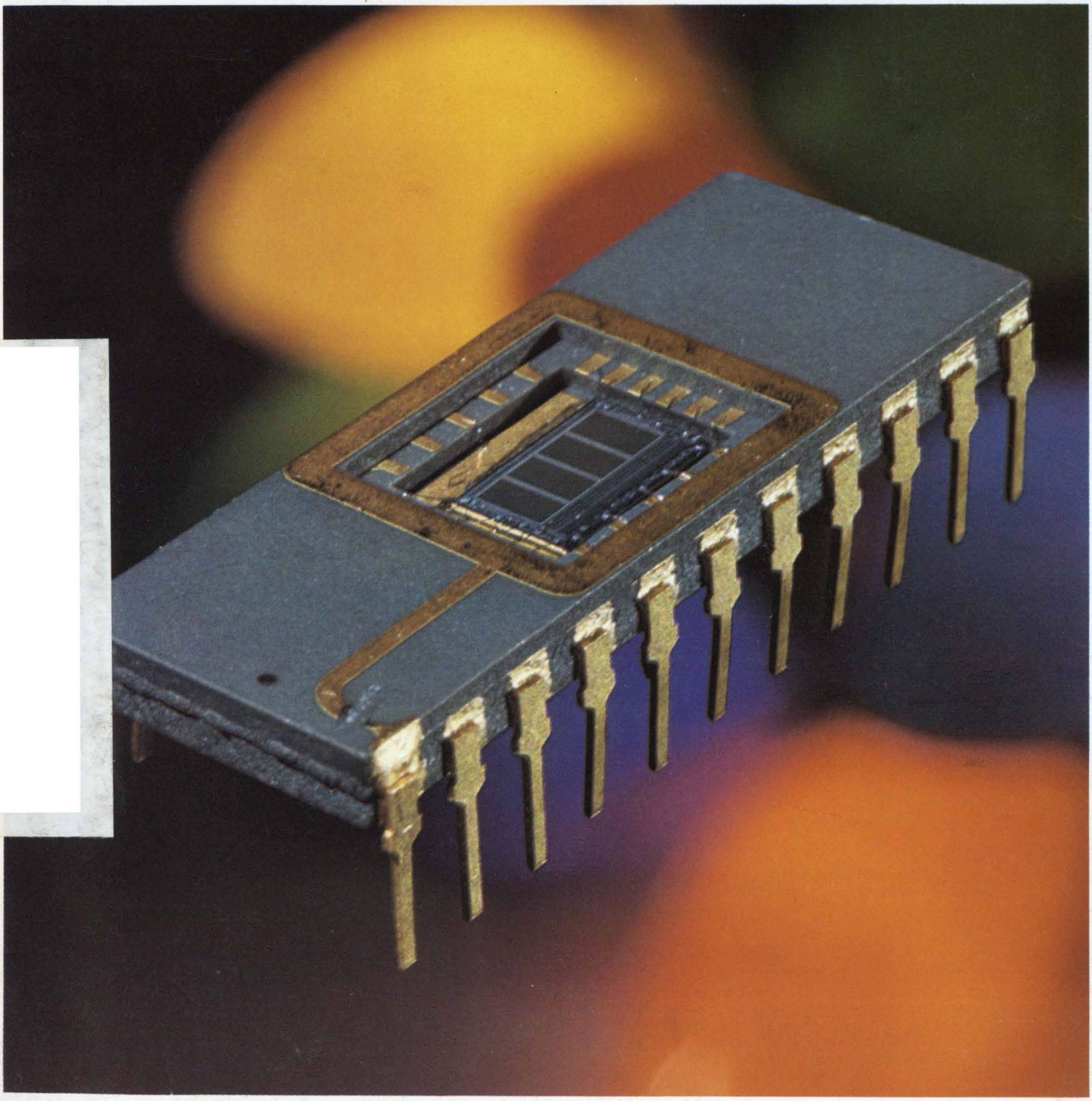
VOL. 23 NO. 4

Electronic Design®

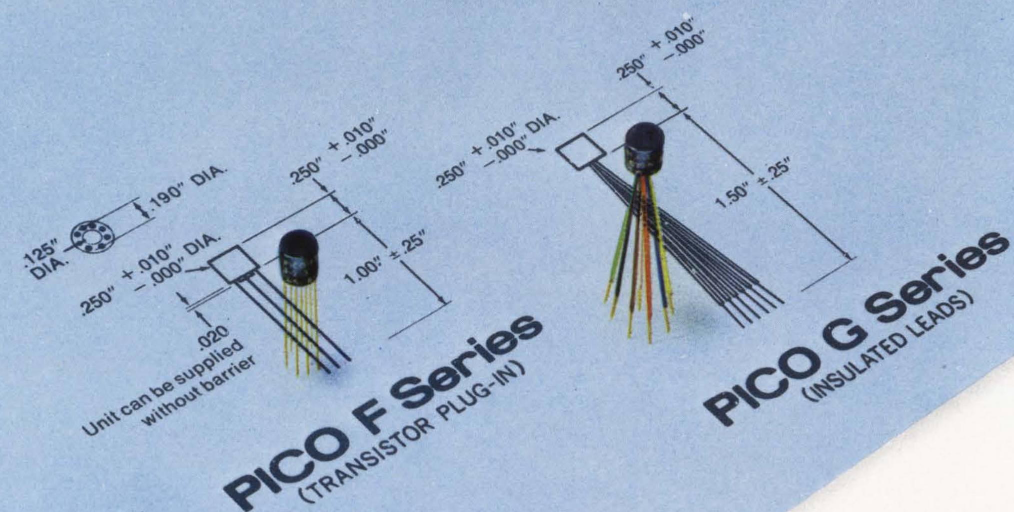
FOR ENGINEERS AND ENGINEERING MANAGERS

FEB. 15, 1975

The first 16-k bit CCD memory chip launches a new generation of increased-density storage ICs. Charge-coupled-device memories threaten electromechanical types with obsolescence. In contrast with discs and drums, the CCDs need less power, work at higher speeds and require a fraction of the space. For more, see p. 100.



ultra-miniature transformers
¼" x ¼"



SPECIFICATIONS

- **MIL-T-27D:** All Units Are Designed to MIL-T-27D and Are Hermetically Sealed in a Metal Case. PICO is a QPL source.
- **Frequency Response:** ±3 db, 400 Hz-250 KHz at 1.0 milliwatt.
- **Maximum Distortion:** 5% With Rated Power Level at 1 KHz.
- **Dielectric Strength:** All Units Tested at 200 V RMS.
- **Insulation Resistance:** Greater than 10,000 Megohms at 300 V DC.
- **Weight:** 1.1 GRAMS.
- **Operating Temperature:** −55°C to 105°C (All Units Can Be Supplied to Class S Requirements 130°C maximum).
- **Terminals:** .012 Diameter Gold Plated Dumet Wire In Accordance With MIL-STD-1276 Type D. Leads May Be Welded or Soldered.
- **Thermal Shock:** 25 Cycles, Method 107C, MIL-STD-202D, Test Condition A-1

