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Trends in Read-Only Memories

A CAHNERS PUBLICATION

AUGUST 1, 1972

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CHECK NO. 1

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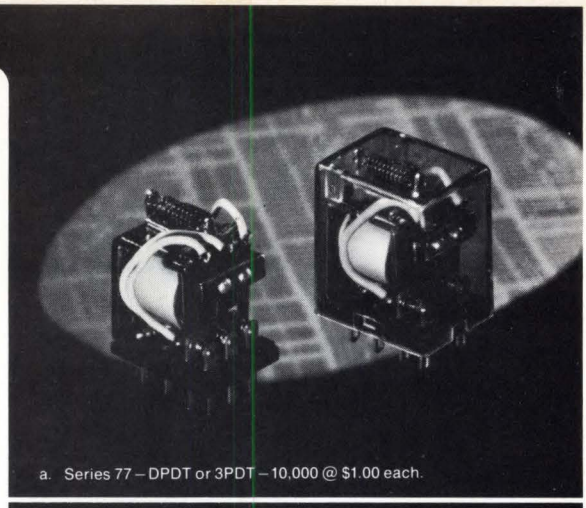

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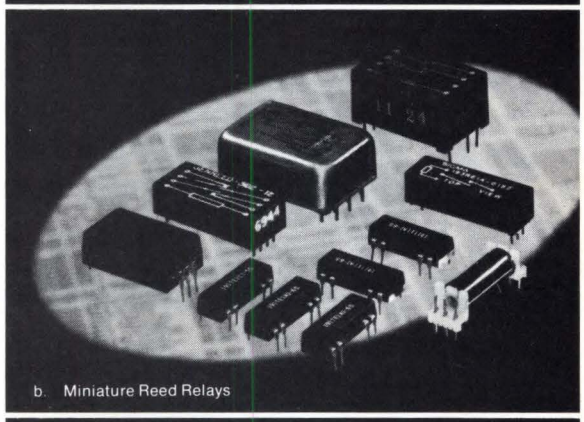
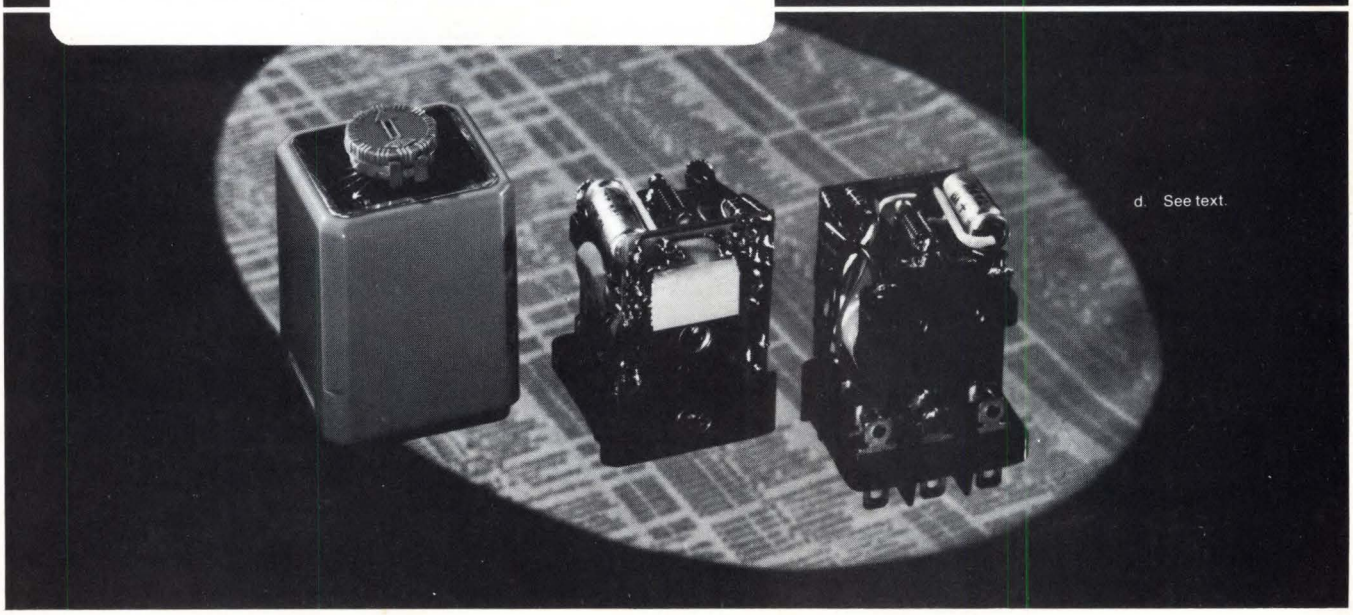


b. Miniature Reed Relays

c. See text.



d. See text.

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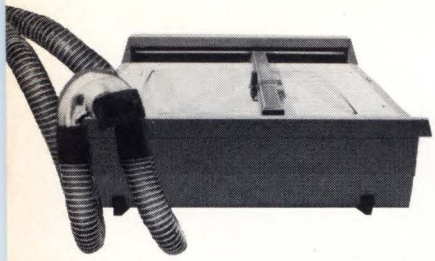

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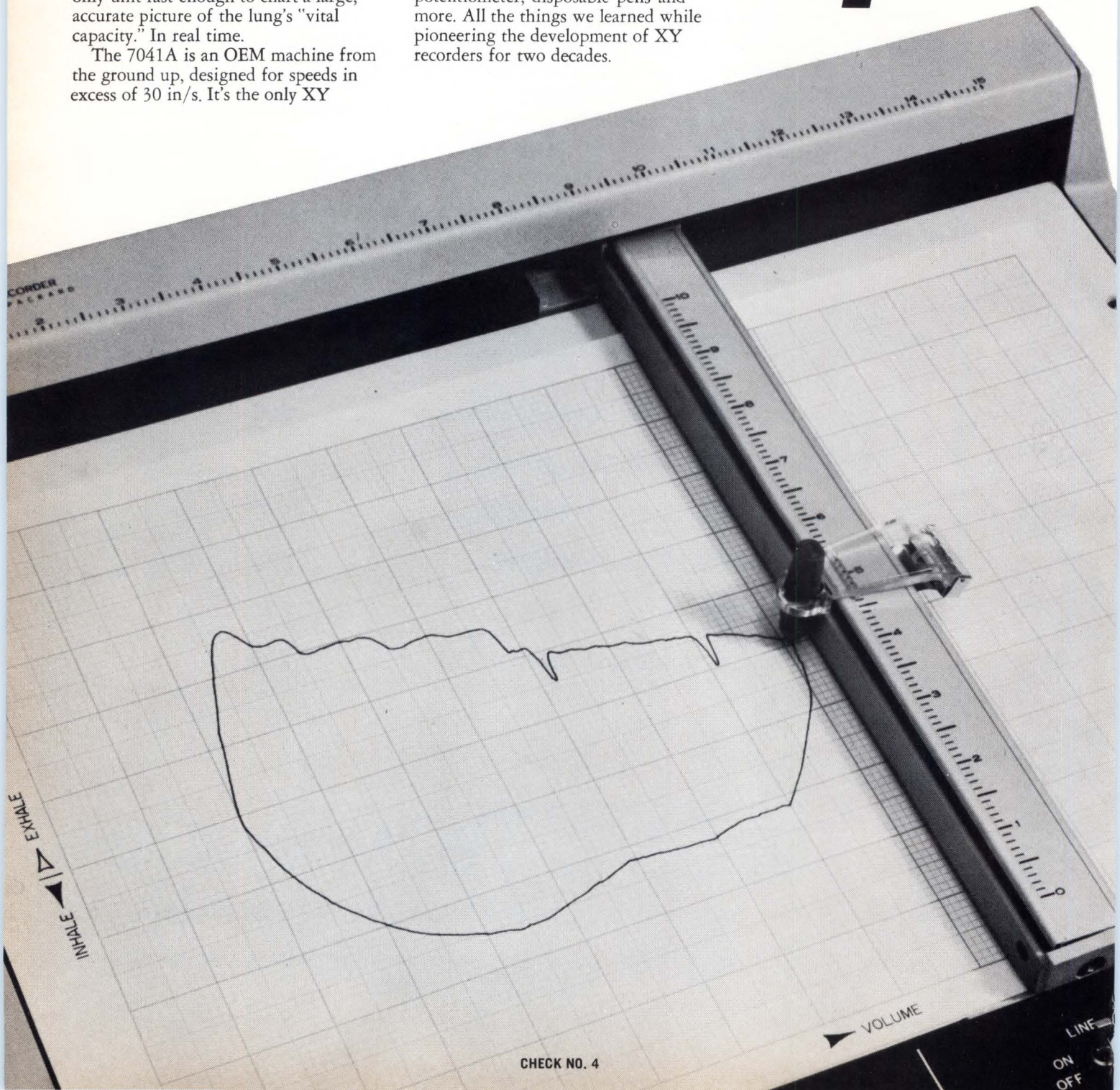

CHECK NO. 4

AUGUST 1, 1972
VOLUME 17, NUMBER 15

EDN with EEE
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

COVER

ROMs are being used for an increasing number of functions in computers. To find out where they are headed, see the story on pg. 24. (Photo of 4096-bit ROMs on a 3-in. wafer and 256-bit RAMs on a 2-in. wafer by Signetics Corp. and SMS, Inc.)

DESIGN NEWS

Future trends in microcircuit packaging probed at ISHM Seminar . . . 14
Conductive polymers promise new installation techniques for MOS/LSI . . . Breakthrough in microstripline oscillator design: a miniature TRAPATT unit delivering 1 kW at 1 GHz.

DESIGN FEATURES

Read-only memories in computers—where are they headed? 24
A review of where ROM has been and where it is now, in terms of technology, provides greater understanding and insight to projected future trends.

Phase locked loops provide accurate dc motor speed control 32
The proliferation of ICs applicable to phase locked loops makes it economically feasible to apply this technique to many low-frequency control problems.

PROMs offer a digital approach to waveform synthesis 38
You can generate virtually any symmetrical waveform using IC counters, a read-only memory and a monolithic D/A converter.

Build your own constant-temperature hot-wire anemometer 43
Standard components and simple adjustment procedures can produce a unit that is both accurate and reliable.

CIRCUIT DESIGN AWARDS 56
Putting the "thumb" on thumbwheel switch multiplexing . . . Monolithic timer generates 2-phase clock pulses . . . Zener diode controls wien-bridge oscillator . . . Analog threshold monitor has threshold and hysteresis controls . . . Transfer parallel information without a clock.

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Static card reader for control and data-collection applications . . . Bi-directional digital cassette recorder uses two moving parts.

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CHECK NO. 6

A change in perspective

This editorial is considerably different than most. Not in intent, or in style or in any of the other more or less mechanical elements that make up a standard editorial. Rather, it is different in outlook.

The reason for the difference is that it is being written by the shore of a picturesque lake in Maine, where fishing, swimming and boating seem to be the only reasons for one's existence. Indeed, the only concern is whether the fish will bite, and if so, how big they'll be.

Of course, this type of living is not everyone's cup of tea. And even for us it would become boring if overdone. But if kept within bounds, it provides an ideal way to gain a new perspective on our jobs and work-related activities. We don't mean by just completely forgetting about work for the duration of the vacation; for although this allows us to return to our jobs rested in both mind and body, it does little to change or improve our outlook towards what we do for a living and how we do it.

The real advantage of "getting away from it all" lies in being able to look at our work situations from the outside, almost like a spectator. With the dissipation of normal frictions, tensions, and irritations, it's far easier to see our job as it really is instead of as it seems to be when we are on the "inside." Actions based on momentary pique and decisions arrived at too hastily can be seen for what they really are. Long-range planning is even helped considerably, inasmuch as it can be done without regard to the exigencies of the moment.

It should be noted that we don't propose that people should go off on a peaceful vacation and spend all of their time thinking of their jobs. This would be foolish and wasteful, and probably unproductive. A little of that time, though, could be used to good advantage. Maybe while waiting for that fish to bite; or while relaxing on the beach; or even while waiting for the rain to stop. (After all, no vacation is perfect.)

Frank Egan

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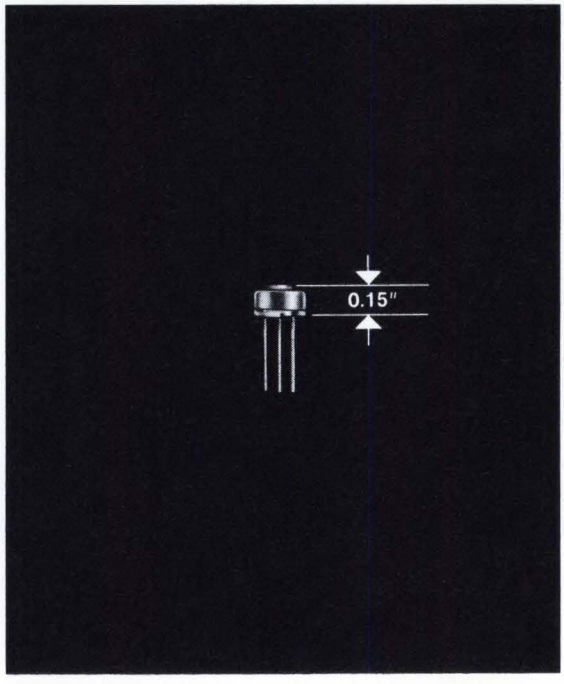

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CHECK NO. 8

WORLD'S FIRST MONOLITHIC COMPARATOR SUBSYSTEM

Our new μA750 is news: A complete dual comparator subsystem that eliminates up to 17 discrete components other comparators require for equivalent function and drive capability.

Our μA750 is important news for system designers. Because it's a totally self-contained subsystem consisting of two high-current independent comparators on a single chip. Because it eliminates the external components, the board space and virtually all the engineering calculations necessary to make other comparators function safely and reliably in complex control applications.
And because it saves money.

The μA750 uniquely provides all these features:

- 125mA per side minimum current handling capability, higher than any other comparator.
- Internal protection against short circuit and thermal overload.
- Subsystem voltage reference.
- Positive switching is assured by built-in hysteresis. (If hysteresis expansion is required for an especially noisy environment, an in-phase comparator output is available.)
- Independent input inhibit.
- Operates from single power supply.

Wide Applications

The μA750 comparator subsystem (instead of a comparator-plus-plenty-of-external-components) can save significant cost and time for the system designer in environmental controls, status indicators with priority override, go-no-go testers, phase meters, minimum frequency detectors. These applications are detailed in a comprehensive Application Note.

The Fairchild Family of Comparators

The Fairchild Comparator family is the largest available. In addition to the μA750, it also includes:

Super High Speed μA760 Differential Comparator with 16ns typical response time. Complementary TTL-compatible and matched t_{pd} outputs. Fanout of 2 TTL gate loads. Designed for use in phase encoding, tape readout systems, this is the most cost-effective, super-fast comparator on the market.

Precision μA734 Voltage Comparator offers maximum resolution through high gain, low input offset current and voltages. Ideal for high-accuracy low-level sensing and measurement in A/D converters and precision level detectors.

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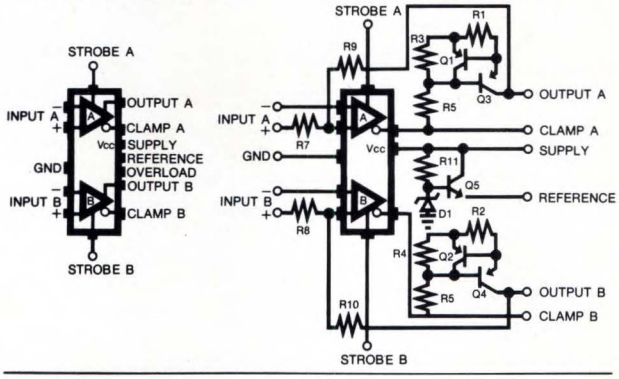

μA750 MONOLITHIC COMPARATOR SUBSYSTEM VS. COMPARATOR-PLUS-COMPONENTS

The best case competitive dual comparator we could find, even with the addition of 17 external components (to provide short circuit protection, hysteresis, high drive current and reference voltage), is still not the equivalent to the μA750 in functional capability or reliability. And, to provide the other comparator with the μA750's current overload indication output and thermal shutdown safety features, it would cost so much more in external components, board space, and design effort, it would be economically unsound.

FAIRCHILD SEMICONDUCTOR, A Division of Fairchild Camera & Instrument Corp., 464 Ellis St., Mountain View, Ca. 94040. (415) 962-5011. TWX: 910-379-6435

CHECK NO. 9

Future trends in microcircuit packaging probed at hybrid society seminar

Aboard the historic Queen Mary, docked at Long Beach, Calif., techniques and trends in circuit interconnection and packaging were recently presented at the International Society for Hybrid Microelectronics (ISHM), 1972 seminar. In the future more and more circuit function will be available to the design engineer in small packages which can be placed close together on multilayer pc or wrap-type panels. Building blocks will be available in greatly varied complexities—discretes, monolithics-SSI, MSI, LSI, super LSI, custom LSI and hybrids. Five approaches to such microcircuit interconnections and packaging were discussed at the ISHM seminar.

An experimental package, designated STD (Semiconductor in Thermoplastic on Dielectric), designed initially in order to find better microwave hybrid packages, is now being tested by General Electric in Syracuse, N.Y.

Semiconductor components and conductor patterns are bonded to an insulating substrate plate, such as alumina ceramic. The components are mounted with their connector pads up, and metallic mesas are located at points where conductors on the substrate are to be connected to other conductors or to the components. The substrate is then covered to the tops of the mesas with a clear Teflon-like thermosplastic, designated FEP. Holes are then etched vertically through the FEP to the pads of the semiconductor components. Next, holes are filled by metal evaporation which also covers the top of the FEP and makes contact with the mesas tops. Finally, this metal is screened and etched to leave metal only between points where conduction is desired.

Clearly, an advantage of this packaging is the FEP encapsulation of the semiconductor components which provides better mechanical stability for the components and improved heat transfer from them, according to Jack Lunden of GE. One disadvantage is that any failure is not readily repaired.

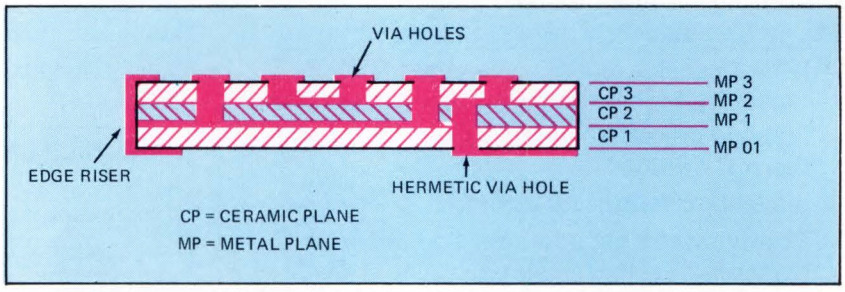

Fig. 1—Three-layer substrate is laminated to 4 layers of metal. Edge risers and "vias" are used to interconnect layers.

The multilayer ceramic package from American Lava Corp. in Chattanooga, Tenn., has external and internal conductor patterns stacked in layers separated by alumina ($A1_2O_3$) ceramic. Metal-filled holes, or vias, in the ceramic connect the conductor patterns much like the structure of a multilayered pc board. The structure is hermetically fused to form a monolithic substrate suitable for multi- or single-chip hermetic packaging, using a cup lid over the chip cavity.

"The composite substrates permit circuit designers to achieve maximum device density by moving conductive lines from the surface to an internal plane." Says American Lava's Bill Hargis. "Greater reliability and stability can be achieved because external wiring is minimized and higher operating speeds can be obtained through shorter conductor paths. The stability of alumina allows the user to further process the unit without degrading the substrate or the mounted devices," he continues.

Fig. 1 shows a 3-layer substrate with its internal and external conductors and the interconnecting vias.

Such a substrate can be used with wire-bonded, beam-lead or flip-chip devices attached to them (**Fig. 2**). As shown, the wire bonded chip is fixed to the ceramic upright. The flip-chip has aluminum bumps on its pads for electrical connection. Beam-lead chips can be mounted as shown or upright with the beams connecting from above.

According to Hargis, "Before a designer can successfully use this con-

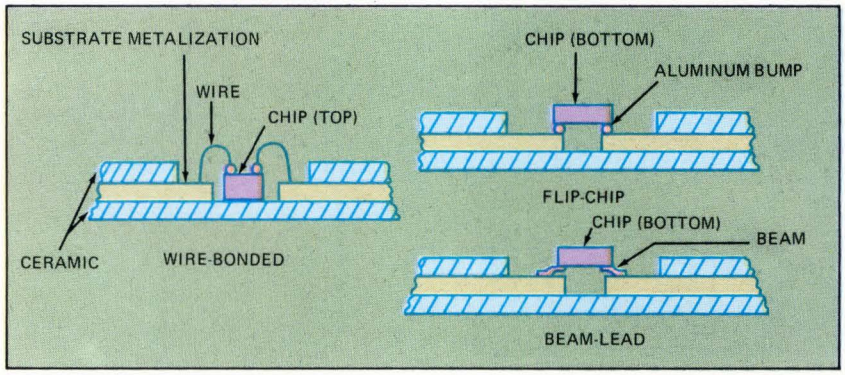

Fig. 2—Multilayer substrates can be configured to accept wire-bonded, flip-chip or beam-lead ICs. Beam-lead chips can be mounted as shown or upright.

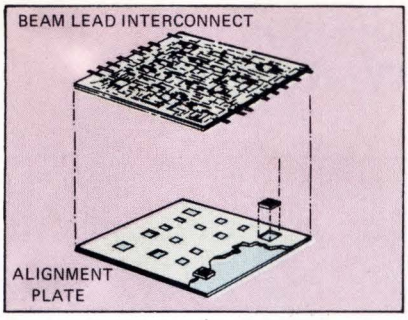

Fig. 3 – Beam-Lead Interconnect Package called a "BLIP" consists of a multilayered interconnect plate and an alignment plate. Automated assembly is the key.

cept, he must fully understand the capabilities and limitations of the materials system and the supplier manufacturing methods."

Multilayer thick-film packages from Du Pont are structured much like the multilayered ceramic packages, with layers of dielectric sandwiching thick-film metal patterns, interconnected by vias through holes in the dielectric. The processes and materials used are quite different. Starting with an alumina ceramic substrate, alternate layers of metallic and dielectric patterns are deposited. The dielectric used can be less than 1-1/2 mils thick and crystaline, making the construction of capacitors in the thick-film substrate possible.

Northrop Electronics Division's package, trademarked BLIP, reportedly exhibits excellent reliability of its interconnections. The ultrasonic beam-lead bonds used in BLIP have shown superior tensile strength and low failure occurrence rates says Norman Grossman of the Burbank, Calif., Division's Navigation Department.

The BLIP (Beam Lead Interconnect Package) has two componennts (**Fig. 3**), the multilayered interconnect plate and the alignment plate. The alignment plate positions all the components to be interconnected when they are placed in its cavities, which are precisely coincident with the aperatures in the interconnect plate. This approach lends itself well to automated loading of any combination of varied or similar components to be interconnected.

The interconnect plate has internal and external beams which project into the component aperatures and out from the edges of the plate, integrally from the metalization patterns of the structure.

The external beam leads can be terminated to a motherboard, or a hermetically sealed package. The chips are face up when bonded in place. This allows ease of bond testing and inspection.

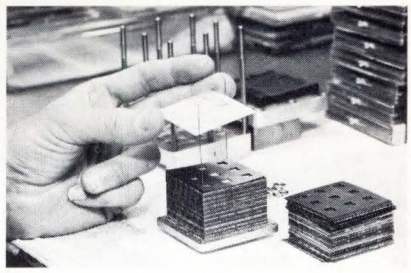

Fig. 4 – PLANAR COAX packaging is claimed to decrease packaging size by two orders of magnitude compared to conventional DIP packaging techniques.

and inspection.

Chip interconnection in three dimensions has been developed by Bunker Ramo Corp., Westlake Village, Calif. Interconnections between chips in the stack and to the outside are copper surrounded by dielectric embedded in the grounded copper block, routed in three dimensions.

The three dimensional PLANAR COAX packaging is said to offer 2 orders of magnitude decrease in size over typical DIP configurations.

Due to the coax nature of the interconnections, crosstalk is virtually eliminated.

Fig. 4 illustrates the application of PLANAR COAX to the assembly of a minicomputer. The wafer being held in the photo contains 9,42 terminal LSI chips. ▭

Conductive polymers promise new installation techniques for MOS/LSI

If you've ever tried to insert or remove a 40-pin DIP you'll welcome these new ideas for zero-insertion-pressure mounts. Developed by Chomerics, Woburn, Mass., these mounts utilyze the silver filled, polymers used in Chomeric's keyboards. The package shown in **Fig. 1** is designed for the new leadless substrate LSI packages and uses conductive pads molded into a dielectric frame. These pads, shown in **Fig. 2**, provide a pinless, solderless, gas-tight connection between the LSI package and the pc board surface.

Chomerics estimates that these mounts could save a volume user about 1¢ per pin because they do away with the lead frame and its plating and assembly, forming of the leads and plated-through holes on the printed circuit. Conventional sockets are also replaced, and losses due to lead

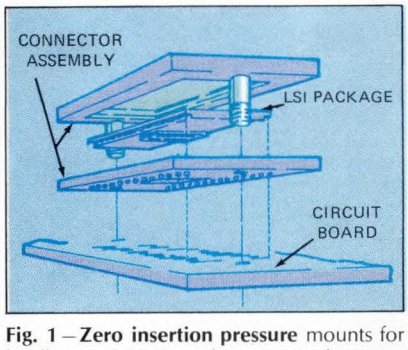

Fig. 1 – Zero insertion pressure mounts for leadless MOS/LSI packages provide a pinless, solderless, gas-tight connection between the package and the PC board.

damage in assembly are reduced, leading to further savings.

The polymer contacts are rated at 30 mA, and 1/4Ω. While this contact resistance may make them unuseable in some bipolar circuits, high-impedance MOS circuitry won't notice it.

Chomerics has recently developed a flexible lead frame which they believe will speed the packaging of MOS/LSI chips by replacing wirebonding with press-in mounting. ▭

For more information check reader service no. **123**

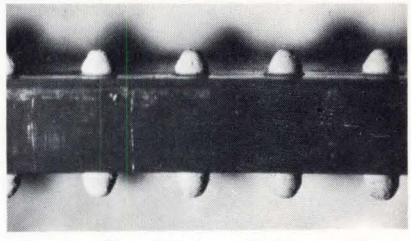

Fig. 2 – Silver-filled polymer contacts swaged through the plastic mount provide flexible contacts with about 1/4Ω resistance, acceptable to most MOS circuits.

Breakthrough in microstripline oscillator design: a miniature TRAPATT unit delivering 1 kW at 1 GHz

A microstripline TRAPATT oscillator employing 4 series-connected TRAPATT diodes capable of producing a kilowatt of rf energy at a frequency of 1 GHz with 27% conversion efficiency has been devised by a Sandia Laboratory engineer. Previous microstripline systems, using one or two diodes, typically operated at 200W of output power at 1 GHz with 25% efficiency. The new oscillator circuit measures 13.4 × 15.8 cm.

TRAPATT is an acronym for trapped plasma avalanche-triggered transit diode. Such diodes have been developed in recent years as alternatives to the relatively large sized LSA (limited spacecharge accumulation) diode and the relatively low-peak-power transistor as a means of generating the high-frequency pulsed signals emitted by radars, transponders, and certain other systems.

An operating TRAPATT diode generates a fast-risetime pulse which, in previous microstrip circuits **(a)** traveled to the end of a quarter-wavelength transmission line; **(b)** returned and changed polarity when it encountered the low impedance of the plasma-saturated diode; **(c)** traveled to the end of the quarter-wave-length line and back again; and **(d)** retriggered the diode—which was then depleted of plasma—to initiate another cycle.

This process caused electromagnetic energy to be generated which could be extracted from the device as an rf signal. The power of the emitted signal was typically determined by a shunt capacitive reactance located approximately one-half wavelength from the TRAPATT diode.

Attempts to increase the output power of microwave oscillators of this "open circuit" type by series-stacking more than two diodes in the circuit, however, have proved unsuccessful.

Analysis of this problem showed that multiple-diode configurations are subject to various kinds of electronic "parasitics" which can influence the propagation characteristics of the fast risetime pulse. Thus, at one critical part of its cycle, the traveling pulse may not encounter a sufficiently low impedance at the diode stack to completely invert and change polarity. If this occurs, the pulse magnitude available at the end of the first cycle is insufficient to sustain the oscillation; hence, no power can be extracted.

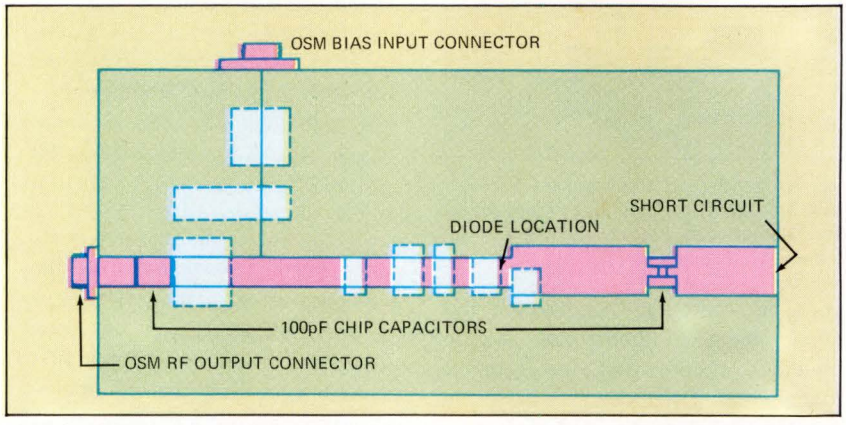

Fig. 1—Delivering 1.075 kW at 1.02 GHz, this 13.4-X-15.8-cm microstripline oscillator was fabricated using four series-connected TRAPATT diodes. Broken-line rectangles represent conductive plates (strips of indium foil) which contact the upper conductor and act as moveable tuning slugs. The chip capacitors shown allow bias to be confined to the diodes, which are located at a 50-25Ω line junction, and act as rf short circuits. Note that the two capacitors which complete the half-wave-length 25Ω rf shortcircuit could be removed to establish a quarter-wavelength 25Ω open circuit.

This problem was resolved by eliminating the secondary use of the diode stack as an inverter. The transmission line was extended to a half wavelength, terminating in a short circuit that provided a complete and reliable sign reversal on every cycle.

With the configuration using four diodes as shown in **Fig. 1**, peak power obtained was 1075W at 1.02 GHz with 27% conversion efficiency (see **Fig. 2**)—an efficiency comparable to those derived from single-diode microstripline TRAPATT oscillators of the "open circuit" design.

The experimental circuit was fabricated on a 0.16-cm thick Teflon-fiberglass copper-clad stripline laminate. The silicon p^+-n-n^+ TRAPATT diodes (0.05 cm in diameter and 0.007 cm in depletion width with 150V breakdown characteristics) were mounted in varactor pill-type packages. One or more packaged diodes could be stacked between the upper conductor and the earth plane. Electrical connection was established by the pressure of the earth plane and contacted the base of the bottom diode package.

Bias pulses 0.5-μsec wide at a 200-Hz repetition rate were applied to the diodes from a pulser with a variable output impedance of 125 to 225Ω.

The oscillator circuit was devised by William E. Wilson of Sandia's Semi-conductor Devices Dept. ▭

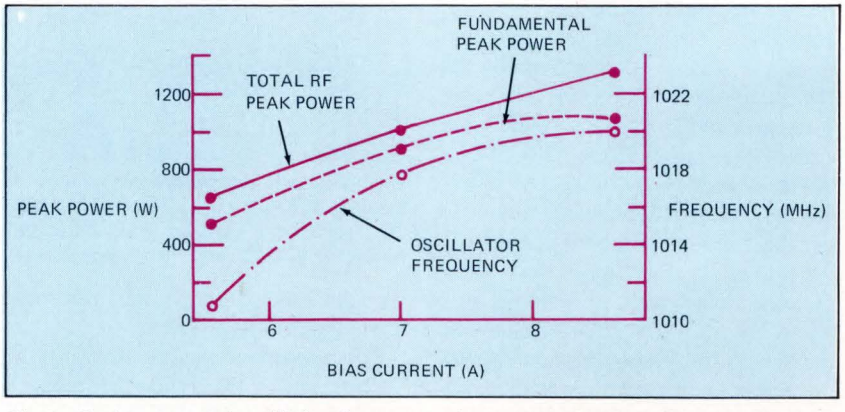

Fig. 2—Peak power and oscillation frequency of a new TRAPATT oscillator as a function of the circuit's bias current. The microstripline oscillator reportedly delivers 1.075 kW at 1.02 GHz with 27% conversion efficiency.

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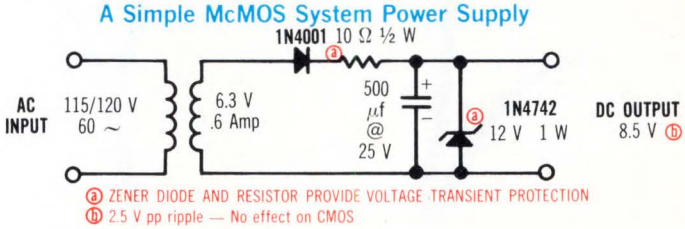
A Simple McMOS System Power Supply



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MC14011AL/CL	Quad 2-input NAND Gate	CD4011AD/AE	3.40/ .78
MC14012AL/CL	Dual 4-input NAND Gate	CD4012AD/AE	3.40/ .78
MC14013AL/CL	Dual Type D Flip-Flop	CD4013AD/AE	4.75/ 1.62
MC14015AL/CL	Dual 4-bit static SR, serial in/parallel out	CD4015AD/AE	10.15/ 4.24
MC14021AL/CL	8-bit static SR, serial or parallel in/serial out	CD4021AD/AE	9.75/ 4.24
MC14025AL/CL	Triple 3 NOR Gate	CD4025AD/AE	3.40/ .78
MC14027AL/CL	Dual J-K Flip-Flop	CD4027AD/AE	5.25/ 2.50
MC14501AL/CL	Triple Gate	—	4.30/ 1.69
MC14507AL/CL	Quad exclusive OR Gate	CD4030AD/AE	3.79/ 1.63
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MC14514AL/CL	4-bit Latch/4-to-16 Line Decoder (Hi)	—	24.70/13.75
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MC14008AL/CL	4-bit Full Adder	CD4008AD/AE	10.15/ 4.02
MC14016AL/CL	Quad Analog Switch/ Quad Multiplexer	CD4016AD/AE	5.15/ 1.62
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Time was, when power supply requirements were significant design and cost considerations in logic systems. Complementary MOS has changed all that.

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This is the year of McMOS . . . the low-power logic of the seventies. The brochure, McMOS '72 tells lots more about McMOS. Get one simply by circling the reader service number or by writing to Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Az. 85036. Bonus! — while it lasts — special McMOS wall chart poster with interface diagrams.

