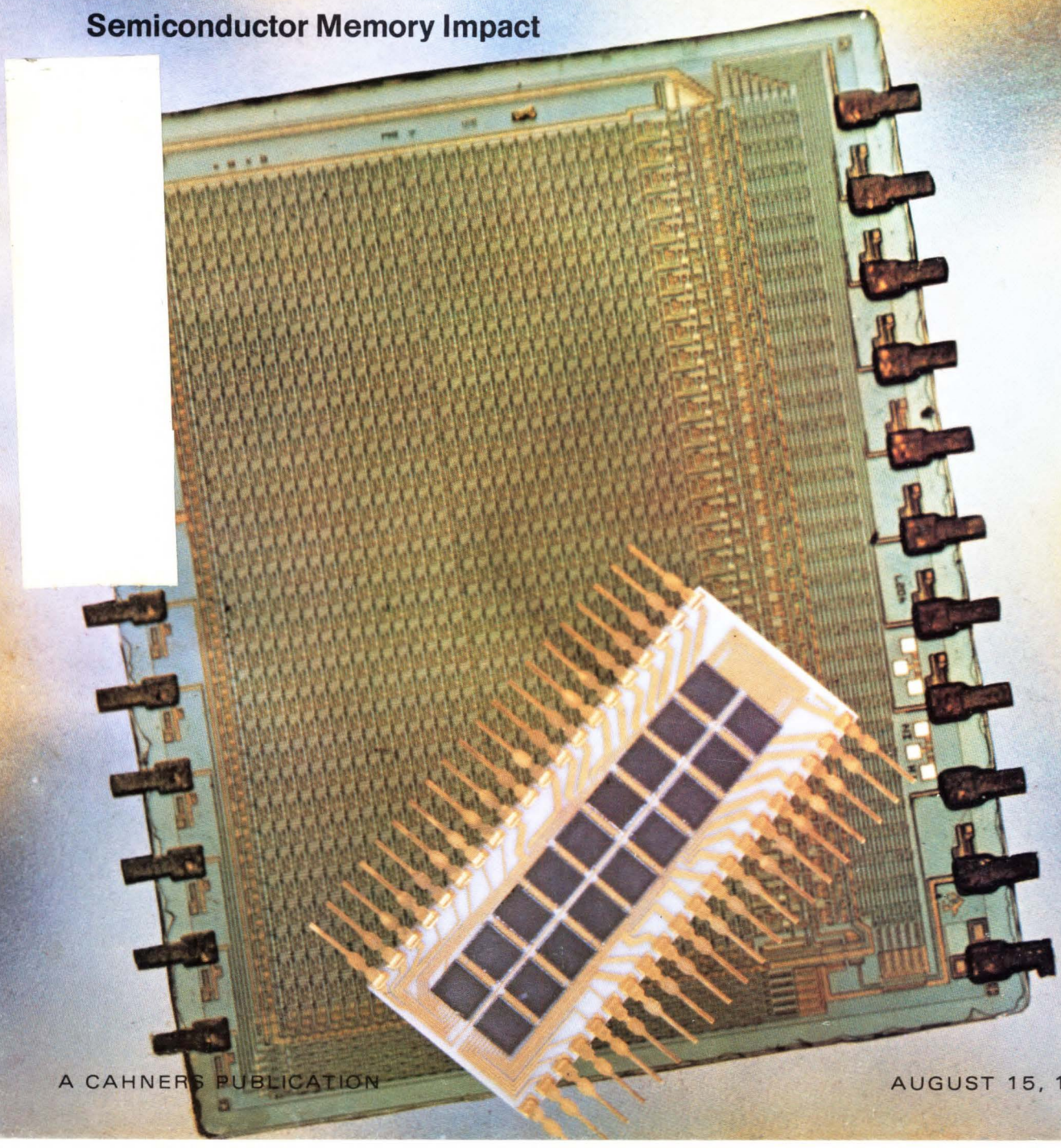
EDN

exclusively for designers and design managers in electronics

EEE

Semiconductor Memory Impact

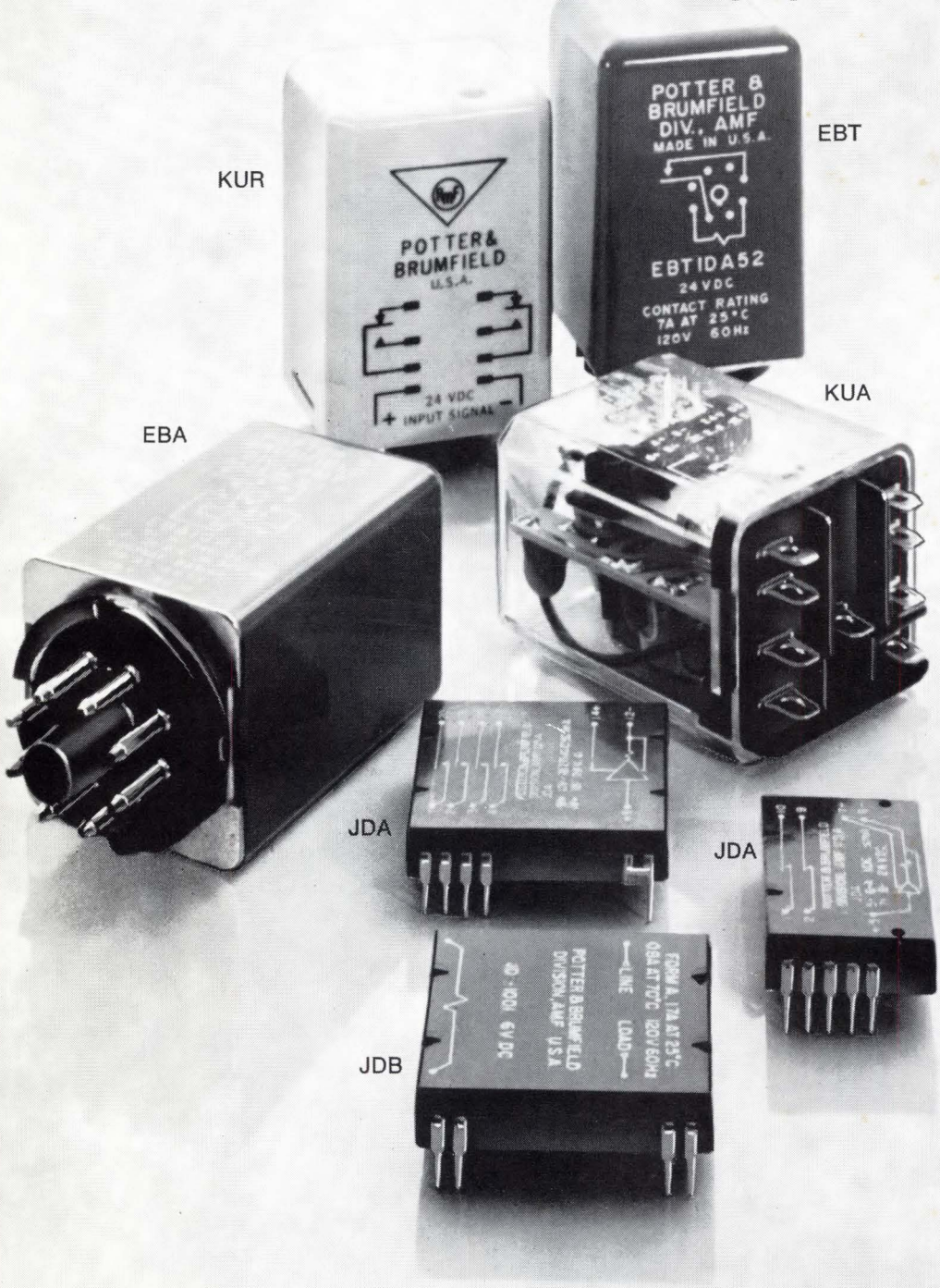


A CAHNERS PUBLICATION

AUGUST 15, 1971

P&B Solid State Hybrid Relays.

We get them by mating semiconductors and relays. You get a whole new range of switching options.



For example, you can interface semiconductor logic circuits with inductive loads like motors, solenoids, contactors. You can use inputs as low as 5 microwatts to switch 7 ampere loads. All with the isolation normal with relays. Wide choice of package sizes and terminations, too.

EBT Solid State Hybrid Relay. A solid state AC switch controlled by a reed relay. It switches 7 amperes rms, 60 Hz at 25°C ambient. Operate time: 2 milliseconds. Coil voltages range from 6 to 48V DC.

EBA Sensitive Solid State Hybrid Relay. Similar to the EBT but with sensitivity as high as 12 microwatts. Available for 12, 18 or 24V DC. Built-in polarity protection. Switching is bounce-free.

KUA Amplifier-Driven Relay. Standard sensitivity: 60 microwatts. DPDT contacts will switch 5 amperes at 28V DC or 120V 60 Hz, 80% PF. Features continuous duty operation, built-in polarity protection.

KUR Alternate, Direct-Action, Impulse Relay. Single coil, DPDT relay has permanent magnet in parallel with normal flux path plus solid state flip-flop circuit. Results? A relay with both permanent memory and alternate action features controlled from a single DC source. Contacts rated 5 or 10 amperes remain in last position without power.

JDA Amplifier-Driven Reed Relay. Low profile Dual Thin-Line reed relay has sensitivity as high as 5 microwatts (96 mw standard). Designed to operate in association with integrated circuits, in particular the output of DTL and TTL logics in current sourcing mode. High input/output isolation. Contact arrangements: 2 Form A and 4 Form A.

JDB Solid State/Reed AC Switch Ideal for interfacing solid state circuits intended to control 120V 60 Hz loads such as fractional HP motors, solenoids, contactors. Seated height: .275". 1 Form A contacts will switch 1.7 amperes at 25°C ambient.

P&B solid state hybrids are available from leading electronic parts distributors. For complete information, call your P&B representative or Potter & Brumfield Division of AMF Incorporated, Princeton, Indiana 47570. Telephone: (812) 385-5251.

AMF
POTTER & BRUMFIELD

P&B performance. Nothing else comes close.

CIRCLE NO. 1

Our new tuning varactors pass the high Q test.

• Q of 2000 in small glass.

Model Number	Total Capac. @ −4V pF 1 MHz	Min. Total Capac. Ratio $C_{T_o}/C_{T_{VB}}$	Min. Q @ −4V @ 50 MHz	Case Style
45 Volt Units				
MA-45103	1.8	4.9	2500	Ceramic Pill
MA-45106	4.7	5.4	2000	Ceramic Pill
MA-45110	4.7	5.4	2000	Do-7 Glass
MA-45164	2.7	5.2	2000	Small Glass
60 Volt Units				
MA-45123	1.8	5.5	2000	Ceramic Pill
MA-45126	4.7	6.5	1500	Ceramic Pill
MA-45130	4.7	6.5	1500	Do-7 Glass
MA-45133	15.0	7.0	900	Do-7 Glass
90 Volt Units				
MA-45141	0.8	5.0	1500	Ceramic Pill
MA-45143	1.8	6.6	1500	Ceramic Pill
MA-45145	3.3	7.5	1000	Ceramic Pill
MA-45147	6.8	8.2	800	Ceramic Pill

MICROWAVE ASSOCIATES
Burlington, Mass. 01803 (617) 272-3000

CIRCLE NO. 2

Someday you'll be able to buy panel meters this good for under $100.

Is today soon enough?

Here are three of the finest digitals around, all designed to fit the industry's most compact front-panel-removable chassis. All for under $100. Two of them you've seen before—the 2½-digit Model 1260 and the 3-digit Model 1261. The 3½-digit Model 1291 is brand new. It features full 100% overrange capability with input impedance as high as 10 megohms per volt.

All three are better on the inside than the usual "economy" models, because they utilize dual slope* circuitry techniques developed by Weston, repairable (non-potted) circuit boards, and top-rated components throughout. Standard options include BCD output and remotely positioned decimal point.

But the best news of all is that Weston has broken the $100 price barrier on the world's foremost DPM line. Choose the ranges and the digits you need—2½, 3, or 3½. Model 1260 costs you only $79.50, Model 1261 is priced at $98.00, and our new Model 1291 at $99.75 in OEM quantities. How's that for value in these days of tight budgets?

*U.S. Pat. #3,051,939

WESTON®

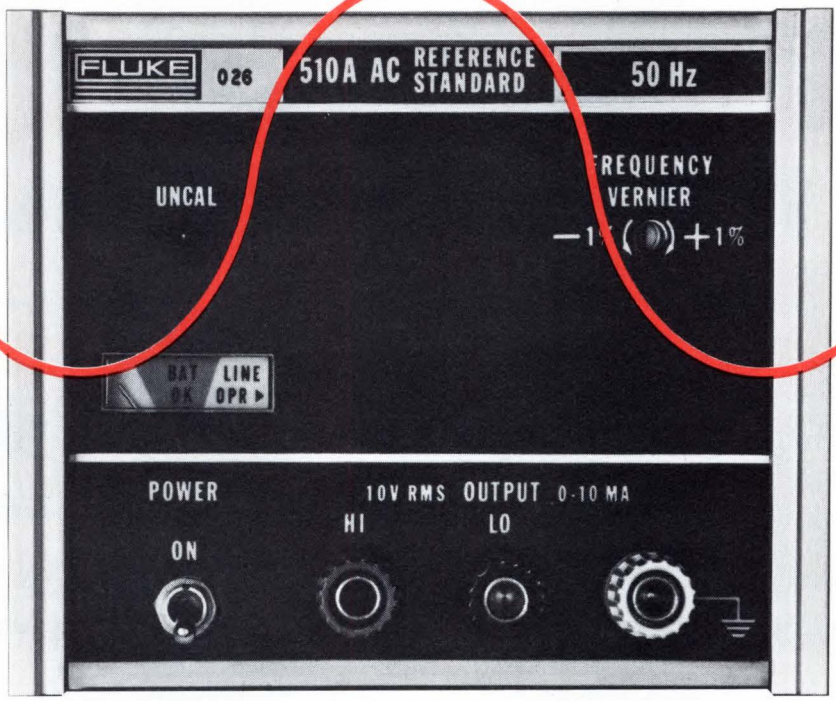
WESTON INSTRUMENTS

614 Frelinghuysen Ave., Newark, N.J. 07114

a Schlumberger company

CIRCLE NO. 3

Our New AC Source, $495. With Rechargeable Battery Pack, $595.



Actual Size

Our new AC Reference Standard, Model 510A gives you accuracy and a wide choice of frequencies with dollars to spare. You can use the new source as a calibration standard or a fixed frequency source for test applications. In the calibration laboratory, the 510A provides an accurate reference for calibrating both true rms and average reading ac voltmeters. On the production line, the 510A can be used to rapidly verify ac test instrumentation or to generate a precise ac stimulus for circuit testing.

Used in conjunction with the new Fluke 4200 Series Programmable Power Sources, the 510A contributes to a very accurate, very stable ac and dc system for automatic test and process control.

Output voltage of the Model 510A is 10 volts rms with an accuracy of ±0.01% for 30 days and ±0.02% for 90 days. Output current is 10 ma rms short circuit protected. Any single fixed frequency output is available from 50 Hz to 100 kHz. Total harmonic distortion is less than 0.005%.

Standard frequencies available at time of order are 50 Hz, 60 Hz, 400 Hz, 1 kHz, 2.4 kHz, 19.2 kHz, and 100 kHz. Other frequencies may be obtained on special order at a price of $50.

An optional rechargeable battery pack provides up to 16 hours of operation without ac line power. Any accurate dc source can be used for calibration.

Up to four 510A's can be mounted side by side and installed in a standard 19" EIA rack.

And you know, you just can't get a 0.01% source for anything like this money elsewhere. Anyway, why would you want to when Fluke's got it?

Model 510A shown in four-up configuration.

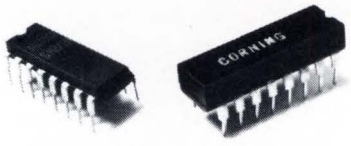
FLUKE®

Fluke, Box 7428, Seattle, Washington 98133.
Phone: (206) 774-2211. TWX: 910-449-2850/In Europe, address Fluke Nederland (N.V.), P. O. Box 5053, Tilburg, Holland. Phone: (04250) 70130. Telex: 884-52237/In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2, 4TT. Phone: Watford, 33066. Telex: 934583.

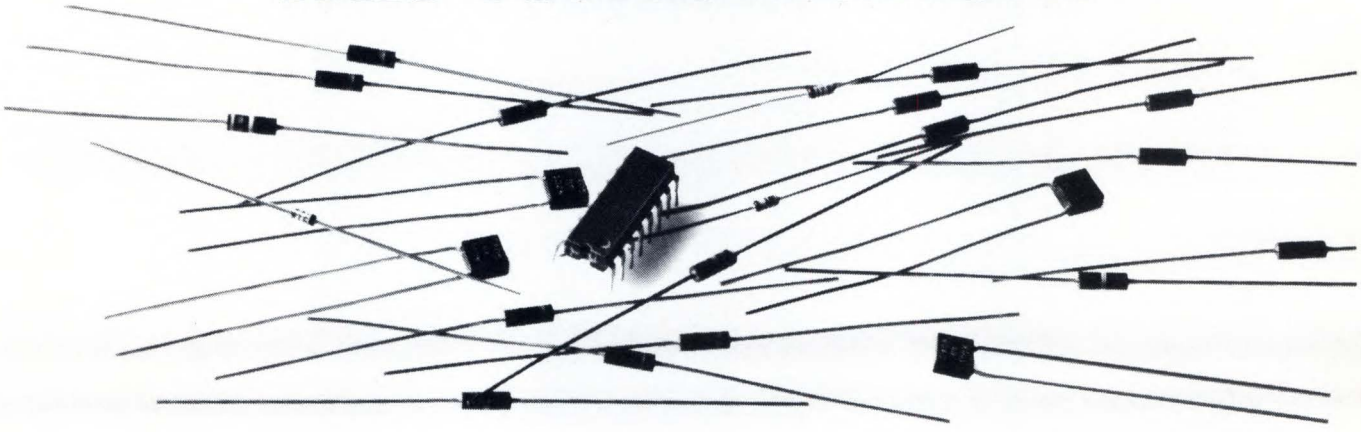
"See us at WESCON Booths 1136-38"

CIRCLE NO. 4

This Combination

Integrated circuit  CORDIP™ Component Network

replaces this combination.



Integrated circuit plus 23 discrete resistors, capacitors, and diodes

Corning's new CORDIP™ component networks take in much of what IC's leave out—outboard discretes.

Unlike screened thick/thin film networks, CORDIP component networks give you custom combinations of discrete resistors, capacitors, and diodes in a dual in-line package.

With combinations of up to 20 components in a standard 14-pin package. Up to 23 in a 16-pin package.

With virtually unlimited circuit complexity. With all inter-connections inside the pretested package.

Which gives you greater reliability and fewer production losses.

Combinations of resistors, capacitors and diodes with different tolerances, temperature coefficients and ratings are available in one package.

Which makes it possible to give you almost any custom combination you specify.

Large orders or small.

And we can make prototypes quickly for you, with almost any combination you specify.

CORDIP component networks are ready to plug in and are fully compatible with IC sequencing and insertion equipment.

CORDIP component networks. You'll save a lot of board space and production costs; you'll gain a lot more reliability and flexibility.

Call or send us your circuit requirements.

Corning Glass Works, Electronic Products Division, Corning, New York 14830.
(607) 962-4444 Ext. 8684.

SPECIFICATIONS

	Resistors	*Capacitors*	*Diodes*
Range	10Ω-150K	10-10,000 pF	Low Signal
Tolerance	from 1%	from 5%	
TC	from 50 ppm	+ 2%, −10%	Silicon Planar
Ratio	>15,000:1	>1,000:1	Types

CORDIP™ COMPONENT NETWORKS
From

CORNING
ELECTRONICS

CIRCLE NO. 5

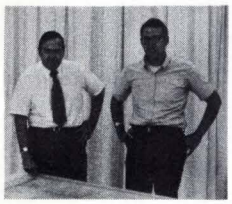
AUGUST 15, 1971
VOLUME 16, NUMBER 16

EDN/EEE

EXCLUSIVELY
FOR DESIGNERS
AND DESIGN MANAGERS
IN ELECTRONICS

Cover

Cover photo furnished by Texas Instruments Incorporated depicts their forthcoming 18k-bit RAM. This fully decoded device makes use of multichip beam-lead technology. See p. 23 for more on "what's happening in semiconductor memories".



Speakout—L. J. Sevin (left) and Bob Proebsting of MOSTEK Speak Out on Selecting MOS ICs. See article on p. 34.

Design News

Design Features

Design Ideas

Circuit Design Award Entries

Design Interface

Progress in Products

Design Products

Design Departments

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ibpa International Business Press Associates
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BROADWAY
W 42 ST

We make components for guys who can't stand failures.

No one likes to be left in the dark. Especially by some "sophisticated" complex of control equipment that failed.

That's why we make our resistors and capacitors for guys who can't stand failures. Guys like your most important customers, guys like you.

We build an extra measure of reliability into all our components to help you build extra reliability into all your systems.

To be specific, we make tin oxide resistors—now including both miniature RLR05's and flame proofs—and glass and Glass-K™ capacitors. They're the best you can get, though they'll cost you no more.

Take our tin oxide resistors—no other resistors can deliver the same stability and reliability over life. They offer guaranteed moisture resistance across all ohmic values, for reliability that can't be matched by metal film, wirewounds, carbon comps or metal glaze resistors.

This kind of extra performance comes in miniature size, too. Our new RLR05 (commercial style C3), developed for dense packaging applications, competes costwise with carbon comps.

And we lead the field with flame proof resistors. Ours will withstand overloads in excess of 100 times rated power without any trace of flame. And because they open rather than short under severe overload, they provide protection for the rest of the system—a vital consideration in critical and expensive EDP, telecommunications, and instrumentation gear.

Or take our glass capacitors. The Air Force has confirmed they have much better stability and much higher insulation resistance than the ceramic, mica, and other capacitor types tested. That's why our glass capacitors have been designed into so many major aerospace and missile projects. And why industry has designed them into the most important EDP and instrument applications.

Or our Glass-K™ capacitors—we developed them to give you the volumetric efficiency and economy of monolithic ceramic capacitors, but with the much improved stability and reliability that only a glass dielectric can add. Our Glass-K™ capacitors are now being used in pacemaker heart units and in several major EDP systems. And these Glass-K™ capacitors can now be used in BX characteristic applications.

As you might expect, both our resistors and capacitors meet Established and High Reliability standards, such as MIL-R-39017, MIL-R-55182, and Minuteman.

At Corning we make components for guys who can't stand failures. Guys like your most important customers. Guys like you.

And even though you might expect to pay a lot more for these features, you don't. Because as the largest manufacturer of these type components, our production volume affords us economies that enable us to be competitive in price.

So the next time you're designing a system, design-in an extra measure of performance. Reach for your CORNING® resistor and capacitor catalogs or look us up in EEM. Or for in-depth technical information write us at: Corning Glass Works, Electronic Products Division, Corning, New York 14830.

Then call your local CORNING authorized distributor for fast off-the-shelf delivery. He not only stocks components for guys who are demanding, but he offers service to match, too.

CORNING
ELECTRONICS

CIRCLE NO. 6

Editorial

It's Time to Start Sticking Our Necks Out Again

While sorting through some old files a few weeks ago, I came across a copy of the August 1948 issue of the Bell Laboratories *Record*. This issue contained an article describing the June 30 press conference in New York at which the invention of the transistor was announced.

The press conference was boldly conducted by Ralph Bown, Bell Labs head at the time, and Bown and his colleagues, including William Shockley, John Bardeen and Walter H. Brattain, went on record to back their belief that the transistor would have "far-reaching significance in electronics and electrical communication." Eight years later the Nobel Prize committee agreed, and Shockley, Bardeen and Brattain were cited for their discovery of transistor action.

In his address, Bown told the press group that the transistor was the first real challenge to the vacuum tube in its 40-year life. He revealed that many Bell Labs researchers had been active in the semiconductor field for several years because its scientists felt that semiconductor devices had practical possibilities and rich scientific interest.

Bown and his colleagues stuck their necks way out at that press conference; they courageously predicted the era of the transistor and its use in radio, television, telephone and countless other applications. The Bell people, of course, were proven to be true prophets in a short period of time.

No doubt you can also remember a few leaders in electronics research who went wildly overboard in lavishing praise for devices that didn't make it big—who can forget the claims made for the tunnel diode shortly after its invention?

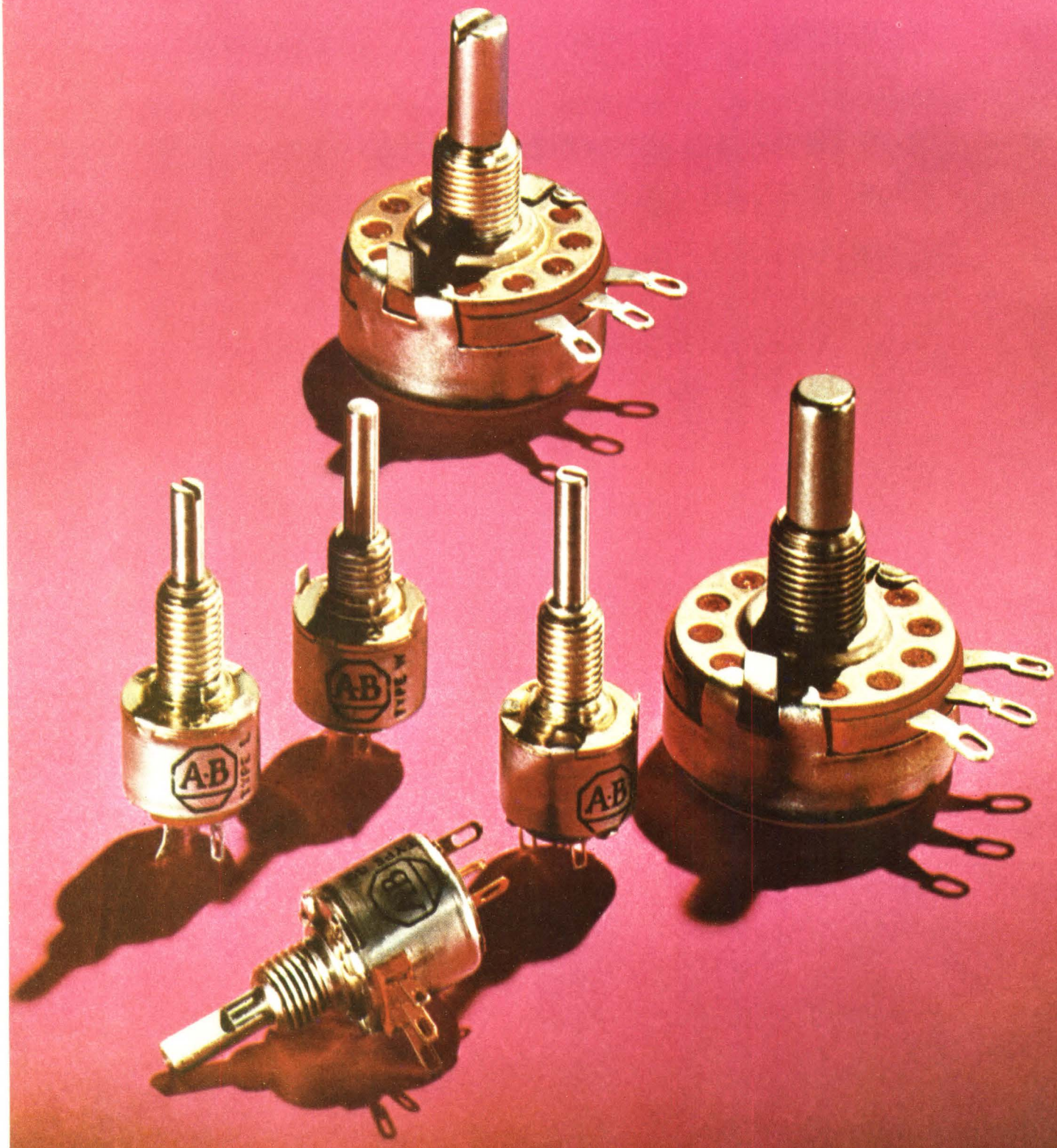
Obviously, not every R&D venture will be a vast success. For every transistor, and even every tunnel diode, there will probably be a thousand or more failures. But although dollars continue to be tight, many companies in the electronics industry have had the sense and have found the money to continue to support and encourage strong R&D efforts.

The electronics industry is coming back, and because many companies have maintained strong R&D positions, we'll be seeing some more "Bowns" sticking their necks out soon. Hope you're one of them.

Jerry Eimbinder

Editorial Director

Fight noise pollution



with this quiet family.

Hot Molding with Allen-Bradley's exclusive technique, gives these composition variable resistors an unusually low noise level. And importantly, this low noise level actually decreases in use. Under tremendous heat and pressure the resistance track is molded into place. A solid element with a large cross-section is produced.

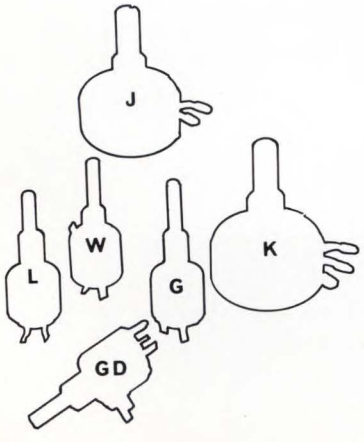
This important Allen-Bradley difference means better short-time overload capacity and a long operating life. Control is smooth, resolution almost infinite. These variable resistors are ideal for high frequency circuits. Why should you trust the performance of your designs or your reputation to anything less than Allen-Bradley quality? Use the most thoroughly "field tested" (over 20 years) variable resistors available today. Quantity stocks of popular types J, G, W and GD available for immediate delivery from your appointed A-B industrial electronics distributor.

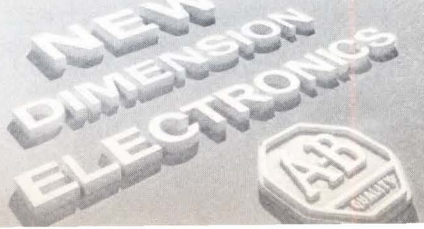
For information write: Marketing Department, Electronics Division, Allen-Bradley Co., 1201 South Second Street, Milwaukee, Wisconsin 53204. Export office: 1293 Broad Street, Bloomfield, N. J. 07003, U.S.A. In Canada: Allen-Bradley, Canada Ltd., 135 Dundas Street, Galt, Ontario.

SPECIFICATIONS

	TYPE J— STYLE RV4	TYPE K	TYPE G— STYLE RV6	TYPE L	TYPE W	TYPE GD
CASE DIMENSIONS	5/8" deep x 1-5/32" dia. (single section)	5/8" deep x 1-5/32" dia. (single section)	15/32" deep x 1/2" dia.	15/32" deep x 1/2" dia.	15/32" deep x 1/2" dia.	35/64" deep x 1/2" dia.
POWER at + 70°C	2.25 W	3 W	0.5 W	0.8 W	0.5 W	0.5 W
TEMPERATURE RANGE	−55°C to +120°C	−55°C to +150°C	−55°C to +120°C	−55°C to +150°C	−55°C to +120°C	−55°C to +120°C
RESISTANCE RANGE (Tolerances: ±10 and 20%)	50 ohms to 5.0 megs	50 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs
TAPERS	Linear (U), Modified Linear (S), Clockwise Modified Log (A), Counter-Clockwise Modified Log (B), Clockwise Exact Log (DB). (Special tapers available from factory)					
FEATURES (Many electrical and mechanical options available from factory)	Single, dual, and triple versions available. Long rotational life. Ideal for attenuator applications. Snap switches can be attached to single and dual.	Single, dual, and triple versions available. Long rotational life.	Miniature size. Immersion-proof. SPST switch can be attached.	Miniature size. Immersion-proof.	Commercial version of type G. Immersion-proof.	DUAL section version of type G. Ideal for attenuator applications. Immersion-proof.

ALLEN-BRADLEY





CIRCLE NO. 8

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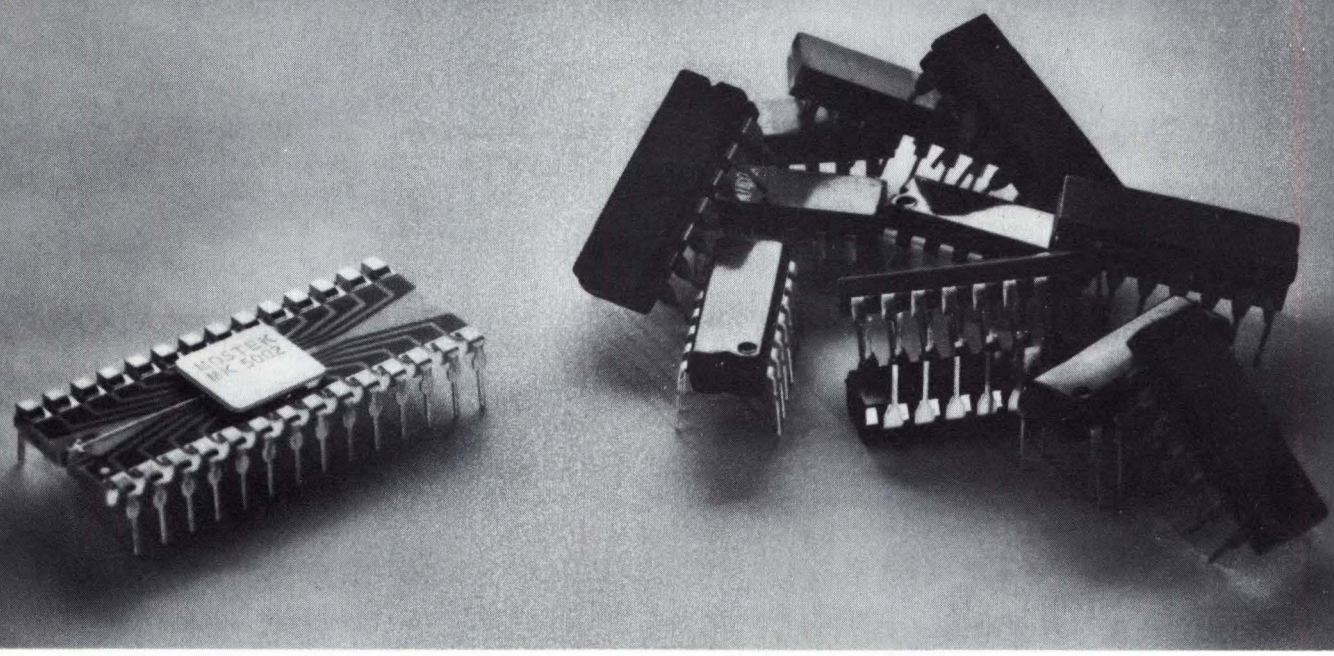
MOSTEK announces

A breakthrough in counter/display circuits!

5002



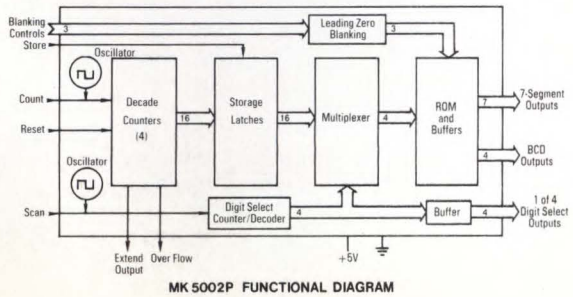
Now...MOS replaces TTL

Four digits of counting/display logic in one package . . . same single +5V supply *but* 1/100th the power!

Our new MK 5002 P gives you all the logic you need for your counting/display systems: four decade-counters, four quad-latches, seven-segment decoder, multiplex logic, BCD outputs, leading-zero suppression. All of this in *one* package, with *one* +5V power supply and less than 20mW of power!

Our point is this. If you're now using TTL, better take a look at what MOSTEK's MOS technology can do for you. We've designed an entire instrument system on a single chip. We've replaced 12 ordinary TTL packages with a single 5002 and given you more performance over a broader power range. (You can operate from +5V supply, or your 6V, 9V or 12V batteries, for instance.) And the cost of our 5002 is lower than TTL—even at today's prices.

Whether your application is in frequency counters, digital voltmeters, digital timers or event counters, for example, you need to consider the advantages of our new breakthrough circuit . . . made possible through MOSTEK's ion-implantation process. Call for detailed information to Gordon Hoffman or Dave West at (214) 242-1494. Or contact your nearest Sprague representative or distributor.



MK 5002P FUNCTIONAL DIAGRAM

MOSTEK CORPORATION

The Calculator-on-a-Chip Company

An affiliate of Sprague Electric Company

1400 Upfield Drive
Carrollton, Texas 75006

CIRCLE NO. 15

Lower-Cost Packages—

Injection-Molded DIPs and Modules May Be Around the Corner

A family of new plastics that appear well-suited to electronic packaging, yet that can be economically injection-molded at high rates may be just what our cost-conscious industry has been searching for. These plastics may help the trend toward cost reductions in electronic packages.

Two major chemical manufacturers, Eastman Chemical Products, Inc., Kingsport, Tenn., and Celanese Plastics Co., Newark, N. J., believe that their new families of thermoplastic polyester resins (as opposed to thermosetting) should find wide use in electronics. These resins have excellent electrical properties—good high-temperature and humid-environment resistivity in particular—say the chemical suppliers. At the same time, these new resins have excellent physical properties: rugged impact resistance, attractive high-gloss finish (even when glass-filled for increased strength at elevated temperatures) and precise dimensional stability.

If electronic assemblies such as ICs and hybrid circuits could be injection-molded at high production rates with these new thermoplastic resins, rather than transfer-molded at present slower rates with thermosetting epoxy resins, packaging costs would decrease according to the chemical companies. These "engineering-quality thermoplastics" may be to the industry today what epoxy thermosets were ten years ago. Just as the epoxies permitted device manufacturers to get past the "metal-can" cost barrier, so these new plastics may help the industry to get past the "transfer-molded encapsulant" price barrier.

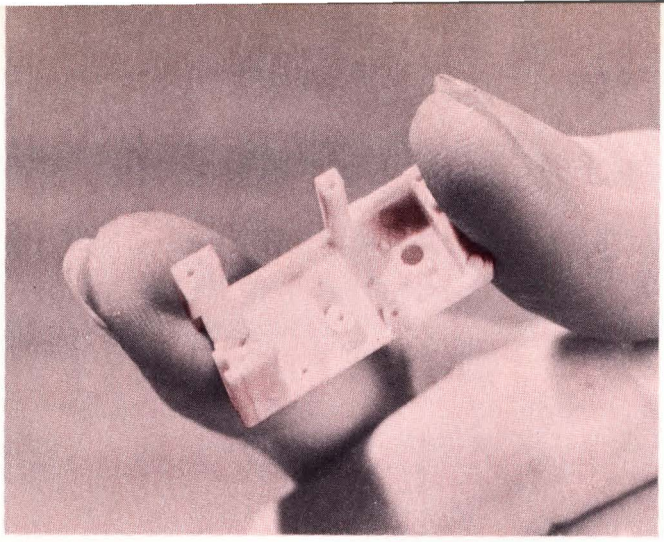
ICs Must Withstand Pressures

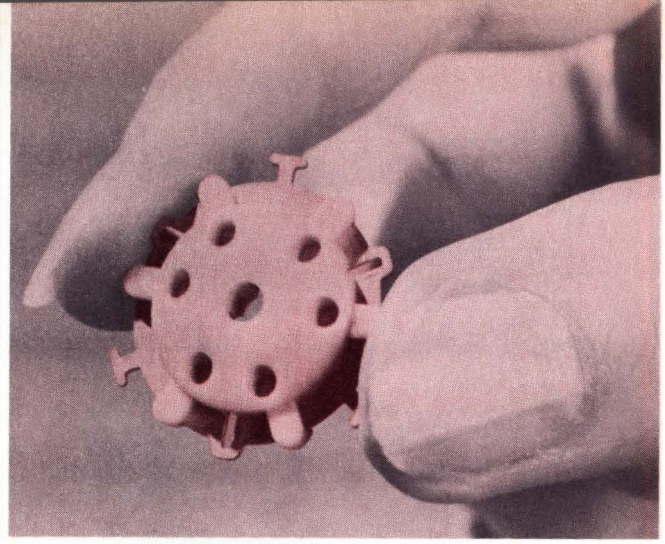
A definite stumbling block will be the higher pressures and temperatures necessary for injection molding, according to Steve Bower of Hull Corp., Hatboro, Pa., the molding machine maker who introduced the industry to transfer molded epoxy packages, and who now also builds injection-molding machines. At present, Bower says, injection-molding is limited mainly to encapsulating rugged components such as coils. But the higher production volumes of certain consumer and industrial parts make the economies of injection molding attractive.