PICO PART NUMBER F Series	PICO PART NUMBER G Series	PRIMARY IMPEDANCE OHMS	SECONDARY IMPEDANCE OHMS	POWER MILLIWATTS at 1 KHz	PRIMARY UNBALANCED DC CURRENT ma	PRIMARY DC RESISTANCE OHMS	SECONDARY DC RESISTANCE OHMS	MILITARY DESIGNATION
F5705	G6005	50	50	100	5.0	7.5	9.0	TF5RX17ZZ
F5710	G6010	100	100	100	5.0	15	18	TF5RX17ZZ
F5715	G6015	120 ct	3.2	100	4.5	15	0.75	TF5RX17ZZ
F5720	G6020	150 ct	12 split	100	4.0	20	2.4	TF5RX17ZZ
F5725	G6025	300 ct	600 split	100	3.0	40	90	TF5RX17ZZ
F5730	G6030	400 ct	400 split	100	2.5	54	58	TF5RX17ZZ
F5735	G6035	500 ct	50 split	100	2.0	62	10	TF5RX17ZZ
F5740	G6040	500	600	100	2.0	62	90	TF5RX17ZZ
F5745	G6045	600 ct	600 split	100	2.0	70	90	TF5RX17ZZ
F5750	G6050	900 ct	600	100	1.5	130	90	TF5RX17ZZ
F5755	G6055	1K ct	1K split	100	1.5	110	140	TF5RX17ZZ
F5760	G6060	1.5K ct	600 split	100	1.2	175	69	TF5RX12ZZ
F5765	G6065	2K ct	8K split	80	1.0	200	1000	TF5RX12ZZ
F5770	G6070	10K ct	500 split	80	0.5	1000	60	TF5RX12ZZ
F5775	G6075	10K	500	80	0.5	1000	60	TF5RX12ZZ
F5780	G6080	10K ct	1 2K split	80	0.5	1100	160	TF5RX12ZZ
F5785	G6085	10K	1.2K	80	0.5	1100	130	TF5RX12ZZ
F5790	G6090	10K ct	2K split	80	0.5	1100	250	TF5RX12ZZ
F5795	G6095	10K ct	10K ct	80	0.5	1100	1100	TF5RX12ZZ
F5800	G6100	10K	10K	80	0.5	1100	1100	TF5RX12ZZ
F5805	G6105	10K ct	10K split	80	0.5	1100	1100	TF5RX12ZZ
F5810	G6110	25K ct	1K split	50	0.3	2100	130	TF5RX12ZZ
F5815	G6115	25K	1K	50	0.3	2100	130	TF5RX12ZZ
F5820	G6120	30K ct	1.2K	50	0.3	2300	180	TF5RX12ZZ

INDUCTORS

PICO PART NUMBER F Series	PICO PART NUMBER G Series	INDUCTANCE HENRIES	DC CURRENT ma	DC RESISTANCE OHMS	MILITARY DESIGNATION
F5825	G6125	SERIES { 10.0 / 2.75	0 / 2	2250	TF5RX20ZZ
		PARALLEL { 2.5 / .65	0 / 4	560	
F5830	G6130	SERIES { 5.5 / 1.5	0 / 2	1000	TF5RX20ZZ
		PARALLEL { 1.3 / .40	0 / 4	250	
F5835	G6135	SERIES { .85 / .25	1 / 6	240	TF5RX20ZZ
		PARALLEL { .21 / .06	2 / 12	60	
F5840	G6140	SERIES { .6 / .15	0 / 5	144	TF5RX20ZZ
		PARALLEL { .15 / .04	0 / 10	36	