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MOTOROLA MOS
Directions in digital designs

CHECK NO. 10

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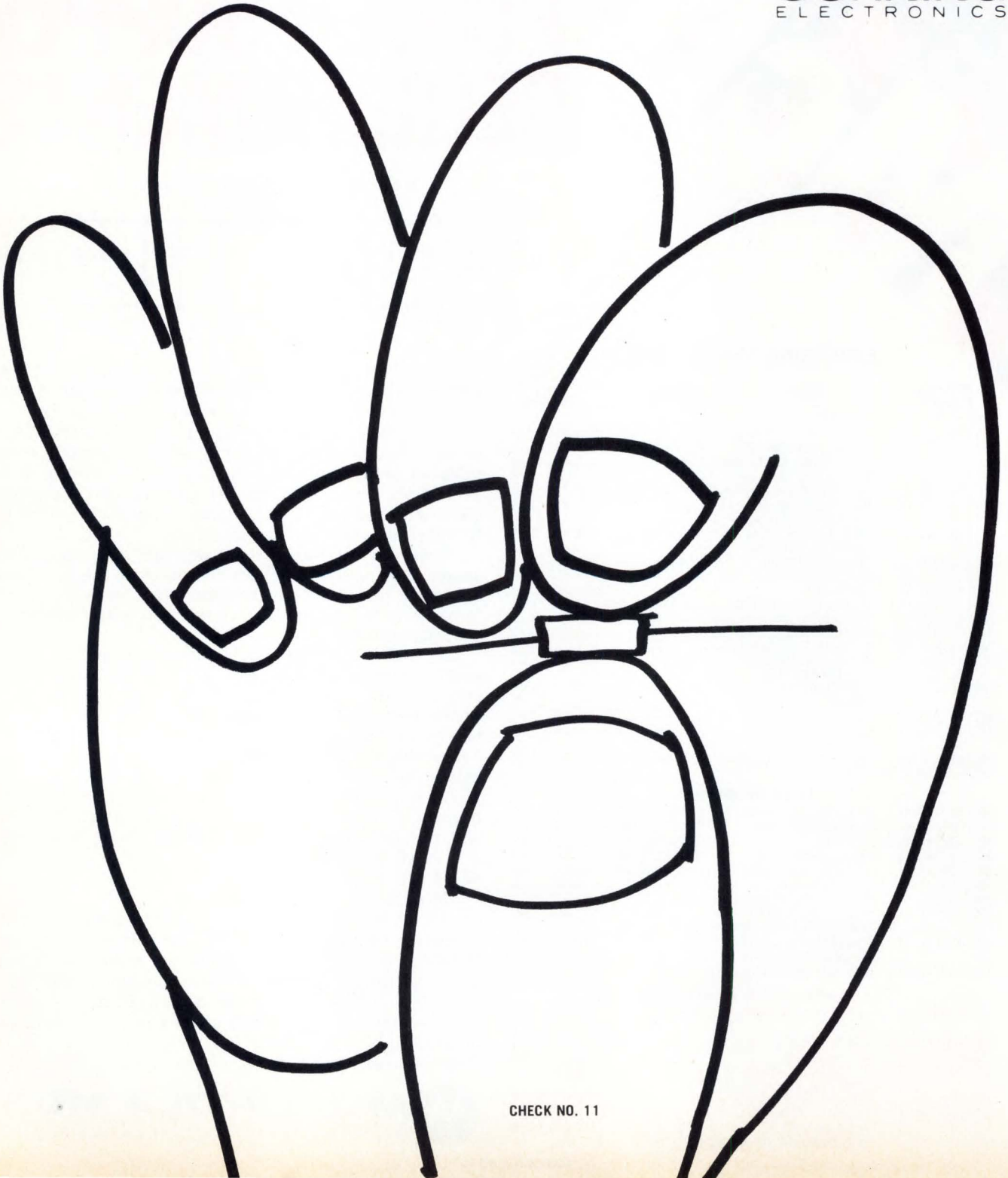

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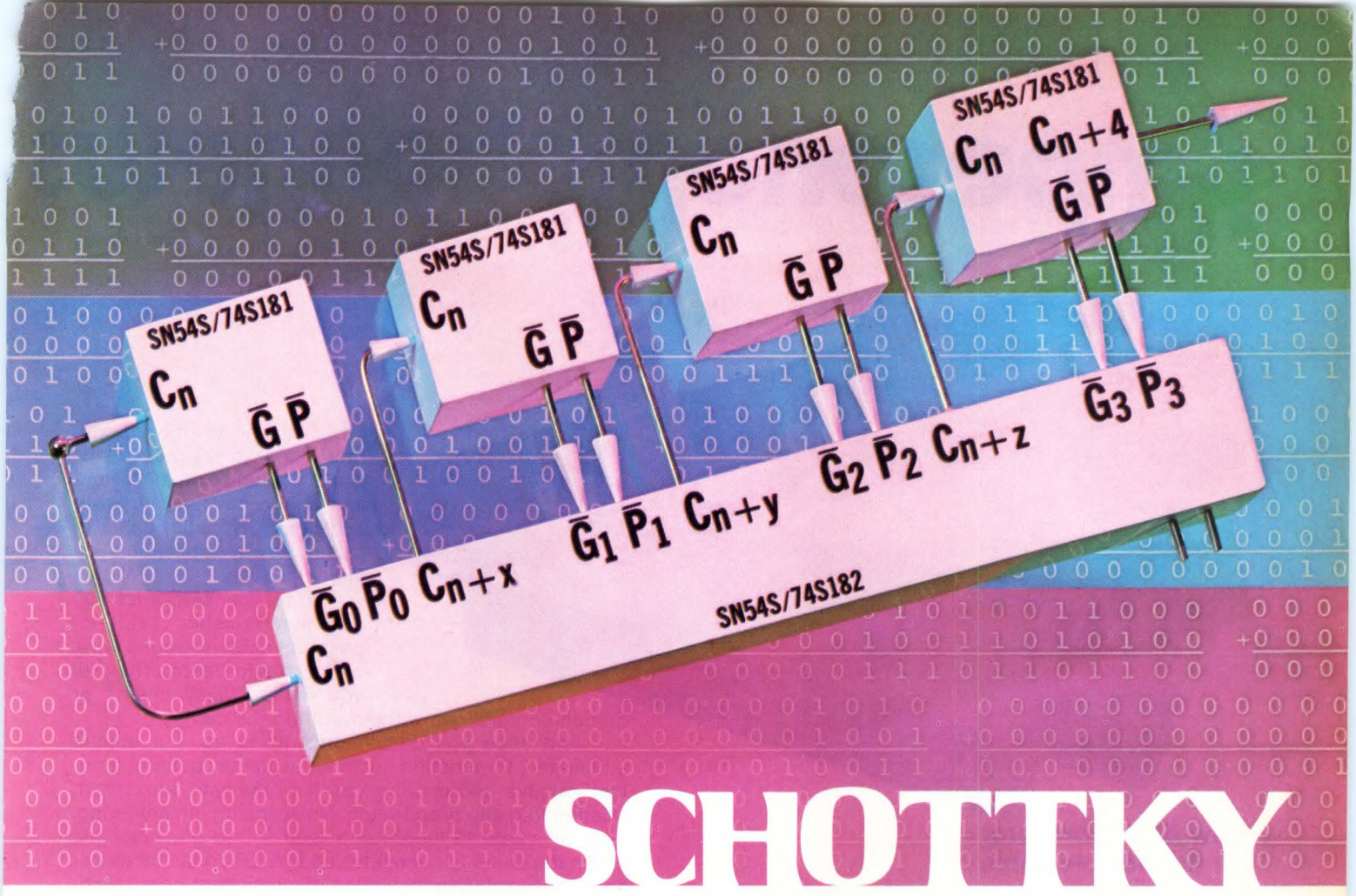

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The Schottky S181/S182 combination is nearly twice as fast as its standard TTL counterpart (see table). And since they are functionally and mechanically interchangeable, it's easy to upgrade existing system designs.

COMPARATIVE SPEEDS

Bits	Schottky S181/S182	Standard S181/S182	ALU Units	Look-ahead Units
1-4	11 ns	24 ns	1	0
5-8	18 ns	36 ns	2	0
9-16	19 ns	36 ns	3-4	1
17-64	28 ns	60 ns	5-16	2-5

High performance for new designs

For new designs, the Schottky S181/S182 offer speeds comparable to nonsaturating logics (19 ns versus 16 ns, typically, for the same function performed with ECL)—with lower power requirements and much greater design freedom.

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TI's Schottky line—including the S181/S182, 15 other MSI functions and 19 SSI circuits—is totally compatible with all TTL. Standard, high-speed, low-power, and low-power Schottky. Together, these TI families offer more than 250 integrated circuit functions with compatible logic levels, voltage swings and noise margins. This enables the designer to optimize the speed/power product of his system.

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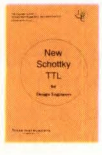
For your copy of "New Schottky TTL" which contains data sheets on all of TI's Series 54S/74S Schottky MSI devices, circle 217 on the Service card. Or write Texas Instruments Incorporated, P.O. Box 5012, M/S 308, Dallas, Tex. 75222.



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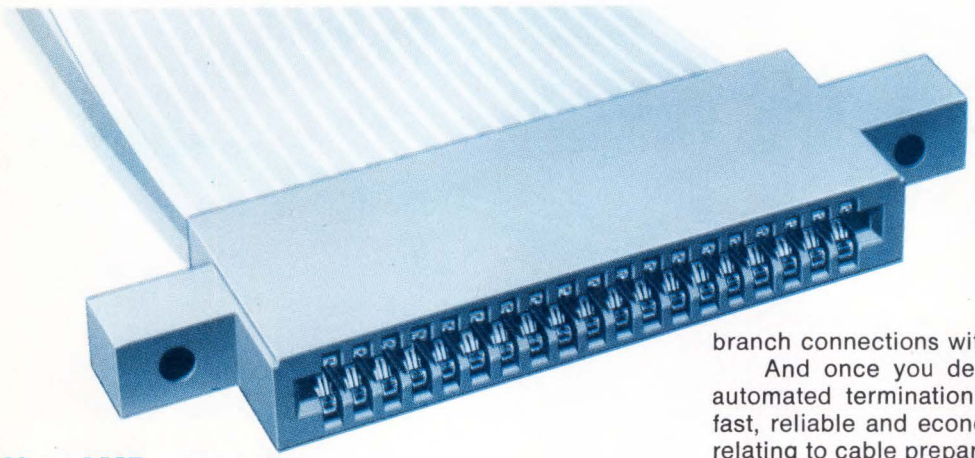

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AMP connectors let you go cable-to-cable, cable-to-post, flat cable-to-round wire, and cable-to-board. They let you make "daisy chain" or branch connections without cutting the cable.

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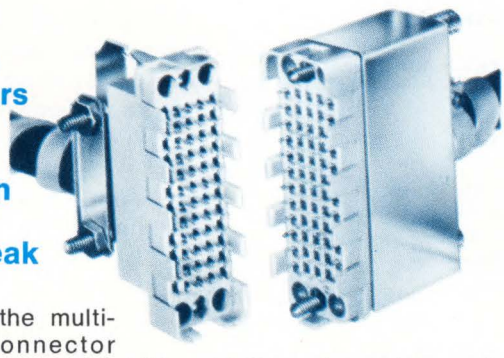

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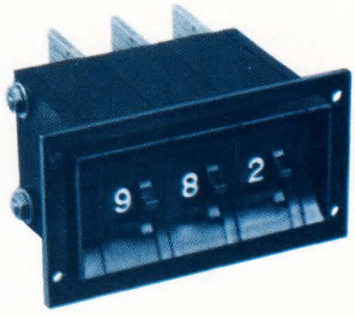
Also available with posts for automatic wiring, compatible with AMP TERMI-POINT* clip wiring. Or with manual, semiautomatic and automatic wrap methods. A variety of contact gold plating thicknesses are available for customer selection.

New thumbwheel switches for manual programming.



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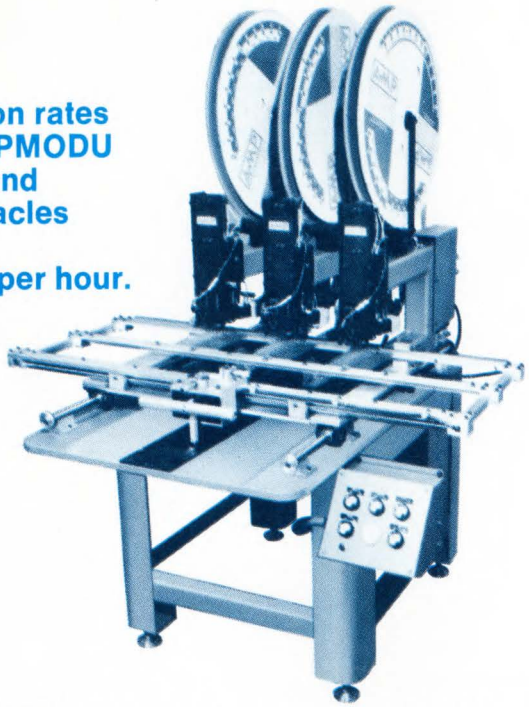

AMPMODU*, our post-receptacle interconnection system, now offers you even higher production capabilities than ever before. It's the ideal technique for modular-designed consumer or industrial electronics.

The secret is the AMP triple-head pantograph machine, which can insert AMPMODU contacts into three of your printed circuit boards at a time. Your operator uses a positioning pin and template . . . the three heads each move simultaneously, accurately. Rates up to 12,000 insertions per hour are readily achieved.

The machine will handle boards from .062″ x .125″ thick, with dimensions from 5″ x 13″ to 16″ x 13″.

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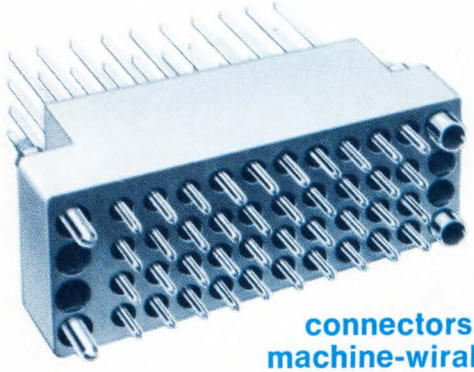

M-Series connectors now with machine-wirable posts.

The latest addition to our M-Series connectors gives you real production economy. They have posts for automatic machine wiring . . . four sizes: .022″ x .036″; .031″ x .062″; .025″ square; .045″ square.

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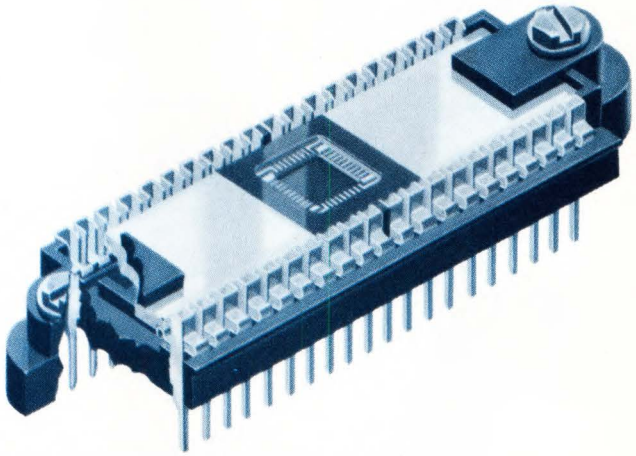

Now—practical pluggability for leadless LSI packages

New leadless substrate LSI packages eliminate the problems of handling and inserting many delicate leads, and simplify field replacement.

AMP now has a line of special connectors designed to make pluggability of these leadless substrates practical and reliable. Our connectors feature zero entry force insertion, a contact design with stored spring energy to maintain reliable contact, and a low profile.

Two types are available for leadless LSI; one mates with top or bottom surface metallization, the other accepts packages with contact pads on the edge of the substrate.

For additional information on any of the above products write: **Industrial Division, AMP Incorporated, Harrisburg, Pa. 17105.**

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MAX
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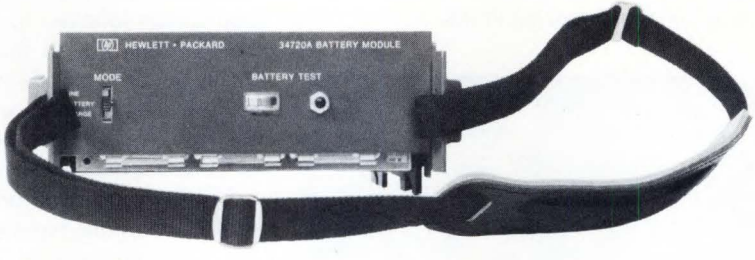
The New Snap-On...



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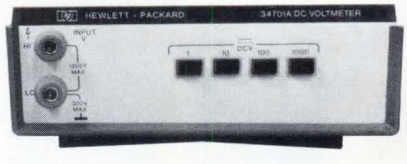

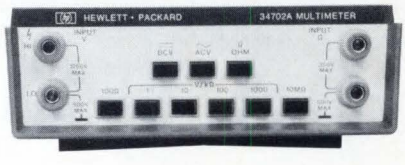

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DIGITAL VOLTMETERS

092/41

CHECK NO. 13

Read-only-memories in computers-where are they headed?

A review of where ROM has been and where it is now, in terms of technology, provides greater understanding and insight to projected future trends.

Roger R. Dussine, Compagnie Honeywell Bull
Robert M. Zieve, Honeywell Information Systems

Read-only memories (ROMs) are those memories into which data can be definitively written only one time. The content of the memory is generally determined at the time of fabrication, and this memory is used in the computer only in the read-mode. This type of memory is also called read-only store (ROS), fixed memory, permanent storage, or dead memory. In a computer, the ROM is generally used to increase access speed to stored information, and the mode of addressing is random access. Therefore, we will not speak about serially addressed ROMs.

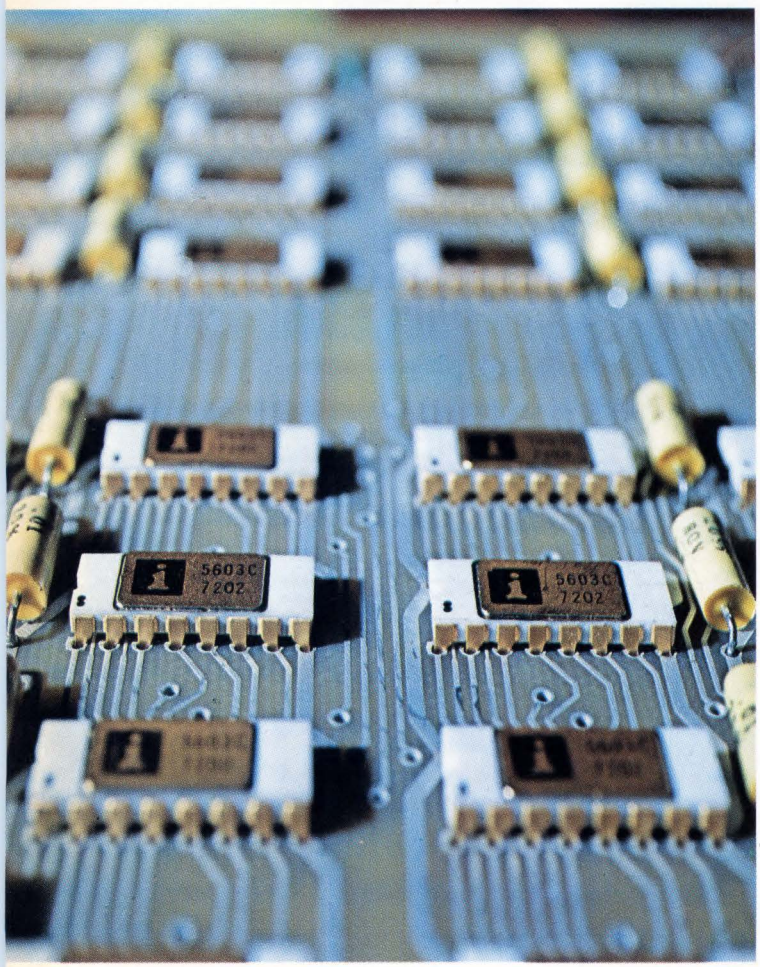


Fig. a Bipolar ROM used in Honeywell Systems 700 remote message concentrator.

Since 1960, numerous computers have used ROMs, principally for storing microprograms, tables of code conversion and simple mathematical functions. This evolution explains why one often associates as synonymous, the notion of control memory and of ROM. The microprogram can also be stored in read-write memory; however, cost/performance analysis generally favors the ROM.

Since speed is an important parameter, read-write memories with nondestructive read-out (NDRO) are also appropriate solutions for control store, thanks to the economy of time due to the absence of a rewrite cycle. An example of this type of memory is the 2 cores per bit, partial-switching memory used in the Honeywell 4200-8200 Systems. We will not speak of this type of memory either because it is more like a read-write memory than a ROM.

The present article does not have the intention of describing all of the types of ROM which have been studied for computers such as: Twistor, Fluxlok, Unifluxor, Eddy-card, Capstor, Litastor, etc . . . For the reader who would like more general information let us suggest two survey articles.[1,2]

First we will discuss the typical uses of ROM. Then we will discuss some specific applications, in particular those read-only memories that have been used by Honeywell Bull in their computers since 1963. Finally we will try to predict the trends of ROM technologies and to discern their areas of future application.

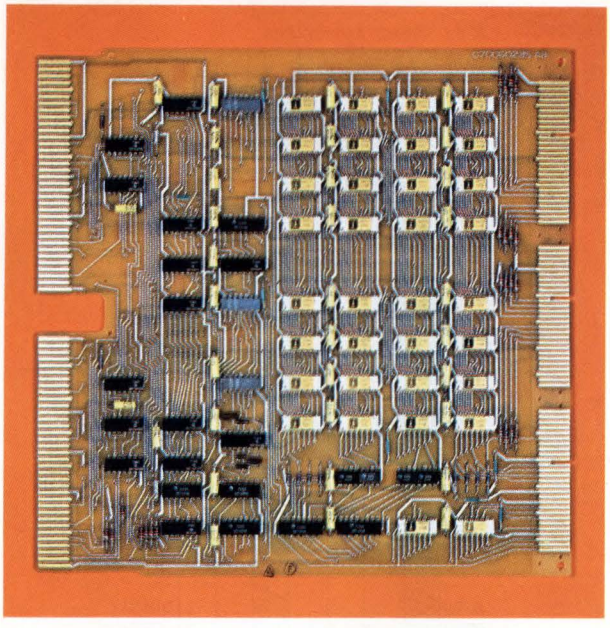
Utilization and application of ROM

Two main needs give rise to the use of ROMs in computers: the need for rapid access to fixed information, and the need for information that is well defined without regard to the status of the computer.

On the average, the ROM cycle time is four times faster than that of the main memory. This fact is linked with the use of ROM principally for microprograms, and sometimes for arithmetic operations.

When the control unit of a computer must execute a program instruction, it is necessary to effect a certain number of successive elementary operations such as: transfer between two registers, shift within one register, command of a main memory cycle or a scratch-pad memory cycle etc . . .

The role of the ROM is to start these micro-operations by way of microinstructions. The ROM must be faster than the read-write memory because there are several microin-



Fib. 1—Bipolar ROM system can be expanded from 500 to 2k 16-bit words per card. Each IC package contains 256 × 4 bits. (Honeywell)

structions per cycle of main memory. According to the particular computer, the microprograms are organized in various ways, and their complexity increases with the complexity of the function to be executed.

In Table look-up, ROMs make conversions between the address given and the data that exists. Thus, one can use it for translating or converting codes, or for carrying out calculations by table.

It is also possible to adapt the computer so that it can execute programs from another computer, by adding the operating instructions of the different computer to the ROM. Thus, the computer can function in the emulative mode. Emulation by microprogram increases the flexibility of modern computers by permitting them to use directly, programs of other computers of the same brand, or of competitors.

Following are two cases where the presence of fixed information in ROM facilitates the working of computers, independent of their current state.

Bootload. A computer not equipped with ROM must have a special program in order to start, because there is no stored information in the memory to perform this function. The presence of a ROM allows the initialization of the system to be carried out by the functions stored within it.

Fault location. If there is a fault in the central unit, it is often impossible to load the test and diagnostic program in the main memory, because this loading operation utilizes many circuits, possibly including the faulty one. By placing the test routines in ROM, one can test the circuits by an internal process and locate the fault. The speed of this fault-diagnostic process intervention is such that it is often possible to isolate intermittent faults, generally very laborious to locate by classical methods.

Introduction of ROM into computers for control storage has allowed development of the structure of microprograms, and introduction of the notion of firmware. **Firmware is to a microprogram as software is to a program.**

As the firmware penetrates throughout the hardware, it increases the level of computer resource management. As the firmware becomes more and more complex, it is able to control operations that were formerly software responsibility, such as the supervision of multiprogramming, main storage management, compilers, etc . . .

The software also takes advantage of these improvements by better achieving its principal function as a more simple interface between the computer and the user.

Which ROM technologies have been popular?

ROM CAPACITIVE COUPLING. In the IBM metal-card system, information is stored in the holes of a metallized card which is then recovered with insulation. In the absence of a hole, there is no coupling between the spots, bit and word, which are on opposite sides of the metallized card. For the IBM System 360 Model 30, the ROM consists of a network of vertical lines on a fixed support, and a network of horizontal lines on a mylar sheet that has perforated spots to define the code. An air pressure system keeps the unetched side of the mylar in contact with the vertical network, and assures uniform characteristics for the coupling capacitors. It also allows one to replace the mylar or change the code. Coupling capacity is 1 pF. IBM's ROM of Models 50 and 65 use the same principle.

Another capacitive ROM made by Integrated Memories has one side of the capacitor array etched as vertical lines on a pc card. The other side of the capacitor is an array of horizontally-connected squares etched on mylar (**Fig. 2**). The presence of a square represents a **ONE** and the absence is a **ZERO**. The program is quickly changed by peeling off the mylar and replacing it with a newly-etched one.

The arguments in favor of capacitive coupling for ROM are:

- The absence of electric contact at coupling points
- The relative ease of etching printed circuits on a substrate or on an insulating foil into an orthogonal pattern of word lines and bit lines with rectangular spots constituting the capacitors at the coupling points
- The possibility of coding the array by photoetching or by perforation of holes in the substrate
- The possibility of having a semipermanent memory

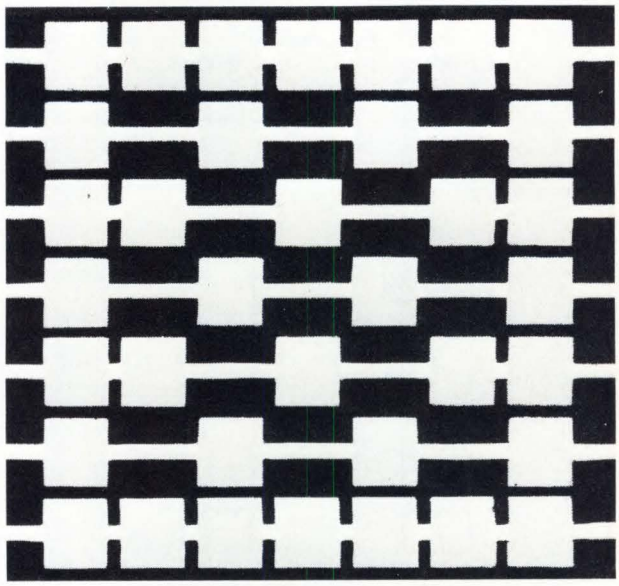


Fig. 2—Mask programmable capacitive ROM has an etched coupling plate at each position in the matrix where a '1' is stored. (Integrated Memories, Inc.)

which is alterable without disconnecting the matrix from the computer

ROM INDUCTIVE COUPLING. Fig. 3 is a schematic drawing showing the principles of a system developed in Japan for telephone applications. The information is punched into a removable copper card. Each hole in the card provides a coupling between a word line and a bit line, corresponding to a stored **ONE**. The change of code by insertion of a card is easy because the card does not have to be in mechanical contact with the word and bit lines as it must be in the case of the capacitive memory. Bit density at system level is 5 bits/cm^3 (about the same as for capacitive ROM).

Linear transformers made of soft ferrite material have been used in the design of numerous inductive ROMs including:

- E core in RCA Spectra 70 computers
- Transformer ROS in IBM Systems 360 Models 20 and 40 computers, with punched printed mylar for word lines

In this technology, Honeywell Bull, in 1963, developed an original principle for ROM, compatible with an automatic weaving of word lines. In this system, each bit is made up of a solenoidal coil wound on a soft ferrite rod (**Fig. 4**). The word line is a woven wire that either does or does not have a turn around each bit-solenoid according to whether or not the logical state of that bit is a **ONE** or a **ZERO**. When the weaving is completed, dummy ferrite rods are inserted between bit ferrite rods in order to close magnetic flux paths. There are 128 words of 72 bits per plane, with several planes put together to form a compact stack. All of the bit lines from the different planes and the word switch drivers are arranged in a grouped organization. Bit density at stack level is 8 bits/cm^3. This ROM design was very economical but it did not allow for very high speed performance.

The 'U'-core approach as pioneered by Memory Technology, also uses automatic weaving of word lines into a braid; however, it substitutes 'U'-cores for ferrite rods.

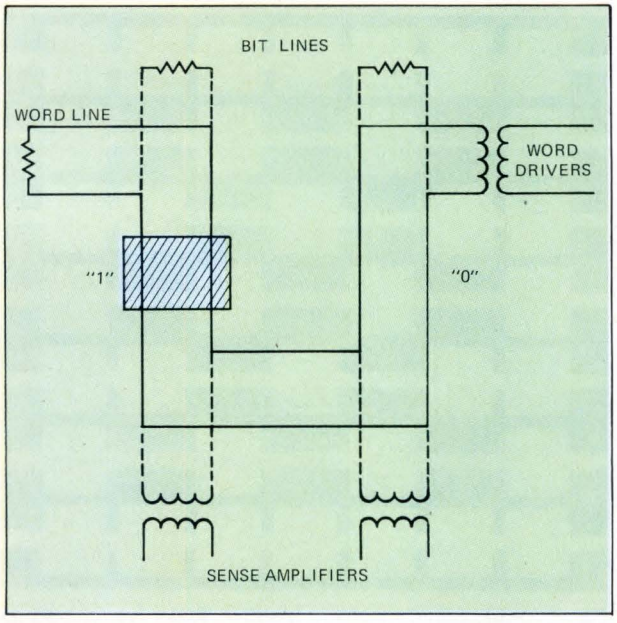


Fig. 3 – Metal card inductive ROM developed in Japan. The hole in a copper card represents a stored '1'.

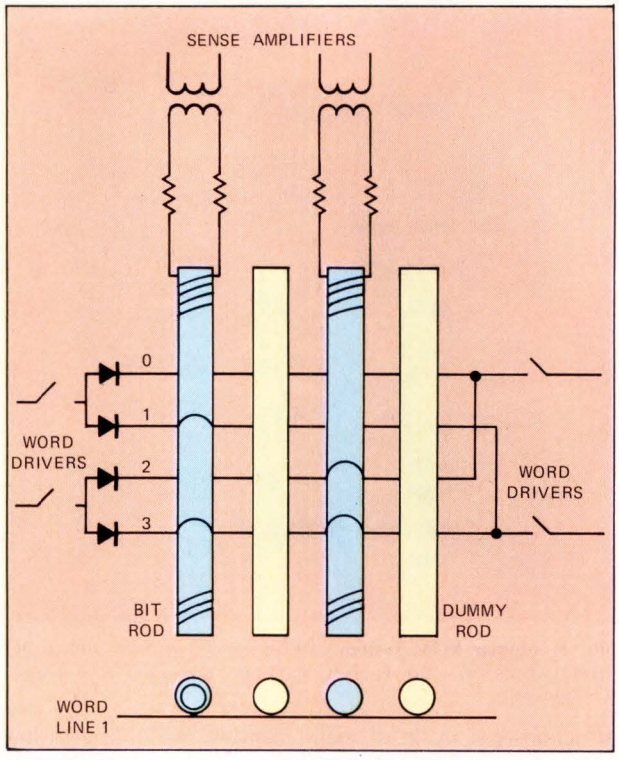


Fig. 4 – Ferrite rod inductive ROM utilizes woven word and bit wires. A '1' is represented by a loop around the rod. Dummy rods are used to close magnetic flux paths.

The advantages of inductive coupling for ROM are:

- Absence of electrical contact at the coupling points
- The optimization of line and associated circuitry impedances due to the transformer effect
- The possibility of functioning in the balanced mode for both word and bit lines allowing for compensation of any parasitic coupling
- In the same manner as is employed in magnetic read-write memories, the selection of one word line at both of its extremities in a low-cost word-driver organization
- The possibility of having a semipermanent memory with easily changeable removable cards

RESISTIVE COUPLED ROM. Resistive coupling presents two main advantages over inductive or capacitive ROMs.

- The amplitude of the read-out signal is determined by a stable voltage across the coupling resistance, and not by the differential of a transient current of voltage submitted to many sources of disperson in high-speed circuits. Resistive coupling allows one to obtain a read-out signal with little dispersion in amplitude, even at high speeds.
- For all types of coupling, there are parasitic signals that come from stray capacitive or inductive coupling between the word and bit lines. In the sense amplifier, it is difficult to separate the useful signals from the parasites because they are of the same nature. But in the Resistrix (**Fig. 5**), the parasitics are distinct from the useful signal. If the parasitic signal is too large, all that is necessary is to place a strobe in the sense amplifier to completely eliminate the parasitic signal.

When work was started (in 1965) on the development of resistor-type high-speed ROMs for computers at Honeywell Bull, the level of integration was at eight resistors per package. In 1969, it was 5k bits per array. **Fig. 6a** repre-

sents the basic principles of the matrix. Also provided are spare words to permit code changes by the user. **Fig. 6b** shows the position of fuses that will be destroyed if one writes a **ZERO** on these spare bits.

The fabrication process is a thin film deposition of chrome and copper on a glass substrate. The copper thickness is increased by electrodeposition. At the time of fabrication all coupling resistors are in the matrix e.g., the plane is in the all **ONE** state. Coding is done as a final step; therefore, the planes may be stored in the uncoded state for coding at a later time. Coding is a simple operation because an opening is left above each resistor on the plane so that it can be etched open. There is about 1 bit per mm^2. Access time is 50 nsec at the connector level.

Where are ROM technologies now?

SEMICONDUCTOR ROM. Those ROM technologies already discussed have been developed during the last 10 years, and they constitute technologies currently in computers in the field. These technologies, unfortunately, cannot be entirely integrated because they are made up of various diverse components such as resistor arrays or ferrite stacks, in connection with semiconductors for word and bit-line circuits. Progress in semiconductor-integrated-circuit technology has made it possible to completely integrate the ROM onto a single silicon chip, with one diode or transistor per bit in the matrix. By grouping these elemental ROMs, one can assemble a subsystem meeting current computer design criteria, and, at the same time, realize a substantial improvement in price and physical size. The evolution of the technology has been very rapid in this domain and there has been a proliferation of products made from both MOS and bipolar semiconductors.

BIPOLAR ROM. Bipolar- or MOS-bipolar hybrid arrays must be used for high-speed ROM in modern computers. Monolithic bipolar is presently the most popular product for this application. The first 256-bit packages appeared on the market in 1968, and the 1024-bit package, arranged into 256 × 4-bit words, appeared at the end of 1969. These have been followed recently by the 2k- and 4k-bit packages. Bipolar-ROM access time is from 40 to 100 nsec at the package level, giving a cycle time of about 200 nsec at the system level. Two main techniques are used for coding these chips.

- **Mask-programmable ROM.** The coding is done during the device processing phase by masking the transistors of the array where, for example, a **ONE** is going to be written. This method is most valuable for mass production, when the risk of code changes no longer exists. This technique yields the largest number of bits per chip.
- **Electrically-programmable ROM.** In this case, the IC manufacturer delivers ROM packages with one transistor for each bit of the matrix, and the user codes the ROM by eliminating the transistors required to obtain the desired code. In the fusible ROM, each transistor of the matrix has a fuse that can be opened by passing a larger than ordinary current through it (**Fig. 7**). Another process allows the selective burnout of transistor junctions in order to obtain the code. These products were introduced in 1970 and they are actually more complex than the mask programmable ROM, but the flexibility of their application is especially attractive during the period of code "debug". The structure and organization of certain ROM-IC packages makes it possible to code them when they are on a pluggable circuit board which is equipped with numerous packages. This simplifies the coding operation and the management of components, but it cannot be used with packages containing faults, because the checking before coding is not exhaustive.

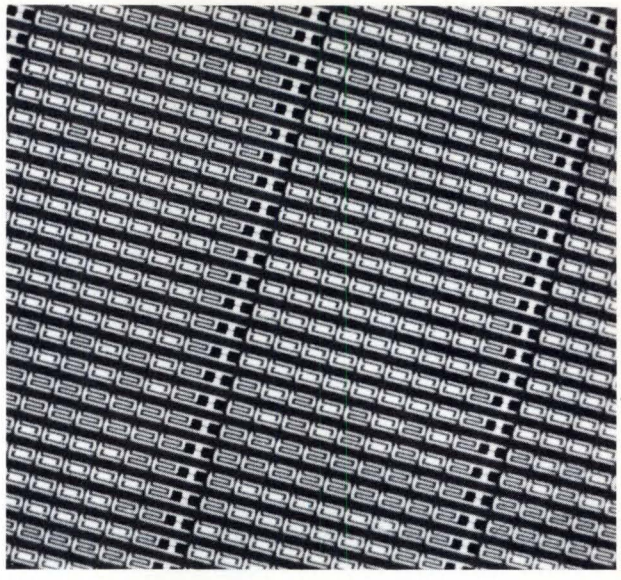


Fig. 5 – Coded Resistrix array shown is a resistor ROM originally developed at G.E.

MOS ROM. The MOS technology has a lower cost per bit, low power consumption and a high level of integration (more than 5k bits per chip), but the access time takes between 300 and 800 nsec at the package level.

Rapid progress is possible in the next few years particularly with N-channel and complementary MOS.

- **Reprogrammable ROM.** In the area of semipermanent ROM (i.e. electrically-reprogrammable ROM), there are some new concepts which allow slow writing into the memory by changing the electrical characteristics of the MOS. In this case, the transistor matrix is completely populated and data is written into the array by applying an abnormally high voltage in order to inject carriers into the gate substrate insulation. Thus, permanent information is stored in the transistor material. These technologies present very interesting solutions in particular for:
  a) the changeable control store
  b) replacement of the removable card ROM

  Intel offers such a programmable ROM (their 1601) using an MOS circuit with a floating gate. The programming voltage produces a charge on the gate, which has no discharge path once the voltage is removed. When reprogramming is required, the circuit is exposed to ultra-violet light to remove the old charge. In the 1601, the lid must be removed to do this, but in a newer version, a quartz lid will permit erasure without disassembly.

  Sony has developed another version called MAOS (Metal Alumina Oxide Semiconductor) which uses a double insulation consisting of alumina above silicon dioxide between the gate and substrate. The storage mechanism consists of charge trapped at the interface between the insulation layers. In this configuration erasure of data can be achieved by reversing the polarity of the writing voltage. Sony plans to incorporate this technology into their products later this year.

Another technology currently under development in the semiconductor industry is MNOS, which also uses a double insulation layer. In this case, the second layer is silicon nitride (hence the N in MNOS). The storage is again, charges trapped between the insulation layers, and rewrite is by appropriate voltage polarity and magnitude.

The electrically-reprogrammable ROMs offer flexibility in exchange for higher cost, when compared with the mask-programmable variety. In some, but not all cases, a PROM/ROM combination of products is offered with pin and mechanical compatability. The electrically programmed version is used for initial design and debug, and the cheaper mask-programmed version is substituted in production runs.

Trends in ROM technology

We are now in a period of transition where the IC ROM has recently replaced the impedance coupled ROM. Semiconductor technology continues to advance, and no other technology is presently seen to be competitive in the capacity zone of up to 10^6 bits. If a new ROM technology is going to intervene, it will probably have to provide capacities $> 10^7$ bits. In this domain, holographic memories on photosensitive materials are particularly attractive.

