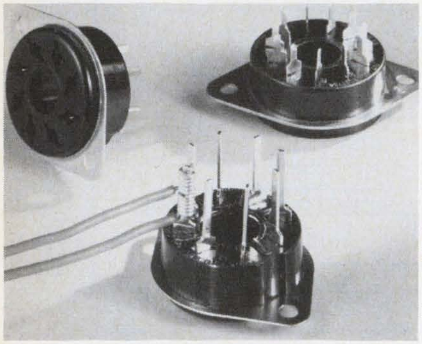
	%		%
Accelerometers	12.6	Microwave Test Equipment	20.7
Amplifiers, Oscillators	59.6	Oscilloscopes	65.1
Bridges	36.9	Power Supplies	71.3
Chart Recorders, Oscillographs	42.0	Pulse Equipment	40.8
Converters, Inverters	26.7	Read-Out Devices	38.2
Counters	56.9	Signal or Sweep Generators	49.1
Filters	35.7	Spectrum Analyzers	31.1
Infrared Devices	12.1	Tape Equipment	29.1
Meters, Electronic	58.7	Timers	35.3

Source: A Profile of Engineers and Engineering Management—Page 12.

Contact your local Electronic Design representative or Ed Clancy, Advertising Services Manager, at (212) PL 1-5530.

Electronic Design
A Hayden Publication
850 Third Avenue, New York, N.Y. 10022

Tube and relay sockets have PC or wrap contacts

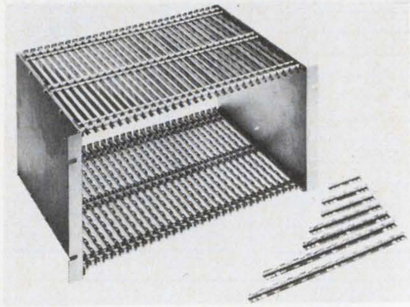


Bunker-Ramo Corp., Amphenol Industrial Div., 1830 S. 54th Ave., Chicago, Ill. Phone: (312) 329-9292.

A complete line of standard-size tube and relay sockets is now available with PC or solderless-wrap contact tails. Both termination styles are offered in 8, 9-, 11-, 12- and 20-contact configurations. The solderless, wrap-type sockets provide an economical method of attaching wire leads.

CIRCLE NO. 296

Circuit-board racks grip 12-in. lengths

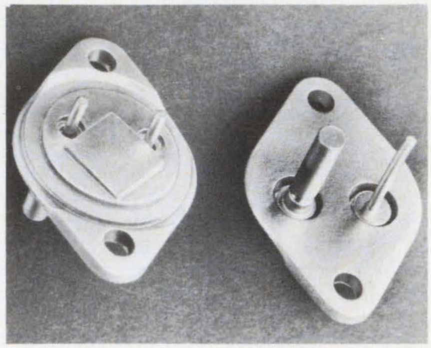


Birtcher Corp., Industrial Div., 745 Monterey Pass Rd., Monterey Park, Calif. Phone: (213) 385-7451.

Series 56 modular racks hold printed-circuit boards up to 12-in.-long by gripping each board at several points along the length with multiple spring fingers. Other structural parts of the racks include end-plates and support-rods. Board spacing can be as close as 3/8 in., and rack length from 2 to 25 in. Tier arrangement can be single or multiple.

CIRCLE NO. 297

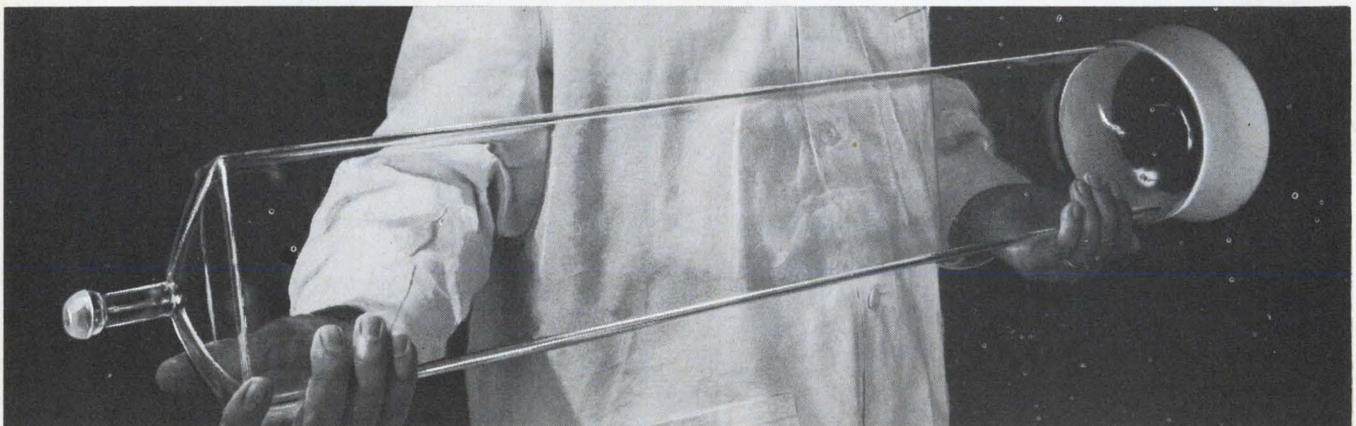
Ceramic-metal package seals and matches



Frenchtown/CFI, Inc., Sub. of Alloys Unlimited Inc., Harrison St., Frenchtown, N.J. Phone: (215) 493-4033.

A ceramic-metal package, shown above functioning as the header of a TO-3 100-A power transistor, survives gross thermal mismatches and maintains a hermeticity of 10^{-8} cm^3/s at 150°C. The header uses OFHC copper for base and pins and high-strength alumina for annular insulators.

CIRCLE NO. 298



No ripples. No bows. No twists. Result: no wafer rejects

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Bubble content is extremely low, for greater mechanical strength. Purity is extremely high. Absolute absence of interior ripples, bows, and twists minimize loading and unloading difficulties. Uniformly heavy walls assure greater ease of handling and longer useful life.

Therefore...Amersil epitaxial reactors eliminate product rejects and increase furnace output.

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685 RAMSEY AVENUE
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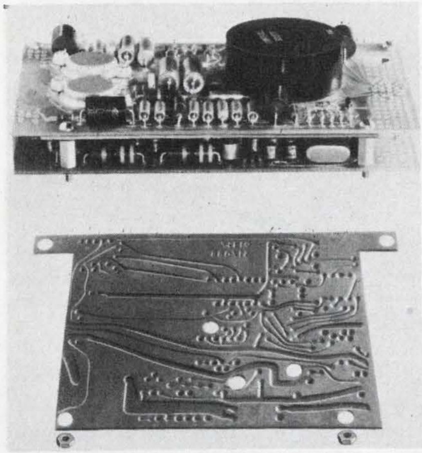
847

INFORMATION RETRIEVAL NUMBER 118

Conformal insulator conducts thermally

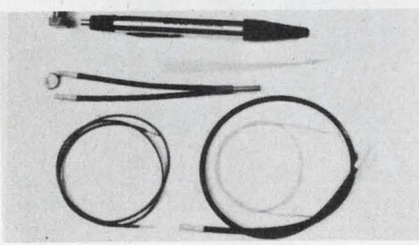


EPD Industries Inc., 2055 E. 223rd St., Long Beach, Calif. Phone: (213) 775-7141.

Thermally conductive molded insulators solve the problem of dissipating heat from components mounted on PC boards, while maintaining electrical isolation. These conformal insulators can be made to closely fit the circuitry side of a board. Circuitry and solder-joint configuration can be reproduced to ensure maximum insulation and thermal conductivity.

CIRCLE NO. 299

Fiber optics package illuminates principles



INFO Inc., P.O. Box 303, Newton, Mass. Phone: (617) 924-2385. P&A: $27.50; stock.

An experimental kit is designed to familiarize the user with the principles and applications of fiber optics. The kit consists of a bundle of 0.0025-in.-dia. loose fibers, an 18-in.-long pipe, a shoestring fiber, a bifurcated bundle, image-transmission blocks, three colored light filters, battery-powered light source, and a booklet describing fiber optics principles.

CIRCLE NO. 321

Don't make a move

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About to make a move to a better job, or a more promising career? Then talk to us, Conductron. We've got both.

The job? We're involved in flight simulation, avionics, medical electronics, collision avoidance systems, even optics.

The career? You'll be with a firm that plans to double its professional force in the next 5 years, where individual identity is invited.

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Mail to: Mr. Tom Walenga, Professional Employment, Conductron Corporation, Conductron-Missouri Division, P.O. Box 426, St. Charles (St. Louis), Missouri 63301.

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ON CAREER INQUIRY FORM, P. 81, CIRCLE 905

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Switching Systems problems? Let our know-how in systems engineering work for you with: **reed matrix switches; crossbar switches** for general purpose/ high performance requirements; **McKee random access matrices** for high voltage and current; **Telefunken OHS (ordinate holding) switches** for low cost applications.

Free Literature. Request new Data Sheet No. 603. Write or call Cunningham, Carriage St., Honeoye Falls, N. Y. 14472. Phone: (716) 624-2000.

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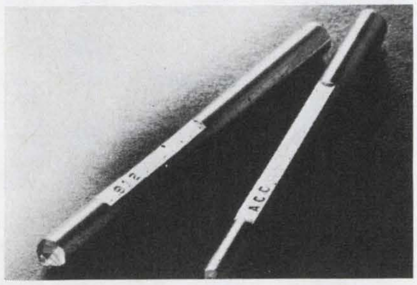
Subsidiary of Gleason Works
Proven capability in engineered switch products and systems.

INFORMATION RETRIEVAL NUMBER 120

Diamond wafer scriber cuts with only 2 edges

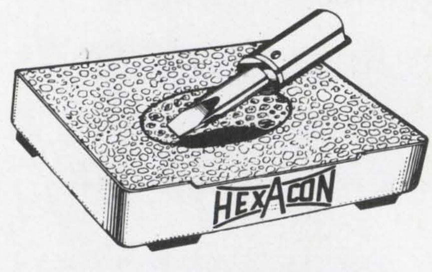


American Coldset Corp., 334 Rt. 17, Upper Saddle River, N.J.

Called the Bi-Scriber, model CT-912 diamond cutter uses only two cutting edges, instead of the conventional four, to scribe germanium or silicon wafers to ultra-close tolerances. The new tool can scribe the most complex device-loaded wafers with such closely spaced protrusions as silver nodules on diodes. It is said that breakup with the CT-912 is excellent.

CIRCLE NO. 322

Soldering-iron cleaner extends life of tip



Hexacon Electric Co., 299 W. Clay Ave., Roselle Park, N.J. Phone: (201) 245-6200.

Free of contaminants, a cleaning sponge saves time in cleaning soldering-iron tips and extends their life. Its dross reservoir holds enough water to keep the sponge soaked and the sponge surface clean. The sponge, measures 31.5 in.^{2} Rubber feet on the bottom of the accompanying aluminum tray prevent slippage.

CIRCLE NO. 324

High-speed programmer controls up to 12 loads

Agastat Div., Amerace-Esna Corp., 1027 Newark Ave., Elizabeth, N.J. Phone: (201) 352-2900. P&A: from $1500; 60 days.

Exercising precise sequential control over machine tools and processes, a new static-control programmer sequences up to 12 loads through as many as 12 steps, at rates as high as 10,000 steps per second. Incorporating a digital-count magnetic-core time base, Model 3512 provides multiple time-base selection for each step, from 0.01 seconds to 10,000 seconds per step. Timing repeatability is within ±0.5%.

CIRCLE NO. 323

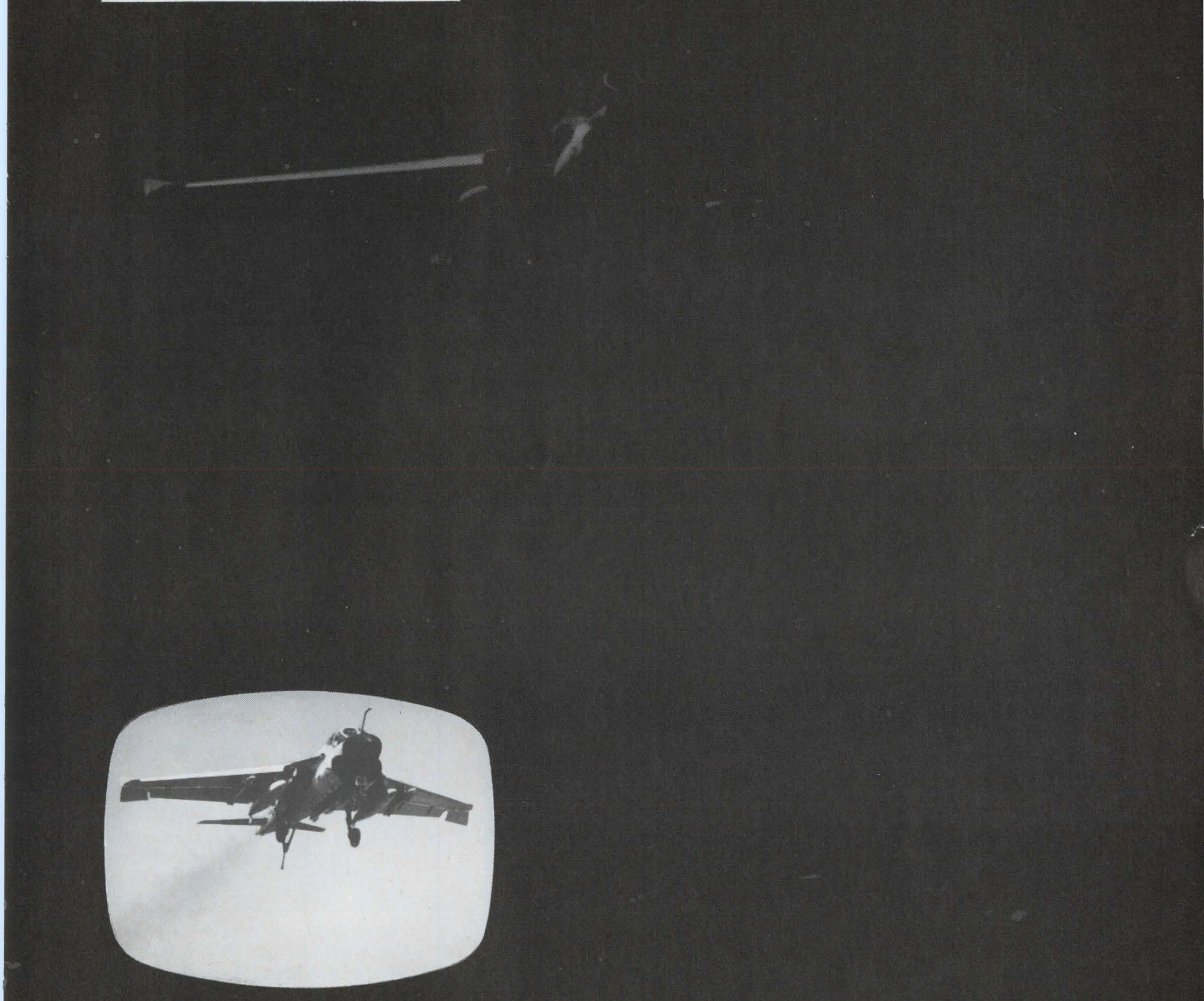
Automatic hand tool cuts and bends leads

Simonds Machine Co., Inc. 248 Worcester St., Southbridge, Mass. Phone (617) 764-3235.

Operating at 60 to 100 lb of air pressure, the Bend-Eze BP-1 hand tool automatically, and in a single operation, cuts and bends component leads with diameters as large as 0.05 in. It can also be used for bending precut leads. Seven interchangeable heads handle various lead diameters and provide three different working angles. Standard layover (bending) is about 1/16-in.-long for light and medium-duty heads and 3/32-in.-long for the heavy-duty head.

CIRCLE NO. 325

Commit in near-zero visibility? Without blurring - only by Westinghouse SEC camera tube with image intensifier



Meat-ball or no meat-ball, the decision to commit or wave-off rests with the Landing Signal Officer. And he must see to decide—even on low, overcast nights.

So meet the unique Westinghouse TV sensor package. The first in the industry to give an un-blurred picture of a moving object in the total dark.

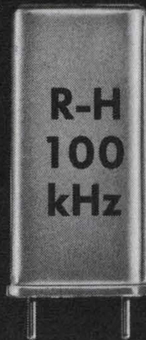
This "off the shelf" package WX-32000 consists of a new Image Intensifier perfectly mated to our exclusive Secondary Electron Conduction camera tube. The Intensifier gives you a brightness gain of 200 with low background, minimum distortion, and good resolution. Together they make a compact unit that gives you crisp, fast-motion, halo-free images at 10^{-5} foot candles.

For full details on our night-seeing, non-blurring TV Sensor Package, write Westinghouse Electronic Tube Division, Elmira, New York 14902. Then we'll talk you in!

ET-4013

You can be sure...if it's **Westinghouse**

NEW production techniques enable Reeves-Hoffman to REDUCE CRYSTAL PRICES



When you need production quantities of, for example, the 100 kHz crystal specified below, write. With our new technical developments in producing crystals, you can buy Reeves-Hoffman quality at lower prices, in quantity. Challenge us! Send us your specs.