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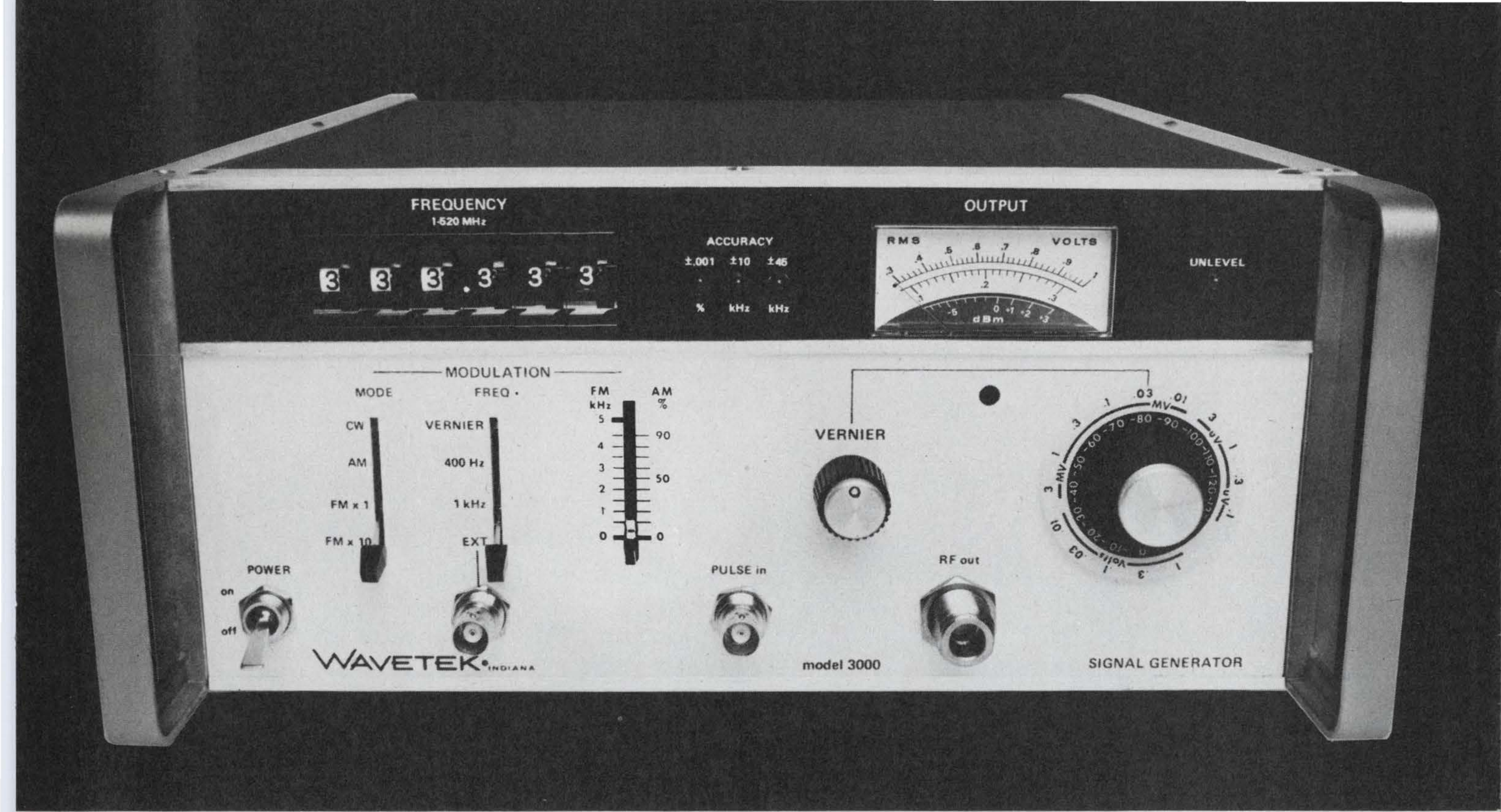