Photographic emulsions with a resolving capacity of 300 lines per mm are presently achievable, and give a theoretical upper limit of 9×10^4 bits per mm^2. In fact, it seems possible to get 10^5 bits per mm^2 in a holographic image recording, and to realize a 10^8 bit ROM by juxtaposition of small holograms in a single plate. Access time will be from 1 to 10 μsec.

The principle of reading this memory is given in **Fig. 8**. The coherent light beam is deflected towards a small hologram on the plate, containing, for example, $128 \times 128 = 16{,}384$ bits. The real image is concentrated in a semiconductor-photo-detector matrix that has the same memory characteristics as the classical ROM. Photo semiconductors are non-conducting or conducting to represent **ZERO** or **ONE**.

Up to now, such special technologies have not been able to compete with purely electronic techniques. However, the holographic ROM should be considered as an outside contender because of the numerous advantages presented by holography:

- High level of redundancy. Some dirt or scratches in the film do not destroy the information which is stored in every part of the hologram.
- Reconstitution of the real image without the aid of lenses, which are a source of error in optical systems.
- Good tolerance versus vertical positioning error for plate and light beam.
- Possibility of removable plate.
- Good power efficiency. 30% of the incident light beam can be expected to impact the photodetector.
- Few components and the absence of mechanical movement will give high reliability.
- Small physical size for system and for data support.

There are several problems that must be resolved before arriving at a holographic memory suitable for use in a computer, but the technologies associated with coherent light are progressing fast because of many other industrial applications.

One low performance device has already been announced. Optical Data Systems is offering a 12-megabit holographic memory as part of an off-line credit-checking system. Low storage densities and access times in seconds make it unsuitable for on-line ROM, but it is significant in that it is a deliverable holographic product.

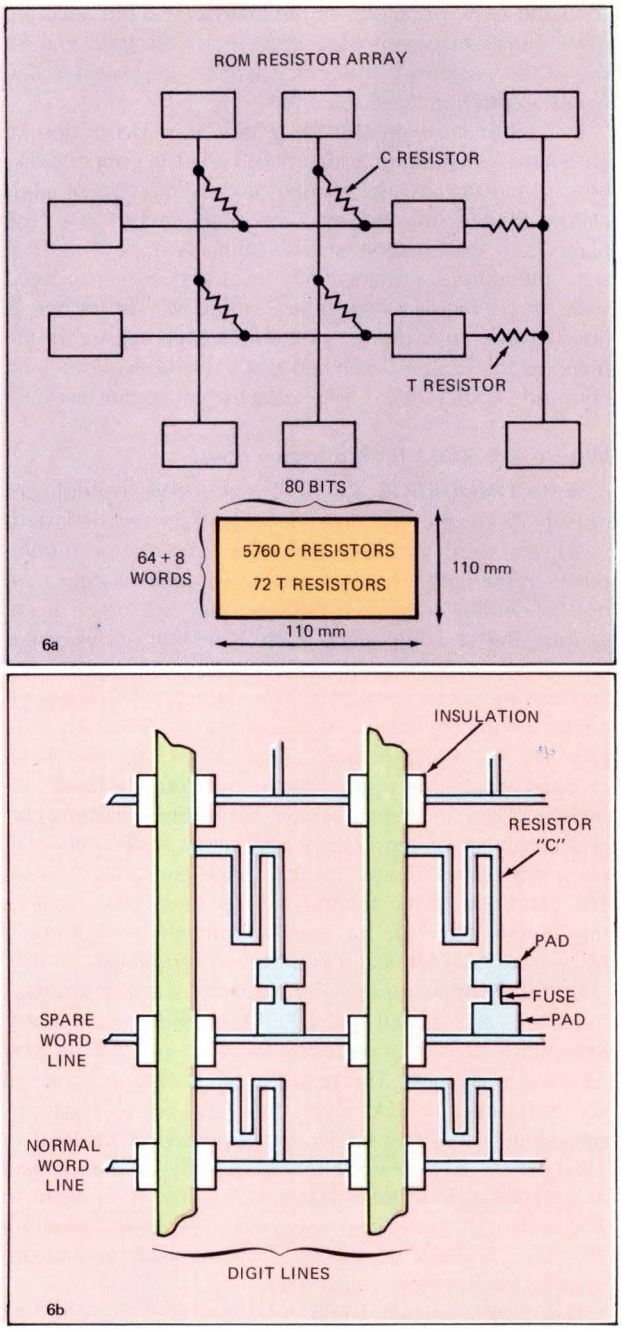


Fig. 6—Principle of early ROM resistor array (**a**). Spare words in the array (**b**) permitted code changes by the user.

At the other end of the spectrum, the research laboratory of Hitatchi Ltd. has developed a holographic memory capable of storing 20,000 bits in a circular space 1/2 mm in diameter. This is equivalent to a storage density of 100,000 bits/mm^2. The technique features a special optical plate to evenly diffuse the laser beam and reduce noise. While this is only a research laboratory model, it was predicted at the IEEE Optical Computing Symposium in April 1972 in Darien Conn., that 10^8 bit read-only holographic memories would be available in 3 to 4 years.

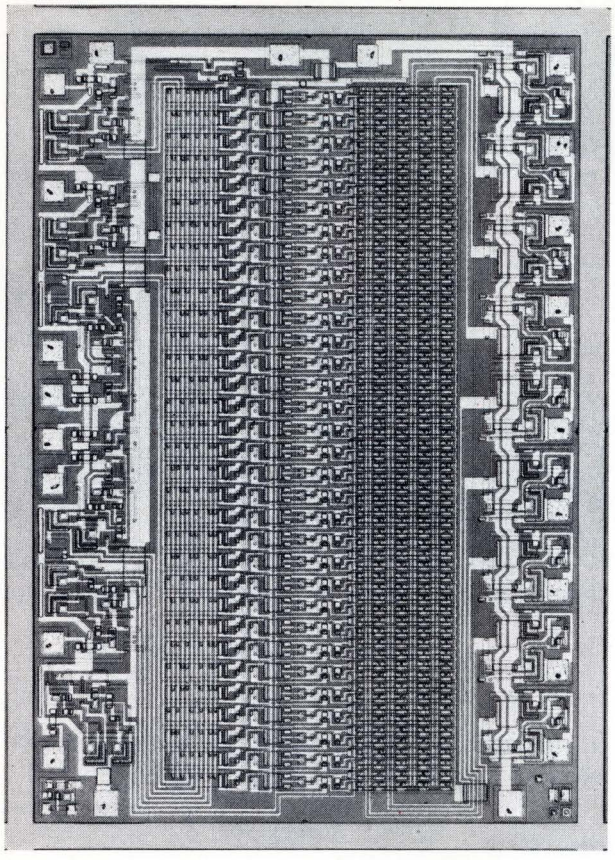


Fig. 7—Electrically alterable bipolar ROM contains 512 bits arranged in a 32 × 32 array. It is programmed by fusing nichrome resistors. An additional row of bits is provided for testing purposes in the MCM 5003/5004. (Motorola)

ROMs in perspective

Before speculating on new trends for ROM applications, it is worthwhile to review the purpose of ROMs. The nonerasability is generally not desirable in itself, since it inhibits flexibility through reprogramming. Rather, the read-only characteristic is tolerated in order to achieve some other performance improvement, such as:

- **Speed.** Many technologies operate faster in read-only implementations than in read/write. For control stores, speed is the dominant parameter.
- **Power-down volatility.** This problem has been magnified by the advent of semiconductor memories. The loss of microcode and other fixed information during power-down, requires increased secondary storage and reload time, and increases reliability problems through erroneous reload.
- **Protection of data.** Microcode and other data essential to the operation of the machine must be protected against equipment failure and erroneous changes by the "uneducated user". In the eyes of the hardware designer, the latter term may also apply to the systems programmer and field service engineer.
- **Bootload.** (previously discussed.)
- **Malfunction fault location.** (previously discussed)

It is important to keep these read objectives in mind, since the read-only attribute is not always inherent in the technology. In the IBM 370/145 for example, the control store is located in the read/write main semiconductor memory, which has sufficient speed for the application. Protection against the uneducated user is provided by logical lockout. The power-down volatility, bootload and fault-location functions are provided by loading the control store from a "floppy disc", which also functions as a read-only device by virtue of deliberate omission of write circuitry.

Clearly, the floppy disc is not really a read-only device. Several independent peripheral suppliers are now marketing these flexible cartridge devices in a full read/write mode as an intermediate cost/performance memory between tape cassettes and conventional discs.

Hence, IBM has deemed it economical to use two read/write devices in tandem to provide the control functions traditionally associated with read-only devices. It does not follow that this indicates any kind of trend, for the economics of other machines and manufacturers may dictate quite different solutions. In many configurations, the cost of semiconductor-mask ROMs can be balanced off against the flexible cartridge reader and its associated circuitry.

Balancing costs is the key concept. Various technologies may be used to implement the traditional ROM functions. Some of these are inherently read-only by virtue of their physical realization. Others are read/write physically, but can be made read-only by logical implementation if necessary. The objective, however, is not the read-only limitation, since the manufacturer is faced with the problem of initial programming and debug corrections. The real objective is an economical solution to a problem of speed or volatity or protection, etc. If an inherently read-only technology provides the most economical solution, the inconvenience of non-reprogrammability can be justified.

Holography is a good case in point. The world is not anxiously awaiting a large capacity read-only holographic memory. What the computer industry really wants is a read/write erasable holographic memory, which would have the cost and capacity of disks/drums, with the access time of pure electronic (i.e. non-rotating) devices. Unfortunately, the technologists are, as yet, unable to provide an erasable recording medium, and there is little likelihood that they will be able to do so in this decade. What they can provide is non-erasable media, which may provide a large (10^8 bits) read-only holographic memory within a few years. If new ROM applications in system configurations can be found to use them effectively, and thereby improve system performance/cost as compared to available alternatives (small disks and drums), then the read-only limitations will be accepted.

Possible trends in ROM applications

Nowadays, semiconductor memories not only permit the construction of control store for microprograms, but they also make it possible to disperse small ROMs of from 1k to 4k bits, throughout the computer. With these small ROMs contained in a single IC package, it is possible to perform complex logic functions with the same speed as is obtained with the gates of classical switching technology.

But truly new applications could appear within the next 10 years with an economic electronic-speed ROM of 10^8 bits or more. It will be possible to store mathematical tables, translation dictionaries, catalogs, operating systems, program libraries, etc . . . The criteria for ROM-storage candidates will be that the data is changed infrequently, if

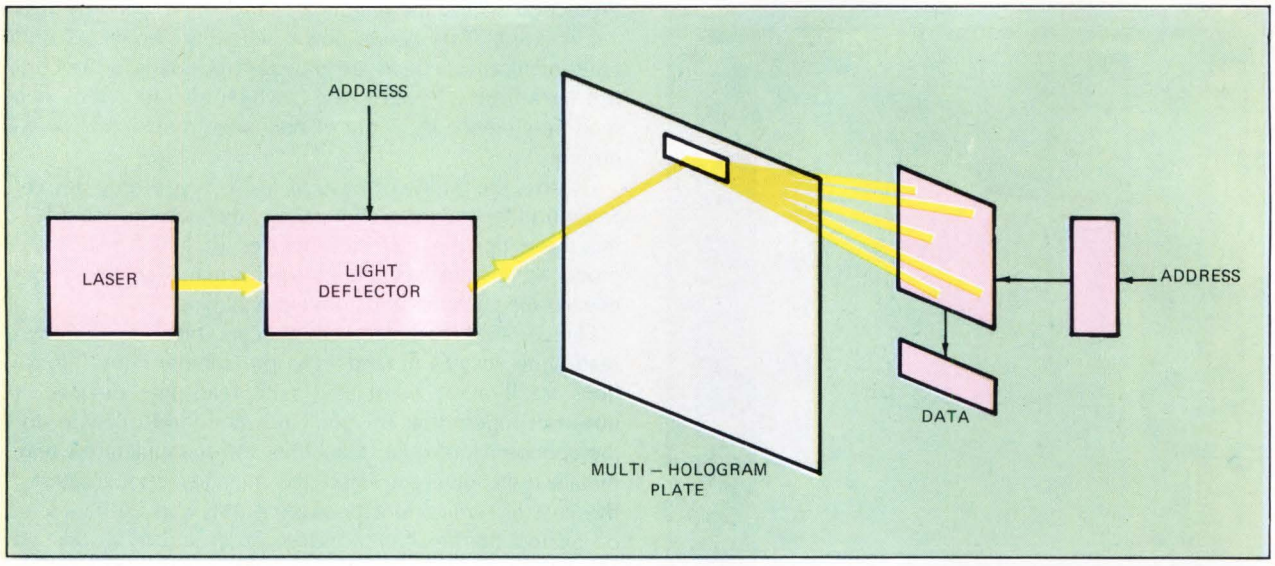


Fig. 8 – Principal of operation for a holographic ROM. The real holographic image is concentred on a SC photo detector matrix in order to read the memory's contents.

ever, and is referenced often enough so that the higher speed of the ROM (compared to disc) makes a significant difference in system throughput. It will be possible to update the information in these memories to the extent that the cost of this operation is compatible with the service that it provides.

One can easily envision a mass-storage analogy to the pin compatible PROM/ROMs discussed before. New programs would be stored on erasable magnetic discs during initial checkout, debug and usage. Once established as a working program, then production-usage performance would be enhanced by moving the programs to the faster read-only memory.

Today, computers are often being employed as business tools, and in this role they have the frequent need for much variable data. With the extension of computer applications, it is probable that the volume of permanent or of semipermanent data will increase enormously.

Given an economical mass-storage ROM, a vast array of relatively fixed data could utilize it. Teaching (texts and teaching programs), medical diagnosis and analysis, language translation, and forms recognition fields come immediately to mind, but the list is limited only by imagination.

Since their conception, ROMs have been the subject of controversy and discussion which says that the same function can be achieved by using logic circuits or read/write memory. Many computers do not have ROM. Others share the control store between ROM and read/write memory. In fact, it is always the economics of the situation that lead to the technical choice. Up to now, most ROMs have 2 to 4 times the speed of read/write memories for essentially the same cost per bit, and they generally have a smaller capacity than the central processor read/write memory. Perhaps, the new mass ROMs will be 2 to 4 times less expensive per bit, and of about the same speed as read-write memories, but with capacities very much larger.

If the cost per bit of this mass ROM with random access, or even with semisequential access, approaches the cost of disk memories, then it may become one of the fundamental components of future computer generations. □

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Authors biographies

Robert Zieve is a senior staff engineer in the Honeywell Advanced Systems and Technology Operation. Prior to this he spent 9-years at RCA and 4-years at Sperry Gyroscope. He received his BEE from Brooklyn Polytechnic Institute and MSEE from the University of Pennsylvania.

Roger Dussine graduated in 1948 from École Supérieure d'Electricité, Malafoff, and has a master's degree in physics from University of Paris.

After four years with Socíete d'Electronique et d'Automatisme, now CII, he joined, in 1953, Compagnie des Machines Bull, now Honeywell Bull. He spent a lot of his hardware activity in memory development from magnetostrictive-delay lines to semiconductor memories. Mr. Dussine is Manager of the Technology Development Division, M.S.D., Honeywell Bull, Paris.

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Phase locked loops provide accurate, efficient dc motor speed control

The proliferation of ICs applicable to phase-locked loops makes it economically feasible to apply this technique to many low-frequency control problems.

L. J. Milligan and **E. Carnicelli,** Peripheral Systems Corp.

There are definite advantages in applying phase locked loops to motor speed controls. The primary advantage is the fact that with a PLL the designer is assured of very precise and stable speeds because the speed of the motor can be tied to the frequency of a crystal oscillator. Whereas speed controls of 1% to 0.1% may have been reasonably tight in industrial applications in the past, it is now quite practical to shoot for accuracies of 0.002% and expect that the system will maintain this level of accuracy over time and temperature.

There are additional reasons for using a PLL motor speed control. With a PLL control, it is possible to slave many motors to a master oscillator and expect them to be synchronized with one other. The PPL approach will invariably produce a smaller and more flexible system than the older method which used many synchronous ac motors driven by the same power-line frequency (or a power oscillator or inverter). The PLL approach uses ordinary inexpensive and compact dc motors and low-power (signal-level) oscillators. The PLL oscillator frequency can be accurate to 0.0015% whereas the ac power-line 60 Hz, may be off 0.1% or more. And, power inverters are expensive, inefficient and electrically noisy (generate RFI).

Applying PLLs to motor control

The basic PLL is diagrammed in **Fig. 1**. It is probably familiar to most engineers but we will review it in order to show how a dc motor fits naturally into this loop. The objective of the loop is to make the output ac frequency in step with the input waveform, to the extent that they will be in phase with each other (or at least have a constant fixed-phase difference). This servo loop's error, e_ϕ (V) then, is proportional to the relative difference between the phase of the input and output phase angles, $\Phi_i - \Phi_o$ (Rad):

$$e_\phi = K_\phi (\Phi_i - \Phi_o)$$

where K_ϕ is the phase comparator gain constant (V/Rad). The loop is "locked" when e_ϕ holds steady, which means that the input and output frequencies must be exactly equal ($\omega_i = \omega_o$).

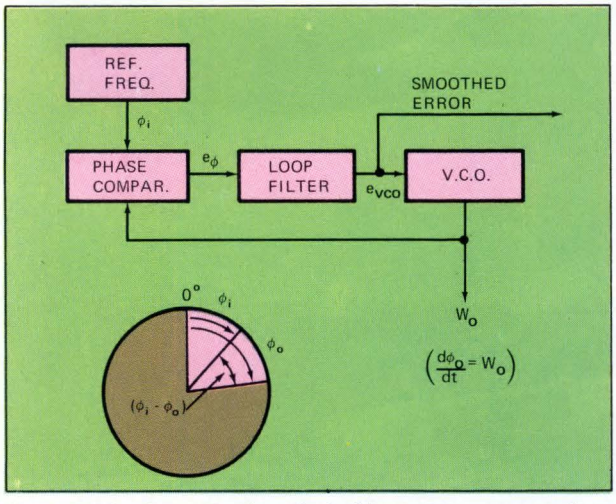

Fig. 1—Basic electronic phase-locked loop (PLL) computes how much the phase of an electronic voltage controlled oscillator (VCO) differs from that of a reference frequency (that a phase comparison is being made assumes that the frequencies are equal). Then the PLL corrects the VCO to keep the phase difference either as small as possible or at a fixed value. (A PLL may be used to lock frequencies together or to detect FM by noting the variations of the error voltage fed the VCO.)

The loop-servo corrective action occurs whenever the output phase Φ_o starts to drift. This will cause an increase or decrease of error e_ϕ of the proper polarity to readjust the voltage controlled oscillator (VCO) and bring the output phase Φ_o back into agreement with the input reference phase Φ_i.

Under large error out-of-lock conditions, such as initial power-up, there will be too great a difference between input and output frequency for the vernier servo-action of the in-lock condition. But the gross frequency difference ($\omega_o - \omega_i$) will cause the error e_o to vary with the time. This timewise variation of e_o will cause the VCO to sweep ω_o until it reaches the frequency of ω_i, at which point the loop will "capture" the VCO and phaselock will be achieved.

The input frequency need not be fixed. The PLL will track any changes of ω_i that are within its bandwidth—which is set by the low-pass filter between the comparator and the VCO.

A clue as to why a dc motor can be substituted for the VCO can be had by developing the mathematics associated with the VCO's transfer function. The relationship between the VCO's input and output is:

$$\frac{d\Phi_o}{dt} = K_{vco}\, e_{vco}$$

where K_{vco} is the VCO gain constant (rad/sec/V), and e_{vco} is signal e_ϕ after it has passed through the low-pass filter. Taking the Laplace transform of this expression:

$$L\left[\frac{d\Phi_o}{dt}\right] = s\Phi_o = k_{vco}\, e_{vco}\ (s)$$

from which:

$$\Phi_o(s) = \frac{K_{vco}\, e_{vco}\ (s)}{s}$$

This shows that the phase of the VCO output Φ_o is proportion to the integral of the VCO input voltage. This both explains why the VCO in a PLL is often referred to as an

integrator and why it is possible to replace the VCO with a dc motor. The transfer function of a dc motor performs a similar integrating function with respect to its driving input voltage.

The graphs of the transfer functions of a VCO and a dc motor shown in **Fig. 2a** and **2b** further emphasize this similarity. Note that the input in each case is voltage and that the output in each case is frequency in rad/sec. Note that the curves themselves are linear and have positive slopes.

But a dc motor can do more than just replace the VCO in a PLL; it can also replace the low-pass filter. The motor's mechanical inertia coupled with its winding inductance makes the motor unable to respond to higher frequencies to the point where there is no need to precede it with an electronic low-pass filter.

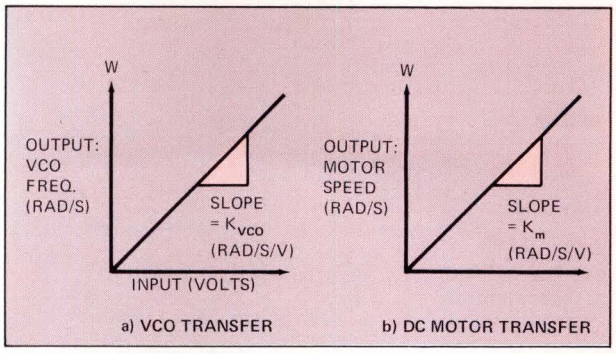

Fig. 2—The transfer function for a VCO (**a**) finds an analog in the transfer function for a dc motor (**b**). This is why a dc motor can be substituted for a VCO in a low-frequency PLL. Actually, as explained in the text, the dc motor is in some respects a "better VCO" than its electronic counterpart.

A practical implementation

A PLL motor speed control system that proves dependable is shown in **Fig. 3**. It's what might be called the digital approach to PLL for it employs digital components to implement most of the loop. Even the crystal oscillator and the power amplifier that drives the motor itself operate in the class D or switching mode. About the only portion of the system that is not digital is the motor itself. The advantage of this digital approach is twofold: it allows the designer to make maximum use of the low-cost digital IC logic circuits (the author has used RCA CMOS mainly) and it permits the maximum efficiency for the power amplifier that drives the motor.

First, the implementations of the various PLL blocks will be discussed; then the operation of the loop itself will be described.

Reference: The reference does not have to be a crystal oscillator but it often is because only an oscillator can provide a rock-solid foundation for the system accuracy. There is an obvious problem in using a crystal oscillator for motor controls. The most stable and economical crystals are "AT" cut and operate up at the 3-8 MHz range. Motors operate down at the 30-1000 Hz range. However, thanks to the wide availability of low-cost IC binary-divider chains, it is rather easy and inexpensive to bridge this frequency gap.

In the example, it is desirable to operate the motor at 1800 rpm (a common speed). As will be seen, it is possible to use a chain of 10 binary dividers (flip-flops connected as counters) and bridge the frequency gap.

In the future, there should be growing selection of economical lower-frequency crystals available, as these are being developed for the electronic wrist-watch industry. Frequencies as low as 10 kHz are being discussed.

Tachometer: This element translates the analog-mechanical output of the motor shaft speed back into the digital-electric language of the rest of the system. The tachometer should be selected to generate sufficient pulses per shaft revolution so that it provides a fine-resolution indication of speed. In the example, a tachometer that produced 100 electronic output pulses per turn of the motor shaft is chosen. This multiplies the 30 rps of the motor to 3 kHz. (If the application called for a low-inertia motor to be used at a low speed, a tach that produced several thousand pulses per revolution might have been

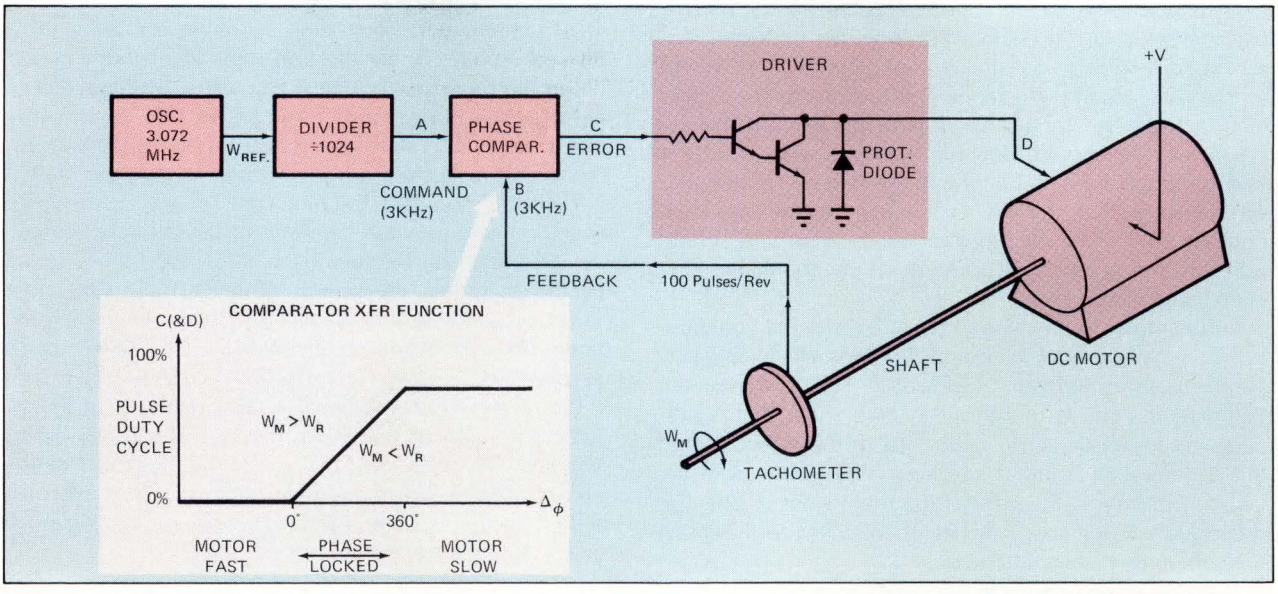

Fig. 3—Practical PLL using a dc motor closely resembles an all-electronic loop. The phase-comparator function (shown in insert) varies the width of the chopped power pulses applied to the motor which produces a shaft rpm proportional to the commanded frequency. A digital tachometer attached to the motor shaft reconverts the mechanical signal back into electronic pulse form to complete the loop. Almost all the components used to implement the loop are digital to keep costs low.

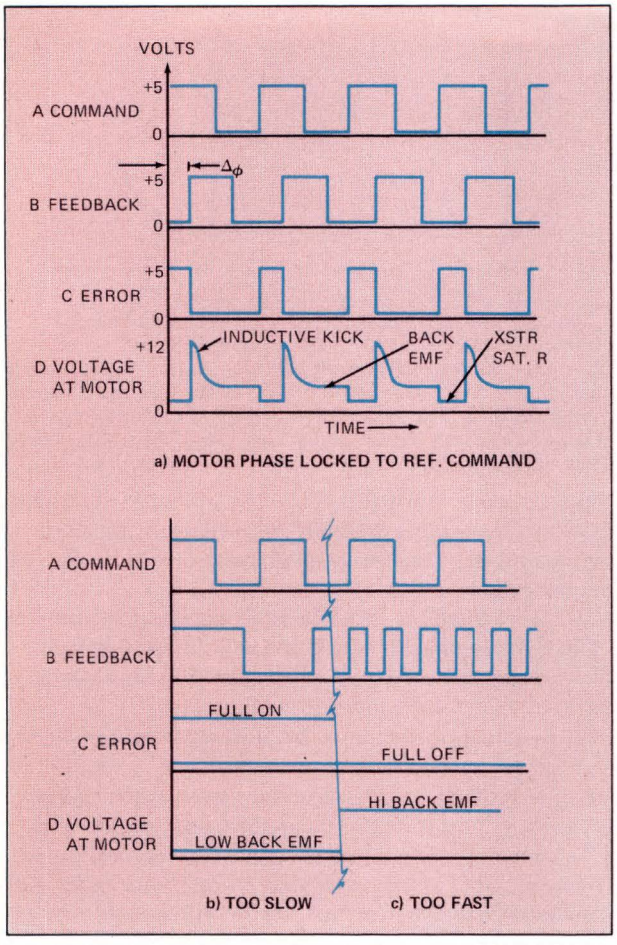

Fig. 4—Waveforms for the motorized PLL loop of **Fig. 3**. When the loop is in lock (**a**) the comparator produces power pulses to the motor that vary in width according to the phase error. When the motor is running too slow (**b**), the comparator puts out a steady dc "full power" command to the motor. When the motor is running too fast (**c**), power to the motor is cut off.

selected.)

There are many operating principles that can be used in constructing a digital tachometer. One can use holes in a rotating disc to gate light pulses to phototransistors. Another can use variable-reluctance coil pickups to sense gear teeth going past. But whatever principle is used, the tachometer itself should be made with precision, or else it will introduce noise and jitter into the system. For that reason, I suggest that unless your company happens to have unusual skill in the electro-mechanical area, you should purchase this component from one of the companies specializing in tachometers.

Comparator: In this type of digital system the comparator is typically a combination of flip-flops and logic gates. As the transfer function sketched in **Fig. 3** shows, the comparator's task is to put out a pulse width that is proportional to the degree of phase lag of the motor behind the reference (in terms of the lag of the pulses from the tachometer behind the pulses from the divider chain). The description of the loop's behavior to follow will explain the comparator's function better.

Transistor power switch: For small dc motors that have currents in the 1A range, a simple power Darlington driver as shown in **Fig. 3** can be used. It should be protected against the motor's inductive kick upon turn-OFF by a power diode as shown. For larger dc motors, proportionately larger drivers should be used and they should have adequate heat sinking. Actually, there is no reason why, with a properly rated driver, the very largest dc motors could not be driven by the same circuit that would drive the smallest miniature dc motors. We've used the same circuit but not the same driver for a large 1 hp motor and a small 25¢ toy motor.

Motor: There are many large and small dc motors commercially available that could be used successfully in this type of system. For most small systems in the fractional horsepower class, permanent magnet motors would be used. It is also possible to use the new brushless dc motors that employ the Hall effect to provide contactless commutating by making minor modifications to the commutation circuits.

The motor's voltage-speed characteristic should adequately approximate the linear VCO behavior of **Fig. 2.** Most small permanent magnet motors have excellent VCO characteristics, but some varieties of larger field-coil excited motors have less desirable nonlinearities in their voltage-speed responses.

The motor should also have the proper low-pass filtering effect. Usually this will not be a problem, unless for some reason one is using a very low-inertia motor in combination with a geared-down tachometer. In that case there may be insufficient pulses per motor-shaft revolution resulting in "cogging."

The operation of this loop is explained by the waveforms in **Fig. 4**. These waveforms show points A, B, C and D of diagram **Fig. 3**, where A is the command input or reference frequency input to the loop, B is the signal fed back from from the tachometer, C is the error from the comparator, and D is the voltage applied to the motor.

The first set of waveforms (**Fig. 4a**) show the system operating normally under locked conditions. The motor is at the proper speed so the tachometer pulse is in step with the command. The feedback pulses lag the command pulses slightly because of the unavoidable mechanical friction and windage loads.

The comparator's operation is rather simple in this "locked" mode: it (via the transistor driver) turns power ON to the motor each time it receives a leading edge of the reference pulse and it turns power OFF again every time it receives a feedback pulse from the tachometer. This action makes the power-ON duty cycle proportional to the degree to which the motor phase lags the reference waveform, and provides the basis for the PLL servo behavior. If the load on the motor increases and tries to retard the motor further, the power pulse lengthens and more power is applied to the motor. If the load lightens and the motor starts to overtake the reference, the power pulse narrows and less power is applied to the motor.

The reason for the somewhat odd waveforms at the input to the motor is that when the transistor driver is first switched OFF, the voltage "kicks" up (because of the motor's inductive kick) and then settles down to the value of the motor's back emf, which is proportional to the motor speed (the motor is acting as a generator).

What happens when the PLL is out of lock

This basic PLL servo action can only occur when $\omega_B = \omega_A$ or the pulses from the tachometer have the same

frequency as the pulses from the divider chain. Only then will the comparator put out a linear variation of pulse width proportional to the phase difference between these signals. When $\omega_B < \omega_A$, which means the motor is running too slow, the comparator will put out a continuous "100%" duty cycle which will apply full power constantly to the motor until it climbs back into the 0-360° lock region again (refer back to the comparator transfer function shown in **Fig. 3**).

When $\omega_B > \omega_A$, which means the motor is running too fast—as it might be if the commanded reference frequency were suddenly reduced or another motor on the same shaft started overdriving the motor—the comparator will put a continuous "0%" duty cycle, which will completely remove power from the motor until it falls back into the 0-360° lock region.

The waveforms for these underspeed and overspeed conditions are depicted in **Figs. 4b** and **c**.

Possible PLL variations

Like every electronic-system concept, the PLL has infinite variations. Each of the circuit functions indicated in the block diagram can be performed in many different ways. For example analog components could have been used to implement a linear version of the loop. The linear system would not have been as efficient as it would not have had the "hard ON," "hard OFF," control of the motor.

There are also many refinements to the digital system shown. One that the author is patenting concerns a method for controlling the motor that greatly reduced jitter, despite the ON-OFF power switching. It would be useful when the control is being applied to audio and video magnetic recording where very low wow and flutter is desired. The author has applied this technique to professional motion picture cameras where the precision speed control, the lower-power consumption and the reduced RFI are appreciated.

There is another advantage besides long life to using the brushless-type dc motors, such as the Hall-effect commutated motor made by Siemens. These motors have, in effect, a built-in flywheel, for they carry their permanent field magnets on their rotors. Ordinarily this would be a disadvantage as it makes them slow in accelerations and decelerations, but it is a definite advantage when they are used for precision speed drives, such as high-fidelity audio recordings. The motor shaft can be used directly as the capstan that drives the magnetic tape. There is no need to go through additional gearing or belt drives to a separate mounted flywheel capstan. Eliminating the gears and belts eliminates the wow and flutter they create.

As was said earlier, the PLL speed control does not have to be a single speed system. It can be made to operate at several fixed speeds by switching in various binary dividers in either the input or the feedback loop. It can be made to operate at an infinite number of speeds by using a variable reference oscillator.

A worthwhile application of a variable-oscillator control would be where a large number of motors have to be adjusted at the same time, and will remain precisely synchronized with each other. The motor drives for the conveyor belts used in automatic factories and for the loom drives in textile mills are both examples where many motors must be kept in step with each other. One master oscillator could be used as input for all the motor PLLs in this type of application and produce centralized, factory-wide control.

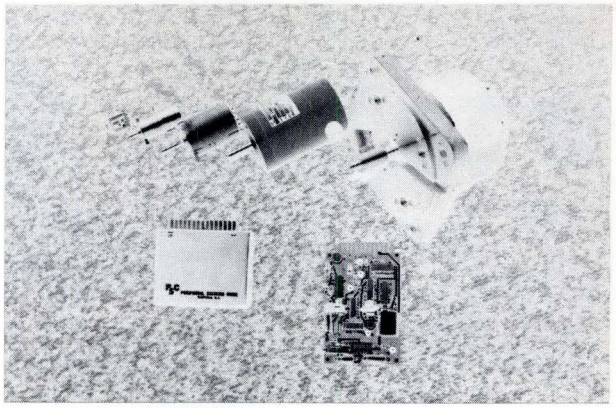

Fig. 5—Physical appearance of PLL motor speed control electronics and some of the motors it will control. The power switch that drives the motor is mounted separately from the PC card version but a 10A driver is included in the epoxy-potted version. All the motors shown are permanent-magnet types. The third one from the left is a brushless type.

The PLL motor control can be easily controlled by a digital computer. The computer can give the PLL motor control coded words that command the basic motions of Forward, Stop and Reverse. Reversing can be accomplished by using a tachometer that also senses direction to gate a pair of opposite-polarity drivers. The rest of the PLL does not care which way the motor is rotating. The PLL can provide feedback signals back to the computer to inform the computer of its operating status. For example, the PLL can provide signal flags to tell the computer when it has reached lock, and if it is out of lock it can tell the computer whether it is out of lock fast or slow. □

Reference

Phaselock Techniques, Floyd M. Gardner, John Wiley and Sons, Inc., New York, NY, 1966.

Authors' biographies

Lee Milligan and **Earnest Carnicelli** have similar professional backgrounds. Both graduated from the Newark College of Engineering and both worked for various aerospace and commercial electronics companies in the New Jersey area. Milligan's experience has been in microwave and servo systems. Carnicelli's has been in rf phase locked loops for frequency synthesizing. But they have quite different non-professional interests. While Milligan finds adventure in piloting a 1948 Stinson, Carnicelli prefers the quiet stimulation of competition chess. Carnicelli has left PSG since this article was written but Milligan remains as the president of this small company.

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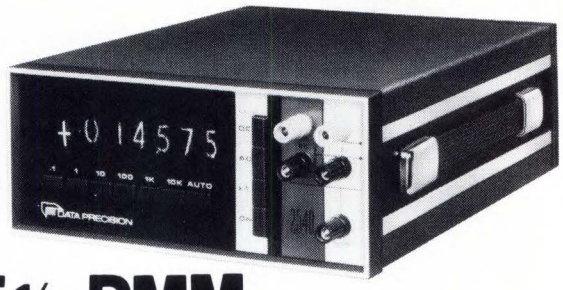

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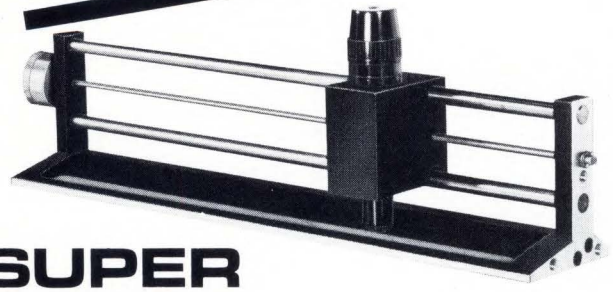

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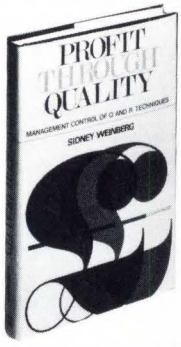

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Theory is straightforward

The best example to use to illustrate the theory of operation is a sine wave, although this technique is by no means limited to sine waves. A good approximation of a sine wave can be made by digitizing the waveform point by point. Notice in the case of the sine wave (and many other waveforms) that only the first 90° of the waveform need be digitized. Once that information is available, it can be manipulated to generate the other 270° and then merely repeated as often as necessary.