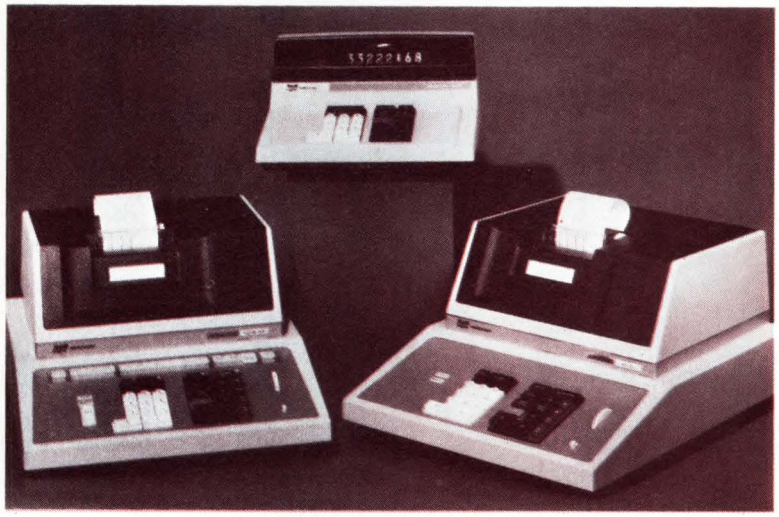
The new plastics would be nearly perfect for automotive electronics, states Stewart B. Neff of Celanese. They can withstand under-the-hood temperatures and chemicals. If the hybrid circuits being developed for such automotive circuits as electronic ignition and battery-charging regulators could be encapsulated "in one shot"—the assembly being placed in

PROPERTIES OF NEW PLASTICS (all plastics glass-fiber filled)

	CELANESE X-917 'CELANEX' AND EASTMAN 6G91 'PTMT' (data based on X-917)			G.E. NORYL (for comparison)
	Room temperature and dry	Elevated temperature (250°F)	After exposure to water (6 weeks at 72°F)	Room temperature and dry
VOLUME RESISTIVITY (Ohm-cm)	10^{16}	10^{12}	10^{15}	10^{17}
DIELECTRIC CONSTANT (1 MHz)	3.63	4.15	3.7	3.11
DISSIPATION FACTOR (1 MHz)	0.022	0.017	0.022	0.0021
DIELECTRIC STRENGTH (volts/mil) SHORT TERM STEP BY STEP	700 530	660 540	630 520	(530)
HEAT DEFLECTION TEMPERATURE (°F at 264 psi)	380	----	----	275
MOISTURE ABSORPTION (percent)	0.07	----	----	0.06
MOLD SHRINKAGE (mils/inch)	3	----	----	1 - 3
TENSILE STRENGTH (psi)	17,000	----	----	17,800
STRUCTURE OF GRAIN	CRYSTALLINE	----	----	AMORPHOUS







New plastics permit economical high-speed injection molding of attractive precision parts. These can be as small as those shown above or as large as the cabinets shown below. They have the strength of many metals and the electrical properties of some of the best of previous electronic plastics. For high temperatures, the material is reinforced with glass fibers, which surprisingly do not reduce the moldability nor harm the surface finish. The part at top (L) is a timer housing molded from Celanex; the one at top (R) is a motor commutator assembly, also molded from Celanex, with the bronze commutator segments molded in; and shown at right is a complete housing for a new SCM calculator. It was molded from GE's NORYL, and "injectable" thermoplastic from a different chemical family.

the mold and the plastic injected around it – a very economical, rugged and attractive module would result, Neff says.

Some of the newer means for fastening IC lead frames and hybrid substrates may provide the strength needed to resist the injection molding flow rates. General Electric's "Minimod" package, for example, does away with the frail flying gold-wire leads of older packages and instead carries the lead frame right up to the chip. The leads are supported on a rugged polyimide film, which can withstand 300°C temperatures and therefore should be safe in the 250°C molding temperatures of the new plastics. The gold-bump connections to the chip will withstand over 280°C. Film-backed lead assemblies such as GE's ought to withstand the high rates of plastic flow during the mold cycles if they are positioned parallel to the flow, states GE's J. W. Ritcy.

Quick Joining

For delicate components, it might prove best to use pre-molded shells according to Neff of Celanese. Because of the mechanical precision of parts molded from this new plastic, it is possible to snap-fit two half shells together for a near-hermetic seal. Fully hermetic seals can be formed by ultrasonic welding, Neff says. These new plastics are well suited to this joining technique, for they are rigid enough to transmit the sonic energy. Ultrasonic welding, according to William P. Gideon, manager of new product sales at Eastman, is a much quicker, less messy production line operation than using an adhesive such as epoxy. It can be completely automated and takes only a second per joint. Already the new thermoplastic resins, which Eastman calls PTMT and Celanese calls Celanex, are being used for miniature electric connectors and trim pots as well as for IC test carriers and sockets. In these applications, they have proven to be a lower-cost but superior replacement for widely-used diallyl phthalate.

IC manufacturers like the way DIP test carriers, made from this material, will withstand higher temperatures (to 380°F). This enables them to save time by going to higher temperatures in their accelerated burn-in tests. On "high-rel" programs, this can mean a considerable money saving. For a similar reason, they would like to use the same material for low-cost DIP, semiconductor, hybrid circuit and other component packages. Celanese says that because of the high temperature resistivity of the plastic, the electronics industry would lose fewer devices from package failure during burn-in tests.

Still other injection-moldable plastics are finding increasing applications in electronic packaging. General Electric's NORYL polyphenaline oxide thermoplastic resin, for example, has equally good electrical properties, though it can't match the high-temperature performance of the Eastman and Celanese thermoplastic polyesters.

The first PROM to offer an extra *bit*...

...for greater reliability!

Introducing the MCM5003A, the industry's first field-programmable ROM with a built-in reliability factor. Basically a 512 bit bipolar device organized as 64 eight-bit words, the MCM5003A offers "instant customizing" by merely "blowing" nichrome resistors and thus breaking metalization links. The blown links change the initial logic "0" state to a logic "1" state to meet specific program requirements.

A *bit* more for reliability

Since unprogrammed ROM's have all outputs low regardless of address, testing does not detect many faults in amplifier inverters, address decoders, memory array and sense amplifiers. Special consideration is required in the areas of Program Element Testing, Functional Testing and AC Testing. To solve these problems, Motorola expanded the memory from a 64 word, 8 bit memory to a 64 word, 9 bit memory with the 9th bit dedicated to testing.

By blowing some of the 9th bits, we can assure that the links can be blown without using up any of the normal 64 x 8 bit array. With some of the links blown, functional and AC performance testing is now possible. This is important in that all of the 64 x 8 bit array elements are in a logic "0" state regardless of the address selected, and no way would be available to determine whether the functions are correctly operating without the 9th testing bit.

The MCM5003A circuit contains six address inputs to select the proper word and two chip enable inputs, as well as outputs for each of the eight bits. Supplied in a hermetic 24-pin dual in-line ceramic package, the MCM5003A has positive enable with open collector outputs. Another version, the MCM5004A, has positive enable with 2.0 kilohm pullup resistors on the collector outputs. Both devices are MDTL/MTTL compatible and access times are less than 75 ns.

By stocking the MCM5003A you can work up custom microprograms, lookup tables, code and number conversions without the worry of turnaround time and costly mask charges. And speaking of costs, either the MCM5003A or 5004A is available for $45.00 (100-up price) — less than 9¢/bit. Programming can be accomplished at your facility, through your distributor, or here at Motorola.

Take advantage of the MCM-5003A's "instant customizing" by calling your local Motorola distributor for evaluation devices today. Or write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036. We'll send complete specifications plus our latest application note describing several programmers that can be built specifically for programming the MCM5003A/5004A.

It'll pay to evaluate the MCM5003A . . .

A Memory To Remember For Reliability

Motorola can now supply memories to meet your specific requirement, whether it be high-speed, low power, or custom products. In traditional Motorola fashion we can draw from the technologies of MOS (Ion-Implanted, Silicon Gate CMOS, N-Channel) or advanced bipolar techniques — each technology offering specific advantages to meet your application.

MEMORIES TO REMEMBER

RAMs				
DEVICE	**FUNCTION**	**TECHNOLOGY**	**ORGANIZATION**	**ACCESS TIME**
MC1680/81	4 Bit RAM	ECL - BiPolar	2 x 2	< 4 ns
MC1682/83	4 Bit RAM	ECL - BiPolar	2 x 2	< 4 ns
MC1684/85	4 Bit CARAM	ECL - BiPolar	2 x 2	< 4 ns
MC1036/37	16 Bit RAM	ECL - BiPolar	4 x 4	50 ns
MC4004/5	16 Bit RAM	TTL - BiPolar	16 x 1	< 25 ns
MCM4064	64 Bit RAM	TTL - BiPolar	16 x 4	< 60 ns
MCM1170	64 Bit Static RAM	Metal Gate P-MOS	16 x 4	500 ns
MCM14505	64 Bit Static RAM	Metal Gate CMOS	64 x 1	200 ns (typ.)
MCM1173/72	1024 Bit Dynamic RAM	Metal Gate P-MOS	1024 x 1	400 ns
ROMs				
MCM4001 (XC170/171)	128 Bit ROM	TTL - BiPolar	16 x 8	< 45 ns
MCM4002	256 Bit ROM	TTL - BiPolar	32 x 8	< 50 ns
MCM4004	1024 Bit ROM	TTL - BiPolar	256 x 4	< 60 ns
MCM4006	1024 Bit ROM	TTL - BiPolar	256 x 4	< 50 ns
MCM5003A/4A	512 Bit PROM	TTL - BiPolar	64 x 8	< 75 ns
MCM1130	2240 Bit Static ROM	Metal Gate P-MOS	Open Option	500 ns
MCM1131/32	2240 Bit Char. Gen.	Metal Gate P-MOS	Col. Sel. 64 x 35 (5 x 7)	500 ns

MEMORIES TO COME

RAMs				
DEVICE	**FUNCTION**	**TECHNOLOGY**	**ORGANIZATION**	**ACCESS TIME**
MC10140	64 Bit RAM	ECL - BiPolar	64 x 1	< 15 ns
MCM4256/7	256 Bit RAM	TTL - BiPolar	256 x 1 / 128 x 2	< 60 ns
MCM2372	1024 Bit RAM (1103 Equiv.)	Si-Gate P-MOS	1024 x 1	300 ns
MCM2374	1024 Bit RAM (1103-1 Equiv.)	Si-Gate P-MOS	1024 x 1	180 ns
MCM2377	2048 Bit RAM	Si-Gate P-MOS	2048 x 1	360 ns
ROMs				
MCM4003	512 Bit ROM	TTL - BiPolar	64 x 8	< 75 ns
MCM4005	1024 Bit ROM	TTL - BiPolar	1024 x 1	< 50 ns
MCM4007	1024 Bit ROM	TTL - BiPolar	512 x 2	< 50 ns
MC10139	256 Bit PROM	ECL - BiPolar	32 x 8	< 17 ns
MCM5005	1024 Bit PROM	TTL - BiPolar	256 x 4	< 60 ns
MCM1110	2048 Bit ROM	Metal Gate P-MOS	256 x 8	600 ns
MCM1120	2240 Bit ROM	Metal Gate P-MOS	64 x 7 x 5	700 ns
MCM1140	4096 Bit ROM	Metal Gate P-MOS	512 x 8	700 ns
MCM1150	2560 Bit ROM	Metal Gate P-MOS	256 x 10	600 ns

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MOTOROLA MEMORIES
. . . IC Systems for the 70's!

CIRCLE NO. 11

Crystals Store Graphic Data

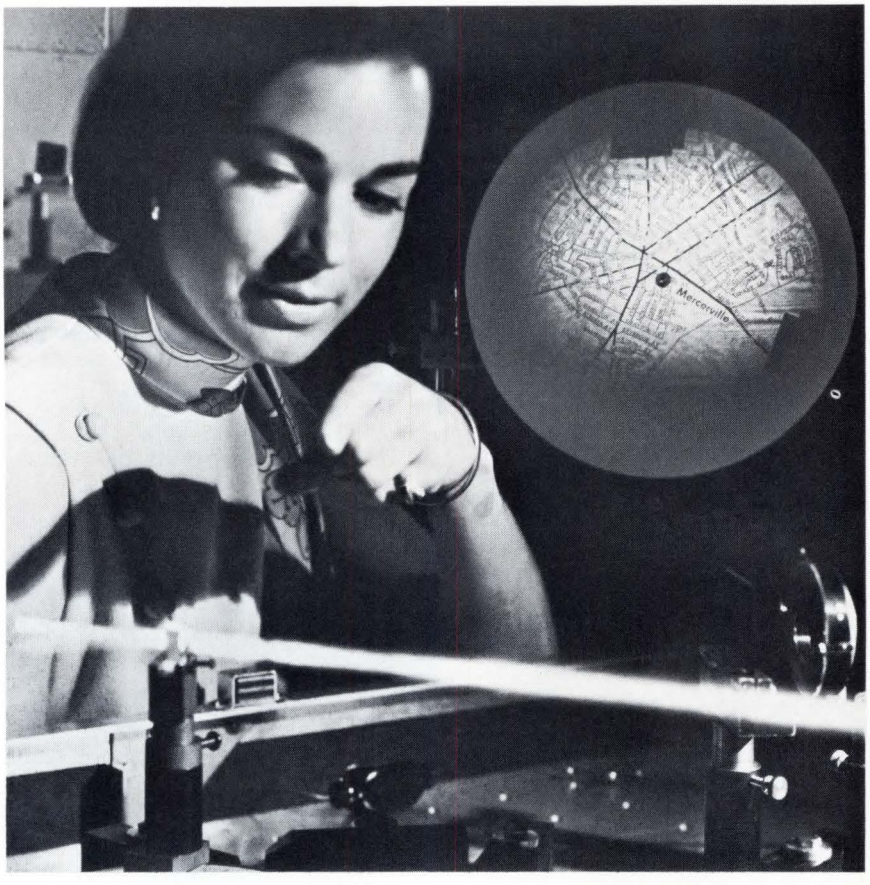
RCA recently announced the development of a crystal that stores holographic images as atomic patterns. These images can be read out and displayed visually like photographic slides by slow rotation of the crystal in a laser beam.

Though holograms have been stored in crystals before, it has taken a very powerful laser to do the job and the holograms have tended to be erased by the read-out process. These problems have been eliminated with simultaneous developments of crystals 500 times more sensitive than those used so far and a technique for permanently "fixing" the holograms stored in the crystal.

The 500-fold increase in sensitivity to laser light is achieved by doping the lithium niobate and barium sodium niobate crystals with metallic impurities. The resultant crystals can be used in read/write applications employing gas lasers. Stored hologram patterns are "fixed" by heating the crystal to about 100°C which, it is believed, frees ions normally locked in their crystal lattice at room temperature. These ions are attracted to electrons arranged in a charge pattern formed by the "recording" laser beams. Upon cooling, the ions are locked in that pattern, thus permanently storing the hologram unless the crystal is again heated to around 100°C.

The field resulting from the charge pattern varies the index of refraction of the crystal in accordance with the holographic pattern. As a result, when the laser beam is directed through the crystal it reconstructs and projects the original holographic image onto a screen.

Advantages of using crystals over conventional photographic film are high storage density—theoretically, a trillion bits of information can be stored in a cubic cm

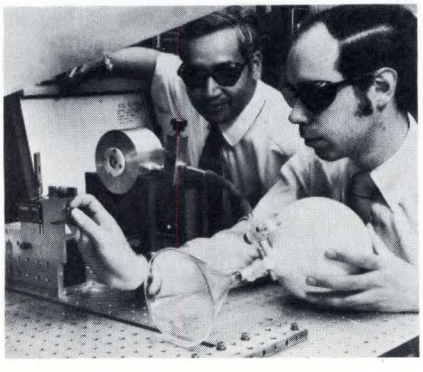


—and a display 15 times brighter using the same readout laser.

Conventional (thin) holograms are read out by moving a laser beam to illuminate the specific hologram desired. However, with holograms stored in crystals and other thick media, only a minute change in the angle at which the readout laser strikes the crystal makes it possible to select one hologram from another.

This advance may lead to a revolutionary document storage system in which files of statistics, architectural drawings, computer data, photographs, maps and other graphic materials are stored permanently in crystals the size of sugar cubes.

Ecological Laser Monitors Air Pollutants



Already performing jobs in such varied fields as medicine and defense, the versatile laser is being put to work by scientists at Bell Telephone Laboratories in an experimental set-up to measure several of the oxides of nitrogen in concentrations as low as 10 parts per billion in air. A tunable laser, called a "spin flip" Raman laser, is used to provide energy in the infrared region of the spectrum. Oxides of nitrogen and other products of combustion such as carbon monoxide, hydrocarbons and sulfur dioxide absorb infrared energy at specific IR frequencies. By measuring the amount of energy absorbed in a special optoacoustic cell, at a specific frequency, it is possible to identify the pollutant and record its concentration.

Infrared absorption techniques have long been used in pollution monitoring equipment; however, interference from other gases and lack of sensitivity at the low PPM range have been serious limitations. This new technique solves both of these problems.

RAYTHEON SEMICONDUCTOR. OUR 64-BIT RAM WON'T QUIT. EVEN AT 125°C.

Some people claim their bipolar 64-bit RAM will work over the entire MIL temperature range. Others keep silent. We guarantee our RR5100 will operate within specs from −55°C to 125°C ambient.

The RR5100 and its commercial version, the RR5102, are available in dual-in-lines, flat paks, and Raytheon Semiconductor's own beam lead configuration. Of course both of these 64-bit RAM's are compatible with our RAY III TTL and other DTL/TTL.

And don't forget our other memory products. We've delivered thousands of our reliable RL80 series 16-bit scratch pad memories. And when it comes to custom devices we're second to none. Our custom 256-bit RAM doesn't know when to quit.

And we have plenty of new things in the mill. Denser bipolar chips with faster cycle times and a MOS-type power dissipation are on the way. Thanks to our new revolutionary V-ATE bipolar process.

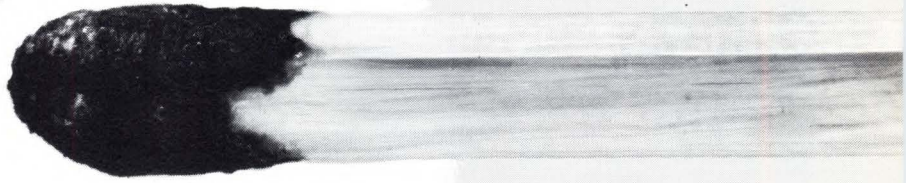
Don't get burned on your present projects. Get immediate delivery on our 16-bit and 64-bit memories from our local sales office or your nearest franchised Raytheon Semiconductor distributor. And call us direct for custom memories.

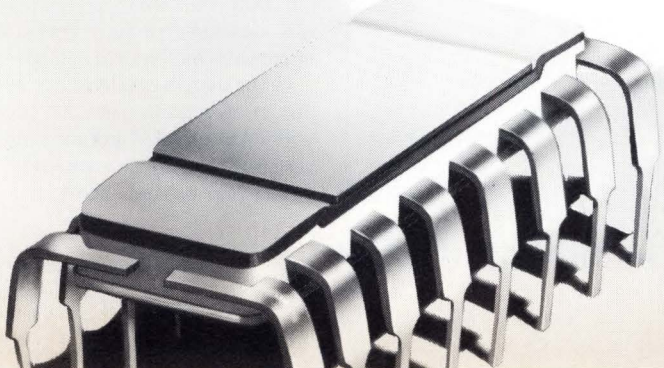
Raytheon Semiconductor, 350 Ellis Street, Mountain View, California, 94040. 415/968-9211.

RAYTHEON

CIRCLE NO. 12

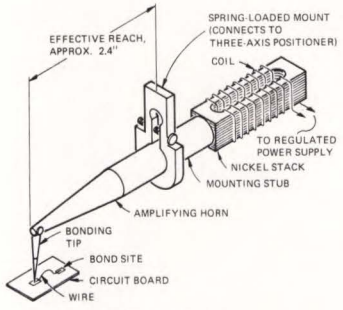
GUARANTEED.



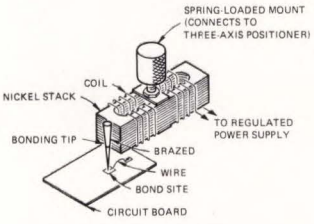


At WESCON attend the Seminar on Advanced Semiconductor Products and Processes.
Daily 1 P.M. - 3 P.M., Wed. 7 P.M. - 9 P.M.
Room 302, Civic Auditorium

Now: Ultrasonic Bonding On Cluttered Boards



CONVENTIONAL DESIGN



STREAMLINED DESIGN

Recent improvements that streamline the bonding head have made it easy to do ultrasonic bonding under conditions where it was previously impractical. That is the word from the IBM Systems Development Lab at San Jose, California that came up with the new design. The conventional bonding train's amplifying horn and mounting stub are replaced by a tip that is affixed directly to the magnetostrictive stack (or piezoelectric element). This gives compactness that translates directly into the ability to be used for bonding on boards of any size or already populated with wires or components.

Broadband 1 Gigabit Laser

A laser system that transmits digital data at 1 gigabit (10^9 bit) per second while simultaneously transmitting analog data with a 1-GHz RF bandwidth was recently demonstrated by Lockheed Missiles & Space Co. at the Conference on Laser Engineering and Applications at Washington, D. C. This working laboratory system was assembled mainly from off-the-shelf microwave and optical components.

In the demonstration, four local TV station signals were used. Digital data was sent during the blanking pulse (retrace) period of the TV transmission, thus providing time shared operation.

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

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

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

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

Model 3852

Model 3859

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

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

Model 3862

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

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

BOURNS

BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507

CIRCLE NO. 13

Protons to Travel At 99.999% of Speed of Light

Sometime this summer or fall protons will be accelerated almost to the speed of light to bombard atomic nuclei in an effort to help nuclear physicists discover secrets of the nucleus. Due to be completed this summer, the new proton accelerator at the National Accelerator Laboratory near Batavia, Ill., will ultimately have an output energy level of 500 billion electron volts.

Over 2,141,000 pounds of copper, supplied by Phelps Dodge Industries, have gone into the construction as conductors for the beam-bending magnet field coils and the quadrupole focusing magnets. These hollow core conductors also carry water for internal cooling.

Each of the 774 beam-bending magnets in the 1.25-mile-diameter main ring uses 2300A to generate a magnetic field ranging to almost 9000 gauss. To collimate and focus the beam, 240 quadrupole magnets draw 2280A, generating field gradients of 125 kilogauss/meter.

A proton making the trip must travel over 600,000 miles in the accelerator before reaching its final velocity.

It is comforting to note during these inflationary times that the accelerator is being completed a year ahead of schedule, with 2.5 times the beam energy originally designed, and at a cost below the original projections.

Call For Papers

The 1972 IEEE International Solid-State Circuits Conference will be held on the campus of the University of Pennsylvania and at the Sheraton Hotel in Philadelphia. Papers not previously published or presented, describing significant contributions in the following or related areas are invited: integrated electronics; circuit techniques; memories; new device applications; optoelectronics; microwave electronics; computer aids to design; medical electronics.

Abstracts and summaries must reach the program committee secretary by Oct. 1, 1971. For detailed information contact Lewis Winner, 152 W. 42nd St., New York, NY 10036.

500 Watts Provided by Thermoelectric Generator

About half a gallon of fuel per hour is all that is needed to supply 500W at 28V dc with a new, portable generator developed by the Army Electronics Command, Fort Monmouth, N. J., with the participation of the 3M Company.

Built for the Army's new low-frequency aircraft beacon, this 57-lb generator will likely find other field duties. With no moving parts, it is inaudible beyond 100 feet and is designed for a minimum of 1000 hours without maintenance.

Each of the unit's 256 thermocouples is a lead-telluride semiconductor whose two sides are "doped" separately and hermetically sealed between "hot" and "cold" walls. Fuel is ultrasonically atomized at 77 kHz and burned to keep the hot wall at 1100°F, while the 'cold' wall is forced-air cooled to remain at 250°F. Power is taken from the cold wall.

Simplicity Pays Off

At least that is what the Air Force has concluded as a result of the use in Viet Nam of its new technical publications known as "Job Performance Aids" (JPA).

These pocket-sized manuals provide all the relevant information for any given job – *but no more*. Information is presented in the exact chronological order that each step of a job is to be performed.

First introduced in 1970 for teaching South Vietnamese crew chiefs and maintenance personnel, the guides have been written for the UH-1 and CH-47 helicopters and the C-123K aircraft.

In test use at the Charleston AFB, S.C., troubleshooting errors were reduced by 92%, training time by 25% and overall troubleshooting time by 11%.

MEMORIES

MODERN DAY "MUSICAL CHAIRS"

PART II

MOS/bipolar memories demand attention because of their promise of improved cost effectiveness. "Cost per bit" equivalence to magnetic memories may occur sooner than you think.

HARRY HOWARD, Senior Editor

Semiconductor memories are rapidly gaining prestige in the computer architecture of the '70s, and mainframe seems to be where the action is. Approximately 40 companies have committed themselves to this area of dynamic growth. Important trends responsible for this movement are the use of high-speed, small-capacity buffers in conjunction with slow-access storage systems and the use of microprogrammed read-only memories (ROMs) for central processing storage.

In the past year there have been many advances, especially in MOS technology and in the perfection of dynamic MOS memories. These devices offer access speeds from 150 to 400 nsec, and already have a price tag of 0.5 cents/bit in large quantities.

Many ingredients have played an important role in the success of semiconductor memories:

- Small computers require smaller memories than optimum core design allows.
- Large computers demand increased speed.
- Designers have gained confidence in LSI technology.
- Flexibility of semiconductor memories has introduced newer concepts in system organization yielding cost and performance benefits.
- Modularity permits field expansion and simplified maintenance.

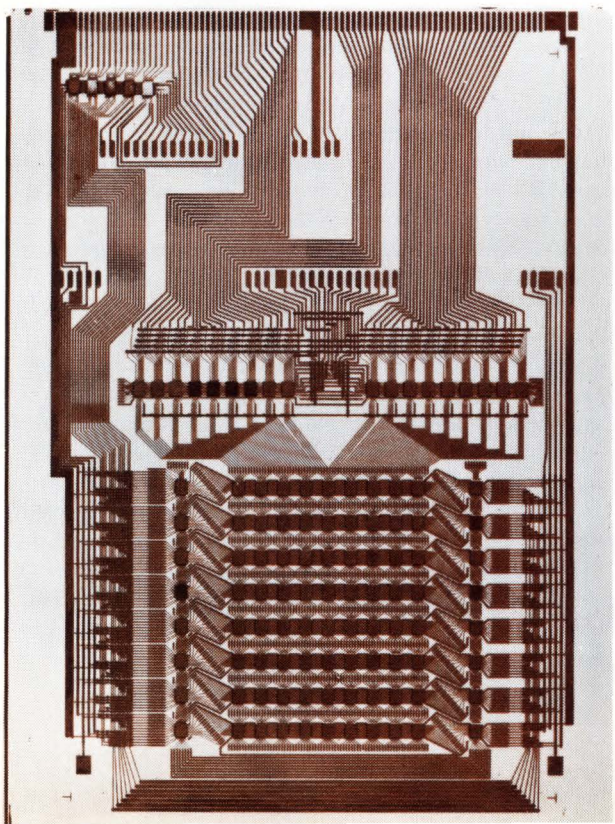
Computer logic invariably makes use of discrete or IC devices. At the interface between logic and memory, circuits generate and decode the signals used by and received from the storage array. Thus, semiconductor memories eliminate many of the restrictions.

Generally, semiconductor memories come in small blocks of a few thousand bits each. Several types of memories may be combined with standard logic to yield a wide variety of functions. These include logic functions, thanks to the concept of content addressable memories (CAMs). However, two serious disadvantages are volatility and power consumption. Even though certain phenomena are under investigation that may solve the volatility problem, solid-state memories still require backup power. Dynamic MOS devices will retain data with several orders of magnitude less power than required for normal operation because they may be clocked at a much lower than normal rate.

Mel Phelps, vice president of Nortec Electronics Corp., feels that it is unlikely that semiconductor houses will enter memory systems to the extent that core manufacturers did in the '60s. Rather, they will attempt to conquer with components—their natural way of doing business. Alert core memory companies already have established engineering projects to evaluate various technologies objectively. Those with sufficient foresight are beginning to come to the conclusion that they cannot be without access to a continuing supply of low-cost semiconductor storage elements. The question is how to achieve this objective efficiently. —Acquire a small nucleus of clever process people and set up a process plant or a captive subsidiary having current technology capabilities? Is it necessarily the best solution? There is a substantial investment involved and the threat of obsolescence is ever present in captive plants. Learning how to design with, handle and economically package semiconductor subassemblies and components available on the open market may be the best choice for memory systems houses in the next several years as standardization and volume build.

How about the OEM as a semiconductor memory designer? Mr. Phelps feels that this is not as unlikely as it may seem. As the LSI technology develops, chips will have more and more functions, and customizing of circuits will become more attractive. Standardization of an industry wide design is less of a necessity in achieving low cost today as design costs continue to plummet.

(Continued)



Bell Laboratories

Reduction of packaging and interconnection costs is further attracting the OEM to custom LSI. And now, for a few thousand dollars, he is able to train his own engineer and cover the cost of his own LSI design as well. The '70s are already witnessing early shipments of equipment designed by OEMs around optimized custom LSI circuits, and many more are on the drawing boards.

However, Gordon Perkins, vice president of marketing for Monolithic Systems Corp., feels that packaging and interconnection costs are already available at very low cost from independent systems houses. In fact, some packaging and interconnection costs are zero. Mr. Perkins adds that some companies already have units that in low quantity are equal in price to what the OEM systems designer would have to pay for chips only.

It's in the Chips

As a brief review, Tudor Finch, head of Digital Device Integration Dept., Bell Telephone Labs, gives an account of the common storage cells—static and dynamic.

Typical static cells are made up of:

—Six MOS transistors: two for flip-flop, two for load elements and two for digit line coupling.

—Two bipolar transistors using multiple emitters for flip-flops and diffused or epitaxial layer load resistors.

—Two bipolar transistors using single emitters for flip-flops and epitaxial layer resistors. Schottky diodes connected to the collector provide digit line coupling. Cells are formed within 50- to 125-mil chips, 64 to 256 cells/chip. Standby power ranges from 50 μW to a few mW.

Dynamic cell configurations include:

—Three MOS transistors, where storage is on the gate capacitance. The Intel 1103 is one example.

—Four MOS transistors: two for flip-flop, two as digit coupling elements. Storage is gate capacitances of the flip-flop and all cells can be refreshed simultaneously. An example is Advanced Memory System's 6002.

—Two diodes: One Schottky with guard ring capacitance for storage, one charge storage pin diode for access. Bit-by-bit or word-by-word refresh is required. (*Described by S. Waaben, 1970 ISSCC.*)

—Single bipolar transistors using reverse beta for access. Storage is separate silicon oxide capacitor and requires word-by-word refresh. (*Described by P. T. Panousis, 1970 International Electron Device Conf.*)

—Single bipolar transistor with storage on the junction capacitance and access provided using junction breakdown, either emitter or collector. Word-by-word refresh is required. (*Described by J. Mar, 1971 ISSCC.*)

Dynamic memories cost less than static, require less silicon area, and in most designs, require less complex processing. Cells now marketed or under study range in area from 2 to 10 square mils compared with 30 square mils minimum for static. Depending on temperature and storage element, the refresh interval ranges between 0.1 and 10 msec.

Chip Processing

Besides the conventional bipolar and MOSFET techniques, other technologies being investigated include silicon nitride, ion-implanted, metal-alumina-silicon, silicon-on-sapphire, silicon-on-spinel and charge-coupled devices. The most promising of the new processes is the nitride-oxide dielectric combination in the gate structure. The metal-nitride-oxide semiconductor (MNOS) structure displays a hysteresis effect that has already been employed to construct small nonvolatile memories. Charges attracted to and trapped at the oxide-nitrate interface create this hysteresis phenomenon. Thus, both read/write and read-only memories are possible. Popularity of this process hinges on the improvement of present manufacturing techniques.

Silicon gate has become the most significant conventional MOS process. Companies such as Intel feel that self-aligned silicon gate MOS offers many advantages in attain-the low-cost projection of the semiconductor memory market. It combines low threshold voltage with simpler gate alignment structure and an additional layer of interconnection. Better performance, higher yields and increased storage densities are the significant results. Feedback capacitance is reduced 75% and turn-on voltage reduced 60% compared to the usual p-channel MOS on a [111] crystal structure.

William Maxwell, MOS product marketing manager, Teledyne Semiconductor, describes their process as a variation of the metal-gate, thick-oxide technology. This is the standard MOS p-channel enhancement mode normally associated with high-threshold. However, their process improvements permit them to build either high-threshold (MOS logic levels) or low-threshold (TTL levels) devices. They are producing devices with $\leq$0.16 pF/mil^2 gate capacitance and >100V oxide rupture voltage and 90% yield for discrete, 30% for complex elements. In addition, Teledyne has major efforts going into the silicon gate process.

Mr. Maxwell feels that there will not be any one dominant technology but that the industry will be limited to metal gate p- or n-channel devices with silicon gate and ion implantation as the major processes. Complimentary MOS (CMOS) will make significant inroads in the low-power market. Regardless of the technology, there will be much higher yields and larger wafers. For instance, 3- to 4-inch wafers with less than 100-mil die will be produced by 1975. The mainstay for chips greater than 100 mils will be on the 2-inch wafer.

David Uimari, digital product marketing manager for Harris Semiconductor, also points out that CMOS offers higher performance than other MOS technologies. The low power features make the volatility problem less serious because battery backup becomes more feasible. In addition, advance processing concepts yield little wasted area and a minimum of additional processing steps. Thus, costs should approach those of p-channel devices.

Many companies have been searching for methods to reduce cell size by reducing the isolation area. In

March, Fairchild Semiconductor introduced the "Isoplanar" process – a technique replacing conventional diffused isolation with silicon dioxide. Thus a nonconductive material, rather than a reverse-biased diode, forms the required isolation. According to Fairchild, this process reduces the bipolar transistor area by more than 40%. Presently, Fairchild is developing a 256-bit bipolar random-access memory (RAM) for scratch pad and buffer storage applications. It is 30% smaller than their present 256-bit RAM, the 4100. Other products to be announced in 1972 include a 1024-bit ECL, a TTL RAM for high-speed mainframe memories and MOS RAMs in the area of 2 to 4k bits with 500-nsec cycle time.

Recently, Bell Laboratories introduced a new concept – the charge-coupled device. According to G. E. Smith, these units are, as the name implies, elements which retain information in the form of a charge that is transferred through potential wells created within a semiconductor. Several characteristics of these devices include:

COMPARATIVE SIZE OF MEMORY MARKET TO DIGITAL IC MARKET

	1970	1971	1972	1973	1974	1975
Digital IC Bipolar Market	291.2	285.1	288.1	318.9	376.4	430.0
% Bipolar Memory	2.3	4.1	7.8	12.0	14.4	17.0
Digital IC MOS Memory	63.4	90.2	148.0	194.4	251.1	316.0
% MOS Memory	29.0	46.0	53.0	65.0	79.0	81.0
Total Digital	354.6	375.3	436.1	513.0	627.5	746.0
Total Memory	25.2	53.0	111.3	165.2	252.3	331.6
% Memory	7.1	14.0	26.0	32.0	40.0	44.0

STORAGE REQUIREMENTS FOR THE FOURTH GENERATION EQUIPMENT

	Size	Speed	Cost	Applicable Technology
Registers	256	10 ns	$.03/bit	LSI
Read Only Memory (ROM)	512	20 ns	$.20/bit	LSI
Write Optional Memory (WOM)	512	R/W 20/30 ns	$.10/bit	LSI/plated wire
Associative Memory	1024	100 ns	$.10/bit	LSI
Main Internal Memory	to 128k words	250 ns	$.02/bit	Core plated wire semiconductor
Mass Storage (random address)	to 100M words	1.0 μs	$.01/bit	Core plated wire
Mass Storage (sequential address)	billions of words	100 μs to first access	$.0001/bit	Electromechanical

COMPUTER MEMORY MARKET SALES ESTIMATES OF SEMICONDUCTOR MEMORY (in millions of dollars)

	1972	1973	1974	1975	1976
0.5 - 1.0 μs	6.0	13.5	34.0	37.5	19.0
250 - 500 ns	5.0	14.0	52.0	102.0	107.0
125 - 250 ns	16.2	75.0	196.0	399.0	597.0
62 - 125 ns	-	-	-	-	95.0
Market Value of Semiconductor Main Memory	27.0	103.0	282.0	539.0	818.0

Signetics Corp.

– no inherent gain
– dynamic shift register capability
– basically, an analog device.

There are two classes of devices being investigated – Charge-Coupled Devices (CCD) and IGFET Bucket Brigade (BB). The basic differences between these devices lie in construction. Mr. Smith referred to them as a semiconductor concept analogous to the magnetic bubbles. Bubbles will probably cost less because of a simpler process, but they are currently slower than the charge-coupled devices.

Chip to System

Advent of Cache generated a new trend in mainframe design. IBM pioneered the monolithic memory technology in the System/370. Monolithic chips used in the Model 155 were 80 mil² and operated at 6 to 8 nsec. The high-performance buffer memories were 112-mil² chips, each containing 64 circuits operating at 80 nsec in the Model 165 and 115 nsec, Model 155. Both models used a two-level memory system – high performance buffer storage backed by a large main core storage (Cache System). This spring, IBM introduced the Model 135, available with four main memory sizes ranging from 96k to 240k bytes.

In this system, microcode for control functions and other optional features is stored in a separate part of the memory, labeled "reloadable control storage" (RCS). The standard 24k-byte capacity of RCS is expandable to 36k or 48k bytes. IBM provides the microcode for a specific Model 135 in a small disc cartridge. Because the system's control storage is reloadable, all microcode for a system need not reside in storage at all times, thus allowing more efficient use of control storage.

Today's semiconductor memory systems reflect a broad spectrum of engineering, financial and managerial judgement. According to Bernard Kute, senior applications engineer for Semiconductor Electronic Memories, Inc., the performance requirement of memory applications can be divided into five basic categories (cost/bit represents system level using existing technology):

CATEGORY	SPEED	SYSTEM LEVEL COST/BIT
I	<60 nsec	<$0.50
II	<200 nsec	<$0.10
III	<500 nsec	<$0.05
IV	<1 μsec	<$0.03
V	>1 μsec	<$0.02

The design decisions made in pursuit of the optimum cost product for these categories must include technology packaging, circuit performance and system architecture (interface, ease of expansion and impact of size on performance).

Semiconductor Electronic Memories' RAM 300 Series is a family of random-access memory systems ranging in size from 2048 to 9216 bits, operating at 300-nsec access time and 400-nsec cycle time. The systems are constructed with monolithic LSI memory arrays and support circuits. The memory modules are 256-bit

(Continued)

storage arrays organized as 128 words by 2 bits. A 512-word by 10-bit memory is constructed from 20 memory modules and five support modules on a 4- by 5.5-inch board. These boards, in turn, form layer systems.

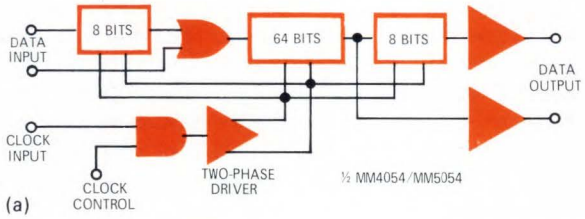
Jerry Larkin, vice president of marketing at Advanced Memory Systems, Inc., describes their concept in computer peripherals—Semiconductor Storage Unit (SSU). This stand-alone system fills the gap that now exists between large core storage and high-speed drums or discs. With an average access time of 135 μsec, the SSU consists of a controller (plug-compatible with the IBM System/360) and a number of basic storage modules—2- (Model I), 4- (Model II) and 8-million bytes (Model III). The memory is organized around dynamic shift register devices using p-channel MOS processing. In addition, Advanced Memory Systems offers an add-on memory for the System 360 using their dynamic MOS RAM, the 6002.

Two 1024-bit MOS RAMs are offered as components

Semiconductor Equivalent for Drums

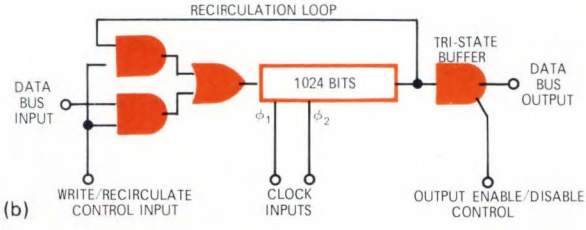
Digital delay lines can simulate many types of memories—and that is what MOS shift registers do best. Several delay lines sequentially loaded and unloaded from a drum, and several drums form a disc system. By controlling the clock so that data enters and leaves the register at different rates, a variety of buffers is possible.