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Frequency Accuracy: ±0.001%
Resolution: 1 kHz
Stability: Less than 0.2 ppm per hour
Output Range: +13 dBm to −137 dBm
Flatness: ±0.75 dB
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FM Deviation: 0–5 kHz and 0–500 kHz
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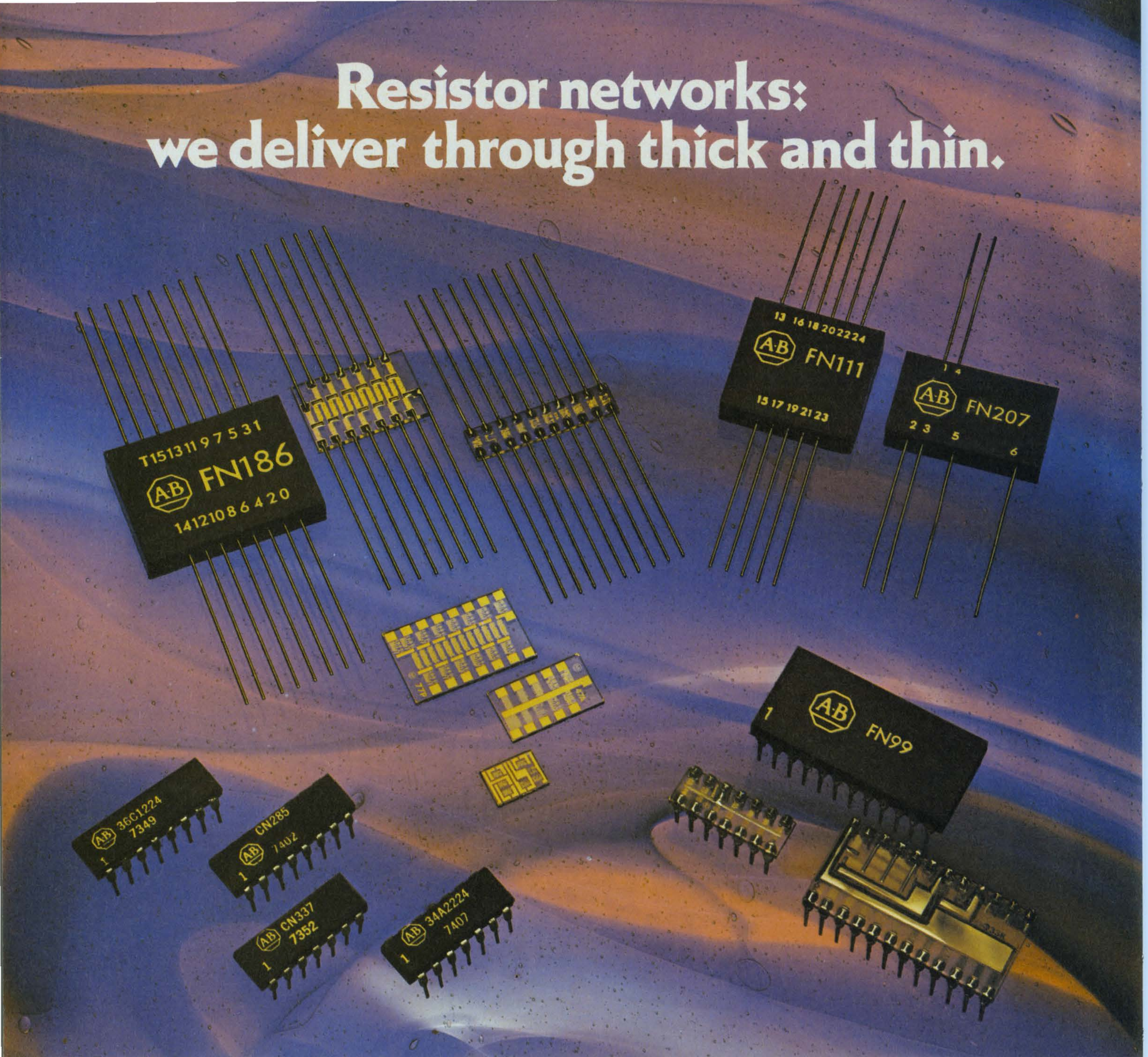

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EC85B

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VOL. 23 NO. **4**

FOR ENGINEERS AND ENGINEERING MANAGERS

FEB. 15, 1975

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by Frank Melgar, courtesy of Intel, Santa Clara, CA