The digitizing process is shown in **Fig. 1** as applied to a sine wave. For clarity the scales are not linear. For reasons that will become obvious I have chosen to sample the sine wave every (90°) ÷ (63) or approximately every 1.43°. Similarly, the waveform will be digitized using 6 bits, or by approximating to the nearest of 64 discrete levels ranging from 0 to 63. This process was actually carried out as described in the information box which accompanies this article. Once we have converted the information to a digital format of 64 words of 6 bits each, it can be entered into a read-only memory of the field programmable type such as the MCM500AL, or equivalent 512-bit TTL ROM.

From this point on, the problem becomes one of reconstituting the digital information into analog form so that we can generate a complete sine wave. A quick look at the format of the information shows that the first 90° are easily retrieved by sequentially scanning the ROM from word 0 to word 63. This is done with a 6-stage up-counter. To generate the wave from 90° to 180°, we need only reverse the procedure by scanning backwards from word 63 to word 0. The remaining half of the waveform is easily obtained by simply switching the polarity of our final output and repeating the up-down process. **Fig. 2** should serve to clarify this concept.

Digitizing the Waveform

Step-by-step details for digitizing the waveform, in this case a sine wave are listed below. Actual electrical programming of the ROM is described in Motorola Application Note AN-550.

The idea is to utilize to the utmost the available storage in the ROM by accurately converting the normalized value of the sine function for the first 90° to the nearest binary equivalent. This task is most easily accomplished by using a computer time-sharing terminal. The basic tasks to be performed are:

1. Divide the first 90° into 64 evenly spaced sample points.
2. Calculate the sine function for each sample point.
3. Multiply each value by 63 (to normalize)
4. Round off each of the values to the nearest whole number
5. Convert each value to its 6-bit binary equivalent
6. Take the complement of each value.

A few selected points to illustrate the procedure are shown in **Table 1**.

A relatively simple computer program can be written to make these calculations.

The only information required for programming the ROM is contained in the "word" and "complement" columns. The "word" information is used to address the ROM and "complement" gives the required output.

Any other waveform may be programmed similarly, keeping in mind that the first 90° are divided into 64 evenly spaced sample points and the maximum value of the function is normalized to 63.

Prototype design serves as a model

Obviously, then, what is needed to complete the procedure is a 6-bit up-down counter, a 6-bit D/A converter and the capability of changing output polarity. The block diagram of **Fig. 3** shows the basic arrangement. The up-

Word	Degrees	Sin	63 x Sin	Whole No.	Binary	Complement
0	0	0	0	0	000000	111111
1	1.43	0.025	1.57	2	000010	111101
21	30	0.5	31.5	32	100000	011111
42	60	0.866	54.56	55	110111	001000
62	88.57	0.999	62.98	63	111111	000000
63	90	1	63.00	63	111111	000000

Table 1—Sample points in the digitization procedure of a sine function are shown here to illustrate the procedure.

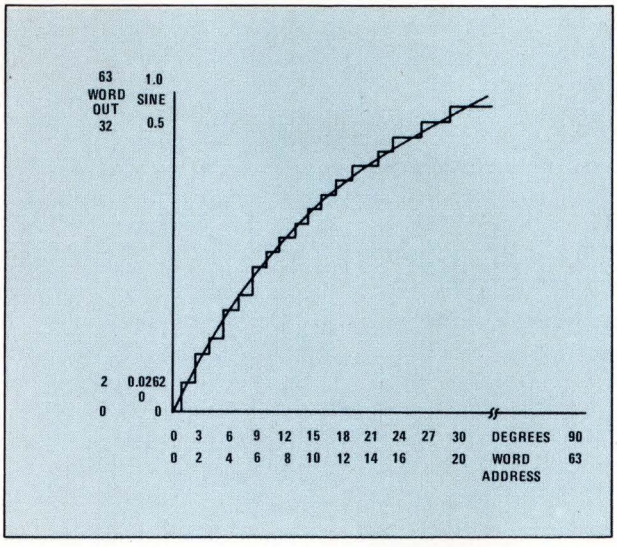

Fig. 1—Digitized sinewave is actually 64 discrete dc levels per quadrant, controlled by the programmable ROM, a DAC and a time base. In the case of waveforms that are symmetrical with respect to time and polarity, only the first 90° need be digitized.

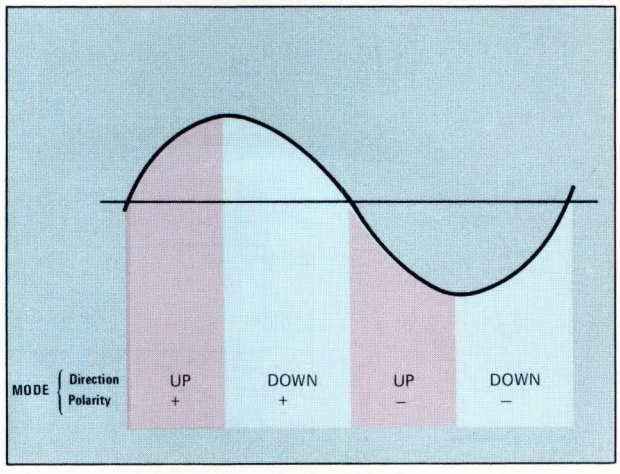

Fig. 2—Function generator control modes repeat the 90°-ROM program in four different modes to produce one full 360° cycle of any symmetrical waveform.

down counter used is a 74193 type TTL up-down counter, the MC1406L 6-bit DAC performs the analog function and a dual op amp, similar to the MC1458CP, acts as an output buffer and polarity switch. For the prototype circuit the clock was supplied from an MC4024 TTL VCM (voltage-controlled multivibrator), while additional TTL circuits performed the housekeeping functions in the block labeled Mode Control.

Because the MCM5003AL programmable ROM is organized as 64 words by 8 bits and the MC1406 is a 6-bit DAC, the waveform was digitized into 64 segments, as mentioned earlier. Also, the inherent time and polarity symmetry of the sine waveform allowed for efficient use of the memory, necessitating storage of only the first quarter of the waveform.

The complete schematic of the prototype generator is shown in **Fig. 4**. Two 74193s are cascaded to provide the 6-bit up-down counter (the last two bits are ignored in this case) while standard logic functions are employed to determine when the counter has reached its maximum and minimum counts, and to advance the two flip-flop mode-control counter. The mode-control counter controls the count direction of the up-down counter and also provides a polarity control signal to the output-buffer amplifier. The six outputs of the counter are routed directly to the address inputs of the ROM. In turn, the six memory outputs interface directly with the D/A converter. The design of the input circuitry of the MC1406 allows use of the open collector output version of the ROM. This allows direct wired-OR connection of more than one ROM which, in conjunction with the chip-enable inputs of the ROM, permits selection of any programmed waveform by merely enabling the appropriate ROM.

The current output of the D/A converter is converted to a voltage for the first op amp, A_2, which has a variable feedback resistor for changing gain and hence amplitude. The second op amp, A_3, is used as an inverting or non-inverting buffer amplifier, in response to the signal from the mode-control counter. Finally, the basic clock for the up-down counter is derived from the MC4024 VCM. Selection of frequency control capacitors across the MC4024

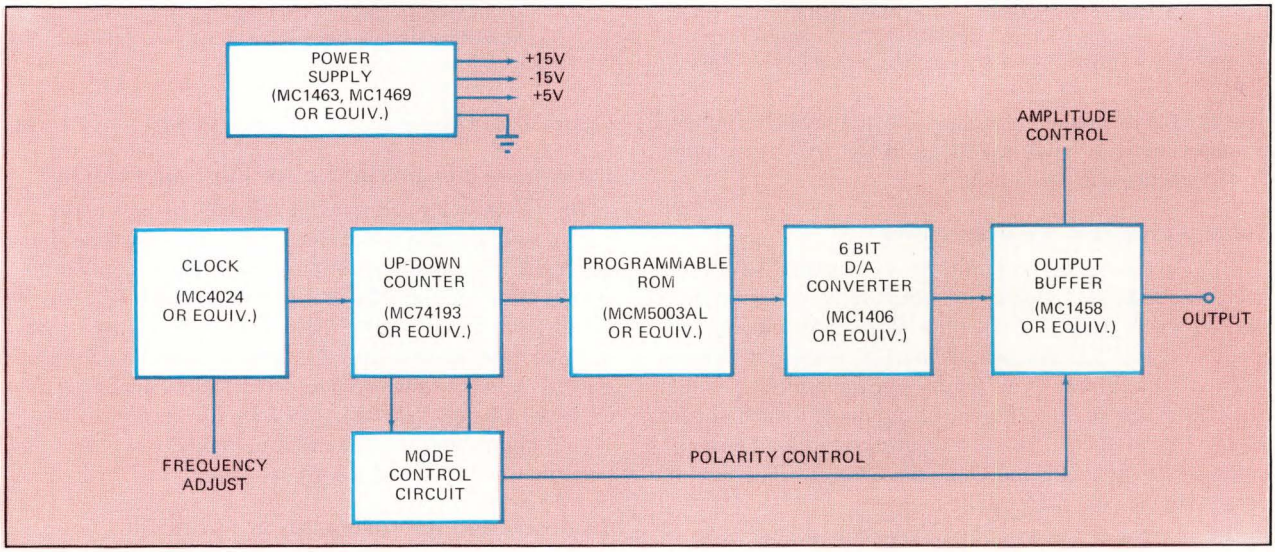

Fig. 3—Function generator block diagram reveals that only six waveform can be programmed using the same basic ICs for each basic functions (plus power supply) are required. Virtually any function.

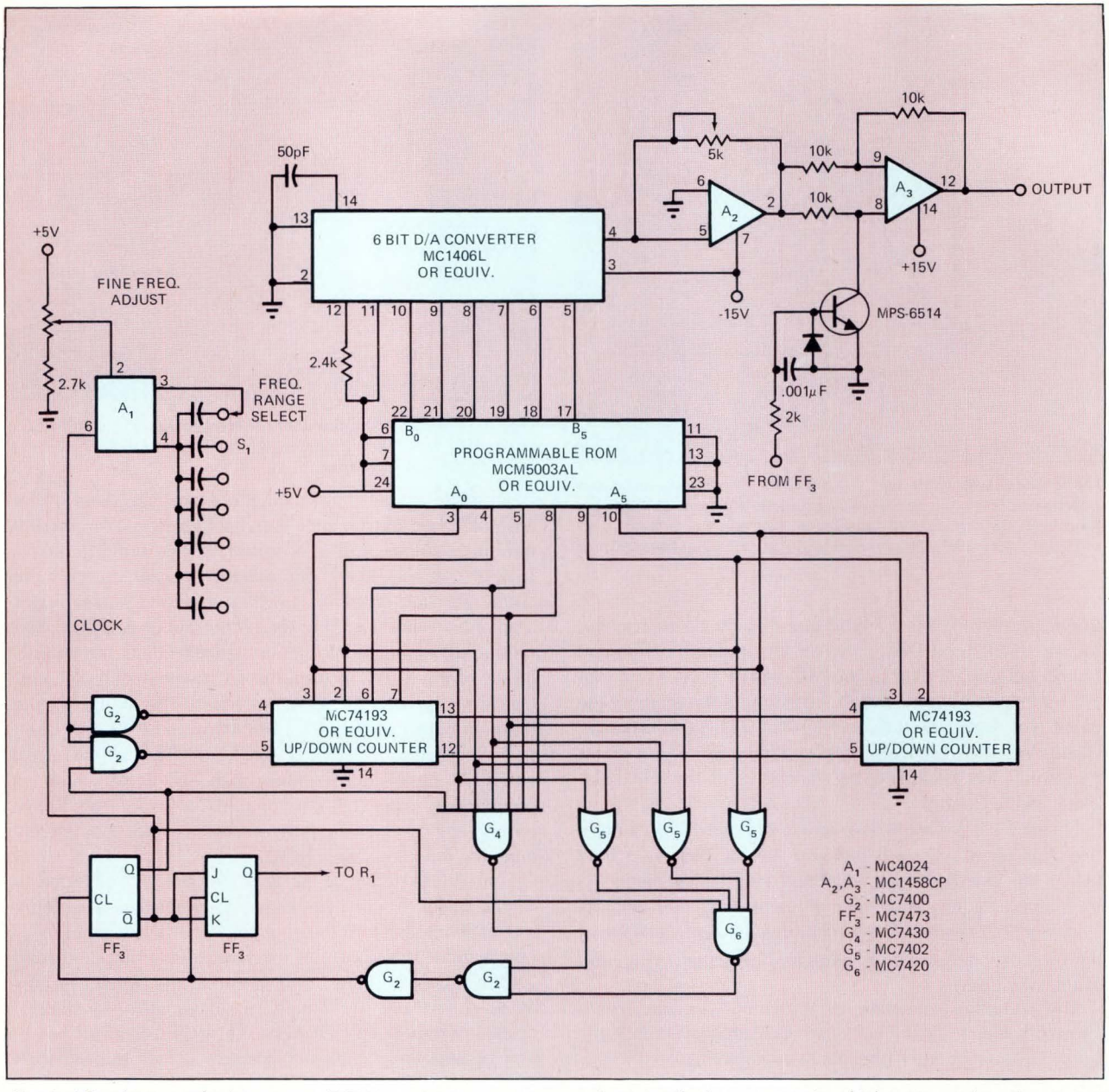

Fig. 4—Waveform synthesizer uses a ROM to program current output of a monolithic DAC (MC1406). This current output is converted to a voltage by op amp A_2. The 5k feedback pot on A_2 adjusts amplitude to op amp A_3 which acts as an inverting or non-inverting output buffer depending on its input from the mode control counter (FF_3).

allows coarse frequency range selection while a potentiometer feeds a variable voltage to the VCM permitting fine frequency adjustement.

Some waveforms are even easier

It is very easy to program other standard waveforms such as triangle, square etc. Square-wave generation doesn't even require a memory since it would be programmed as all ONES for all time. It turns out that, in reality, the MC1406 DAC requires negated inputs, so that all ZEROS are really required at its inputs for the square wave. The triangle is another interesting case. Since the counter is 6 bits, as is the D/A converter, a single hex inverter can take the place of the memory.

The approach really shines, however, in the case of non-standard waveforms that are sometimes needed to simulate unique inputs to a system. **Fig. 5** illustrates the capabilities of the generator to create complex sequences.

Performance is acceptable for most applications

The scope-trace photograph on **Fig. 6** compares the output sine waveform with that of a laboratory-type signal generator. Reasonable correlation is evident. Maximum output frequency at 20V p-p is limited to 10 kHz by the large-signal bandwidth of the op amps. Since the counter must be clocked at a rate 252 times that of the output frequency, a much faster op amp would allow operation only to approximately 100 kHz (25 MHz clock rate). There is no minimum limit to the output frequency—it is only dependent on the slowest clock available.

Tradeoffs and improvements are available

One of the first tradeoffs to come to mind is that of lower frequency range for improved time resolution. The

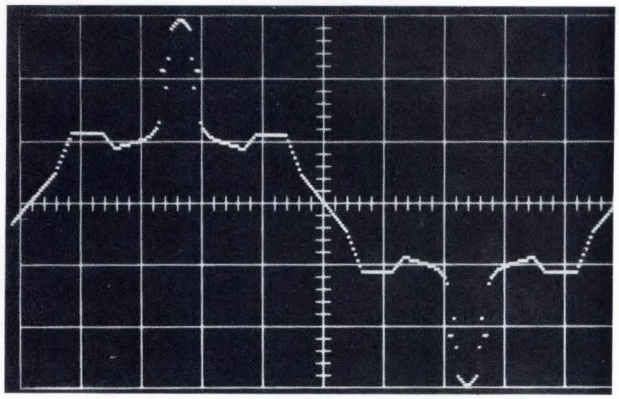

Fig. 5—Random waveform demonstrates ability of digital synthesizer to provide waveforms which would be difficult or impossible to achieve by conventional techniques.

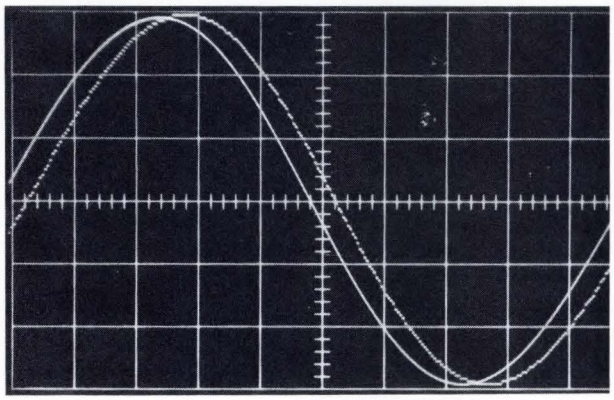

Fig. 6—Close approximation of digitally generated sine wave produced by the circuit described in this article to that of a standard signal generator is apparent in this side-by-side comparison.

more time increments that are used to describe a waveform, the greater will be the time resolution, but this results in a lower output frequency for the same clock rate. Also, because of the slew-rate limits of the op amp, greater frequency may be obtained at the expense of a lower-output voltage swing.

To accommodate non-symmetric waveforms such as the ramp or sawtooth or other applications, such as a programmable voltage supply, the up-down counter and associated housekeeping logic are not necessary. In fact, they are not useable, but without them you would make very inefficient use of the memory when symmetric waveforms are needed.

It might also have been noted that only 6 bits of the 8-bit word available from the memory are used. This means that you can achieve better resolution, where needed, by using an 8-bit DAC.

Should a programmable supply type of operation be desired, either a power booster such as the MC1438R could be added to the output (yielding ±300 mA), or the output, as it stands, could be used as a reference for a power-voltage regulator.

Although programmability per se was not a part of the prototype design, the digital nature of the generator lends itself well to programmable control, which is becoming the trend for test equipment that is used under computer control. Frequency control is easily accomplished by following a crystal controlled oscillatory with a chain of programmable counters such as the MC4016. The output frequency of the chain, thus controlled by the digital inputs to the counters, is applied to the up-down counter as is the output of the MC4024 in the prototype. Digital control of the amplitude is less obvious but could be achieved by using another MC1406 DAC to control the reference current of the MC1406 in the prototype.

Only off-the-shelf ICs have been used here to yield a truly unique instrument. Many of the details must be changed to meet individual requirements, but the basic concept remains the same. It is expected that the future availability of counters and memories in ECL and CMOS will offer increased speed and decreased power, respectively. It is also reasonable to expect that larger field-programmable ROMs, and higher resolution monolithic DACs will become available in the future, making the procedures outlined here almost universally adaptable. □

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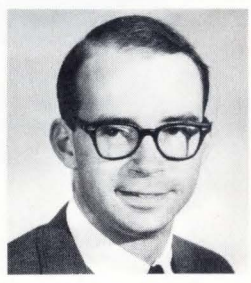
1. Forsberg, Roy W.: "ROM Shrinks Function Generator," EDN/EEE, June 1, 1971.
2. Prioste, Jerry E.: "Programming the MCM5003/5004 Programmable Read-Only Memory;" Motorola Application Note AN-550.
3. MC1406L Data Sheet, Motorola, Inc.
4. MCM5003AL Data Sheet, Motorola, Inc.

Editors Note

As this article was going to press, EDN learned in a telephone conversation that the author had just completed testing of the prototype circuit using an 8-bit monolithic DAC. This new monolithic DAC, the MC1480, will be announced later in the year by Motorola, and makes full use of the 8-bit word capability of the PROM. This offers better resolution than was possible using the 6-bit DAC described in this article since 256, rather than 64, discrete output levels are available. Karl was quite enthusiastic about the dramatic improvements in fidelity and accuracy that he achieved in generating a sine wave to 8-bit accuracy with the new DAC. One other IC manufacturer, Precision Monolithics, presently has an 8- and a 10- bit monolithic DAC, and several 1024-bit PROMs have been introduced in the last month. Improvements in PROMs and monolithic DACs promise to make the technique discussed in this article a more powerful design tool than it is now.

Author's biography



Karl Huehne is Section Manager of Instrumentation Applications group at Motorola Semiconductors Industrial Applications Dept. in Phoenix. He is responsible for the application of semiconductor devices to instrumentation problems, and is specifically involved in the knowledge and use of optoelectronic, digital and linear ICs. He joined Motorola Semiconductor Products Division in 1968, moving from Motorola's Government Electronics Division, where he had worked for 4 years as a design engineer. Karl received his BSEE from the University of Illinois and his MSEE from Arizona State University.

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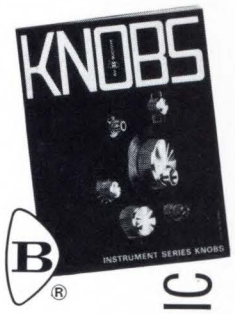

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Wolfgang Bank, University of Colorado, Department of Aerospace Engineering Sciences

Hot-wire anemometers are widely used in many areas of research work for accurately measuring the flow of liquids. These units are relatively expensive when high accuracies are required. With a single op amp, one transistor and some descrete components, though, a reliable hot-wire anemometer with excellent performance characteristics can be built. A schematic of the unit is shown in **Fig. 1**, and its operation is as follows:

A hot-wire (R_2) is heated to a higher-than-ambient temperature. The hot-wire is one arm of a Wheatstone bridge, the other arm being overheat resistor R_1, which is calibrated 30 percent larger than the cold resistance of the hot-wire. The bridge is fed from a power transistor, which is within the feedback loop of an op amp that senses bridge imbalance. As the hot-wire is cooled because of an increase in wind or liquid velocity, the bridge imbalance is sensed by the op amp. The imbalance voltage is fed back in proper phase to the power transistor, and the constant temperature condition in which $R_2 \approx R_1$ is reestablished.

Amplifier or bridge offset voltages have to be canceled to obtain the required stability and optimum frequency response from the anemometer. This is done with resistor R_3 and capacitor C_1.

Optimum frequency response is achieved by means of a square-wave test. To do this, a square-wave signal such as that available from most Tektronix oscilloscopes is fed into the bridge of the anemometer. The output pulsewidth ob-

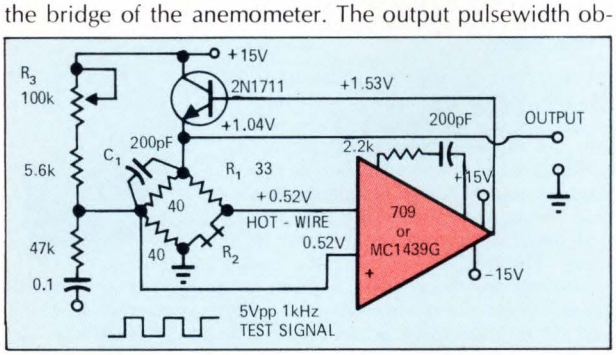

Fig. 1 – Bridge imbalance is sensed by the op amp and a resulting signal is fed back to the bridge, via the power transistor, to keep it in balance. The feedback signal serves as the anemometer output.

served on the scope is then minimized by consecutively adjusting the bridge offset voltage by means of R_3 and C_1 until further adjustment leads to an overshoot of the pulses (**Fig. 2**). The upper limiting frequency response (−3 dB) of the anemometer is then given by $F_{-3\,dB} = \frac{1}{1.5\,\tau}$, where τ is the time width of the pulses.

This method has been used for a 30-kHz bandwidth with over 50 feet of shielded cable between the anemometer and the hot-wire. Voltage readings in **Fig. 1** were taken with the hot-wire in still air.

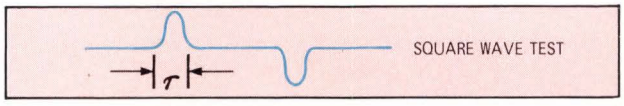

Fig. 2 – A square-wave signal is used to adjust the anemometer. R_3 and C_1 are adjusted to the point where further adjustment would lead to overshoot of the output waveform, shown here.

The hot-wire is a Wallaston wire, 10 percent Rh/Platinum, with a 0.0001 in. diameter, available from Sigmund Cohn Co., Mt. Vernon, NY. Other similar types can also be used. The wire is soldered to the tips of two sewing needles which are positioned 3 mm apart (**Fig. 3**). The silver is etched from the wire at the center exposing the 0.0001 in. Rh/Platinum wire within. This is done with a weak nitric acid directed with a hypodermic needle onto the wire while a dc current of 1 mA is passed through it. Since the hot-wire has to be repaired at intervals, it is best to construct a simple etching set-up. The whole operation of soldering and etching is done in 15 minutes.

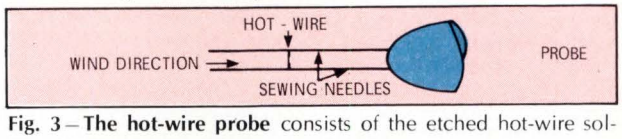

Fig. 3 – The hot-wire probe consists of the etched hot-wire soldered to two sewing needles positioned 3 mm apart.

Overheat resistor R_1 is best made accessible for ease of exchange, since it should be 20-30 percent larger than the hot-wire, which can vary slightly because of the etching process. The unit can be operated from standard ±15V supplies or with ±12V batteries. Since the relationship between wind velocity and output voltage is nonlinear, some type of linearizing circuit has to be used at the output if large velocity fluctuations are being measured. □

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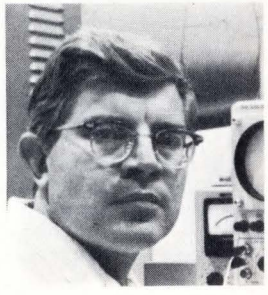
1. P. Freymuth, "Feedback control theory for constant-temperature hot-wire anemometers," **Review of Scientific Instruments**, 38-677 (1967).

Author's biography



Wolfgang J. Bank is a research technician in the Aerospace Engineering Department of the University of Colorado, and has been employed there for six years. Prior to this he was with the University of Manitoba where he operated the School's 50 MeV cyclotron.

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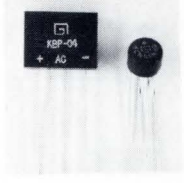
Miniature Bridge Rectifiers



General Instrument's Semiconductor Div. offers their popular WO4M and KBP04, 1.5A single-phase bridges. In production quantities they cost as low as $.25 each. These units have proven to be extremely versatile and are now being used in various consumer and industrial products. Voltage ratings through 1000V PIV are available. General Instrument Corp., Semiconductor Div., Semiconductor Products Group, P.O. Box 600, 600 W. John St., Hicksville, NY 11802. Phone (516) 733-3000. **275**

Terminal Block

A new, thermoplastic terminal block from Curtis offers savings over present phenolic models and is virtually unbreakable, according to the manufacturer. The reason behind both of these advantages is the material. Thermoplastics are more pliable than thermo-setting plastics, hence the greater resistance to breakage. Thermoplastic materials can be molded at much faster rates, thereby providing production economies which are reflected in lower costs. Curtis cites a price of approximately 7 cents per pole in volume purchases. Curtis' new block is available with any number of poles from one to 25 on 7/16 in. centers. The surface terminals on all variations of this block are clamps. Electrical ratings: 10A, 300V. Curtis Development and Mfg. Co., Inc., 3266 N. 33rd St., Milwaukee, WI 53216. Phone (414) 276-2872. **276**

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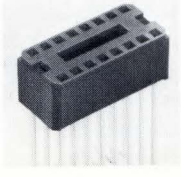
Closed Entry Wrap-Type IC Sockets*



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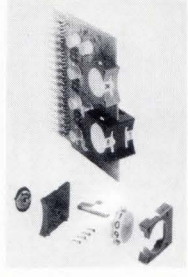
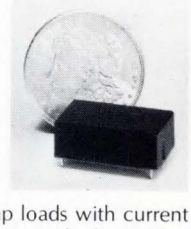
Unique Thumbwheel Switch Kits



Electronic Engineering Co. (EECo) offers the only thumbwheel switches available in kit form. The switch parts mount directly to and become an integral part of the users printed circuit cards. These switches, designated the 8000 Series, are less than 1 in. high and less than 1/2 in. wide allowing dense packaging. The 8000 Series switch kits can be assembled in a matter of seconds and requires no soldering or wiring. The user benefits by increased reliability and a reduction in labor costs. Both sealed and unsealed switches are available with service life better than 1,000,000 detent operations. Prices start at $3 in single quantities and are less than $2 in production quantities. EECo of California, 1441 E. Chestnut Ave., Santa Ana, CA 92701. Phone (714) 547-5651. **279**

5 Amp Relay



Minature relay, model 535, measures only 0.435 in. high and is capable of switching 5A at 26V dc. The Model 535, has been designed for applications with either demanding space limitations, such as 0.6 in. center-to-center PC card mounting, or operating requirements that cannot be met by reed relays or conventional contact-type relays. The high-pressure SPDT contact enables the unit to switch capacitance or lamp loads with current spikes that would normally weld the contacts or reed relays. Price is $1.81 in 1000-piece quantity. Delivery from stock. American Zettler, Inc., 697 Randolph Ave., Costa Mesa, CA 92626. Phone (714) 540-4190. **280**

Fasteners

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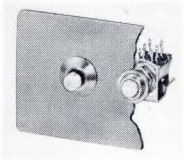
Dual Visual Recognition Switch



A new low-cost multi-function pushbutton switch featuring immediate, continuous recognition in "in" and "out" positions without lamps or indicators is available from Switchcraft, Inc. A new concept in man-machine interface switching, nonilluminated DVR (dual visual recognition) switches visually present a black color band behind a color recognition cap to indicate the "out" position. When pushbutton is depressed ("in" position) black band disappears, leaving only the bright colored Recognition Cap showing which readily signals that switch is set to "in" position. There is no possibility of a false identification caused by a malfunctioning lamp. Recognition Caps can be specified in choice of seven colors. DVR Switches, which feature up to 4-C switching are available with momentary (non-lock) and push-lock/push-release actuation. Prices for the new components range from $1.50 (1-C) to $2.50 (4-C). Recognition Cap Kits (25 Caps per kit) are $2.50. Switchcraft, Inc., 5555 N. Elston Ave., Chicago, IL 60630. Phone (312) 792-2700. **282**

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Glass sealed ceramic capacitors, models CG150 and GC250, feature high capacitance per unit volume, ultra stable TC and ceramic monolithic construction. Capacitance tolerance available include ±1%, ±2%, ±5%. Temperature coefficient range from 5 ppm to 30 ppm. Capacitors of 0.5 pf to 680 pf (CG150) and 10 pf to 3800 pf (GC250) at 25V can be specified. Elpac Inc., 18651 Von Kerman Ave., Irvine, CA 92664. Phone (714) 833-1717. **283**

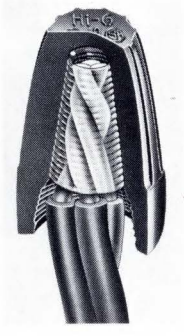
Molded Alumina Parts

Ceram's alumina molding process allows parts to be molded from 0.050 in. square to 24 in. square and thickness up to 1/4 in., controlled to ±0.002 in. Hole patterns or 3-dimensional geometry molded into the part and nickel metallization can be provided. Material used is aluminum oxide. Prices vary with quantity and configuration. Ceram Corp., 1126 N. Marshall Ave., El Cajon, CA 92020. Phone (714) 449-4522. **284**

Miniature Bus Bar

Multilayer planar bus bar (mini/bus) is used to distribute power and provide ground return to several components on a printed circuit board. Typically, it is a 2-layer (one carrying 5V dc and the other a ground return) for distribution of power to ICs mounted on PC cards. Also available are samples of strip/bus, a low-cost point-to-point wire form for commoning selected in-line pins in connector arrays. Strip/bus prices are as low as $0.01 per connection. Mini/bus prices are as low as $0.10 per bus. Rogers Corp., Rogers, CT 06263. Phone (203) 774-9605. **285**

Wire Connectors

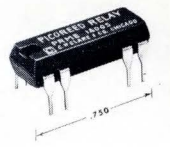


Wire connectors are available in bakelite and plastic. All sizes have a large, deep throat to permit easy entrance of wires, while internal threads help draw bulky insulation into skirt. The skirt is especially long to protect every approved wire splice, provide safe insulation and prevent the possibility of shorts or grounds. The protective, Bakelite shell has thick, strong walls so you can exert full pressure while screwing connector onto wire. Sizes available to connect 2, No. 19 wire (model Hi-0) through 2, No. 10 wire (model Hi-6). Nonporous plastic connectors are designed for production lines. Holub Industries, Inc., 413 De Kalb, Sycamore, IL 60178. Phone (815) 895-2161. **286**

Epoxy Resins And Fire-Retardent Chemicals

Dow epoxy resins include four distinct types: bisphenol-A/epichlorohydrin resins (both liquid and solid), epoxy novolac resins, flexible (polyglycol/epichlorohydrin type) epoxy resins, and flame retardant (brominated) epoxy resins. Dow has complete control of all the critical raw materials required to produce each type of epoxy. Fire retardant chemicals also made with bromine are also available. Dow Chemical Co., Bennett Bldg., 2030 Dow Center, Midland, MI 48640. Phone (517) 636-1000. **287**

Dry Reed Relay For 5V Operation

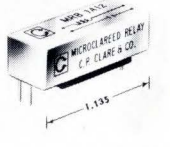


The Clare PRM1A005 molded epoxy dual-in-line package relay is compatible with most DTL/TTL drive ICs. The low contact noise and low thermal emf characteristics make the PRME ideal for electronic process control applications and low level applications. The Device has one Form A contacts rated at 10 VA, 100V or 0.5A maximum. Contact resistance is 200 mΩ measured at 10 mA, 1000 Hz. The nominal coil voltage is 5V dc and draws 65 mW. The relay's operate time is as low as 500 msec including bounce. Life expectancy is 100×10^6 operations at signal levels and 5×10^6 operations at rated load. List price is $3.00 each. C.P. Clare & Co., Pratt Blvd., Chicago, IL 60645. Phone (312) 262-7700. **288**

Monolithic Ceramic Chip Capacitors

KEMET chip capacitors in six popular chip sizes designed for hybrid circuits are available in two dielectrics—KEMET's unique BX that optimizes high capacitance with electrical characteristics and precision N.P.O. that provides outstanding stability for use in critical circuits. They feature, as standard, an exclusive end metallization process that eliminates open circuits resulting from silver "leaching" or "scavenging," common in conventional end termination systems. The chips are pre-tinned with solder for convenient circuit application and contain a conductive internal "barrier" that prevents the absorption of silver from the electrodes into adjacent solder. They will withstand 260°C exposure for twenty minutes with no degredation of electrical continuity and performance. Capacitance range is 10-330,000 pF and 10-5,600 pF in the BX and N.P.O. dielectrics, respectively. Union Carbide Corp., Components Dept., P.O. Box 5928, Greenville, SC 29606. Phone (803) 963-7421. **289**

Miniature Dry Reed Relay for 12V Operation



The MRB1A12 miniature Microclareed relay is packaged with a stamped metal cover and molded epoxy base measuring only 0.350 in. high for mounting on 0.5 in. PCB centers in 1.000 in. × 0.100 in. grid patterns. The relay features total input/output isolation, 800 msec switching speeds and 10 VA load switching. The 1 Form A contacts are rated at 10 VA, 200V or 0.75A maximum. Contact resistance is 200 mΩ measured at 10 mA, 1000 Hz. Life expectancy is 100×10^6 operations at signal levels and 10×10^6 operations at rated load. Typical operating time is less than 800 msec including bounce. List price $2.40 each. C.P. Clare & Co., 3101 Pratt Ave., Chicago, IL 60645. Phone (312) 262-7700. **290**

Shielding Tapes

Scotch brand shielding tapes Nos. X-1245 and X-1267 for EMI and RFI energy control have been developed by the 3M Co. The shielding tapes are designed to restrict radiating energy conveniently. They provide long-term effectiveness for such applications as: shielding for enclosures; electronic test equipment shielding; cable shielding; static charge draining and trouble shooting. Tape No. X-1245 has an embossed copper backing which permits solder connections; tape No. X-1267 is an embossed aluminum foil-backed tape. Both have pressure-sensitive adhesive backing for fast, clean application. Prices range from $2.70 to $10.80 per 18-yard roll, depending on width and quantity. 3M Co., Dielectric Materials and Systems Div., 3M Center, St. Paul, MN 55101. Phone (612) 733-1100. **291**

Mosfets*

General Instrument Corp., offers samples from their GIFET product line. Included are P-channel enhancement, N-channel enhancement, and N-channel depletion MOSFETs. The line also contains RF devices and high-speed switches. These devices are available for evaluation to qualified personnel in single, dual, or MULTIFET device structures. MULTIFETS are monolithic-multiple devices available in hermetic flat packs, and ceramic and plastic DIPs. MOSFET Marketing Group, General Inst. Corp., Semiconductor Div., 600 W. John St., Hicksville, NY 11802. Phone (516) 733-3535. **292**

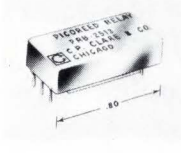
Standoff-Off Insulators

Stand-off insulator, model H1840-1, is molded of ROSITE 3250C, a non-tracking, glass-fiber, reinforced polyester, which has a U.L. listing, and is rated SE-0 self-extinguishing. This standoff is 1 in. high and 15/16 in. hex across the flats. In lots of 1,000, H1840-1 costs 23¢ each. Rostone Corp., Lafayette, IN 47902. Phone (317) 474-2421. **293**