Emphasis in the past was on increasing storage capacity/chip when registers were too short to store a complete data block. This is no longer a problem. Within the past year, bipolar-compatible static registers storing 200 bits and dynamic registers storing 1000 bits or more have become mass producible, while cost/bit dropped to as low as a penny. These lengths are ample for most applications. In fact, the standard word length for a teletypewriter static buffer is 72 bits. Printer columns run 80, 128, 136 or 144 bits wide. So this extra room now available on MOS chips is being used to improve control flexibility and compatibility.



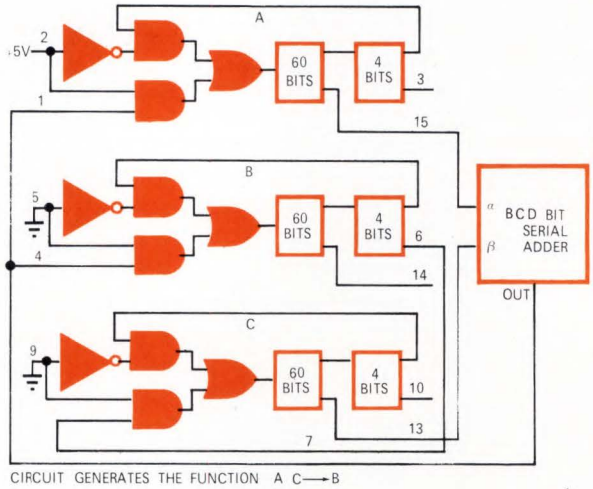
(a)

To illustrate, National Semiconductor's MM4054/MM5054 has extra input and output taps for capacities mentioned above. One of the two 64/72/80-bit static registers in each chip is shown in (**a**). This design uses a silicon-gate process to boost maximum shift rates about 50 percent (to 3 MHz), cut power dissipation (<600 μW/bit) and achieve bipolar compatibility.



(b)

The dynamic register in (**b**) is just the right length—1024 bits—to store large data blocks in computer disc memories (they are longer than static registers because the storage cells are simpler). Stored data is continuously refreshed via the internal recirculation loop. I/O gating was added to the basic register for read/write selection. Note the output buffer gate has three states: normal 1 and 0 logic levels plus a third high-impedance state if disabled. The third state almost disconnects the output from the data bus, allowing many outputs to time-share the bus at high data rates. Conventional wired-OR MOS outputs would be loaded too heavily for high data rates.



(c)

Dynamic registers MM4019/MM5019 are dual 256-bit registers programmed by metallization mask changes to vary capacity. The MM4015/MM5015 triple accumulator in (**c**) is tapped for high speed addition of stored data without interrupting register recirculation.

A configuration that withstands voltage transients of −100V and sustaining voltages of −55V is another significant development. This permits registers to drive indicator lamps or other high-voltage displays without special interface. National has developed the MM5081 (serial in, serial and parallel out) for billboards, stock tickers and other moving lamp displays. *(National Semiconductor)*

—the AMS 6001, first of the monolithic 1024 RAMs, and the AMS 6002, a faster version. Advanced Memory Systems is also involved with bipolar memory devices. They manufacture two ECL units, 16 × 1 and 128 × 1 RAMs, and a 25-nsec, 128 × 1 TTL unit. In the modular ECL memory cards, they have a 32 × 8/9, 128 × 8/9, 512 × 8/9 and a 4k × 1. As a result, Mr. Larkin feels that they are unique in their ability to interface with the customer at the device, card or system level, either in bipolar or MOS technologies.

A newcomer to the system market is Monolithic Systems Corp. Hugh DeVries, vice president of engineering, feels that their approach will provide an excellent vehicle for minicomputer designers who require a readily available custom or standard semiconductor memory system. One of the systems, designated Monostore III, has a 650-nsec cycle time and is packaged in a 5.25- by 19- by 18-inch rack-mount chassis. Up to 393,216 bits of storage are provided per chassis including power supply and nonvolatile battery pack. The modular design permits expansion from 1k to 65k words and the user may select word lengths from 4 to 96 bits. This design uses memory array cards containing up to 16,384 bits/card and may be organized as 1k × 4, 2k × 4 or 4k × 4. The system makes use of 1k × 1 dynamic RAMs that plug into individual dual in-line sockets.

Memory Bank

Any level of design activity is feasible for a computer manufacturer. Simplest is to purchase a complete system from a vendor. Semiconductor memories will fit within the customer's cabinets, sharing power, printed-circuit space and cooling with the logic circuits themselves.

More common is the use of a vendor-designed and packaged memory array. The computer manufacturer designs this array into his system in the same manner as the logic circuits, working around any inadequacies. Another method involves the computer manufacturer's specification of the array chip depending on his particular needs. In this case, the vendor merely processes the chips with customer-supplied masks. Finally, the manufacturer performs the entire job, including chip processing. This requires the largest resources and greatest sophistication of design, and is the approach that could offer the greatest added value. The following paragraphs describe the activities of companies involved with semiconductor memories.

Advanced Micro Devices Inc. As a newcomer to the semiconductor memory field, they chose silicon-gate because of increased packing densities, low threshold, increased speed and increased reliability. Advanced Micro Devices began with the introduction of a bipolar 64-bit RAM, AM3101, having a 35-nsec access time. Now they offer two 256-bit RAMs—AM2700 (bipolar) and AM1101A (MOS). For designers needing serial memories, they offer two dual 100-bit MOS shift registers (AM14/1506 and AM14/1507) with a 1024-bit, dual 512-bit and a quad 256-bit shift register as future products.

Cambridge Memories Inc. Using their proprietary magnetic domain technology, they offer a random-access expandable memory, DOTram-16, designed to replace mass storage devices (drums, disc, cassettes, etc.). Readout is nondestructive and the technique is inherently nonvolatile. A complete 4-million bit system is housed in 10.5 inches of rack space and requires less than 100W power consumption. Random access to any block of data is attained in < 1 μsec and parallel word transfer is 1 μsec.

Computer Microtechnology Inc. Another concept for increasing capacity is through hybrid design. Jim Kubinec, product planning manager, describes their 4096-bit read/write memory module, CM 2400. Employing beam lead approach, these modules contain 16 MOS storage chips and six bipolar circuit chips. All of the chips are interconnected on an alumina substrate, mounted in a 26-pin package. Possible memory organizations with these modules are 1, 2 or 4 bits/word, depending on how the external pins are interconnected.

Electronic Arrays, Inc. Producing LSI circuits for calculators is one of Electronic Arrays major interests. One of these circuits incorporates a 1024 × 12 ROM on a 135- by 141-mil chip. In addition, another family of devices offered by Electronic Arrays includes a static 5120-bit ROM, EA 4000. This MOS device, organized as 512-words by 10-bits contains 5746 active devices on a 93- by 100-mil die. Maximum power consumption of the chip is only 0.06 mW/bit.

Electronic Arrays' next step will probably take them up to 16k on a standard chip. The present problem is not so much the hardware, but that it is difficult for a user to work with this size and make sure that it is error free. Another area under investigation is the development of a 1024-bit n-channel RAM.

Four-Phase Systems Inc. In 1970, they introduced an 8192-bit/chip MOS ROM as part of the world's smallest central processing unit (June 15, 1970 EDN). Together, three ROMs handled all of the CPU's (control processing unit) microprogramming storage. As their next innovation, they are planning to use a single chip to perform the equivalent function—24,576 bits/chip.

General Instrument Corp. In keeping with an aggressive committment as a memory components supplier and recognizing the customer's need for viable alternate sources, General Instrument offers several popular p-channel, silicon-gate products. The RA 9-1101A is a fully decoded 256-bit static RAM with <1 μsec access time in a 16-pin DIP. The RA9-1103 is a 1024-bit dynamic RAM with <300 nsec access time and <580 nsec cycle time in an 18-pin DIP. In the serial memory line, General Instrument offers a quad 256-bit (DL9-1402A), a dual 512-bit (DL9-1403A) and a single 1024-bit (DL9-1404A) shift register.

Harris Semiconductor In April 1970, a considerable amount of interest was shown over their entry into the field of electronically programmable semiconductor ROMs—a first of a kind in the industry. These devices

(Continued)

used a fusible link in the basic storage cell. Now, three configurations are available: a 512-bit device organized as a 32-word by 8-bit array and two 256-bit devices organized in a 256-word by 1-bit and a 32 word by 8-bit array. To be announced soon is a 256- by 4-bit ROM that will be available in both a mask- and an electronically-programmable version.

In the field of RAMs, Harris' first two products were 16- and 64-bit bipolar devices, both using Schottky technology for higher yield and increased speed. Currently in development are a 256-bit bipolar unit and a 1024-bit dynamic device which uses an advanced CMOS process. This latter device is expected to have performance features approaching those of bipolar memories at costs approaching those of equivalent p-channel devices. In addition, this new CMOS process will permit direct DTL/TTL input/output interface with the low power requirements typical of CMOS circuits.

Intel Corp. Bob Graham, vice president and director of marketing, attributes their success to three major areas. The first is mainframe memories where the 1103 has made the biggest impact. He points out that some feel the next step in mainframe development is 2k and 4k chips. However, he feels it necessary to prove the dynamic circuit 1k chip is not only here but can be produced reliably and in volume by multisource. Intel plans to fully exercise the 1103 and then proceed to a 4k design.

The second area is small buffers and special purpose memories using bipolar or static MOS memories.

A third major area is the PROM (Programmable Read-Only Memory) where Intel's initial effort is the 1601, a 2048-bit MOS PROM. According to Bob, their approach is to build devices that can be completely tested at the factory prior to shipment to the customer for final programming.

Additional bipolar products include 3104, high-speed 16-bit CAM; 3205, 1-of-8 decoder for expanding small buffer memories; 3207, level shift driver for the 1103; and 3404, 6-bit address data register with an output delay of 12 nsec.

Monolithic Memories Inc. Using silicon controlled elements rather than conventional flip-flops in the cell design, Monolithic Memories developed a 256-bit bipolar RAM that operates as low as 2V, 0.6 mA – ideal for battery operation over extended periods of time. Also, the unit will hold information for 10 msec – long enough to switch over to battery power. Designated MM 6510, the memory incorporates epitaxial resistors occupying extremely small areas, a Schottky-barrier diode for fast access speed (70 nsec) and pnp-npn circuitry for low fan-in capability.

At SJCC in Atlantic City, Monolithic Memories introduced an 8192-bit bipolar ROM, MM6280/MM5280 in a 24-pin package. Power dissipation is 60 μW/bit and access time is 100 nsec. Because of its high capacity, one unit can provide the entire standard ASCII alphanumeric code with control codes for upper and lower case modes.

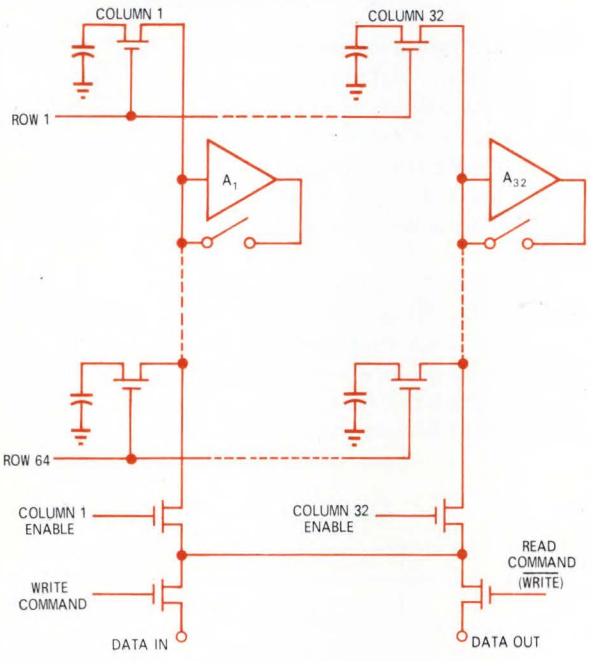
It was pointed out that because masking costs are equivalent for the popular 1k and 8k units, the customers could realize a savings of 87% in masking costs. Since one mask permits the user to identify a program, with 8k bits of the system, he can save essentially the cost of seven masks. In conjunction with this announcement of the 8192-bit ROM, Monolithic introduced a 2048-bit PROM, the MM 5305/6305. This unit, contained in a 16-pin package, exhibits an access time of 30 nsec. Monolithic also offers a 32 × 8 PROM that is available in either the open-collector or tri-state output configuration. In addition, they have an extensive family of character generators including 32, 64 and 128 characters of 5 × 7 matrix fonts as well as 64 and 128 characters of 7 × 9 matrix fonts.

MOSTEK Corp. Berry Cash, vice president of marketing, identifies the MK 4006, a 1024-bit RAM, as their most significant product for the high-volume random-access memory market. The philosophy and technique used to develop this component differ somewhat from the competitive parts – ion implantation is used so that no high-voltage or high-power clocks are required. In addition, they were able to put the unit in a 16-pin package. Although depletion devices are used extensively throughout the unit, the dynamic storage cells (a three-transistor configuration) are made up of enhancement mode devices only. Mr. Cash projects a $0.02 to $0.05/bit price for the MK 4006 by 1975. Other random-access memories offered by MOSTEK include a static fully-decoded 64 × 4 RAM (MK 4002 P) and a static fully decoded 256 × 1 RAM (MK 4007 P). In both cases, the devices are ion implanted and offer complete TTL compatibility.

Motorola Semiconductor Programmable ROMs indeed are attractive new elements for the designer's repertoire. However, several testing problems exist that are not encountered in the conventional masked ROM. According to Michael Boho, Digital Integrated Circuits Products, Motorola adds a ninth bit to their 64 × 8 device, the 512 PROM. Originally 16 of the ninth bits are programmed as 1s. Thus, the amplifier inverters are tested during wafer probe. Another 16 of the ninth bits are programmed as 1 in the same manner as the customer would. This step checks the nichrome quality and drive capabilities of the word drivers under operating conditions. Physically the ninth bits are located as a worst case condition regarding propagation delay. With 32 bits as 1s and 32 as 0s, an ac test is performed. In addition, the customer can perform his own tests before programming the device. Also Mr. Boho indicated that a 256-bit static memory using CMOS decoding is being investigated as a future product.

Bud Broeker, manager of memory applications, describes the design of a 4k × 16 mainframe memory system, using 1024-bit chips, that was built and used to demonstrate the versatility of the dynamic MOS RAMs. According to Mr. Broeker, this project disproved the myth that dynamic MOS RAMs are hard to use and require expensive control circuits. He feels dynamic

One Device Per Cell



In 1967, General Instrument developed the first three transistor/cell fully-coded 256-bit RAM, using a thick oxide (MTOS) process, on a 96- × 112-mil chip. The cell area was 12.4 square mils. Presently, 1024-bit RAMs (MOS) using similar cell structure with a cell area of 5.6 square mils are marginally competitive with core, but the MOS industry could breathe easier at 2048 bits. Leo Cohen, product line manager for Memories, General Instrument Corp., describes a p-channel, silicon gate one device/cell RAM (RA9-2048) that achieves the 2048-bit goal with a 3.6-square-mil cell area.

Each storage cell contains a capacitor connected to the drain of an MOS device. The cells are organized in a matrix of 64 rows by 32 columns. Each word location is uniquely defined by row/column intersection. Six- to 64-row and 5- to 32-column decoders convert the 11-bit address into discrete row/column commands. Data output lines may be wired-OR and serviced by one sense amplifier. Output sense current (>10 mA) permits low-cost single-ended sensing directly into TTL devices, thus reducing system access time by 20 to 30 nsec. The memory, contained in a 22-lead 0.4-inch DIP, exhibits a read access of <250 nsec, cycle time of <400 nsec. This package achieves the highest board density to date for MOS memory, 2850 bits/square inch—a 40% increase over present 1k RAMs in 18-pin, 0.3-inch DIPs.

When the corresponding chip select and address lines are activated, an entire word is updated (in the presence of the Write Command) or read out nondestructively (in the absence of the Write Command). Presence of a row address refreshes that entire row on all chips in the system within one clock cycle. Refreshing of the entire memory is achieved by accessing each of the 64 rows, regardless of column address at least once within the 4-msec refresh storage time. *(General Instrument Corp.)*

RAMs are here and are economically feasible for minicomputer mainframe storage. They will become even more economically attractive in the future when larger chips are available.

National Semiconductor Corp. When National decided to enter the mainframe market, they asked users what they would like to have in an MOS memory device. The key requirements were speed, size, power dissipation and bipolar compatibility. Thus, their design goals included an access time of 300 nsec, density of 4000 bits/in² of board space, power consumption of 300 mW/1024 bits and the elimination of high level inverters and sense amplifiers. To achieve these requirements, Gene Carter, microcircuit product manager, explains that they pooled their experiences in ROM design and silicon-gate technology to attain the best compromise, the MM 5260. This unit is bipolar compatible with the exception of the precharge and read/write lines, has a common I/O line with "Tri-State" output, is packaged in a 16-pin DIP, and has 400-mW power dissipation and 350-nsec access time. A possible disadvantage appears to be speed, but according to Carter, their customers have improved system speeds through the associated logic design. Because of this, he feels that it is time to begin considersystems rather than device characteristics.

North American Rockwell Microelectronics Co. (NRMEC) Making use of silicon-on-sapphire (SOS) technology, NRMEC has developed a 3300-bit ROM exhibiting 20-nsec access time. These memories use diode arrays that are encoded with laser techniques. The diodes can be arranged in matrices of 1- to 35-bit words. Densities of up to 1 million diodes/in² are possible when encoding is performed with a custom mask. Devices are available in a 42-lead flat pack.

Raytheon Semiconductor For all of its memories and associated logic, Raytheon Semiconductor is firmly committed to bipolar technology. Presently, they are featuring the RR5100/5102, a 64-bit RAM built with beam-lead technology. They are not pursuing MOS for several reasons, mainly because they are not convinced of its soundness and reliability for military and aerospace applications. Later this year, Raytheon will have a bipolar processing technique yielding chip densities in excess of MOS with faster than present bipolar speeds. Using beam-lead process, they will be able to offer 800k to 1 million components/in² with about 50% less power than existing bipolar chips. They are developing a 1024-bit bipolar RAM on a chip smaller than similar MOS chips with 50-nsec access and 500-mW power dissipation. Raytheon also has 256-bit monolithic RAMs (RR 5300 and RR 5302) and will have 1024-bit PROMs available later this fall.

Signetics Memory Systems Using a 3-micron epi-

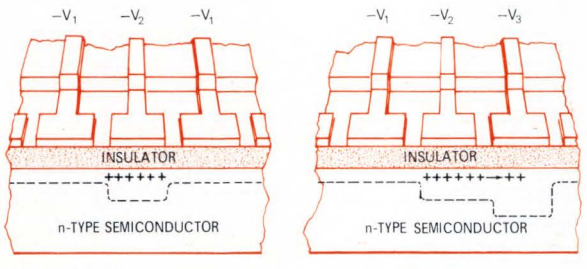
(Continued)

taxial layer process and employing Schottky-barrier diode clamps, Signetics offers a 4096-bit bipolar ROM (1024 × 4) organization. Access time is 50 nsec with 0.125 mW/bit typical power dissipation. The unit has on-chip decoding and is available in a 16-pin DIP. Signetics also offers a 256-bit bipolar RAM, 128 × 2 organization in addition to an extensive family of inexpensive 1024- and 2048-bit ROMs.

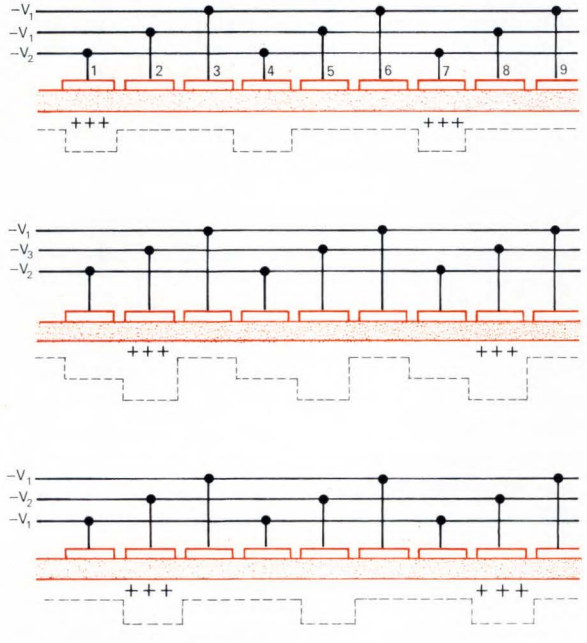
Solid-State Scientific Their major efforts are CMOS devices, including a 256-bit RAM (SCL 5553) and a 16-bit programmable ROM (SCL5510). Quiescent power dissipation for the 256-bit RAM is 200 nW/bit worst case. The programmable ROM consists of two single p-channel devices with a fusible link per bit, together with n-channel strobe and a CMOS output buffer for voltage sensing. Robert Lesniewski, Memory Products Manager, describes several other products soon to be announced: a 64 × 4 CMOS RAM and a 1024-bit n-channel silicon gate RAM. The 1024-bit RAM is dynamic and will have an access time <110 nsec, cycle time <200 nsec and 10 to 100 msec refresh time.

Texas Instruments Incorporated Daniel Baudouin, manager of the MOS Standard Products Program, tells about their activity in both RAM and ROM products. Their first practical device, introduced three years ago, was the TMS4003, a 256-bit static MOS RAM with 18-nsec access time. However, this product became slightly outmoded because of the lack of on-chip decoding.

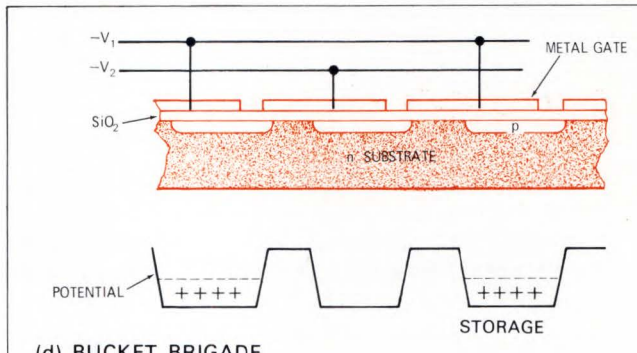
He points out that users of RAMs fall into two categories: individuals who require small memories (256 to 10k bits) that are easy to design with, and designers requiring huge amounts of high-speed, low-cost storage. For the small memory people, Texas Instruments offers static devices such as the TMS1101 (similar to



(a) STORAGE (b) TRANSFER



(c) CCD SHIFT REGISTER



(d) BUCKET BRIGADE

Charge-Coupled Devices

Charge-coupled devices (CCD) are arrays of MOS capacitors placed in a row along a thin oxide channel. Leads to these capacitors enter over the thick oxide section as shown in (**a**). A negative potential V_1, applied to the two outer plates, forms shallow depletion regions in the n-type semiconductor. A more negative potential V_2, applied to the center electrode, forms a potential well in which a quantity of positive charges (holes) are stored. Magnitude of this charge represents information. This charge is transferred to the next plate by application of a more negative voltage ($V_3 > V_2$) as shown in (**b**). If the plates are close enough so that no potential maximum exists, the charge will completely transfer. Drift and diffusion govern the transfer time. Reducing V_2 to V_1, V_3 to V_2 completes the transfer cycle. For a linear array, every third plate is tied together forming a three-phase shift register, shown in (**c**). A two-phase device can be developed by building asymmetry in the potential under the plate.

An IGFET Bucket Brigade (BB) exhibits similar features and is shown in cross section (**d**). This two-phase device has storage sites that are offset p-regions under the MOS capacitors. In the storage phase, V_1 equals V_2. To transfer, V_2 is made large enough to reduce the potential

the Intel device). Guaranteed access time for this unit is 750 nsec.

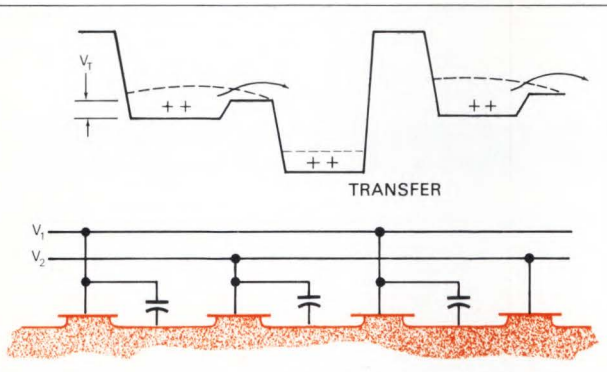
Designers who fall into the second group work within the 10k- to 50k-bit region and require low-power devices. Their main interest is dynamic memories. In this area, Texas Instruments offers 1024- and 2048-bit units. The 1024, designated TMS1103, has parameters similar to the Intel device. However, to meet the demand of higher density cost, two 2048-bit memories are available—TMS4020 and 4025. The TMS 4020, requires a simpler clocking scheme and operates with a two-phase clock. On the other hand, the TMS4025 offers low power and higher speed but requires a three-phase clock.

Mr. Baudouin describes their ROM program in terms of three generations. First generation consists of dynamic devices having speeds of 1 to 2 μsec and requiring $\pm$12V dc. One-μsec static devices subdivided into two application groups comprise the second generation. General purpose devices include a 1024-bit and a 2048-bit ROM—TMS-2800 and 2600, respectively. The second application group, character generators, offers up to 2048-bit capacities.

Third generation ROMs include special memories such as Programmable Logic Arrays (PLAs) and PROMs with 1024- to 4096-bit capacities and speeds as low as 400 nsec. These are similar to the second generation, but the devices are TTL compatible. For general-purpose applications, Texas Instruments offers two ROMs: TMS4400 (4096-bits) and TMS2500 (2560-bits) organized as 256 $\times$ 10 and having a 400-nsec access time. Devices for special applications include a 90-key dynamic keyboard encoder, the TMS-5000.

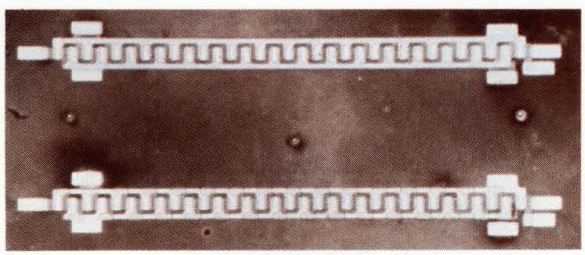
Jack Carsten, marketing manager, described Texas Instruments' activity in the bipolar area. Presently they are developing two different organizations of a 256-bit RAM, both having on-chip decoding and 50-nsec access time. Also, investigation is in progress to improve the reliability of their programmable ROM devices. For instance, they are applying a glass coating over the chip. When the Nichrome fuse blows heat forms a crater and the residue is evaporated onto the glass. □

Part I of this article appeared in the July EDN/EEE.



barrier and to allow charge to flow from the first p-region to the second. This device may be viewed as a row of IGFETs with sources and drains connected and the gates capacitatively coupled to the drains (see interconnecting diagram). In this sense the device is an IC and can be made with discrete devices. On the other hand, CCD is inherently a functional device because the charge always exists in the form of minority carriers at the surface rather than as majority carriers in a p-region.

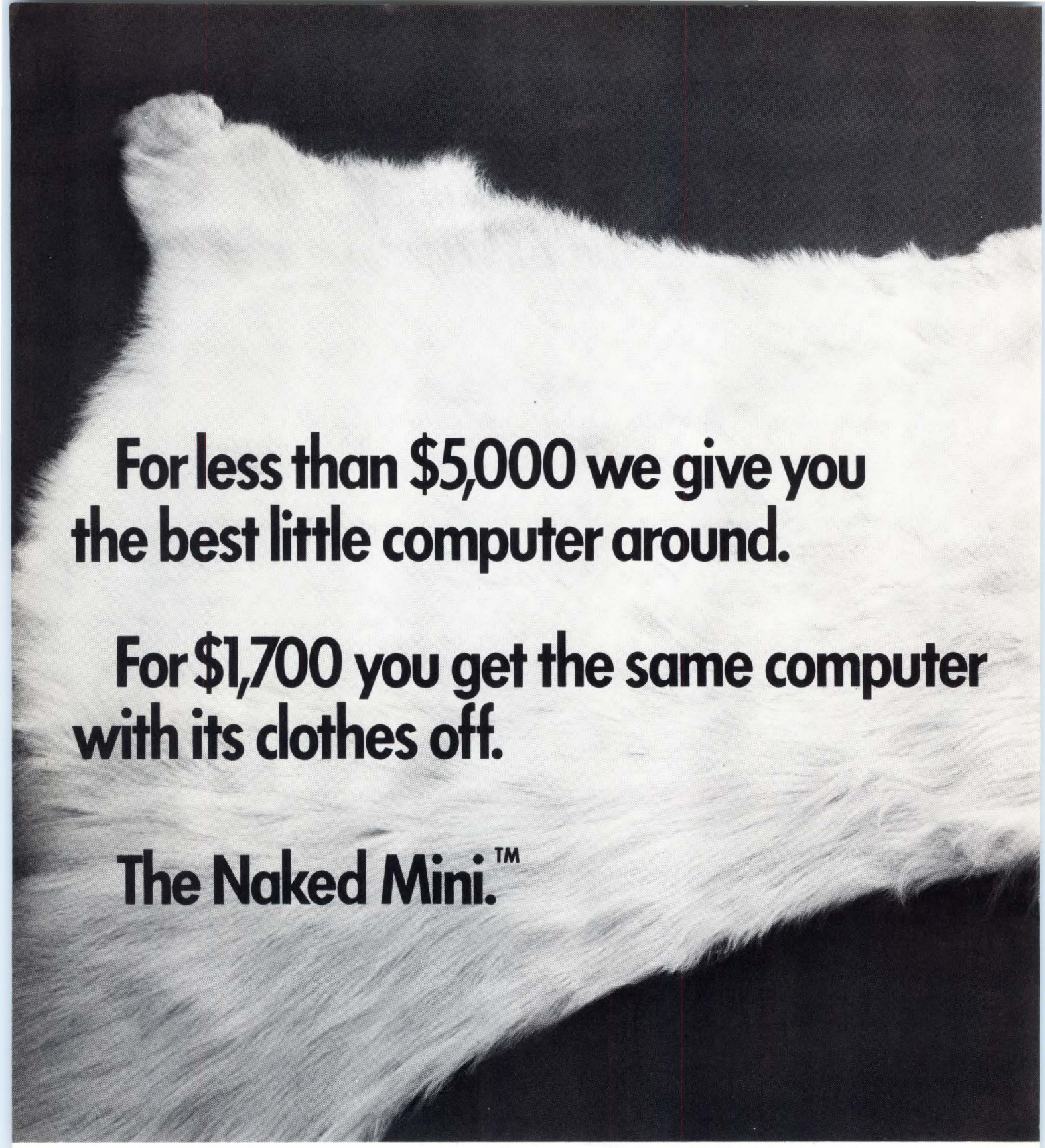
Photograph of a CCD is shown below. This unit uses silicon for the first level of metallization and aluminum for the second. This represents a 16-bit register that uses a four-phase drive. *(Bell Laboratories)*



Acknowledgments

EDN/EEE *wishes to thank the following companies for making the story of semiconductor memories possible through their contributions of time and information.*

ADVANCED MEMORY SYSTEMS, INC., Sunnyvale, Calif.; ADVANCED MICRO DEVICES INC., Sunnyvale, Calif.; AMERICAN MICRO-SYSTEMS, INC., Santa Clara, Calif.; BELL LABORATORIES, Murray Hill, N. J.; CAMBRIDGE MEMORIES, INC., Newtonville, Mass.; COMPUTER MICRO-TECHNOLOGY INC., Sunnyvale, Calif.; DATA GENERAL CORP., Southboro, Mass.; ELECTRONIC ARRAYS, INC., Mountain View, Calif.; FAIRCHILD SEMICONDUCTOR, Mountain View, Calif.; FOUR-PHASE SYSTEMS, INC., Cupertino, Calif.; GENERAL INSTRUMENT CORP., Hicksville, N.Y.; HARRIS SEMICONDUCTOR, Melbourne, Fla.; IBM CORP., White Plains, N.Y.; INTEL CORP., Mountain View, Calif.; MONOLITHIC MEMORIES, INC., Sunnyvale, Calif.; MONOLITHIC SYSTEMS CORP., Denver, Colo.; MOSTEK CORP., Carrollton, Texas; MOTOROLA SEMICONDUCTOR PRODUCTS INC., Phoenix, Ariz.; NATIONAL SEMICONDUCTOR CORP., Santa Clara, Calif; NORTEC ELECTRONICS CORP., Santa Clara, Calif.; RAYTHEON SEMICONDUCTOR, Mountain View, Calif.; SEMICONDUCTOR ELECTRONIC MEMORIES INC., Phoenix, Ariz.; SIGNETICS CORP., Sunnyvale, Calif.; SOLID STATE SCIENTIFIC INC., Montgomeryville, Pa.; TELEDYNE SEMICONDUCTOR, Mountain View, Calif.; TEXAS INSTRUMENTS INCORPORATED, Dallas, Texas.



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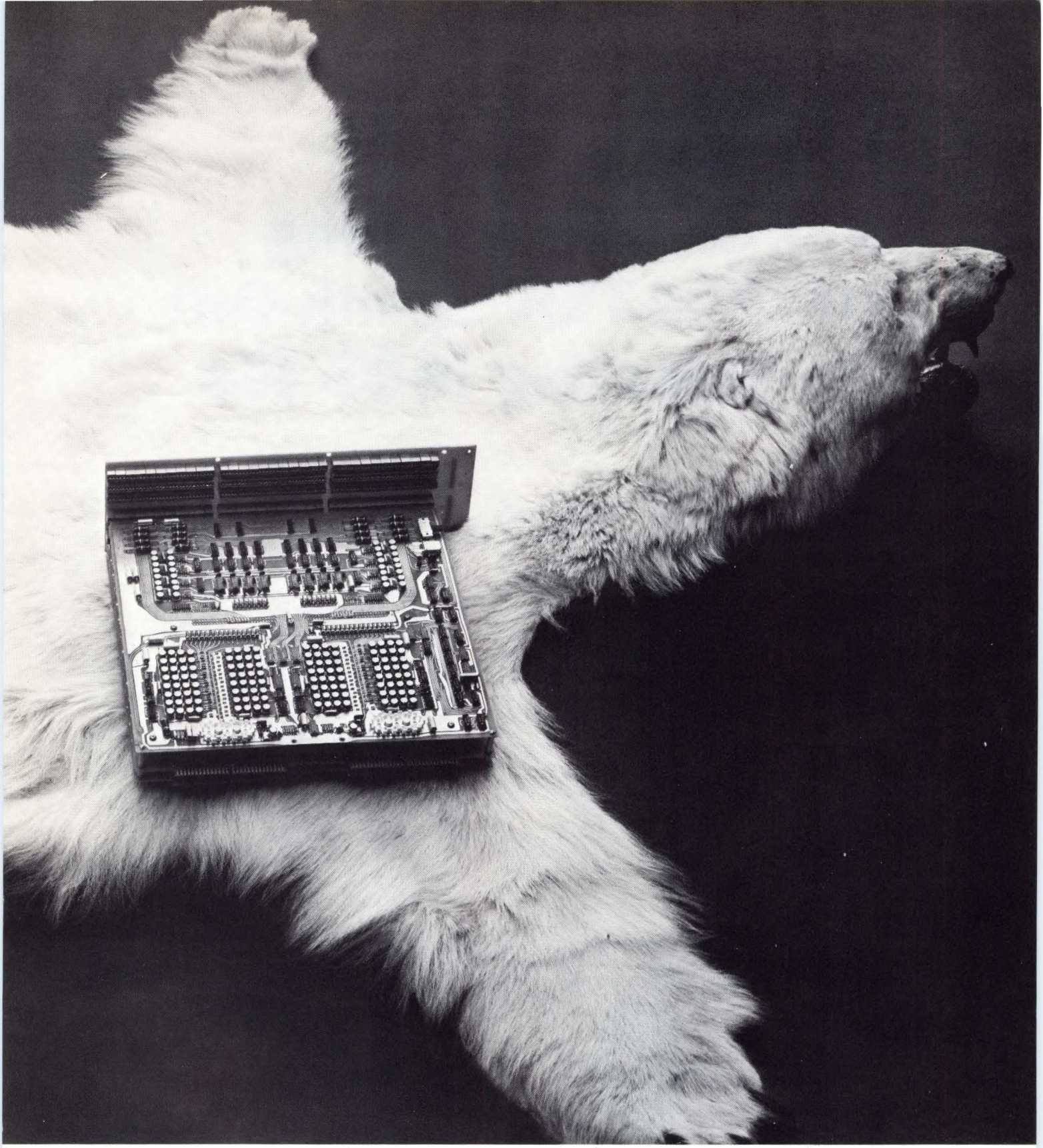

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CIRCLE NO. 16

L. J. Sevin And Bob Proebsting Of MOSTEK Speak Out On Selecting MOS ICs

The manufacturer's position on tradeoffs can be more important than the basic process he uses.

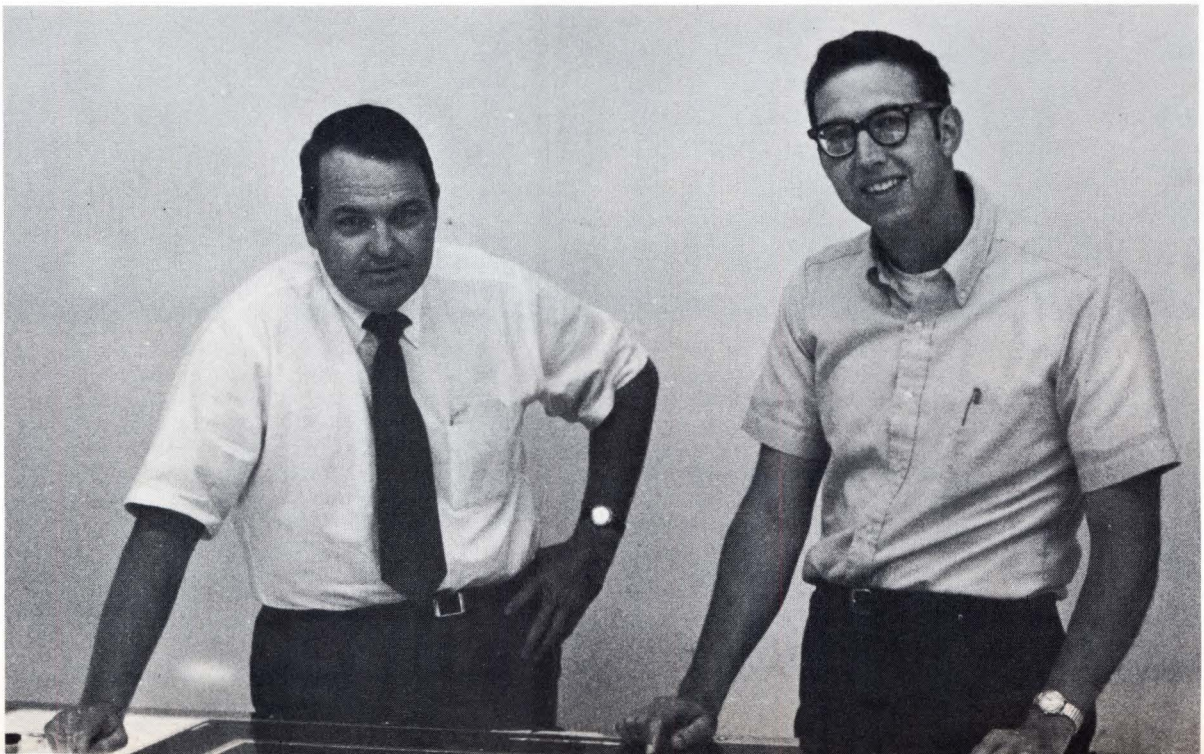
Too many people shop for an IC by looking only for a technology they think is good—such as silicon gate, silicon nitride or ion implantation—but it may be just as important for them to check what tradeoffs each manufacturer thought were best, regardless of the particular processing technique used.

Two manufacturers using the same type of MOS process but having different viewpoints on tradeoffs can produce some widely differing circuits.

As one example, circuits can be made completely TTL-compatible, clocks as well as inputs and outputs, gaining convenience but at a sacrifice in power and speed. For circuits up to 1 or 2 MHz, the user will probably want the convenience of TTL compatibility and of single TTL-level clock operation. For higher-speed applications he may be forced to use less convenient circuits requiring multiple high-level clock inputs.

Although the design competence of the manufacturer plays a more important role in the final product than does the technology used, each technology offers unique advantages. For example, consider the two leading technologies—ion implantation and silicon gate.