Frequency	100 kHz
R_1, ohms	1,800
L_1, henries	67
C_1, picofarads	0.037
C_0, picofarads	5.78
Q	24,000
Holder (1.526 x .757 x .352 in.)	HC-13

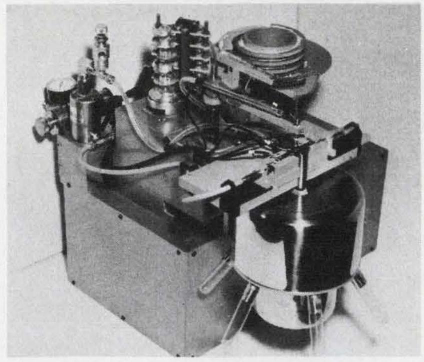
5° X crystal for filter or oscillator applications, fundamental extensional mode.

REEVES-HOFFMAN
DIVISION, DYNAMICS CORPORATION OF AMERICA
400 WEST NORTH ST., CARLISLE, PENNSYLVANIA 17013 • 717/243-5929

QUARTZ CRYSTALS
CRYSTAL FILTERS
OSCILLATORS
COMPONENT OVENS

INFORMATION RETRIEVAL NUMBER 122

Automatic chip handler tests 3000 pieces/h

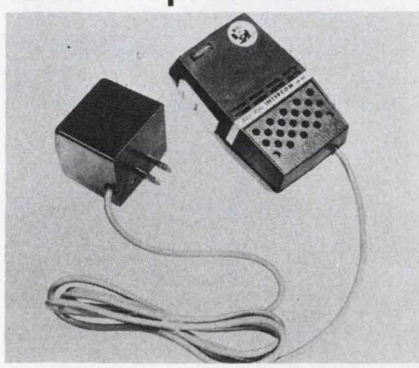


Affiliated Manufacturers, Inc., P.O. Box 248, Whitehouse, N.J. Phone: (201) 534-2103. P&A: $4500 to $8275; 4 to 6 wks.

A new automatic system that handles capacitor, resistor and semiconductor chips can test as many as 3000 piece parts per hour. With certain modifications and additions, the system can process as many as 6000 piece parts per hour. The standard handling system includes a vibrator parts-handler, a parts-transferer, a test nest and a probe station with collecting devices.

CIRCLE NO. 326

Wireless intercom links shop to desk



Line-Master Products, Sandefur Engineering Co., Inc., 14507 S. Hawthorne Blvd., Lawndale, Calif. Phone: (213) 772-5255.

Instant communications can be provided between an engineer's desk and any other area in plant, shop or lab by a wireless intercom that plugs into any ac outlet. After the call is completed, it may be unplugged and pocketed. A hand-held unit, the LM 340 operates at 200 kHz.

CIRCLE NO. 327

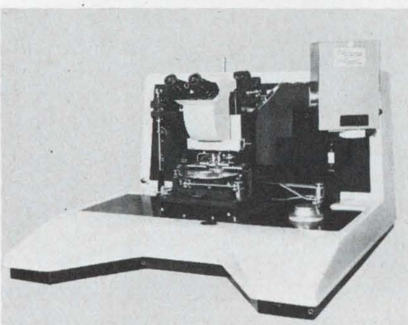
Miniature heaters cover 40 to 250°C

Circon Component Corp., Santa Barbara Municipal Airport, Goleta, Calif. Phone: (805) 967-1113.

Constant temperatures are provided by heating devices that span the range from 40° to 250°C. Each unit weighs 14 g. Operating directly from standard ac power lines, these heaters are one inch in diameter and 11/16-in.-high. An insulated-pad accessory can be used to protect work surfaces or for transport from one location to another.

CIRCLE NO. 328

Mask alignment system eliminates idle time



Kulicke and Soffa Industries, Inc., 135 Commerce, Fort Washington, Pa. Phone: (215) 646-5800.

Providing high wafer yields, a high-speed mask alignment system eliminates idle time and simplifies controls. The system handles wafers with a simple turntable arrangement that allows successive wafers to be prealigned within a tolerance of ±0.002 in. This reduces the time required for subsequent alignment steps and eliminates idle time, because a new wafer can be inserted while the previous one is being exposed.

CIRCLE NO. 329

Atec's New SLIM LINE

1¾" (H) x 17" (W) x 12" (D)

2802 Electronic Counter/Timer

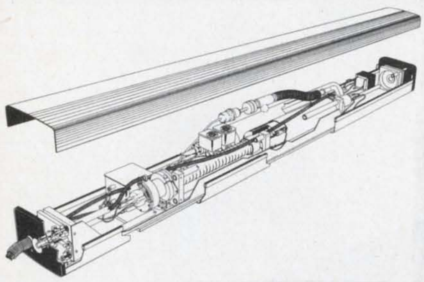
gives you more capability for less money than **any** other model available . . . and in a compact configuration. ■ Compare these features with other counter-timers ■ measures frequency from DC to 12.5 MHz and time intervals to 1 μsec ■ measures ratio ■ totalizes ■ BCD 1-2-4-8 output available on rear chassis for driving printers and punches ■ input sensitivity of 10 mV DC to 5 MHz, 30 mV DC to 12.5 MHz ■ remote programming ■ pushbutton switching ■ dual input channels ■ IC circuitry ■ illuminating overflow indicator. Now compare the price . . . $455! ■ The 2802's plug-in, modular design allows the following options to be added at any time ■ additional digits (seven maximum) ■ display storage ■ 1 MHz, crystal-controlled time base. For complete specifications or a free demonstration, call your local Atec engineering-sales representative or contact Atec directly.

Atec, Inc.

P. O. Box 19426 / 1125 Lumpkin Street, Houston, Texas 77024
Telephone: (713) 468-7971

INFORMATION RETRIEVAL NUMBER 123

Cw ion laser system cuts size and cost

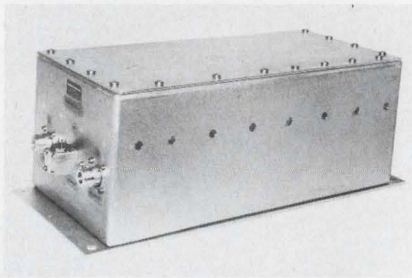


Coherent Radiation Labs., 932 E. Meadow, Palo Alto, Calif. Phone: (415) 328-1840. P&A: $9990; 60 days.

Reduced in both size and cost, model 52 cw ion lasers emit in the TEM_{00} transverse mode. A 2-W argon model emits eight lines in the blue-green region of the spectrum. A krypton unit is specified at 300 mW in the red, yellow, green and blue spectral regions. The model 52 system emits almost as much power as its $20,000 predecessor, at half the cost.

CIRCLE NO. 330

Varactor multiplier spans 500-MHz-band

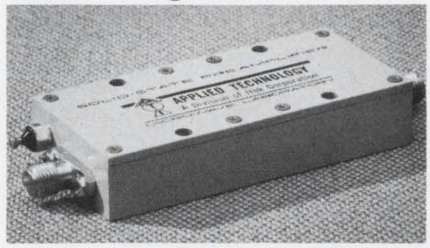


Applied Research Inc., 76 S. Bayles Ave., Port Washington, N.Y. Phone: (516) 883-5700.

A broadband varactor multiplier offers a multiplication ratio of 32 with an input bandwidth of 500 MHz. When input frequency is 104 to 119.7 MHz, then output frequency is 3.33 to 3.83 GHz. Model UHM-2(TX)-3580/500-32 has a nominal power of 20 mW for an input driving signal of 100 mW. It uses monopole network output filters to achieve a spurious suppression of 50 dB. Input and output impedance is 50Ω.

CIRCLE NO. 331

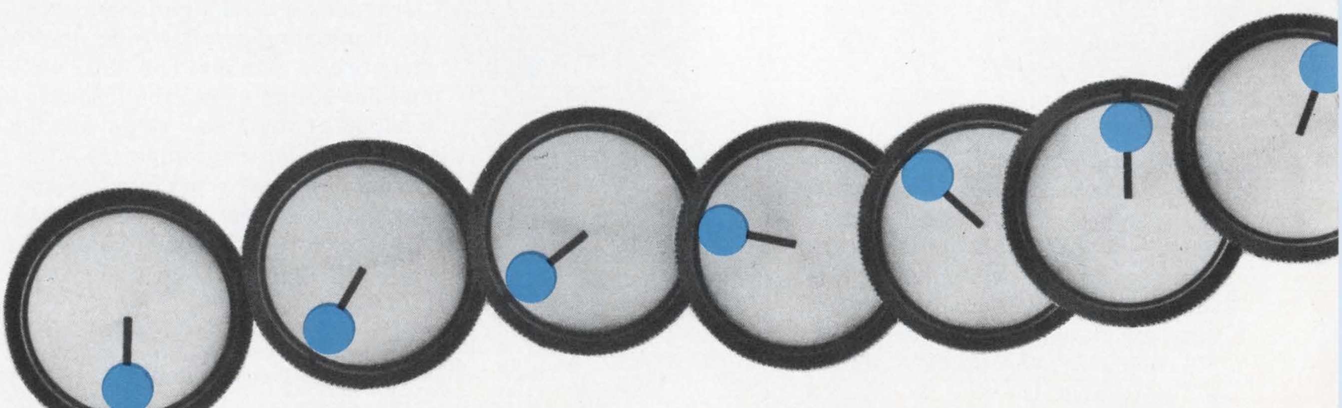
S-band preamplifier boosts signals 25 dB



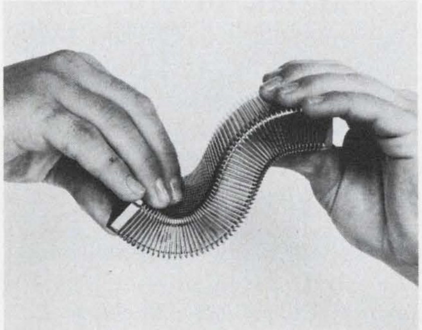
Applied Technology, Div. of Itek Corp., 3410 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. Phone: (415) 321-5135. Availability: 60 to 75 days.

Covering the frequency range of 1.5 to 3 GHz, a solid-state preamplifier provides a 25-dB gain with flatness of ±2 dB. Model SP-2250/1500 has a minimum output power of 0 dBm at 1-dB gain compression. Its maximum noise figure is 9 dB, and input VSWR is 2.5. The unit meets the requirements of MIL-E-5400, Class 2. It measures 1.2 by 2.5 by 0.5 in. and weighs less than 2 oz.

CIRCLE NO. 332



Flexible waveguide uses nickel bellows

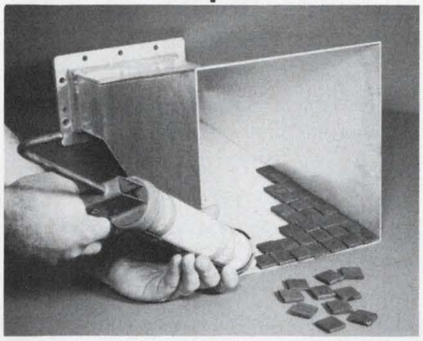


Servometer Corp., 82 Industrial East, Clifton, N.J. Phone: (201) 773-0474. Availability: 4 to 5 wks.

A thin-walled rectangular waveguide uses bellows construction to achieve high flexibility. In fabrication, nickel is electrodeposited on a mandrel of the desired configuration. After the mandrel has been removed, surface finishes of silver, rhodium, or gold can be applied. The new waveguide is available in 1/4- to 8-in. sizes, and up to 6-in. lengths.

CIRCLE NO. 333

Lossy ferrite has tile shape

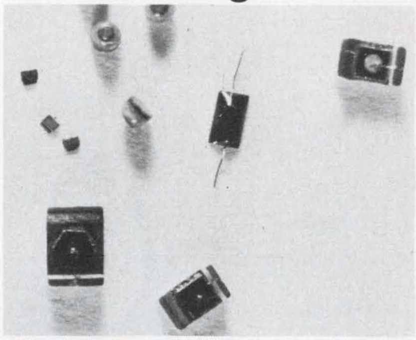


Emerson & Cuming, Inc., Microwave Products Div., Canton, Mass. Phone: (617) 828-3300.

Supplied in a tile configuration for convenient attachment to complex geometrical surfaces, Eccosorb ZN is a lossy ferrite that is useful for damping surface and creeping waves in a variety of uhf and microwave devices. The ceramic tiles are 1-in. square by 1/8-in. thick. They can be used from −65°F to +1000° F and weigh 2.25 lb/ft^2.

CIRCLE NO. 334

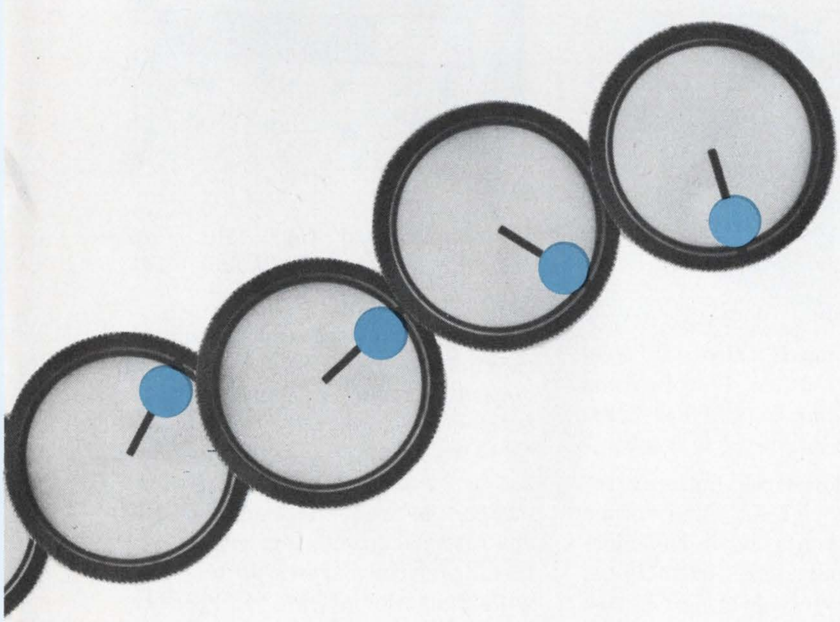
Semiconductor elements aid MIC design



Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

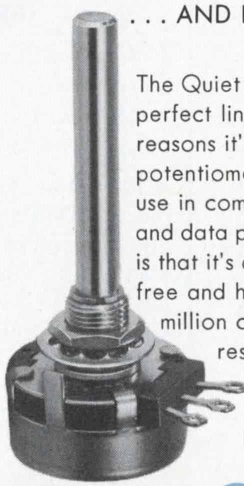
Varactor and p-i-n elements consist of a chip mounted on a bonding pad. Designed for microwave integrated-circuit applications, they provide great flexibility in designing MICs. Tuning varactor chips are available. P-i-n elements, available for low power switching, phase shifting, limiting, duplexing and modulation, are also designed for series mounting in stripline microstrip circuits.

CIRCLE NO. 335



THE QUIET ONE HAS TWICE THE LINEARITY OF THE ALLEN-BRADLEY J SERIES POT

. . . AND ITS PRICE IS COMPETITIVE



The Quiet One is within 5% of perfect linearity. That's one of the reasons it's the one low cost potentiometer that's a natural for use in computers, test equipment and data processors. Another reason is that it's almost perfectly noise-free and has been field tested 2 million cycles with less than a 5% resistance change. Write for full information. Dept. 102, Dover, N.H. 03820

CLAROSTAT

INFORMATION RETRIEVAL NUMBER 124

Bulova forks solve low frequency problems

Let the experience behind 300,000 forks per year help you!

American Time Products forks are now available up to 25 kc, thanks to years of experience plus new design techniques developed by Bulova. (Including the tiny forks for Accutron® electronic timepieces, Bulova made 300,000 last year alone!)

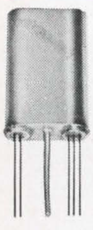
Result: ATP units provide lower cost, smaller size, lighter weight and greater long term stability in such applications as Computers, Navigation Systems, Doppler Radar, Motor Drives, Encoders and Timers. Accuracies of up to 0.001% are available.

Bulova fork oscillators offer the added advantage of simplicity of design and circuitry. Fewer components mean greater reliability. Finally, Bulova fork products are uniquely capable of withstanding severe shock and vibration environments.

No wonder Bulova sold 300,000 last year!

FS-11 FORK FREQUENCY STANDARD

Standard Frequencies: Up to 10,000 cps
Accuracy: Up to ±.001%
Input: 28V DC (others on request)
Output: 5 volts p-to-p min. into 10K ohms
Temperature Range: As low as −55°C to as high as +85°C
Size: 1½ in. sq. x ⅜"



SUB-MINIATURE TF-500 TUNING FORK
Standard Frequencies: Up to 2400 cps
Accuracy: Up to ±.001% at 25°C
Input: 28V DC (others on request)
Output: Up to 5V rms into 20K ohms
Temperature Range: As low as −55°C to as high as +85°C
Size: ⅜" x ¾" x 1½" max.

Write or call for specifications on Bulova's complete line of tuning fork products. Address: Dept. **ED-16**

BULOVA

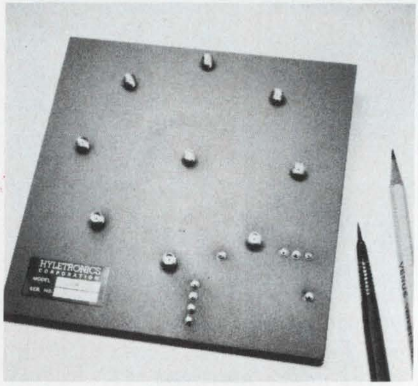
AMERICAN TIME PRODUCTS

ELECTRONICS DIVISION
OF BULOVA WATCH COMPANY, INC.