Quadrature Couplers*

FILMBIRD 90° quadrature coupler, model QHF-2-.312G is one of a new series of −3 db couplers printed on thin dielectric films which are sandwiched between two ground planes. Frequency range is 225-400 MHz with typical isolation of 25-30 db. Other key specifications include: amplitude balance ±0.4 db, insertion loss 0.3 db, and average power 50W. The model QHF-2-.312G and other members of Merrimac's FILMBIRD family are ideally suited for such applications as arraying or paralleling solid state amplifiers, single-sideband modulators, imageless mixers, and power splitters and combiners. Price is $10 in small quantities. Merrimac Industries, Inc., 41 Fairfield Place, W. Caldwell, N J 07006. Phone (201) 228-3890. **294**

Micro-Miniature Dry Reed Relay



The Clare PRB2513 low-profile relay is packaged with a stamped metal cover and molded epoxy base measuring only 0.225 in. high for mounting on 0.375 in. PCB centers in 0.70 in. × 0.100 in. grid patterns. The relay is compatible with 5V DTL/TTL logic families and features total input/output isolation, immunity to false operation and insensitivity to transients. The PRB2513 has 1 Form A contacts rated at 10 VA, 100V or 0.5A maximum. Contact resistance is 200 mΩ measured at 10 mA, 1000 Hz. The nominal coil voltage is 12V dc. Operate times are typically less than 500 msec including bounce. Life expectancy is 100×10^6 operations at signal levels and 5×10^6 at rated load. List price at $2.75 each. C.P. Clare & Co., 3101 Pratt Ave., Chicago, IL 60645. Phone (312) 262-7700. **295**

Relays*

A variety of relays is available from Electronic Specialty Div. The line consists of twenty standard relays. Contact configurations ranging from 2PDT to 6PDT are capable of switching from dry circuit to 10A resistive. All relays are available in either the latching or non-latching version. Included are the 25 series time-delay relay available in either adjustable of fixed delays and the LG Series reed relay. One of its unique advantages allows the user to have a multi-packaging contact configuration. Also available are series 50N, 55N, 71N, 79N and 93N relays. Datron Systems, Inc., Electronic Specialty Div., 18900 N.E. Sandy Blvd., Portland, OR 97220. Phone (503) 665-0121. **296**

Reed Switch

A bounce-free miniature, mercury-wetted, Form A reed switch, Model WR-126, with life measured in hundreds of millions of operations is available from Gordos Corp. The capsule is pressurized for high voltage breakdown capability. Loads from dry circuit to 1A, 50 VA can be switched reliably. Life expectancy at low loads and 60 Hz max. cycle rate is 5 billion operations. Maximum cycle rate for the model WR-126 is 200 Hz. Switch resistance is 50 milliohms maximum. Priced from $4.50 to $2.90. Gordos Corp., 250 Glenwood Ave., Bloomfield, N J 07003. Phone (201) 743-6800. **297**

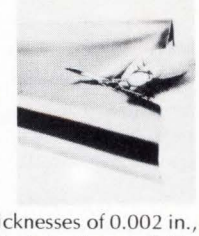
Reed-Switch Pushbutton

The FEATHER TOUCH Model, reed-switch pushbutton features small size rigid construction and keystem versatility. Available with one or two poles (Form A, B or C) the switch is rated at 28V dc, 1/4A. Life expectancy at full load is 20 million operations. Small diameter enables packaging on 5/8 in. centers. The keystem is designed to accept all popular keystops. Prices start at $2.40 each. Gordos Corp., 250 Glenwood Ave., Bloomfield, N J 07003. Phone (201) 743-6800. **298**

Lighted Push Button

Gordos lighted push button combines reed switch reliability with unique mechanical design. Available as a single pole switch, this model has max. ratings of 28V dc and 1/4A. A built in lamp ejector mechanism simplifies bulb changing. No tools are needed for replacing the T-1 3/4 lamps. The standard keytop is light-transmitting white Lexan, 1/2 by 1/2 in. square. Special keytops can be custom molded. Priced at $4.50 each in single quantities. Gordos Corp., 250 Glenwood Ave., Bloomfield, N J 07003. Phone (201) 743-6800. **299**

Netic and Co-Netic Magnetic Shielding Foil



Shielding foil stock for both high-and low-intensity magnetic fields is available with adhesive backing from Perfection Mica Co. The adhesive provides a positive grip for the foil for quick shielding application on prototype or production runs. The stock is fully hydrogen annealed to obtain maximum magnetic shielding properties. Netic or Co-Netic foil is stocked in 4 in. and 15 in. widths on 50 or 100 ft. rolls with nominal thicknesses of 0.002 in., 0.004 in., 0.006 in., and 0.010 in. Sheet Stock is also available 0.30 in. Perfection Mica Co., 740 Thomas Dr., Bensenville, IL 60106. Phone (312) 766-7800. **300**

Indicator Lights

A choice of indicator lights is available from the Sloan Co. Included are LED panel lights with flat- or dome-lens styles, circuit board mount, front replaceable incandescent and neon indicator lights, front-panel indicator lights and fixed lamp incandescent and neon indicator lights. The Sloan Co., PO Box 367, 7704 San Fernando Rd., Sun Valley, CA 91353. Phone (213) 875-1123. **301**

Spring-Loaded Seal

A line of spring loaded Teflon seals intended for use in applications where low friction and long seal life are required to eliminate seal maintenance are offered by Bal Seal. The seal consists of a sealing ring and a new garter type spring with slanted coils. Applications include linear potentiometers, rotary antennas, encoders, etc. Bal Seal Eng. Co., 17592 Sherbrook Dr., Tustin, CA 92680. Phone (714) 833-9640. **302**

DPDT, 5A Relays

A space-saving DPDT Series of enclosed plug-in miniature relays featuring 5A control capacity is available from Guardian Electric Mfg., Co. The new relays measure less than three-fourths of a cubic in. (1.10 in. × 744 in. × 894 in.) and feature rugged construction with mechanical life of 100 million operations dc, 50 million ac. They are available with a choice of termination: Plug-in termination (Series 1330) with a choice of sockets having either solder lug or printed circuit terminals or printed circuit termination (Series 1330P) that solders right on a PC board. Guardian Electric Mfg. Co., 1550 W. Carroll Ave., Chicago, IL 60607. Phone (312) 243-1100. **303**

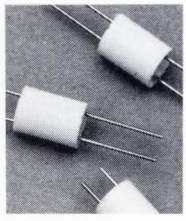
Aluminum Electrolytic Capacitors

Miniature, low-voltage, 85°C Aluminum Electrolytic Capacitors utilizing welded construction are offered. Available as axial lead (TAD Series) or upright radial lead (PCD Series), the new capacitors are designed for high performance printed circuit applications. Capacitance range is 0.5 μF to 2200 μF. Voltage range is 6.3V dc to 50V dc. Sizes as small as 0.197 (dia.) × 0.433 (length). In quantities of 1000, average price is under $.10 per unit. Available from stock to six weeks. Capacitor Div., International Electronics Corp., Melville, NY 11746. Phone (516) 694-7700. **304**

Sub-Miniature Switches

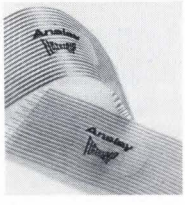
The McGill 4800 Series switch is a sub-miniature switch with a basic electrical rating and UL listing at 5A, 125-250V ac with 5A resistive and 2-1/2A inductive ratings at 30V dc. Case dimensions are approximately 0.400 in. (height) × 0.800 in. (width) × 0.250 in. (thick). Available with six different terminal types as standard, and various types of lever actuators. Other optional features include bifurcated and dual gold contacts to meet special operating requirements. McGill Mfg. Co., Inc., Electrical Div., Valparaiso, IN 46383. Phone (219) 464-1081. **305**

Bipin Bases



Samples of a two-lead bipin base used in the assembly of tiny incandescent lamps and other lighting products is offered by General Electric. The bases are made of nylon and come with two nickel leads in place. The bases are 0.198 in. ID, 0.228 in. OD, 320 in. high, and lead wire diameter is 0.020 in. The leads are spaced 0.125 in. apart. Although a major part of its current use is in incandescent lamps, this configuration can be utilized for encapsulation of light emitting diodes, photo cells, and other solid-state devices. Lamp Parts and Equipment Sales Operation of General Electric Co., 21800 Tungsten Rd., Cleveland, OH 44117. Phone 216-266-2121. **306**

PC Board Jumper



Flex-Strip jumpers consist of thin, flat copper conductors held firmly in position by two thin sheets of Teflon insulation. The sheets are bonded together resulting in an extremely flexible multi-conductor jumper. Even though the conductor length between sheets of insulation is flat for flexibility, the section of the conductor which protrudes beyond the insulation edge is a round pin for compatibility with holes in circuit boards. Conductor and pin are one continuous piece of copper. There is no joint. Available with a choice of number of conductors spaced on 0.050, 0.100, 0.125, 0.150 or 0.200 centers in various lengths. Pins can be straight, bent 90° and staggered. The jumpers are rated at 2A at 600V ac. Typical cost for a 20 conductor jumper, 2 in. long is $1.77 each in 50 unit quantities. Ansley Electronics Corp., Old Easton Rd., Doylestown, PA 18901. Phone (215) 345-1800. **307**

PC Material

Westinghouse SOLDER FLEX flexible printed circuit material is a unique new product which eliminates the adhesive interface common to other flexible circuitry materials. A high temperature film on copper, it is fully solderable under normal printed-circuit processing conditions. Full solderability and availability in roll form for continuous processing, plus 180° flexibility make SOLDER FLEX an outstanding circuitry material. SOLDER FLEX is ideal where space, weight, and cost requirements are critical. Westinghouse Electric Corp., Industrial Plastics Div., Box 657, Bedford, PA 15522. Phone (814) 623-9014. **308**

PC Card Handles

Plastic printed-circuit card handles are available in a variety of colors to suit the requirements of most equipment. Two of the handles, Models 10035 and 10037, have a specially designed clip-on feature which enables them to be assembled into a PC Board without any mounting hardware, since they snap into pre-drilled holes on the PC Board. The former is used with PC Boards mounted at a minimum center distance of 0.25 in. while the latter is used with boards at a minimum pitch of 0.4 in. The third series is the Model 10036, which attaches to the PC Board by means of two screws or rivets. It is used with PC Boards mounted at a minimum center distance of 0.35 in. All three handles have card-identification provisions. The prices range from $0.16 to $0.12 each. Vero Electronics Inc., 171 Bridge Rd., Hauppauge, NY 17787. Phone (516) 234-0400. **309**

Modular Power Supplies*

Teco 15V modular power supplies are designed for use with operational amplifiers and logic circuitry wherever designers or manufacturers require reliable, regulated and short-circuit protected power supplies at economical prices. They are packaged in a standard encapsulated plastic case which may be plugged into available sockets, or they may be soldered directly onto a printed circuit board. Standard supplies are available with output currents of 25 mA, 60 mA, 100 mA and 200 mA. Voltage is 115V ac. Line regulation depending upon model varies from 0.2% to 0.05%. Load regulation similarly varies from 0.2% to 0.1%. Prices range from $28.80 to $43.75 in unit quantities. Tilton Electronics Corp., Box 218, Winnisquam, NH 03289. Phone (603) 524-1998. **310**

Pads And Core Supports

FOTOCERAM pads and core supports provide improved manufacturing yields and better field reliability because of the unique material. It is a non-porous glass ceramic and is completely homogeneous. Its surface is free of void, pits, grain pullout or hardness differences common to alumina or barium titanate ceramics. Surface finishes of less than 1μ in. are easily obtainable using common mechanical machining techniques and equipment. In general, ±0.001 in. tolerances can be held in small parts. Slot widths as narrow as 0.006 are practical. Using no sealing glasses, two laminations of FOTOCERAM can be permanently bonded by Corning during the standard manufacturing process. Corning Glass Works, FOTOCERAM Products Group, Fluidic Products Dept., Houghton Park, B-2, Corning, NY 14830. Phone (607) 962-4444. **311**

Miniature Scott "T" Transformers*

Miniature Scott "T" transformers, Models 50720 and 50734, are available in printed circuit mounted types with pins on 0.1 grid and operate over the full military temperature range. Application is for synchro-to-digital and synchro-to-linear output conversion and digital-to-synchro conversion. Synchro input for the 50720 is 90V or 11.8V rms line to line, 400 Hz. For the 50734 the input is 11.8V. Resolver output is 6V rms center tap. Angular accuracy: 60 arc sec (50720); 30 arc sec (50734). The price is $70 for 50720 and $60 for 50734. Magnetico, Inc., 6 Richter Court, E. Northport, L.I., NY 11731. Phone (516) 261-4502. **312**

Connectors

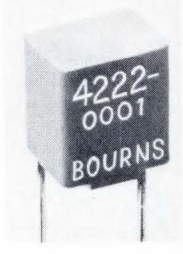
Compact 20 contact-connector units can be used to provide plug-in convenience for intricate wiring problems. These units are available in solder-lock terminals or in tapered-tab terminals. The 20 contact unit is a basic building block module for 40, 60, 80 and 100 contact connector assemblies. Price for either jack or socket is $0.45 each. North Electric Co., PO Box 688, Galion, Ohio 44833. Phone (419) 468-8100. **313**

Pulse Transformer*

Miniature pulse transformers are available in a wide variety of primary pulse inductors and in different package sizes including DIP. Typical electrical characteristics include 25% duty cycle, 50V peak pulse voltage, 250 mW maximum average power and ±10% inductance stability over the temperature range of 0 to 70°C. Prices average $4 each in 10-24 piece lots. Bourns Pacific Magnetics Corp., 28151 Highway 74, Romoland, CA 92380. Phone (714) 657-5195. **314**

Microinductor*

Microminiature inductors, Model 4222, that operate over the frequency range of 50 Hz to 50 kHz are available from Bourns Pacific in inductance values varying from 0.1 to 6H. Laminated core gives high efficiency to these inductors. Typical voltage levels are from 0.1 to 20V. Dc currents range up to 20 mA. Q's vary from 0.5 to 50. Bourns Pacific Magnetics Corp., 28151 Highway 74, Romoland, CA 92380. Phone (714) 657-5195. **315**



Flame Retardant Tape

A tape designed to meet the flame retardance requirements for color television and other electronic components has been developed by 3M Co. Called Scotch brand electrical tape No. C-1266, it features flexible handling characteristics similar to conventional paper and acetate cloth tapes, yet it has a functional upper temperature limit of 130°C., according to 3M. The tape can be used on flyback transformers, yoke coils, convergence coils and other components. A tough tape, it conforms to irregular surfaces and can be applied with automatic tape winding machines. It has a thermosetting type, pressure sensitive adhesive backing made of a modified rubber resin. In addition, the tape is easily printable by methods such as typewriter, stamping and pen. The thermosetting cycle of the tape is 1 hr. at 300°F., 2 hrs. at 275°, or 3 hrs. at 250°F., tests showed. Prices range from $1.40 to $5.60 per 60-yard roll, depending on width and quantity ordered. 3M Co., Dielectric Materials and Systems Div., 3M Center, St. Paul, MN 55101. Phone (612) 733-1100. **316**

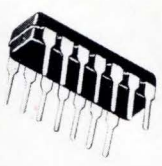
Woven Interconnect System

Cables and harnesses woven with nylon, teflon, nomex, metal and other fibers are produced by Woven Electronics for a fast increasing number of routine and highly specialized applications. Some of the variety of cables available include controlled-impedance cable, accordion-fold cable, programmed-woven cable, twill-weave cable, woven cable with mixed conductor sizes, woven cable with twisted pairs or twisted triads, short jumper cables, woven-harness assemblies, woven flat-coax cable, shielded cable, woven cables with fold and strip lines, woven cable with branches and woven cable with multiple layers. Woven Electronics, PO Box 189, Mauldin, SC 20662. Phone (803) 288-4411. **317**

Connectors and IC Sockets

Fourteen and 16-pin DIP sockets for back panel assemblies and PC connectors on 0.1 and 0.2 in. grids are available from Dynatech. All of these items can be supplied on laminated aluminum back panel assemblies. Laminated back panels utilizing any of the above parts have significant electrical, mechanical and economic advantages over other back-panel designs. Chief electrical advantage is the filtering which results from the very low impedance of the separate planes in the capacitance coupling resulting from the thin dielectric use. As faster circuits are used, this filtering capability becomes more important. In most cases the cost of these units is lower than other combined ground and power back panels. Dynatech Corp., 1225 E. Wakeham Ave., Santa Ana, CA 92702. Phone (714) 547-6559. **318**

DIP Reed Relay



Fourteen-pin DIP reed relay is automatically insertable and will retrofit existing IC sockets. Contact forms of 1A, 2A, 1B and 1C are available in nominal coil voltages of 5, 6, 12 and 24V dc. Life expectancy of the 814 Series relays is said to be 50 million operations. Contact voltage is 28V dc; contact current is 0.110A. The relays have a service temperature range of −55 to +105°C. Dc contact power is 3W. Also available as samples are dry reed relays in both standard and miniature configurations in the 800 Series and solid-state relay modules Series 930. New Product Engineering, Inc., A Subsidiary of Wabash Magnetics Inc., First and Webster Sts., Wabash, IN 46992. Phone (219) 563-2191. **319**

Heat Sinks

Three natural convection semiconductor coolers are available from Tran-Tec. Corp. The Model 10 is an ideal compact unit for conduction applications. Thermal resistance is as low as 3° C/W. Size is 2.94 in. wide by 1.31 in. high by 3 in. long. The Model 15 has a thermal resistance of 1.3° C/W and is 4.63 in. wide. The Model 11 is a powerful conduction unit. Low thermal resistance of 2.5° C/W. Model 11 is 4.81 in. wide by 1.31 in. high by 5 in. long. Tran-Tec Corp. PO Box 1022, Columbus, NB 68601. Phone (402) 564-2748. **320**

Semiconductors*

Samples from the complete line of semiconductors is offered by Amperex Electronics Corp. Devices offered include diodes and rectifiers, transistors, linear ICs and photo semiconductors. Amperex Electronic Corp., Semiconductor Div., PO Box 98, Slatersville, RI 02876. Phone (401) 762-9000. **321**

CMOS Devices*

Solitron Devices, Inc., is offering engineering samples of CMOS devices. The devices can be chosen from Solitron's extensive list of the 4000 A Series of CMOS ICs. Solitron Devices, Inc., PO Box 1416, 8808 Balboa Ave., San Diego, CA 92112. Phone (714) 278-8780. **322**

Connectors

A gripping type connector, the Berg/Griplet, is offered for use in circuit boards. Machine-insertable at rates up to 100,000/hour. Griplets assure solderability that is more reliable and less costly than other terminals or through plating. Berg Electronics, Inc., New Cumberland, PA 17070. Phone (717) 938-6711. **323**

Interconnection System

Samples of parts for the BergCon interconnection system are offered. This system includes crimp to wire interconnects, receptacle, daisychain (continuous length of wire with insulated TV disconnects crimped at uniform intervals), pin and ferrule assembly and posts for IC mountings. Also included are snap housings and PV card connectors. System provides interconnections for 0.100, 0.125 and 0.150 spacing. Berg Electronics, Inc., New Cumberland, PA 17070. Phone (717) 938-6711. **324**

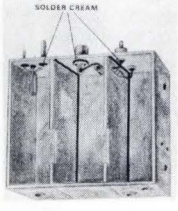
Miniature PC Socket

The Berg MINISERT, a low profile plugable socket, provides positive functional reliability over repeated insertion/withdrawal cyclings; accepts many sizes of round or flat leads. The socket assures positive retention in the circuit board prior to soldering and spring board electrical contact after soldering. The socket is of 2-piece design. It has a heat-treated beryllium copper spring which is assembled into a tin plated copper cup. The spring is gold plate and provides multiple cycle life with high contact forces. The miniature sockets accept round leads ranging from 0.012 in. to 0.022 in. in diameter or flat leads from 0.008 in. to 0.015 in. thick by 0.015 in. to 0.023 in. wide. Berg Electronics, Inc., New Cumberland, PA 17070. Phone (717) 938-6711. **325**

Solder Preforms

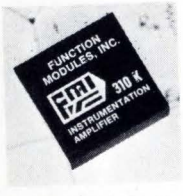
Alpha flux coated preforms provide important improvements over solid, solder and flux-filled solder preforms for automatic soldering. Flux coated preforms are preshaped solder parts coated on the outer surface with water/white rosin flux in nonactivated, mildly activated formulations. Flux coated preforms are available in all standard configurations – discs, wire forms, washers and squares – and also in multilayer preforms and spheres. Alpha Metals, Inc., 56 Water St., Jersey City, N J 07304. Phone (201) 434-6778. **326**

Solder Creams



Solder creams are homogeneous combinations of solder and flux and provide for rapid production of dependable solder joints in a single operation. They are ideal for continuous or indexed mass production lines and suitable for use on any solderable metallic surface. The advantages of solder creams include: controlled deposits in area and thickness; elimination of a separate fluxing operation; availability in a wide variety of alloys and flux combinations; reduction of time and labor costs; controlled viscosity for easy application. Alpha Metals, Inc., 56 Water St., Jersey City, N J 07304. Phone (201) 434-6778. **327**

Modular Instrumentation Amplifier*



The Model 310J instrumentation amplifier is offered to qualified engineers by Function Modules, Inc. It is packaged into a module 1.5 in. sq. and 0.5 in. high and offers the performance of expensive rack mounted instrumentation amplifiers. The Model 310J has a maximum input voltage drift of ±3 μV/°C and maximum input offset of ±500 μV. Input range is ±10V. with an input impedance of 10 MΩ. No external trimming is needed to obtain a minimum cmr of 100 dB from dc to 100 Hz. The gain can be set by one external resistor to any value between 10 and 1000. In 1-24 quantity the price is $29 each. Function Modules, Inc., 2441 Campus Dr., Irvine, CA 92664. Phone (714) 833-8314. **328**

Capacitors*

Samples from the complete line of El-Menco capacitors are offered. Included are dipped mica, molded mica, transmitting mica, silvered mica films, mylar dipped, mylar paper dipped, paper dipped, tubular paper, tubular mylar-paper and mylar with a mylar wrap. Also available are variable mica compression capacitors. The Electro Motive Mfg. Co., Inc., Willimantic, CT 06226. Phone (203) 423-9231. **329**

Microwave Choke*

Series M coil, only 0.025 in. in diameter by 0.05 in. long is available from Piconics for special ultra-high frequency microwave devices. Piconics, Inc., Cummings Rd., Tyngsboro, MA 01879. Phone (617) 649-7501. **330**

Miniature Relays

Samples of the Series 900 subminiaturized crystal-case relays and the M, J and H Series miniature relays are offered. Crystal-case miniature relays are designed to meet advanced circuitry requirements for high density packaging and circuit board. They all feature balanced rotary type armatures to provide maximum immunity to severe shock, vibration, acceleration forces. All relays are designed to meet or exceed the requirements of Mil-R-5757. Life expectancy is 100,000 operations at rated loads. Westinghouse Air Brake Co., Aerospace Dept., Pittsburgh, PA 15218. Phone (412) 242-5000. **331**

Thick-Film Chip Resistors*

An expanded product line of precision/thick-film chip resistors which meet a wide range of hybrid microelectronic applications is offered by Mini-Systems, Inc. Wire-bond resistor types feature gold metalization; reflow solder types feature silver bearing solder pinning. All chip-resistor types have glass passivation over the resistor body. Resistors are available in values from 1Ω to 10 mΩ and standard tolerances of 1%, 2%, 5% and 10%. Mini-Systems, Inc., 20 David Rd., PO Box 67, N. Attleboro, MA 02761. Phone (617) 695-0206. **332**

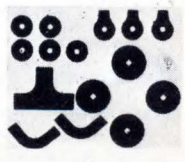
IC Op Amp*

An hermetically sealed IC op amp, Type 741, is available from Mini-Systems, Inc. The 175-mil diameter device combines chip-size advantage with conventional mounting and handling techniques in the hermetic and pretested device with 5-mil lead spacing. All major performance advantages of the standard μA 741 amplifier have been retained with this new package. The TINY-PAK package by Mini-Systems offers a space reduction of 3 times over that required by the conventional 1/4-in. by 1/4-in. flat pack (To-91) but retains normal lead spacing to permit handling and testing in standard carriers. Leads can be easily bent or cut as required. Price in 1 to 24 quantity is $9.50 each. Mini-Systems, Inc., PO Box 429, N. Attleboro, MA 02761. Phone (617) 695-0206. **333**

Fastening Devices

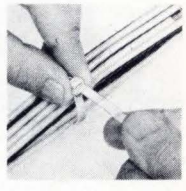
Samples of screws, nuts and washers are available from the J. I. Morris Co. Included are popular sizes of unified miniature screws in brass and stainless steel with flat fillister and flat heads, pan heads and binding heads. Self-tapping stainless steel screws and stainless lock washers are also available. J. I. Morris Co., 394 Elm St., Southbridge, MA 01550. Phone (617) 764-4394. **334**

Printed Circuit Drafting Aids



Samples of pressure-sensitive printed-circuit drafting aids are available from By-Buk. Patterns include multipad artwork such as TO-5 and TO-18 cans, 4, 6, 8, and 10 lead steel cans, patterns for dual in-line packages and flat packs. Additional patterns include transistors, space IC pads, connector contacts and conductor lines. All parts are standard sizes conforming to Mil-STD-275 and the Institute of Printed Circuit Standards. By-Buk Co., 4326 W. Pico Blvd., Los Angeles, CA 90019. Phone (213) 937-3511. **335**

Cable Ties



Easy to use, low-cost one-piece "Quik-Wrap" cable ties save time on all kinds of wire and cable bundling. They're inexpensive, infinitely adjustable and self-locking. They make a permanent, neat installation. "Quik-Wraps" are applied by hand or tool. Molded of virgin nylon, the cable ties combine the important physical properties of light weight, resistance to abrasion, toughness, high tensile strength and exceptional dielectric properties with chemical resistance to common solvents, dilute acids, oils and grease. Temperature range is 66°F to +340°F. For bundle dia. from 1/8 in. to 4 in. Holub Industries, Inc., 413 De Kalb, Sycamore, IL 60178. Phone (815) 895-2161. **336**

Microelectronic Inductor

A new low-cost microelectronic inductor is available for computer and commercial application. This device should find use in chokes, peaking coils and RF and IF tank circuits. Price is $0.25 each at 100 pieces, $0.19 each on large quantities. Piconics, Inc., Cummings Rd., Tyngsboro, MA 01879. Phone (617) 649-7501. **337**

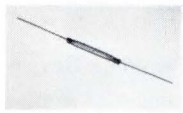
Miniature Reed Switch

The MLC-2 miniature, form A, dry reed switch designed specifically for reliable operation over an intermediate life where low cost is a prime consideration is available from Hamlin. Hermetically sealed contacts insure that the switch will be unaffected by dust, corrosion or oxidation. PC contact rating 10W max.; switching voltage 28V dc; dc current rating 1/2A. Hamlin priced as low as $0.24 in OEM quantities. Hamlin, Inc., Lake and Grove Sts., Lake Mills, WI 53551. Phone (414) 648-2361. **338**

Magnetic Reed Switches

Various groups of ampere-turns of sensitivity are available from a total range of 15-80A turns. Rhodium contacts provide reliable, miss-free operations in the order of one hundred million closures. Operate times are 10 msec when actuated with a permanent magnet and less than 500 msec when actuated with an electromagnetic coil. Contacts are rated at 10W at 200V dc. Glass length is 0.750 in. and overall length is 2.250 in. Magnetic reed switches are sealed in glass containing inert gasses for total protection from amb. environments. Switches are not position sensitive. Prices are $0.20 in 10,000-pc quantities. Flair Electronics, Inc., P.O. Box 543, Glendora, CA 91740. Phone (213) 963-6077. **339**

Magnetic Reed Switches



Various ranges of ampere-turns are available from a total range of 10-50A turns. Rhodium contacts provide dependable, miss-free operations in the order of one hundred million closures. Operate time when actuated with a permanent magnet is less than 10 msec. When actuated with a coil actuation time is less than 250 msec. Contacts are rated at 3W at 30V dc. Glass length is 0.450 in. and over all length is 2.0 in. Magnetic reed switches are sealed in glass containing inert gasses for total protection from amb. environments. Switches are not position sensitive. Prices are $0.33 in 10,000-pc quantities. Flair Electronics, Inc., P.O. Box 543, Glendora, CA 91740. Phone (213) 963-6077. **340**

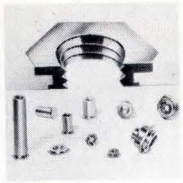
Magnetic Reed Switches

Various groups of ampere-turns of sensitivity are available from a total range of 40-150A turns. Rhodium contacts provide reliable, miss-free operations in the order of 10 million closures and more. Operate times are 15 msec when actuated by a permanent magnet and less than one msec when actuated with an electromagnetic coil. Contacts rated at 15W at up to 1500V dc. Glass length is 2.100 in. and over all length is 3.250 in. Magnetic reed switches are sealed in glass containing special gas formulations for total protection from amb. environments and capacitive discharges. Switches are not position sensitive. Prices are $1.20 in 10,000-pc quantities. Flair Electronics, Inc., P.O. Box 543, Glendora, CA 91740. Phone (213) 963-6077. **50**

Heat-Sealable Teflon Tapes

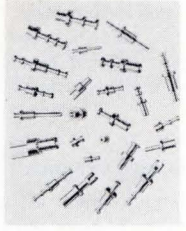
Type DF-1700-DB is a unique heat bondable Teflon TFE multilaminar cast tape that can be heat sealed to itself, TFE or FEP. This composite is formed by casting a thin layer of Teflon FEP on both sides of the base Teflon TFE. Type DF-1700 is coated on one side only with FEP. Both type DF-1700 and type DF-1700-DB heat bondable cast tape provide excellent insulation for wire wrapping, flat-ribbon cable, printed circuit bases, layflat tubing, flexible-strip heater covers, and closures. Dilectrix Corp., 69 Allen Blvd., Farmingdale, NY 11735. Phone (516) 249-7800. **51**

Captive Nuts and Studs



A series of Pressert captive nuts and studs which mount easily in brass, aluminum, and mild steel chassis' for panels up to 5/16 in. thick is offered by Precision Metal Products. No special tool is required. Presserts install in a drilled or punched hole with a simple arbor press. Material displaced by the head cold flows into the Pressert's channel to form a lock that will withstand hundreds of pounds of push-pull pressure. The hex design of the head secures the Pressert against torque. PMP's Presserts are made of 303 stainless steel to provide a mounting which is superior to threaded holes or conventional nut/bolt assemblies. In addition, the stainless steel provides long life in applications requiring repeated fastenings without burring, cross-threading or stripping. Precision Metal Products Co., 41 Elm St., Stoneham, MA 02180. Phone (617) 438-3650. **52**

Ultra-Miniature Precision Metal Pins



A sample kit of ultra-miniature precision metal pins is being offered by Precision Metal Products Co. Pins are available in various configurations and sizes, ranging from 0.005 in. to 0.093 in. in diameter, and up to 1 in. in length. Made of free-cutting brass per QQB-626, composition 22, the pins are offered in a variety of platings including goldflash, nickel and silver. Applications for these ultra-miniature, precision metal pins include: connector plugs, plug-in integrated circuit packages, relays, crystals, components, logic modules or wherever an interconnection is made through the use of a male/female pin and socket. Precision Metal Products Co., 41 Elm St., Stoneham, MA 02180. Phone (617) 438-3650. **53**

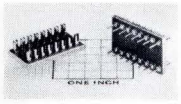
Aerosol Cleaner

A new aerosol cleaning fluid for electronic components is available from Percy Harms Corp. The new cleaner is specially designed to clean without any deleterious effects on plastics, rubber or painted surfaces. It will remove oils, greases, fingerprints, accumulation of dirt, waxy deposits, etc. Called Slide-Electronic Contact Cleaner, this product will leave no residue after evaporation says the manufacturer. It provides a constant source of clean solvent for selective delivery to chosen areas to be cleaned. Electronic Contact Cleaner is recommended for use on circuit boards, tape heads, switches, tuners, motors and other precision components and equipment. It is non-conductive and non-flammable. Percy Harms Corp., 7349 N. Hamlin Ave., Skokie, IL 60076. Phone (312) 679-0587. **54**

Pressure Sensitive Adhesive Mount

A snap-in adhesive backed mount for securing harnesses to smooth surfaces in light duty applications is available from Panduit Corp. The unique mount has a pressure sensitive adhesive backing with a peel-off paper cover and can be used with either locking or releasable cable ties. The new mount includes a retaining notch which holds the cable tie head in place below the bundle. In addition to the advantage of eliminating protruding heads, this design facilitates one-hand threading of cable ties by properly orienting and holding the head in place. The snap-in adhesive mount is used in conjunction with standard cross-section PAN-TY(R) PLT2S (locking) and PRT2S (releasable) cable ties which accommodate harness dia. up to 1-3/4 in. and 2 in. respectively. These cable ties are available in ivory and telephone gray to match the adhesive mount colors. Mounted to virtually any clean, dry, smooth surface, the new SMS-A mount is designed to support one-half pound when used without screws or rivets. Panduit Corp., 17301 Ridgeland Ave., Tinley Park, IL 60477. Phone (312) 532-1800. **55**

IC Socket Adapters

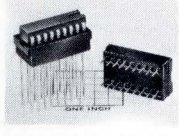


Samples from a family of 8 component socket adapters are offered by Cambion. These adapters are used for mating discrete components (such as resistors and capacitors) with dual in-line sockets. These adapters increase electronic packaging flexibility and cover a wide range of needs. Some socket adapters fit directly on a single IC socket, while others straddle two sockets thereby serving for mounting larger components. The complete family includes 2, 8-pin; 1, 12-pin; 2, 14-pin; 2, 16-pin; 1, 18-pin adapters. Terminal portions of the posts are slotted for easy component mounting. Terminal material is brass with hard gold plating over gold flash. Cambion Thermionic Corp., 445 Concord Ave., Cambridge, MA 02138. Phone (617) 491-5400. **56**

80-Pin Dual In-Line Socket

Integrated socket assembly 703-1000-01-04-00 consists of a rigid structural member of glass reinforced diallyl phthalate with Wire-Wrap™ posts and spring contacts accurately positioned and held in place by four removable covers. Two rows of 40-pins each are positioned so that a maximum of 5,16-pin ICs may be inserted with ends butting one another. Any dual in-line package may be used with the integrated socket which also provides for V_{cc} and ground busses. No printed circuit board is required for support. Cost competitive on a functional basis with other electronic packaging techniques, the integrated socket is ideal for unique designs where high concentrations of dual in-line devices and Wire-Wrap interconnections are required. Cambion's integrated sockets are available from stock and are priced at $5.00 each in quantities from 50 to 99. Cambion Thermionic Corp., 445 Concord Ave., Cambridge, MA 02138. Phone (617) 491-5400. **57**

18-Pin Sockets



Cambridge Thermionic Corp., offers two basic styles of 18-pin sockets with configurations for Wire-Wrapping (Series 703-3895) and for soldering (Series 703-3787) to PC boards. Both types are available in either gold plated contacts or tin plated contacts, making a total of four individual part numbers. The rapid growing use of semiconductor memories packaged in 18-pin dual in-line cases, makes this Cambion socket family particularly attractive. These sockets are made to strict IC tolerances and with reliable mechanical strength. Cambridge Thermionic Corporation, 445 Concord Ave., Cambridge, MA 02138. Phone (617) 491-5406. **58**

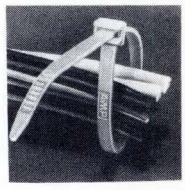
Ceramic Capacitors

Mono-Kap, an extended line of miniature ceramic capacitors, are available from USCC/CENTRALAB. The 50, 100 and 200V cd units are now available in six sizes (0.100 × 0.100; 0.150 × 0.150; 0.200 × 0.200; 0.300 × 0.300; 0.400 × 0.400 and 0.500 × 0.500) and four dielectrics. With 100% monolithic construction, capacitance values of 4.7 pF to μf are offered in this radial lead, epoxy coated ceramic capacitor. Delivery is from stock on 146 standard distributor items, with prices starting at $0.09 each in production quantities. USCC/CENTRALAB, 2151 N. Lincoln St., Burbank, CA 91504. Phone (213) 843-4222. **59**

Molded Clamps

Tyton Corp. is offering samples from a new line of injection molded nylon clamps for wires, cables, conduit, etc. Called NX Series Ty-Clamps the clamps are made of Nylon 66. Sixteen sizes are available from stock, with clamping capacities of 0.13 in. to 2.00 in. The seven larger sizes from 0.5 in. up are adjustable. The adjustment feature allows the installer to fit the clamp sizes required. Nylon NX Series are black, resistant to ultra-violet rays, climatic conditions and a wide range of chemical attack. A molded-in tongue on the adjustable types assures accurate alignment when tightening. Working temperature range −50° to 80°C (+90° to 175°F) continuous, 125° (260°F) intermittent service. Tyton Corp., 9055A N. 51st St., Milwaukee, WI 53223. Phone (414) 354-0100. **60**

Cable Ties

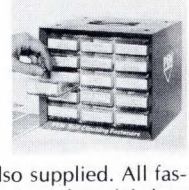


New lines of AMP-TY nylon cable ties incorporate dual stainless steel pawls to provide up to twice the bundling tensile strength of all-plastic cable ties. AMP-TY cable ties are available in four sizes to accommodate bundles from 1/16 in. to 4 in. in dia., with each size being infinitely adjustable within its range. Requiring only light hand tension for threading, the ties are self-locking and provide tensile strength in excess of MIL-S-23190B requirements. The ties are supplied in natural color nylon. Outdoor weather-resistant black and other colors are available upon request. AMP Inc., Harrisburg, PA 17105. Phone (717) 564-0101. **61**