Silicon-gate technology offers an effective extra level of interconnect that saves substantial area in some types of circuits, particularly dynamic shift



registers. In dynamic shift registers, the savings may justify the increased wafer processing costs associated with the silicon-gate process. In contrast the silicon-gate process is the least efficient of all technologies for building read-only memories. Ion implantation, which begets depletion load capability, substantially increases speed/power performance over other p-channel MOS technologies. Of equal importance, the area of a depletion-load transistor is three to eight times smaller than that of the load transistors used in more conventional MOS structures. Since most of the area of a static shift register or memory cell is occupied by the load resistor, this space saving is more than that afforded by the extra level of interconnect offered with silicon gate technology.

In large dynamic read/write memories, the cell needs neither depletion-mode transistors nor an extra level of interconnect, since neither technology offers clear cut advantages. The way to go is a matter of which route provides the best design and is most practical from a manufacturing standpoint.

A good design using any technology as a vehicle is certainly better than a poorly designed circuit using the spiffiest, newest technology.

Many times a user will find that no existing catalog item will perform the function he needs to meet his requirements. He then must consider the tradeoffs involved between building his circuit from simpler building blocks (TTL gates) or contracting with an IC vendor for a custom LSI.

Confidence in the IC supplier is one of the factors to be considered in choosing a manufacturer to meet the application's requirements.

In engaging an IC manufacturer to provide a custom design the user will find himself working very closely with his IC supplier. He will also find the experience of his supplier a vital input.

In a few instances, his requirement will dictate the technology to be used. For example, for micropower circuits such as those used for electronic wristwatches and space applications, only complementary MOS technology should be considered even though the complex processing required by this technology dictates very high cost per function. For other battery operated devices in which power is at a premium, but where a few milliwatts can be justified, ion-implanted depletion load circuits are a likely choice. An example of the latter's selection over other possibilities might be a four-decade counter/latch/multiplex/decode circuit to replace TTL MSI packages in a 1 to 2 mA application using a single 5V supply.

In many instances several technologies can provide a suitable solution to the user's requirements. In the final analysis, the user will be wise to find a manufacturer who understands his application and can contribute to the design of the system, both in terms of optimizing the existing design to the manufacturer's technology and in suggesting new ideas and new approaches.

Sometimes the user's selection will involve considering whether or not the manufacturer has computer aided design capability for mask-making.

For well defined systems having low volume requirements, a computer can be used to quickly and inexpensively convert the logic design to an MOS layout. This approach, however, does not lend itself to a very efficient layout, and the cost per circuit is not competitive with that attainable by a skillful engineer-layout designer team. For high volume requirements, the emphasis should be placed on cost per circuit rather than development cost. □

L. J. Sevin (on left in photo) is a graduate of Louisiana State University where he received B.S. and M.S. degrees. He spent 2 years as instructor in undergraduate electrical engineering courses.

He has been in the semiconductor industry for 12 years in engineering and management positions. He was one of the founders of MOSTEK Corp. in early 1969, and served as Vice President until 1970 when he became President.

He authored a book on field-effect transistors while with Texas Instruments Incorporated and holds patents in MOS circuitry, magnetic film memories and industrial control circuits.

Bob Proebsting earned a B.S. in physics and math at Knox College. After completing the requirements for an M. S. in physics at the University of Wisconsin, he switched to the study of practical electronics—abandoning the more abstract theory of advanced physics—and earned a doctorate degree specializing in solid-state electronics. During his academic career he was a member of the faculty and taught both undergraduate and graduate courses.

After completing his formal education, he joined the MOS/LSI group at Texas Instruments Incorporated where he did advanced circuit development in a research group. He later switched to a product group and headed the MOS/LSI random-access memory group. Bob took over greater responsibilities in the following months and was engineering manager in charge of all catalog and most custom MOS/LSI when he left in 1969 to join MOSTEK.

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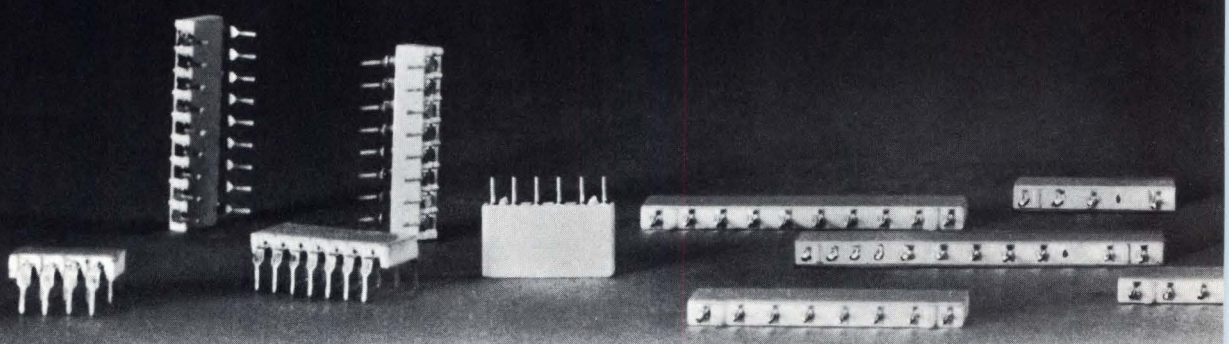

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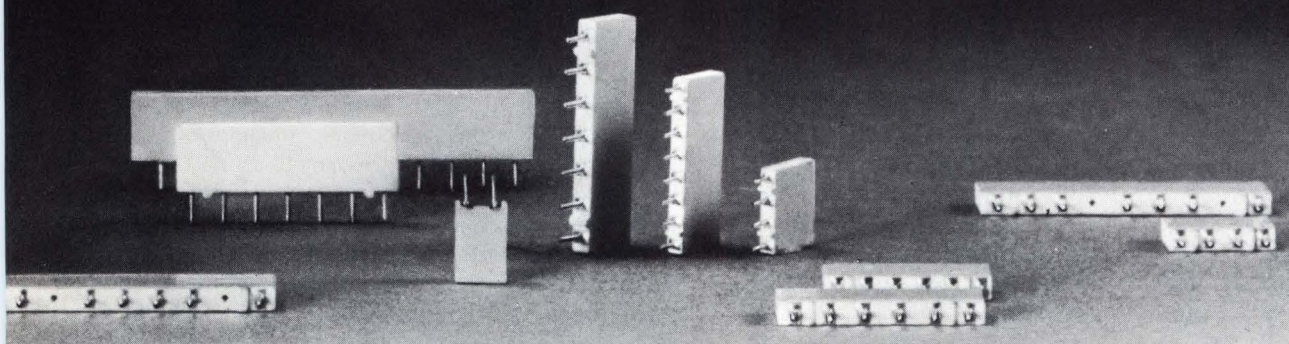

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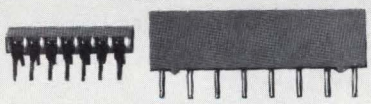

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CIRCLE NO. 17

RECOVERABLE TIME DELAY

by F. C. Marino

A simple circuit can provide time delays ranging from microseconds to kiloseconds. The circuit employs a unijunction transistor and a bistable transistor loop configuration. It has been used to provide deskewing delays in NRZI magnetic-tape systems and to detect pulse trains with excellent delay-to-recovery-time ratios.

How the circuit works

The recoverable time-delay circuit (RTD) appears in Fig. 1. In the quiescent state, the input is low and the state of the bistable loop, comprising transistors Q_2 and Q_3, is such that the collector of Q_2 is low while that of Q_3 is high. In addition, the high level from the collector of Q_3, applied through diode D_2, keeps Q_1 in saturation so that no charge appears across the capacitor C.

During an input pulse, the input is high for a time t_p. At the leading edge of this pulse, the state of the bistable loop is altered.

The high input level is applied to the base of Q_3 through D_7, causing Q_3 to conduct into saturation. The resulting low level at the collector of Q_3 is applied to the anode of D_5. Since the anode of D_4 is also low at this time, Q_2 is cut off, producing a high level at the anode of D_6, maintaining Q_3 in saturation, and Q_2 cut off.

The capacitor does not begin to charge until Q_1 is cut off. Since the collector of Q_3 is now low, this occurs at the end of the input pulse when the input is returned to the low level.

Author: Mr. Marino is senior staff engineer with Digitronics in Albertson, L.I., N.Y.

When Q_1 is cut off, the capacitor charges toward the peak voltage, V_p (or avalanche potential) of the unijunction. The time required for this is the delay time t_d and is a function of the magnitudes of the capacitor C and the resistors R_4 and R_5.

Significantly, the voltage developed across the capacitor will not reach the UJT peak value, if a subsequent input pulse arrives in a time less than t_d. This follows from the fact that the high level of a subsequent input pulse is applied to the base of Q_1 through D_1. Consequently, Q_1 is forced to conduct into saturation, resulting in complete discharge of the capacitor through R_3. This resistor is made small enough so that the discharge time or recovery time t_r is less than the input pulse duration, t_p. However, it is large enough to limit the peak collector current of Q_1 to specified maximum values.

When input pulses stop arriving at the input, either permanently or at intervals greater than t_d, the voltage developed across the capacitor will reach V_p in the predetermined delay time, t_d. At this point, the emitter-to-base-1 junction of the UJT is transformed from a relatively large positive resistance into a negative resistance. This results in a discharge of the capacitor through the UJT emitter-base-1 junction and through D_4, R_8 and the base-emitter junction of Q_2 as well as through R_7 and the negative voltage supply, $-V$. The effect is illustrated in Fig. 2 as a positive pulse, e_3, developed across D_3.

As Q_2 is thus made to conduct, the resulting low level at the anodes of D_6 and D_7, causes Q_3 to cut off. Consequently, the high level at the collector of

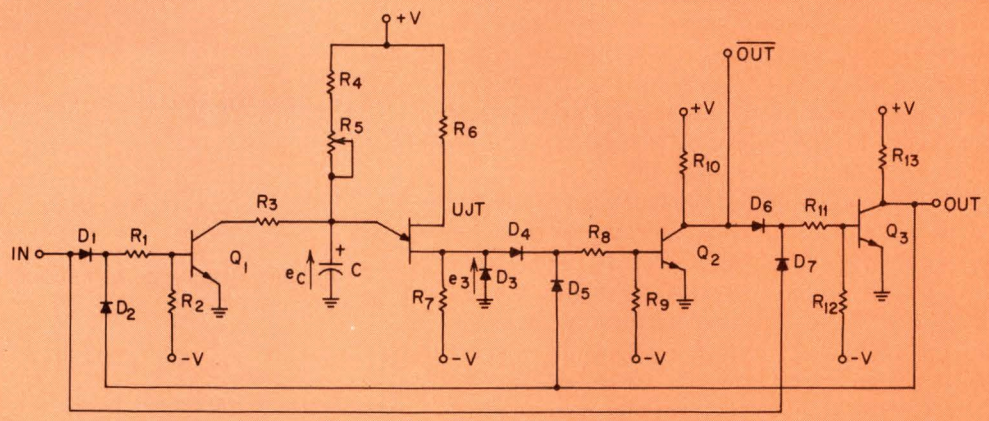


Fig. 1. This simple circuit provides a very wide range of time delays.

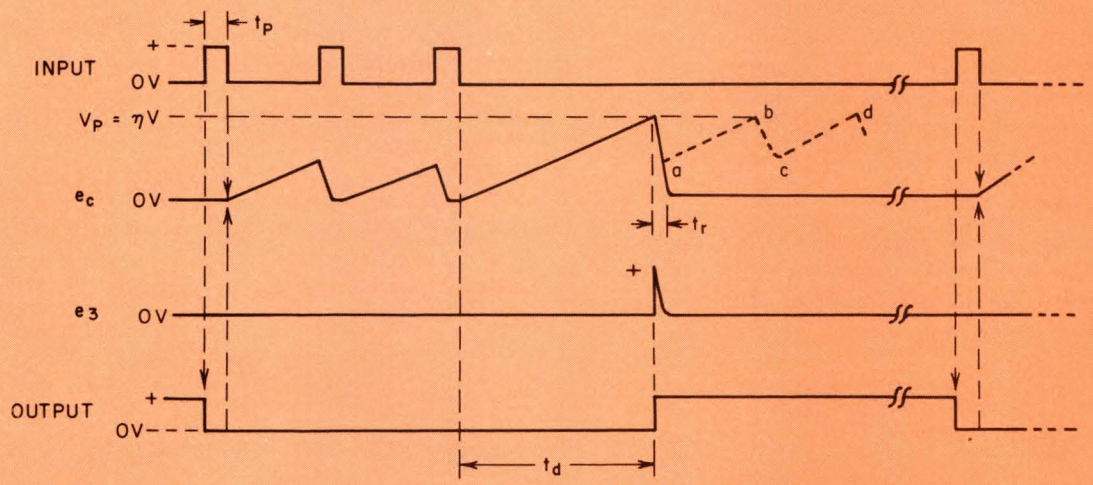


Fig. 2. Waveforms for the circuit in Fig. 1.

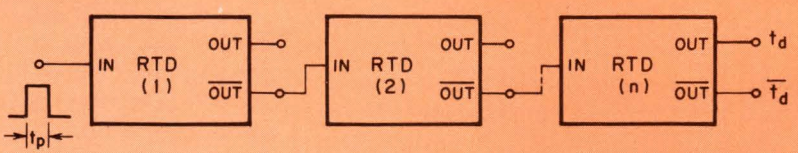


Fig. 3. Tandem connection of RTD circuits.

Q_3 is applied through D_5, maintaining Q_2 in saturation and Q_3 cut off.

Feedback prevents oscillation

The high level at the collector of Q_3 is simultaneously applied to the anode of D_2, which forces Q_1 into saturation, effecting an additional and permanent discharge path for the capacitor through R_3. This is an important aspect of the circuit. The additional feedback from Q_3 to Q_1 through D_2 prevents the UJT circuit from behaving as a relaxation oscillator during the absence of input pulses, independent of the values of R_5 and R_4, and the valley characteristics of the UJT.

Without this additional feedback, an oscillating voltage waveform can occur across the capacitor (especially with large values of R_4 and R_5) as shown by the dotted line *abcd*, in Fig. 2. The recovery time, *bc*, of these oscillations can be larger than the input pulse width t_p. Thus, if a short-duration input pulse were to arrive during this interval, a possibility exists for the outputs of the loop configuration to alternate between bistable states following the first of a train of such pulses. This would follow from high-level pulses appearing simultaneously at the anodes of D_4 and D_7.

Therefore, the completely closed-loop arrangement prevents high-level pulses from appearing, simultaneously, at the anodes of D_4 and D_7, thereby eliminating all possibility of ambiguous output signals at the start of a new train of input pulses.

Design considerations

To compensate for slight reductions in the avalanche potential with increasing temperature, R_6 is added in the base-2 circuit of the UJT. Its proper value is given by:

$$R_b \leqq \frac{0.7\ (R_{bb}+R_{be})^2}{(\eta R_{bb}+R_{be})V} \tag{1}$$

where R_{bb} = UJT interbase resistance, R_{be} = effective UJT base-1 external resistance $\cong e_3 R_{bb}/(V-e_3)$ and η = UJT intrinsic standoff ratio. R_7 is chosen such that:

$$\frac{V}{R_7} \geq \frac{V}{R_6+R_{bb}} \tag{2}$$

Consequently, D_3 normally conducts, maintaining the UJT base-1 potential at approximately

$$-0.3\ V = e_3. \tag{3}$$

With the changes in the UJT avalanche potential adequately compensated by R_6 the UJT peak potential is given by:

$$V_p = \eta V \tag{4}$$

Assuming that the sum of the collector cutoff impedance of Q_1 and the emitter cutoff impedance of the UJT is much larger than $R_4 + R_5 = R_c$, we can write:

$$V_p = V\left(1 - \epsilon^{-t/R_cC}\right) \tag{5}$$

Substituting (4) in (5) and solving for the delay time we have:

$$t_d = R_c\, C \ln\left(\frac{1}{1-\eta}\right) \tag{6}$$

The equation defining the discharge of the capacitor is:

$$e_c = V_p\, \epsilon^{-t/R_3C} \tag{7}$$

whereupon the maximum recovery time is given by:

$$t_r \leq R_3 C \ln\left(\frac{V_p}{e_c}\right) \tag{8}$$

If complete discharge is defined as $e_c = 0.01\ V_p$, then:

$$t_r \leq 4.6\ R_3 C \tag{9}$$

Letting μ = recovery ratio = t_d/t_r we have, from (9) and (6):

$$\mu = \frac{0.218\ R_c}{R_3} \ln \frac{1}{1-\eta} \tag{10}$$

The value of η for most UJTs is usually greater than 0.5. Therefore, from (10) we have:

$$\mu > 0.15\ \frac{R_c}{R_3} \tag{11}$$

Typical values of R_c and R_3 are in the order of 300 kΩ and 30 Ω, respectively. Thus $\mu > 1500$ (typical).

Note that Q_1 must tolerate a peak collector current of:

$$I_{Q1} = \frac{\eta V}{R_3} \tag{12}$$

For example, if $V = 12$ V, $\eta = 0.5$, and $R_3 = 30$ Ω, then:

$$I_{Q1} = \frac{(0.5)\ (12)}{30} = 200 \text{ mA pk.}$$

Tandem connection for long delay

In some applications, a recovery ratio much greater than 1500 is required. This would occur, for example, where the delay times are in the order of kiloseconds while the available input pulse widths are in the order of microseconds. In such applications a tandem connection of the RTD is very effective. In this case, if n is the number of RTDs in tandem $t_d \leq \mu^n\ t_p$ and the recovery ratio of the tandem connection becomes an exponential function of the number of stages used. That is, $(t_d/t_p) \leq \mu^n$ where μ is the recovery ratio of a single RTD circuit. Thus:

$$t_d \leq t_{d1} + t_{d2} + t_{d3} + \ldots\ t_{dn-1} + t_{dn}$$

$$t_d \leq \mu t_p + \mu^2 t_p = \mu^3 t_p + \ldots\ \mu^{n-1} t_p + \mu^n t_p$$

$$t_d \leq \mu^n\ (1 + \mu^{-1} + \mu^{-2} + \ldots\ \mu^{1-n})\ t_p$$

Then, for $\mu \geq 100$, $t_d \leq \mu^n\ t_p$.

Op Amp Control Without Relays

This op amp control circuit is much faster than the conventional approach that includes relays to short output to input. It also eliminates inductive transients that could be induced into high-gain circuits when relays are used.

LEE STRAHAN, Exact Electronics, Inc.

Integrators, linear amplifiers, differentiators or nearly any inverting configuration using op amps can be controlled by one simple circuit that provides two basic functions. First, an electrical command can strobe or reduce the gain of the amplifier to nearly zero by effectively shorting output to input. And second, a clipping function is provided that holds all outputs below a predetermined level (**Fig. 1**). This latter function is especially useful with integrators where the output after relatively long periods of time approaches the limits of the amplifier.

Both the input signal requirements for the strobe action and the activation time of this circuitry are compatible with TTL and DTL logic systems.

When used in an integrator, this circuit will not discharge the integrating capacitor as rapidly as a switch or relay. Instead, it provides a constant rate of discharge that is controlled by the size of the integrating capacitor and the design value of current supplied to the diode bridge. With a constant rate of discharge, the amplifier always operates within its output current limitations which enhances high-speed operation by not requiring recovery from overload.

To analyze operation, refer to **Fig. 2**, where the circuitry is separated into functions. Clipping is accomplished by the four-diode bridge with three external diodes acting as a zener, while the strobe function is the four-diode bridge with resistor current sources; external diodes are not shown since they are reverse biased during strobing action. Input circuitry for strobing is shown with its single-ended input and differential output connections.

Clipping circuitry draws no cur-

(Continued)

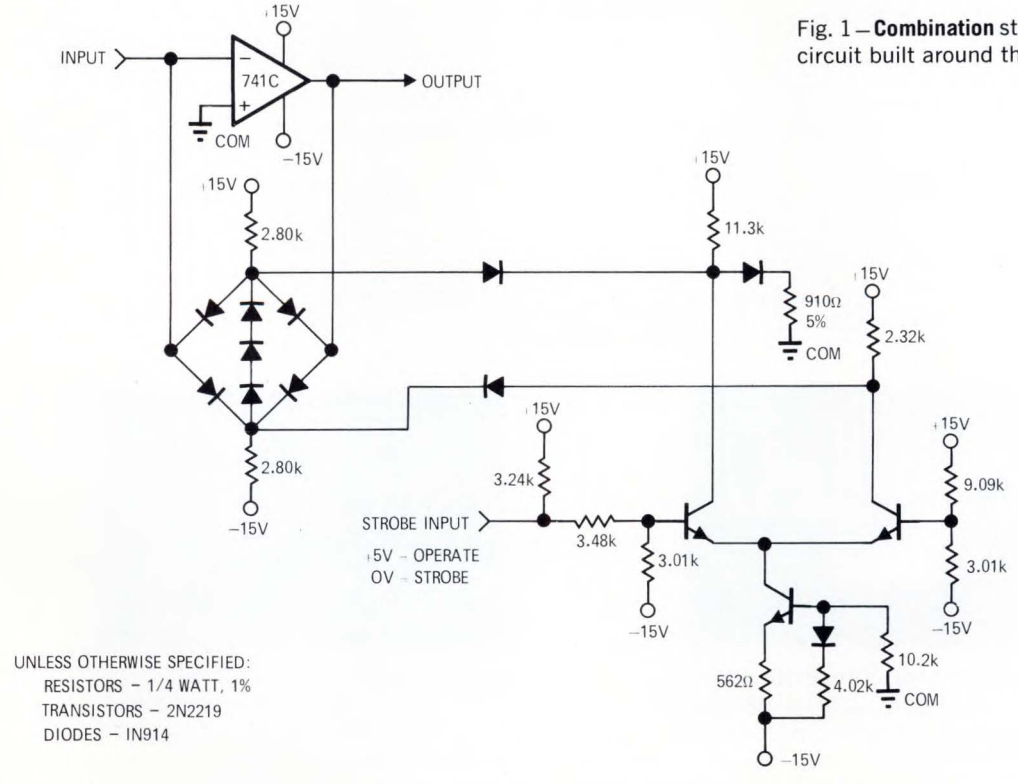


Fig. 1 – **Combination** strobe and clipper circuit built around the 741C op amp.

(Continued)

rent from the input or output of the op amp during normal in-range operation of 5V pk-pk.

The strobing circuit has two balanced current sources that forward bias the diodes connected to them. With the op amp input and output voltages equal, the current supplied by these sources splits, with half going to the diodes on the output side of the amplifier and half going to the diodes on the input side. Because these currents cancel, no current flows into or out of the op amp. When an input signal, assumed negative, is applied to the op amp, the output tends to rise positively which allows the current division in the diodes to unbalance. Result is a current flow to the amplifier input that is equal and opposite to the external input current. The actual amount of output voltage error (when the amplifier is strobed) is controlled by the design current level of the circuit, the characteristic curve of the diodes used, and the amplifier input current level.

The strobe input circuitry has a differential amplifier used to sink current from the strobing bridge which deactivates the strobing action. As current is drawn from the resistors that supply the bridge, the bridge diodes around the op amp are reverse biased and no current flows into or out of the amp from the clamp circuitry. With strobe deactivated, the reverse bias on the clamp diodes is equal on each side of the bridge.

With the clamp circuit activated, each diode connected between the differential amplifier output and clamping bridge is reverse biased and no current is drawn from the bridge. The constant current source is necessary to maintain the delicate balance of operating currents under a varying range of input voltages used in activating the clamp circuit.

The combination of these three basic functions into the circuit shown represents a versatile addition to the building blocks often used when doing analog computation, signal processing, etc. Although this version was built using discrete components, it can be built with commercially available ICs. Actual results obtained from this circuit are shown in the two photographs. □

Lee Strahan is a project engineer for Exact Electronics, where for 3 years he has been designing and packaging the company's line of function generators and waveform synthesizers. Before Exact, Strahan spent 5 years with the University of Calif. Lawrence Radiation Lab.

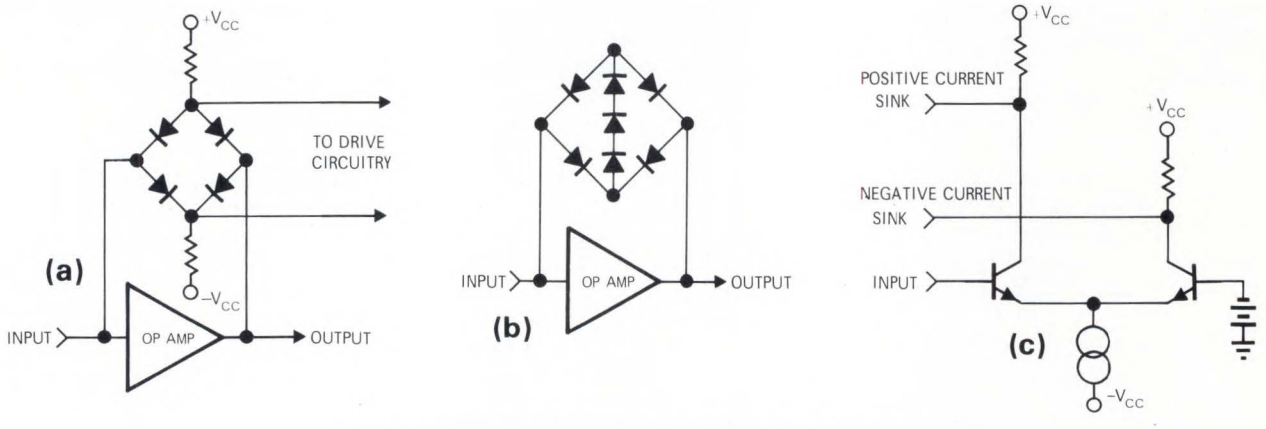
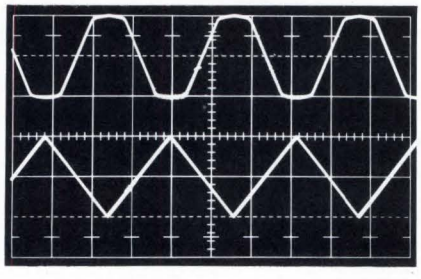
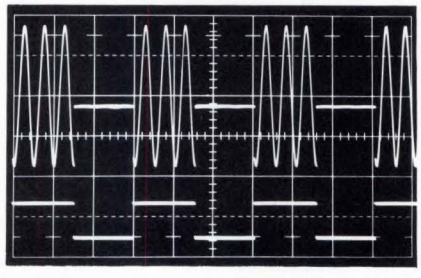


Fig. 2—**a) Basic bridge** strobing circuit, **b)** Basic bridge clipping circuit, **c)** Differential drive for bridge strobe.



Input (bottom trace) and output voltages using 741 as linear amplifier. Because input exceeded clipping level, upper waveform results.



Bottom trace is strobe signal input control to circuit. Top trace is op amp output. Note high on-to-off ratio which is approximately 45 dB.

FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE NO. L64**

Narrow Peaks Caught by Better Detector

Slewing rates for general purpose op amps sometimes cause peak detectors to miss the short ones. A simple circuit solves the problem.

ROBERT KLATT, Scan-Optics, Inc.

If the peak is gone by the time the op amp gets there, you've got a problem. The obvious solution would be an op amp with a faster slew rate. Here's a nifty solution which is a bit cheaper and not as "speed-limited".

The circuit shown in **Fig. 1** is a standard op amp peak detector that is slew-rate limited. The output of A_1 is in positive saturation until the input falls below the previous minimum. When a new minimum occurs, e_o must slew between positive saturation and the input signal level. For a general purpose op amp (such as the 741) this may take 10 μsec or more, and peaks of shorter duration are lost.

The problem may be avoided by causing the amplifier output to track the input at all times, and then connecting C_1 to the amplifier output only when a new peak occurs. A simple method of accomplishing this is shown in **Fig. 2.** R_1 is chosen to furnish the input bias current of A_1, plus a small (less than 1 μA) emitter bias for Q_1. When the input signal is more positive than the stored negative peak, feedback is through the forward biased base-emitter junction of Q_1, and the amplifier output follows the input, offset by the base-to-emitter voltage of Q_1. In this condition, the only current flow into C_1 is the collector current of Q_1. This may cause significant drift (or droop). In many applications, however, the peak signal will be buffered, and droop can be minimized by choosing R_1 to make the collector current equal to the buffer-amplifier input-bias current.

When the input signal falls below the stored mimimum, current flows through the base-collector junction of Q_1 into C_1. Q_1 is now in the inverted common-emitter mode, with C_1 connected to the inverting input of A_1. The error due to the offset voltage of Q_1 typically will be comparable to the input offset voltage of A_1. When the input again rises above the stored minimum, Q_1 returns to common collector operation, leaving C_1 with the negative peak signal. □

Fig. 1

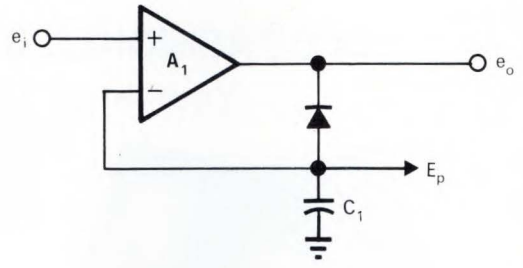
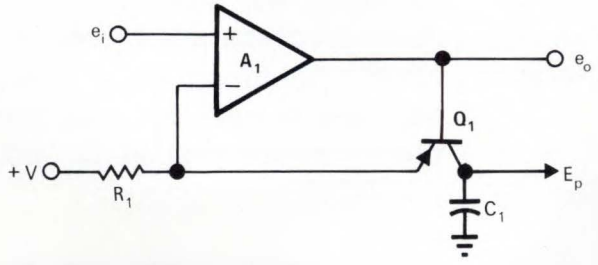


Fig. 2



Robert W. Klatt is Director of Analog Systems at Scan-Optics, Inc., East Hartford, Conn. His duties involve the development of analog and electro-optical systems for optical character readers. He is a member of IEEE.

FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE NO. L65**

CYCON REVOLUTIONIZES ANALOG/DIGITAL INTERFACE TECHNOLOGY

WHO?

CYCON was formed to exploit a significant breakthrough in analog/digital interface technology. With an advanced proprietary design and construction technique, CYCON manufactures high-performance signal interface building blocks at half the cost of conventional module or integrated circuit technologies.

54 NEW PRODUCTS

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CYCON's line of digital-to-analog converters ranges from a complete 8-bit DAC for $12.00 (in 100-piece quantities) to one of the most complex and accurate DAC's ever offered commercially . . . with 12-bit precision over the full specified temperature range.

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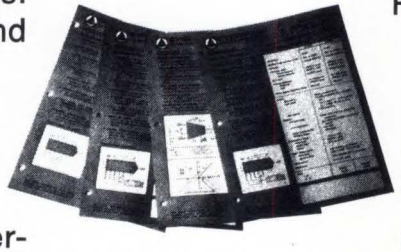

Your letter, telephone call or Reader Service Card inquiry to CYCON's Wayne Peacock will bring a double handful of good old fashioned data sheets in return . . . with complete performance data under specified test conditions, a usable functional diagram, and prices printed on each sheet. Additional data sheets describing the new transducer amplifiers and multipliers will be mailed to you as they are published.

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CIRCLE NO. 18

CIRCUIT DESIGN AWARD PROGRAM

UNUSUAL CIRCUITS ☐ Designed by readers ☐ For use by readers ☐ Voted on by readers.
Your vote determines this issue's winner. All circuits published win a $25 U.S. Savings Bond. All issue winners receive an additional $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Savings Bond Grand Prize.
VOTE NOW . . . by circling the appropriate number on the reader inquiry card. Submit your own circuit, too. Mail entries to Circuit Design Program Editor, EDN/EEE, 270 St. Paul St., Denver, CO 80206.

Readers voted Karl Karash winner of the $1000 Savings Bond for the best circuit of 1970. His winning circuit was called "Adjustable Low-Impedance Zener". Mr. Karash is with Raytheon Co., in Sudbury, Mass.

Squaring circuit makes efficient frequency doubler

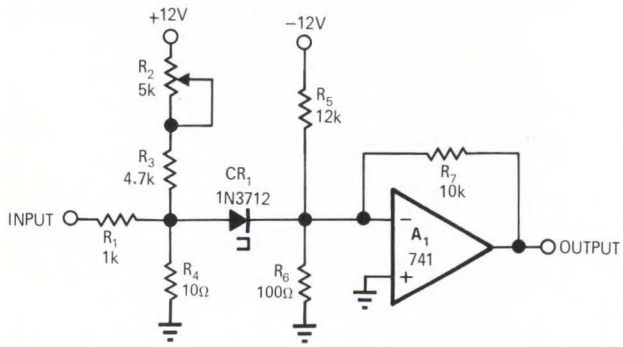


Fig. 1—**Simple tunnel-diode** circuit provides efficient frequency doubling without the use of tuned circuits.

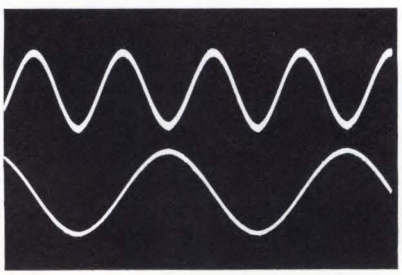


Fig. 2—**Input** (bottom) and output (top) waveforms at 1 kHz. Voltage scales are 1V/cm for the bottom trace and 0.1V/cm for the top trace.

To Vote For This Circuit Circle 161

by Russell Kincaid
Sanders Associates
Nashua, N. H.

Using the tunnel-diode squaring circuit shown in **Fig. 1,** it is possible to double the frequency of input signals, without the use of tuned circuits.

With an input signal A sin ωt, the output will be A cos 2 ωt. The fundamental and other harmonics will be at least 30 dB below the level of the frequency-doubled output signal. Satisfactory operation is possible from dc to the upper frequency limit of the amplifier. The scope picture (**Fig.2**) shows the input and output at 1 kHz.

Potentiometer R_2 in the positive bias supply allows the diode current to be adjusted to the peak of the tunnel-diode bias current, thus preventing offset at the amplifier output. Resistor R_6 shunts the op amp input and prevents oscillation at frequencies above the amplifier response range.

The circuit relies on the parabolic shape of the tunnel-diode characteristic near the peak current, and on the following mathematical relation:

$(\sin x)^2 = 1/2\text{-}1/2 \cos 2x$

Ideally, the tunnel diode should operate with zero impedance for the source and load. In this circuit, the source is 10Ω and the load is the op amp summing point. □

Variable dc offset using a current source

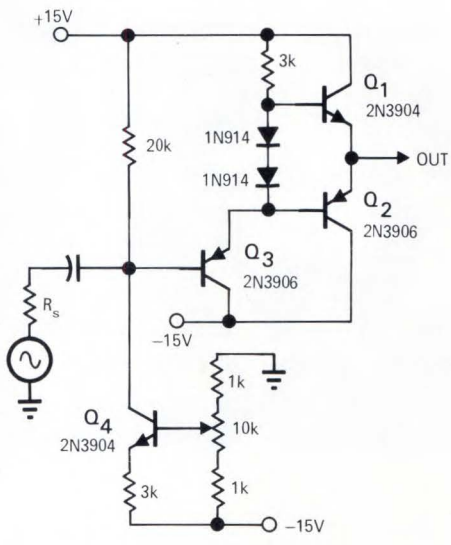
To Vote For This Circuit Circle 162

by P. Bruce Uhlenhopp
NOAA
Boulder, Colo.

In many circuit applications it is useful to offset ac signals at varying dc levels. Some designs call for offsetting signals that are to be fed into a moderately high input impedance. A dc offset can be added to an ac signal without significant interaction by using a high-impedance current source to provide the desired level shift as illustrated in the figure.

Transistor Q_4 and its resistive network form a high-impedance adjustable current source. The input signal and the offset signal are fed to the base of Q_3 which drives Q_1 and Q_2, a complementary-symmetry emitter follower.

For the values shown, the level can be shifted about ±7V dc. This is particularly useful in a video circuit whose dc level controls the intensity of a CRT. DC level can be controlled from a panel-mounted potentiometer since the high-frequency video signal does not pass through the pot. □



This simple circuit, using an adjustable current source, allows a video signal to be offset ±7V dc.

Efficient and simple zero-crossing switch

To Vote For This Circuit Circle 163

by A. S. Roberts and O. W. Craig
Univac
Bristol, Tenn.

A zero-crossing switch eliminates the high surge currents and transients that normally occur when switching line voltage to a load. For example, the surge current in an incandescent lamp that is switched on at peak line voltage is many times the peak current for a lamp switched on at a zero crossing. Another advantage of the circuit described here is that it needs no dc power supply (see **Fig. 1**).

When the line switch is closed, power will not be applied to the load until the next time the voltage goes through zero.

Identical circuits control each half cycle of the ac line, so only one of the two possible sequences of events will be described here. Assume that the line switch is closed at a time when the switch side of the line is positive and the voltage is greater than 1.4V. Transistor Q_1 immediately conducts, thus prohibiting C_1 from charging to the voltage required to trigger SCR_1. During the remainder of the half cycle, the high resistance of R_1 limits the load current. Diodes CR_2, CR_3 and CR_4 limit the voltage across the transistor circuit to about 3V, while R_2, CR_5 and R_4 provide proper bias for the transistor. Resistor R_3 limits Q_1's collector current and controls the charge rate for the capacitor.

When the line voltage crosses zero, current flows through resistors R_5 and R_6 thus beginning to charge C_2. This capacitor charges to the SCR trigger voltage (0.4 to 0.8V) and triggers SCR_2 within 0.02 msec (assuming a 115V, 60-Hz line). This occurs before the line voltage reaches an amplitude of 1.4V, which would be sufficient to turn on Q_2 and hold the SCR gate voltage below the minimum trigger voltage, as described earlier for

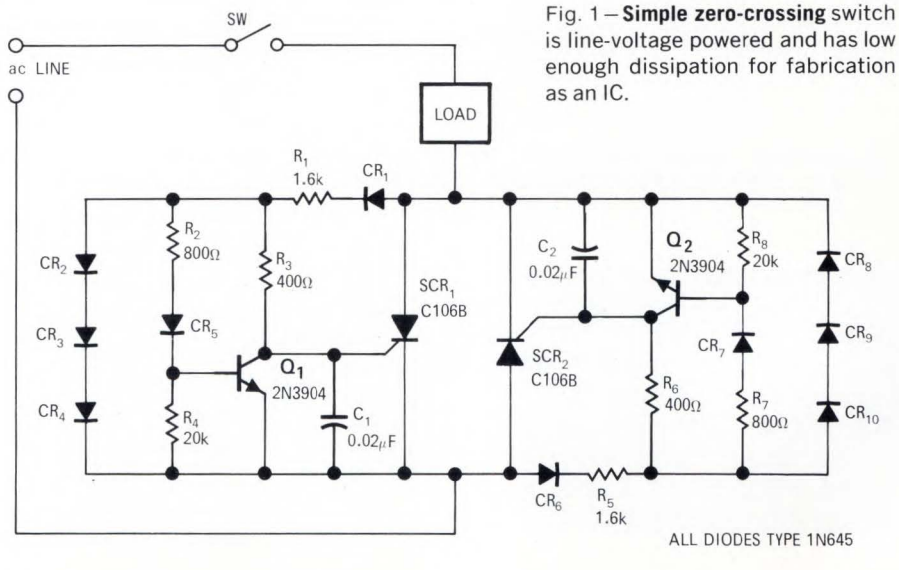


Fig. 1—**Simple zero-crossing** switch is line-voltage powered and has low enough dissipation for fabrication as an IC.

the other half of the circuit.

Because SCR turn-on occurs approximately 0.013 msec after zero crossing (less than a third of an electrical degree) and each SCR conducts for almost a full half cycle, essentially no power is wasted in the circuit. Because of this low dissipation, the circuit lends itself to fabrication as an IC. Note also that the circuit is never subjected to full line voltage except during the time interval between line-switch closure and the first zero crossing. □

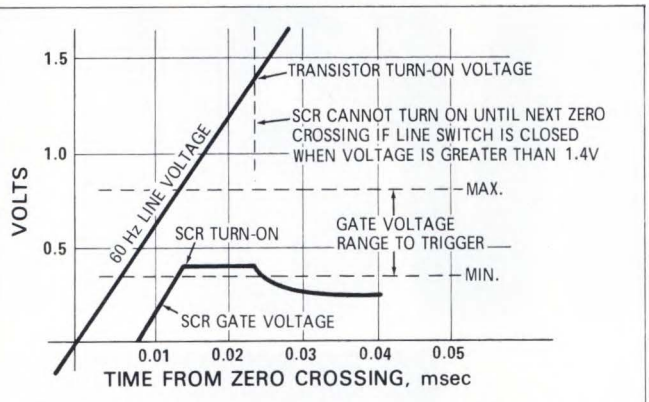


Fig. 2—**Transistor turn-on** at 1.4V prevents SCR triggering until after the next zero-crossing point. Timing diagram shows sequence of events after zero crossing.