61-20 WOODSIDE AVENUE
WOODSIDE, N.Y. 11377, (212) DE 5-6000

INFORMATION RETRIEVAL NUMBER 125

S-band diode switch operates in 10 ns



Hyletronics Corp., Ainsworth Rd., Wilmington, Mass. Phone: (617) 272-0670. Availability: 30 to 60 days.

Available with or without a driver, a solid-state diode switch has a switching time of 10 ns. Model SS-99 is a single-pole eight-throw unit that spans the frequency range of 2 to 4 GHz. It features a low-insertion loss of 1 dB and an isolation of 40 dB.

CIRCLE NO. 336

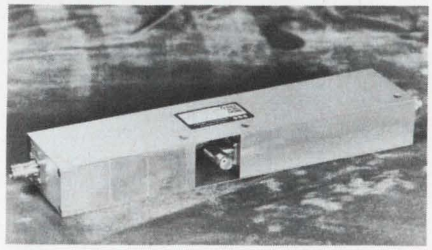
Low-level limiter replaces TWTs

DeMornay-Bonardi, Div. of Systron-Donner, 1313 N. Lincoln Ave., Pasadena. Phone: (213) 681-7416. P&A: $600 to $1000; 2 to 4 wks.

Precision low-level limiters replace TWTs, TDAs, and other active components with considerable size and cost reductions. DB-X-359 series limiters use silicon epitaxial devices combined with a filter structure to provide dual functions of limiter and filter in a single passive component. Out-of-band signal rejection extends from dc to 4 f_0.

CIRCLE NO. 337

S-band converter attenuates to vhf



TRF Inc., subsidiary of Quanta Systems Corp., 6627 Backlick Rd., Springfield, Va. Phone: (703) 451-5131.

Stressing high sensitivity, low intermodulation distortion, and excellent rf preselection, a three-channel converter, model TC-301, attenuates signals from S band to vhf. Each channel consists of a four-section rf filter, a balanced mixer down-converter, and 10 selectable oscillators that provide tuning increments from 2.2 to 2.3 GHz. Over-all noise figure is 6 dB, over-all gain is 20 dB, and rf output is 130 to 140 MHz.

CIRCLE NO. 338

Fm signal generator has new IRIG bands

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto. Phone: (415) 326-7000. Price: $5750.

Providing broadband modulation capabilities, model 3205A fm signal generator calibrates receivers in both new IRIG telemetry bands: 1.435 to 1.54 GHz in L band and 2.2 to 2.3 GHz in S band. Its output can be frequency modulated by an internal oscillator, or by external sources at rates up to 2 MHz with peak deviations to ±3 MHz. Modulation linearity is better than 0.3% with deviations to ±0.5 MHz, at modulation rates up to 0.5 MHz in band 1; and is 1% with deviations to ±1 MHz, at modulation rates to 1 MHz in band 2.

CIRCLE NO. 339

Far Superior

TO ANY VTVM OR VOM

A NEW STANDARD OF THE INDUSTRY . . .

- Only Sencore makes a true field effect meter
- Less circuit loading than VTVM/obsoletes VOM
- Zero warm-up time — instant stability
- Complete circuit and meter protection
- Complete portability
- Greater frequency responses than most scopes

FE149 SENIOR FET METER

The only true Senior FET meter available today with outstanding accuracy and unbelievable ease of operation.

- **Unmatched Accuracy.** 1.5% on DC, 3% on AC, plus large 7-in. meter and mirrored scale, assure the most accurate tests possible.
- **Eight AC and DC ranges** .5V to 1500V full scale.
- **Zero center scale** with .25 v. either side assures measurements to less than .1 v. for transistor bias measurements.
- **AC peak to peak** readings to 4500V maximum with freq. response of 10HZ to 10MHZ ± 3DB.
- **Eight resistance ranges** to R x 10 megohms with 6 OHMS center scale.
- **Nine DC and nine AC current ranges** 150ma to 5 amps.
- **Eight decibel ranges** for audio measurements.
- **Three HI-Voltage ranges,** 5 KV, 15 KV, 50KV with 39A21 high voltage probe. **$14.95**
- **Absolute meter and circuit protection** against circuit overload.
- Non-breakable, scuff-proof, vinyl-clad steel case.
- **Three-way power.** Operates on AC, on self-contained rechargeable batteries, or on AC with batteries plugged in. Same readings all three ways.

$149.50

Exclusive push-button design. Just push two buttons for any test — top row selects function, bottom row selects range. Action is instant and automatic.

FE14 and FE16 popular 4 1/2 inch FET Meters

- **Hi Accuracy.** For unsurpassed measurements. Mirrored scales prevent parallax errors.
- **Minimum circuit loading.** 15 megohm input resistance on DC; 10 megohm on AC.
- **Zero center scale** ± 0.5 v. readings for transistor bias measurement.
- **Full meter & circuit protection** against possible circuit overload.
- **7 DC & AC voltage ranges** 1 to 1000 volts full scale.
- **AC peak to peak readings** 2800 v. maximum with freq. response of 10HZ to 10MHZ ± 3DB.
- **5 resistance ranges** to 1000 megohms.
- **5 DC current ranges** 100ma to 1 amp.
- **3 Hi-Voltage ranges,** 3 KV, 10 KV, 30 KV, extended with 39A19 ($9.95) high voltage probe.

$69.95

FE14 — STANDARD FET METER

ACCURACY DC ± 2.5% AC ± 4.5%

- 4½-inch meter, vinyl-clad steel case.

$84.50

FE16 HI ACCURACY FET METER

ACCURACY DC ± 1.5% AC ± 3%

- 4½-inch high-styled meter, high-styled knobs, and special meter-tilting metal handle. Vinyl-clad steel case.

See your Sencore distributor today or write factory for complete line catalog.

SENCORE

426 SOUTH WESTGATE DRIVE, ADDISON, ILLINOIS 60101

STANDARD OF THE ELECTRONIC INDUSTRY

INFORMATION RETRIEVAL NUMBER 111

HICKOK

DMS 3200

DIGITAL MEASURING SYSTEM
(Fully solid state with IC's)

This all-solid-state precision measurement system offers unlimited expansion capability through plug-in additions, resulting in a specialized instrument for each type of measurement. New plug-ins now broaden the measurement capability of this field-proven unit. Over 10,000 are in use at present.

Scaling controls make possible resolution of up to seven digits on the three-digit display by utilizing the overrange capability of many of the plug-ins, thus providing high resolution and accuracy with minimum investment. Companion devices such as the PR 4900 Digital Printer and 1050 Digital Set-Point Controller further extend the utility of the DMS 3200 System.

DC VOLTMETER PLUG-IN DP 100 **$175**
00.1 mv to 999. volts
± 0.1% rdg ± 1 digit

DC MICROVOLTMETER PLUG-IN DP 110 **$450**
0.001 mv to 999.9 volts
± 0.05% rdg ± 1 digit
4-digit resolution

AC VOLTMETER PLUG-IN DP 130 **$375**
0.01 mv to 999. volts
± 0.1% rdg ± 1 digit
22 Hz to 1.0 MHz

EVENT COUNTER/SLAVE PLUG-IN DP 140 **$90**
Up to 1,000,000 counts/sec
Cascade with second DMS to obtain 6-digit display

1 MHz COUNTER PLUG-IN DP 150A **$230**
00.1 Hz to 999. kHz
± 0.0005% rdg ± 1 digit
7-digit resolution

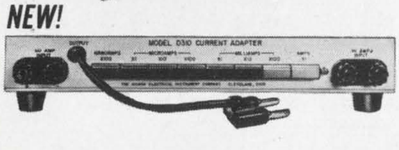
80 MHz COUNTER PLUG-IN DP 160 **$395**
00.1 Hz to 80.0 MHz
± 0.00005% rdg ± 1 digit
7-digit resolution

OHMMETER PLUG-IN DP 170 **$275**
.001 ohm to 999. megohms
± 0.1% rdg ± 1 digit
Microamp test current

CAPACITY METER PLUG-IN DP 200 **$275**
.001 picofarad to 9,999 mfd
± 0.1% rdg ± 1 digit
Low DC test voltage

TIME INTERVAL METER PLUG-IN DP 210 **$230**
0.01 ms to 999. seconds
± 0.0005% rdg ± 1 digit
Period or time interval

NEW!

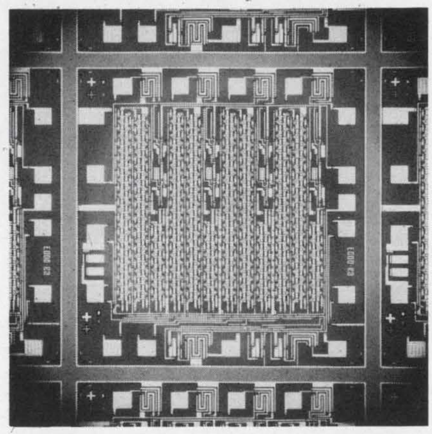


DC CURRENT METER ADAPTER D 310 **$90**
.0001 microamp to 9.99 amps
± 0.15% rdg ± 1 digit

HICKOK ELECTRICAL INSTRUMENT COMPANY, 10514 Dupont Ave., Cleveland, Ohio 44108

INFORMATION RETRIEVAL NUMBER 129

MOS shift registers eliminate interfacing



Electronic Arrays, Inc., 501 Ellis St., Mountain View, Calif. Phone: (415) 964-4321. P&A: $15 to $65; Jan., 1969.

A line of mutually compatible MOS shift registers, can drive bipolar circuits directly. The new registers help to simplify the transition from IC families of RTL, DTL, and TTL circuits to LSI configurations.

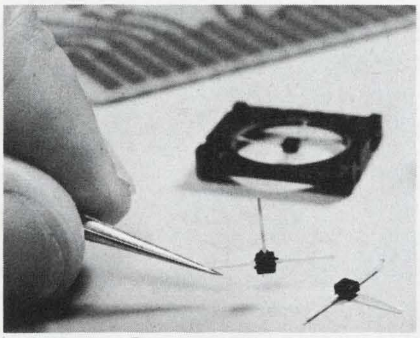
The first units in this new line include: a quad 32-bit dynamic shift register, available as a one-phase (1201) or a two-phase (1200) device; variable-length 64-bit dynamic shift registers in both one- and two-phase versions (1202 or 1203), that establish register length with six control inputs; a one- or two-phase 256-bit dynamic shift register (1204 or 1205); and a quad 32-bit static shift register (1000) that requires only a single-phase clock.

Creating a standard product line involves selecting designs that possess both electrical compatibility and commonality in their customer-oriented features. Conforming to these criteria, these new MOS shift registers directly interface with each other with no adjustment of power supplies, clock levels, data levels, or timing relationships. They also hold the use of externally furnished clocks to a minimum. In addition, all output buffers, properly biased, directly drive bipolar loads without interfacing.

The new shift registers are supplied in hermetic dual-in-line packages.

CIRCLE NO. 340

Silicon transistors have spider shape

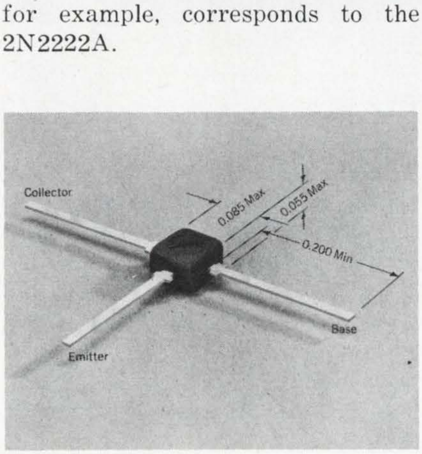


Texas Instruments Inc., P.O. Box 5012, Dallas. Phone: (214) 328-2011. P&A: $1.05 to $1.95; stock.

Recommended for high-density applications, 14 miniature silicon transistors are available in a spider-type package. The new A3T configuration occupies only 18% of the volume of a TO-46 can. Its flat leads can be welded or soldered. Arranged in a radial pattern, they can be wired into high-density circuits with little or no bending.

On request, the A3T will be supplied in a carrier to facilitate incoming inspection. Satisfactory operation of all devices in the line is guaranteed at temperatures from −65 to +150°C. Rated dissipation is 225 mW continuous at 25°C and 27 mW at 135°C. Extensive lifetesting has demonstrated that these devices meet the military acceptance criteria of their metal-can counterparts.

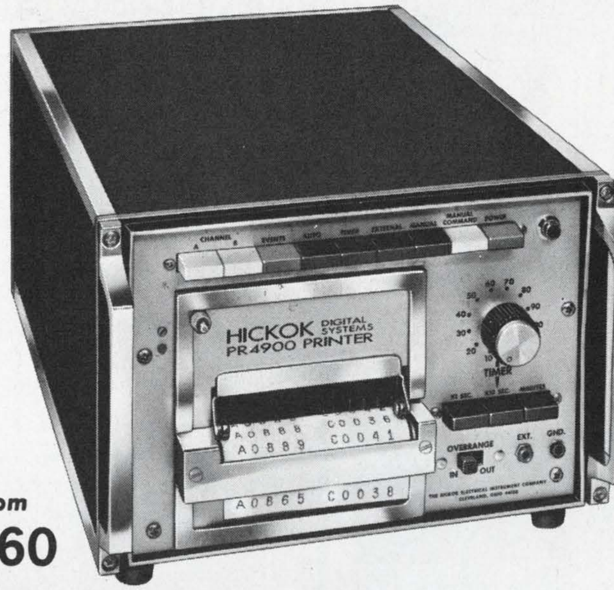
Types presently available are A3T918, -929, -930, -2484, -2221, -2222, -2221A, -2222A, -2906, -2906A, -2907, -2907A, -3011 and -2894. The digits following the A3T code correspond to standard JEDEC notation; the A3T 2222A, for example, corresponds to the 2N2222A.



CIRCLE NO. 341

HICKOK

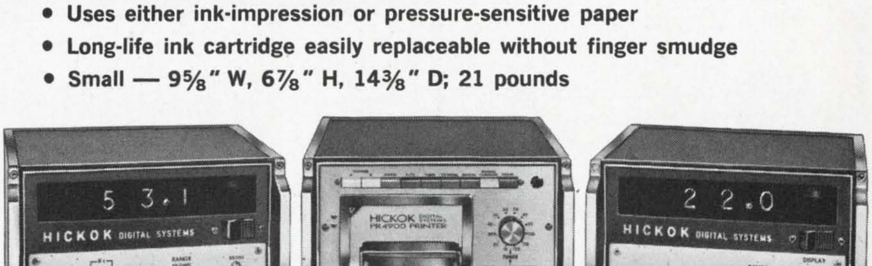
PR 4900
DIGITAL PRINTER



From
$760

This professional printer provides print-out of up to 10 columns of digital information from one or two independent sources. It is a companion unit to the Hickok DMS 3200 Digital Measuring System; however, it may be used with any device which provides 10-line decimal or BCD coded data outputs. Voltage, frequency, time period, resistance, capacitance or event counts are examples of data which may be recorded in printed form on paper tape for storage and future reference.

- **Direct print-out on ink-impression or pressure-sensitive paper**
- **4 to 10 column print-out, fully modular for field expansion**
- **Operates directly from DMS 3200 Digital Measuring System — just interconnect and operate**
- **Will operate from other 10-line decimal or BCD sources**
- **Built-in timer for pre-set print cycle**
- **Fast, convenient push-button selection of command mode**
- **All solid state logic circuitry**
- **Gives 4-digit print-out of DMS Digital Measuring System 3-digit display through print-out of "overrange" digit**
- **Two print wheel types — decimal and symbol data**
- **Selectable print command — Auto, Timer, External, or Manual**
- **Plug-in printed cricuit boards and print modules**
- **Will print from two independent sources**
- **Low-voltage, low-power data inputs**
- **Uses either ink-impression or pressure-sensitive paper**
- **Long-life ink cartridge easily replaceable without finger smudge**
- **Small — $9\frac{5}{8}$" W, $6\frac{7}{8}$" H, $14\frac{3}{8}$" D; 21 pounds**

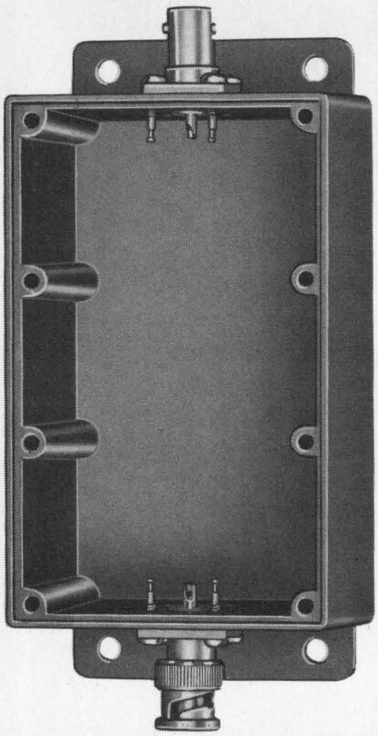


Printer will print the output from two independent DMS 3200 Digital Measuring Systems.