Linear & Digital ICS*

Advanced Micro Devices, offers evaluation samples of any of the more than 100 line items available. All AMD's hermetic circuits undergo temperature cycling stabilization bake and hermeticity testing to the requirements of Military Standard 883. Epoxy encapsulated circuits are subjected to applicable stress tests. The firm's TTL/MSI line offers all the popular MSI functions including second-source circuits from Fairchild's 9300 line and TI's Series 54/74, as well as proprietary devices. The computer interface circuits include proprietary as well as second-source drivers and receivers and one shots. The company's bipolar memory line currently is composed of a 64-bit RAM, a low-power version of the same device and a proprietary 256-bit RAM. Advanced Micro Devices, Inc., 901 Thompson P1., Sunnyvale, CA 94086. Phone (408) 732-2400. **62**

Self-Clinching Fasteners



24 different types of fasteners (23 self-clinching and one weld type), including PEM nuts, standoffs, studs, flush nuts, self-locking nuts, panel fasteners, template drill bushings and PEM weld nuts are available. Many of these fasteners are represented by several thread sizes and materials. Three types of self-clinching, self-locking nuts are also supplied. All fasteners were selected to meet a broad cross section of model shop requirements. Penn Engineering & Mfg. Corp., Box 311, Doylestown, PA 18901. Phone (215) 766-8853. **63**

Self-Adhesive Stripline Conductors

Circuit-Stik's new self-adhesive stripline parallel-conductor subelements have insulated epoxy glass substrates and are designed for high-density prototype applications. The stripline subelements are available in many conductor line widths from 0.010 in. to 0.250 in. When used with other standard Circuit-Stik component subelements, the stripline may also be used for high frequency breadboarding, for making card extenders, and for repair of production circuit boards. Circuit-Stik, Inc., 24015 Garnier St., P.O. Box 3396, Torrance, CA 90510. Phone (213) 530-5530. **64**

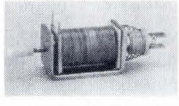
High Resolution Wirewound Potentiometer

The 901 wirewound potentiometer is designed to interchange with all of the popular 1-1/4 in. wirewound trimmers on the market today (RT11P and RT12Y configurations). It is not only physically interchangeable but meets or exceeds all performance parameters of the larger, old-style 1/4 in. devices. At 10Ω, the lowest resistance value, the 901 has 1% resolution. A very low 0.15% resolution is available at 20 kΩ. This resolution is housed in a flame retardant molded plastic case measuring only one inch long. Offered in a resistance from 10Ω to 50 kΩ, it has a power ratings of 1W at 70°C with an operating temperature range of −55°C to +150°C. Absolute minimum resistance is 0.2% or 1.0Ω, whichever is greater. A temperature coefficient of +50 ppm per °C is stated. Also manufactured in a panel mount, leadwire version, the 901 is priced as low as $1.68 in quantity. TRW Electronic Inc., 2801 72nd St., N. St. Petersburg, FL 33733. Phone (813) 347-2181. **65**

Drafting Aids

Pressure-sensitive artwork symbols and drafting aids precisely matched to circuit board component specifications are offered by Centron. Centron has significantly expanded its product line of circuit board artwork materials and drafting aids with the addition of over 3500 new items. New items featured include individually precut sequential reference designations and a complete assortment of letters and numbers of various sizes, related drafting words, schematic and logic symbols, new connector fingers, and fillets. These additions now make all PC master-artwork drafting aids available from Centron as one source. Precision Printed Artwork Symbols, Centron Engineering Inc., 24015 Garnier St., P.O. Box 3396, Torrance, CA 90510. Phone (213) 530-5530. **66**

Industrial Solenoids

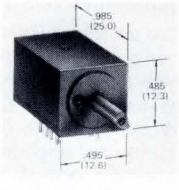


Industrial solenoids featuring standard options, including clevis, pushrod, nylon tip, shock dampener, and return spring, and/or combinations are offered by Hi-G. 2304 possible combinations of size, coil voltage, duty cycle, and coupling options are possible says the manufacturer. 8 frame sizes using all UL approved materials with nominal coil voltages of 6, 12, 24, and 120V dc are available. Ambient temperature range of −40°F to +140°F. Basic "A" size solenoid price is 86¢ each in 1000 lots. Availability is from stock. Hi-G, Inc., Spring St. & Route 75, Windsor Locks, CT 06096. Phone (203) 623-2481. **67**

Molded Phenolic Parts

Cavity molded phenolic parts molded to individual specifications for different buyers using interchangeable inserts in one mold-set are provided by Security Plastics Inc. The company's modular tooling concept allows parts' buyers to order tooling and parts on a single insert basis. Each insert produces a minimum of 30,000 parts per month. Hetero-cavity molding provides 3 basic economies to parts buyers; low-cost tooling, low parts prices and maximum tooling flexibility. Typically, parts are produced in one-third the time required for other molding systems such as compression, transfer or conventional injection molding. Tooling charges are as low as $175 per insert (for simple bushings.) Parts are produced in nylon and acetal as well as phenolic. Security Plastics, Inc. 4297 E. 11th Ave., Hialeah, FL 33013. Phone (305) 685-2462. **68**

BCD Dip Switch



The "DIGIDIP" shaft-driven switch, designated the Series 26000, a tiny binary-coded decimal switch is scarcely larger than standard dual-inline packaged discrete components and can be plugged directly into a circuit board to set up codes behind a panel. "DIGIDIP" measures less than a 1/2 in. square by under one inch in length. The tiny DIP switch is designed for infrequent code setting or programming, and is available in either BCD or single-pole 10-position styles. Unit weight is less than 1.4 ounce per switch. While designed for direct mounting on a circuit board, the new Series 26000 DIGIDIP can be PC mounted for front-panel applications where only minimal space is available. Rated at 200,000 detent operations at −40°C to +71°C, the DIGIDIP has rated loads of 28V ac or 28V dc at 125 mA resistive. The Digitran Co., 855 S. Arroyo Pkwy., Pasadena, CA 91105. Phone (213) 449-3110. **69**

Coaxial Cable Terminations

Raychem offers samples of: SOLDERTACTS, preassembled, one-piece contacts for termination of a broad range of coaxial and shielded cables. They provide a soldered, strain relieved, insulated joint for both center conductor and shield. Soldertacts are interchangeable and intermateable with existing coaxial contacts. No adapters or part changes required. Raychem, Special Devices Div., 300 Constitution Dr., Menlo Pk., CA 95204. Phone (415) 373-1728. **70**

Thumbwheel Switch

Series 29000 Economy switch, offers product designers all the features of a miniature thumbwheel switch at a price competitive with standard rotary switches. Modular in design concept, the Series 29000 offers an easily-read in-line display with large 0.200 in. black characters against a light background. Modules measure only 0.350 in. wide by 1.200 in. high, and as many switch modules as required may be ganged together using simple snap-on stainless steel straps. Digitran Series 29000 offers a selection of codes, including BCD; BCO; BCD with complement; single-pole decimal; and single-pole double-throw, repeating. A pin terminal option is available for mother board termination. Digitran Co., 855 S. Arroyo Pkwy., Pasadena, CA 91105. Phone (213) 449-3110. **71**

Expandable Sleeve

Bentley-Harris offers samples of Expando, an expandable sleeve designed to protect flat-ribbon cable and other bunched wires. The highly flexible sleeve conforms readily to varied wire assemblies up to 3 times its own diameter without distorting or exerting heavy pressure. There is no need to remove end fittings and connectors because the lightweight sleeve can stretch and slip over them. The braided, open-weave material is transparent and allows visual inspection and identification of encased assemblies. Its "one size fits all" feature also eliminates the need to maintain a large inventory of different sized sleeves. Operating temperature range is from −65 to 325°F. Available in sizes covering an ID range from 1/8 to 3 in. Custom designed upon request. Price: 2 to 30 cents a ft. Bentley-Harris Mfg. Co., Conshohocken, PA 19428. Phone (215) 828-7600. **72**

Box to PCB Termination

Raychem offers samples of: PADDLECARD SOLDER SLEEVES, a new termination technique for attaching coaxial cables to printed circuit cards. Designed to prevent conductor breakage, the small sleeve allows closer spacing for more wires attached per card. Ground and signal leads are easily inserted into the Paddlecard. Heat-shrinkable Solder Sleeve provides low voltage drop with outstanding electrical and mechanical strain relief. It can be terminated with standard heating tools. Raychem Corp., Thermofit Div., Dept. 140, 300 Constitution Dr., Menlo Pk., CA 95024. Phone (415) 373-1728. **73**

Terminations

Raychem offers samples of: SOLDERPAK, a rapid, automated system of terminating connectors of almost any configuration. Solderpak utilizes bandoliered, heatshrinkable SOLDER SLEEVES, to permit the loading and terminating of an entire row of terminals in one simultaneous and simple operation using standard heating tools. Every terminal is uniformly soldered, insulated and strain relieved. Raychem Corp., Thermofit Div., Dept. 140, 300 Constitution Dr., Menlo Pk., CA 95024. Phone (415) 373-1728. **74**

Connectors

Elco Corp. offers samples of a new family of versatile connectors called the Varipost Box. The new series mates with any 0.025 in. square post on the market. The connector features low insertion force contacts with long spring members designed to yield maximum performance and reliability. Contacts are rated at 3A, and 12 MΩ maximum. The Varipost Box is available in two versions. First is cable-to-board, featuring wire crimp/removable contacts, with spacing on 0.100 in. or 0.125 in. centers, single row, and any number of contacts from 4 to 30 positions; or 0.100 in. × 100 in. spacing for dual row with any number of contacts from 8 to 50 positions. The second version is for board-to-board applications, featuring solder tail contacts, with spacing on 0.100 in. centers, single row, and any number of contacts from 4 to 50 positions; or 0.100 in. × 0.100 in. spacing for dual row with any number of contacts up to 100 positions. Elco Corp., Willow Grove, PA 19090. Phone (215) 659-7000. **75**

Terminations

Raychem offers samples of LOW TEMPERATURE SOLDER SLEEVES, shield terminations designed for PVC/PVC nylon wires. A thin wall, heat-shrinkable Kynar insert insulates and protects the center conductor. The Solder Sleeve is Poly insulated and contains a precisely measured amount of solder and flux to guarantee a uniform, reliable termination. Using standard infrared heating tools, the Solder Sleeve shrinks rapidly to provide a soldered, insulated and strain relieved termination. No calibrations, or changing of dies required. Raychem Corp., Thermofit Div., Dept. 140, 300 Constitution Dr., Menlo Pk., CA 95024. Phone (415) 373-1728. **76**

Heat Shrinkable Tubing

Raychem offers samples of: RNF-100, a tough, flexible, heat-shrinkable tubing designed for insulation, wire strain relief, color coding and general purpose packaging of electronic components. Available in sizes from 3/64 to 4 in. Price: 8 to 44 cents per ft. Raychem Corp., Thermofit Div., Dept. 140, 300 Constitution Dr., Menlo Pk., CA 95024. Phone (415) 373-1728. **77**

Polypropylene-Foil Capacitors

WESCO TYPE 32PL polypropylene-foil capacitors are designed to fill the gap between polycarbonate and polystyrene dielectrics. Operating temperature range is −55°C. to +150°C. Temperature coefficient is negative −290 +75 ppm/°C. Dissipation factor is less than 0.1%. Stability is less than 0.2%. Insulation resistance is well over 100 kMΩ. Physical sizes are smaller than polystyrene and slightly larger than polycarbonate. Encapsulation is accomplished by utilizing a space saving thermosetting tape enclosure with epoxy end seals. Lead termination is axial. Capacitance range is 0.001 MFD through 1.0 MFD in voltage ratings of 100, 200 and 400V dc. Prices for 100V dc portions vary from $0.16 to $0.44 in 1000 lots. Wesco Electrical Co., Inc., 27 Olive St., Greenfield, MA 01301. Phone (413) 774-4358. **78**

Hermetic Dips

Glasseal Products offers the 1100 Series hermetic dual-in-line package. Features include a ceramic combination glass and nickel-iron-cobalt alloy resulting in higher reliability at greater economy. All packages are plated with 50 micro in. gold per MIL-G-45204B and are capable of passing a 1×10^{-8} std. cc/sec helium leak rate. Packages available range from 14 leads through 40 leads in both metal and glass back designs. For hybrid applications, Glasseal offers the 14- and 16-lead versions. Glasseal Products, Inc., 725 Commerce Rd., Linden, N J 07036. Phone (201) 486-2067. **79**

Plastic Clamps

Loop-type clamps that open to any diameter are made from resin and are carefully molded to close tolerances. Rounded edges protect wire insulation or tubing. As a non-conductor, they help prevent short circuits. They are unaffected by atomospheric conditions; are non-corrosive, non-sweating, non-rusting, and will not support fungus growth. Available in ethyl cellulose (−66°F to +180°F), polypropylene (−20°F to +220°F) and nylon (−66°F to +340°F). Holub Industries, Inc., 413 De Kalb, Sycamore, IL 60178. Phone (815) 895-2161. **80**

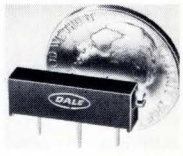
Terminals

A newly-designed Wire-Wrap terminal with a funnel-like entry for easier insertion of IC leads is offered by Electronic Molding Corp. Named the Funnel-Entry terminal, its large, tapered entry vastly facilitates insertion of the IC lead, either manually or by automatic equipment, thereby speeding up assembly. The terminal also features the Nurl-Loc design which prevents twisting during wrapping. The terminal is available in two or three levels of wrap, and is designed to mount on 100-grid centers. The Funnel-Entry terminals may be used separately or mounted into standard E.M.C. packaging panels. Electronic Molding Corp., 96 Mill St., Woonsocket, RI 02895. Phone (401) 769-3800. **81**

Miniature Tape Cores*

Miniature, square-loop, tape wound cores on stainless steel bobbins are available in O.D. sizes form 0.218 in. to 0.685 in. from Dynacor, a division of Vectrol, Inc. Designated the "M" Series, these low-cost cores are ideally suited for high-frequency magnetic amplifiers, transformers, counters, and other miniature magnetic devices that operate over a wide frequency range of 2 kHz to 500 kHz. Offering low-power/high frequency for magnetic amps or guaranteed maximum magnetizing current at high-frequencies over a wide temperature range, these devices also have applications in dc to dc converters. Dynacor tape cores have a protective epoxy coating, are hermetically sealed, and have an Armag protective jacket to prevent damage in winding and manufacturing. The 1000-piece price on these cores is as low as $0.45. Dynacon, a Div. of Vectrol, Inc., 1010 Westmore Ave., Rockville, MD 20850. Phone (301) 424-6900. **82**

"Low-Profile" Trimmers



New low-profile trimmer potentiometers offering space-saving dimensions and a choice of wirewound or film elements are now available from Dale Electronics, Inc. Available in two series—2700 (wirewound element) and 8700 (cermet element), the new trimmers combine small size with a choice of three standard terminal configurations. This combination makes them ideal as a universal, low-cost replacement in a number of applications where trimmers with varying case sizes are now used. Series 2700 dissipates 1W at 70°C and is available in a resistance range from 10Ω to 60 kΩ with a temperature coefficient of ±50 ppm/°C. Series 8700 dissipates 1W at 70° and is available in a resistance range of 10Ω to 2 mΩ with a temperature coefficient of ±100 ppm/°C. Both new low profile trimmers feature 20-turn screwdriver adjustment with clutching action to prevent overtravel damage. Delivery: 2-3 weeks depending on quantity, Price, approx.-less than 60¢ each in 10,000 lots. Dale Electronics, Inc., Dept. 860, Box 609, Columbus, NB 68601. Phone (402) 564-3131. **83**

Silicon Photovoltaic Detector*

EG&G's new PV-100 Silicon Photovoltaic Detector provides maximum sensitivity in the visible and near infrared spectrum while exhibiting ultra-low noise levels. Quantum efficiency is greater than 70%. NEP is less than 4×10^{-14}W. EG&G, Inc., 35 Congress St., Salem, MA 01970. Phone (617) 745-3200. **84**

Wafer Processing

Free wafer processing as a demonstration vehicle to prospective clients is offered subject to Integrated Frequency Devices acceptance of commercial quality mask sets and is limited to one wafer per company in the continental USA. The offer will expire October 1, 1972. The processing required on the wafer must be consistent with the capabilities of IFD's facility. The following standard process range illustrates our most typical processing capabilities.

STANDARD PROCESS RANGE

Starting Material (111)	10-20 ohm-cm, P-type
Epi	5-15 μM, 0.1 to 5 ohm-cm, N-type
Isolation	2-6 ohms/sq, P-type
Base	1-4 μM, 130 to 200 ohms/sq, Boron
Emitter	1.5 − 3 ohms/sq, $POCL_3$
BVCEO	10-50 V
Beta	20-300 @ 1 mA
Minimum Oxide Cut	0.3 × 0.3
Minimum Metal Line & Sapce	0.4 and 0.3

Integrated Frequency Devices, 4900 E. Indian School Rd., Phoenix, AZ 85018. Phone (602) 959-4760. **85**

Tantalum Capacitors

Type HA and IC capacitors are particularly well suited to applications which require subminiature sizes. The HA type is a cylindrical unit. The TC has a rectangular outline. Both are available with either axial or radial-leads. Both types are available unencapsulated for hybrid ciucuits where compact size is critical. Capacitance Range is from 0.001μf at 35V dc to 220μf at 3V dc. The 100 piece price range depending on rating is from $.42 to $1.44. Tansitor Electronics, West Road, Bennington VT, 05201. Phone (802)442-5473. **86**

Tantalum Capacitors

Type ET and EZ capacitors are epoxy sealed solid tantalums. Their miniature size and high CV product make them particularly well suited for applications where space is limited. Type EZ capacitors are a high capacitance series. Capacitance Range is .0047μf at 35V dc to 100μf at 2V dc. The 100 piece price range depending on rating is from $.28 to $.52. Tansitor Electronics, West Road, Bennington VT, 05201. Phone (802)442-5473. **87**

Electrical Contacts

Specially developed to produce an economical composite contact and overcome the limitations of other methods of manufacturing composites, Economet Rivet Contacts are high speed, precision made from wire. There is no intermediate bonding meterial in the metallurgically bonded Econornet so these composite contacts perform reliably even at comparatively high operating temperatures. For most applications, the entire contact is silver plated. Deringer Mfg. Co., 1250 Town Line Road, Mudelein, IL 60060. Phone (312) 566-4100. **88**

Metal Oxide Film Resistors

Metal oxide film resistors offering a power range from 2.5W at 10 kV to 10.0W at 40 kV, and an overall resistance range from 100Ω to 20 GΩ are available from RPC. These components are desinged for power circuit applications. Tolerances range from $\pm$0.5% to $\pm$30% with a temperature coefficient from $\pm$50 ppm/°C to $\pm$600 ppm/°C; a voltage coefficient of 5 ppm max.; and a stability factor of $\pm$0.2%/k-hrs. at 150°C (operating temperatures). Resistance Products Co., 914 S. 13th Street, Harrisburg, PA 17104. Phone (717) 236-5081. **89**

Modules and Linear ICs*

All products manufactured and sold by Analog Devices are available on an evaluation sample basis. These products include: A/D and D/A converters, amplifiers, function modules, linear IC's, digital panel meters, power supplies and accessories. A complete 180-page 1972 PRODUCT GUIDE, and soon to be issued supplement, is available. Analog Devices Inc., Route 1 Industrial Park, P.O. Box 280, Norwood MA, 02062. Phone (617) 329-4700. **90**

Wire Insulation

Samples of the rugged wire insulation, "Tefzel" ETFE fluoropolymer resin, are available in 12-, 20- and 30-gage sizes from the Du Pont Co. Compared to traditional industrial wire insulations, "Tefzel" has superior mechanical, electrical, chemical and thermal characteristics. The resin is sold by Du Pont at $6.50 a lb. in 1,000 lb. quantities. Du Pont Co., Rm. 23065, Wilmington, DE 19898. Phone (302) 774-2421. **91**

Connectors

Connectors designed to meet the critical requirements of aircraft and electronic devices are offered by SDI. These threaded panel connectors insure a no-load condition on soldered connections. Sheet metal connector will mount in plate areas as small as 1/16 in. or as large as 3/8 in. The male connector or Model 700166, although designed for printed circuit board installation, is also being used successfully when imbedded in edge lighted panels. Prices in single quantities vary from $2.65 to $5.03 each. Symbolic Displays, Inc., PO Box 4322, 1762 McGaw Ave., Irvine, CA 92664. Phone (714) 546-0601. **92**

Precision Carbon Film Resistors

RPC offers a line of carbon film resistors. Many types are available in order to fulfill a variety of requirements and applications, including high voltage, encapsulated high voltage, high frequency and high megohm. Resistance Products Co., 914 S. 13th Street, Harrisburg, PA 17104. Phone (717) 236-5081. **93**

Closed Entry Solder Sockets*

Ranging in pin-out designs from 8 to 40 positions, the Series C82 (plated) and the Series C92 (gold clad at point of contact) sockets provide wide design flexibility in all systems requiring reliable, pluggable packaging. Price range is $.15 to .57 in volume, depending on model. Texas Instruments Inc., Attleboro, MA 02703. Phone (617) 222-2280. **94**

Terminals

SOLDERCON terminals provide the advantage of plug-in packages for connecting transistors and ICs with economy. Offered are Molex Model 1875, Series 02-04, round female transistor socket types taking 0.015/0.020 in. diameter leads. The terminals rise 0.197 in. above the board. Also offered are pc board IC inline connectors with assembly nest, Model 1938-4, Series 05-30/35 with nest; Model 2460, Series 0605. Molex, Inc., 2222 Wellington Ct., Lisle, IL 60532. Phone (312) 969-4550. **95**

Low Profile Solder Sockets*

Series C93 sockets provide low cost, reliable packaging for DIP IC's resistor, relay and LED arrays. 0.150 in. max. height on 0.100 × 0.300 or 0.100 × 0.600 pin matrices. Glass filled nylon bodies incorporate gold stripe contacts which increase wear resistance; contact design provides highest contact pressure. Built in barriers prevent wicking and lead contact with PC boards. 8, 14, 16, 18, and 24 pin models available from stock; price range is $.10 to .21 in production volume, depending on model. Texas Instruments Inc., Attleboro, MA 02703. Phone (617) 222-2280. **96**

Dual-In-Line Cable Assemblies*

Low-cost interconnection systems designed to mate with standard IC DIP sockets or direct plug-in to boards. Choice of designs and styles which include 22 to 20 AWG cable, 8, 14, 16, 18, 24, 28, 36 or 40 pin-mating plugs, single or double ended harness termined to ribbon cable, twisted-pair ribbon, individual- or twisted-pair individual conductors. Complete choice of lengths. Operating temperature range 65° to 105°C. 6 in. and 1 ft. lengths available from stock. Other lengths, 3 weeks ARO. Texas Instruments Inc., Attleboro, MA 02703. Phone (617) 222-2280. **97**

Miniature Pin Connectors

Miniature pin connectors having 0.062 in. diameter, crimp-type terminals for insulated wires ranging from 18 through 30 gage are offered by Molex. These connectors are available with integrally molded connector mounting ears for 1 to 36 circuits, Model 1625-6, Series 03-06. Molex, Inc., 2222 Wellington Ct., Lisle, IL 60532. Phone (312) 969-4550. **98**

Beryllium-Copper Alloys

Several non-magnetic beryllium copper alloys which have many applications in areas requiring good electrical conductivity, high fatigue strength and wear resistance are available from Kawecki Berylco. These alloys are age hardenable with a simple, low temperature heat treatment. The alloys are available in various forms; e.g. strip, wire, rod, bar, extruded tubing and shapes, plate and ingot. Base prices of beryllium copper are from $2.18 per lb. Kawecki Berylco Industries, Inc., P.O. Box 1462, Reading, PA 19603. Phone (215) 929-0781. **99**

Cable Assembly

Cicoil "Super-Flex" Cables and Harness assemblies are available with 100% exterior non-metallic shielding. Wire density of up to 40 conductors per in. in width is possible. A wide variety of conductors including bare, insulated, single sheilded, twisted-pair shielded, twisted triad-shielded, etc. may all be combined in a single cable. Cicoil Corp., 9342 Topanga Canyon Blvd., Chatsworth, CA 91311. Phone (213) 882-2021. **100**

Drafting Aids

Pressure-sensitive preprinted sheets save time and money on drafting jobs. Drawing-board time is reduced when preprinted repetitive symbols and drawing details from Stanpat Products are used. Stanpat Products, Inc., Main & Covert St., Port Washington, NY 11050. Phone (516) 883-8401. **101**

Light Assembly

Y-R light assembly has been designed to provide solutions to many problems encountered in the design of edge-lighting panels. The top of the assembly is equipped with a limited transmission reflector filter. The lamps may be placed anywhere. Unskilled personnel are able to relamp the assembly with only a screwdriver. Price in unit quantities is $3.55 each. Symbolic Displays, Inc., PO Box 4322, 1762 McGaw Ave., Irvine, CA 92664. Phone (714) 546-0601. **102**

Cable Ties

Two types of one-piece, all nylon cable ties are offered by Panduit. These are self-locking and releasable types. Cable ties are available in a wide variety of sizes and colors. Self-locking ties can be hand or tool applied; releasable type are hand applied. Panduit Corp., 17301 Ridgeland Ave., Tinley Park, IL 60477. Phone (312) 532-1800. **103**

PC Board Connectors

KONEKTCON pc board connectors and terminals are versatile and adaptable interconnecting systems designed by Molex for almost any printed circuit requirement. Samples offered include the Model 2139, Series 09-50, crimp-type harness connector, Model 2145, Series 09-52, perpendicular and parallel board connectors. Available with a number of different circuits per connector. The circuits have 0.156 in. center terminal spacing and include molded-edge locking devices. Molex, Inc., 2222 Wellington Ct., Lisle, IL 60532. Phone (312) 969-4550. **104**

Load Cells*

Low-profile sheer-web design load cells are available in standard ranges from 50 lbs. to 200,000 lbs. These units are used to measure weight, thrust and other forces that can be applied to the load cell. Load cells are manufactured for fatigue, compression and universal (compression and tension) and are available in utility, mid-range precision and ultra-precision types. Prices for standard models range from $380 to $2850, depending upon the size ordered. Interface, Inc., PO Box 1652, Scottsdale, AZ 85252. Phone (602) 946-9100. **105**

Electromagnetic Indicator

DC pulse driven indicator, Model 8500, is offered by Control Data Corp. A dc pulse generates a magnetic field which drives the permanent magnet in the drum. The drum displays the desired readout. De-energized, readout remains in position due to the magnetic detent. The Model 8500 has a 10-position drum, response time of 500 msec or 180-degree positioning. Lettering height is 1/4-in. Price in large quantities for the Model 8500 is $35 each. Magnetic Component Div., Control Data Corp., 7801 Computer Ave., Minneapolis, MN 55435. Phone (612) 920-8600. **106**

Flat Ribbon Cable

Samples of flat ribbon cable and IC interconnect assemblies are available from Spectra-Strip Corp. Cables are available in a wide variety of configurations for use on many applications. Prices on cables can be as low as $0.05 per conductor foot in quantity. Spectra-Strip Corp., PO Box 415, Garden Grove, CA 92642. Phone (714) 892-3361. **107**

Conductive Plastic

Samples of a linearity corrected conductive plastic element used for potentiometers is available from Waters Manufacturing. Used for potentiometer applications with up to 10^7 cycles. Output smoothnesses is better than 0.1% and linearity to 0.07% are available. Waters Manufacturing Inc., 436 Boston Post Rd., Weston, MA 02193. Phone (617) 899-3250. **108**

Power Supplies*

Complete line of standard power supply modules for use in a variety of computer and peripheral applications is available from Armour Electronics. Output voltages available range from 3.8V through 22V dc. Output currents as high as 10 amps at 5V are available. Single part price starts at $29. Armour Electronics Corp., 51 Jackson St., Worcester, MA 01608. Phone (617) 753-8103. **109**

Photoconductive Cells

Two high-speed cadmium sulfide photoconductive cells – one, the VT-833, a single element device; the other, the VT-833/2, a dual element device of the same material – are offered by Vactec. Both devices use Type 3 material with peak response at 5500Å for the VT 833 and 5150Å for the VT-833/2. Minimum dark resistance is better than 10 MΩ. The photoconductive cells are thin-film photoconductors mounted on ceramic substrates. The price for either part is $0.25 each in 10,000 quantity. Vactec, Inc., 2423 Northline Industrial Blvd., Maryland Heights, MO 63043. Phone (314) 872-8300. **110**

Fasteners

Samples from the wide variety of fasteners for use on all types of electronic equipment are offered by ESNA. Included are hex-type nuts, chassis-type nuts for fastening to chassis or console with single-hole mounting, self-locking cap screws and clip nuts. Amerace-ESNA Corp., Elastic Stop Nut Div., 2330 Vauxhall Rd., Union, N J 07083. Phone (201) 686-6000. **111**

Solid-State Avionic Keyboards

Illuminated keyboards specifically designed for use in navigation, guidance and other avionic systems. Each switching circuit employs a LED optically coupled with a photo-Darlington amplifier. Contact bounce, internal resistance and mechanical variables are virtually eliminated. Standard T-1-3/4 midget flange based lamps are used for illumination. Keys are rated for 100 million operational cycles. Approximate price per key is $5 in quantity. Symbolic Displays, Inc., PO Box 4322, 1762 McGaw Ave., Irvine, CA 92664. Phone (714) 546-0601. **112**

Non-Skid Molded 'Feet'

Tiny, self-adhering molded bumpers can serve as non-skid protective "feet" on a variety of products. The feet, called 3M brand molded bumpers, are made of an elastomeric material that won't dry out, rot or become brittle. The molded bumpers are available in different-sized squares, round shapes and in strip form. They are supplied in five colors – white, gray, black, brown, beige. Industrial Special Products Dept., Bldg. 220-8E, 3M Co., St. Paul, MN 55101. Phone (612) 733-1100. **113**

Precision Interchangeable Thermistor

A family of Yellow Springs Instruments Co. precision thermistors with resistances from 100Ω to 1 MΩ at 25 C, is available for use over a temperature range from −80 to +150°C. The engineering sample being offered is model 44007. It has a 5000Ω resistance at 25°C and time constants of 1 sec. in a well stirred oil bath and 10 sec. in still air. Prices begin at $4.90 each in quantities of 1 to 9. Yellow Springs Instrument Co., Inc., Box 279, Yellow Springs, OH 45387. Phone (513) 767-7242. **114**

CIRCUIT DESIGN AWARDS

Putting the "thumb" on thumbwheel switch multiplexing

Eric Breeze
Fairchild Semiconductor, Mt. View, Calif.

Thumbwheel switches are becoming increasingly popular for remote programming of counters, displays, industrial control systems, etc. To reduce the number of interconnections between the switches and the destination, it is desirable to use multiplexing techniques. Ten decades of BCD thumbwheel switches unmultiplexed would require 50 interconnections, while a multiplexed system would require only 10 interconnections.

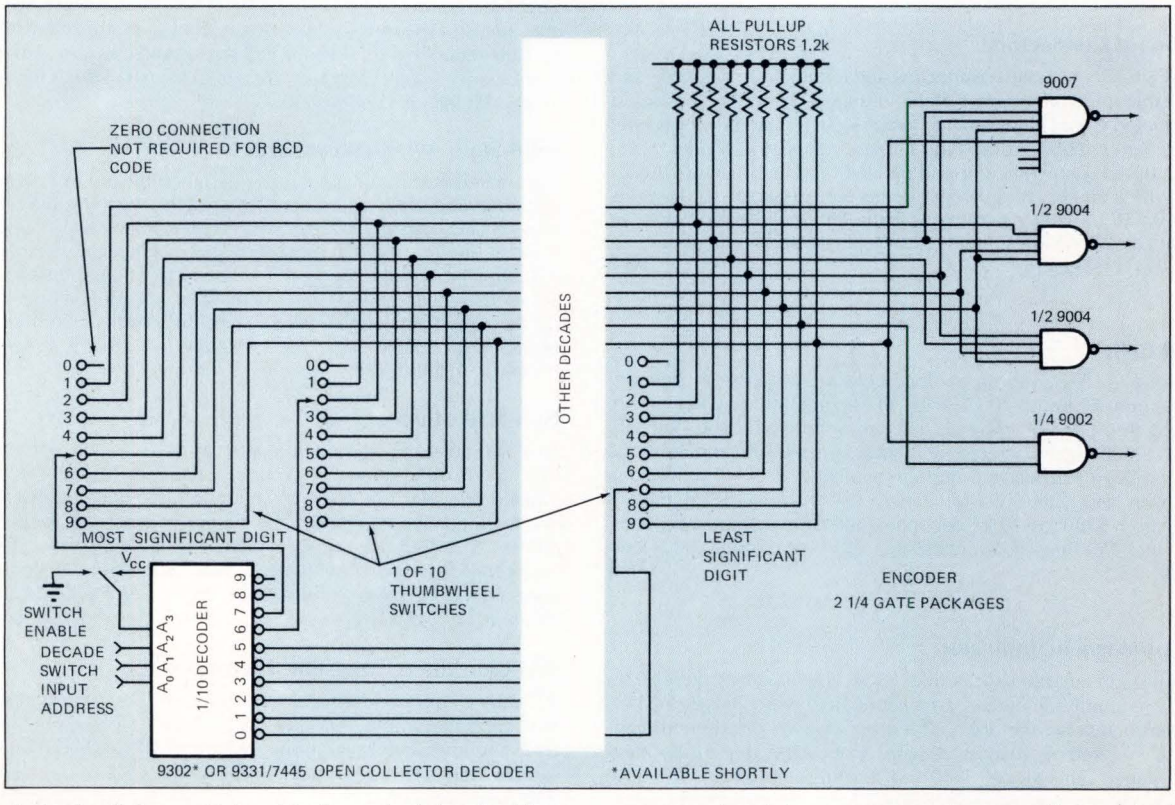
The usual method of multiplexing is to use BCD (or any 4-bit code) thumbwheel switches, each with a diode in series with the four outputs. These are connected to four parallel bus lines to the system output. The wiper arm of each switch is then selected to get decade location.

This system uses standard-low-cost, single-pole decade switches with all ten outputs of the switches parallel bussed and the wiper arm connections brought out separately. The ten parallel outputs are fed into a simple encoder comprised of four NAND gates to generate the desired 4-bit output code (diagram shows BCD). Only the "true" connection of the ten outputs are required, as ambiguous outputs cannot be generated due to the mechanical design of the switches.

The wiper arm of each of the switches is addressed from an active low open-collector decoder. Collector pull-up resistors are placed on the encoder NAND gate inputs. The use of an open-collector decoder prevents undefined logic levels whenever two or more switches are in the same position.

In operation the 3-bit input address determines which decade switch is addressed. Switch position then determines which encoder NAND gates are activated. The common of each of the switches is addressed from an active low open-collector decoder. □

To Vote For This Circuit
Circle 150



Thumbwheel switches multiplexed in the method described here provide system economies by allowing use of low-cost "1-of-10" switches, rather than encoded switches. Wiring interconnections are also reduced, from 50 to 10 in this case, offering reduction of assembly costs. Reliability is increased appreciably since there is only one moving contact per switch.

Monolithic timer generates 2-phase clock pulses

Gerd Schlitt
Signetics Corp., Sunnyvale, Calif.

The Signetics 555 Timer can be used as an oscillator to generate non-overlapping clocks, which are required for most 2-phase dynamic MOS memories and shift registers. The features that make this device appealing for the application shown in **Fig. 1** are its accuracy and adjustable duty cycle. The 555 has a temperature stability of 0.005% per °C and is insensitive to supply-voltage variations.

As shown in **Fig. 2,** the duty cycle can be programmed by two external resistors which, together with the timing capacitor, determine the frequency of oscillation.

The pulse-width of clock phases ϕ_1 and ϕ_2 is readily adjustable by varying R_A and R_B. The 7473 flip-flop controls the phase that is switched on through the 7402 NOR-Gates. The timing waveforms shown in **Fig. 3** give the response of the circuit for the timing component values shown in **Fig. 1**.

The maximum operating frequency of this configuration is 1 MHz, limited by the timing circuit. □

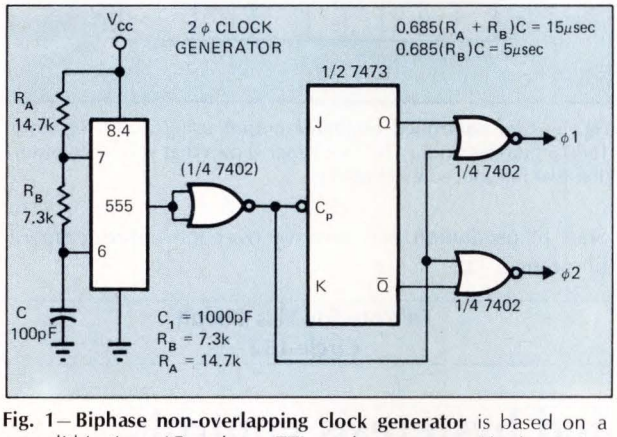


Fig. 1—Biphase non-overlapping clock generator is based on a monolithic timer IC and two TTL packages to provide the timing pulses required for MOS memory operation.