Circuit Design Entry Blank

U. S. Savings Bond Awards ● $25 for all entries selected by editors ● An additional $50 for winning circuit each issue, determined by vote of readers ● Additional $1000 bond for annual Grand Prize Circuit, selected among semi-monthly winners by vote of readers.

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EDN/EEE
Cahners Publishing Co., Inc.
270 St. Paul St., Denver, Colo. 80206

I hereby submit my entry for the CIRCUIT DESIGN AWARD PROGRAM of EDN/EEE.

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Print full name (no initials) and home address on line below exactly as you wish it to appear on Bond, if entry is selected for publication.

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Entry blank must accompany all entries. Circuit entered must be submitted exclusively to EDN/EEE, must be original with author(s) and must not have been previously published (limited-distribution house organs excepted).

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EDN

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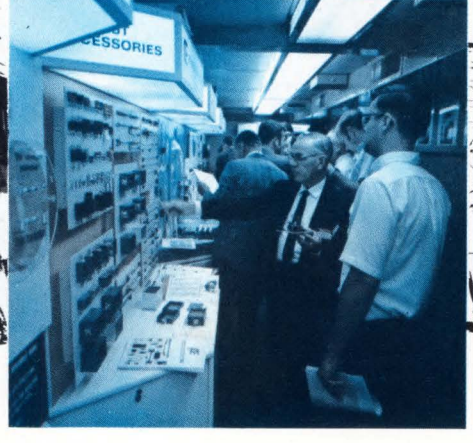

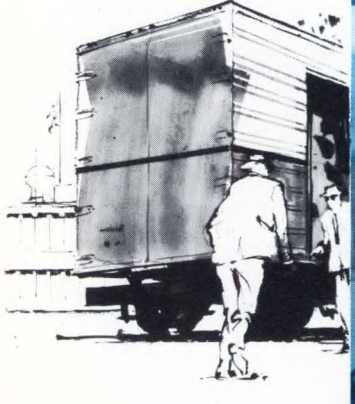

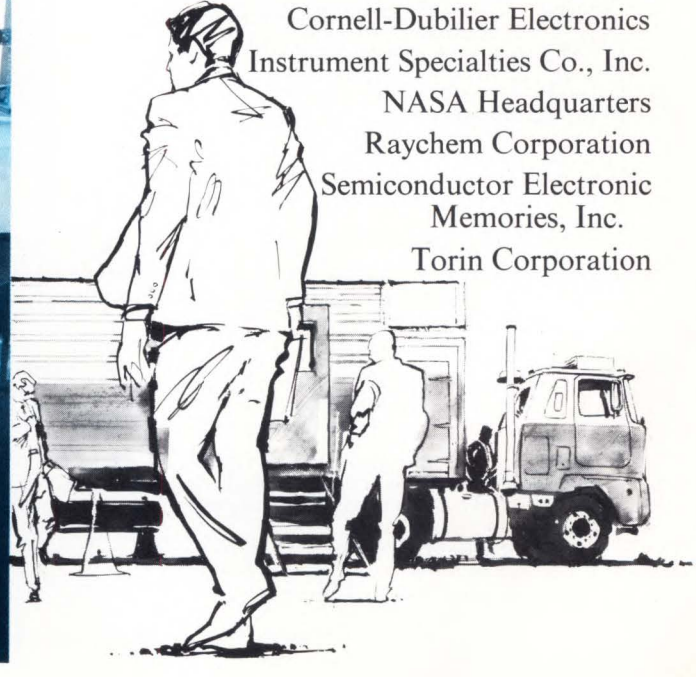

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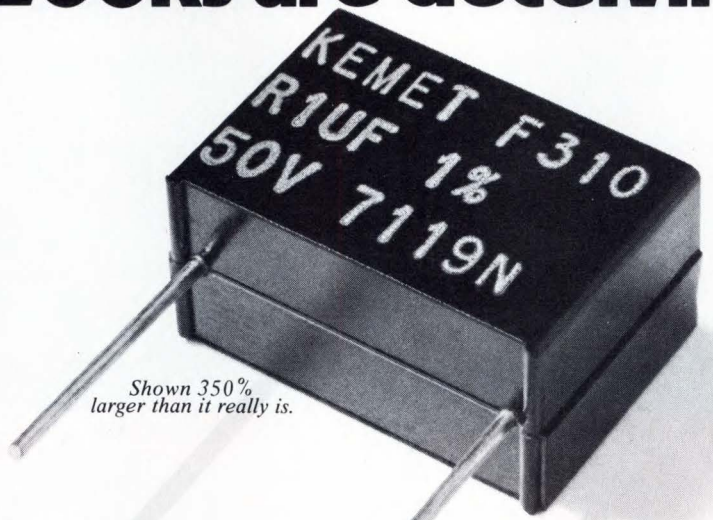
It doesn't look like ceramic, glass or mica. Looks are deceiving.



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STABILITY (Temperature Coefficient in PPM/°C	Characteristic A – 200 ±30 B 0 ±100 C 0 ±50	–120 ±30	Varies to ±350	+1150	Characteristic C ±200 D ±100 F – 0 to +70	0 ±30	+180
ELECTRICAL							
Dissipation Factor – % at +25°C	0.10	0.10	0.30	0.40	0.10	0.10	0.10
Insulation Resistance Megohm at +25°C	1 x 10^7	1 x 10^6	1 x 10^5	1 x 10^5	5 x 10^4	1 x 10^5	1 x 10^7
Dielectric Absorption	0.03	0.02	0.25	0.25	4.80	0.29	5.10

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UNION CARBIDE COMPONENTS DEPARTMENT

CIRCLE NO. 22

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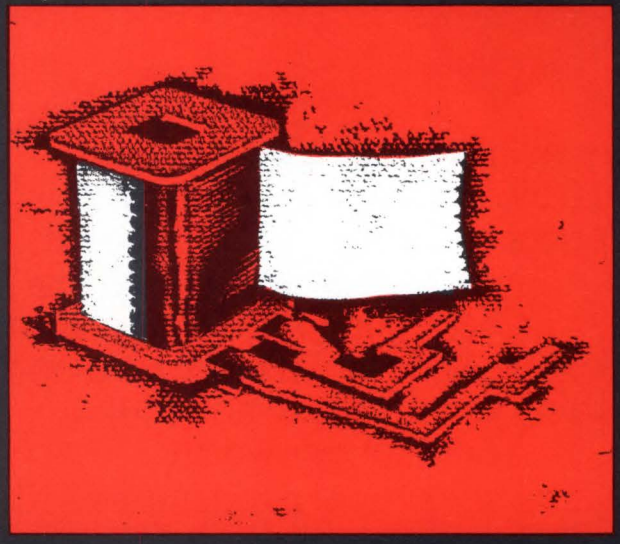

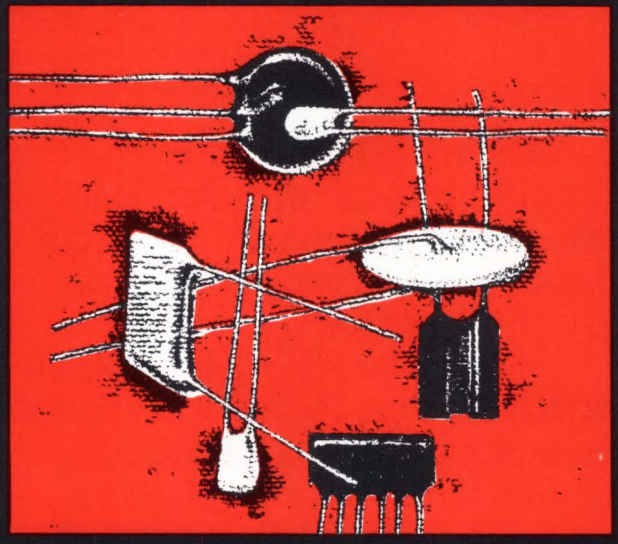

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TUBINGS.
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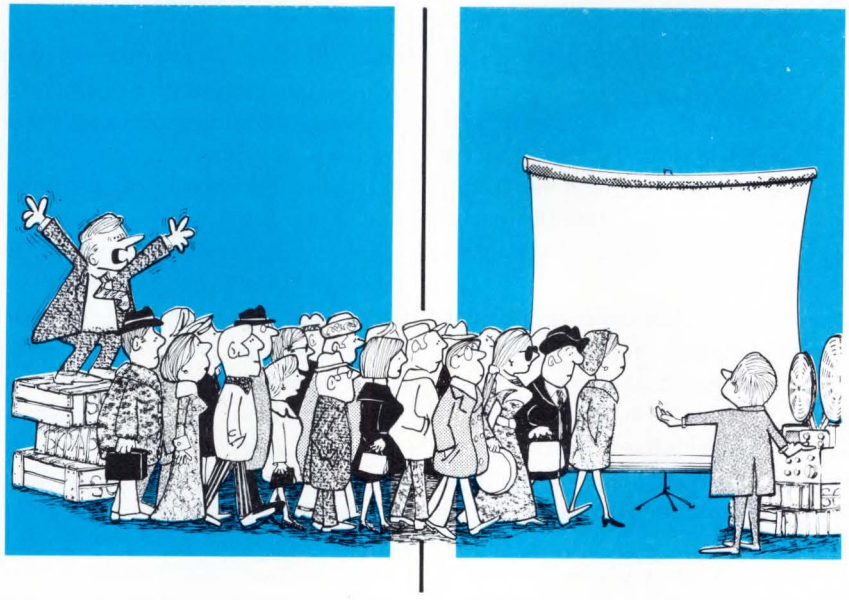


Showing and Selling . . .
With the Proper Medium

Nobody appreciates having the "right tool for the job" more than today's design engineer. Accordingly, designers who are called upon to communicate visually should know what tools are available—and be aware of their strengths and weaknesses.

STEPHEN A. KALLIS, JR., Motion Picture Consultant

Information transfer, for whatever purpose, is increasingly important to today's designer. Whether presenting a conference paper, helping sell a product or simply recording test results, pictures are an important and valuable tool. Like other tools, there are specialized forms to handle specific tasks.

One of these, videotape recording (VTR), was touted as *the* medium for industrial communications in a previous Design Interface (March 15, 1971, EDN: "Show And Sell With VTR"). Though VTR is indeed a powerful tool, as pointed out by this article, it is by no means the only tool—nor is it necessarily the best tool for all visual communication requirements.

To place VTR in proper perspective, it should be related to the other basic visual media, namely slides and motion picture film. As we shall point out, each medium has its special characteristics, strengths and weaknesses. Consequently, each is a superior tool for a specific job; no one medium is a panacea.

Videotape Revisited

Though videotape was discussed in the previous article, let's review its strengths and point out some of its weaknesses. Perhaps its greatest strength beyond being a medium that naturally depicts motion is its "instant playback" feature. Videotape does not have to be processed like any of the film-based recording techniques. Accordingly, a presentation can be made fairly rapidly, if necessary.

VTR is the optimum medium for making visual presentations that are very transitionary in nature—presentations that have a lifespan measured in hours, days, and weeks rather than those measured in months, years, and perhaps decades. It is also more practical where only a single copy of the presentation is desired.

Consequently, VTR is quite useful in training situations. Whether it is self-correctional training (a salesman analyzing his spiel immediately after delivery, for example), or training about a product with a short life span, VTR is undoubtedly the best medium to employ.

Videotape can be erased and reused, cutting down recording medium costs for short-term presentations. By the very nature of the medium, adding a sound track is trivial.

Of course, videotape also has disadvantages. The inexpensive units that most industries would consider buying have no color capabilities. Most audiences expect color presentations these days, and often feel

(Continued)

something important is missing when color is not present.

Moreover, videotape—unlike either slides or films—cannot be inspected directly by eye. To view a videotape image, you must play it back. This can make editing rather difficult. Another problem is that the resolution of the inexpensive videotape units is considerably below broadcast quality.

Also, there is the matter of playback equipment. First, with respect to an audience, we are speaking in terms of a tiny TV monitor screen as compared to the relatively giant screens of either film or slides. Therefore, your audience must be relatively small, or you must make elaborate arrangements, such as multiple playback monitors (thus breaking your audience into several smaller audiences).

Perhaps VTR's most critical drawback is the lack of standardization. Videotape comes in various widths, is recorded in various scan patterns, and is played at different speeds. Currently, a sizeable amount of VTR equipment is incompatible with other VTR equipment. This could be awkward for a salesman visiting the offices of a prospective client—either he would have to make certain that the company he was visiting had compatible VTR equipment (if it had any VTR equipment at all), or he would have to arrive with an armload of electronic gear. Hardly a way to make a good impression, no matter which choice he makes.

To be sure, there are attempts being made at standardization. Even so, there is a lot of VTR incompatibility already in the field.

Slides Cost Less— And Are Easy To Edit.

Of the three basic media, slides are by far the least expensive. Indeed, the basic equipment required to produce a slide show can be purchased for a few hundred dollars.

Slides lend themselves primarily to presentations with a live speaker. Although there are ways to automate an entire slide presentation, the static nature of a slide picture usually demands some form of movement such as a speaker's pointer.

Slides can be shown on a large screen to a considerable audience, occasionally up to 200 people. Because most slide shows are in color, there's the added input that color brings to an information display. For these reasons, slides are usually the preferred method of augmenting an orientation or training lecture when no critical motions are involved in the subject under discussion.

Since each slide forms a separate information unit, slides are frequently the easiest medium to edit or update. For example, you can easily change a slide showing an obsolete product for another slide at a trivial cost. Further, supplementary information can be included in a presentation the same way.

Because a slide is projected for an appreciable period of time—anywhere from a few seconds to several minutes—a slide show is often the most "compact" visual medium. A half-hour presentation can fit in a shirt-pocket-sized box. Consequently, presentations on a variety of subjects can be stored in a relatively small volume, and this could be very important to a sales office that markets a great variety of products.

By connecting a special tape recorder to the projector, it's possible to "automate" an entire slide presentation. In such a set up, the audio tape carries a narration plus a synchronizing sound track that signals, via tones, the appropriate time for a slide change. With this arrangement, even a slide presentation can have a synchronized "sound track".

Among slide variants, there is the filmstrip. This is a length of film with individual static picture "frames" that are presented in sequence similar to a normal slide show. This method has most of the limitations of a standard slide show. Additionally, the editing of a filmstrip is considerably more difficult. However, the filmstrip generally takes up less space than a slide show (some filmstrips come in handy little 16 mm film cartridges; one of these cartridges takes up less space than a standard book, yet it could contain a 2-hour show), and in the automated systems the frames can be changed rapidly enough to produce a limited illusion of motion.

Another slide variant is the stereoscopic slide. Though rarely projected, they can often be effective sales presentation tools. A stereoscopic (or 3-D) picture can show a prospective customer an accurate physical representation of something that might be highly impractical to transport (e.g. an environmental testing chamber). Because the item is being presented in 3-D, the prospect often feels he has a more complete understanding of what he is being shown than would be possible with conventional photographs.

Chief weakness of slides is the static nature of the presentation. Psychologically, an audience expects some motion in a scene—some change beyond the mere succession of slides. Consequently, an audience is more easily distracted than it would be if watching something with motion.

Film For Flexibility

Though the most expensive medium to produce, film is probably the most effective for major and long-term presentations. Having been around the longest, film enjoys international standardization—and that includes both sides of the Iron Curtain. No matter where you might go, you can almost be assured of finding standard film projection equipment.

Before detailing the attributes of motion picture film, let's first consider some of the areas where film is definitely *not* the best medium to use.

Only in extraordinary circumstances should film be used for sales messages and company "party lines". Film is a reasonably permanent medium, and such messages are not usually permanent since they reflect an immediate and temporary marketing situation. Though videotape has been suggested for this purpose, I believe that the proper medium for such fleeting presentations is almost always the nonvisual audiotape, reel or cassette.

If you don't want to be disappointed like one company I know, you should never use film for modified flip-chart presentations. The company in question put together a half-hour flip-chart presentation and filmed the whole thing. Then, the film was distributed and management was faintly puzzled why nobody seemed particularly enthusiastic about the film. The answer of course, was that the filmed flip-chart presentation lacked the vitality of a live presenter. In effect, the film captured all the bad aspects of a flip-chart presentation without adding anything of its own. Similar mistakes are made by trying to film static pictures; you could do as well with a slide show, and get away with it a lot cheaper.

Film is a highly flexible recording medium. Motion picture cameras can be light, portable, and relatively independent of their surroundings (necessary for field work). They can also be heavy, sound-deadened, and steady (useful for studio sound work). They can record in either black and white or color, and they can record motions from slower than a frame a day (e.g. erosion studies) to thousands of frames a second. They can be used for "animated" scenes, imparting motion to a diagram or model.

Like the videotape camera, the motion picture camera can give you a close-up of a process as no human eye would be likely to behold it, but unlike the videotape camera, the speed restrictions are a lot less exacting for film. Further, depending on the type of film you use, the same camera can record the scene in normal light or infrared, permitting the viewer to see things he otherwise could not about a process or a product.

Film can easily be inspected by eye. This makes editing considerably easier. Additionally, it permits you to "pull" still pictures from individual frames of the film, should you desire. Film occasionally captures something on one of its frames that is important and unexpected. During the filming of a routine Hollywood western some years ago, for example, the cameras accidentally caught a midair collision of two aircraft.

Although production of film is relatively costly (the "industry standard" rule-of-thumb calculation is $1000 per finished minute of film; that is, a 10-min film should cost about $10,000 to produce), duplication of the finished result is quite inexpensive, costing between $100 and $150 for a half-hour color sound film in 16 mm. If you expect a large distribution for your film, then, the costs drop sharply.

An important way to gain perspective on a film is to examine its per-viewer cost. One film that was produced rather inexpensively for $5000 has already had an audience in excess of 50,000 and is still in demand. On a per-viewer basis, this film cost its sponsors 10¢/viewer, which is considerably cheaper than an equivalent number of sales brochures to carry the same sort of message. To be sure, not all films are this popular, yet many films have tremendous lasting power. One film, *Building the Golden Gate Bridge,* first shown in the fall of 1937 was so popular that it was still in demand in 1959 when it was decided to re-edit and re-release it! The new version is still in circulation. And the longer the lasting power, the lower the per-viewer investment becomes.

If the film is of reasonable quality, the audience becomes a somewhat captive audience. Once the lights have been extinguished, the screen image has all the proper characteristics for capturing attention. Since it is usually the only thing in the room that is clearly visible, the eye is naturally drawn toward it. This is enhanced by its large size. Interest is continually reinforced by the motion within its frame. And finally, the added dimension of color makes it a visually pleasing form; the vast majority of information films are in color. Frequently, a member of an audience has to fight to keep from watching a film when someone is trying to get his attention. All in all, it is a highly satisfactory environment in which to put a sales message.

Several producers are now making films with more than one language narration, but on the same copy of the film. To understand how this is done let's first explore the method for putting sound tracks on films.

The "classic" way of placing a recorded sound track on film is photographically. There are two basic means of modulating the audio information on a film photographically, but the basic result is the same: light shining through a sound track is intensity modulated; and the intensity variations are transformed into audio signals by means of a fast response photodetector.

Since the advent of magnetic recording, another method now used is what the motion picture industry calls "magstripe recording". In this technique, a magnetic strip is bonded to the film over the location usually reserved for the optical track. The magstripe reproducing assembly is located at approximately the same position as the conventional optical pickup and functions in precisely the same way as on a normal audio tape recorder. The results are actually better than optical sound.

(Continued)

A technique coming into use known as "half striping" permits film producers to put two separate sound tracks on the same film. In this method, only half the width of an optical sound track is magstriped. The optical track can show in the uncoated half, and the coated half is available for recording a completely separate sound track in a different language. Shown on an optical projector, only the optical track will be picked up; on a magnetic projector, only the magstripe track will be heard. Of course, you can't get something for nothing: each track will be about 6 dB down from a full-width track, but field experience has shown this to be unobjectional. By increasing the volume level slightly acceptable compensation can usually be achieved.

By means of a "split screen", film permits techniques to be compared. Thus it is possible to show the improvement of a newer process over one it replaces. Such a technique could not be duplicated by the type of videotape equipment normally available to most industrial concerns, and of course such a comparison would be meaningless on slides.

Films need not be 16 mm for showing to larger audiences. They are also being used in the new "Super 8" format for smaller presentations. In this mode, the projector and screen are integrated into a briefcase-sized assembly that can be carried by the salesman to a prospective client's office. When the show is ready to commence, the salesman merely flips open the cover, snaps a rear projection screen in place, plugs the unit into a wall outlet, and snaps a film cartridge into place (the whole process typically takes about 30 sec). Then, the color, sound production takes over.

Using one of these "Super 8" systems, the salesman does not have quite the captive audience he would have using a larger projector and a theater, and hence the audience is more subject to distraction. Yet even so, the presentation equipment is not bulky, sets up fast, is light enough for the salesman to carry with him without being hindered, and produces an image that is at least as good as that of a videotape unit with the same size screen – and is in color to boot.

Film does have one big disadvantage – an audience expects more of it. An audience is more forgiving of a slide or videotape recording that is not of professional quality, but they tend to be critical of a film that is substandard. This means that if you contemplate a film, whether it be done in-house or contracted to a producer, it is advisable not to scrimp. Many companies have tried to take financial shortcuts in making films by renting a motion picture camera, placing it in the hands of the company's still photographer and requesting that he make a film. This hardly ever works out, and paradoxically because the photographer in question is proficient! Without digressing into details, suffice it to say that the rules of still photography are somewhat different from those of motion picture photography, and it is asking a lot of a man to "unlearn" many of his ingrained skills.

Further, professionalism in films goes all the way from the initial story conference through scripting, shooting, editing, narration, sound effects, and titles. That is why film is the most expensive medium.

This is not to discourage anyone from producing films – far from it! A good film can be made quite inexpensively (sometimes as low as $200/finished minute), but if you budget for a film, don't expect to cut costs once it's under way. The results will be worth the expense if there is any kind of a rational goal in sight when the film is commissioned.

Summing Up

To hark back to the beginning of this discussion, there are different tools for different jobs – and there is no one tool equally good for all jobs. This is true for visual media as well as elsewhere.

Therefore, when you're called upon to make a visual presentation, it's important to weigh the factors that concern the job before selecting the medium. A reasonable checklist of questions should include:

- How fast is the presentation needed?
- What type of audience am I aiming at?
- How many copies of the presentation are required?
- Will the presentation have to be updated frequently?
- What is the availability of compatible reproduction equipment?

Going through such a checklist should enable you to select not only the most effective – but oftentimes the most economical medium for your visual presentation. □

Databank

"Show and Sell with VTR" by T. P. Rigoli, San Francisco Editor; EDN Magazine; March 15, 1971.

"The Video Cassette – Looking for a Home" prepared by Quantum Science Corp., information specialists. This report, dated July 9, 1971, analyzes competing video cassette technologies and projects market/technological trends together with recommended action for investors. For more information, circle **150**

Stephen A Kallis, Jr. has been producing industrial motion pictures since the mid '60s. An active member of the Society of Motion Picture and Television Engineers (SMPTE) and the Information Film Producers of America (IFPA), Kallis is shown with a studio/field camera that he affectionately calls his "all-around workhorse".

And Then There's Cassette TV . . .

CBS/EVR TV cassette, not much bigger than a 45 RPM phonograph record, is shown being loaded into a Motorola Teleplayer.

Cassette TV—the concept of playing a cartridge program through your television set the way you play a record on a hi-fi—is causing a rash of conflicting claims and predictions.

The controversy swirls around several basic points. Among them:

1. How soon will Cassette TV be a major home entertainment industry?
2. Will systems be compatible, and when?
3. What kind of programming will be available and at what price?

Some marketers have predicted a large consumer market by 1972 and a $12 billion volume by 1980.

But not everyone agrees. Arnold Picker of United Artists, a production company interested in making films for Cassette TV, has said, "It's going to take longer than some people think before the rainbow figures being endlessly tossed around become realities."

Lloyd Singer, vice president of Motorola Systems Inc., and director of Motorola's Education and Training Products unit, said recently, "Despite a flood of press announcements forecasting Cassette TV for the home as early as 1972, there will be no meaningful impact on the consumer until 1973 at the earliest."

"There is no doubt," he said, "that Cassette Television is an exciting medium, which can be the basis of a great new industry. But a foundation for orderly growth of the industry must be laid, and that foundation includes seeing that sufficient programming is available on video cassettes, developing a workable system of distribution for consumer programs, and working toward some form of standardization of the many systems now proposed. This is going to take time."

Three things are definite now: (1) no one system is compatible with another so manufacturers can't make a concerted attack on the consumer market; (2) the only system now for sale to anyone is "Electronic Video Recording" (EVR), developed by CBS with Motorola manufacturing the "EVR Teleplayer" unit; and (3) worldwide acceptance of the "EVR" format seems assured by the large number of manufacturing licensees already involved in "EVR" around the world.

"We are committed to meeting the challenge of the education and training market in industry, institutions, and government," said Motorola's Singer. "That's where Cassette TV will prove itself."

Motorola's initial thrusts in this direction have been announcements of combined packages of "EVR Teleplayer" units and programs aimed at two specific markets—hospitals and law enforcement agencies. To hospitals, Motorola is offering entertainment and enrichment programming for patients who are bored with daytime TV programs, and training programs for hospital staff. The package for law enforcement agencies is based on professional programs on social problems, such as drug abuse and alcoholism, for use by police in community relations work.

By one count, there are 18 announced cassette and cartridge television systems. Twelve are on varying sizes of videotape, four utilize different kinds of film, and one has a plastic foil disc. Except for "EVR", no other system is much beyond the hardware development stage. Close on the heels of "EVR" is Avco's "Cartrivision".

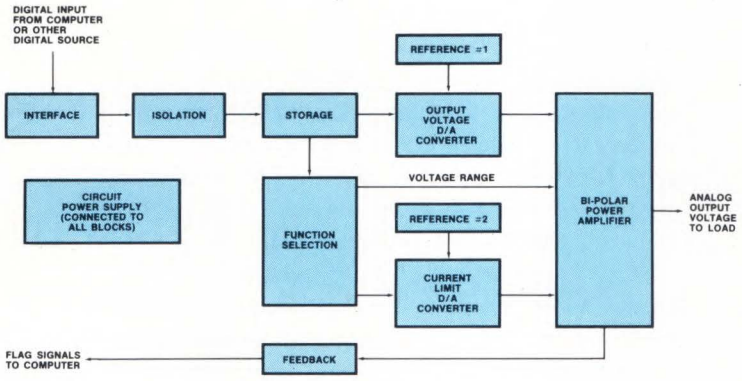
Other systems based on magnetic tape have been announced as under development. Companies involved are mainly those with strong history in magnetic tape—Ampex, Sony, North American Phillips, Matsushita, etc. One official of Matsushita, manufacturer of Panasonic products, has been quoted as saying "1974 is more or less our target for commercial production of a player."

CBS's traditional rival, RCA, has announced "SelectaVision", a proposed playback system based on a completely different technology from "EVR" or videotape. Aiming for a 1973 consumer introduction, "SelectaVision" uses an inexpensive plastic film as its medium.

The "Picture Disc" system developed by Germany's AEG Telefunken operates like a phonograph and picks up audio and video images from a thin-film disc. Playing time is limited to a few minutes/disc, and only black-and-white pictures can be produced as yet.

Quantum Science Corp., a leading technological information service company, has just disclosed a report on competing video cassette technologies (see Databank). Quantum Scientists foresee the video cassette surpassing color TV in sales revenue, and that future impact on entertainment and education will be greater than that caused by the explosive growth of TV broadcasting. Further, the report says that almost every major TV manufacturer in the world is developing equipment that will permit the consumer to play, and in some cases to record, his choice of visual entertainment—with full control of content and viewing hour.

all this



in one compact package

Write for Technical Data Sheet.

Digitally Controlled Power Sources Include Added Systems-Oriented Functions

Digitally Controlled Power Sources (DCPS's) are complete digital-to-analog links between a computer (or other digital source) and any application requiring a fast, accurately settable source of dc or low frequency ac power. Such applications generally require more than a programmable power supply or D/A converter with a power amplifier — the DCPS's include these added functions in a single compact trouble-free package:

INTERFACE Customized plug-in interface cards match the Digitally Controlled Power Source to the computer (8421 BCD or Binary).

ISOLATION All digital inputs are floating and isolated from the floating analog output, thus avoiding troublesome loops between the output ground and computer ground.

STORAGE Inputs from all digital data lines are stored upon receipt of a gate signal from the computer. Output levels are maintained until a new gate signal is received — thus, the computer is free to perform other tasks in the interval between voltage level changes.

FUNCTION SELECTION Selects the output voltage range, and isolates the three input bits to the current limit D/A converter.

OUTPUT VOLTAGE D/A CONVERTER Converts one polarity bit plus 16 BCD voltage bits or 15 binary voltage bits to an analog voltage for input to the power amplifier. Thus, resolution is 0.5mV for straight binary and 1mV for BCD operation.

REFERENCES Provide voltage for the Output Voltage and Current D/A Converters.

CURRENT LIMIT D/A CONVERTER Sets current limit of power amplifier to one of eight values.

CIRCUIT POWER SUPPLIES Provide all the necessary dc power — no external power supplies are required.

FEEDBACK Informs the computer when each programming operation is completed and when the output current is overloaded.

BIPOLAR POWER AMPLIFIER Programs either side of zero or through zero without output polarity switches or "notch" effects, with an accuracy of 1mV, 5mV, or 10mV depending on range and model. Outputs now available include ±50V @ 1A, ±50V @ 5A, and ±100V @ 0.5A.

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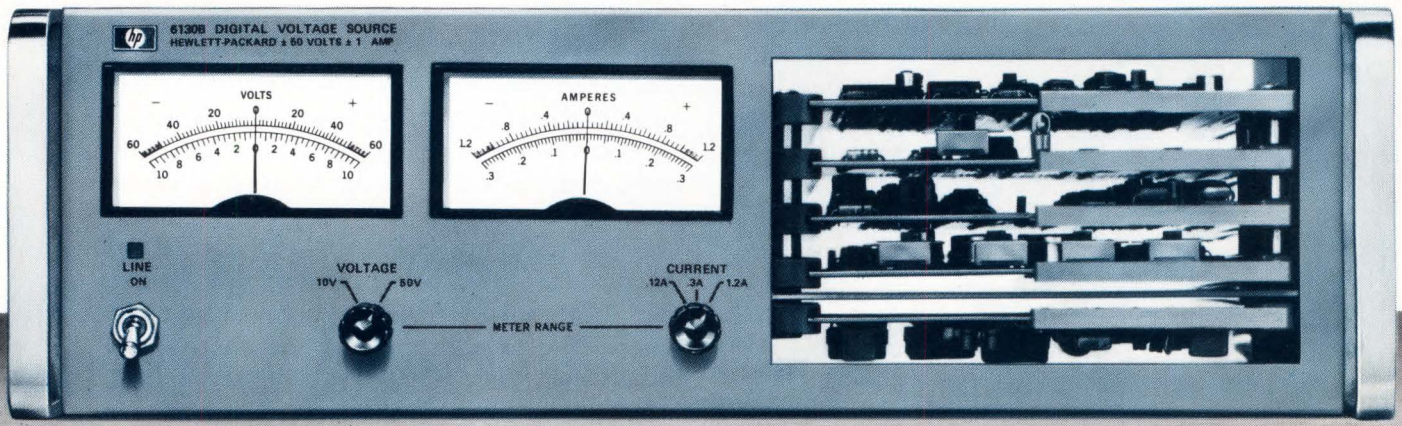


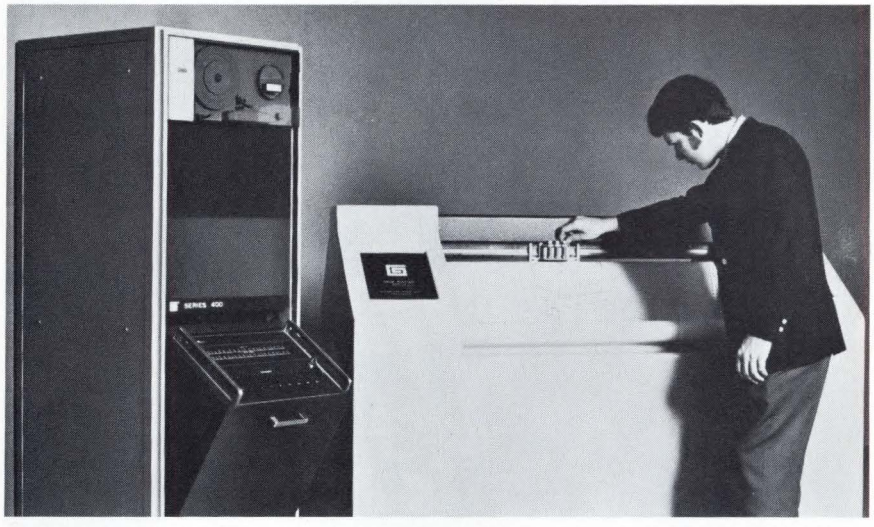
Swift Drum Plotter Tops Flatbeds

PROGRESS IN GRAPHICS

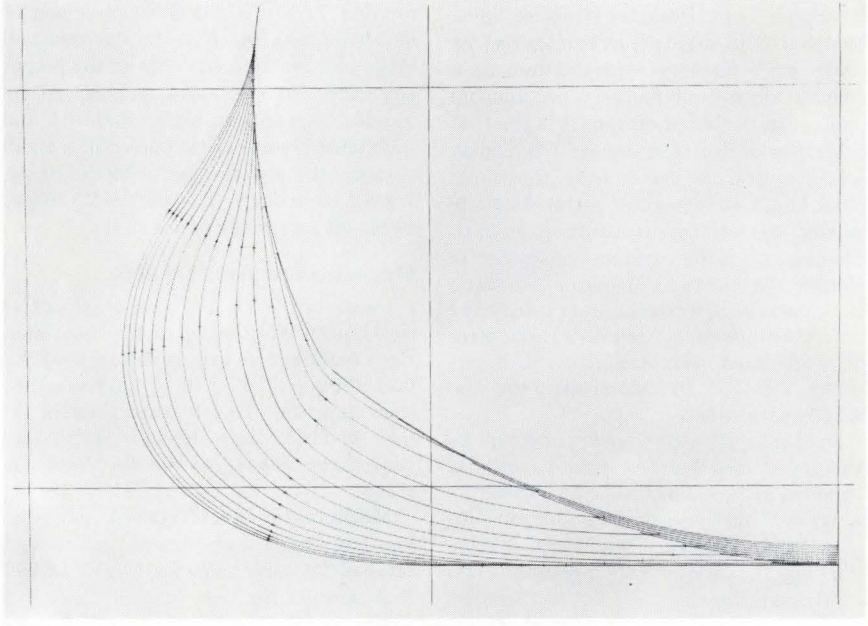
The newly-announced Model 62 drum plotter by Gerber Scientific Instrument Company is a real breakthrough in graphic displays. Previously, in order to verify printed-circuit board or IC artwork masters with high accuracy, it was necessary to buy a big, slow and expensive flatbed plotter. Drum plotters could not do a satisfactory job because they used a coarse motor step which resulted in rugged, poor-quality lines. What is really desired is a combination of the compactness and relatively low cost of a drum plotter, along with the positional accuracy and fine line quality of a flatbed—and an increase in throughput over both. That's what has been made possible by Gerber's drive system.

Because the low mass of the pen carrier eliminates inertia problems, the recorder's throughput is five times faster than it would be for a conventional flatbed drafting system, and about three times faster than that of other drum plotters. The velocity obtained is around 2000 inches/min (33 inches/sec) which is reached in less than 30 msec. This creates an acceleration load on the pen carrier of about 3 to 3.5 Gs. At this velocity the system can maintain a resolution of 0.002 inch with machine accuracy of 0.010 inch and repeatability of 0.005 inch. A special feedback system does not permit accumulated error in either axis—thus the high repeatability. This system can be compared to the output from a hypothetical CRT with a travel of 3 by 125 ft except that it results in a hard copy. Line quality is very high because of linear interpolation between data points and is equal to that of a flatbed system (greater in some cases). It can be configured to run off-line as a stand-alone system and on-line to a general purpose computer.

Standard drawing sizes up to and including E-size (34 by 44 inches) and roll size (36 inches by 125 ft) can be accommodated on the standard 44-inch-wide drum without interchanging of drums to match the drawing size. In unattended operation, the unit can continuously plot in lengths to 125 feet. Thus, in addition to artwork verification drawings, it is capable of producing large plots such as lofting drawings, N/C tape verification, schematics, charts, and graphs.



Drum plotter, Model 462—claimed to be the fastest, largest and most accurate of its type available—consists of the Series 400 control (L) and Model 62 drum plotter (R).



Drawing of aircraft wheel well completed on the Model 462 in 1 min, 33 sec.

A complete system, Model 462, is made up of a new Gerber Series 400 magnetic tape control tailored as an input device and the Model 62 drum plotter. Input to the control is through an IBM-compatible 800-bpi, 9-track magnetic tape transport. The main module of the control is a Hewlett-Packard Series 2100 computer with 4k core memory and word size of 16 bits.

Complete system prices start at $35,000, and delivery is about 120 days. Gerber Scientific Instrument Co., 83 Gerber Rd., South Windsor, CT 06087.

ROMs Create Several Calculators in One

PROGRESS IN CALCULATORS

An entirely new concept in calculator systems has been introduced by the Calculator Products Div. of Hewlett-Packard in Loveland, Colo. Designated Series 9800, Model 10, this desk-top calculator has six times more memory capacity than comparable units and features an unusual concept in keyboard design. It is the first calculator of this type to use LED display and the first to use plug-in functional blocks built with semiconductor ROMs to expand operational capabilities. In fact, Thomas L. Kelly, general manager of Hewlett-Packard's Calculator Products Div., sums it up by stating that nearly any user—businessman, scientist, engineer or statistician—can design his own personal calculator by customizing the machine's capabilities.

In 1968, Hewlett-Packard introduced the 9100A calculator to perform everyday complex calculations involving a moderate amount of data. Not only did this machine solve these problems, but it cost a great deal less than a computer. Features of this machine included a CRT display; tremendous range of numbers that could be handled accurately; programming capacity of 196 steps; magnetic card for data entry and retaining programs for future use; and printout and a number of peripherals for system expansion.

Now the basic Model 10, priced at $2975 has 51 registers and 500 program steps. This configuration performs all basic arithmetic functions, including square root, squaring and finding the reciprocal of a number. Programming is simply a matter of setting the machine to the program mode and pressing the keys in the proper sequence. No special languages are required. In addition, high reliability and high performance are achieved in a small package through the use of MOS/LSI advanced technology. The unit is 5.5 inches in height and weighs only 34 lb.

Machine for your Needs

Function blocks, the size of a deck of cards, plug into the top of the calculator. Each block has its own keyboard template that slips over a set of 15 keys to define their function. This feature permits the user to tailor the calculator to his own immediate needs. Available blocks include:

Mathematic block 11210A solves all log, trig and transcendental functions—a total of 28—and includes a "DO LOOP" that permits the user to cycle through a subroutine or function a specified number of times. In addition to converting angles to degrees or radians (achieved by a switch on the 9100A), this block provides the ability to specify angles in grads—a common unit of angle measurement used in Europe.

User definable block 11213A makes available to the user nine keys for designating any functions that apply specifically to his profession. For example, the Bessel function could be computed with a single keystroke, or any subroutine may be keyed in and then executed. Editing features are included with this block. Single program steps may be located, inserted, or deleted using the keys designated FIND, INSERT and DELETE.

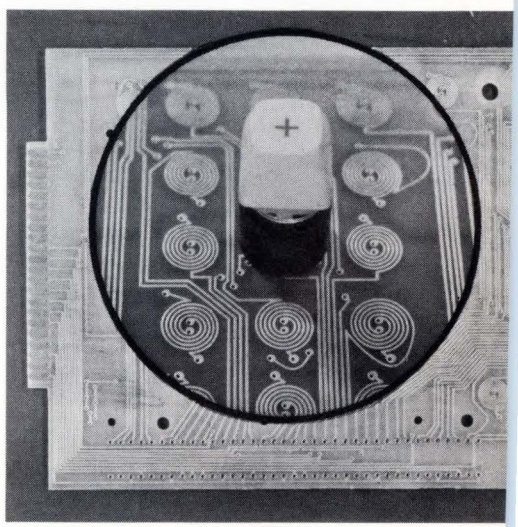
Statistics block 11214A is used for statistical data reduction. Its primary function is to carry out summations of variables, sums of cross products and sums of squares needed as fundamental quantities in a variety of commonly used analyses. A RANDOM key generates a sequence of pseudo-random numbers. Data can also be deleted from a statistical analysis with a single key stroke—CORRECT.

A Look at the Keyboard

The 9100A calculator had a keyboard comprised of 63 molded plastic keys with imbedded markings. Each key operated a single switch having gold alloy contacts. A contact closure activated a matrix that encoded six data lines and generated an initiate signal. This signal prevented the effects of contact bounce and an electrical interlock prevented erroneous operation caused by depressing more than one key at a time.