HICKOK ELECTRICAL INSTRUMENT COMPANY, 10514 Dupont Ave., Cleveland, Ohio 44108

INFORMATION RETRIEVAL NUMBER 130

NEW



MODEL 2903
Shown ⅔ Actual Size

LARGER SHIELDED "BLACK BOXES"

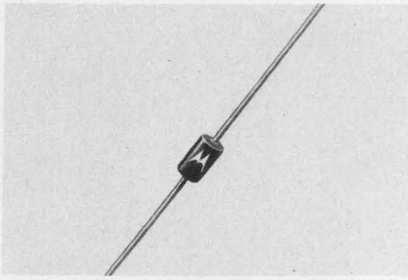
Useable inside space: 4" long x 2" wide x 1½" deep. Large enough to permanently protect and shield custom test circuits. Six models, with four connector combinations. Rugged die-cast aluminum boxes supplied with aluminum cover.

Featured in our 1968 general catalog. Write for your free copy.

POMONA
ELECTRONICS CO., INC.
1500 E. Ninth Street, Pomona, Calif. 91766

INFORMATION RETRIEVAL NUMBER 131

Silicon rectifiers halve prices

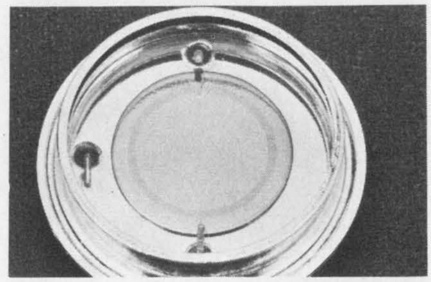


Motorola Semiconductor Products Inc., P.O. Box 955, Phoenix, Ariz. Phone: (602) 773-6900. Price: 25¢ to 99¢.

Motorola Semiconductor Products Inc. has reduced OEM prices on its line of Surmetic plastic- encapsulated silicon rectifiers up to 57%. The greatest reductions are in the high-voltage rectifiers with peak reverse voltages up to 1000 V; smaller reductions are in effect for large quantities of lower voltage units. This line of rectifiers, 1N4001 through 1N4007, contains seven semiconductor devices that handle 50 to 1000 V.

CIRCLE NO. 342

Large-area photodiodes reduce leakage current

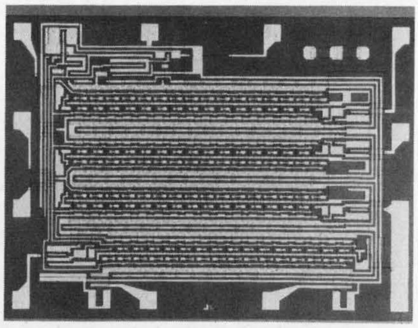


Electro-Nuclear Laboratories, Inc., 115 Independence Dr., Menlo Park, Calif. Phone: (415) 322-8451.

Although they have large active areas (10-mm dia for type 671 and 5-mm dia for type 663), silicon diffused photodiodes minimize leakage currents from the visible range to 1.1 microns. When biased at approximately the same potential as the active area, a thin diffused guard ring around the active-area perimeter causes the leakage current to bypass the load resistor. The photodiodes are packaged in an hermetically sealed can with a highly transmissive flat window.

CIRCLE NO. 344

Static shift registers operate at 1 MHz

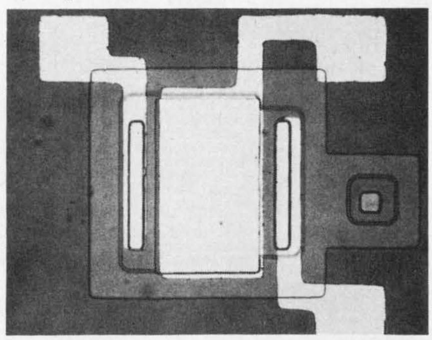


Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530. Price: $28 to $50.

Two 64-bit shift registers, each with a single-phase clock, provide high-speed operation from dc to 1 MHz with power consumption of less than 3 mW per bit. These MOS products are the 3305 quad 16-bit static shift register available in a dual-in-line package, and the 3306 dual 16-bit static shift register, packaged in a TO-100 container.

CIRCLE NO. 343

MOSFET electrometers surpass tubes



Hughes Aircraft Co., 500 Superior Ave., Newport Beach, Calif. P&A: $2.80 to $4.80; 2 wks.

MOSFET devices, designed to replace electrometer tubes, are packaged in 3-lead TO-5 and 4-lead TO-72 cans and are graded for input-leakage and noise-voltage characteristics. Typical warm-up times of 30 s and bias voltage drifts of less than 0.5-mV per day contrast with 20 minutes and 1 mV per day for typical electrometer tubes.

CIRCLE NO. 345

The only total portable, laboratory quality oscilloscope.

Model S1301A

And only $665.

Goes anywhere you need it. And at $665,* there's no need for scope sharing. Operates from optional internal battery or 110/220 vac 50 to 400 Hz line. Compact 8½" x 9" x 15" size, weighs less than 20 lbs.

Features include: 20 MHz bandwidth; 17 nsec rise time; 18 sweep speeds; internal voltage calibrator; and triggering stability over 30 MHz.

Write for Bulletin TIC 3316 to Motorola Communications & Electronics Inc., 4501 W. Augusta Blvd., Chicago, Ill. 60651.

*Exclusive of options.

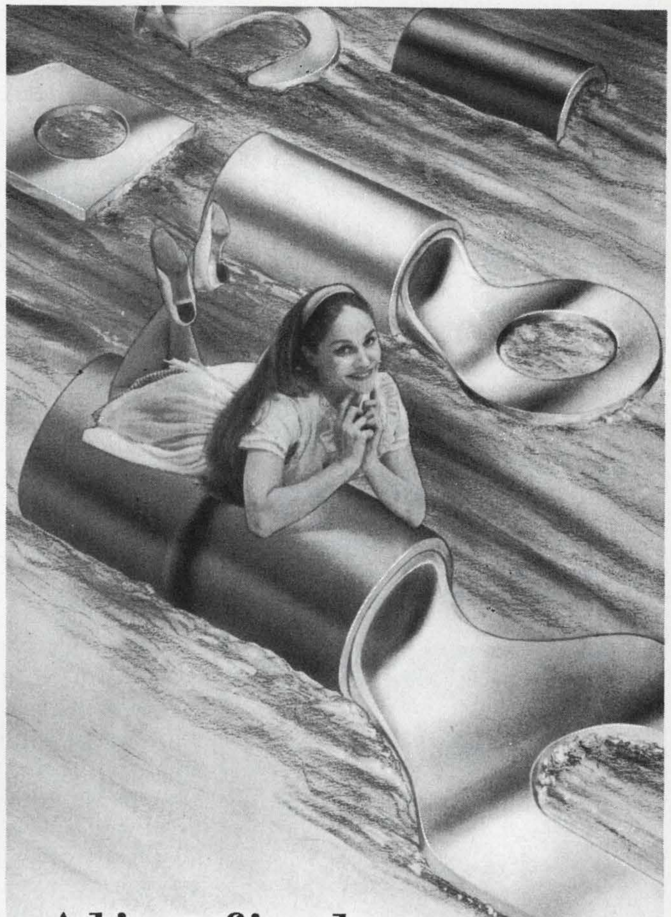
MOTOROLA
Precision Instrument Products

INFORMATION RETRIEVAL NUMBER 132

"IT'S GOOD BUSINESS TO HIRE THE HANDICAPPED."

ISN'T THAT A GREAT IDEA, SNOOPY?

THE PRESIDENT'S COMMITTEE ON EMPLOYMENT OF THE HANDICAPPED, WASHINGTON, D. C.



Alice finds smooth sailing in Waldomland

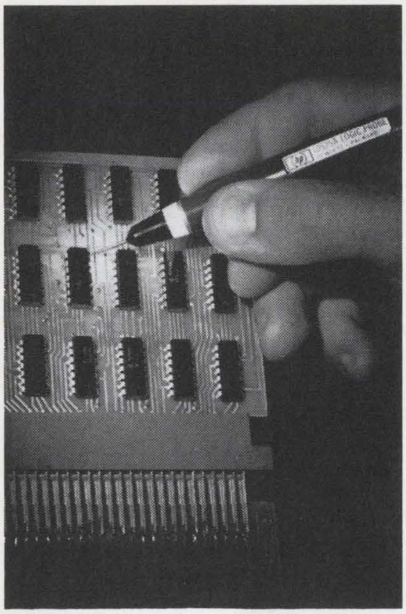
To Alice, wiring circuit assemblies with Waldom Solderless Terminals is as easy as floating downstream. There's nothing easier than crimping a Waldom Solderless Terminal . . . and once crimped, they grip like the jaws of a bulldog! And wired assemblies with solderless terminals by Waldom have a professional neatness no other method can match. Why not specify Waldom Solderless Terminals for your next prototype, pilot or production run? Like Alice, you'll have smooth sailing all the way!

- Broad selection including Quick Disconnects.
- All construction styles.
- Absolute dependability.
- Saves time and labor.
- Easier servicing.
- All types made to mil specs.

Fast delivery from your electronics or electrical distributor. Write for FREE Waldom catalog listing more than 4000 electronic hardware items.

waldom
ELECTRONICS, INC.
4643 West 53rd Street, Chicago, Illinois 60632

INFORMATION RETRIEVAL NUMBER 133



This probe lights up when a pulse goes by.

Even a pulse as short as 30 ns—positive or negative—will cause this logic indicator to flash a signal. You can trace pulses, or test the logic state of TTL or DTL integrated circuits, without taking your eyes off your work. In effect, the probes act like a second oscilloscope at your fingertips.

No adjustments of trigger level, slope or polarity are needed. A lamp in the tip will flash on 0.1 second for a positive pulse, momentarily extinguish for a negative pulse, come on low for a pulse train, burn brightly for a high logic state, and turn off for a low logic state.

The logic probe—with all circuits built into the handpiece—is rugged. Overload protection: −50 to +200 V continuous; 120 V ac for 10 s. Input impedance: 10 kΩ. Price of HP 10525A Logic Probe: $95, quantity discounts available.

Ask your HP field engineer how you could put this new tool to work in logic circuit design or troubleshooting. Or write Hewlett-Packard, Palo Alto, Calif. 94304; Europe: 54 Route des Acacias, Geneva.

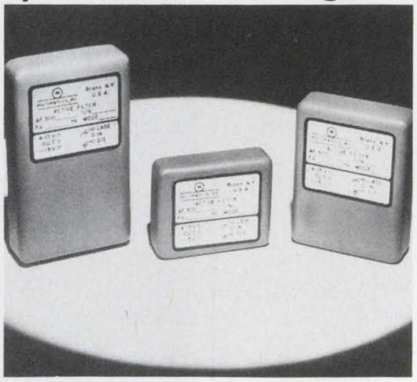
02825A

HEWLETT hp PACKARD

INFORMATION RETRIEVAL NUMBER 135

MODULES & SUBASSEMBLIES

Active filter modules span 200-kHz range

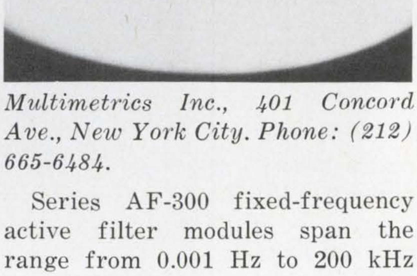


Multimetrics Inc., 401 Concord Ave., New York City. Phone: (212) 665-6484.

Series AF-300 fixed-frequency active filter modules span the range from 0.001 Hz to 200 kHz with low-pass, high-pass, band-pass and band-reject functions. Response characteristics of this computer-designed, solid-state series include maximally flat amplitude (Butterworth), maximally flat phase (Bessel), or sharpest cut-off slope (Chebyshev or Legendre).

CIRCLE NO. 346

Readout package counts and stores

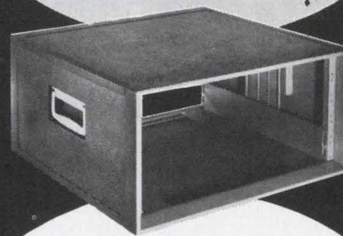


Integrated Circuit Electronics, Inc., P.O. Box 647, Waltham, Mass. Phone: (617) 899-2700. Price: $65.

Consisting of a 15-MHz decimal counter and a display module with storage capability, model CS-100 readout package retains the count in a quad latch memory so that it can be displayed on a cold-cathode readout tube. The numerical display is up-dated when a gating signal is applied to the quad latch memory. Using TTL monolithic integrated circuits to achieve maximum speed and minimum size, the module incorporates both carry and reset functions.

CIRCLE NO. 347

SETTING A *trend* in electronic instrument enclosures...



CLASSIC CABINETS

* The cabinet often is a key that opens the door to sales. What the eye conveys to the user is a basis of his first impression of quality and performance. That's why, year after year, Bud Sheet Metal Enclosures are the overwhelming choice of engineers who design and build both simple and sophisticated systems.

Classic Cabinets have the clean lines and exclusive construction that enhance the value of the contents. Some exclusive features include sturdy aluminum extrusions that form the framework; the patterned aluminum panels; the vinyl texture finish and the manner of supporting the contents.

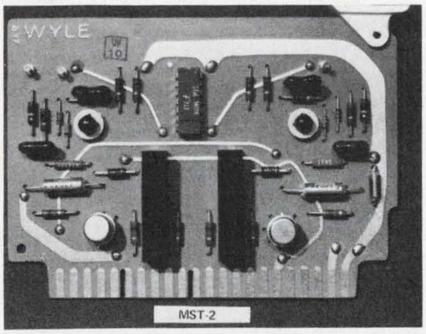
Creators of electronic equipment will find that these Classic Cabinets offer an attractive as well as a practical solution to most of their housing problems. Ask your authorized Bud Distributor to demonstrate the advantages of these and other Bud enclosures. Our catalog is available upon request.

BUD RADIO, INC.
Willoughby, Ohio

your product *Belongs* in a BUD cabinet

INFORMATION RETRIEVAL NUMBER 136

IC level comparator contains two circuits

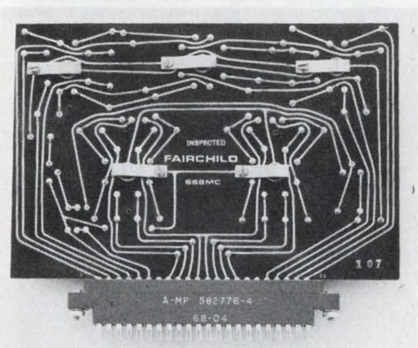


Wyle Labs, 128 Maryland St., El Segundo, Calif. Phone: (213) 678-4251.

A large margin of protection against oscillations in high-gain, wide-bandwith amplifiers is offered by the MST-2 level comparator IC card. Containing two completely separate, gated and squared level comparator circuits, the card has applications that include dc level detection, wave form restoration, pulse-shaping and Schmitt triggers.

CIRCLE NO. 348

PC attenuator card handles 4 channels



Fairchild Recording Equipment Corp., 10-40 45th Ave., Long Island City, N.Y. Phone: (212) 688-3300. Price: $215.

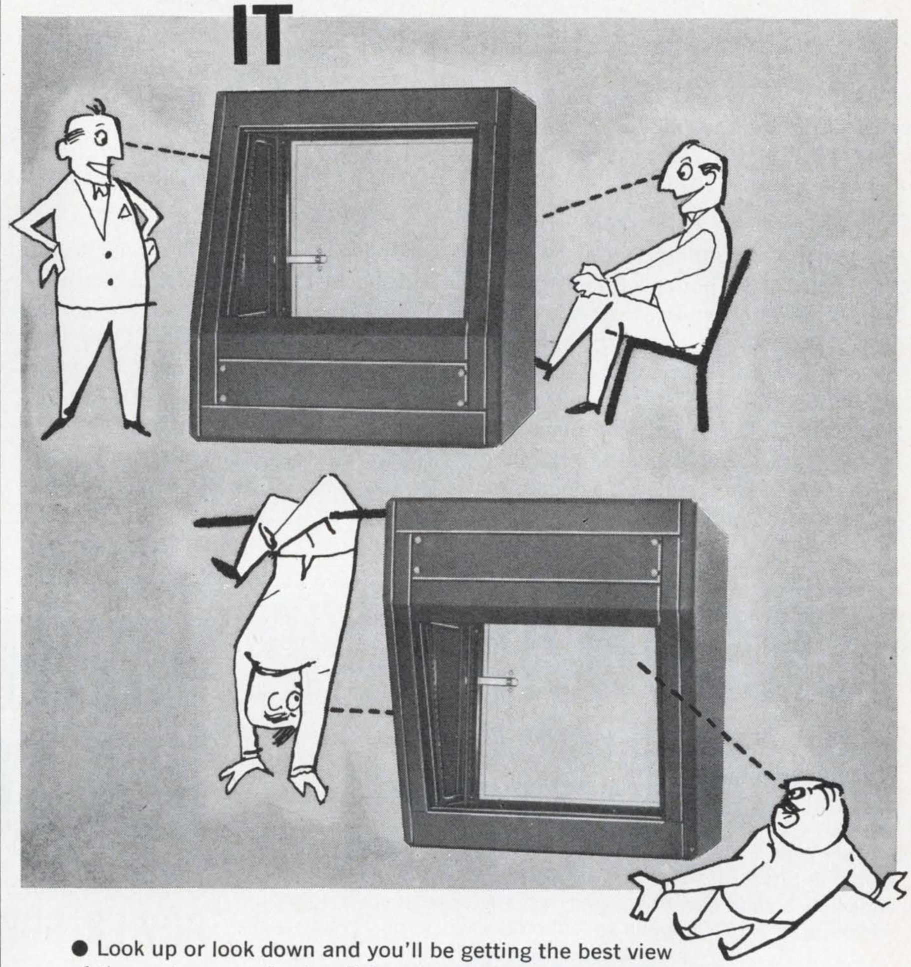
Packaged on a single plug-in card, a multiple-channel attenuator provides four interlinked faders capable of simultaneously attenuating four radio channels, with less than 1 dB of mistracking between channels. Model 668MC has light-dependent circuitry that allows all four channels to be attenuated by remote control with a minimum of crosstalk.