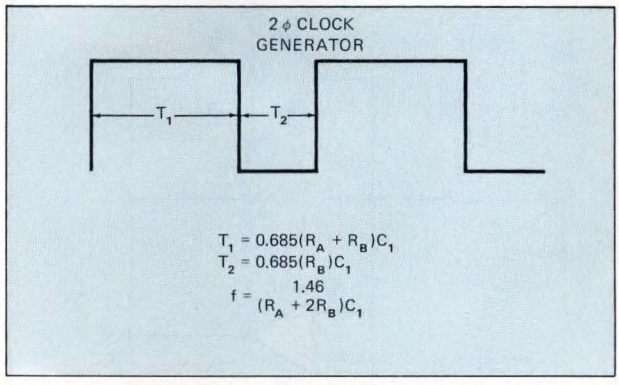


Fig. 2—Timing equations given here determine component values required to achieve the duty cycle and desired frequency of the pulse circuit shown in **Fig. 1.**

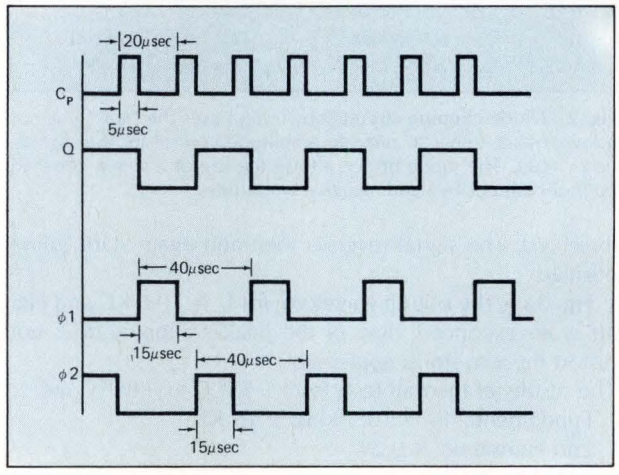


Fig. 3—Timing and waveforms from the clock generator shown here are those produced by the values of R_A, R_B and C_1 given in **Fig. 1.**

To Vote For This Circuit
Circle 151

Zener-diode controls Wien-bridge oscillator

W. B. Crittenden and E. J. Owings, Jr.
Westinghouse Electric Corp., Baltimore, Maryland

The usual method employed to control the amplitude of a wien-bridge oscillator such as the one shown in **Fig. 1** is to employ a light bulb or an FET as a variable resistance element to maintain a gain of 3 from point one to point two.

The gain and phase from two to three at $F_{osc} = 1/(2\pi RC)$ is equal to $1/3<0°$, thus the overall loop gain $= 3 \times 1/3<0°$.

The circuit shown in **Fig. 2** operates to maintain the amplitude symetrical about ground by using a single zener (D_5) and a bridge of diodes (D_1, D_2, D_3 and D_4). As the output e_0 approaches the soft knee threshold of conduction of D_5, the zener impedance decreases and shunts R_2. This violates the requirement for oscillation that $R_2 = 2R_1$. The output then starts to decrease sinusoidally, and as the swing decreases the gain increases until e_0 reaches the negative

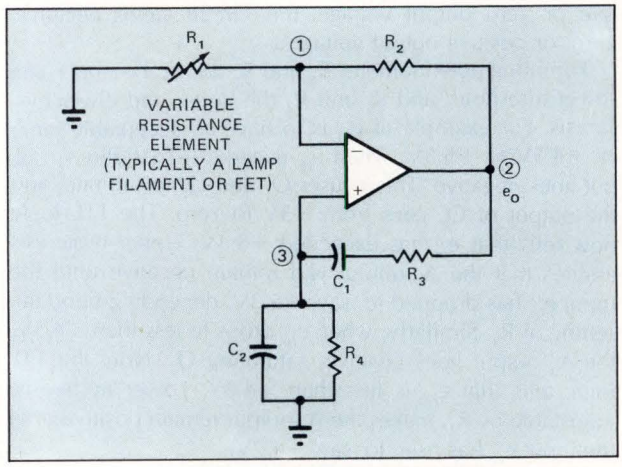


Fig. 1—Conventional Wien bridge circuit employs a variable resistance element, typically a lamp filament or an FET to maintain the required op-amp gain.

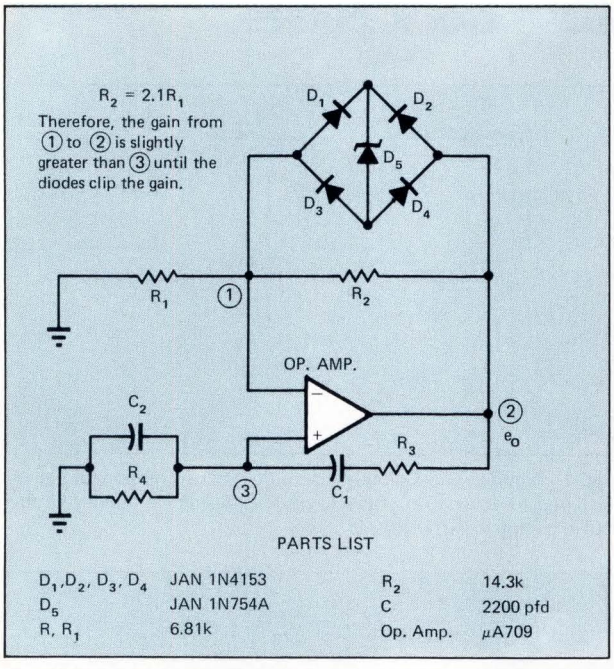


Fig. 2—Diode clipping circuit shown here uses the "soft" knee of a low-voltage zener to provide amplitude control for the oscillation circuit. The diode bridge allows the use of a single zener to control both positive and negative amplitudes.

threshold. The signal reverses then and again starts going positive.

Fig. 3a is the output waveform for f_o = 10.5 KC and **Fig. 3b** is an expanded view of the peaks. Clipping does not distort the waveform appreciably.

The results of thermal tests from −55° C to +95° C are:

Fundamental F_o = 10.5 KHz ±.15 Kz
2nd Harmonic ≤ 0.2%
3rd Harmonic ≤ 1%
e_o = 5 ±0.15 VRMS

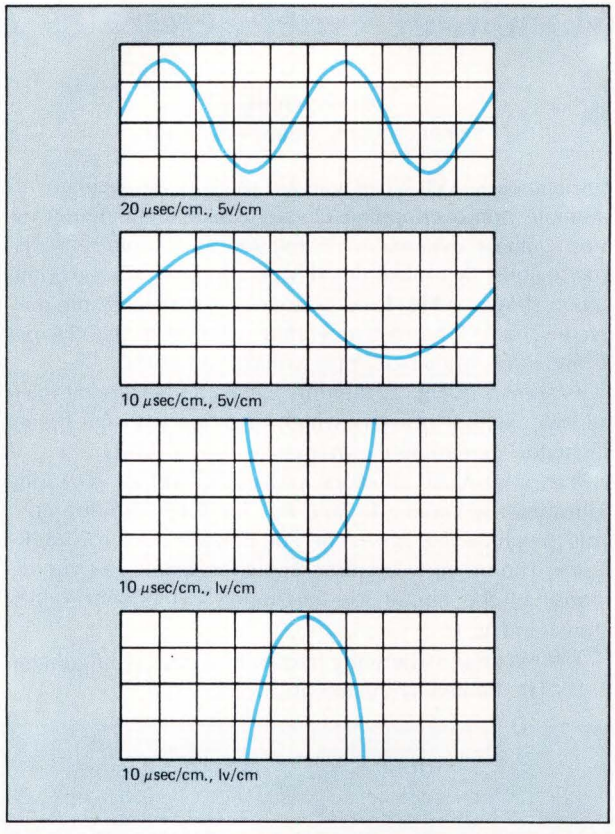


Fig. 3—Clip controlled oscillator output using a 709 op amp, 1N4153 diodes and a 1N754A zener shows that very little distortion was introduced by clipping.

Start of oscillation was positive over the entire temperature range. □

To Vote For This Circuit
Circle 152

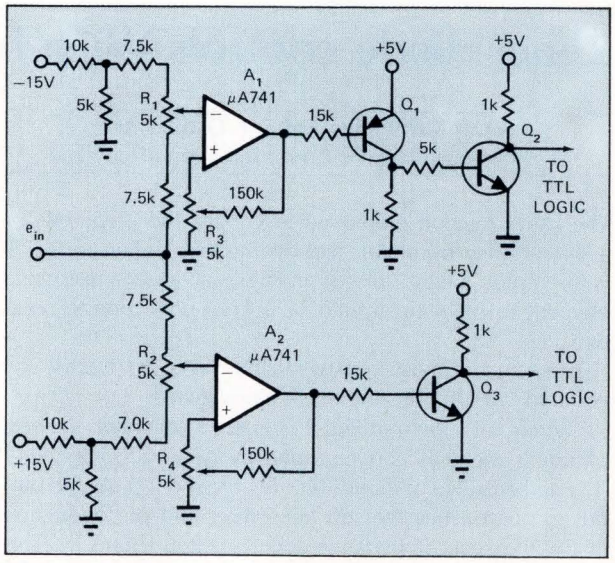
Analog monitor has threshold and hysteresis controls

Irving Krell
US Engineering Co., Los Angeles, Calif.

Unlike the usual window detector which provides a positive or zero output voltage, this circuit yields negative, zero, or positive output voltages.

Trimming potentiometer R_1 and R_2 adjust the upper and lower threshold, and R_3 and R_4 the upper and lower hysteresis. For example, if e_{in} is to have an acceptable range of +4.5V to +5.5V, when e_{in} exceeds +55V, the A_1 output goes negative. This causes Q_1 and Q_2 to saturate, and the output of Q_2 goes from +5V to zero. The TTL logic now tells that e_{in} has exceeded +5.5V. Upper hysteresis assures that the A_1 output will remain negative until the input e_{in} has dropped to, say, +5.3V, depending upon the setting of R_3. Similarly, when e_{in} drops to less than +4.5V, the A_2 output goes positive, saturating Q_3. Now the TTL logic tells that e_{in} is less than +4.5V. Lower hysteresis, adjustable by R_4, makes the A_2 output remain positive until the input e_{in} has risen to, say, +4.7V. □

To Vote For This Circuit
Circle 153



Window detector circuit provides adjustment of both threshold and hysteresis levels. Outputs indicate high, low or acceptable input levels, rather than the normal in-tolerance or out-of-tolerance indication.

Transfer parallel information without a clock

Tim O'Toole
Tektronix, Inc., Beaverton, Oregon

The design goal of this device is to take BCD from a 10-key adding machine type keyboard and shift each number, as it is entered, from left to right on the display panel. In the summation, G_8 is the first to be clocked, then G_7, then G_6, then finally G_5. The information in these latches is transferred in a parallel mode.

The secondary goal is economy and the least number of ICs possible. No internal clock was to be used in this design and there are no ac coupling devices.

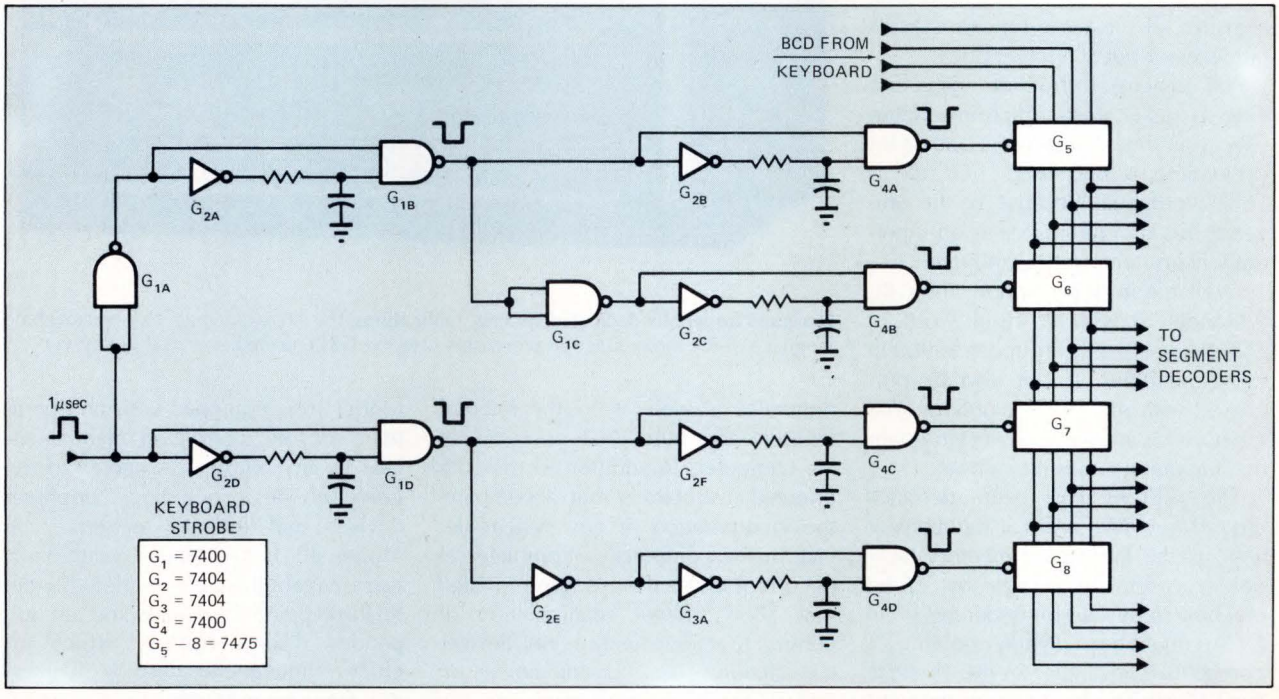
The BCD is direct from the keyboard decoder, which is not debounced. The keyboard strobe is delayed 2 msec to allow time for the keyboard switches to quiet down. On the positive edge of the keyboard strobe, G_{2D} and G_{1D} send out a 250 nsec negative pulse. On the negative edge of this 250 nsec pulse G_{3A} and G_{4D} generate a 70 nsec pulse to clock G_8. On the positive edge of the 250 nsec pulse from G_{10}, G_{2E} G_{2F} and G_{40} send out a 70 nsec pulse to clock G_7.

On the negative edge of the keyboard strobe, G_{7A}, G_{2A}, and G_{1B} send out a 250 nsec negative pulse. On the negative edge of the pulse from G_{1D}, G_{2D} and G_{4B} combine to send out a 70 nsec pulse to clock G_6. On the positive edge of this 250 nsec pulse from G_{1B}, G_{2B} and G_{4A} combine to send a 70 nsec negative pulse to clock G_5.

The BCD outputs from G_{5-8} go directly to 7 or 10 segment decoder-drivers, such as SN7447 decoders driving RCA DR-2100 series low-voltage readouts.

All resistors in this circuit are 220Ω (±1%). Capacitors for G_{1B} and G_{1D} are 1000 pF (±5%), capacitors for G_4A, B, C and D are all 240 pF (±5%) □

To Vote For This Circuit
Circle 154.



Inexpensive solution to calculator problem allows display of each digit, as entered on the keyboard, to be shifted one digit to the left without the use of a system clock circuit.

Rules & Announcements

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, 221 Columbus Ave., Boston, MA 02116.

Readers have voted: Roger Melen winner of the April 15 Savings Bond Award. His winning circuit is "2 CMOS gates convert counter into capacitance meter." Mr. Melen is with Stanford University, Stanford, Calif.

Maxwell Strange winner of the May 1 Savings Bond Award. His winning circuit is "DPM makes self-contained digital thermometer." Mr. Strange is with NASA, Greenbelt, Md.

8k Dual Function Processor sells for less than $3000

PROGRESS IN COMPUTERS

The new low-cost series of 16-bit minicomputers recently introduced by GRI Corporation utilize the patented dual-bus structure of the GRI-909. The GRI-99 series, newest of a class of general-purpose digital computers called Direct Function Processors, provides all the same functions as its predecessor but at a lower price.

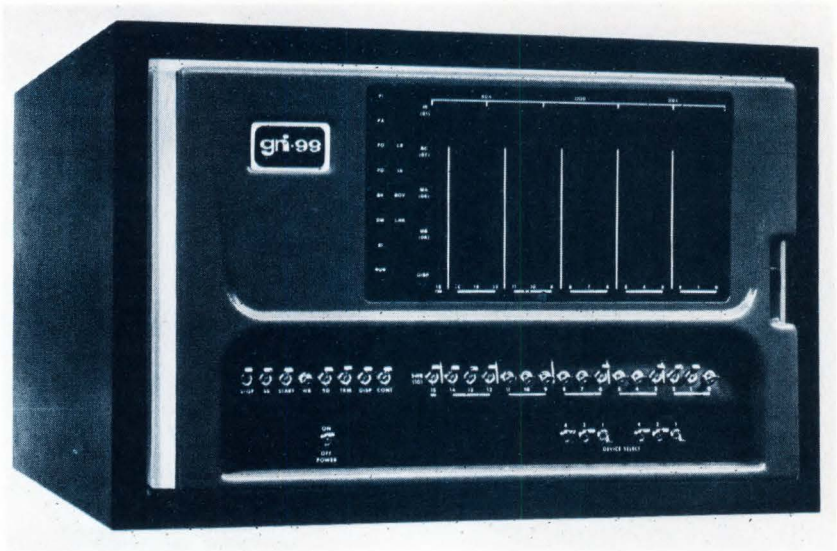
Full (macro) instruction execution time is 1.76 μsec, microinstruction execution time is 440 nsec, and ROM cycle time is 880 nsec. I/O rate is 568k words/sec. Because of the universal bus structure, DMA is an inherent function in this minicomputer.

Available in three models, the GRI-99 Model 10, with 8k, 16-bit words of core memory, sells for under $3000 in OEM quantities. It can also be purchased with 4k, 16-bit words of core memory for as low as $2500 in quantity, including a full software set.

The GRI-99 has been designed around new MSI and LSI functions as well as the latest core memory technology, allowing a 32k by 16-bit machine to be sold for under $8000 in OEM quantities. While holding a competitive advantage in the 4k range the GRI-99 is believed to be the most economical machine available in the 8k to 32k range.

A substantial number of general-purpose registers, including an index register, can be added as simple plug-ins due to the dual bus architecture. Up to 32k, 16-bit words of directly-addressable memory can be plugged into its 10½ inch main frame in 8k modules, with up to nine additional ports available for I/O options.

Of great significance in programming a direct function processor, is its inherent efficiency and the simplicity with which the instructions can be understood and used. Instructions refer directly to system devices and peripherals, as well as to the internal registers and functional operators of the computer. In addition to the data oriented instructions that accompany the incorporation of any system device in the computer, a complete set of control instructions is also provided that allows direct manipulation of control functions within the device: e.g. clearing flags, turning power on and off, rewinding tape drives, etc. Up to sixteen levels of horizontal priority interrupts, and unlimited vertical interrupts are provided.



Designed for wholly dedicated systems applications, the internal architecture and machine language of the direct function processors uses the GRI patented universal bus system.

The intrinsic modular design of the direct function processor permits a variety of machine configurations ranging from highly-economic minimal processors for systems requiring simple data manipulations, to large configurations with a variety of peripheral devices with powerful computing capabilities.

The three models of the GRI-99 currently offered are Models 10, 30 and 40. The Model 10 is sold with a blank console for dedicated applications requiring no operator interaction. The Model 30 is equipped with an operator's console, permitting manual access to any register connected to the universal bus, including peripheral devices and internal registers. The Model 40 has extended math-hardware capability with multiply/divide, floating point hardware and an expanded display console, which includes simultaneous display of internal computer registers.

Released software for the GRI-99 includes a relocatable assembly language which uses less than 4k of memory, a loader package, generalized real-time executive, floating-point interpretive package and a large, well-documented library of routines available from the GRI-909 family. All GRI-909 software is upwards compatible with the GRI-99.

The GRI-99 interfaces are pin-for-pin compatible with the GRI-909 series computers, thus making all GRI-909 peripherals compatible with the new GRI-99. GRI Computer Corp., 320 Needham St., Newton, MA 02164. Phone (617) 969-0800. **271**

Static card reader for control and data collection applications

PROGRESS IN DATA HANDLING EQUIPMENT

The new Hickok Model 960A reads all 80 columns of a standard 80-column tab card. Matrix is 12 rows × 80 columns for a 960-bit output. It costs less than $500 compared to $1500 for competitive readers.

The continuous brush technique used for reading the cards leads to more reliable operation and long-term durability. The number of moving parts has been minimized, thus enabling the Model 960A to operate reliably for long periods, even under continuous usage.

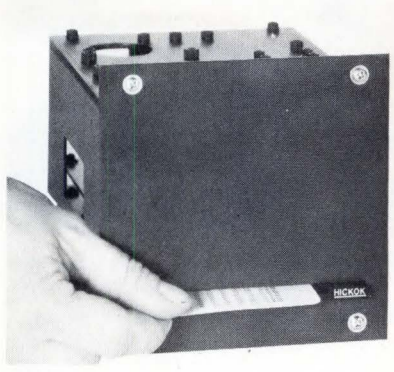
Accurate readings are insured by the use of multi-strand type contacts. Three to five strands make electrical contact through each hole to contact pads on a pc board under the card at all 960 positions. Contact will be made even if the card holes are slightly off center due to expansion under high humidity conditions, or from mispunching. The Model 960A will tolerate misalignment in the horizontal direction up to 0.009 in. greater than the EIA specification.

In addition, the brush contact provides a positive double wiping action, so that contaminants on the card will not interfere with proper readings.

Hickok also offers a choice of interface electronic packages for use with the 960A Card Reader and the customer's system. The Model 80 scanner has two operating modes: sequential and addressable. In the sequential mode, an externally supplied advance pulse steps the scanner to the next column in sequence. In the addressable mode, columns may be addressed randomly.

Corner sensing insures proper card insertion into the Model 960A. Readings will not occur until correct position is accomplished. Remote reset is standard with the Model 960A.

Five diode-isolation matrices for column bussing are available with the Model 960A for use when the card has information with multiple busses



per column. Thus, 256, 128, 64 and 40 Hollerith character sets and special codes such as "five of ten" can be accommodated.

Front panel size is 6 in. high × 5 in. wide.

Model 960A is 6 in. high × 5 in. wide × 9 in. deep. Price is single unit quantities is $495; discounts up to 45% are available. Delivery is 90 days ARO in volume quantities. Hickok Instrumentation Group, 10514 DuPont Ave., Cleveland, OH 44108. Phone (216) 541-8060. **272**

Bi-directional digital cassette recorder uses two moving parts

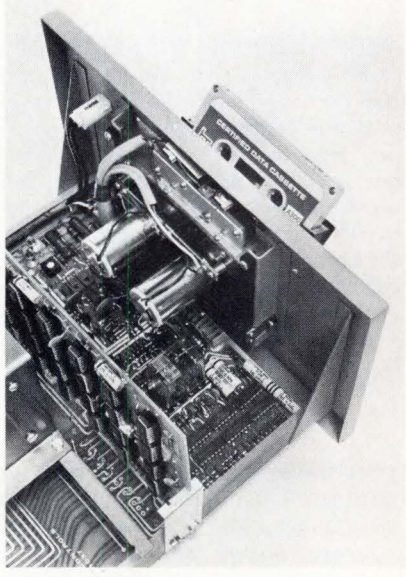
PROGRESS IN DATA HANDLING EQUIPMENT

The Series 1000 digital cassette-recording equipment provides direct, bi-directional tape drive using a reel-to-reel servo instead of the conventional capstan-and-pressure roller. The tape transport, Model 1000, whose only moving parts are the two dc reel-drive servo motors, is available singly for $225, and for OEM users lists at $150 in 100-lots. The Model 1000 cassette deck is also assembled-along with servo, read/write amplifiers, interface, formatting logic, power supply, and enclosure-into a Model 1111 digital cassette recorder, which lists singly for $850, and $575 in 100-lots.

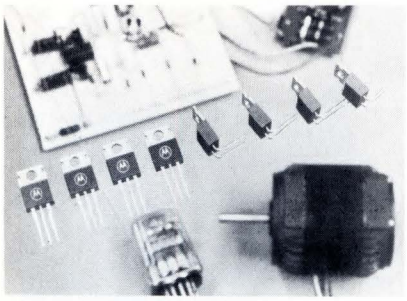
Designed for data communications, minicomputers, off-line data storage, and N/C machine tool applications, the new Model 1111 recorder provides 1.5×10^6 bits storage capacity using a standard Philips-type cassette with 300 feet of 0.15 in. tape. The unit records and plays back at 20 ips and has a data rate of 10,000 bps. The servo controlled reel-to-reel tape drive holds tape velocity at 20 ips ±5% with ±3% maximum flutter, develops readable signals within 3 msec of a 'start' command, attains the 20 ips stabilized speed in 35 msec, and stops completely within 50 msec.

Tape direction is reversed simply by reversing the servo-drive motors. Tape tension is controlled electronically during record/playback, fast rewind, and fast data search. High-speed rewinding drives the tape at 120 ips in either direction, while high-speed data search at 120 ips locates any piece of data on the tape in a statistical average of roughly 10 sec.

The company can also supply electronic interface cards that link Model 1111 recorder to particular minicomputers, data channels, logic levels, or special codes. Ross Controls Corp., 381 Elliot St., Newton, MA 02164. Phone (617) 969-9240. **273**



Digital cassette recorder with servo-controlled reel-to-reel tape drive permits all-electronic reversing, tension control, and bi-directional high-speed search and rewind. The Ross Model 1111's electronic sophistication replaces mechanical complexity, eliminates capstan, solenoids, clutches, belts, etc.



PLASTIC THERMOWATT TRIACS PROVIDE AC CONTROL OF UP TO 12A. The Thermowatt offers the industry its first 12A plastic TO-66 equivalent. Blocking voltages of 200 to 800V are available. Gate triggering can be specified for two or four mode firing for all voltage and current ranges. Prices for this series in 100-up quantity are from $0.90 to $3.60 each. Motorola Semiconductor Products Inc. P.O. Box 20912, Phoenix, AZ 85036. Phone (602) 273-6900 **170**

GLASS-COATED TRANSISTOR CHIPS FOR HYBRID CIRCUIT APPLICATIONS include the NPN 2N2222A, 2N2484, and 2N3725 families of devices, along with the PNP 2N2605 and 2N2907A series of units. The glass coating is a 7000A thick deposition of Pyrolytic Oxide. The new glass coated devices are priced 15% above their non-coated equivalents. Dionics, Inc., 65 Rushmore St., Westbury, NY 11590. Phone (516) 997-7474. **171**

REFERENCE DIODES FOR HYBRID CIRCUITS are temperature compensated and completely encapsulated and mounted in microstrip packages. The microstrip package, measuring 0.075 in. maximum diameter and 0.045 in. max height, is mounted on two flat Kovar electrical contacts. Diodes MRD821 to MRD829 are microstrip versions of IN821-IN829, and have 6.2V ±5% reference, with temperature coefficients to 0.0005%/°C. Codi Semiconductor Div. of Computer Diode Corp., Pollitt Drive S., Fair Lawn, N J 07410. Phone (201) 797-3900. **172**

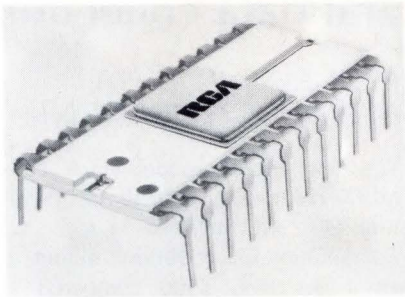
VOLTAGE REGULATOR HYBRIDS HAVE OUTPUT-VOLTAGE RATINGS OF 5, 12 and 15V. Total regulation available is ±1% V_{OUT} (max.) for the "A" versions, and ±3% for the 4005, 4012 and 4015, with load currents up to 4A. They are supplied in an 8-pin "TO-3" hermetic package. Price at the 1000 unit level is $7.50 for the HC4005, HC4012 and HC4015, and $7.95 for the "A" versions. RCA, Solid State Div., Box 3200, Somerville, NJ 08876. Phone (201) 722-3200. **173**

LOW-DRIFT OP AMPS DRIFT ONLY 10 μV IN 1000 HOURS. Max initial offset of the LM725 is 1 mV. When nulled, its offset drift is typically 0.6 μV/°C between −55°C and +125°C. Prices in 100-up quantities are: LM725−$15, LM725A−$20 and LM725C−$5.95 in TO-5 cans. The LM725C in mini-DIP is $2.25. National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, CA 95051. Phone (408) 732-5000. **174**

POWER TRANSISTORS PROVIDE SOLID-STATE RELIABILITY IN TV DEFLECTION CURCUITS The TIP550 and TIP553 perform the same function as a horizontal deflection vacuum tube. Continuous collector current and ratings are from 3 to 5A and collector-emitter voltage is from 1200 to 1400V. Switching speed for the TIP550 and 551 is 0.6 μsec at 2A and for the other two devices it is 0.7 μsec at 4.5A. Price in 100-piece quantities for the TIP550 is $2.10; $2.50 for the TIP551; $4.05 for the TIP552; and $4.55 for the TIP553. Texas Instruments Inc., 13500 N. Central Expressway, Dallas, TX 75222. Phone (214) 238-2011 **175**

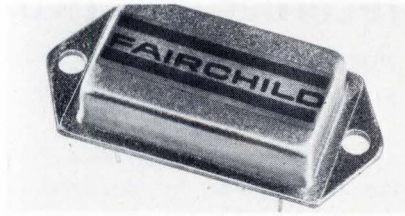
D-MOS SD300 IS A DUAL-GATE SILICON IGFET. It is made by a new principle which gives superior high-frequency performance to S-band. Special diodes are diffused and connected electrically between the two gates and source. These diodes bypass any voltage transients which lie outside the range −0.3V to +25V. Price is $12 each in 100-249 quantities. Signetics, 811 E. Arques Avenue, Sunnyvale, CA 94086. Phone (408) 739-7700. **176**

FET-INPUT MONOLITHIC OP AMP OFFERS 1 pA INPUT CURRENT. The 8007 is a pin-for-pin replacement for the 101A, 709, 740 and 741 op amps. The device offers input bias current of 2 pA, with 6V/μsec slew rate, $10^{12}\Omega$ input impedance and internal frequency compensation. It is priced at $5.00 in 100-unit quantities. Intersil, 10900 N. Tantau Avenue, Cupertino, CA 95014. Phone (408) 257-5450 **177**



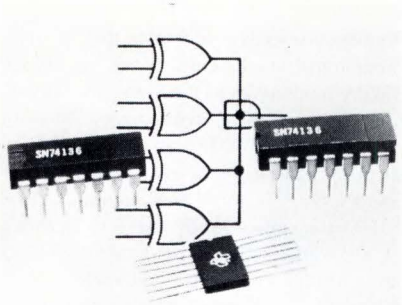
CMOS 8-STAGE STATIC BUS REGISTER has bidirectional parallel/serial input/output. This device, CD4034A, features bidirectional- asynchronous- or synchronous-parallel data loading and fully static operation from dc to 5 MHz. Prices (100-unit level): 34AD, $15; 34AK, $18. RCA, Solid State Div., Route 202, Somerville, N J 08876. Phone (201) 722-3200. **178**

IC PROVIDES ALL FUNCTIONS OF A FM/IF SYSTEM. IF amplifier, quadrature detector, AF preamplifier, and specific circuits for AGC, AFC, muting (squelch), and tuning meter are included in this new device, designated CA3089E. Features are: exceptional limiting sensitivity (12 μV typ. at −3 dB point), low distortion (0.1% typical with double-tuned coil), and internal supply-voltage regulators. Price: $2.20 (1000 unit level). RCA/Solid State Division, Route 202, Somerville, N J 08876. Phone (201) 722-3200. **179**



MULTISTAGE HYBRID AMPLIFIERS NOW IN DUAL-IN-LINE PACKAGE. The FMA 105 is a low-noise amplifier tuned to provide optimum performance over the range of 375 to 500 mHz. Specifications are flatness: +0.5 dB; P_{out}: 5 dBm at 1 dB compression; VSWR: 1.5:1 max into 50Ω. Price is $90. Fairchild Microwave and Optoelectronics Div., 464 Ellis St., Mountain View, CA 94040. Phone (415) 962 3816. **180**

EPOXY LENSED LEDs BOAST GREATER THAN 750 ft-L AT 20 mA dc. Forward voltage is 1.65V, and peak emission wavelength is at 6500Å. Turn on and off time is 5 nsec. Maximum operating and storage temperature is −55 to 100°C. and max power dissipation at 25°C. is 80 mW. Overall package size is 0.100 inch diameter. Antex Industries, Inc., 1059 E. Meadow Circle, Palo Alto, CA 94303. Phone (415) 326-2441. **181**



TTL/MSI QUAD EXCLUSIVE-OR GATE INCLUDES AN OPEN-COLLECTOR OUTPUT. The SN54/74136 is ideally suited for implementing equality detectors or simple comparisons. Four of the circuits can be connected to perform a single comparison to two 8-bit complementary binary words since the open-collector outputs can be wire-AND connected. Price in 100 pc quantities is $0.90. Texas Instruments Inc., 13500 N. Central Expressway, Dallas, TX 75222. Phone (214) 238-2011. **182**

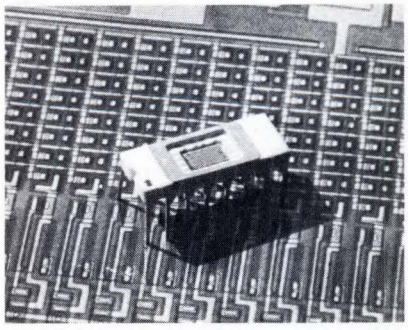
MONOLITHIC MODEM MODULATES AND DEMODULATES FREQ-SHIFT-KEYED SIGNALS. The XR-210 was designed to interface teletypewriter or computer terminals with voice-grade telephone lines. It can be used to convert binary logic pulses from the computer into FSK audio tones for transmission over voice-grade telephone lines or, to decode the frequency-shift audio tones received from telephone lines into binary logic pulses at the receiving end. The XR-210 can handle data rates up to 1800 bps. Exar Integrated Systems, 733 N. Pastoria, Sunnyvale, CA 94086. Phone (408) 732-797 **185**

A LINE OF FET LINEAR ICs ANNOUNCED. Included are the HA-2000 FET Input Preamp, HA-2050 High Slew Rate FET Input Op Amp and HA-2060 Wide-band FET Input Op Amp. The HA-2050 combines a very high slew rate, 120v/μsec, a bandwidth of 20 MHz, ultralow, 1 pA, input current, and an input resistance of 10^{12} Ω. Settling time is 400 ns. Price is $11.75 to $24. Harris Semiconductor, P.O. Box 883, Melbourne, FL 32901. Phone (305) 727-5405. **186**

MULTIPLE MOSFET PRODUCT LINE ANNOUNCED. The new line includes an ultra high speed, N-channel quad switch, the MEM 780, featuring nsec switching time with "ON" resistance of 20Ω. Applications for these new devices include: high speed multiplexer, memory gating, and high speed choppers. The MEM 780 sells for $5.15 in the 100-999 piece quantity level. General Instruments Corp., 600 West John Street, Hicksville NY 11801. Phone (516) 733-3535. **187**

MOS FIRST-IN FIRST-OUT MEMORY, the 3341, offers solutions to many problems associated with interfacing digital systems that have different data rates. It is organized 4-bits wide by 64-bits long. Data at the inputs are transferred into the memory when a shift-in pulse is applied. Once entered, they propagate to the farthest unfilled location, with no clocking required. Prices for 100 to 999 quantities are $22 for the 1 MHz version and $15.60 for the 0.6 MHz version. Fairchild Semiconductor Components Group, 464 Ellis Street, Mountain View, CA 94040. Phone (415) 962-3816. **188**

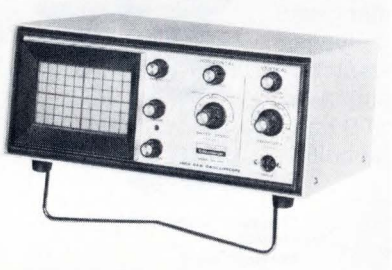
SOLID-STATE OPTO-ISOLATOR SENSES OBJECTS FROM THE REFLECTED LIGHT OF A LED. The MCA7 reflective object sensor, incorporates LED infrared emitter and a photo-darlington detector in a single package. Power rating is 150 mW for the input diode and 150 mW for the output darlington. The rise and fall time of the darlington is typically 0.6 mS. Pricing is $4.80 (1-9). Monsanto Commercial Products Co., 10131 Bubb Road, Cupertino, CA 95014. Phone (408) 257-2140. **183**



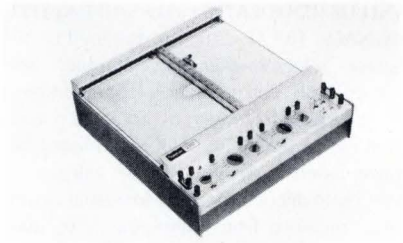
PROGRAMMABLE 1,024-BIT ROM HAS 35-nsec ACCESS TIME. Organized into 256 four-bit words, the Signetics "82S26" contains "open-collector" outputs and the "82S29" contains "tri-state" outputs. Fully field-programmable, both memories permit the user to generate his own custom patterns by following a simple procedure which opens a nichrome fuse-link. Price is $49.00 each when purchased in a quantity between 1 and 24. Signetics, 811 East Arques Avenue, Sunnyvale, CA 94806. Phone (408) 739-7700. **184**

60-MHz COUNTER COSTS $299. The Digipet-60 has a frequency range of 1 kHz to 60 MHz (or 130 to 160 MHz when used with the Digipet-160 converter) and a resolution of 1 kHz to 1 Hz (at 1-msec or 1-sec gate times). It can be operated from ac or dc sources with complete overload protection and has a stability aging rate of 1 part in 10^6/week. The entire unit is only 7-in. deep and 2-1/2-in. high. Miida Electronics, Div. of Marubeni America Corp., 2 Hammarskjold Plaza, New York, NY 10017. Phone (212) 973-7152. **191**