Switch contacts are eliminated from the Model 10 keyboard. Instead, Hewlett-Packard designed an inductive key sensing scheme. This contactless keyboard is made up of an array of printed-circuit transformers which have their secondaries and primaries interlaced in a spiral coil. All secondaries are tied in series to form a sense line, and the primaries are arranged in separate pairs. Each coil is connected in series with opposite polarity to its pair. Every pair has a drive and sink line that is selected and driven by a scanner or counting circuit.

Centered above each printed-circuit coil



is an aluminum disc mounted on the end of the key shaft. When the key is depressed, the disc simulates a shorted turn, thus reducing the coil coupling and unbalancing the pairs. A comparator senses this unbalance and triggers a one shot which stops the scanner operation. The scanner or counter remains at its present state corresponding to the drive and sink line of the depressed key. When the key is released, a spring retracks the key and disc, and the comparator turns off and readies the scanner for a new key. Two bias levels associated with the comparator operation give the key a mechanical hysteresis.

With reference to the 9100A, six new keys appear on the Model 10 keyboard for improved programming and operation:

1/x – reciprocal of a function

x^2 – square of a function

KEYLOG – gives the user a printed record (when printer is installed) of selected keys in a particular program.

BACK STEP – moves the program step display backwards for editing operations.

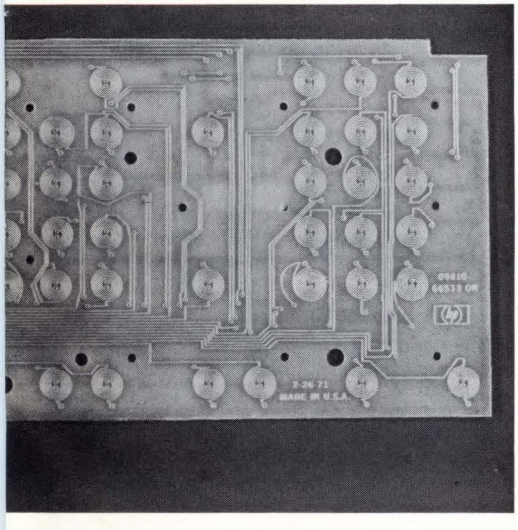
LABEL – provides symbolic addressing in place of actual address of a routine.

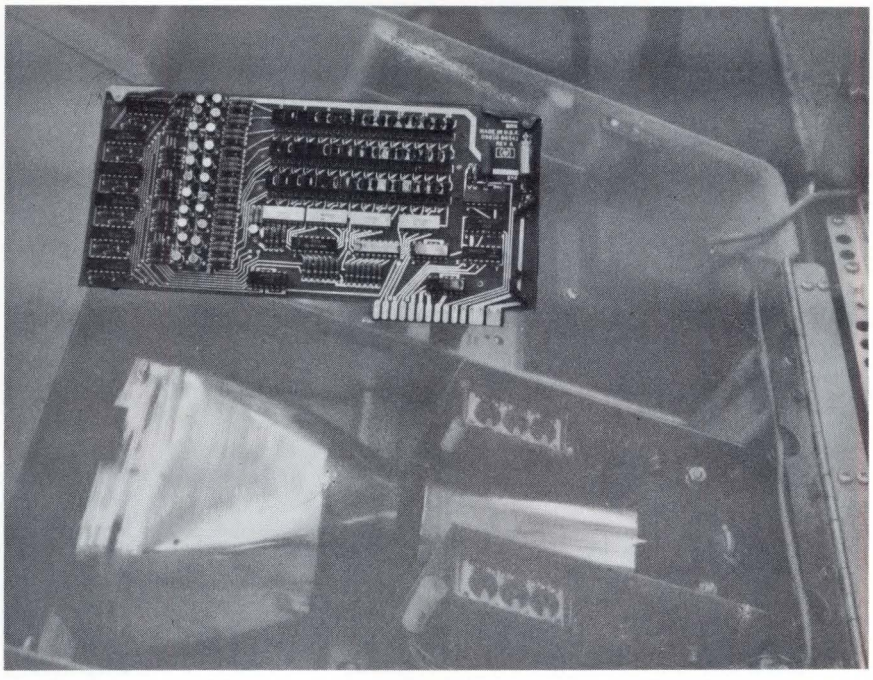
INDIRECT – permits indirect addressing and indirect arithmetic operation.

Seeing the Results

To achieve display flexibility in the 9100A, Hewlett-Packard decided on a CRT – a first for a calculator system. This display consisted of an X register for numbers entered by keyboard, Y register or accumulator, and Z register for temporary storage. Now for the first time in a programmable calculator, solid-state display is used. In the Model 10, segmented characters comprised of LEDs display the X, Y, and Z registers – a total of 45 characters.

There are several advantages to a solid-state display over the CRT concept. The major advantage is power. For the CRT, several high voltage sources are required as compared to a single 5V supply for the entire Model 10 display. In addition, the Model 10 display, including the LEDs, decoding and drivers, is on one printed-circuit board (as emphasized in the photo). Display characters are only 1.5 inches high and each character is comprised of seven segments. A strobing concept under control of a dynamic ROM is used to enable a specific character.





Storage Capabilities

A data memory of 51 registers and a program memory of 500 steps come with the basic Model 10. Either the data storage, program memory or both can be expanded with simple plug-in modules. Thus a Model 10 can be configured with 51 or 111 data registers and with 500, 1012, or 2036 program-step capability. MOS technology is used for both read/write and ROM memories. Consequently, the total memory power is only 15W.

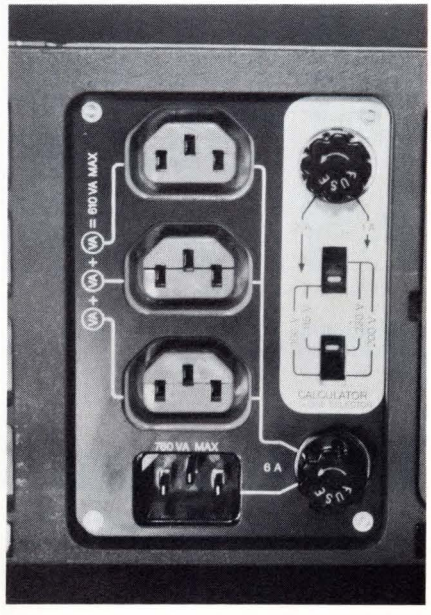
Program Entry

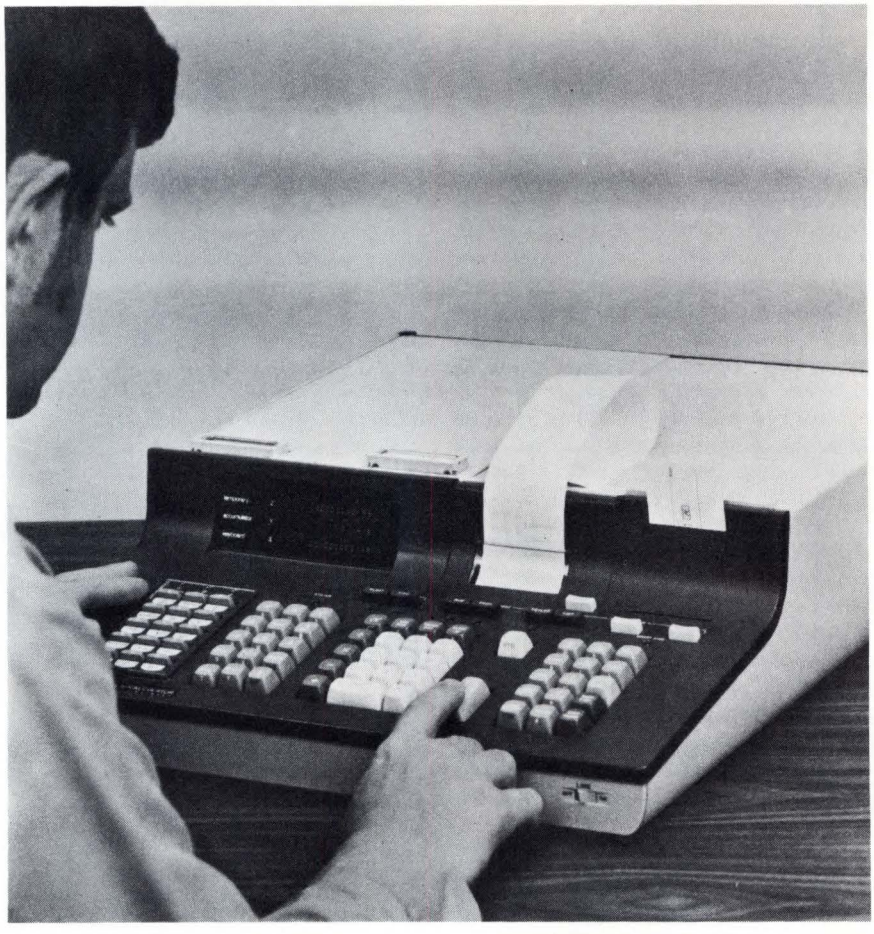
A popular feature of the 9100A calculator was the wallet-sized magnetic card that provided a permanent record of a program. Two complete 196-step programs could be entered on each card. This feature also comes with the Model 10. However, a new feedthrough reader accepts magnetic cards up to 6 inches long, and the cards may be linked automatically for longer programs. A punched-out tab on the leading edge of the magnetic card can be removed to prevent accidental erasure of the information. Up to 2000 program steps can be recorded on two cards. In addition, magnetic card LOAD, data record and read are programmable.

Power Supply

Power supplies within the Model 10 are modular for easier service and conform to International Electrotechnical Commission (IEC) standards for the overseas market. All supplies have crowbar protection against overvoltage, a common line filter for reducing RFI in both directions, IEC approved power cord and outlets, and a double pole ON/OFF switch to switch both sides of the line.

Screwdriver-actuated switches on the rear panel are operated to select a variety of line voltages. The Model 10 will operate on 100V (Japan), 115V, 230V (Europe) and 200V (Europe low voltage) from 48 to 66 Hz. Three convenient outlets (non-switched) are on the back.





Options for Computing Power

A well-received option of the 9100A was the Model 9120A calculator printer which used an electric writing technique to print 3 lines/sec. For the Model 10, a Hewlett-Packard-designed thermal printer is available. The unit prints a 16 character line —5 × 7 dot matrix forms each character —on inexpensive heat-sensitive paper. Loading of the paper is simple—just drop the roll in and the paper threads itself automatically. Line spacing is set at 6 lines/inch vertically, a match to typewriter spacing. Thus the printed data can be taped directly onto a typed report.

If alphanumeric characters are desired, a plug-in ROM module alpha block 11211A is placed into the third slot on top of the calculator. This gives the Model 10 the ability to print out all 26 letters, numbers and commonly used punctuation marks on the column printer.

Four individual I/O slots in the rear panel are for system expansion. Available peripherals include a 10-ips plotter, Model 9862A, marked card reader Model 9860A and an electric output typewriter Model 9861A. Combination of the mathematics plug-in with the plotter allows the user to automatically scale his function for full surface plots. With an optional ROM plug-in, the user has complete alphanumeric plotter output, axis generation, automatic function scaling and special symbol point plotting.

The marked card reader optically reads 8-column cards marked with soft lead pencil. Two cards are available—the standard card which holds up to 30 program steps and a longer card with 50-program-step capacity.

The electric typewriter configuration includes a typewriter, an I/O and a ROM plug-in that goes into the second slot located on top of the calculator. This plug-in converts the Model 10 keyboard to a keyboard containing all typewriter characters, including upper and lower case and a red/black ribbon change. The unit has formatted output capability. Model 9861A handles single sheets of paper with an option for the handling of continuous forms.

More peripherals will be introduced later. Among them will be a paper tape reader for reading a variety of ASCII formatted tapes, and a digitizer for converting analog graphics to digital information. Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **208**

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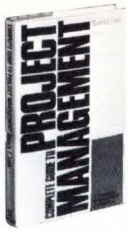

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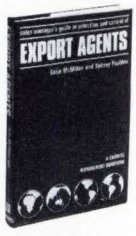

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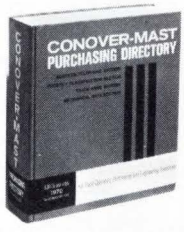

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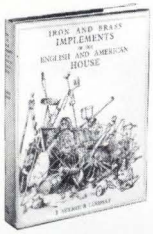

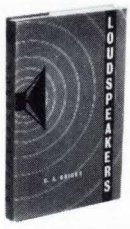

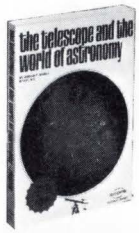

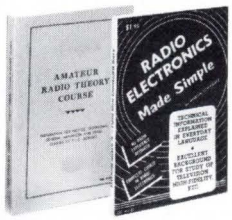

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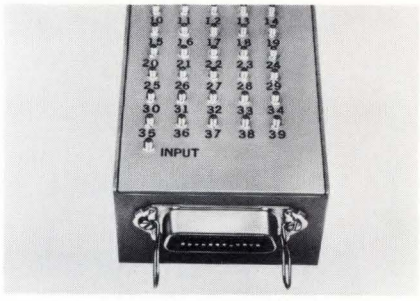
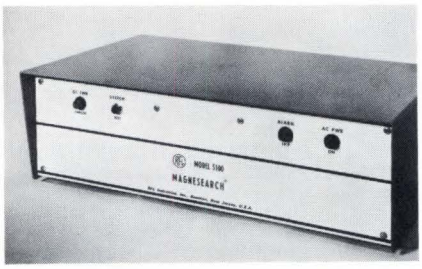
Programmable calculator, 700C Series, features versatility. Starting with the basic unit, memory can be added in 4k increments up to 524k. In addition, dual magnetic tape cassettes that operate at 800 cps can be used to store up to 300k program steps. Peripherals include an alphanumeric typewriter printer, an X-Y plotter, I/O interface, paper tape editor and card reader. Wang Laboratories, Inc., 836 North St., Tewksbury, MA 01876. **210**

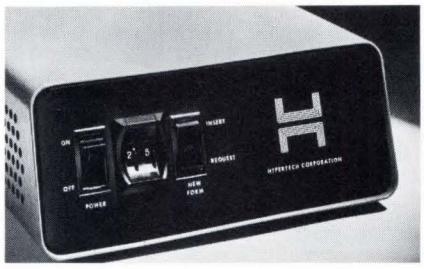
RAM/ROM tester automatically or manually exercises the element under test for production or engineering evaluation. The unit is specifically designed to logically test static DTL/TTL-compatible 256 × 1 RAMs and 256 × 4 bit ROMs. A "Go" or "No Go" indication of the element status is given. As an option, the unit may be modified to test up to 4096 × 8 bit memories and interface to other logic levels. C-O Manufacturing Co., Inc., Box 125, Brockton, MA 02403. **213**



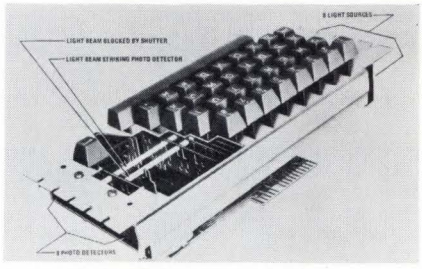
Computer compatible 40 × 1 RF switch, Model SWR-40/1-L, is a dc to 50 MHz switch that uses shielded hermetically sealed reeds. Unit weight is <1 lb and the dimensions are 4-1/8 by 2-5/8 by 1-5/8 inches. Features include minimum 50 dB isolation and maximum 0.5 dB insertion loss. The VSWR is 1.5 to 1 maximum and the connectors are Microdot "Lepra-con" Series. Small quantity price is $850 ea. Integral Data Devices, Inc., 35 Orville Dr., Bohemia, NY 11716. **216**



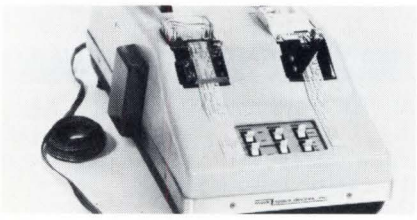
Magnetic field detecting system, Model 5100, provides protection and detection against the intrusion of stray magnetic fields onto magnetic tapes and discs. Operating on a fluxgate magnetometer principle, the unit detects any changes in the ambient magnetic field on the order of 30γ. Sensing element is a fluxgate probe that is 0.75-inch in diameter and 5.5 inches long. RFL Industries, Inc., Instrumentation Div., Boonton, N J 07005. **211**



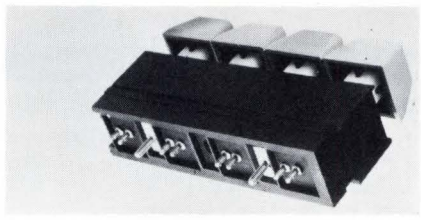
Interface units, called "Hyper-Typer", enable users to incorporate an IBM I/O Selectric typewriter into their data processing systems as either an output printer or an input station. Two models are available—Models 100 and 101. Model 100 converts ASCII to code required for using the I/O Selectric as an output. Model 101 performs the same functions plus converting the I/O Selectric to an input device. Hypertech Corp., 7343 W. Wilson Ave., Harwood Heights, IL 60656. **214**



Optoelectronic keyboard, Citation 600 Series, employs light beams and key operated shutters to generate ASCII code. By means of fiber optics, light is piped into eight different beams representing seven-level parallel ASCII and a strobe signal. These light beams are projected from one end of the keyboard through a pattern of open shutters and strike photo detectors on the other end. Keyboard is TTL/DTL compatible. TEC, Inc., 9800 N. Oracle Rd., Tucson, AZ 85704. **217**



Paper tape punch/reader, MSD 300 P/R, offers plug-in ASR capability for data terminals. The unit has complete set of operator controls. Send and receive speeds of 10, 15, and 30 cps are switch selectable with full and half duplex operation. Standard 1-, 7/8- and 11/16-inch tape (including fanfold) may be used for 5-, 6-, 7- or 8-level punching. Mark-Space Devices, Inc., 17835 Sky Park Circle, Box 4260, Irvine, CA 92664. **212**



Keyboard reed switches, the SIX-PAC Series, come in a 1- to 6-key configuration and are designed for fast "do-it-yourself" keyboard assembly and precise keytop alignment. Priced as low as $0.55/station (production quantities), the units feature plug-in terminals for push-on leads or solder-connection ease. A wide choice of shapes and colors is available. Controls Research Corp., 2100 S. Fairview, Santa Ana, CA 92704. **215**

Optical card reader RCR-2 reads preprinted or manually-marked cards 4.625 inches wide and 0.008 inch thick—with maximum length of 11.5 inches. Up to 100 columns/side may be printed on a maximum-length card yielding 3200 bits/side. Card speed is nominally 1 ips. Output format is asynchronous serial transmission of data, column by column. Raymond Engineering Inc., 217 Smith St., Middletown, CT 06457. **218**

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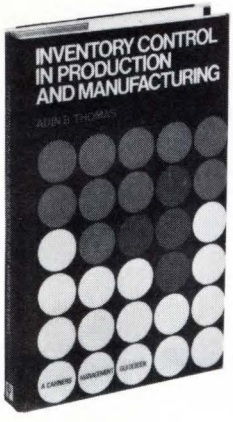

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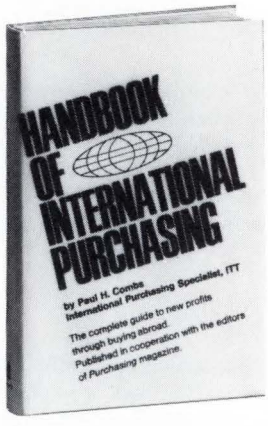

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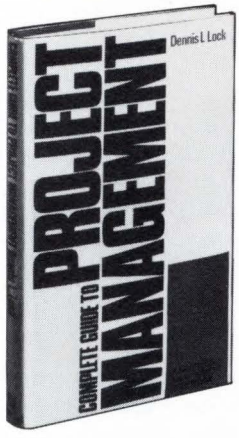

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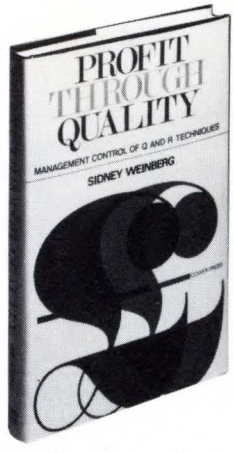

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Plotting system TSP-300 takes full advantage of 30-cps transmission. The instrument drives an 11- by 17-inch recorder (10- by 15-inch maximum plot size) at 450-600 pen movements/min. Unit will plot an 18-inch line in <1 sec. Time Share Peripherals Corp., Miry Brook Road, Danbury, CT 06810. **219**

Low profile, hard contact key uses an exclusive "Gold Crosspoint" contact. Composition of the contacts is 69% gold, 25% silver and 6% platinum. Typical contact resistance is 25 mΩ. Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, IL 60085. **220**

Solid-state linear encoder LE 601 can be used for positioning the read/record heads in a magnetic disc file. A light emitting diode with sensor generates the necessary control signals required for disc application. Advantages are higher reliability and improved accuracy. Spectronics, Inc., 541 Sterling Dr., Richardson, TX 75080. **221**

Bulk magnetic tape eraser can be used either on a table top or as a hand-held unit. Priced at $18.31, this unit cleans audio tape reels, cassettes, cartridges and video tape. GC Electronics, 400 S. Wyman St., Rockford, IL 61101. **222**

Data modem, Model 883P, is a quadrature-phase, differentially coherent modem designed for synchronous applications where data rates of 2400/1200/1000 are required. Two versions are available, the 883A stand alone and the 83PD single card for OEM or multi-modem rack configurations. Kearfott Div., Singer-General Precision, Inc., 250 Crossways Park Dr., Woodbury, NY 11797. **223**

Disc storage module housed within the System/7 computer offers storage capacities of either 1.23 or 2.46 million 16-bit words. Average access time is either 126 or 269 msec. IBM Corp., Data Processing Div., 1133 Westchester Ave., White Plains, NY 10604. **224**

Printing counter, Model 900-21, provides both a visual display and a permanent printed record of input data. Counting rate is 10 counts/sec, and it can be modified with a plug-in buffer memory to accept up to 1000 counts/sec. Lehigh Valley Electronics, Inc., Box 125, Fogelsville, PA 18051. **225**

Avionic computer BR-1018 is built with "Planar Coax" technology and has outside dimensions of 6 by 9.2 inches. Thickness varies from 0.85 to 1.25 inches. The Bunker-Ramo Corp., Electronic Systems Div., 31717 La Tienda Dr., Westlake Village, CA 91361. **226**

Cassette drive C-20 features a read-after-write dual-gap head in one- or two-track versions. Design conforms with the new proposed ECMA/ANSI standards for information interchange, including 800-bpi phase-encoded recording, uniform IRGs and precise bit-to-bit spacing. Cipher Data Products, 7655 Convoy Court, San Diego, CA 92111. **227**

Laboratory computer system, Lab-11, consists of a PDP-11 processor, programmable range A/D converter, programmable real-time clock, paper tape reader and punch, and color CRT display. Digital Equipment Corp., Maynard, MA 01754. **228**

Series of send/receive terminals is ideal for such operations as computer interaction, batch processing and form letters. Called TYCOM 35/37, the unit consists of an IBM Selectric typewriter equipped with a baseplate, logic translator, acoustic coupler and optional paper tape reader/punch. Terminal Equipment Corp., 750 Hamburg Turnpike, Pompton Lakes, N J 07442. **229**

Digital panel display DPD-100 requires <0.6 inch rear panel space. Input requirements are BCD logic levels that are TTL/DTL compatible. Price for up to five digits starts at $59. Durgin and Browne, Inc., 80 Allen Rd., South Burlington, VT 05401. **230**

Video display unit, called TelTerm, has a 7 × 9 dot matrix and uses video scanning technique to generate readable characters in both upper and lower case. Also an exclusive PAGING feature helps in editing of displayed data. Delta Data Systems Corp., Woodhaven Industrial Park, Cornwells Heights, PA 19020. **231**

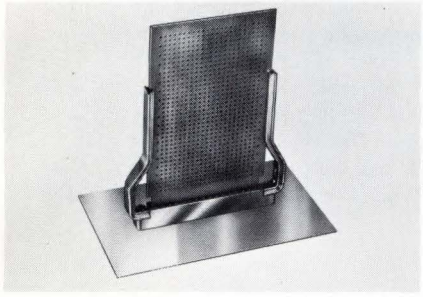
Analog output system, RTP7450 Series, is plug compatible with most popular minicomputers. Basic system is completely wired for full complement of 16 channels. Computer Products, 1400 Gateway Dr., Box 23849, Fort Lauderdale, FL 33307. **232**

MOS encoded keyboards, Series 600, come in standard 47-, 56- and 73-key configurations. These units provide ASCII 9 bits plus strobe, odd/even parity, electronic lockout, quad mode of operation and TTL/DTL compatibility. A 47-key unit sells for about $88 in quantity. George Risk Industries, Inc., Box 1035, Kimball, NE 69145. **233**

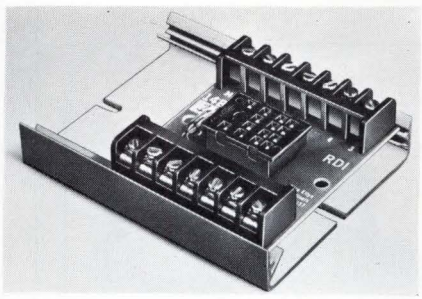
Magnetic tape controller handles up to four 7- or 9-track tapes. Designated MTU, the unit provides on-line tape drive control from a variety of small computers. Xebec Systems, Inc., 918 N. Rengstorff Ave., Mountain View, CA 94040. **234**

Data interface access panel, Model 50, simplifies failure isolation for modems, terminals and communication networks. Unit provides access and switching for each signal at the RS-232 interface. There are 25, 3-position slide switches, one for each output connector signal. Unit price is $60. Communication Div., International Data Sciences, Inc., 100 Nashua St., Providence, RI 02904. **235**

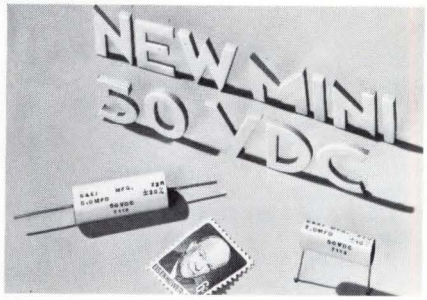
Programmable data controllers, Series FDC-300, find application in process control, monitoring and data-acquisition. Data capacity is field-expandable over an 8 to 1 range in increments of 4k × 18. Ferroxcube Corp., Saugerties, NY 12477. **236**



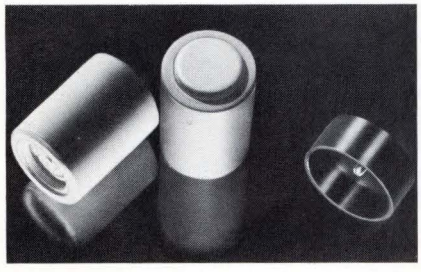
Card guide brackets attach to circuit receptacles or mount directly to chassis. Various models are available for varying width cards. Price of one model is $0.38 each in quantity. Vector Electronic Co., Inc., 12460 Gladstone Ave., Sylmar, CA 91342. **237**



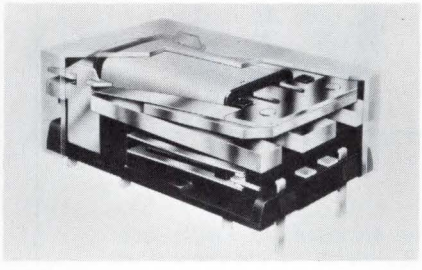
Relay socket provides screw terminal connections for miniature 4PDT relays. "Snaptrack" mounting system with tracks up to 48 inches long will accommodate 19 Type 214BS sockets. Reed Devices, Inc., 21W183 Hill Ave., Glen Ellyn, IL 60137. **240**



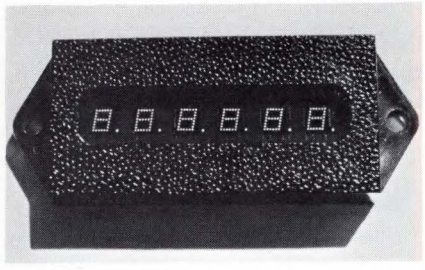
Mini-miniature metallized polycarbonate capacitors are available in a variety of encasements with 50 and 100V dc ratings. The Series 22 values range from 0.001 through 50 μF with tolerances to $\pm 1\%$. S&EI Manufacturing, 18800 Parthenia St., Northridge, CA 91324. **243**



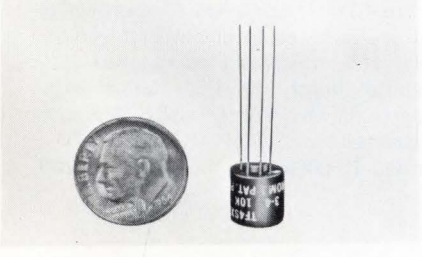
High-energy lithium battery has a nominal voltage of 3.2V and operates on a flat discharge curve. Storage life of the G2600-B is up to 10 years because of encapsulation of the electrolyte in a glass ampule which is shattered with a special cup prior to use. Honeywell Inc., Power Sources Center, Montgomeryville, PA 18936. **238**



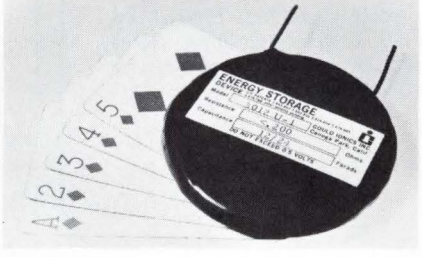
PC board relay features high sensitivity, chatter-free operation and a flat magnetic system allowing a thin design. The Series NF relays are available in two- and four-pole models for operation at 2A. Voltage ratings are 6, 12, 24, 48 and 60V dc. Babcock Electronics Corp., Subs. of Esterline Corp., 3501 N. Harbor Blvd., Costa Mesa, CA 92626. **241**



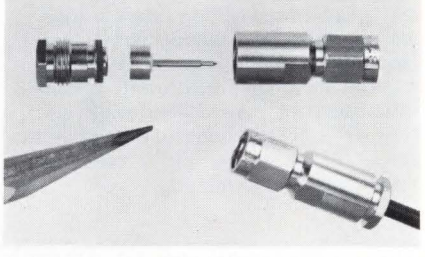
Solid-state display has six individual monolithic digits which are brightness matched, on a common ceramic substrate. Designed only for multiplex drive applications, the FND21 is priced at $7.95 per digit in quantities of 1-17. Microwave & Optoelectronics Div., Fairchild Camera & Instrument Corp., 3500 Deer Creek Rd., Palo Alto, CA 94304. **244**



Ultra-miniature audio transformer has typical specifications of 3Ω to 100 kΩ primary and secondary impedances; ±3 dB 400 Hz to 100 kHz; 600 mW. Dimensions are 0.34-inch diameter by 0.34-inch length. Price is $3 to $10. Pico Electronics Inc., 316 W. First St., Mount Vernon, NY 10550. **239**



Energy storage devices with 3-inch diameter provide high capacitance (potentially into the thousands of farads) and low ESR values. Applications include standby power for volatile semiconductor memories or other circuits where loss of power supply is undesirable. Gould Ionics Inc., Box 1377, Canoga Park, CA 91304. **242**



Connector for subminiature coax cables is pre-assembled into three component parts to cut customer production line costs. SMA connectors are available in various configurations for RG-174, 180, 188, 195 and 316/U cables. Amphenol RF Div., Bunker-Ramo Corp., 33 E. Franklin St., Danbury, CT 06810. **245**

Clamps for the permanent positioning of flat, flexible cable, ribbon cable and flat harnesses have a self-adhesive for easy, permanent installation. Standard sizes hold flat cable 1/2, 1, 2 or 3 inches wide and up to 3/32 inch in thickness. Because of their flat configuration, they may be stack mounted. Richco Plastic Co., 5825 N. Tripp Ave., Chicago, IL 60646. **246**

Worm-gear actuated, 3/8-inch and 1/2-inch cermet and wirewound potentiometers are available in four new models for panel mounting with clip-on brackets. Trimpot Products Div., Bourns, Inc., 1200 Columbia Ave., Riverside, CA 92507. **247**

Proximity switch houses its own sensor, amplifier, and switching circuitry. Sensing range is 1/4 inch at the front of the 1-inch diameter probe. The Model PAR 3 provides solid-state switching for computer interfacing, numerical control or remote relays. Farmer Electric Products Co., Inc., Subs. of American Cyanamid Co., Tech Circle, Natick, MA 01760. **248**

Press-on heat sink for TO-66 and TO-8 devices is priced at $0.19 each in 1000 lots. Rating is 30°C/W for TO-8 and 22°C/W for TO-66 devices. Thermalloy Co., 8717 Diplomacy Row, Dallas, TX 75247. **249**

Card edge connector with selective shorting contacts for shorting any or all contacts when a board is removed is available in 44-pin model. Any combination of open or shorted contacts is available in the Series 186, which can be supplied with extended length terminals on shorting contacts for easy identification. Methode Electronics, Inc., 7447 W. Wilson Ave., Chicago, IL 60656. **250**

Conductive epoxy adhesive is a one-part, heat-curing formulation containing silver alloy. Temperature range of the E-Solder 3212 is −55 to 205°C, and minimum cure temperature is 135°C. Epoxy Products Co., Div. of Allied Products Corp., 166 Chapel St., New Haven, CT 06513. **251**

Designer kit contains seven panel fuseholders of low-profile, square cap design. Three basic series accommodate standard 3AG, indicating pin 3AG, and 8AG fuses. Holders snap into a 5/8-inch square hole with no mounting hardware. The price of kit #094106 is $2.95. Littelfuse, Inc., Subs. of Tracor, Inc., 800 E. Northwest Highway, Des Plaines, IL 60016. **252**

Epoxy preform pellets permit oven bonding of many dissimilar materials in minutes. The material is room-temperature stable, and pellets are available in a variety of shapes, flow grades and colors. Amicon Corp., 25 Hartwell Ave., Lexington, MA 02173. **253**

Gas discharge displays are available in 3-, 2-, and 1-1/2-digit models with 1/2-inch character height. Center line spacing of characters is 0.531 inch. The SP-750 Series requires 170V dc at 250 μA per segment. Price is $5.50 per digit in single-unit quantity. Sperry Information Displays Div., Sperry Rand Corp., Box 3579, Scottsdale, AZ 85257. **254**

Lighted pushbutton power switches, designated Types 571, 581, 572 and 582, feature latching operation and unique positive snap action. A wide range of standard caps, legends and colors is available. Price starts at $3 each in 1000 lots. Marco-Oak, Subs. of Oak Electro/Netics Corp., 207 S. Helena St., Anaheim, CA 92803. **255**

Resistor networks in DIP packages are available off the shelf. Both 13-resistor and 7-resistor networks are offered. All have TO-116 pin configurations with Cermet resistors on a 96% alumina substrate. TCs are <200 PPM, and available resistance range is 50 to 100,000Ω. MEPCO, Inc., Columbia Rd., Morristown, N J 07960. **256**

Piezoelectric accelerometer that weighs <1 carat, the "Picomin", is described as the closest thing to noncontact vibration measurement yet achieved. Model 22 has flat frequency response from 2 Hz to 10 kHz and measures from 0.01 to 2000G. Endevco Dynamic Instrument Div., 801 S. Arroyo Pkwy., Pasadena, CA 91109. **257**

Test socket for DIP ICs allows insertion and removal of ICs with zero pressure exerted upon the leads. A unique locking lever clamps or releases DIP leads. Five models are available to accept 16-, 18-, 22-, 24-, and 40-lead DIPs. Prices start at $2.59 each in quantities of 100. Textool Products, Inc., 1410 Pioneer Dr., Irving, TX 75060. **258**

Electrically conductive silver/acrylic paint costs <$0.01/inch²/mil thickness and is available in standard 1-lb cans or 6-oz jet spray packs. Uses include EMI/RFI shielding, metallizing for plating and static prevention. Tecknit, 129 Dermody St., Cranford, N J 07016. **259**

Wirewound resistors feature extremely low resistance values and temperature coefficients. The LVR Series is available with power ratings of 2, 5 and 10W and resistance ratings from 0.008 to 0.8Ω. Typical price for 1000 0.05Ω resistors (3% tolerance) is $0.60. Dale Electronics, Inc., Dept. 860, Box 609, Columbus, NE 68601. **260**

Temperature compensated crystals for the frequency range from 6 to 25 MHz provide stability of $\pm 5 \times 10^{-6}$ over the ambient temperature range of −30 to 60°C. Prices vary with frequency, ranging from $9.85 to $10.09 each in 1000-piece quantities. CTS Knights, Inc., 400 Reimann St., Sandwich, IL 60548. **261**

Glass-ceramic capacitors feature high volumetric efficiency, general use performance specifications and low pricing. Units are ideal for use in automatic insertion equipment. Prices for the CGC Series in 10,000-piece quantities range from $0.16 to $0.35. Corning Glass Works, Electronic Products Div., Corning, NY 14830. **262**

Reed relays can be driven directly by any TTL or DTL gate. The new "Zestron" Series 530 and 540 relays feature magnetic shielding, vacuum encapsulation and 1- by 0.1-inch pin patterns. Price is less than $1 in quantities above 1000. Self-Organizing Systems, Inc., Box 9918, Dallas, TX 75214. **263**

Crystal piezoelectric accelerometers with an improved seismic element provide high stability and almost infinite life. Advanced design of the 200, 300, and 600 Series provides super-high performance and accuracy. Prices range from $70 to $175 each. Columbia Research Laboratories, Inc., MacDade Blvd. & Bullens Lane, Woodlyn, PA 19094. **264**

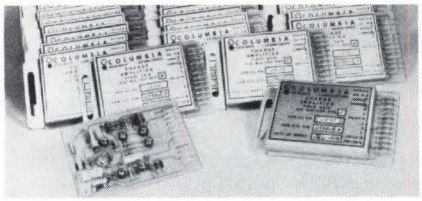
Solid-electrolyte aluminum foil capacitors, designated Series 121, offer high reliability and stability over a wide range of temperatures. They have electrical characteristics similar to solid tantalum types. Amperex Electronic Corp., Component Div., Hauppauge, NY 11787. **265**

Miniature unshielded RF inductor for hybrid circuit applications is only 0.14 inch long and 0.075 inch in diameter. Minimum Q values at RF frequencies range from 21 to 55, and inductance values range from 0.1 to 1000 μh. Standard tolerance of the "Pee Dee Ductor" is ±10%. Essex Electronic Products/Darlington Div., Nytronics, Inc., Darlington, SC 29532. **266**

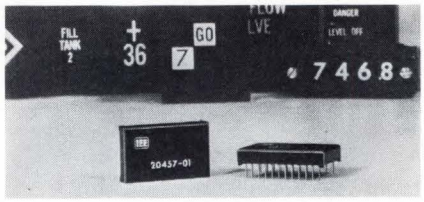
Thumbwheel switches mount directly onto the user's printed circuit cards. Available in kit form, the 8000 Series units are less than 1 inch high and 1/2 inch wide. Prices start at $3 in single quantities. Electronic Engineering Co. of California, 1601 E. Chestnut Ave., Santa Ana, CA 92701. **267**

Aid for designers consists of an actual-size printed version of the Sperry SP-730 Series display (in orange and black) with pressure sensitive backing. The 16-digit paper strips can be readily cut apart to meet individual requirements. Write for free copies. Sperry Information Displays Div., Box 3579, Scottsdale, AZ 85257.