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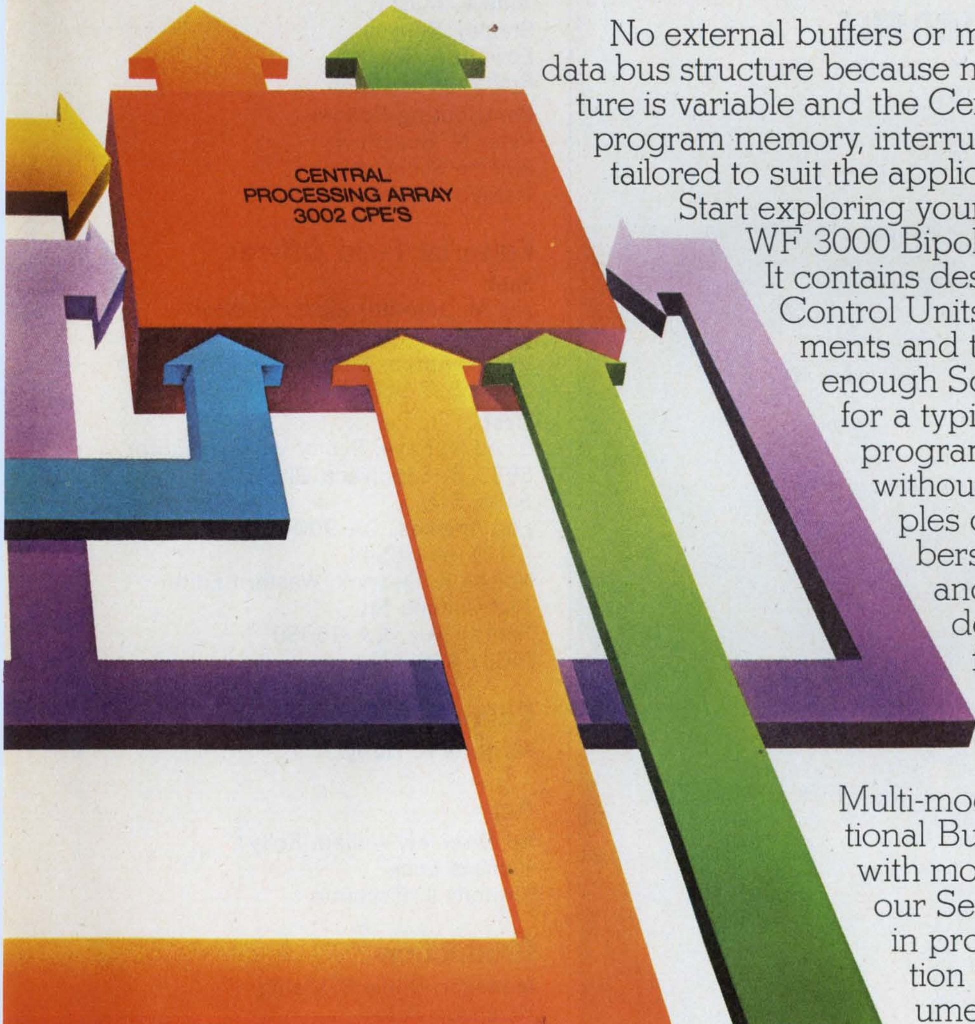
at half the cost with uting bipolar LSI.



No external buffers or multiplexers are shown in the data bus structure because none are needed. The bus structure is variable and the Central Processing Array, microprogram memory, interrupt and I/O structure can be tailored to suit the application.

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across the desk

APL language is alive and well

In your Oct. 25, 1974 issue, I was very interested in the large article on time sharing in engineering applications—and, in particular, network analysis ("Time Sharing: For Engineers Who Need Computing Punch Beyond That of the Calculator," ED No. 22, p. 56). I was surprised that I saw no mention of the programs for circuit analysis, which are up and running, alive and well, in the only programming language that is truly interactive. It allows the user to take output data, select what he wants, save selected portions, rows and columns to compare with previous runs, and so on.

The programs I refer to are MARTHA, copyrighted by MIT, and APLADDER, copyrighted by Scientific Time Sharing Corp.

The language, of course, is APL. And let me offer one subjective opinion: No engineer who has learned APL will ever again write a program in FORTRAN or BASIC.

For further information, and a side-by-side comparison, call on me anytime.