CIRCLE NO. 349

ANY WAY YOU LOOK AT IT

SERIES SIXTY **CONVERTIBLES**

provide the right angle for your viewing comfort



● Look up or look down and you'll be getting the best view of the meters, read-outs, dials, etc. on the sloping panel of the Convertible. It's extremely useful on a table or bench or placed on top of a tall cabinet.

The Convertible is built along the same structural lines as other Bud Series Sixty Cabinets. It is an extremely rugged enclosure for delicate instruments and systems. Maximum access to interior for installation of components or service is provided. Standard 19" panels are used.

See these practical new enclosures at your authorized Bud Distributors. Comprehensive literature is available.

BUD Series Sixty . . . *The Growth Line*

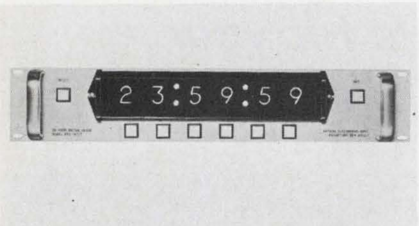
BUD — THE MARK OF PERFECTION

BUD RADIO, INC.
Willoughby, Ohio

your product *Belongs* in a BUD cabinet.

INFORMATION RETRIEVAL NUMBER 137

Digital 24-h clock displays real time

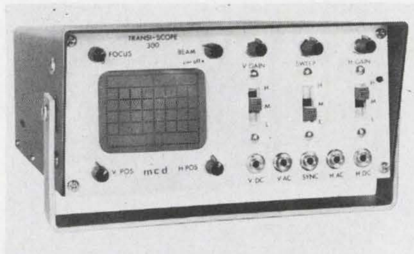


Artisan Electronics Corp., 5 Eastmans Rd., Parsippany, N.J. Phone: (201) 625-0220. P&A: $750; 4 to 6 wks.

Operating directly from the ac line, a rack-mount digital clock displays up to 24 hours of time with 1-in. glow-tube indicators. Its display, which is distinctly visible from any point in a control or testing area, allows the operator to read real time without the need for interpolation. The clock may be preset to any exact time. It measures 3-1/2 by 19 by 6 in.

CIRCLE NO. 407

Portable oscilloscope has same X/Y amps

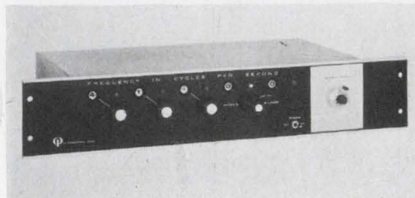


Measurement Control Devices, Inc., 2445 Emerald St., Philadelphia, Pa. Phone: (215) 426-8602. P&A: $169.50; 30 days.

Model 300 portable oscilloscope, weighs less than 7 lb and features identical dc vertical and horizontal amplifiers with a sensitivity of better than 10 mV pk-pk. The frequency response for both amplifiers is 0 to 100 kHz for dc, and 10 Hz to 100 kHz for ac. Input impedance is 0.5 MΩ shunted by 100 pF.

CIRCLE NO. 408

Polyphase oscillator supplies 4 outputs



Optimation, Inc., 9421 Telfair Ave., Sun Valley, Calif. Phone: (213) 768-0830. P&A: $1490 or $1520; 30 days.

Supplying virtually perfect waveforms, a precision polyphase oscillator generates four simultaneous phase outputs of 0°, 90°, 120°, and 240° from 0.01 Hz to 10 kHz. Model RCD-11 has a 90° phase angle accuracy of ±0.01° to 1 kHz and ±0.10° at 10 kHz. It could be called a phase angle standard since its waveform purity is 99.98%, while amplitude stability is 50 ppm short-term and 200 ppm long-term.

CIRCLE NO. 409

POWER/MATE CORP.

BP-118 UNIVERSAL BENCH SUPPLY

❋ 0-34 volts at 1.5 amps. ❋ 0.01% regulation ❋ 250 microvolts ripple ❋ Short circuit and overload protected ❋ 100,000 hours MTBF ❋ 5 year warranty. Send for Literature describing thousands of Power Supplies to 400 Volts and to 50 Amps.

SAME DAY SHIPMENT

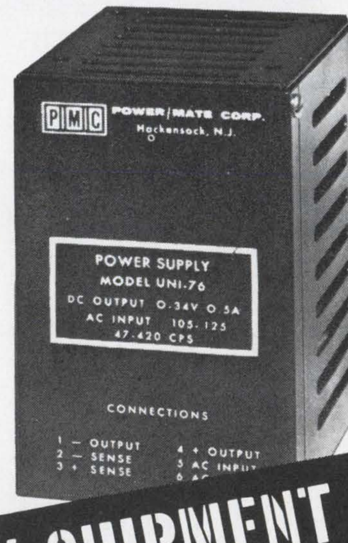
$118.00

PMC POWER/MATE CORPORATION
163 Clay St. ▪ Hackensack, N. J. 07601
(201) 343-6294 ▪ TWX (710) 990-5023

INFORMATION RETRIEVAL NUMBER 138

POWER/MATE CORP.

UNI-76 UNIVERSAL POWER SUPPLY



- ❋ 0 to 34 volts at 0.5 AMPS.
- ❋ .005% regulation
- ❋ 250 Microvolts ripple
- ❋ Meets MIL-E-5272 specs
- ❋ 100,000 hours MTBF
- ❋ 5 year warranty

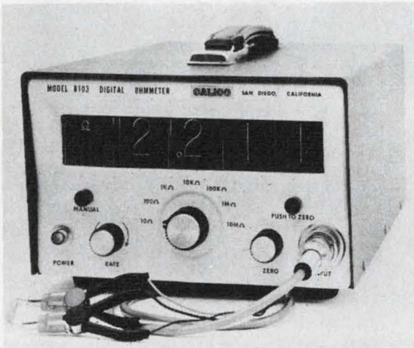
SAME DAY SHIPMENT

$76.00

PMC POWER/MATE CORPORATION
163 Clay St. ▪ Hackensack, N. J. 07601
(201) 343-6294 ▪ TWX (710) 990-5023

INFORMATION RETRIEVAL NUMBER 139

Digital ohmmeter resolves 100 μΩ

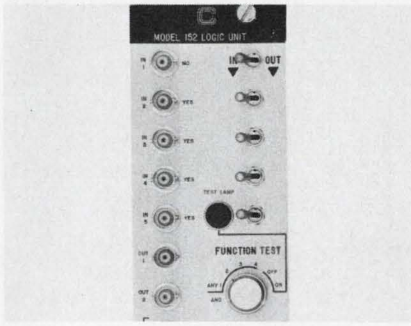


California Instruments Corp., 3511 Midway Dr., San Diego, Calif. Phone: (714) 224-3241. P&A: $1295; 30 days.

With a full-scale accuracy of 0.1% and a resolution of 100 μΩ, a low-level digital ohmmeter measures resistances from 0.1 μΩ to 10 MΩ. Model 8103-421 has a four-digit display with 10% overranging to the fifth digit.

CIRCLE NO. 410

200-MHz logic unit has 1.5-ns resolution

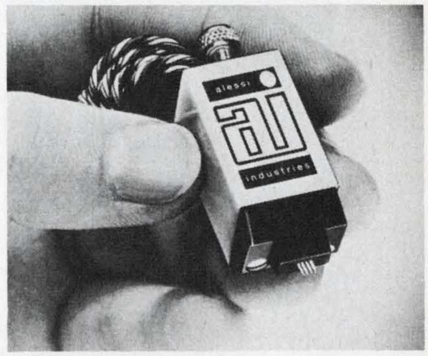


Chronetics, Inc., 500 Nuber Ave., Mt. Vernon, N.Y. Phone: (914) 699-4400. P&A: $600; stock to 30 days.

Operating at speeds greater than 200 MHz, model 152 logic unit performs the functions of AND, OR, majority logic, selective AND, and anti-coincidence. Another module of the Nanologic 150 system, the unit provides coincidence resolution of better than 1.5 ns.

CIRCLE NO. 411

Four-point probes vary test pressure



Allessi Industries, 418 Main St., El Segundo, Calif. Phone: (213) 322-6690. P&A: $55; 3 to 5 days.

Four-point probes feature continuously adjustable point pressures from 70 to 180 grams, for optimum dimensional and electrical accuracy in testing thin semiconductor slices or raw crystals. Probe pins are held in a precision casting to assure accuracy.

CIRCLE NO. 412

POWER/MATE CORP. POWER TWIN-99

DUAL OP AMP SUPPLY

- Dual output 12.0 to 18.0 VDC at 400 ma.
- ± 0.05% regulation
- 1.0 Mv rms ripple
- Overload and Short Circuit protected
- Meets MIL-E-5272 specs

SAME DAY SHIPMENT

Send for Literature describing thousands of Power Supplies to 400 Volts and to 50 Amps.

$99.00

PMC POWER/MATE CORPORATION
163 Clay St. ▪ Hackensack, N. J. 07601
(201) 343-6294 ▪ TWX (710) 990-5023

INFORMATION RETRIEVAL NUMBER 140

UNIVERSAL DUAL OUTPUT POWER SUPPLY POWER/MATE UniTwin 164

- Dual, separately controlled outputs 0-25 volts at 0.75 amps
- Regulation 0.005%
- Ripple 250 microvolts
- Meets MIL-E-5272 specs
- 100,000 hours MTBF
- 5 year warranty
- Compact — Just 4³⁄₁₆″ x 3⁵⁄₁₆″ x 6⁷⁄₈″.

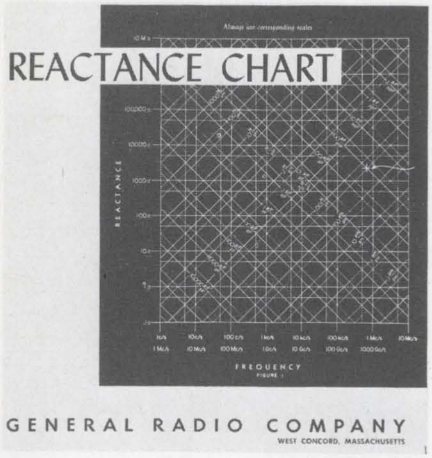
SAME DAY SHIPMENT

$164.00

PMC POWER/MATE CORPORATION
163 Clay St. ▪ Hackensack, N. J. 07601
(201) 343-6294 ▪ TWX (710) 990-5023

INFORMATION RETRIEVAL NUMBER 141

Design Aids



Reactance chart

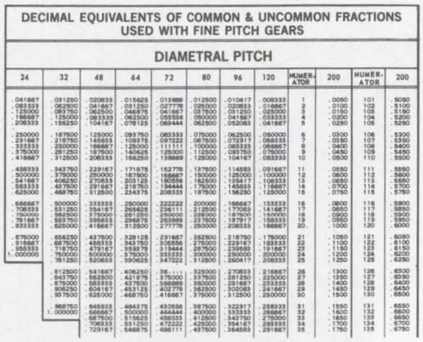
Reactance and resonant frequency are easily determined with a reactance chart that offers three-figure accuracy. Horizontal and vertical lines represent frequency and reactance, while capacitance and inductance are found on intersecting diagonals. Frequency range extends from 1 Hz to 1000 GHz, and reactance values are indicated from 0.1 Ω to 10 MΩ. General Radio Co.

CIRCLE NO. 350

Tape length calculator

Estimation of the length of punched paper tape on a reel is a simple task with the aid of this unique slide rule. Calculations are performed with only 2 settings of the rule. The outside diameter of the tape is first set at an arrow and area factor is read off opposite the inside diameter of the tape. By setting this area factor at tape thickness, the user can read off tape length opposite packing density. Usually assumed between 80 and 90%, packing density includes such factors as tape tension. Remex Electronics, A Unit of Ex-Cell-O Corp.

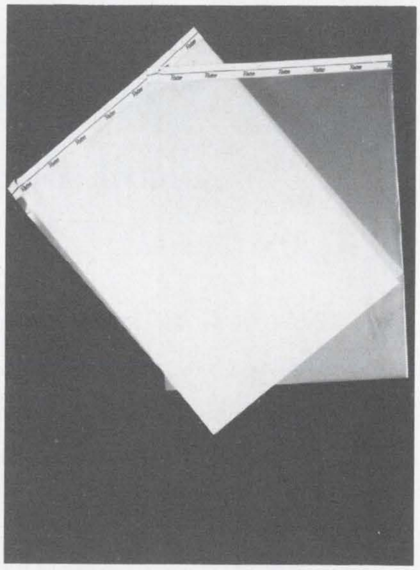
CIRCLE NO. 351



Decimal equivalents

Decimal equivalents are carried to 6 places on an 11-by-16-in. wall chart that folds to fit a notebook or file drawer. The chart also presents spur gear formulas and data, as well as user tips on gear meshes. The chart's reverse side contains data on a broad line of quick-release synchro clamps that feature instant nulling. Timber-Top, Inc.

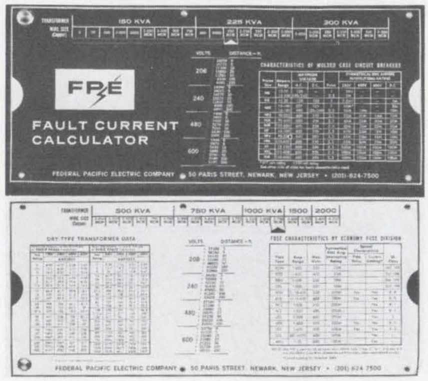
CIRCLE NO. 352



Designer's worksheet

A new plastic material can be used to make corrections or alterations on drawings or documents without damaging the original copy. Hundreds of erasures can be made on its permanent, matte-finished surface without damage. Useful to the designer in a number of ways, samples of this material are available without charge. Sepsco Films Division of Gladwin Industries.

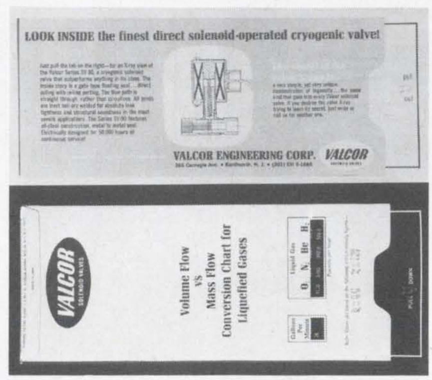
CIRCLE NO. 353



Fault current calculator

Take the mystery out of fault current calculations. Once fault current is determined, this calculator can be used to select a protective device with adequate interrupt rating. Characteristics of molded-case circuit breakers and fuses, along with dry-type transformer data, are listed on the rule. Federal Pacific Electric Co.

CIRCLE NO. 354



Cryogenic calculator

A liquid-to-gas conversion calculator is now available at no charge from a manufacturer of solenoid-operated cryogenic valves. The calculator contains a handy conversion chart for liquefied gases, in terms of volume flow versus mass flow. Measured are liquid gases O, N, He and H at flow rates that range from 0.2 to 20 gallons a minute. On its other side, the slide chart contains a diagram of a cryogenic solenoid valve. By pulling out on a tab, liquid gas is shown "moving" through the valve. Valcor Engineering Corp.

CIRCLE NO. 355

If one of your pet projects is suffering from heat exhaustion, Mystik may have a solution.

We have tapes that prevent projects from going up in smoke.

One of them is sure to fit your particular needs.

Take our Teflon* film tape, for example. It can withstand temperatures of –100 degrees F to 450 degrees F. It's an excellent insulator for all kinds of electrical equipment.

If you're more interested in shielding heat, we'd recommend our aluminum foil/glass cloth tape. It's been known to shield as much as 6,000 degrees F during short term rocket blastoff.

We have plenty of other tapes, too, for all kinds of jobs. Printed circuits. Ground lines. Electro-plating. Just about any tape connected with the electronics and electrical fields.

Check us out in the Yellow Pages under "Tapes." Or write direct to Dept. MT-7, Borden Inc/Chemical Division, Mystik Tape, 1700 Winnetka Ave., Northfield, Illinois 60093.

MYSTIK® TAPE
THE MARK OF QUALITY

* DU PONT REGISTERED TRADEMARK

INFORMATION RETRIEVAL NUMBER 142

Application Notes

Vibration isolation

This collection of reprinted articles covers the development of a new concept for isolating selected low frequencies without large static deflection requirements. With this new technique, system resonances may be suppressed without degrading low-frequency isolation. Lord Manufacturing Co.