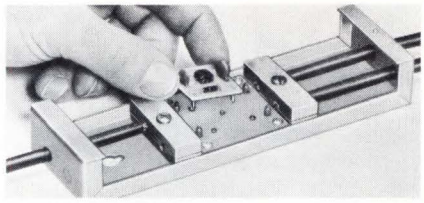
Seven-bar numeric readouts with 3-inch high characters, Series 68033, have integral decoder-drivers and can be relamped from the front. Memory and decade counting logic are also available. Price is $42 each in single lot or $29 in 250-unit lots. Info-Lite Corp., 2337 Lemoine Ave., Fort Lee, N J 07024. **269**



Plug-in amplifiers, Series 9020, permit designers to develop their own custom systems. Unit prices start at $74.50 (quantities of 100 or more) with little or no special design charges. The boards are standard 3- by 4.5-inch cards with Elco Varicon connectors. Input/output parameters can be designed for specific needs. Columbia Research Labs, Inc., MacDade Blvd. & Bullens Lane, Woodlyn, PA 19094. **270**

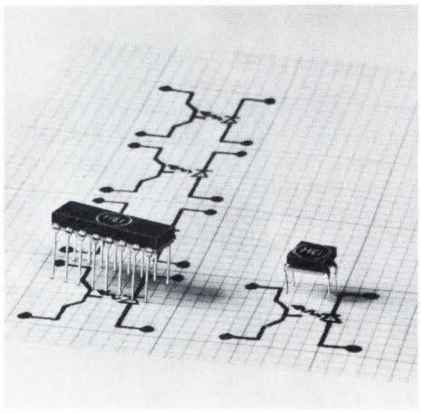


Driver/decoder circuits, 20457, 20488 and 20463, are hybrid devices mounted in a 24-pin DIP measuring 0.762 by 1.277 inches. Units will handle 300-mA lamps at 30V. The decoding chip translates 8421 BCD code to 12 outputs. If only 10 outputs are required, the remaining two may be used as lamp buffers. Price range is from $15.15 to $16.65. Industrial Electronic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405. **273**

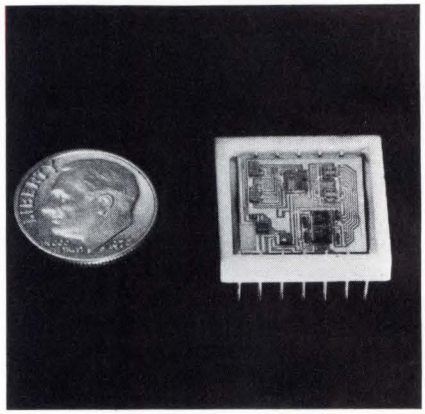


A CATV directional coupler can change the direction of signal flow without the need for rerouting cables or moving the coupler box. The heart of the system is a securely anchored center conductor consisting of a mother board and a plug-in coupler with selected dB ratings (3 to 27). The installer has a four-way signal flow option determined by 90° position changes of the plug-in coupler. MPI Co., Box 6130, Philadelphia, PA 19115. **276**

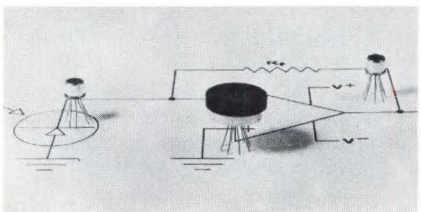
Seven-bar readouts, 1200 Series, can function as a single unit or in combination as part of a system. Units are available with equal size figures or any combination of 1-, 1.5-, 2-, 3-, 5-, 7- and 8-inch digits. These devices provide maximum visibility in high ambient light for both indoor and outdoor installations. Allard Instrument Corp., 770 Main St., Westbury, NY 11590. **271**



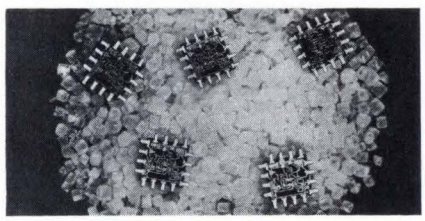
Optically-coupled isolators, called "4-PAC", combine four separate LED-phototransistor pairs in a single 16-pin DIP. Each unit is available as an infrared LED combined with either a phototransistor, a photodarlington or a photodiode. Each of the four isolators is completely light-sealed from the other. HEI, Inc., Jonathan Industrial Center, Chaska, MN 55318. **274**



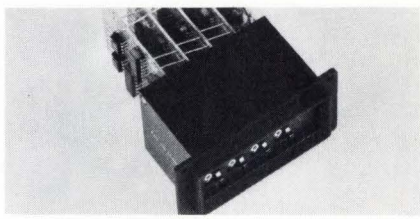
0 to 10 kHz function generators, MN350 (sine wave), MN351 (parabolic) and MN-352 ("S" wave), develop an output that is 1/128 of the input clock frequency. A 7-bit counter, a 1024-bit ROM and an 8-bit D/A converter with internal reference and output amplifier are all contained in a 0.785 inch², 14-pin DIP. For 25 to 99 units, the price is $150 each. Micro Networks Corp., 5 Barbara Ln., Worcester, MA 01604. **277**



Photodetector-op amp combinations, UDT-400, 500 and 600, offer solutions to problems associated with the interfacing of a low-noise photodiode and preamplifier. These devices operate over a range of 10^{-12} to 10^{-2}W light energy input with >1% linearity and frequency response to 10 MHz. They respond to radiation from 350 to 1000 nm. Active areas of the devices are 0.05 and 1.00 cm². United Detector Technology, 1732 21st St., Santa Monica, CA 90404. **272**



Beam-lead devices, MCBC1709 and MCBC1709F, are electrically identical to the MC1709 op amp, but different in their unique mechanical structure. The MCBC-1709 is a beam-lead chip strictly for hybrid circuitry, and the MCBC1709F is a beam-lead chip housed in a flat package. Both units are available at prices of $1.85 (MCBC1709) and $6.20 (MCBC1709F) for quantities greater than 100. Motorola Semiconductor Products Inc., Box 20924, Phoenix, AZ 85036. **275**



Thumbwheel-switch assembly converts up to six-digit numbers to their binary equivalents. For example, the four-digit model supplies a 14-bit output binary equivalent of 9999, with 2-msec response time. Other features include automatic zero reset on switching transistors, zero reset for power-off condition and a data-ready signal. Both standard and miniature sizes are available. The Digitran Co., 855 S. Arroyo Parkway, Pasadena, CA 91105. **278**

Component package for digital clocks, Y-4119, consists of four alphanumeric readout tubes driven by a single IC driver/decoder. Time keeping function is electronically processed using 60 Hz ac pulses from regular power lines. Cost is $15/unit in 1000 quantities. General Electric Co., 2100 Gardiner Lane, Suite 216, Louisville, KY 40205. **279**

Two-stage YIG filter, Model M2003, tunes from 0.7 to 20 GHz and provides a 3-dB bandwidth of 60 MHz maximum. Connectors are 3-mm female, package size is 1.7 inch^3 and tuning power is <3.6W maximum at 20 GHz. Advanced Microwave Labs, 825 Stewart Dr., Sunnyvale, CA 94086. **280**

FET-input operational amplifiers, A-156 and 157, drive capacitive loads up to 1000 pF, slew at 45V/μsec and settle to 0.01% in 600 nsec. Both units come in a 1.125 by 1.125 by 0.4 inch plug-in module. Prices are $26 (A-156) and $29 (A-157) each. Intech, Inc., 1220 Coleman Ave., Santa Clara, CA 95050. **281**

Solid-state time-delay relays feature repeat accuracies of ±5%. Two timing ranges are available: 0.03 to 30 and 3 to 300 sec. Voltages offered are 115V ac and 24V dc. Deflecto Mfg. Div., Amperite Co., Inc., 600 Palisade Ave., Union City, N J 07087. **282**

High-frequency analog switch AM1000 switches signals of ±10V at toggle rates to 4 MHz. The AM1000 (JFET IC) has a maximum R_{on} of 30Ω and maximum leakage of 250 pA at 25°C. Price for 100 and up is $5.50 each. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **283**

Solid-state fundamental oscillators of the ROL Series operate at frequencies from 0.5 to 3 GHz. Typical price for a 1-GHz unit with 2W output and voltage tunable bandwidth of 5% is $350. Raytheon Co., 4347 Raytheon Dr., Oxnard, CA 93030. **284**

Photocell amplifier Model PCT, has an adjustable setpoint, adjustable differential or dead band and adjustable time delay. The unit can be wired for either dark- or light-energized operation. Price in 100 lots is $18.25 each. Curtis Development & Mfg. Co., 3250 N. 33 St., Milwaukee, WI 53216. **285**

Twelve-bit DAC, Model ZD432, provides linearity of ±1/2 LSB, settling time of 20 μsec, tempco of 20 PPM/°C and full scale accuracy of 0.05%. Voltage ranges of ±10, ±5 or 0 to +10V are selectable. Modules are 0.4-inch high and require <4 inches^2 of board space. Price is $49 each. Zeltex Inc., 1000 Chalomar Rd., Concord, CA 94520. **286**

AC relay is full zero switching (ON and OFF). The Model 11Z25 is all solid-state, rated at 2.5A continuous, 1 to 230V rms, 40 to 400 Hz. Size is 1 by 1-1/2 by 5/8 inch, and single unit price is $34.75. Flight Systems, Inc., Box 25, Mechanicsburg, PA 17055. **287**

DC to DC converters—Model D-16, an adjustable 8-16 kV at 1 mA anode supply, E-10, a 0-1 kV at 10 mA focus supply and E-30, a 0-3 kV at 5 mA focus supply, are fully encapsulated and shielded in black anodized aluminum cases. Venus Scientific Inc., 399 Smith St., Farmingdale, NY 11735. **288**

IC power regulator LM337 delivers 15V output at 450 mA with <1% line and load regulation. Typical ripple rejection is 62 dB. Price in 100 lots is $3.70 each. European Electronic Products Corp., 10150 W. Jefferson Blvd., Culver City, CA 90230. **289**

A 20-dB baseband directional coupler covers the four-decade frequency range from 1 kHz to 10 MHz. Completely passive, this coupler has insertion loss of <0.25 dB and directivity of >30 dB. Two models (50 and 75Ω) are available, both priced at $120. Reaction Instruments, Inc., 215 Mill St. N.E., Vienna, VA 22180. **290**

Solid-state zero-crossing heavy duty relays, Models 19 and 20, are offered in two-pole and three-pole versions for multiphase operation. Both models are suitable for operation in contaminated or explosive atmospheres. Profile Controls, 44 S. Main St., Concord, N H 03301. **291**

5V dc, 20A power supply, M-5-20, can operate from 90 to 150V ac, 45 to 1000 Hz, and from 90 to 240V dc without modifications or derating. Efficiency for the 6- by 4- by 2-3/8-inch unit is 80%. Price range is from $170 to $250. Aaron-Davis Co., 1150 S. Beverly Dr., Los Angeles, CA 90035. **292**

Double-balanced mixer, Model M6KC, is a low-cost, RFI shielded unit for use from 5 to 400 MHz. Isolation is typically 35 dB, conversion loss typically 6 dB. Electrical specifications are guaranteed from −54 to 100°C after environmental stressing/MIL-STD-202D. Price each is $12 in 100 lots. Relcom, 2329 Charleston Rd., Mountain View, CA 94040. **293**

Detector video log amplifiers of the "DVL" Series cover 500 MHz to 18 GHz in octave and multi-octave bandwidths. Logging is over a dynamic range of 50 dB. Unit price ranges from $750 to $850 each. Microphase Corp., 35 River Rd., Cos Cob, CT 06807. **294**

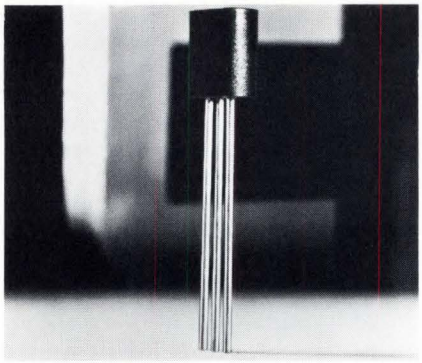
DC-DC converter operates at 70% efficiency over the input voltage range of 20 through 32V. There are single, dual and triple output models in the 50W SLA Series. Size is 2-7/8 by 1-1/4 by 4-1/8 inches, and price is $295 each. Arnold Magnetics Corp., 11520 W. Jefferson Blvd., Culver City, CA 90230. **295**

Lumped constant delay line, DIP 5, offers five tapped increments of delay ranging from 10 to 1000 nsec. Unit dimensions are 0.8 by 0.46 by 0.345 inch and standard lines are available in 100, 500 and 1000Ω impedances. Allen Avionics, Inc., 224 E. 2nd St., Mineola, NY 11501. **296**

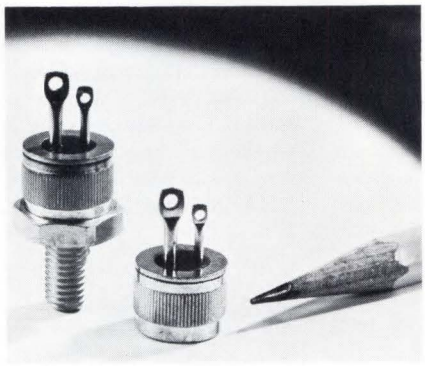
Miniature lowpass and bandpass filters operate in the 5 to 100 MHz frequency range with a 3-dB bandwidth range of 2 to 80% on bandpass filters. Physical size is approximately 1 by 1 by 2-3/8 inches, less connectors. Price range is $55 to $170. Texscan Corp., 2446 N. Shadeland Ave., Indianapolis, IN 46219. **297**

Single-sideband modulators of the 900 Series are stripline units that have an RF input, an RF output and two IF inputs. They produce either the upper or the lower sideband output (carrier suppressed). Microwave/Systems, Inc., 1 Adler Dr., East Syracuse, NY 13057. **298**

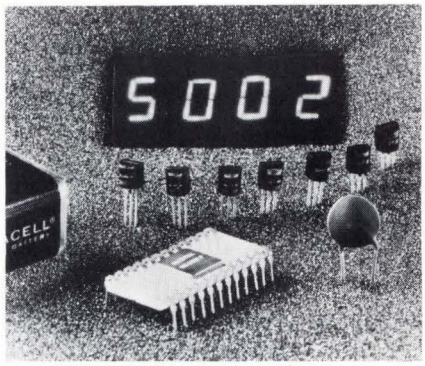
High-speed FET comparator module features DTL and TTL level compatibility, switching speed of 75 nsec, true differential input with input resistances of $10^{12}\Omega$ and an output of ±10V at 20 mA. Package size is 1-1/8^2 by 1/2 inch. Model 675A is priced at $37. Dynamic Measurements Corp., 6 Lowell Ave., Winchester, MA 01890. **299**



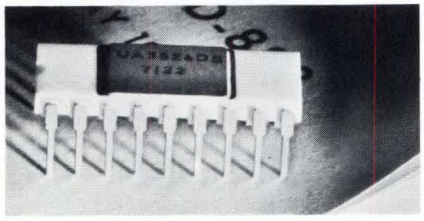
Plastic-package SCR, Series IP100-104, comes in a rugged TO-92 case made of a special epoxy compound that has excellent moisture resistance and good thermal transfer characteristics. Available voltage ratings are from 30 to 200V. Maximum current rating is 0.8A forward current and 6A rms surge current. Gate sensitivity is 200 μA. Prices start at $0.37 (1000-lot quantities). Unitrode Corp., 37 Newbury St., Boston, MA 02116. **300**



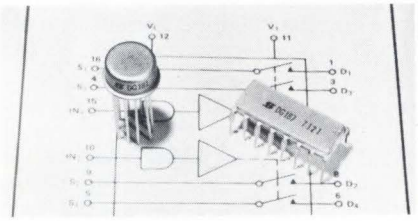
SCRs IR30 to 33 have 25A rms current ratings, and come in either a press fit or stud package. Two units, 33 and 31, require only 10 mA gate signal. Models are available with peak-forward blocking voltage ratings from 25 to 400V and nonrepetitive peak reverse voltage ratings from 35 to 500V. Price range is from $2.50 to $7.86 (100-999). Semiconductor Div., International Rectifier Corp., 233 Kansas St., El Segundo, CA 90245. **303**



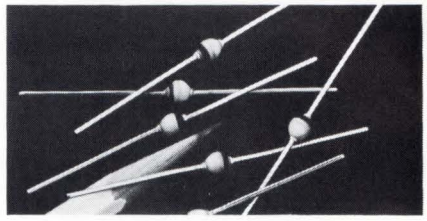
MOS/LSI counter/display MK5002 contains a four-decade counter, four quad latches, two 4-bit multiplexers, a 7-segment decoder and control logic interface. Total power dissipation is 6 mW, and it operates on a 5V source. Unit is available in either 24- or 28-pin DIPs. Prices range from $17 (100-499 lots) to $30 (1-24 lots) for 24-pin units and $19 (100-499 lots) to $33 (1-24 lots) for 28-pin. MOSTEK Corp., 1400 Upfield Dr., Carrollton, TX 75006. **306**



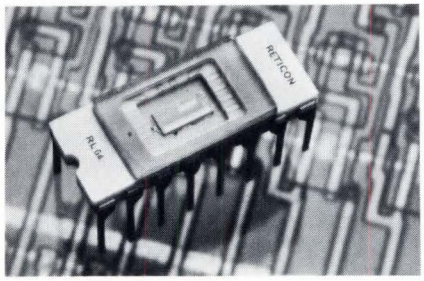
Dynamic MOS RAM, 1024 × 1, features stable operation over the full military temperature range. Designated UA2524 (MIL-temperature) and UA3524 (commercial), these devices are packaged in a standard 18-lead ceramic DIP. Each unit is fully decoded and has static-charge protection on all inputs. Access time is 250 nsec and average power dissipation is 320 mW. Unisem Corp., Box 11569, Philadelphia, PA 19116. **301**



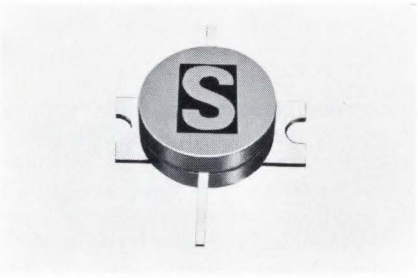
Two families of high-speed drivers with JFET switches, DG181 and DG187, feature 100-nsec typical switching time and BBM action. The DG181 family is available in 2-channel versions with both SPST and DPST switching. The DG187 Series includes both 1- and 2-channel devices with SPDT function. Prices for 100-unit quantities are $17.50 (military) and $8.75 (commercial). Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. **304**



Three-amp silicon rectifiers, Types IN-5624-5627 and Type SPD5628, exhibit maximum peak-inverse voltages of 200, 400, 600, 800, and 1000V, respectively. Their unusual construction makes them ideal replacements for stud-mounted rectifiers. Characteristics include 1V maximum forward voltage drop at 25°C, and 200 μA maximum reverse current (Tj=175°C). Solid State Devices, Inc., 12741 Los Nietos Rd., Santa Fe Springs, CA 90670. **307**



A 64-element self-scanning optical array, RL 64, operates in the charge-storage mode, permitting the use of very low illumination levels. Through TTL compatibility, the insertion of a simple pulse train yields high-level, low-impedance video output at scan rates up to 10 MHz. OEM quantity price is $150. RETICON Corp., 365 Middlefield Rd., Mountain View, CA 94040. **302**



Five-amp plastic power npn transistors, S-6000 and S-8000 Series, are extremely small (0.105 inch high by 0.27 inch diam) and come in an X-53 case. Typical specifications include power dissipation of 25W at V_{CE} = 10V, I_C = 2.5A and TC = 100°C. One outstanding feature is tin-plated leads for optimum solderability. Solitron Devices, Inc., 1177 Blue Heron Blvd., Rivera Beach, FL 33404. **305**

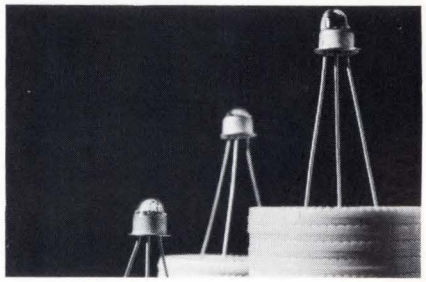


Photo darlington QS-507 provides light current of 5 mA with irradiance of only 2.0 mW/cm^2. Power dissipation is 125 mW. Packaged in a TO-18 header with an epoxy dome for easy mounting and positioning, the device is sensitive to both visible and near-infrared illumination. Price for quantities of 1000 is $0.45 each. Quantum Sensing Inc., 1650 Locust Ave., Bohemia, NY 11716. **308**

An FM-IF integrated circuit, CA 3089, features exceptional limiting sensitivity, low distortion, single-coil tuning capability and high recovered audio (typically 425 mV). Packaged in a 16-lead plastic DIP, it is priced at $2.20 each. RCA/Solid State Div., Route 202, Somerville, N J 08876. **309**

Dual 50-bit static shift register UC7355 is a p-channel MOS device, and is DTL/TTL compatible. Unit is available in a hermetically sealed TO-99 metal can. Operating temperature range is 0 to 70°C. Solitron Devices, Inc., 8808 Balboa Ave., San Diego, CA 92123. **310**

Power regulator LM335 delivers 5V at 600 mA with <1% line and load regulation. Overload and short circuit protection are provided. Ripple rejection is typically 62 dB. Operating temperature range is 0 to 70°C. Price in quantities of 100 is $3.60 each. European Electronic Products Corp., 10150 W. Jefferson Blvd., Culver City, CA 90230. **311**

Thermo-detectors operate in the range from ultra-violet to 30 μm with response times down to 4 msec. Sensors, Inc., 303 W. Ann St., Ann Arbor, MI 48103. **312**

Four MOS/LSI random logic circuits operate at 4-MHz clock rates—achieved through proprietary four-phase design techniques. Chip sizes range from 0.134 by 0.194 to 0.173 by 0.198 inch. Wafers are processed using standard high-threshold p-channel MOS techniques. LSI Computer Systems, Inc., 1 Northwest Dr., Farmingdale, NY 11735. **313**

Receiver and driver (Am9620 and 9621) are new additions to a family of peripheral circuits. The Am9620 is a dual differential line receiver capable of receiving 500 mV differential signal over a 30V dynamic range. The Am9621 is a dual line driver that can be used as either a single-ended line driver or a differential driver. Advanced Micro Devices Inc., 901 Thompson Place, Sunnyvale, CA 94086. **314**

Stud-mounted SCR, Type 175RA, is capable of handling 275A rms, and has an improved surge rating of 4500A. Ten versions are offered with voltage ratings from 500 to 1600V. The 1600V unit is priced at $372 each. Semiconductor Div., International Rectifier Corp., 220 Kansas St., El Segundo, CA 90245. **315**

A 5120-diode SOS ROM can be encoded to customer specifications within 24 hrs. Interfaced with TTL/DTL, the SOS ROMs have a 20-nsec maximum access time with 0.06 mW/diode power dissipation. Units are packaged in a 42-lead flatpack and priced as low as $26 (quantities of 1000), each custom-encoded. North American Rockwell Microelectronics Co., Box 3669, 3430 Miraloma Ave., Anaheim, CA 92803. **316**

Commercial npn power transistors packaged in hermetically sealed TO-3 cases and priced from $1.40 to $9 each in lots of 1-9 are available. TRW Capacitor Div., Solid State Operation, 112 West First St., Ogallala, NE 69153. **317**

A balanced modulator/demodulator, designated the S5596K, is equivalent to Motorola's MC1596G device. Typical carrier suppression is −65 dB at 500 kHz and −50 dB at 10 MHz. Typical common mode rejection is −85 dB. Price for quantities of 1 to 99 is $6 each. Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **318**

Zener diodes with ratings of 1, 2 and 3W, and with a voltage range from 6.2 to 33V are available in hermetic DO-7 cases. American Power Devices, Inc., 7 Andover St., Andover, MA 01810. **382**

Signal processor MC1345 provides sync separation, noise inversion, AGC keyer, AGC amplifier and adjustable RF AGC delay for monochrome or color TV sets. Device generates either positive- or negative-going AGC voltage within the 10V range for the tuner and a 16V pk-pk sync output. In 1000 to 4999 quantities, the MC1345P sells for $0.95. Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, AZ 85036. **383**

Double-balanced mixer/modulators, LS-1496/1596, feature up to 175-MHz operating frequency range, low power drain and typically 65 dB carrier suppression. Price of the LS1596 (100-999 quantities) is $4.80. Lithic Systems, Inc., 10010 Imperial Ave., Cupertino, CA 95014. **319**

A 9-bit parity generator and checker, designated N8262A, is capable of generating either even or odd parity as part of a data word. Available in a 14-lead package, the unit sells for $3.62 each. Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **322**

Silicon gate static MOS random access memory Am1101A is a 256-bit unit that operates with 1.2 mW/bit of power dissipation and in the 100-up mix quantity prices start at $15.40 each. Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, CA 94086. **325**

μA 747 contains two 741 op amps in a 1/8- by 1/4-inch hermetic flat pack. In lots of 1-24, price is $11.50 each. Mini-Systems, Inc., David Rd., Box 429, North Attleboro, MA 02761. **320**

Op amps RM4531 and RC4531, provide the dc performance of the 741, plus a 30V/μsec slew rate. Raytheon Co., Semiconductor Div., 350 Ellis St., Mountain View, CA 94040. **323**

Photo Darlington QS 506 provides light current of 5 mA with irradiance of only 0.2 mW/cm^2. Its price, in lots of 1000, is $0.85 each. Quantum Sensing, Inc., 1650 Locust Ave., Bohemia, NY 11716. **326**

Precision comparator, the monoCMP-01, makes use of Schottky-compatible processing to achieve optimized speed. Available in TO-99, DIP and flatpack, the unit is pin-compatible with μA710, LM106 and LM111 devices. Price is $3.25 each (0 to 70°C operation) for 100 pieces. Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, CA 95050. **321**

FET input op amps, 2404BG and 2741CF, have had substantial price cuts. The 2404BG, in lots of 100 to 999, has been changed from $58.50 to $38.80. The 2741CF, in similar quantities, has been reduced from $17.50 to $10.80 each. Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, CA 94040. **324**

Silicon click-suppressors are available at less than 1/2 the cost of germanium devices. They are designed for click suppression in telephone circuitry and other signal-suppression applications where low diode voltage characteristics are desirable. CODI Semiconductor, Div. of Computer Diode Corp., Pollitt Drive S., Fair Lawn, N J 07410 **327**

SCR type IR122 is an 8A unit packaged in a TO-55-compatible plastic case. It has a guaranteed dv/dt rating, and is available in the voltage range from 50 to 400V. Semiconductor Div., International Rectifier Corp., 233 Kansas St., El Segundo, CA 90245. **328**

Silicon triac 40842 is rated at 6A rms and 450V peak, and is designed for power control and power switching applications. Its price in lots of 1000 units is $1.06 each. RCA Commercial Engineering, Harrison, N J 07029. **329**

Decade counter display driver HCTR-0107D includes an up-down decade counter that can be preset, four latches for BCD data storage, buffered BCD outputs, and BCD to 7-segment decoding with 30 voltage switches. Price in lots of 1000 is $6 each. Hughes Microelectronic Products Div., 500 Superior Ave., Newport Beach, CA 92663. **330**

MOS static RAM MM1101A2, breaks the 1 μsec max access time by offering a 500-nsec capability, yet with the same power dissipation as slower types. In lots of 100 items, its price is $23.10 each. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. **331**

LSI/MOS circuits include three new devices: a 512-bit dynamic shift register (3329), an 8-channel multiplex switch (3708) and an MOS up/down counter decoder driver (1056). ITT Corp., 320 Park Ave., New York, NY 10022. **332**

Switching, mixing and detecting, as well as voltage-variable capacitance tuning of TV receivers, are among the applications covered by a new series of diodes. In lots of 100-999, prices range from $0.35 to $0.80 each. Technical Information Center, Motorola Inc., Semiconductor Products Div., Box 20924, Phoenix, AZ 85036. **333**

Nineteen inexpensive new digital MOS ICs are now available for use in such computer-oriented applications as CRT terminal memories, line printers, card equipment buffers and code conversion. Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **334**

Gallium arsenide infrared-emitting diodes with performance up to 3 mW at 50 mA include Types 40843R and 40844R. In lots of 1000 units, prices are $1.95 and $2.50 each, respectively. RCA Commercial Engineering, Harrison, N J 07029. **335**

Four-bit comparators, 343 Series, have three active-high outputs: equal to, less than and greater than. Typical noise immunity is >4V. Available in either the J-type silicone DIP or L ceramic DIP, the 343CJ sells for $6 each in quantities of 100 to 999. Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, CA 94040. **336**

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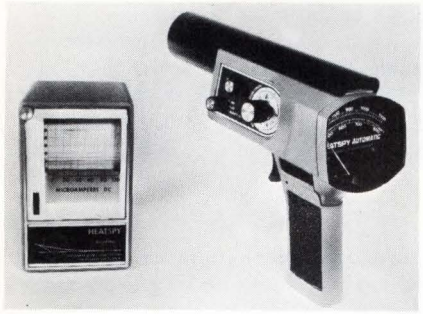
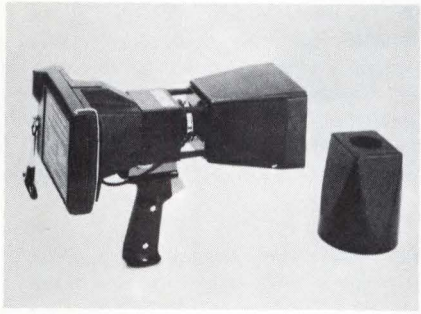
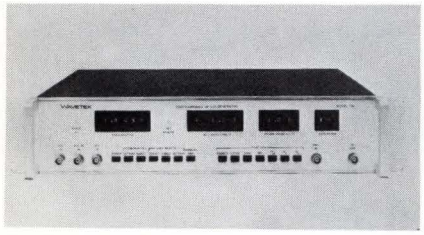


Infrared thermometer plus battery-operated miniature chart recorder provide permanent temperature recordings without auxiliary amplification. Available ranges cover from 0 to 1100°F, and system accuracy is ±2%. Heat Spy Div., William Wahl Corp., 12908 Panama St., Los Angeles, CA 90066. **337**

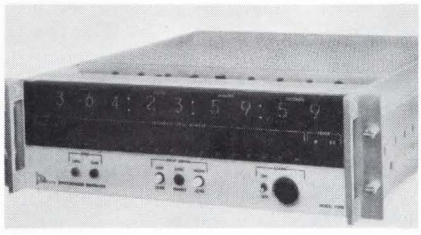


Polaroid camera for hand-held scope trace recording provides hard copy in 15 sec. Model CR-9 weighs less than 24 oz and costs $179.95. Eight interchangeable hoods equip it for light-tight operation with most oscilloscopes. No focusing is required to operate. Polaroid Corp., 730 Main St., Cambridge, MA 02139. **340**

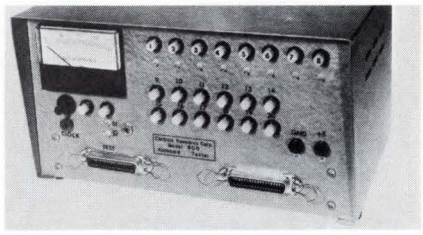
Deposition controller has keyboard for entry of all data, and pushbuttons for selection of all functions, permitting fully-automated deposition control. Memory circuits allow programming for up to five layers from up to five different sources. Sloan Technology Corp., 535 E. Montecito St., Santa Barbara, CA 93103. **343**



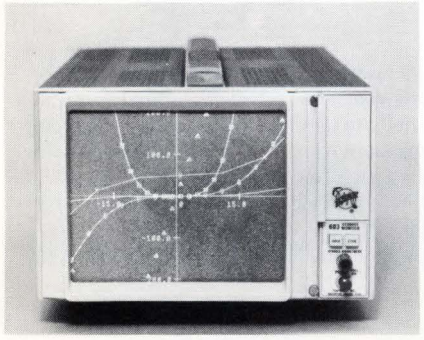
Programmable waveform generator allows local and remote digital control of frequency, function, offset and amplitude. Model 154 provides sine, square and triangle waveforms and dc voltage output. Frequency coverage is from 0.1 Hz to 10 MHz with calibrated output between 0.01 and 10V pk-pk. Wavetek, Box 651, San Diego, CA 92112. **338**



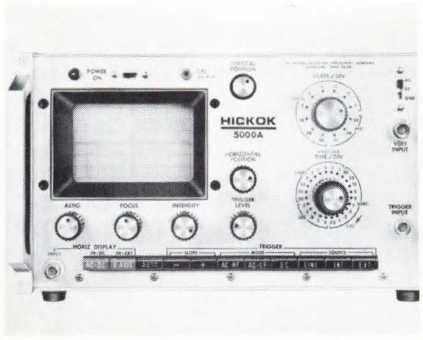
Synchronized generator for timing applications, Model 9390, is intended as a remote timing terminal capable of functioning with relative immunity to transmission system problems, system noise, dropouts or power failure. Modular design concept and numerous options make this a versatile instrument. DATUM. Inc., 170 E. Liberty Ave., Anaheim, CA 92801. **341**



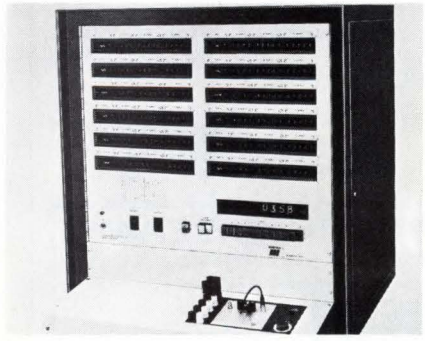
Keyboard tester for the detection and display of discrepancies needs no pre-programming or set-ups. Model 800 directly compares a known standard against the one under test. It verifies the strobe and will also verify that certain logic levels have been attained. Price is $890. Controls Research Corp., 2100 S. Fairview, Santa Ana, CA 92704. **344**



Storage monitor has X-Y amplifiers with 2-MHz bandwidth and is packaged in half-rack size. The Model 603 provides stored displays of alphanumeric and graphic information from computers and other data transmission systems. Viewing time is at least 1 hour and may be extended to 10 hours. Information storage rate is 200,000 dots per sec. Remote programming is by contact grounding. Tektronix, Inc., Box 500, Beaverton, OR 97005. **339**



25-MHz oscilloscope has stable triggering beyond 50 MHz and sells for $595. Model 5000A offers wide dynamic range and sensitivity (10 mV/division). A built-in vertical delay line provides 50 nsec of display prior to the trigger point on the input waveform. Vertical sensitivity is calibrated within ±3%, while rise time is 14 nsec. Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, OH 44108. **342**



SCR test set, Model 2610/SCR, has direct digital readout that is a true display obtained by successive approximation. It measures breakdown voltages and leakage currents, gate voltage and current, holding current and forward voltage drop. The standard test set has 12 digitally-programmed test positions with an operating range of 600V and 10A. Prices start at $14,500. MASTECH, Inc., 478 E. Brighton Ave., Syracuse, NY 13210. **345**

Digital recorder, the 20-megabit/sec Model ADR-2015, operates at seven selectable tape speeds from 15 to 960 ips for read/write transfer rates from 0.3125 to 20 megabits/sec. Start/stop time is less than 2.5 sec at 960 ips. Datacord, 795 Kifer Rd., Sunnyvale, CA 94086. **346**

Static 1-kVA inverter supplies 120V, 60 Hz power from a 120V dc battery. Size of the Model 20 inverter is only 15 by 5 by 3-1/2 inches. Features include automatic recovery, short circuit protection and 95% efficiency. Price is $500. Integrated Systems, Inc., 2315 Interstate 85, Norcross, GA 30071. **347**

Frequency monitor indicates frequency of single-phase power lines to within 0.05 Hz. Both over- and under-frequency alarm relay points are screwdriver settable. The unit is insensitive to voltage excursions from 95-135V. Solidstate Controls, Inc., 600 Oakland Park Ave., Columbus, OH 43214. **348**

Digital difference-to-analog converter, Model DD/A 840, retains accuracy of one part in 199,999,999 over temperature range of 0 to 70°C. The device computes the difference between two parallel numbers and converts the difference to a proportional analog voltage. Dynamic range is 1 MHz and the output linear range is ±10V. Prices range from $195 (±199) to $990 (±199,999,999). Computer Central, Box 5194, Seven Oaks Station, Detroit, MI 48235. **349**

Tunable active filter offers switch selection of low pass, high pass, band pass or band reject functions. Model LH4 also provides switch-selectable filtering characteristic or mode. Price for the standard model with cut-off tuning range of 20 to 200,000 Hz is $445. Spectrum Instruments, Inc., 35 Grand St., New Rochelle, NY 10801. **350**

Thermocouple digital thermometer, TS-701 Series, is available to measure and display temperatures up to 2000°F with 1° resolution and conformity to 1/4% of span. Standard models employ types J, K and E thermocouples. Readout is by 0.6-inch "Nixie" tubes. Both panel and instrument case versions are available with prices starting at $495 each. RdF Corp., 23 Elm Ave., Hudson, N H 03051. **351**

Storage oscilloscope, the portable Model 434, has an 8 by 10 cm CRT that permits bistable split-screen storage. Bandwidth is 25 MHz and the fastest sweep is 20 nsec/div. Price each is $2150. Tektronix, Inc., Box 500, Beaverton, OR 97005. **352**

Voltage-to-frequency converter is a high-level bipolar, remote ranging device with full-scale ranges of 10, 100 and 1000V. Model 252 is available with full-scale, TTL-compatible frequency pulse output ranges of 2, 20, 200 and 1000 kHz. Vidar Corp., 77 Ortega Ave., Mountain View, CA 94040. **353**

Selective amplifier, Model 210A, provides a choice of adjustable resonant circuit bandpass or rejection notch characteristics and frequencies between 0.1 Hz and 110 kHz. Packaged in a RIM module, it is priced at $715. Princeton Applied Research Corp., Box 565, Princeton, N J 08540. **354**

Reflex scanners for retro-reflective applications in material handling, the 400 Series, employ a common optical system for projecting the light source and receiving the reflected light beam. Model 402 units for general purpose use scan up to 20 ft with standard 3-inch disc. Model 403 units read retro-reflective mark 1/16 inch diam at a 12-inch range and at speeds up to 1000 ft/min. ACCU-SORT Systems, Inc., 601 Lawn Ave., Sellersville, PA 18960. **355**

Multi-tester combines dc voltmeter, phase-angle voltmeter, phase meter and synchro-angle conversion and display. Voltage ranges are from 300 μV to 300V RMS with 2% accuracy. Bandwidth coverage is 40 Hz to 50 kHz. Price is approximately $4000 each. North Atlantic Industries, Inc., Terminal Dr., Plainview, NY 11803. **356**

Reed relay input-output scanner, Series 1701, is a low level input-output scanner for monitoring temperatures, pressures, weights, flow or other data from up to 100 stations. Scan rates may be as fast as 5 msec. The unit can be programmed by computer, tape, card or other external systems. Price varies between $17 and $24 per channel. Matrix Corp., 520 N. 11th Ave., Beech Grove, IN 46107. **357**

Alignment oscilloscope with true X-Y display, the 7-inch Model 573, features sensitivity of better than 1 mV/cm with bandwidth of 2 Hz to 200 kHz. Price is $410. Kikusui Electronics Corp., c/o Marubeni-Iida (America) Inc., 200 Park Ave., New York, NY 10017. **358**

"Signature Ratio" adapter, Model SD306, when used with any SD301-Series real-time analyzer permits analysis of the vibration of rotating machinery in real time. In a second operating mode the vibration amplitude is displayed vs rpm. Spectral Dynamics Corp., Box 671, San Diego, CA 92112. **359**

Reference generator, Model RG-10, provides narrow, positive-going "time-mark" pulses at intervals ranging from 100 nsec to 10 sec. It also provides a variable amplitude 1-kHz square wave with 11 selectable output amplitudes. Price is $395. Harlan Labs., 3555 Aero Ct., San Diego, CA 92123. **360**

Calibrated phase shifter, Model PAS 360, accepts sine wave input at any one of three customer specified frequencies between 60 Hz and 50 kHz. It provides a calibrated output (up to 10V pk-pk) that is precisely offset in phase by any amount selected by the front panel switches. Phase shift range is 0 to 360° in 1° steps, and a continuously-variable vernier is provided. Unit price is $700. Electronic Development Corp., 11 Hamlin St., Boston, MA 02127. **361**

Paper-tape reader provides photoelectric reading with silicon sensors and reads all standard paper tapes in either direction at speeds to 200 characters/sec. In the Model AR20, all signals are TTL-compatible and are designed to allow operation directly from system logic without buffers or level shifters. Adtrol, Inc., 700 Abbott Dr., Broomall, PA 19008. **362**

High-voltage supplies of the Series 4000 operate as dc-to-dc converters supplied from ±12V dc ±5%. Multiple outputs are 8 to 12 kV at 100 μA, 500V at 1 mA and −150V at 1 mA. There is short-circuit and arc-over protection. Model 4001 (0.1% regulated) is priced at $122 in 100 lots and Model 4002 (0.05%) at $149. CPS, Computer Power Systems, Inc., 722 E. Evelyn Ave., Sunnyvale, CA 94086. **363**

Electronic position control systems, the CD-400 Series, are self-amplifying and react in milliseconds. Price of these non-contact displacement control systems varies from $250 to $550. Columbia Research Labs., Inc., MacDade Blvd. & Bullens Lane, Woodlyn, PA 19094. **364**

Solid-state AM-SSB Citizens Band transceiver, Model SSB 600, uses standard miniature plug-in crystals (one per channel) and is powered from either 12V dc or 110V ac. Price of this 11-meter unit is lower than for comparable imported versions. Telcomm Industries Inc., Box 180, Pomona, CA 91769. **365**

Torque tester, Model M-200, measures tape torque in cassettes. The meter is calibrated in gram-centimeters and ounce-inches. Ranges of 30 and 60 grams full-scale are provided. Power is furnished by alkaline cells with 600-hr service life. Information Terminals Corp., 1160 Terra Bella Ave., Mountain View, CA 94040. **366**

RF load resistor modules dissipate up to 20 kW continuous power in 5 to 45°C ambients while keeping VSWR to 1.1 from dc to 1300 MHz. No external water supply is required. Price of the 20 kW "Moduload" is $3300. Bird Electronic Corp., 30303 Aurora Rd., Cleveland, OH 44139. **367**

Precision millivolt source, Model 101, has switch selectable outputs of 1 to 99 mV and 10 to 990 mV with accuracy of better than 1% and output resistance of <1000Ω. Operation is from a single low-cost battery. The Model 101 sells for $69 each. W-P Instruments, Inc., Box 4059, Hamden, CT 06514. **368**

Two-phase oscillator with its variable phase output adjustable with 0.5° resolution over the range of 0 to 180° leading or lagging, Model RCD-2006, features phase stability of 0.025°/hr. Frequency response is ±0.05% from 50 to 20,000 Hz. Optimation, Inc., 9421 Telfair Ave., Sun Valley, CA 91352. **369**

Phase shifter operates from 1 Hz to 1 MHz, provides a square-wave output at controllable phase shift with respect to the input and does not require frequency adjustments. Model 811 offers both auto and manual triggering modes and will give a clean square-wave output from virtually any wave form. Second-harmonic operation is switch selectable. The price is $1100. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139. **370**

Control module, the "Event Sequencer", will activate up to 40 external devices or functions, output positioning data, accept three BCD numbers for high/low comparison and provide internal timing intervals. The base price is $2500. Information Transfer Inc., Box 357, Holcomb, NY 14469. **371**

Boxcar detector, the "System 88", recovers both amplitude and waveform of signals hidden by noise and provides a time-expanded display of a repetitive waveform. Priced at $2500, it resolves waveform segments as short as 10 nsec and can reject up to 1V of superimposed noise. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139. **372**

Digital capacitance meter measures from 0.01 to 2000 pF at 1 MHz with basic accuracy of 0.25%. BCD and dc analog outputs are standard, while autoranging and logic-level programming are available as options. All four decimal push-button ranges have 100% overrange capability. Price each is $1100. Boonton Electronics Corp., Rte. 287 at Smith Rd., Parsippany, N J 07054. **373**

Portable analyzer/generator/character sequence recognizer, Model 2651, operates at 10 preset crystal-controlled baud rates and is designed to interface high-level and low-level neutral and polar keying loops. Digitech Data Industries, Inc., 66 Grove St., Ridgefield, CT 06877. **374**

Time interval meter, Model 355, has selectable resolution of 1 μsec or 1 msec which permits readout of the five-digit display over the range from 1 μsec through 99.999 seconds. The internal crystal oscillator's aging rate is 1 PPM/30 days. Size is 3.5- by 5.6- by 8-inches and price is $450. Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, CA 94520. **375**

Guarded DMM with 5-digit display uses dual-slope integration techniques, provides high noise rejection and 30/sec reading speed at full accuracy. Model 7110 autoranges from ± 1 μV to ± 1100V dc including ratio. Base price including autoranging, switchable filter and 100 mV dc full-scale range, including ratio, is $1695. Price complete with all standard options is $2700. Systron-Donner Corp., 888 Galindo St., Concord, CA 94520. **376**

Automatic frequency meter covering from 1 to 18 GHz is priced at only $1500. The Model 310A/313A provides completely automatic CW frequency readings accurate to 0.1% on a five-digit "Nixie" display. EIP Inc., 380 Martin Ave., Santa Clara, CA 95050. **377**

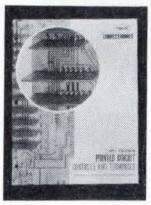
DC-AC inverters convert a dc input source to a 60-cycle regulated sinusoidal ac output. Input is 26-29V dc and output is 115V 60 Hz ac. Power rating is 250 VA into inductive, capacitive or resistive loads. Model IT2256RS is priced from $335 to $450 dependent on order quantity. ERA Transpac Corp., 67 Sand Park Rd., Cedar Grove, N J 07009. **378**

Seven-channel monitor scope features absence of vertical drift, response from dc to 10 MHz and a variety of triggering modes. The Model 7500 uses rectangular 1 by 3-inch CRTs with >2000V accelerating potential. Price per 7-channel unit is $2895 including rack-mounting slides. Calico Div., California Instruments Corp., 5150 Convoy St., San Diego, CA 92111. **379**

Regulated dc power supplies of the OEM Series are offered with voltage ratings from 5-24V and with 42 different voltage/current ratings. Prices range from $24.95 for open-case 5V at 3A model to $299 for open chassis 5V at 75A model. Powertec, Inc., 9168 DeSoto Ave., Chatsworth, CA 91311. **380**

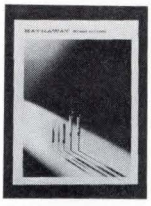
Totalizing 4- or 5-digit impulse counters, Type RG, are rated for operating life of 200 million counts without count loss. Standard voltages are 12, 24, and 110V dc with voltage tolerance of $\pm 15\%$. Rating is for continuous duty at 35 impulses/sec. Prices run between $9 and $11, depending upon quantity. Landis & Gyr, Inc., 4 Westchester Plaza, Elmsford, NY 10523. **381**

Transistor reliability is discussed in an eight-page brochure entitled "Some Plain Talk About Motorola's TO-92 Plastic Transistor Reliability". Also covered is information on failure rates and tests performed. Available by letterhead request to Motorola Semiconductor Products Inc., Box 20924, Phoenix, AZ 85036.