William B. Lurie
Independent Consultant
4909 Banyan Lane
Fort Lauderdale, FL 33319

A further suggestion on network design

Readers who found potential use in the excellent graphical technique described by James E. McKay in his Idea for Design suggestion "Simple Serial/Parallel Transformations Aid Network Analysis and Synthesis" (ED No. 22, Oct. 25, 1974, p. 144) may also be interested in "Draw Your Network's Impedance," ED No. 1, Jan. 4, 1968, pp. 102-103, which describes this technique and some other useful geometrical relationships as well.

R. E. Johnson
GTE Sylvania Inc.
Parts Div.
816 Lexington Ave.
Warren, PA 16365

Don't kill the kilos

A typographical error in a New Product item on "High-Voltage Packs Have Simple Controls" (ED No. 21, Oct. 11, 1974, p. 158) gave the output of these Hipotronics (Brewster, NY) units as 60 V. The correct value is 60 kV.

Reader feedback uncovers a blooper

Two comments on articles in ED No. 20, Sept. 27, 1974:

First, the Ideas for Design section features what the author, M. Barry Greenberg, calls a divide-by-five synchronous counter with symmetric output ("Counter Has Symmetrical Output Though the Input Signal Is Asymmetrical," p. 118). The logic circuit and timing diagram shown are actually a divide-by-four. Mr. Greenberg's technique works only for even pulse-counter circuits.

Second, it is worth pointing out a limitation in the techniques given in "Look to Asynchronous Sequential Logic" (by Michael J. Charland, pp. 98-103). If these tech-

(continued on page 10)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St. Rochelle Park, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

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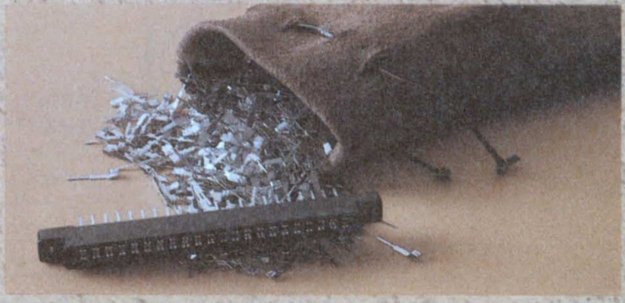


BUNKER RAMO AMPHENOL

INFORMATION RETRIEVAL NUMBER 7

ACROSS THE DESK

(continued from page 6)

niques are used to design a controller for multiple autonomous asynchronous devices (multiple independent processors contending for memory; multiple peripherals contending for a priority interrupt; etc.) then the value of d—the maximum time difference between input changes in Eqs. 1 through 8—must be set to infinity, resulting in an incredibly slow controller.

Jerry Burchfiel
Computer Scientist
Bolt Beranek and Newman Inc.
50 Moulton St.
Cambridge, MA 02138