CIRCLE NO. 356

Selective plating

A four-page booklet tells how to deposit many different metals in precisely defined areas of any conductive substrate, without requiring use of a plating bath. Extensive masking or stop-off are avoided, and generally no disassembly is necessary. Selective plating techniques are explained in detail. Selectrons, Ltd.

CIRCLE NO. 357

Computer amplifiers

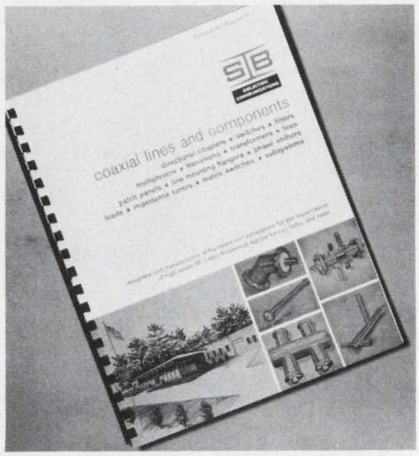
A 116-page technical manual contains detailed information on design philosophy, equipment selection and practical feedback circuits for modern operational solid-state amplifiers. The manual acquaints the reader with the capabilities of op amps and equips him to think creatively in the language of analogs. It includes a reference dictionary of nomenclature and symbology. Philbrick/Nexus Research.

CIRCLE NO. 358

Thermoelectric manual

A 104-page manual covers a complete line of thermoelectric products. Termed the most complete thermoelectric publication in the industry, the catalog includes application notes and technical data on thermoelectric components, assemblies, power supplies, temperature controllers, instruments and accessories. Cambridge Thermionic Corp.

CIRCLE NO. 359



Coax components handbook

A 72-page application manual provides detailed design data for selecting coaxial components. Diagrams, graphs, and product photos, along with easy-to-use ordering information are included. Dielectric Communications Div. of Sola Basic Industries.

CIRCLE NO. 360

Permanent magnets

A 2-page bulletin explains permanent magnets. Through the theory of locked-in magnetic domains it tells how a permanent magnet acts as an energy converting device, rather than an energy storing device. The bulletin discusses three reasons why a permanent magnet can become demagnetized, and the metallurgical and magnetic factors that affect the magnetic domains. It briefly explains unstable domains, vibration and shock, elevated temperatures, external magnetic fields, contact with ferromagnetic material and changes in the magnetic circuit, and their effect on magnetic remanence. Indiana General Corp.

CIRCLE NO. 361

Tape topics

Designed to provide semi-technical background information on magnetic recording tape, a series of quarterly bulletins will cover topics relating to audio recording tape. 3M Co., Magnetic Products Div.

CIRCLE NO. 362

Cathode-ray tubes

A comprehensive literature package comprises seven application notes on various aspects of cathode-ray tube technology. The topics include CRT resolution measurement, cutoff conversion, spot-size measurement and phosphors. Two of the notes discuss high-resolution cathode-ray tubes, and an 11-page technical bulletin covers fiber optics and their applications. Westinghouse Electric Corp., Electronic Tube Div.

CIRCLE NO. 363

Varistor brochure

A technical bulletin discusses varistors, nonlinear resistors with large negative voltage coefficients. In addition to complete product information that includes electrical and physical specifications and characteristic curves, the new bulletin contains a thorough treatment of varistor applications, along with typical circuit diagrams. The Carborundum Co.

CIRCLE NO. 364

Dc clutches and brakes

Emphasizing the factors involved in specifying the proper unit for a particular application, a six-page article briefly discusses the operating principles of dc clutches and brakes. Rules of thumb and formulas are listed as working guides to proper application. Stearns Electric Corp.

CIRCLE NO. 365

Capacitor data

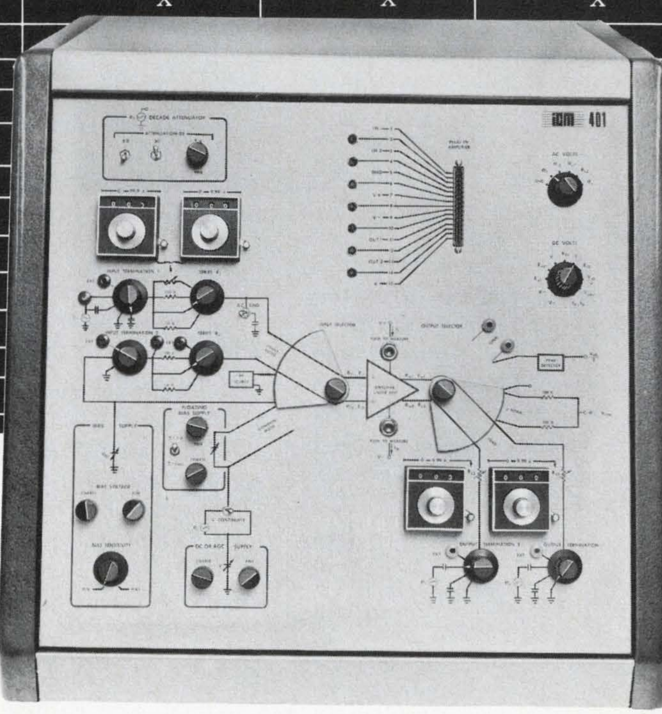
A 24-page engineering bulletin on stabilized wax and subminiature metal-clad paper capacitors includes complete standard ratings, performance characteristics, and size information. A double-spread nomogram for determining ac ratings is also included. Sprague Electric Co.

CIRCLE NO. 366

IC METRICS, INC.

Parameters	SYMBOL	Amplifier Types and Configurations: Differential, Video, RF, General Purpose	Operational, Wide Band, IF, Audio Frequency	Audio Frequency, Video, IF, RF, Wide Band, HF, General Purpose
AC Unbalance	U	X		
Automatic Gain Control Range	AGC	X	X	X
Bandwidth	BW	X	X	X
Common-Mode Input Voltage Range	V_{cmi}	X	X	
Common-Mode Output Voltage	V_{cmo}	X		
Common Mode Rejection Ratio	CM_{rr}	X	X	
Common-Mode Voltage Gain	A_c	X		
DC Power Dissipation	P_d	X	X	X
Differential Input Impedance	[illegible]	[illegible]	X	
Differential Voltage Gain	[illegible]	[illegible]	X	
Input B[illegible]urrent	[illegible]	[illegible]	X	
Input O[illegible]Current	[illegible]	[illegible]	X	
Input Of[illegible]urrent	[illegible]	X	X	
Input Off[illegible]oltage	[illegible]	X	X	
Input Offs[illegible]	D_{vio}	X	X	
Maximum Ou[illegible]oltage Swing	V_{om}	X	X	X
Maximum Single-Ended Input Voltage	V_{sei}	X	X	X
Noise Figure	NF	X	X	X
Output Impedance	Z_o	X	X	X
Output Offset Voltage	V_{oo}	[illegible]	[illegible]	[illegible]
Phase Margin	PHM	[illegible]	[illegible]	[illegible]
Power Gain	PG	[illegible]	[illegible]	[illegible]
Power Supply Rejection Ratio	PS_{rr}	[illegible]	[illegible]	[illegible]
Quiescent Input Voltage	Vi	[illegible]	[illegible]	[illegible]
Quiescent Output Voltage	V_o	[illegible]	[illegible]	[illegible]
Single-Ended Input Impedance	Z_i	[illegible]	[illegible]	[illegible]
Single Ended Voltage Gain	A_v	[illegible]	[illegible]	[illegible]
Slew Rate	SL_r	[illegible]	[illegible]	[illegible]
Total Harmonic Distortion	THD	[illegible]	[illegible]	[illegible]
Transient Response		[illegible]	[illegible]	[illegible]

UNIQUE



LINEAR INTEGRATED CIRCUITS

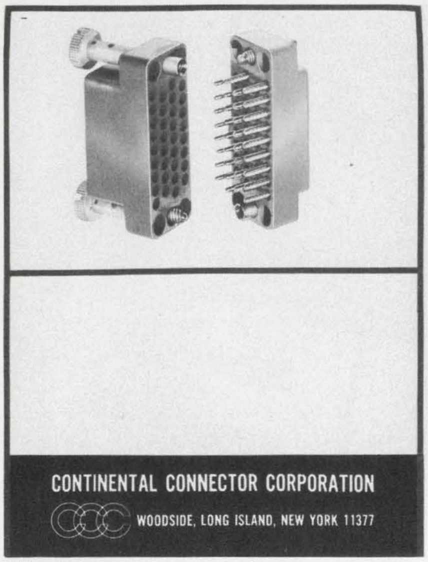
- REPEATABLE MEASUREMENTS
- STANDARDIZED METHOD
- **Quantitative measurement of 24 Parameters**
- **Perform go no-go testing**
- **Determine performance characteristics under extra-ordinary conditions**

Unique? very much so! Only IC Metrics offers a Linear Integrated Circuit Tester capable of evaluating 24 static and dynamic parameters. Model 401 can be used for all linear integrated circuits now in use and operates in conjunction with standard laboratory auxiliary equipment.

IC METRICS, INC.
121-03 Dupont Street, Plainview, L.I., N.Y. 11803
Representatives Inquiries Invited

INFORMATION RETRIEVAL NUMBER 143

New Literature



Miniature connectors

Miniature and microminiature rectangular plug-and-socket connectors, and crimp termination removable contacts that conform to MIL-C-22875 specifications, are described in a 28-page catalog. Complete specifications and detailed information, along with data on automatic and hand-operated crimping tools, are included. Continental Connector Corp.

CIRCLE NO. 367

Gold plating

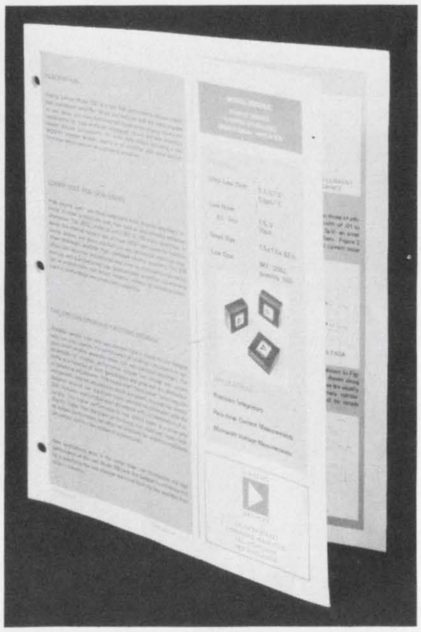
Free reprints are available of a technical article dealing with the electroplating of gold onto high-reliability electronic devices. The article discusses development of a plating specification and process for gold plating components used in semiconductor devices. Technic, Inc.

CIRCLE NO. 368

Rubber grommets

An eight-page catalog contains information about hundreds of grommets (commercial and mil spec) and bumper feet. For ease of selection, physical dimensions of these parts are listed in ascending order, according to outside diameter, inside diameter, height, etc. Russell Industries, Inc.

CIRCLE NO. 369



Operational amplifiers

Included in a four-page data sheet and application note are specifications and application information for chopper stabilized operational amplifiers. Encapsulated into conventional op-amp cases, these amplifiers employ hybrid circuitry and MOSFET choppers to provide a low voltage drift (0.1 $\mu V/^{\circ}C$); they feature low price ($67 in 100-lots, $89 singly), and small size. Analog Devices, Inc.

CIRCLE NO. 370

Photoelectric controls

A bulletin describing transistorized photoelectric controls includes descriptions, features and specifications. Information is given on sensing heads, coaxial scanners, light-source transformers, lamp burn-out relays, and electromagnetic counters. General Electric.

CIRCLE NO. 371

Rf coils

Rf coils with Qs up to 157 are listed in a four-page flyer. These tunable devices are usable at vhf, and some at over 500 MHz. Coil-Craft, Inc.

CIRCLE NO. 372

Convection heat sinks

Describing a complete line of natural convection heat sinks, a new catalog covers 21 different models ranging from miniature-sized milliwatt transistor and diode coolers to king-size, high-power radial-fin heat sinks. To aid the engineer in specifying the most efficient model, a section on heat sink applications explains the general principles of heat transfer, as applied to cooling of semiconductors. George Risk Industries, Inc.

CIRCLE NO. 373

Disc-pack tester

Performance specifications of a new instrument for high-speed testing of the IBM 2311 compatible disc pack are available in a 12-page booklet. The brochure describes the four operational modes of the device, which takes about five minutes to detect, interpret and record the location of every error on the pack. Peripherals Inc.

CIRCLE NO. 374

Relays and switches

A six-page product-line summary features a comprehensive selection of electromechanical relays and switches. The components illustrated include many types standard to industry, as well as new proprietary specialties that were developed to solve modern system packaging problems. ITT Jennings.

CIRCLE NO. 375

WE GOT 'EM, YOU GET 'EM.

You've heard by now about the new Dumont. Now we'll tell you about the great Dumont products you can order **today.** Like our 700 series 'scopes, including the great 766H, our 'scope cameras, signal generators and . . . well, more. All ready now for shipment within twenty-four hours after we get your order. So just turn a peeled eye below and see what you need, want, are curious about, don't believe or would like to know more about. Then call our rep, call us, write or mail the coupon below and you'll get yours . . . fast.

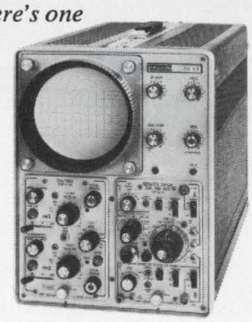
DUMONT OSCILLOSCOPE LABORATORIES, INC.
40 Fairfield Place West Caldwell, New Jersey 07006
(201) 228-3665/TWX (710)-734-4308

DUMONT
OSCILLOSCOPE LABORATORIES, INC.

Oscilloscopes:

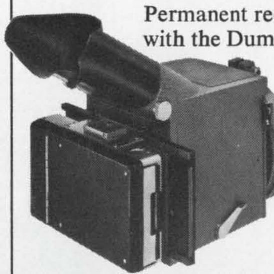
Beautiful. We now have in stock and are ready to ship these complete lines of 'scopes, many of which have the highest writing rate, 13 Kv acceleration and high light output, frequency range DC to 100 MHz, rise time to 3.5 ns., 5 sec/div to 5 ns/div.

Here's one



DUMONT 766H with silicon solid state circuitry, no-fan 200 watts power consumption, greater display area, fully interchangeable X and Y plug-ins, internal graticule, and . . . well, what more could you want?

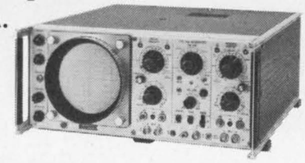
Oscilloscope Camera Systems:



Permanent records of your readings with the Dumont 'scope camera. Can be equipped with a Polaroid Back for instantaneous recording and reading or comparing. Fits any 5" 'scope. 35 mm, anyone?

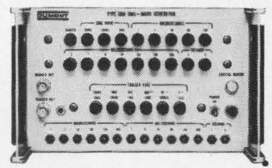
More Oscilloscopes:

DUMONT 704A. Complete line of rack or bench low frequency, high sensitivity, low cost 'scopes.



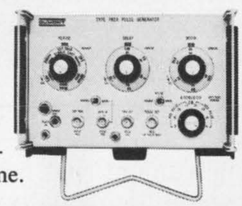
Pulse, Square Wave and Time Mark Generators

DUMONT 781A
Time Mark Generator
Extremely precise and accurate time markers. Provides 14 time markers, 6 trigger rates and 3 sine wave outputs. This time mark generator is among the smallest and lightest available and has very low power consumption.

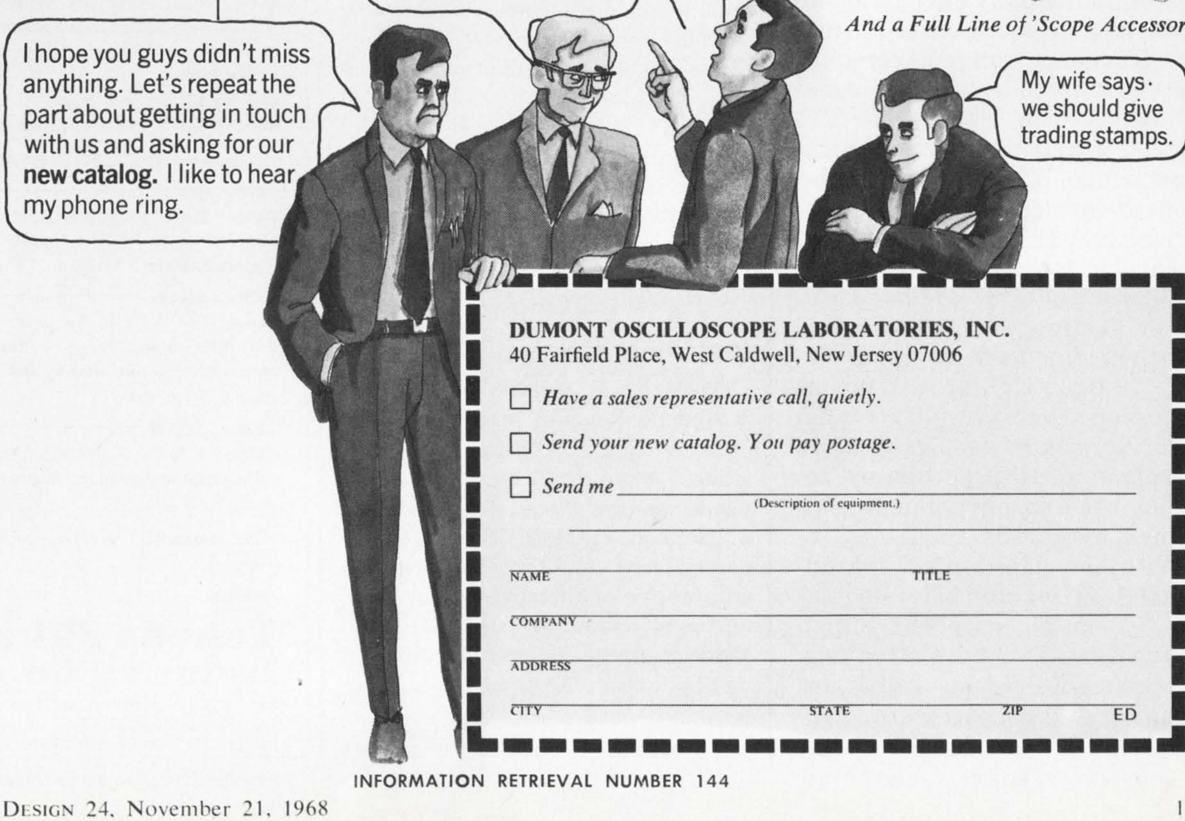


DUMONT 791
Square Wave Generator
Gives nanosecond rise and fall times, extremely wide operational frequency range, from 7 Hz to 10 MHz.