"Printed Circuit Contacts and Terminals" describes "Varicon" high-reliability, low-cost connection systems. This 12-page catalog shows contact variations for parallel, perpendicular, or tandem PC board connections. Elco Corp., Maryland Rd. & Computer Ave., Willow Grove, PA 19090. **104**

FET amplifiers are the subject of a data sheet describing three unique, low-cost FET-input differential amplifiers available in a choice of four packages. Complete electrical and mechanical specifications plus several typical applications are included. Zeltex Inc., 1000 Chalomar Rd., Concord, CA 94520. **108**

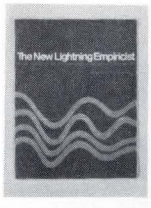


Drireed switches from microminiature to standard sizes are presented in a 16-page catalog with specifications, application information and dimensions. Hathaway Instruments, Inc., 5250 E. Evans Ave., Denver, CO 80222. **101**

Liquid crystal displays are described in Bulletin 102, which gives complete specifications, dimensional drawings, application ideas and ordering information. Optel Corp., Box 2215, Princeton, N J 08540. **105**

Guide to spectrum analyzer family provides photos and key features of four tuning units, three display units, two IF sections, tracking generators and an automatic preselector. Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **109**

High-performance electric motors and blowers for computer-peripheral, business-equipment and other demanding applications are described in Bulletin A-100, an eight-page brochure which provides product descriptions, performance charts and specifications for a wide range of motors. Ametek/Lamb Electric, 627 Lake St., Kent, OH 44240. **102**



"The New Lightning Empiricist" is a 20-page booklet that clarifies such enigmatic topics as "The Subtleties of Settling Time" and "deglitched" digital-to-analog converters. A free subscription to this quarterly publication is available by returning a reply card. Teledyne Philbrick, Allied Dr. at Route 128, Dedham, MA 02026 **106**

Discretes and ICs are featured in a 16-page catalog describing FETs and ICs with special emphasis on MOS and JFET switches, analog drivers and gates. Technical data is given on digital and linear ICs, current and voltage limiters and high-frequency devices. Siliconix, Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. **110**

"Lasertrim Users Manual" describes laser resistor trimming and ceramic scribing techniques and equipment. The 25-page manual is designed to assist hybrid microcircuit manufacturers in the selection of production hardware and techniques. Apollo Lasers, Inc., 6365 Arizona Circle, Los Angeles, CA 90045. **103**

"Solid State Modules" is a 140-page catalog describing choppers, signal isolators, relays, dc amplifiers, freqmeters, phasemeters, oscillators, analog-to-digital converters, pressure transducers and miniature FM telemeters. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **107**

"MOS/LSI In Plastic Packages" is the title of a bulletin describing assembly steps, package dimensions, environmental results and life-test results of the company's plastic dual in-line packages for MOS/LSI ICs. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, M/S 308, Dallas, TX 75222. **111**

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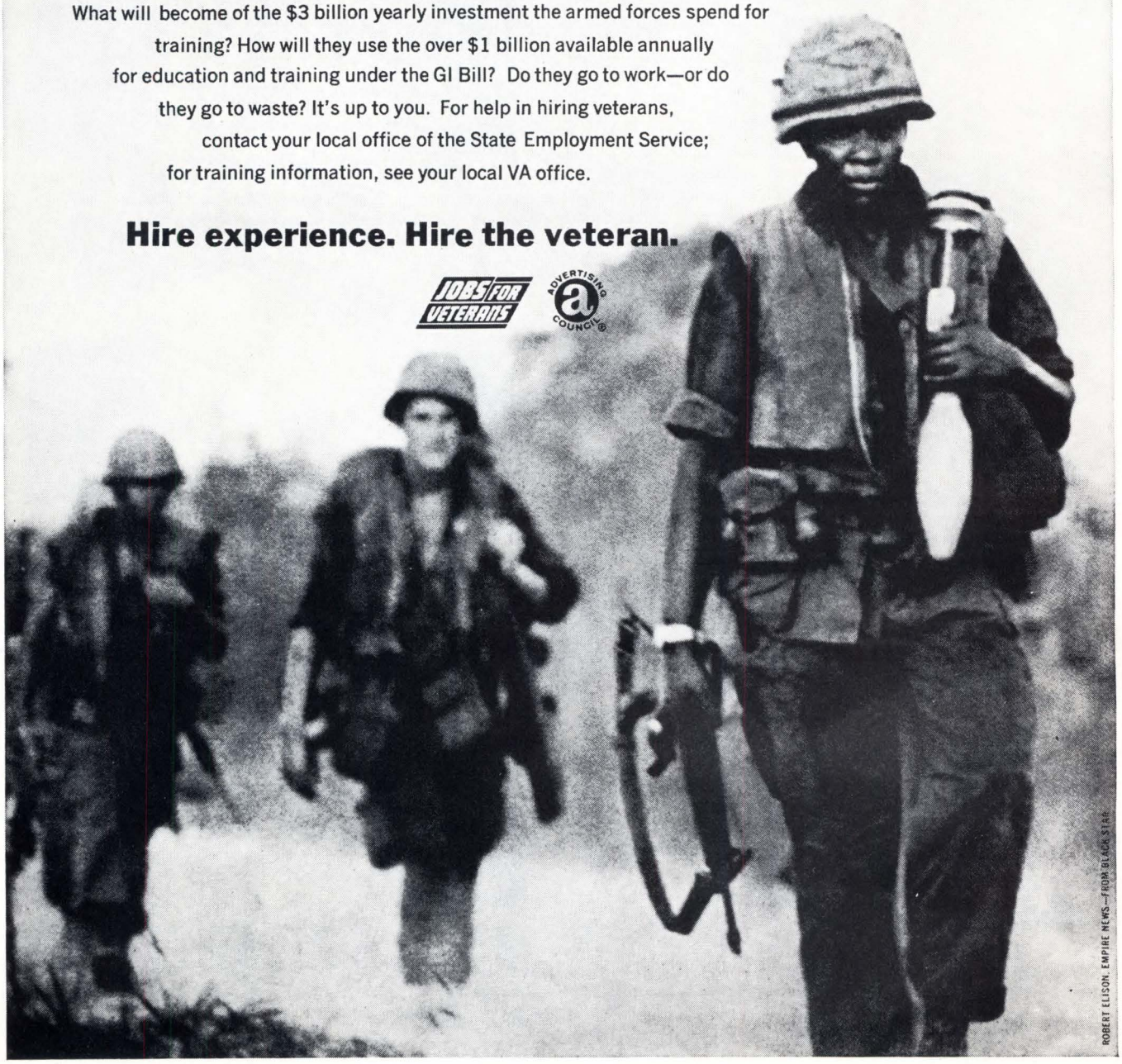


ROBERT ELISON, EMPIRE NEWS—FROM BLACK STAR

"Microwave Devices", a 16-page condensed reference guide, is a condensation of a 120-page book. The new digest, ETD-6028, outlines planar triodes and power tubes, circuit modules, magnetrons, klystrons, and solid-state devices. Tube Products Dept., General Electric Co., Room 309, 2100 Gardiner Ln., Louisville, KY 40205. **112**

Dual-trace oscilloscope PM 3210 is a 25-MHz, 1-mV unit that is described in a four-page brochure from Philips Electronic Instruments, 750 S. Fulton Ave., Mount Vernon, NY 10550. **113**

Thyristors in chip form are the subject of a four-page applications bulletin which covers the use and handling of thyristors and also describes a new chip construction technique. Hutson Industries, 2019 W. Valley View Lane, Dallas, TX 75234. **114**

Relays and contactors are listed in 24-page Catalog SC-5 which is complete with pictures, prices, full technical data and specifications. Essex International, Inc., 1801 Wall St., Fort Wayne, IN 46804. **115**

Low TC, high resolution metal film trimmers are covered in a two-page data sheet from Vishay Resistor Products, Div. of Vishay Intertechnology, Inc., 63 Lincoln Highway, Malvern, PA 19355. **116**

Resistors and potentiometers are detailed in this eight-page catalog from TRW Electronics, 10880 Wilshire Blvd., Suite 1700, Los Angeles, CA 90024. **117**

"Helium-Neon Selection Guide" is a 6-page brochure covering modular laser products. Its purpose is to help the designer select modules or an entire operating system for a particular application. RCA Commercial Engineering, Harrison, N J 07029. **118**

Low-noise high-gain differential preamp, useful in a wide variety of applications in biology, chemistry, physics and engineering, is described in Bulletin T-224. Complete specifications and performance graphs of the Model 113 are included. Princeton Applied Research Corp., Box 565, Princeton, N J 08540. **119**

Copper finger contact strips for RFI/EMI shielding are covered in six-page Bulletin A-71, available from Instrument Specialties Co., Inc., 244 Bergen Blvd., Little Falls, N J 07424. **120**

"Soldering Tips for 1971" is the title of 32-page Catalog 6004 which provides engineering data and a tip selection guide describing the effects of tip length, diameter and point shape in various applications. Hexacon Electric Co., 161 W. Clay Ave., Roselle Park, N J 07204. **121**

Core memory designed for manufacturers of medium to large computer systems is described in Brochure C-166 which features the compact, low-cost Series 3690 memory. Ampex Corp., 401 Broadway, Redwood City, CA 94063. **122**

Magnetic shielding properties of PRIMAG 90, a nickel iron alloy, are covered in two data sheets, MS-680 and MS-681, from TECKNIT, 129 Dermody St., Cranford, N J 07016. **123**

Relays, reed switches and optoelectronic components are covered in a 20-page catalog from Sigma Instruments Inc., 170 Pearl St., Braintree, MA 02185. **124**

Industrial timers are covered in an illustrated six-page brochure which gives full details of the "Value Line", including electromechanical delay, interval and percentage timers. Raymond Controls Corp., 2081 S. Main St., Middletown, CT 06457. **125**

Seal-coated monolithic ceramic capacitors are the subject of a 12-page catalog which describes in full detail the "EMCAP" line of economical miniature radial-lead ceramic capacitors. Electro Materials Div., Illinois Tool Works Inc., 11620 Sorrento Valley Rd., San Diego, CA 92121. **126**

Gas-filled surge voltage protectors are fully described in four-page, full-color Bulletin SCD-0271-S102 from Siemens Corp., 186 Wood Ave. S., Iselin, N J 08830. **127**

"White Noise Generator Bulletin" provides information on 25 types of modules and 16 types of diodes with various amplitudes and output frequencies in the range from 20 Hz to 500 MHz. CODI Semiconductor, Pollitt Dr. S., Fair Lawn, N J 07410. **128**

Low-cost modular logic panels for high-density logic packaging are described along with specifications of 70 standard panels. Prices are included. Stanford Applied Engineering, 340 Martin Ave., Santa Clara, CA 95050. **129**

Crystal oscillator frequency standards from 1 Hz through 150 MHz are covered in this 24-page catalog from Vectron Labs., Inc., 121 Water St., Norwalk, CT 06854. **130**

Subminiature ceramic capacitors are the subject of 12-page Catalog G-1. Republic Electronics Corp., Dept. K, 176 East 7th St., Paterson, N J 07524. **131**

PC board nests and patented locking card guides are the subjects of a six-page brochure describing in full detail the "Stak-Rak" Series, with special emphasis on the new "Rak-19". Zorak Co., Inc., 103 Morse St., Watertown, MA 02172. **132**

Precision servo motors, including combined motor-generator units, velocity- and inertia-damped types, are described in an eight-page catalog which also gives detailed performance specifications and dimensional diagrams. Sawyer Industries, Inc., 5445 Peck Rd., Arcadia, CA 91006. **133**

Industrial and laboratory equipment catalog features precision welding equipment, ultrasonic impact grinders, microwave power generators and sonic oscillators. Raytheon Co., 676 Island Pond Rd., Manchester, N H 03103. **134**

Transistorized motor controllers are detailed in a four-page folder containing engineering data on each of six different dc controllers for use in virtually all types of dc servo or torque motor applications. Spec sheets describe applications and give information on increased motor efficiencies. Control Systems Research, 1811 Main St., Pittsburgh, PA 15215. **135**

Sample and hold, Model SHM-2, is described in a two-page data sheet with electrical and mechanical specifications, technical description, applications, block diagram and curve of error due to time uncertainty versus input frequency. Varadyne Systems, 1020 Turnpike St., Canton, MA 02021. **136**

DC power supplies and power supply module systems are presented, with pictorial product summaries, in Catalog C671. Prices, available options, accessories and rack adapters are also presented. Trygon Electronics, 111 Pleasant Ave., Roosevelt, NY 11575. **137**

DVMs, electronic counters, data amplifiers and frequency synthesizers are presented in a 12-page brochure which describes performance as well as outstanding features of the various instruments in these lines. Selection guides for counters and DVMs and an abbreviated price list for all lines are included. Dana Laboratories, Inc., 2401 Campus Dr., Irvine, CA 92664. **138**

HF receivers, mixers, electronic switches, amplifiers, attenuators, frequency doublers, hybrid junctions, transformers, directional couplers, bandpass and lowpass filters and power splitters are featured in an eight-page short-form catalog. Lorch Electronics Corp., 105 Cedar Lane, Englewood, N J 07631. **139**

Synchro bridge Bulletin 4-20B describes in detail instruments used to measure a precise angular position of any system containing synchros or resolvers. Theta Instrument Corp., 22 Spielman Rd., Fairchild, N J 07006. **140**

Connectors and barrier terminal strips are covered in 20-page Catalog No. 76-DA which describes the full line of standard and new "Jones-type" connectors, barrier terminal strips and recently-introduced single-row and closed-back barriers. Included is dimensional data on plugs and sockets. Vernitron Electrical Components, Beau Products Div., Laconia, N H 03246. **141**

Fastest in the West?

Gentlemen:
Your Progress in Products section (May 15 issue) contains an item on Xintel's LSI Tester ("Fastest LSI Tester") that requires rebuttal. As old hands in the Great LSI Tester Race, we at Adar are painfully aware of the ephemeral nature of having the fastest LSI tester both inside and outside of Silicon Gulch. But we don't want to relinquish our claim any sooner than we have to.

Adar's testers (Doctor 32 and Doctor 64) test at up to 8 MHz (vs Xintel's 5 MHz) no matter how many pins. It is true that Doctor 32 senses one DUT output at a time, but it is wishful thinking on Xintel's part to imply that we scan across all DUT outputs before proceeding on to the next clock time. We do the sensible thing, which is to test the DUT at full speed—one pass per DUT output. An 8-bit ROM, for instance, requires eight passes, but each pass can be at the full 8 MHz—and, at half the cost of Xintel's equipment.

Our Doctor 64 model does the job by sensing all DUT outputs at once, in parallel, also at 8 MHz.

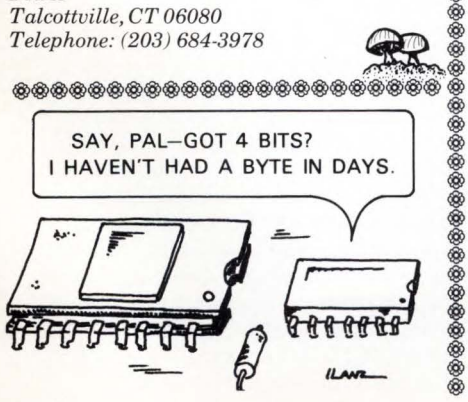
And so, as the sun sinks slowly in the west, the old Tester walks away alive from yet another challenge. But in his heart he knows that somewhere, in some small dusty town, he will meet a Steely-Eyed Kid with a lightning cycle time, who . . .

Ramon L. Alonso
Adar Associates, Inc.
Cambridge, MA 02140

EML's Address

Quite a few readers have asked for the address of the three engineers who went off on their own ("R&D in Basements and Garages", p. 55, May 15, 1971). Though they actually have three basements, they use one box number:

Electronic Music Laboratories, Inc.
Box H
Talcottville, CT 06080
Telephone: (203) 684-3978



Duty Cycle Modulator Questioned...

Gentlemen:
I've just finished reading Mr. Loe's interesting article, "Duty Cycle Modulators Are Simple and Versatile", in the April 15 issue. I'd like to suggest a simpler circuit for use as the basis of the applications.

By inverting the op-amp input connections, an additional 180° phase shift (which is independent of frequency) is added to the loop. This eliminates the need for two of the resistors and capacitors in the frequency determining network. That is to say, a single R-C is all that's required to obtain essentially the same properties and performance. A latching problem could arise with the simple circuit if one used a 709 as shown in Mr. Loe's **Fig. 2**. Most of the other 709 pin-compatible units are latch proof and would be all right, however.

Bob Widlar mentions this circuit in his AN-4 from National Semiconductor. The oscillator circuit is in **Fig. 1** of AN-4, and the text above the figure explains how to modify the duty cycle. With apologies to Mr. Widlar, his LM 101 is now just one of many amplifiers or comparators which can be used economically in this circuit.

By the way, I'm wondering if there weren't a few words of explanation or description omitted from the Analog Multiplier circuit. The output voltage will contain the gain of the "Diff Amp" as a factor. The circuit of **Fig. 6** gives values for most components, but it neglects the gain of this amplifier. In fact, an ordinary differential op amp fits the picture, but won't work as described since its open loop gain is not well controlled.

I'll send along a copy of the first page of AN-4 for your use.

A. Paul Brokaw
Communication Technology Inc.
Burlington, MA 01803

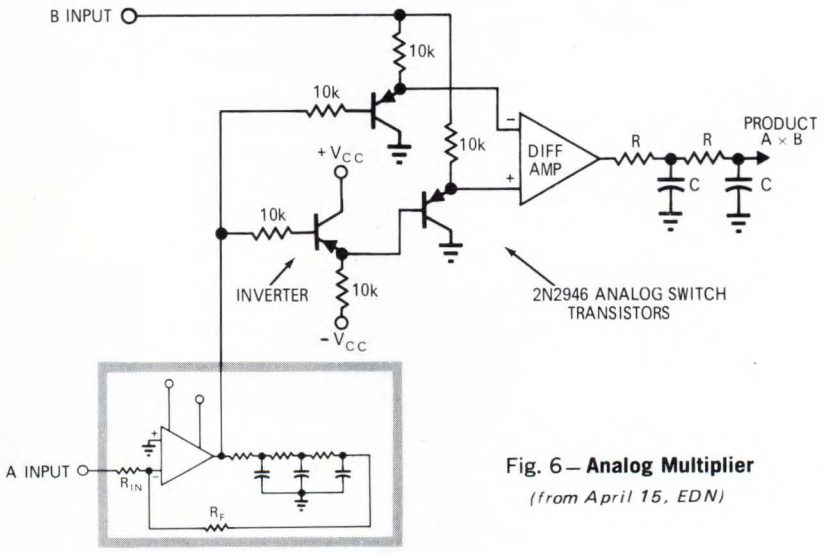


Fig. 6—**Analog Multiplier**
(from April 15, EDN)

...and Answered

Gentlemen:
Thank you for sending a copy of Mr. Brokaw's comments on my article, "Duty Cycle Modulators Are Simple and Versatile". My comments to Mr. Brokaw are as follows:

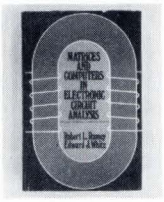
1. Replacing the 3-RC network oscillator with the "free running multivibrator" of Widlar's design does not produce a circuit with the same properties and performance. Specifically, the one R-C "multivibrator" shows gross frequency change with input voltage change, when used as a duty cycle modulator.

2. Latch-up cannot occur in my circuit of **Fig. 2** as long as R_{IN} is $< \frac{3R + R_F}{2}$; this condition is met in most designs by the desire to provide reasonable circuit gain.

3. The gain of the multiplier circuit will contain the gain of the differential amplifier.

J. M. Loe
Philco-Ford Corp.
Philadelphia, PA 19134

Matrices and Computers in Electronic Circuit Analysis



R. L. Ramey and Edward J. White; McGraw-Hill Book Co., 330 W. 42nd St., New York, NY 10036; 390 pages; $13.95.

This text couples electronic circuit design with computer-aided circuit analysis to free the reader from the tedious labor of calculations. Doing this permits him to concentrate on the information obtained from the analysis. BASIC is introduced in the early chapters. To analyze all advanced circuits, comprehensive programs in FORTRAN IV (USASI) and Burroughs Extended ALGOL 60 are developed. The complete program is listed in the appendix, with copies available from the authors in card deck or tape form.

The text, while written for a third or fourth year course in electronic circuits or communication networks, will also prove valuable to designers in the field.

IEEE Sixth Region Conference Record

450 Pages; $12.00 in bound form.

This conference record of the 1971 IEEE 6th Region Conference held May 11-13 in Sacramento carries the theme "Engineering for the Conservation of Mankind." The conference included fourteen sessions. Copies are available by order to M. G. Jerome, 4056 Esperanza Dr., Sacramento, CA 95625.

Electronic Analog/Digital Conversion

Hermann Schmid; Van Nostrand Reinhold, New York, NY; 1970; 519 pages; $18.95.

Problems associated with the translation of analog voltages into digital signals and digital signals into analog voltages are dealt with in this book. The author states that often A/D and D/A converters are "bottlenecks" in applying digital control and computational circuits to analog control systems. His stated purpose is to help eliminate these bottlenecks.

Subjects covered include applications of converters, techniques used, operation and implementation, components and their effect on performance and parameters needed to specify performance. In addition, there is a summary of the theory and background information needed to design converters.

Electronic Circuit Design Handbook

Editors of EEE; Tab Books, Blue Ridge Summit, PA; 1971; Fourth Edition; 416 pages; $17.95 (hardbound).

The fourth edition of this well-known circuits handbook has been expanded to include descriptions of almost 650 circuits, and is illustrated with over 750 schematics and waveforms.

This valuable reference book provides solutions, or a "spring board" to solutions, of problems facing circuit designers in a wide range of categories. It also has a section on test and measurement circuits and another on generator and simulator circuits that should help in evaluating circuits and instruments.

Modern Data Communication

William P. Davenport; Hayden Book Co., Inc., 116 W. 14th St., NY 10011; 200 pages; $7.95.

A fundamental guide covering concepts, language and media, this book avoids complex mathematics. It clearly explains how information from some storage medium such as magnetic tape, punched cards, paper tape or from a computer memory is moved from point to point in machine language. An extensive glossary defines data communications and other technical terms.

Its author, who is Vice President and General Manager of Scott-Buttner Communications of Oakland, Calif., is an authority on management systems and networks. He has conducted seminars and workshops and has written extensively for professional periodicals.

RCA Transistor, Thyristor and Diode Manual

RCA Commercial Engineering, Harrison, NJ 07029; SC-15; 768 pages; $2.50.

This popular manual is now available in a new edition that contains the latest information on basic technology, operating principles, characteristics and ratings, applications and testing of RCA solid-state devices.

Technical data is given for more than 1000 devices, divided into seven major categories: small-signal bipolar transistors; MOS transistors; low- and medium-frequency power transistors; RF power transistors; thyristors; silicon rectifiers and other diodes; and discontinued types. Schematic diagrams, descriptions, and detailed parts lists are provided for 35 circuits in a broad range of applications. An application guide is included to help the user choose the optimum types of devices for a particular application.

Copies can be obtained from RCA distributors or by sending $2.50 to RCA.

Also Worth Noting

"Handbook of Universal Active Filter Use" contains information and tables for the design of practical active filters. General application data on the use of active filters is included. Tables are provided for the design of Butterworth highpass and lowpass, Bessel, Chebyshev, elliptic function (Cauer parameter), Gaussian highpass and lowpass and Legendre filters. Graphs of the magnitude, phase and group-delay characteristics of most of these filters are also included. Price is $1.95. Kinetic Technology Inc., 3393 De La Cruz Blvd., Santa Clara, CA 95050.

"D.A.T.A. Book of Miniature and Subminiature Relays" describes more than 4000 relays of 1.0 inch^3 or less volume. A tabulated format is designed to aid in selections for specific applications. Full-size and fractional crystal can, TO-5, mercury wetted reed, dry reed, solid-state, hybrid and time delay types are included, along with schematics and drawings. Price is $27.50. D.A.T.A., Inc., Dept. 71A, 32 Lincoln Ave., Orange, N J 07050.

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Application Notes

Constant current and constant potential coulometry are discussed in an eight-page issue of MPI Application Notes (Vol. 6, No. 2). Six methods of endpoint detection and readout are illustrated and the flexibility of instrument modules used for various set-ups is shown in eight diagrams. Literature references for further information are given. McKee-Pedersen Instruments, Box 322, Danville, CA 94526. **90**

"New Techniques in Electrostatic Printing and Plotting" is an article reprint which discusses electrostatic writing and how it compares to conventional impact printers and pen-plotting systems. Versatec, Inc., 10100 Bubb Road, Cupertino, CA 95014. **91**

Uses of digital panel meters, including specific applications and operation of a line of 2-1/2, 3-1/2 and 4 digit panel meters, are described in a set of technical notes. Included is a discussion of noise rejection and active filtering techniques, digital display of sensor outputs and optional features of the Type 2330 digital panel meter. Tech notes are added to the set periodically and will be mailed to those requesting the set. Digilin, Inc., 1007 Air Way, Glendale, CA 91201. **92**

Torque motor fundamentals are reviewed in "Motorgram" Vol. 51, No. 2. The article includes a brief discussion of torque motors in general and concentrates on induction-type motors with information on rating methods, performance characteristics and application and performance considerations. Performance graphs are included. Bodine Electric Co., 2500 W. Bradley Place, Chicago, IL 60618. **93**

Technical handbook details the characteristics, capabilities and uses of Delrin acetal resins. Data is provided on strength, resilience, friction and bearing properties as well as electrical, chemical and heat resistance properties. Cadillac Plastic and Chemical Co., Box 810, Detroit, MI 48232. **94**

Interfacing incremental shaft encoders to control and monitoring systems is the subject of an eight-page pamphlet outlining problems encountered in interfacing counters to encoders. A section is devoted to angular position monitoring and control, with block diagrams depicting general approaches to interfacing major subsystems. Presettable controllers, frequency counters and digital stop watches are also discussed. Instrument Displays, Inc., 223 Crescent St., Waltham, MA 02154. **95**

Application of high noise immunity digital logic devices is the subject of a series of seven application briefs. Topics included are: eliminating internally generated noise, implementing collector ORing, second-level gating, quad 60 mA flip-flops, and others. The briefs are illustrated with many schematics and logic diagrams. Teledyne Semiconductor, 1300 Terra Bella, Mountain View, CA 94040. **96**

An inexpensive method of interfacing the MOS portion of a system with conventional bipolar logic, or system output devices using reed relays is described in a two-page application note with illustrations. Astro Space Laboratories, Inc., Research Park, Huntsville, AL 35806. **97**

Article reprint describes the electrical design and microcircuit construction of a high-reliability receiver, and the mutual influence of the packaging and electronic design. Principal design objectives included development of microwave hybrid and IC configurations providing precision performance, smallest possible size, high reliability and capability of fabrication into contamination-free equipment. American Electronic Laboratories, Inc., Box 552, Lansdale, PA 19446. **98**

Reprints Available in this issue are offered as follows:

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L61	Memories—Modern Day "Musical Chairs"—Part II	23
L62	Speakout	34
L63	Recoverable Time Delay	38
L64	Op Amp Control without Relays	41
L65	Narrow Peaks Caught by Better Detector	43

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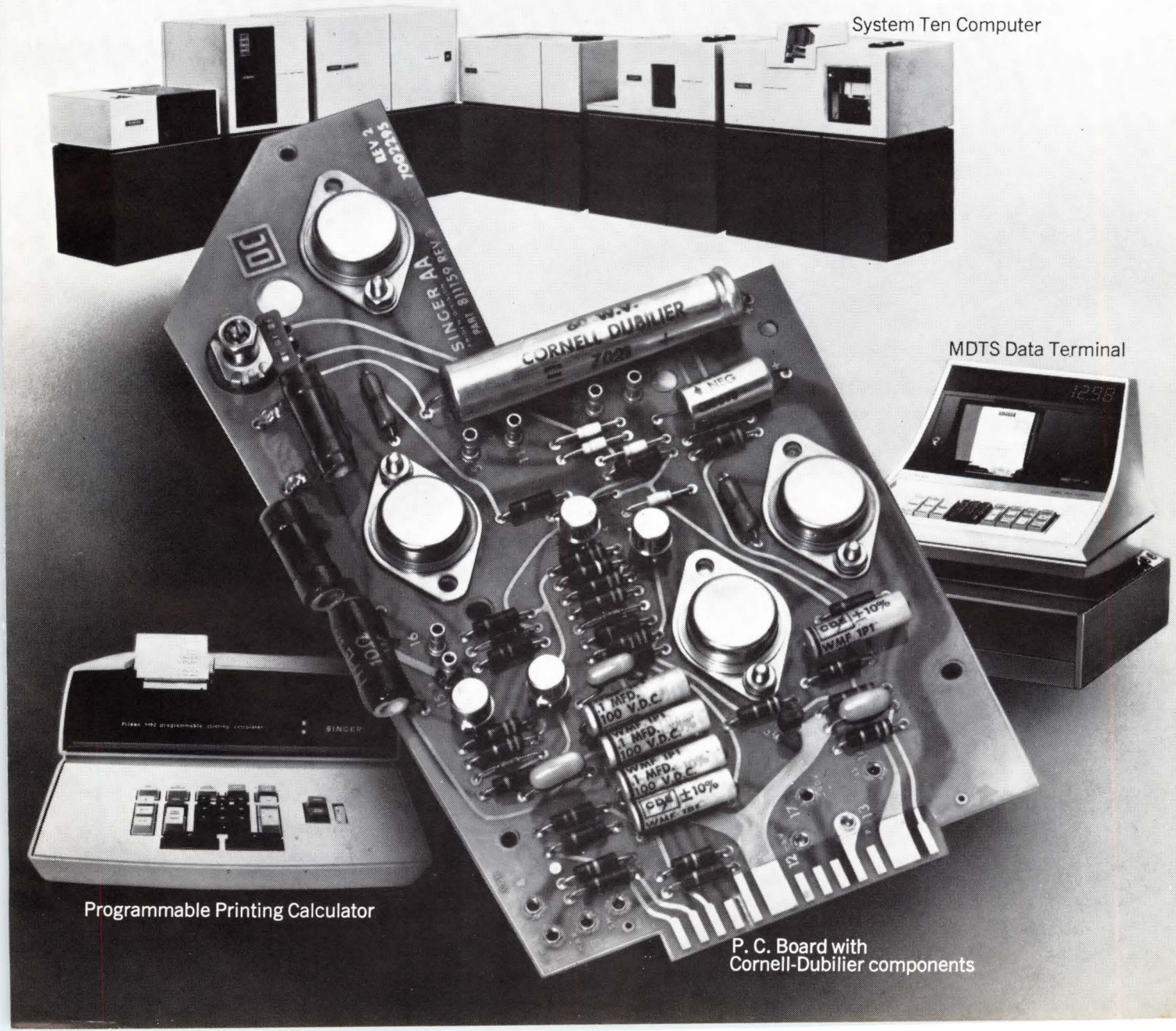

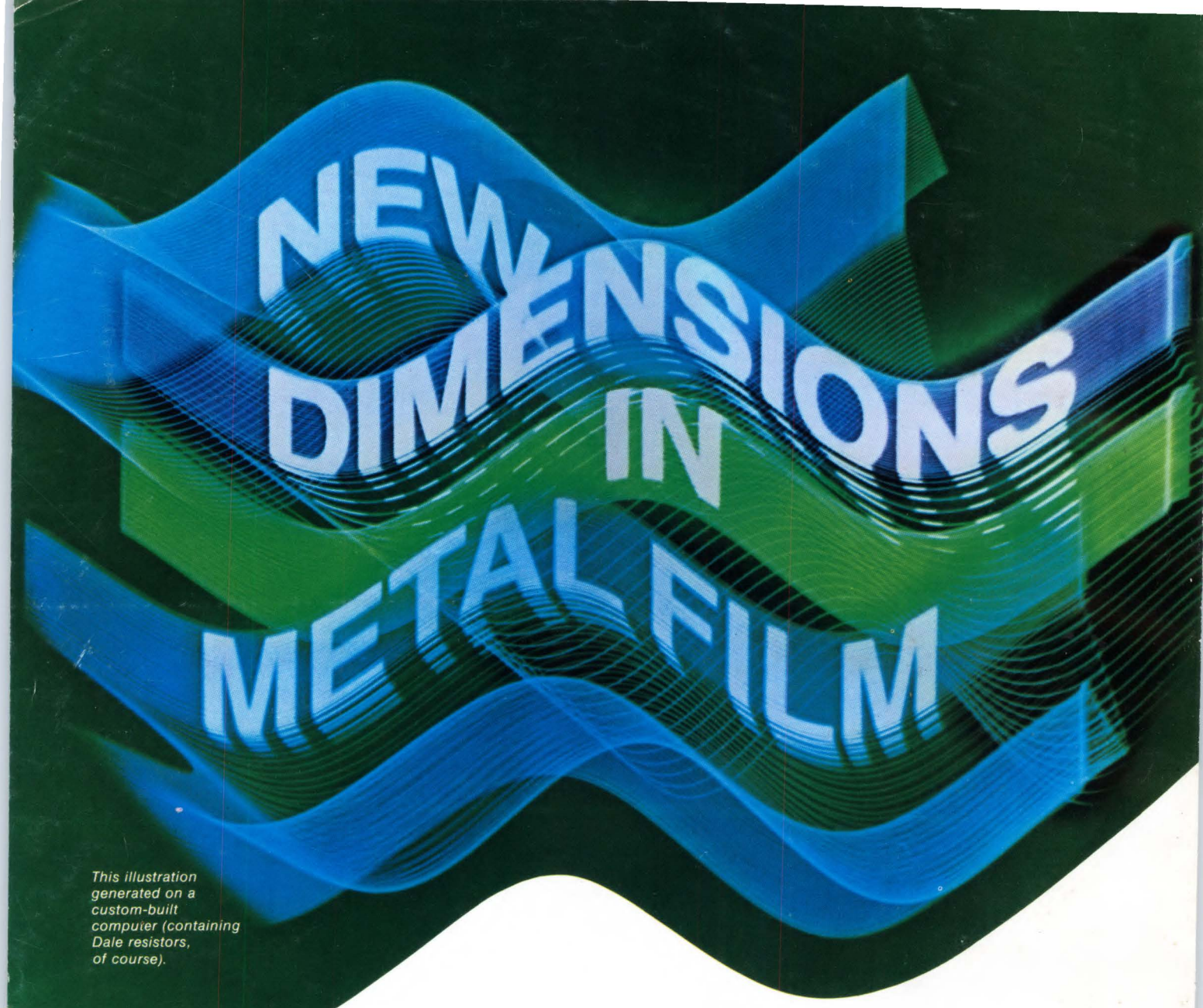

This illustration generated on a custom-built computer (containing Dale resistors, of course).

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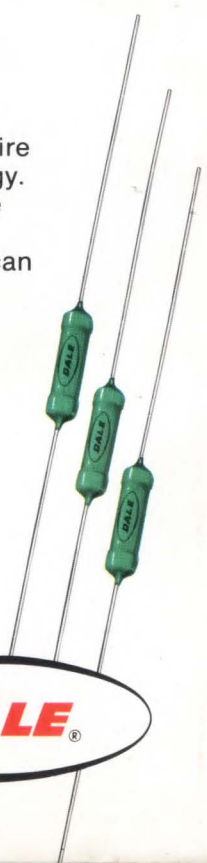

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