25-MHz $795 SCOPE WITH X-Y CAPABILITY. The Telequipment D66 dual-trace 25-MHz scope uses a 10-kV potential on its rectangular 5-in. CRT which has an 8-×-10-cm display area. Sweep rates range from 2 sec/div. to 100 nsec/div. (20 nsec/div. with X5 magnifier). Accuracy of 5%, 14-nsec risetime, deflection factors up to 10 mV/cm at full bandwidth and up to 1 mV/cm at 15 MHz are other features. The scope can be triggered at TV field or line rates. Tektronix, Inc., Box 500, Beaverton, OR 97005. Phone (503) 644-0161. **192**



HIGH GAIN $495 SCOPE WITH 50-μV/CM SENSITIVITY. The new SO-29A provides 7 calibrated sensitivity ranges from 50 μV/cm to 150 mV/cm and a completely automatic timebase with 7 calibrated ranges from 3 sec/cm to 1 msec/cm to allow hands-off triggering. Additional features include automatic intensity ranging to prevent phosphor burning on lower-sweep speeds and a vertical output that provides 1V out for every cm of deflection for driving strip-chart recorders and DVMs. Heath/Schlumberger Scientific Instruments, Benton Harbor, MI 49022. Phone (616) 983-3961. **193**



POTENTIOMETRIC X-Y RECORDER Model 2747 offers 0.2% accuracy and sensitivity up to 20 μV/cm. The instrument features electrostatic paper hold down, variable and calibrated sensitivities, eight built-in, switch-selected time bases for the X axis and an electric pen lift. The new 2747 accepts paper up to 11 × 17 in. Its writing system uses a cartridge-filled capillary pen with a 0.4-mm trace width. Simpson Electric Co., 5200 W. Kinzie St., Chicago, IL 60644. Phone (312) 379-1121. **197**

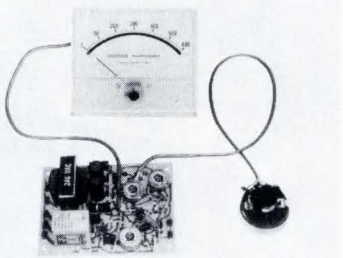
2-CHANNEL AND TIME-SHARE ANALOG RECORDERS are available for industrial, aerospace, laboratory and field use. The 3-1/2-lb. portable units include two-channel Minigraphs which have two independent galvanometer-type measuring systems to record side-by-side on identically calibrated chart areas, and time-share Minigraphs which synchronously switch two inputs to produce two independent traces on the full chart width. For identification, one trace is broken, the other is solid. Over forty chart speeds are available. Esterline Angus, Box 24000, Indianapolis, IN 46224. Phone (317) 244-7611. **198**

1-TO-1400-MHz SWEEP/SIGNAL GENERATOR Model 2000 provides cw sweep to 500 MHz, an output leveled to ±0.5 dB, a calibrated output from +10 dBm to −80 dBm and sweeps from 0.01 to 100 sec/sweep. The unit's p-i-n diode attenuator may be programmed for output level, AM or pulse modulation. The Model 2000 is priced at $1375. Wavetek Indiana, Inc., 66 N. First Ave., Beech Grove, IN 46107. Phone (317) 783-3221. **199**

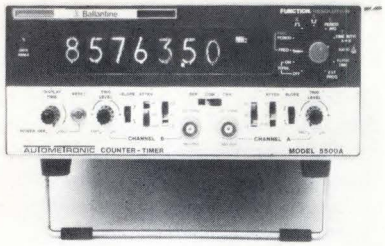
AUTOMATIC MEASUREMENT OF AMPLITUDE, PHASE AND GROUP DELAY is possible with a new 50-Hz-to-13-MHz network analyzer. Model 3040A is a two-channel, frequency-selective voltmeter that is fully programmable. It consists of a Model 3570A tracking detector with any one of four new automatic synthesizers—Models 3320A/B and 3330A/B—as its source. Swept displays can be obtained if either Model 3330A or B is the signal source. Model 3570A tracking detector costs $5000, Model 3320A/B synthesizer costs $1900/$2550 and Model 3330A/B synthesizer costs $5100/$6000. Hewlett Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **194**

DPMs REJECT 400V PK-PK LINE TRANSIENTS. The meters feature single-plane displays and input bias current under 100 pA. Three models are available with 2-1/2, 3-1/2 and 4-1/2-digit displays. Each model is available in unipolar and bipolar versions in any of 11 different ranges from 200 mV to 1000V dc, and from 20 μA to 200 mA dc. The 3-1/2-digit meter is priced at $95 in quantities of 100. Data Technology Corp., 2700 S. Fairview Rd., Santa Ana, CA 92660. Phone (714) 546-7160. **195**

DIGITAL FUNCTION GENERATOR, Model 410.31, features 10V fullscale single-amplitude sine, haversine, square, triangular, trapezoidal, and ramp signal outputs. Both positive-going and negative-going versions of all outputs are available. Output frequency of periodic functions is from 0.001 Hz to 990 Hz and fullscale ramp rates are adjustable from 1 msec to 990,000 sec (11.46 days). Dual ramp rates may be set, with a rate change taking place at a predetermined breakpoint. MTS Systems Corp., Box 24012, Minneapolis, MN 55424. Phone (612) 941-3200. **196**



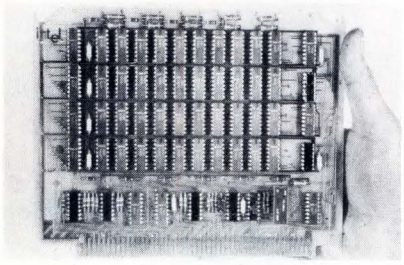
LOW-COST UNIVERSAL THERMOCOUPLE TEMPERATURE CONTROLLER, CN 100, features insensitivity to thermocouple load resistance, is fail safe on an open probe, has electronic cold-junction compensation and incorporates a local or remote setpoint potentiometer. On-off or proportional output is obtainable at no extra cost. Standard temperature ranges vary from 0 to 600°F to as high as 0 to 2000°F. The basic controller costs $44.44. Contronautics, Inc., 269 Mechanic St., Marlboro, MA 01752. Phone (617) 481-4633. **115**



70-MHz FREQUENCY COUNTER-TIMER AUTORANGES FREQUENCY AND TIME INTERVALS. The Autometronic 5500A counter-timer uses a ROM which enables time and frequency measurements with the desired resolution to be made without operator adjustments. Resolution is selectable in 4, 5, 6 or 7 digits. The Model 5500A has ten operating modes and a check or test mode: count, frequency, period, positive pulse width, negative pulse width, period average, ratio A/NB, time A to B, time interval and remote programming. The basic six-digit display package is priced at $650. Ballantine Laboratories, Inc., Box 97, Boonton, NJ 07005. Phone (201) 335-0900. **116**

DIGITAL LOCK-IN AMPLIFIER, Model 4101, features a 1-Hz-to-100-kHz frequency range and separate differential voltage/current inputs. A BCD output option allows coupling measurements into a data-acquisition system. Pushbutton controls set-meter multiplier, filters, time constant, internal oscillator range, phase quadrant, second-harmonic operation, locking-frequency source and power. Evans Associates, Box 5055, Berkeley, CA 94705. Phone (415) 653-2616. **117**

LASER INTERFEROMETER FOR PRECISE LINEAR MEASUREMENTS, Model 5900-R, incorporates a remote inter a remote interferometer. This permits isolation of the laser's heat from the measurement area and allows measurements to be made in confined spaces. Accuracy of the 5900-R is ±1 part per million +1 count over distances up to 200 feet and resolution is 3 μ-in. Included with the 5900-R is a versatile, target prism, mounted in a small lightweight cell which can be permanently affixed to the equipment being measured or set into its own mounting base. Perkin-Elmer Corp., Main Ave., Norwalk, CT 06856. Phone (203) 762-1000. **206**



PLUG-IN BIPOLAR MEMORY SYSTEM FEATURES 100 NSEC CYCLE TIME. System in-50 read/write memory stores 1024, 10-bit words on one 6 × 8 in. pc card. Each card is a complete operational memory system. The number of words stored and/or the word length may be increased by adding identical cards. Power required is +5.0V ±5% at 5.5A. Price is 5¢ to 7¢ per bit in small OEM quantities. Memory Systems Operation, Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. Phone (408) 246-7501. **207**

COMBINATION MODEM AND DIALER FITS IN ONE CABINET. The modem/dialer is compatible with Bell 103A (300 baud) or 202C (1200 baud with or without reverse channel) modems and with Bell 801A (pulse) or 801C (touch-tone) autqmatic calling units. The chassis features complete diagnostics, front panel display of all interface leads, plus audible monitoring of line signals. $700 for 300 baud and $800 for 1200 baud units. Vadic Corp., 916 Commercial, Palo Alto, CA 94303. Phone (415) 321-6201. **208**

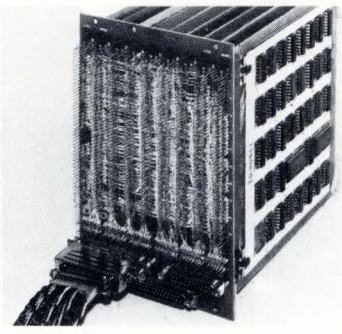
COMPUTER IS DESIGNED FOR DATA COMMUNICATIONS SYSTEMS. The Tempo II processor features a read-restore memory with 750 nsec cycle time; DMA I/O port; built-in program load with ROM; choice of operator control panel or security panel, and input/output processor. It is compatible with the Tempo I and is available in a range of lease prices from under $300 a month up to $7000. GTE Information Systems Inc., 4 Corporate Park Dr., White Plains, NY 10604. Phone (914) 694-8840. **209**

VIDEO TERMINAL CONTROLLER FEATURES 80 x 16 A/N DISPLAY. Model 206 provides a soundless A/N display at asynchronous data rates to 1200 cps, plus full graphics in black/white or color. It can drive multiple displays, which may be either conventional TV sets or standard 525-line video monitors. Standard units provide serial or parallel RO33- or KSR33-equivalent interface with RS232C, TTL, or current loop compatibility, and a 64-character ASCII repertoire. $945. Ann Arbor Terminals, Inc., 6107 Jackson Rd., Ann Arbor, MI 48103. Phone (313) 769-0926. **210**

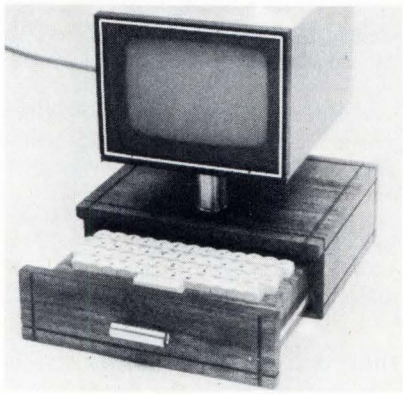
DISC MEMORY ADDS ONE MILLION WORDS TO HONEYWELL 316/516 MINIS. The 1737 is a high-capacity, fast access, head-per-track disc memory peripheral with capacity available in five levels from 65k to 1048k words. The average access time is 16.7 msec, and the average data transfer rate is selectable in four increments from 8 to 64 msec per word. Data Disc Inc., 686 W. Maude Ave., Sunnyvale, CA 94086. Phone (408) 732-7330. **211**

FIELD-ALTERABLE ROM MATES WITH PDP-14 MINI. The lk × 12-bit ROM system is comprised of two separate assemblies. The drive circuit card replaces the G924 circuit card in the PDP-14. The braid assembly replaces the G922 and G923 circuit cards. Operating from a single +5.0V power supply, system access time is 150 nsec and cycle time is 480 nsec. Datapac, Inc., 3180 Redhill Ave., Costa Mesa, CA 92626. Phone (714) 546-7781. **212**

ADD-ON CORE MEMORY DOUBLES HP 2114A/B MINICOMPUTER CAPACITY. Three add-on sizes 4k, 8k and 12k allow for combinations of HP and DSS memory totaling 16,384 words. The DSS extension memory is completely hardware and software compatible with the HP 2114A/B and is divided into three modules; the memory interface, the memory controller and the core memory module. Digital Systems Services, P.O. Box 1239, Mountain View, CA 94040. Phone (415) 968-4257. **213**



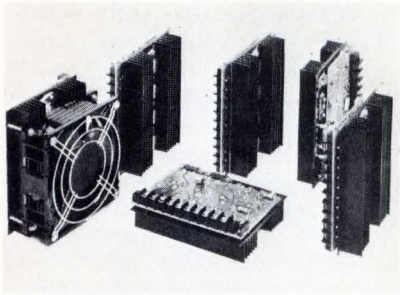
MICROPROCESSOR IS DESIGNED FOR DEDICATED USES. The AES-80 microprocessor is a byte oriented programmable processor. Full cycle time is 240 nsec. Modules of bipolar, MOS, core memory, etc, can be intermixed in both data and instruction memories. Up to 4k of 12-bit ROM and 4k of 8-bit RAM can be added in modules of 256 words, with additional memory available on an indirect basis. Software support includes a cross assembler, minicomputer emulator, a self assembler, and system development routines. Automatic Electronic Systems Inc., 5455 Pare St., Montreal 309, Canada. Phone (514) 735-6581. **214**



MINIATURE CRT TERMINAL DESIGNED FOR EXECUTIVE'S DESK. Made of solid walnut the B-401 EXECUTERM is plug interchangeable with standard Teletypes. The desktop display presents 16 lines with 32 characters/line using the full 64 character ASCII upper case set on a 6 in. CRT. A full typewriter-style keyboard is mounted in a drawer at the display base. Unit price is $1760 on a minimum order of 10. CARMEL Electronics, Inc., 5794 Venice Blvd., Los Angeles, CA 90019. Phone (213) 934-1866. **215**

TAPE READERS INTERFACE WITH PDP-8. The LED 9000 Series family transfers data at 300 cps. An interface card plugs directly into the DEC "Omnibus". Model TRF9300-BOCBA fan-fold reader with Model R-9000-8e, f, i, l, or m interface, sells for $1280. Electronic Engineering Co. of California, Electronic Products Div., 1441 E. Chestnut Ave., Santa Ana, CA 92701. Phone (714) 547-5651. **216**

INTEGRAL MODEM ACHIEVES LESS THAN ONE BIT/MILLION ERROR-RATE. Standard features of Model 2011 include answer back tone, automatic answering, carrier detect, clear to send delay, external/internal transmitter timing, local copy, receiver squelch, and MARK hold on receive data when carrier is lost. The modem operates at 2000 bps on the DDD network via a CBS data access arrangement following typical Bell 201A call establishment procedures. $1115. Intertel, Inc., 6 Vine Brook Park, Burlington, MA 01803. Phone (617) 273-0950. **218**



LINEAR POWER AMPLIFIER Series IC-160 includes three versions: Models 20-IC-160, 30-IC-160 and 40-IC-160. These produce output currents of 20, 18 and 20A, respectively, and single-unit output powers of 320, 465 and 720W, respectively. These amplifiers can be used in a bridge configuration that increases their output powers by a factor of two—640, 930 and 1140W, respectively. Inland Controls, Inc., 250 Alpha Dr., Pittsburgh, PA 15238. Phone (412) 782-3516. **222**

A $149 1-μSEC (TO 0.01%) S/H AMPLIFIER. The Model ZD-452 also has a decay rate of 100 μV/msec, aperature time of 5 nsec and a 4-MHz bandwidth. It has a slew rate of 150 V/μsec (inverting or non-inverting), an input impedance of $10^{10}\Omega$ and input current of 1 nA. Additional features include a low power drain of 35 mA at ±15V, DIP compatibility and an overall volume of 1.4 $in.^3$. The $149 price is for single units. Zeltex, Inc., 1000 Chalomar Rd., Concord, CA 94520. Phone (415) 686-6660. **223**

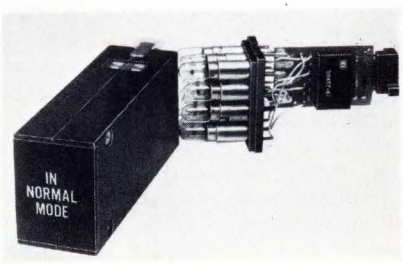
FAST MULTIPLYING D/A CONVERTERS. New Series 200AM 8, 10 and 12-bit d/a converters are capable of settling to ±LSB a fullscale digital input in 500 nsec and a fullscale analog input in 1 μsec. No external driver amplifiers or current boosters are required as all the converters have ±10V 40-mA outputs capable of driving 75Ω coaxial cable. Eight-bit units start at $125. Dynamic Measurements Corp., 6 Lowell Ave., Winchester, MA 01890. Phone (617) 729-7870. **224**

14-BIT SYNCHRO OR RESOLVER-TO-DIGITAL CONVERTER, Model 1623E, converts 60 or 400 Hz at 26 or 115V 3-wire synchro or 4-wire resolver inputs to binary or BCD outputs. It will track inputs up to 2400 degrees/sec and is available in conversion rates of 400 or 800/sec. Rates can be factory set to as low as one per three seconds and one per second, respectively. Price is $595. Transmagnetics, Inc., 210 Adams Blvd., Farmingdale, NY 11735. Phone (516) 293-3100. **225**

LINE OF ACTIVE NOTCH-FILTER MODULES is capable of being mounted in PC boards. The 7-pin plug-in modules are available in a wide number of notch frequencies spanning the audio range within sharply defined limits and offer no insertion losses. Required bandwidth is conveniently set by an external resistor without affecting either tuning or amplification factor. A dc offset capability is also included. Minimum attenuation at the notch frequency is −40 dB. A. P. Circuit Corp., 865 West End Ave., New York, NY 10025. Phone (212) 222-0876. **226**

BROADBAND AMPLIFIER COVERS 30 TO 300 MHz. PAM-300 Series solid-state amplifier features a 5.5-dB noise figure and an output of up to +10 dBm at 1-dB compression. Gain is 24 dB while gain variation is only ±0.5 dB. For two −20-dBm input signals, second-order intermodulation products are −40 dB down and third-order intermodulation products are −65 dB down. Input and output VSWR are 1.7:1 and 1.3:1, respectively. American Electronic Laboratories, Inc., Box 552, Lansdale, PA 19446. Phone (215) 822-2929. **227**

5V, 5A HYBRID VOLTAGE REGULATOR DPS-2001 is designed for TTL power-supply and other 5V high-current applications. The unit is rated to operate over a temperature range of −55 to +125°C. Packaged in a standard two-lead, TO-3 case, the DPS-2001 requires no external components. Single-unit price is $35 and 100-unit price is $16. Dickson Electronics Corp., Box 1390, Scottsdale, AZ 85252. Phone (602) 947-2231. **228**



LOW-COST DRIVER/DECODER Series 7610 has been developed for use with the popular Series 0010 rear-projection readout. The $21.45 driver/decoder features a drive capability of up of 300 mA at 30V, DTL/TTL logic input and 10, 11 or 12 decoded output operations. Memory, nonmemory and reverse data operations are available as options. Lamp blanking is standard. Industrial Electronic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405. Phone (213) 787-0311. **229**

DIP SINE-WAVE CRYSTAL CONTROLLED OSCILLATOR produces 3V rms nominal into a 10-kΩ load. The oscillator also offers distortion of less than 5% at fixed frequencies over 1 kHz to 10 MHz and a frequency tolerance of ±0.001%. It operates over 0 to +50°C, or 0 to +65°C or −25 to +75°C. Voltage requirements are +5V dc and either −5, −12 or +9 to +20V dc. Conner-Winfield Corp., Winfield, IL 60190. Phone (312) 231-5270. **230**

COMMUNICATIONS RECEIVER FRONT ENDS WITH NOISE FIGURES OF 10 dB SSB AT 37 GHz. The TRG Series A9100 front ends use reversible GaAs Schottky barrier diodes and exhibit a signal frequency of 36.25 to 38.25 GHz, i-f frequency (3 dB) of 670 to 1170 MHz, rf/i-f gain of 25 dB and LO power of 4 mW. VSWR is only 1.5:1. Control Data Corp., 400 Border St., E. Boston, MA 02128. Phone (617) 569-2110. **231**

DUAL 15V POWER-SUPPLY MODULE PROVIDES 110 mA FROM A 4.5 TO 5.5V DC SOURCE. The 0.4-X-2-X-2-in. Model 602 requires no heat sink from 0 to 70°C ambients. For full-load steps, recovery is 5 μsec maximum with less than 0.4% over or undershoot. Combined line and load regulation is 0.2%. Output ripple is 35 mV pk-pk and 1 mV rms maximum. The 602 costs $59. Delta-Tronics Corp., 1316 E. Princess Dr., Tempe, AZ 85281. Phone (602) 966-9380. **232**

$65, 90° QUADRATURE HYBRIDS WITH OCTAVE BANDWIDTHS. Two low-profile (3/8-in.-high) four-port hybrids, Models JH-116 (20 to 40 MHz) and JH-117 (40 to 80 MHz), feature 25-dB isolation, phase linearity within 3° from the best straight line and 0.5-dB maximum insertion loss. Third-order intermodulation ratio is −85 dB with two +20-dBm signals. ANZAC Electronics, 39 Green St., Waltham, MA 02154. Phone (617) 899-1900. **233**

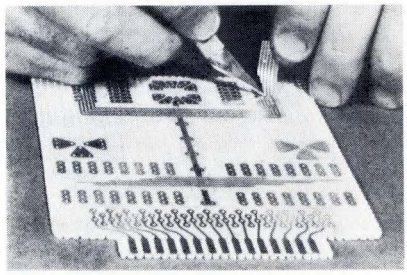
A HIGH SPEED ACCELERATOR is designed to handle a broad range of steppers, loads and stepping frequencies. It will accelerate drive systems to any frequency of an input pulse train between 200 and 20,000 pulses/sec. The unit begins acceleration with the first pulse of the input pulse train and continues until the required stepping rate is obtained. Called the A6, it will phase lock to the input frequency such as reference time standards. Dahmen Burnett Electronics, Grenier Industrial Village, Londonderry, N H 03053. Phone (603) 688-2777. **234**

ELECTRO/OPTICAL DETECTORS HAVE INTEGRATED SIGNAL PROCESSING. Units combine windows, lenses, filters, silicon PIN diode-type detectors, amplifiers and associated transfer-function electronics. Units are for dc or ac light detection, with sensitivites to 10^{-12} W, bandwidths to 20 mHz, 10^{8} dynamic range and NEPs to 10^{-13} w/$\sqrt{Hz}$. Pricing: $62.00 each in 100 quantity. Bell & Howell, Control Products Div., 706 Bostwick Ave., Bridgeport, CT 06605. Phone (203) 368-6751. **239**

MINIATURE 10-CONTACT CONNECTORS ACCEPT WIRES CRIMPED TO MIL-C-39029/01 insertable/removable pin contacts. Plugable T.J.S. type connectors are available in solder or crimp termination. Socket contact incorporates cylinder sections with independent pressure springs and integral bussing to insure consistent uniform performance. Appleton Electronics Div., Appleton Electric Co., 1701 Wellington Ave., Chicago, IL 60657. Phone (312) 281-6400. **240**

ULTRA-HIGH CONTRAST CATHODE-RAY TUBE CAN BE READ IN BRIGHT SUN without hoods or shields. Designated the HC-500 series, the tubes can legibly display five shades of gray in the presence of direct sunlight at 10,000 foot candles. Tubes in the 4 in. × 6 in. rectangular size will be available for evaluation within 45 days and will be priced at $200. Dumont Electron Tubes, 750 Bloomfield Ave., Clifton, N J 07015. Phone (201) 773-2000. **241**

THIN-TRIM CAPACITORS PROVIDE A NEW TECHNIQUE FOR MICROCIRCUIT TUNING. Their small body size (0.200 sq. × 0.045 thick) allows them to be used for critical applications where high-capacitance trimming is required. They are available in two mounting styles for printed circuit or stripline mounting. The 9410 series includes 5 models with capacitance ranges up to 40.0 pf. Price, 95¢ each in volume. Delivery, 6 weeks. Johanson Manufacturing Corp., 400 Rockaway Valley Rd., Boonton, N J 07005. Phone (201) 334-2676. **242**



NEW 'STRIPLINE SUBELEMENTS' FOR HIGH- AND MEDIUM-DENSITY INTERCONNECTIONS in prototype circuit boards. Self-adhesive stripline parallel conductor subelements have insulated epoxy glass substrates and are available in conductor line widths from 0.010 in. to 0.250 in. When used with other standard CIRCUIT-STIK component subelements, the stripline may also be used for high-frequency breadboarding, for making card extenders, and for repair of production circuit boards. Circuit-Stik, Inc., 24015 Garnier St., Torrance, CA 90510. Phone (213) 530-5530. **243**

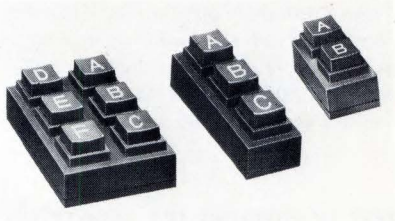
18-PIN DUAL-IN-LINE SOCKET AIDS SEMICONDUCTOR MEMORY FABRICATION. Designed for the new 18-pin MOS & bipolar memory and complex ICs, the 2200/2900 Series of DIP sockets provide circuit designers with the highest possible component density. The 2200 is used with wire wrap packaging techniques, the 2900 with soldered interconnections. Price $0.51, for solder terminals; $0.59 for wire wrap terminals in 1000 quantities. Stanford Applied Engineering, Inc., Advanced Packaging Products, 2165 S. Grand Ave., Santa Ana, CA 92705. **244**

LINEAR-MOTION SLIDE CONTROL OFFERS DESIGNERS SPACE SAVINGS. This new design gives the performance full-size rotary control in a thin, compact molded housing. Power capabilities of 1/2W, full 1-3/4 in. travel, resistance values from 200Ω to 5MΩ; wirewrap, PC, or solder lug terminals; top- or bottom-twist-tab mounting. CTS of Brownsville, Inc., 1100 Roosevelt St., Brownsville, TX 78520. Phone (512) 546-5184. **245**

PLUG-IN AUDIO TRANSFORMER LINE FOR PRINTED CIRCUIT BOARDS. Ouncer, Subouncer and Sub-subouncer audio transformers, are now available in plug-in, PC board versions. TRW/UTC says the units, maintain the reliability and utility of the insulated lead Ouncer lines. Pricing and quantity: 0-$4.70, 50-$3.20, 550-$3.30. TRW/UTC Transformers, 150 Varick St., New York, NY 10013. Phone (212) 255-3500. **246**

TEMPERATURE-SENSITIVE LIQUID CRYSTALS ARE NOW AVAILABLE in a continuous-coating film form in widths up to two ft. and lengths up to 1000 ft. The films are available as standard in several formulations each of which reacts over a temperature range of approximately 10°F. These fall within a range of approximately 60°F to 110°F. These new products can be used to check printed circuit boards before mounting components, to find hot spots in cabinets, etc. Adman, Inc., 111 E. Market St., York, PA 17403. Phone (717) 845-9679. **247**

ENERGY-DISCHARGE CAPACITORS FOR LIGHT-DUTY APPLICATIONS. Designated as Type PX, energy discharge capacitors are available in working voltages from 5 kVdc to 125 kVdc and a range of capacitance values from 0.4 μf to 120 μf. The units feature rigidly controlled and carefully processed paper dielectrics, liquid impregnants and are housed in welded steel or drawn steel cases. Terminals are available to meet all inductance and voltage requirements. Aerovox Corp., New Bedford, MA 02741. Phone (617) 994-9661. **248**



PUSHBUTTON-SWITCH MODULE FOR PC BOARD APPLICATIONS. Modules will be available in 6-, 3-, 2-, and 1-button versions. SPST (N.O.) to 4PST (N.O.) is available under each button, Circuitry can be the same throughout the module or different for each button. Each switch section is rated to make and break 100 mA at 5V dc for an anticipated life of 250,000 operations. Grayhill, Inc., 561 Hillgrove Ave., La Grange, IL 60525. Phone (312) 354-1040. **249**

IC-COMPATIBLE REED RELAYS, 74-A1 PROVIDE ISOLATION. Contact is rated at 10 VA max. and 0.5A or 200V RMS maximum. Configuration is SPST-NO with four P.C. mount pins on 0.1-in. grid. 3.6V dc pull-in coupled with the 475Ω coil resistance allows direct driving by 54/74 TTL series. Pricing: $4.00 each, quantity 10-99. MKC Electronics Corp., 454 E. Donovan Rd., Kansas City, KS 66115. Phone (913) 371-1351. **250**

LITERATURE

THE VISIG II SIGNAL-CONDITIONING SYSTEM from Vidar Corp., is detailed in a new brochure. The system provides high-quality signal conditioning and complements current comprehensive Vidar data-acquisition systems. Vidar Corp., 77 Ortega Ave., Mountain View, CA 94040. **251**

A LOW COST A/D CONVERTER is described in a two-page data sheet. The sheet contains detailed electrical and mechanical specifications and performance data. The converter is suited for medical, geophysical and oceanographic data-logging applications. Datel Systems, Inc., 1020 Turnpike St., Canton, MA 02021. **256**

OPEN-TYPE POWER SUPPLIES. A brochure on Power Pac's two new EP Series (10 models) of Econopac power supplies gives complete specifications and prices. These low-cost units have outputs ranging from 5 to 24V and 0.8 to 6A. Power Pac, Inc., 24 Stage St., Stamford, CT 06901. **118**

DIGITAL PRINTER CATALOG. . . . A new 12-page catalog in four color describes a complete range of digital printers for industrial applications. The catalog offers complete printer specifications, options and operating principles for two major printer lines; a ticket printer series, and a tape printer series. Hecon Corp., P.O. Box 247, Eatontown, N J 07724. **252**

MICROWAVE IC MIXERS AND MIXER PREAMPS are described in a six-page product bulletin. Described are a new line of double-balanced mixers, mixer preamps and image-rejection mixers. Over 100 models are shown along with nine graphs noting specific performance characteristics. RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, NY 11735. **257**

AC-LINE CONDITIONERS AND REGULATORS. A broad line of ac-line conditioners, regulators, converters, inverters and switching dc power supplies are described in a 28-page catalog. The catalog gives specifications and prices of line conditioners from 60 to 5000VA with noise suppression as high as 400:1. Tele-Dynamics/Wanlass, 525 Virginia Dr., Fort Washington, PA 19034. **119**

D/A CONVERTERS are featured in a new four-page catalog which provides specifications on 24 different models in DIP package and module form. Included are 6, 8, 10, and 12-bit units. Micro Networks Corp., 5 Barbara Lane, Worcester, MA 01604. **253**

PHASE LOCKED GUNN OSCILLATORS which operate from 8 to more than 30 GHz are described in a bulletin. The new sources are suitable for both commercial and military applications. Micromega Div., Bunker Ramo Corp., 12575 Beatrice Ave., Los Angeles, CA 90066. **258**

LASER AMPLIFIER SYSTEM literature is available on high-performance, solid-state laser amplifier systems. The amplifiers are up to 21-in. long and are suitable for use with both ruby and glass laser systems. Apollo Lasers, Inc., 6365 Arizona Circle, Los Angeles, CA 90045. **120**

DIGITAL TAPE RECORDERS—A new six page short-form catalog describes incremental and synchronous tape transports for generating IBM compatible magnetic tape. Detailed specifications are listed so the systems designer can easily compare the seven models. Descriptions of dual buffers for high speed operation, formatters and minicomputer interfaces are included. Digi-Data Corp., 4315 Baltimore Ave., Bladensburg, MD 20710. **254**

ASYNCHRONOUS COMMUNICATIONS CONTROLLERS—A four-page bulletin describes the Models 2612 and 2612-1 asynchronous communications controllers which enable the Micro 1600 minicomputer to communicate with local or remote asynchronous devices. The bulletin contains detailed operating information and a general description along with a list of features and specifications. Microdata Corp., 644 E. Young St., Santa Ana, CA 92705. **259**

A 32-PAGE TELEMETERING CATALOG describes a line of telemetering products which includes voltage controlled oscillators, oscillators, FM discriminators, frequency-to-dc converters and amplifiers. Also included are analog signal isolators, pressure transducers, power supplies and wireless data links. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **121**

XEROX COMMUNICATIONS SYSTEMS—Xerox Corporation's capabilities in computer-controlled data communications systems are described in a new 8-page brochure. The brochure describes the Xerox "turnkey" approach to systems design, highlights the benefits and features of Sigma communications systems, and summarizes the hardware, software, and support available to communications customers. No. 64-33-24A. Xerox Corp., Dept. (A3-05), 701 S. Aviation Blvd., El Segundo, CA 90245. **255**

INFORMATION DISPLAY DIGEST, containing 61 technical papers given at the 1972 SID symposium, San Francisco, is a wealth of information on display hardware and applications. Included in the text are developments in liquid crystal displays, solid state devices, computer terminals and graphics, plasma in new display packages, display drivers and CRT devices. This bound 176 page volume is available at $15 ($10 for SID members). SID, Lewis Winner, 152 W. 42nd Street, New York, N.Y. 1036. **260**

ADD-ON MEMORIES—Add-on memory units for the DEC PDP-81, -11 and -12 minicomputer are discussed in a new 12-page brochure. Called "How to Enlarge Your Little Memory", the brochure describes the advantages of purchasing add-on memory from an independent memory manufacturer and covers such considerations as installation, cost savings, and quality procedures. Information Control Corp., 9610 Bellanca Ave., Los Angeles, CA 90045. **122**

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Application Notes

DIODE APPLICATIONS IN MICROWAVE CIRCUITS. Reprints of a tutorial recently delivered by Dr. Frank E. McDonnell of American Electronic Laboratories, Inc., to the Lehigh Valley Section of the IEEE are available. Dr. McDonnell presents numerous examples of the circuit-optimized semiconductor and package as he explores a broad variety of diode applications. A table lists the more common applications and the most common diode types. American Electronic Laboratories, Inc., Box 552, Lansdale, PA 19446. **261**

4 WATT POWER IC DESCRIBED IN APPLICATIONS BULLETIN. The LM354 is designed for use as an audio amplifier in TV sets, record player, and industrial uses. The package is 14 lead plastic, with an external heat-sink soldered to a thermal mass. The Circuit has been designed to minimize the number of external components, making it suitable for highly compact apparatus, and is described in this 8 page bulletin. European Electronic Products Corporation, 10180 W. Jefferson Blvd., Culver City, CA 90230. **262**

PLASTIC CAPLUG SERVES AS SHOCK "PILLOW" FOR PHOTOCELL. Fact Sheet No. 712, describes how a university laboratory staff discovered that they could protect delicate instruments. The Caplugs act as a cushion between the instruments and mounting boards. A copy of this application can be obtained by requesting "Fact Sheet No. 712" from Caplugs Division 2164 Elmwood Avenue, Buffalo, N.Y. 14207. **263**

"TRIAC POWER CONTROLS FOR THREE-PHASE SYSTEMS," lists basic design rules, describes an integrated-circuit zero-voltage switch used for triac triggering, and explains methods for isolation of the dc logic circuity in power controls for three-phase systems. The Note contains seven illustrations that show voltage phase and timing relationships and circuit diagrams for practical power controls. Copies may be obtained from RCA Solid State Division, Box 3200, Somerville N. J. 08876. **264**

MODEMS—A free six-page brochure describes the Model 2011, a Bell 201A-compatible modem. Included in the brochure are descriptions of important features, detailed theory of operation, complete technical specifications, a data mode timing diagram, an illustration showing the transmitted signal frequency spectrum, and a block diagram of both calling and answering station call procedure sequences. Intertel, Inc., 6 Vine Brook Park, Burlington, MA 01803. **265**

AM AND FM MEASUREMENTS WITH TRANSFER OSCILLATORS. A new 20-page application note tells how to make AM and FM measurements with the transfer oscillator. Transfer oscillators, in combination with electronic counters, are widely recognized as the least costly means of measuring great frequency ranges, such as 50 MHz to 18 GHz or more. They are equally well accepted as the preferred or only way to measure pulsed rf or heavily modulated signals. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. **266**

MICROCIRCUIT RELIABILITY BIBLIOGRAPHY AD-740 131, by B. A. Petersen, Reliability Analysis Center (IITRI), Chicago, paper copy only $40.00, this 430 page report contains complete bibliographic information with abstracts for more than 2,200 references. Instructions on ways to obtain the many kinds of documentation cited are included. U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22151. **267**

PERIODICAL SHOWS SPECIAL USES OF COUNTERS AND CONTROLS. "Counter Action", a periodical, illustrates and explains typical applications for their equipment used in many industries as production or counting controls. Articles cover a wide range of applications and interest. To receive free copies of the ECCI Counter Action, write to Electronic Counters & Controls Inc., 33 Baker Road, Lake Bluff, Ill. 60044. **268**

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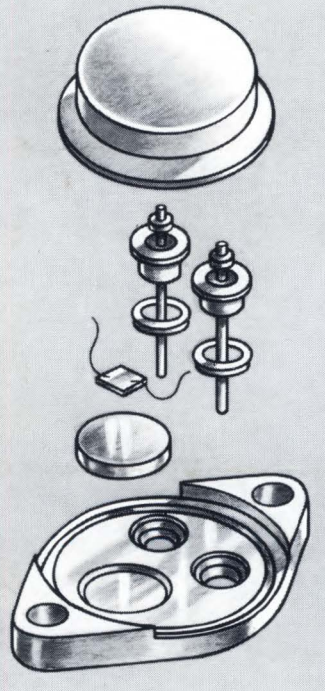

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