DUMONT 792A
Pulse Generator
50 Hz to 10 MHz rep rate, double or single pulse, single shot operation. Gives nanosecond rise and fall time.



And a Full Line of 'Scope Accessories



DUMONT OSCILLOSCOPE LABORATORIES, INC.
40 Fairfield Place, West Caldwell, New Jersey 07006

☐ *Have a sales representative call, quietly.*

☐ *Send your new catalog. You pay postage.*

☐ *Send me* ____________________
(Description of equipment.)

NAME ______ TITLE ______

COMPANY ______

ADDRESS ______

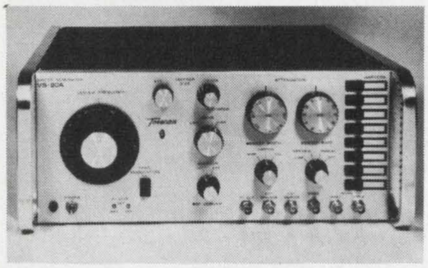
CITY ______ STATE ______ ZIP ______ ED

7A

INFORMATION RETRIEVAL NUMBER 144

Advertisement

Sweep/Signal Generator

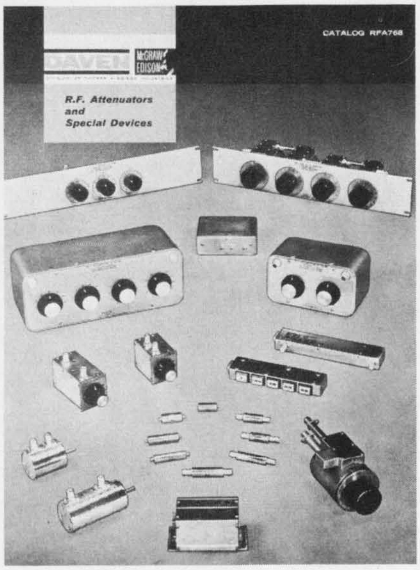


Texscan Corporation,
2446 North Shadeland Ave.,
Indianapolis, Indiana.
Phone: (317) 357-8781.
Price: $1550.
Delivery: 2 Weeks.

The VS-80, in a single two band instrument, covers the frequency range of 1 to 1200 MHz with up to 400 MHz sweep width. This solid state instrument provides an RF output level of at least 0.5 volts rms over this complete frequency range. This instrument finds wide application as a general lab unit and for field installations where a minimum number of instruments can be maintained. Its wide frequency coverage, wide sweep width capability and excellent CW characteristics result in an instrument that can provide test capabilities usually only available from two or more instruments. The frequency range covered by the VS-80 includes all the normal IF bands, the FM, VHF TV, UHF TV and most communications bands. The instrument can be used for radar and communications RF, IF and video testing. It can be used as a chirp radar simulator and for wide band amplifier testing. Its stability is sufficient for narrow band circuit testing. This instrument could conceivably replace signal generators and sweep generators in repair facilities, thereby reducing the total instrument complement required.

With the addition of the optional 1 kHz amplitude modulation, it is an excellent signal source for use with a slotted line. The variable sweep rates are ideally suited to x-y recorder applications.

INFORMATION RETRIEVAL NUMBER 145



Attenuator catalog

Precision rf attenuators and special devices are the subject of a 16-page catalog. Described and illustrated are devices that operate at frequencies to 500 MHz and higher. Daven Division of McGraw Edison.

CIRCLE NO. 376

Wire catalog

ITT has issued a comprehensive 52-page catalog that describes hookup wire, airframe wire, coaxial and CATV cables, and audio and marine cables. The coaxial-cable section contains an RG/U table for all cable configurations, and a complete attenuation table. Indexed inside the back cover are all commonly used military and government wire specifications. ITT Wire and Cable Div.

CIRCLE NO. 377

Instrumentation

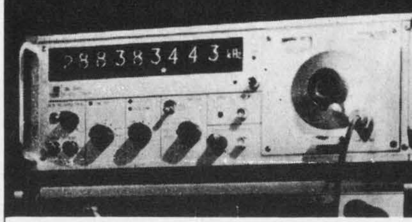
Modern dc techniques and instrumentation for production, test and calibration purposes that include manual and automated operation are covered in detail in a 16-page catalog. Featured are descriptions and specifications of a wide range of instruments, systems and components. A special section containing theory and information on application is included. Julie Research Laboratories, Inc.

CIRCLE NO. 378

12.5GHz

with -*TR*-3016 Frequency Converter Plug-in

250 MHz -*TR*-5589L Universal Counter



- Counts directly up to 250 MHz in decimal form, up to 500 MHz with prescaler plug-in, covers 10 Hz to 12.5 GHz with plug-ins.
- Interchangeable plug-ins increase versatility.
- Timing resolution of 10 nanosec.
- High input sensitivity···10mV rms. with ANS(Automatic Noise Suppressor)mode.
- 5 parts in 10^{10} per day time base stability.
- 9-digit storage display.
- BCD (8-4-2-1) code output is available.

Plug-ins for -*TR*- 5589L

-*TR*- 3083
Range: 10 Hz to 500 MHz/Input Voltage: 10mV rms. to 2V rms./Input Impedance: Approximately 50 ohms

-*TR*- 3015
Range: 500 MHz to 4.5 GHz, covering in 200 MHz steps/Input Voltage: 100mV rms. min./Input Impedance: Approximately 50 ohms.

-*TR*- 3016
Range: 4 to 12.5 GHz/Input Voltage: —7 dBm/Input Impedance: Approximately 50 ohms.

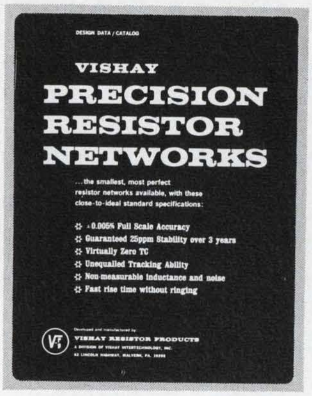
For details, write,

TR

Takeda Riken Industry Co., Ltd.
285, Asahi-cho, Nerima-ku, Tokyo 176, Japan
Tel: Tokyo 930-4111
Cables: TRITRONICS TOKYO

INFORMATION RETRIEVAL NUMBER 146

FREE 16-PAGE SHORT COURSE



The standard specs on the cover above tell you these are networks with total performance never before available. The other pages tell you the how and where . . . how and where this performance is needed and important...how and where Vishay (and only Vishay) achieves it...how simple network design can be and where you can get experienced assistance. There's even a streamlined Design Check List that'll bring you an immediate quote.

About the only thing we've left out it just how much less this total performance can cost . . . and how much time you'll save (in design and delivery).

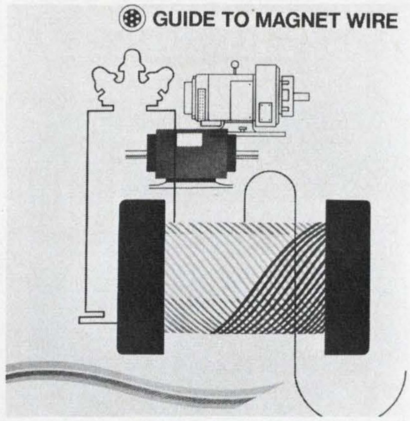
To find out, send for your copy of this Design Data/Catalog today. Return the Checklist with your application's specs (we're used to meeting the tightest). We promise a quick response (and quick delivery when you order).

Write to Vishay Resistor Products, 76 Lincoln Highway, Malvern, Pa. 19355

VISHAY RESISTOR PRODUCTS

a division of Vishay Intertechnology, Inc.

INFORMATION RETRIEVAL NUMBER 147



Guide to magnet wire

Issued to simplify the task of selecting magnet wire by insulation classifications as well as by trade names, a 12-page magnet wire guide contains an easy to read cross reference chart that shows over 200 trade names, applicable to each type of insulation offered by 15 manufacturers in the field. Thirty-one sections in the booklet describe advantages and disadvantages of various types of film and served-wire insulations. General Cable Corp.

CIRCLE NO. 379

Lighting products

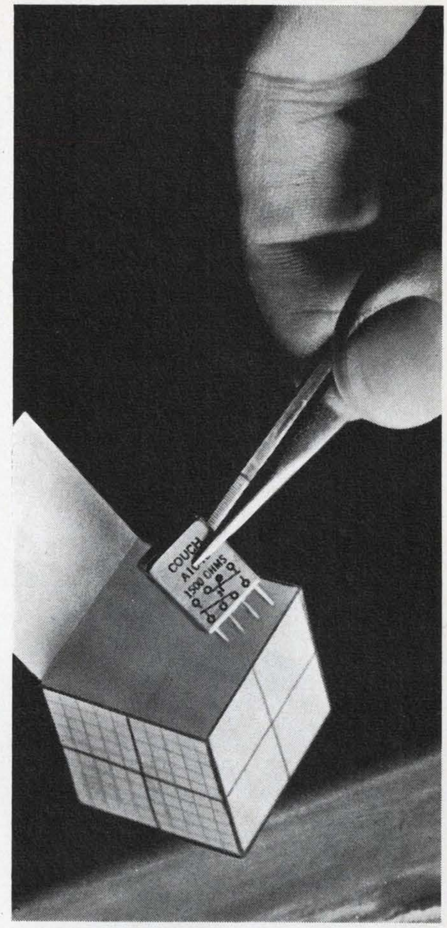
A 16-page lighting guide that is actually four catalogs in one, has been designed to aid in selecting lamps and lampholders best suited to particular applications or products. Various sections cover lamps, lampholders, brackets and indicator lights. Leecraft Manufacturing Co., Inc.

CIRCLE NO. 380

Pressure transducers

An eight-page booklet that describes wafer-thin and flush-diaphragm types of subminiature pressure transducers offers information on a wide variety of special configurations. It includes transducers that operate up to 400°F and describes a special cooling jacket that extends operating temperatures to over 1000°F. Sensotec Div. of Scientific Advances, Inc.

CIRCLE NO. 381



Couch 2X 1/7-size relays meet MIL-R-5757D/19 in 1/25th of a cubic inch

The new, third generation Couch 2X relays solve switching problems where space and weight are critical. Thoroughly field-proven in electronic and space applications. Relays are delivered *fully tested.* Additional screening tests available at your option.

	2X (DPDT)	1X (SPDT)
Size	0.2"x 0.4"x 0.5"	same
Weight	0.1 ox. max.	same
Contacts	0.5 amp @ 30 VDC	same
Coil Operating Power	100 mw 150 mw	70 mw 100 mw
Coil Resistance	60 to 4000 ohms	125 to 4000 ohms
Temperature	—65°C to 125°C	same
Vibration	20 G to 2000 Hz	same
Shock	75 G, 11 Ms	same

Broad choice of terminals, coil resistances, mounting styles. Write for detailed data sheets.

RUGGED ROTARY RELAYS *Dynamically and Statically Balanced*

Couch 1894

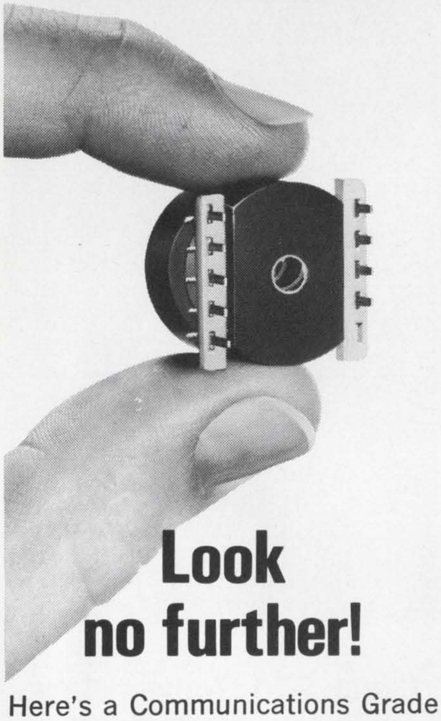
COUCH ORDNANCE INC.

3 Arlington St., North Quincy, Mass. 02171
Area Code 617 CYpress 8-4147
A subsidiary of S. H. COUCH COMPANY, INC.

INFORMATION RETRIEVAL NUMBER 148

SANGAMO

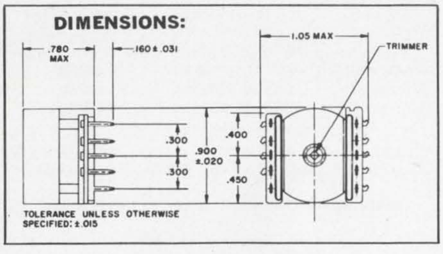
TUNABLE TONE FREQUENCY TRANSFORMERS



Here's a Communications Grade tone frequency transformer as attractive in quality as it is in price. Designed for use in push-button telephones, in data sets, in any oscillator circuit requiring adjustable transformers.

Stock items available in a low frequency design from 694 to 937 Hz and a high frequency transformer from 1207 to 1633 Hz with a ±3% frequency adjustment.

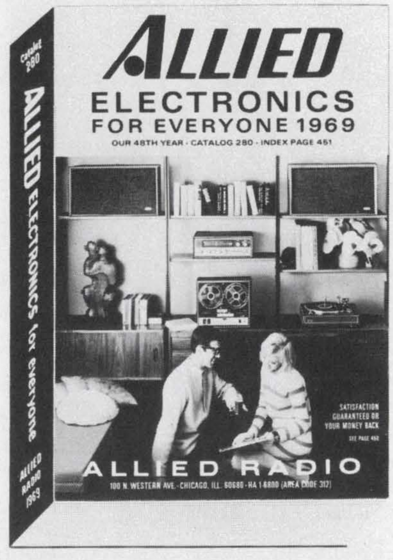
Price: 50 for \$2.59 each; 250 for \$2.25 each. Larger quantity pricing available on request.



Communication Systems
SANGAMO ELECTRIC COMPANY
Springfield, Illinois 62705 T68-11

INFORMATION RETRIEVAL NUMBER 149

NEW LITERATURE



Allied 1969 catalog

Supplementing their previously announced industrial catalog, Allied Radio's general catalog, *Electronics for Everyone,* is now available on request. The 536-pp book presents the latest in electronics products and gadgetry. Both industrial products and consumer goods are included. Allied Radio Radio Corp.

CIRCLE NO. 382

Government specs

A 20-page catalog lists Government specifications and Federal stock numbers for a wide variety of adhesives, coatings and sealers. The catalog includes specification and stock number descriptions, and discusses intended applications with regard to use of the proper adhesive, coating or sealer for meeting specified requirements. 3M Co., Adhesives, Coatings and Sealers Div.

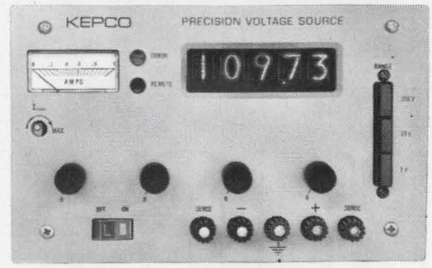
CIRCLE NO. 383

Numerical displays

A new catalog describes a comprehensive line of numerical displays, counters, memories, tubes and accessories. The six-page brochure provides complete specifications and line drawings with complete ordering information and prices. Integrated Circuit Electronics, Inc., a Datatronics Co.

CIRCLE NO. 384

KEPCO



Model PVS 100-1M-Price \$875.00

DIGITALLY CONTROLLED VOLTAGE

KEPCO'S PRECISION VOLTAGE SOURCE features a 4½ digit voltage readout with four rotary selectors and a three-button decade range switch. The combination provides 100 microvolt sensitivity in ranges of: 0.0000 – 1.0999 volts
00.000 – 10.999 volts
000.00 – 109.99 volts

Model PVS 100–1M is a husky power supply capable of delivering 100 watts with a source impedance less than 1 milliohm at d-c. Line variations (105-125V a-c) have less than 0.0005% effect on the output setting and the oven-controlled reference, reduces temperature effects to 0.005% per °C.

The overall accuracy of 0.02% qualifies the Precision Voltage Source as a working standard for low cost voltage calibration.

For systems, the output can be programmed by remote 1-2-4-8 BCD switch closures.

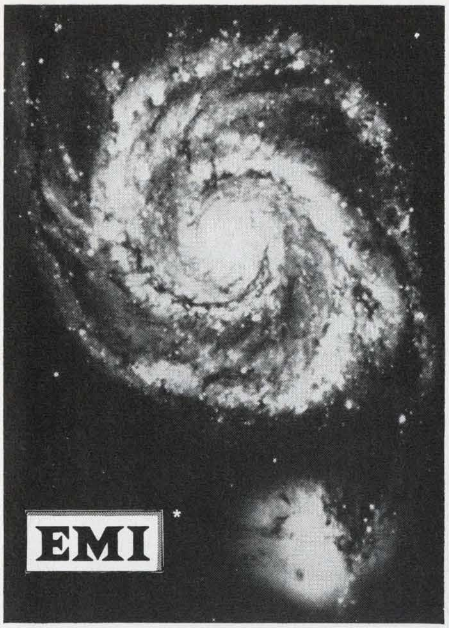
For more information, write Dept. AV-5 for Kepco's new catalog supplement.

with* KEPCO *IT'S CONTROL!

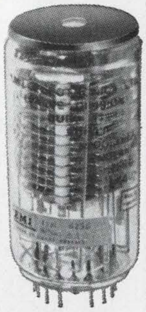
kepco®

131-38 SANFORD AVENUE • FLUSHING, N.Y. 11352
(212) 461-7000 • TWX #710-582-2631

INFORMATION RETRIEVAL NUMBER 150



Measuring low light levels

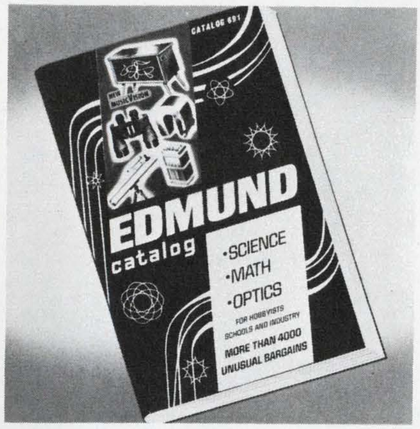


...requires extremely low dark currents coupled with maximum useful sensitivity. The EMI 6256, a 13-stage venetian blind 2" photomultiplier tube has the essential characteristics that are necessary for low light level applications. The unique 10mm cathode-DI geometry, together with the ultra-stable EMI venetian blind design, has resulted in its widely successful use in astronomy, biology and spectrophotometry. The EMI 6256B has a quartz window and the S-11 cathode (S-13) which has a peak quantum efficiency of 17% at 4,200 A. The EMI type 6256S has 5 to 10 times lower dark current than the 6256B, and should be used when system performance is dark current limited. This type is also available for visible light applications as 9502B/9502S, or with 11 dynodes as 6094B/6094S. Many other EMI photomultiplier tubes are available for special applications from stock in sizes from 1" to 12". EMI photomultiplier tubes are available through qualified engineering representatives located in major marketing areas throughout the United States. A request on your company letterhead will bring you the name of your nearest representative as well as a copy of our latest catalog.

Whittaker CORPORATION
GENCOM DIVISION

80 Express St., Plainview, L. I., N. Y.
516-433-5900 TWX 516-433-8790
*EMI ELECTRONICS, LTD.

INFORMATION RETRIEVAL NUMBER 151



Edmund catalog

A valuable tool for engineers and procurement people, Edmund Scientific's latest catalog is hot-off-the-press. Contained in its 148 pages is a vast assortment of hardware, instruments, and equipment that ranges from ultrasonic cleaning equipment to motors and optical goods. Edmund Scientific Corp.

CIRCLE NO. 385

Resistance alloys

Covering a family of nickel-chromium electrical resistance alloys, a 35-page handbook includes data on the properties of wire, ribbon and strip sizes. A 10-page section covers such topics as heating element design with tables on current-temperature relationships. Three pages of reference tables include wire gauge and decimal equivalents, temperature conversion tables and a listing of miscellaneous conversion factors. Hoskins Manufacturing Co.

CIRCLE NO. 386

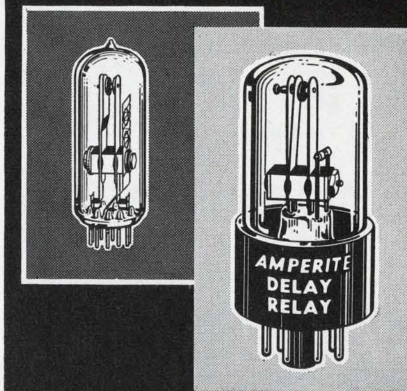
Relay catalog

Providing technical and buying data on more than 500 electromechanical relays and opto-electronic components, a 20-page catalog introduces three new product lines. All products are illustrated, with dimensions, and descriptive copy and tabular data provide basic specifications, ordering information and prices. Sigma Instruments, Inc.

CIRCLE NO. 387

AMPERITE

Thermostatic DELAY RELAYS



Only a glass seal offers true hermetic sealing
... assuring maximum stability and life!

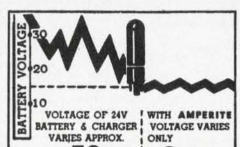
Delays: 2 to 180 seconds . . Actuated by a heater, they operate on A.C., D.C., or Pulsating Current . . . Being **hermetically sealed,** they are not affected by altitude, moisture, or climate changes . . . **SPST only**—normally open or normally closed . . . Compensated for ambient temperature changes from —55° to +80° C. . . . Heaters consume approximately 2 W. and may be operated continuously . . . The units are **rugged, explosion-proof, long-lived, and—inexpensive!**

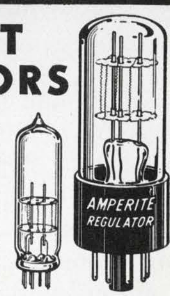
TYPES: Standard Radio Octal, and 9-Pin Miniature.
List Price, $4.00

PROBLEM? Send for Bulletin No. TR-81

AMPERITE

BALLAST REGULATORS





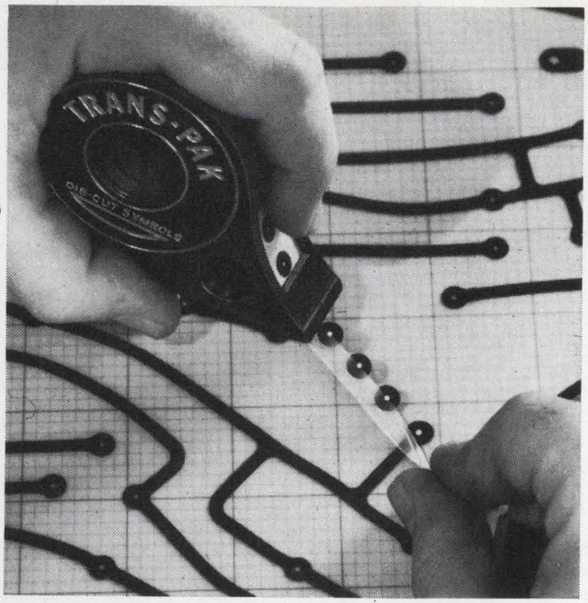
Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—50° to +70° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . **List Price, $3.00.**
Write for 4-page Technical Bulletin No. AB-51

AMPERITE

600 PALISADE AVE., UNION CITY, N.J.
Telephone: 201 UNion 4-9503
In Canada: Atlas Radio Corp., Ltd.,
50 Wingold Ave., Toronto 10

INFORMATION RETRIEVAL NUMBER 152

Chart-Pak® short cuts get printed circuit masters off the board fast!



- Trans-Pak die-cut symbols and Chart-Pak pressure sensitive tapes cut time, cut cost.
- Trans-Pak's unique patented "position, press and peel" method permits fast application of distortion-free symbols.
- Chart-Pak crepe paper tapes precision-slit guaranteed to ±.002" accuracy.
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Newly revised, a 16-page catalog gives pertinent data and the latest prices for 60 standard relays in more than 800 different contact arrangements and coil voltages. Catalog 100 also includes mercury-wetted, dry-reed, high-performance, polarized, sensitive, special-purpose, and power relays. Potter & Brumfield Div. of American Machine & Foundry Co.

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Teflon tech tips

A 12-page brochure describes properties, applications and machining techniques of fluorocarbon basic shapes. The brochure also contains data and uses for FEP fluorocarbon film. Charts and tables show sizes available and where they can be obtained. Other graphs and tables show chemical, electrical and physical properties. Cadillac Plastic and Chemical Co.

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Semiconductor devices

A semiconductor-device catalog that lists a wide variety of transistors, diodes and rectifiers, contains a complete index of all EIA-type designations offered by the company. Included is applicable information on case style, polarity, voltage, dynamic impedance, zener current, zener voltage and other specifications. Semi-Elements, Inc.

CIRCLE NO. 391

Scope topics

Published monthly by Tektronix, Inc., Service Scope covers facts of interest to oscilloscope users and purchasers. A regular feature is a listing of used instruments for sale or wanted. Complimentary subscriptions are available. Tektronix, Inc.

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CIRCLE NO. 394

Materials

Technical information, in condensed form, on silicones, fluorosilicones and solid-film lubricant formulations is offered in a colorful 12-page bimonthly publication. "Materials News" is available free to qualified electronics personnel. Dow Corning Corp.

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Design Data from Manufacturers

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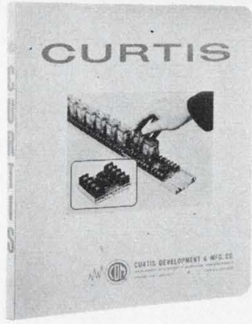
NEW RELAY SOCKET ASSEMBLIES CATALOG



The new Curtis line of printed circuit snap-in track-mounted relay socket assemblies is completely illustrated in this new 2-color, 6 page catalog. Variations include RS8 octal relay sockets, as well as RS11 and RS15 with eleven and fifteen pin relay sockets. Complete dimensional drawings and list prices are included. All units snap in or pop out vertically from prepunched vinyl track and feature Curtis barrier terminal blocks. CSA approved. Send today for your free copy.

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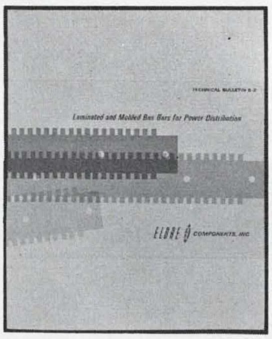

A 16 page Technical Bulletin is now available, describing a new concept in power or signal distribution. Basic mechanical and electrical design principles, along with descriptive pictures and diagrams, are included in this bulletin. These compact buses can replace bulky cable harnesses and repetitive wiring for computer or modular application. This method of construction satisfies the demanding requirements of low inductance and resistance of high speed, solid state systems, while controlling electrical noises.

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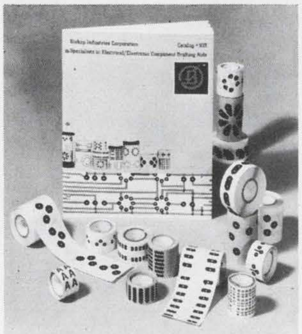

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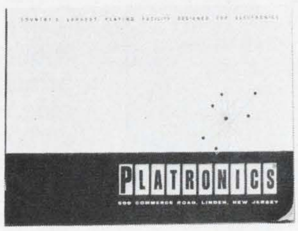
How To Plate Electronic Parts



Details step-by-step procedures for plating electronic components — particularly with precious metals — to maintain functional reliability in the most severe environmental and end-use conditions. Provides a pictorial tour through the country's largest plating facility designed for electronics—from pilot plant operations, to modern volume production techniques and stringent quality control procedures. Also describes prototype sample plating service, to specifications, which the company offers at no cost or obligation.

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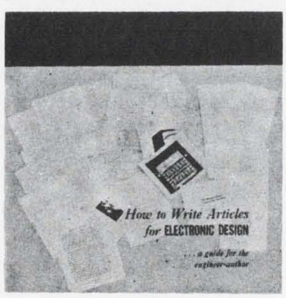
How To Write Technical Articles



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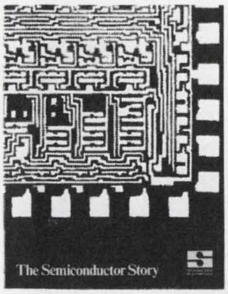

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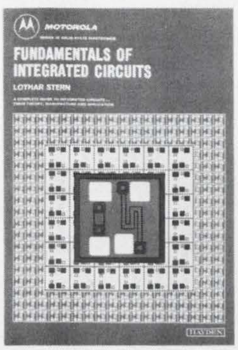

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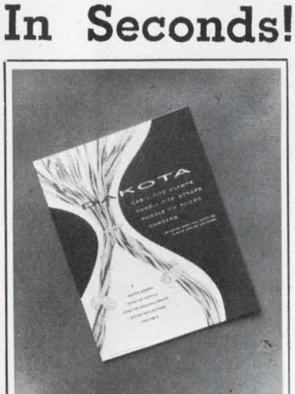

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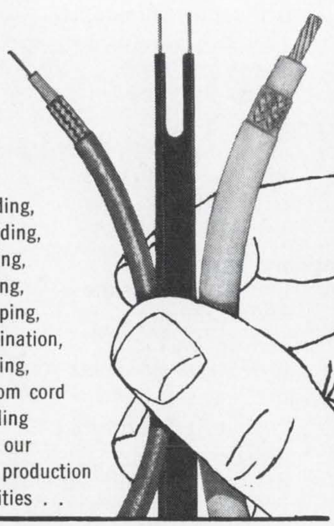

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Advertisers' Index

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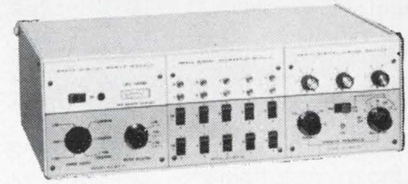

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Models: 8187, printed circuit pins; 8188, stranded vinyl leads; 8189, solder hook; 8184, panel mount version of 8189; 8186, panel mount version of 8188

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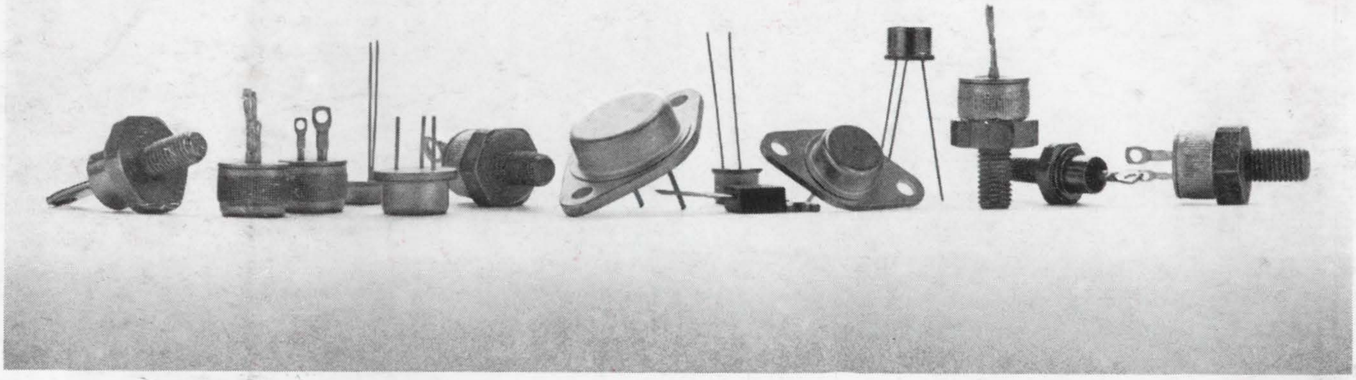

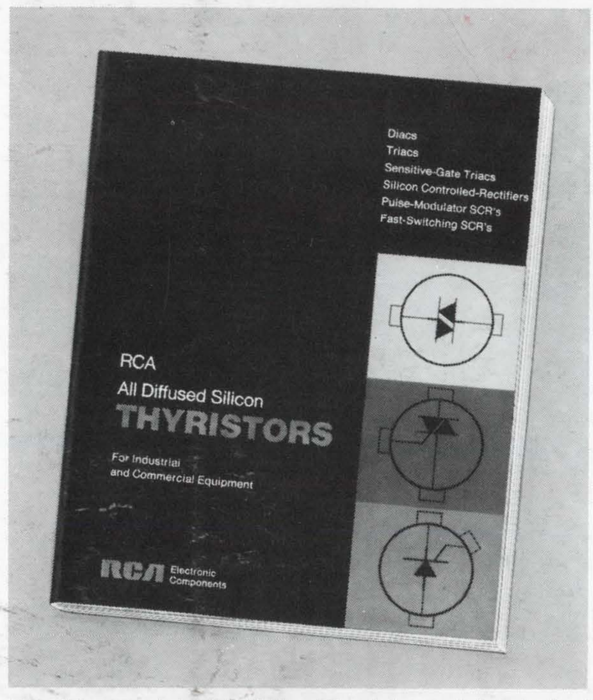

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Company__________

Address__________

City______ State______ Zip______

INFORMATION RETRIEVAL NUMBER 244