The authors reply

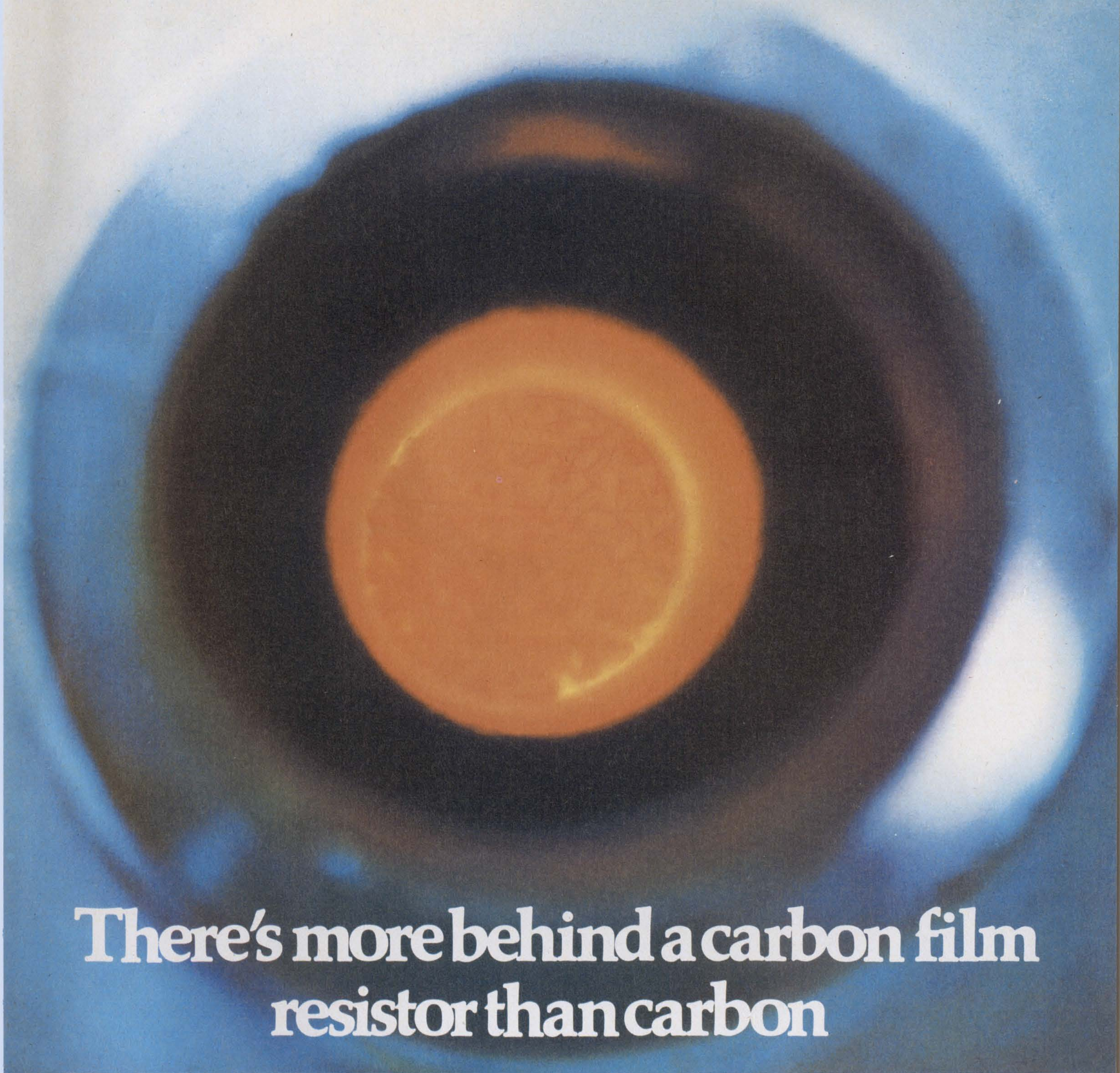
A re-evaluation of my article "Counter Has Symmetrical Output Though the Input Signal Is Asymmetrical" yields a divide-by-four synchronous counter rather than a divide-by-five, as claimed. The outputs of the circuit shown can be used as three subclock sources for edge-triggered logic. My sincere apologies to the readers of ED for my error.

M. Barry Greenberg
Project Engineer
G B Instruments
2030 Coolidge St.
Hollywood, FL 33020

In response to the comment of Mr. Burchfiel concerning the techniques discussed in "Look to Asynchronous Sequential Logic," it is true that the design of any asynchronous controller would present this type of problem. To alleviate the uncertainty of the maximum time difference d, due to multiple autonomous asynchronous inputs, a buffer register can be added to synchronize input changes to each other. Obviously the register clock can be asynchronous, and for best speed optimization, the period should be equal to Δ, the total cycle time of the controller.

Michael J. Charland
Development Engineer
Canberra Industries
45 Gracey Ave.
Meriden, CT 06450

(continued on page 14)



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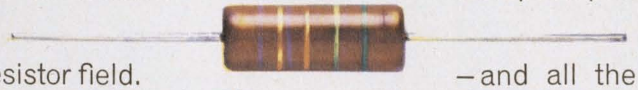

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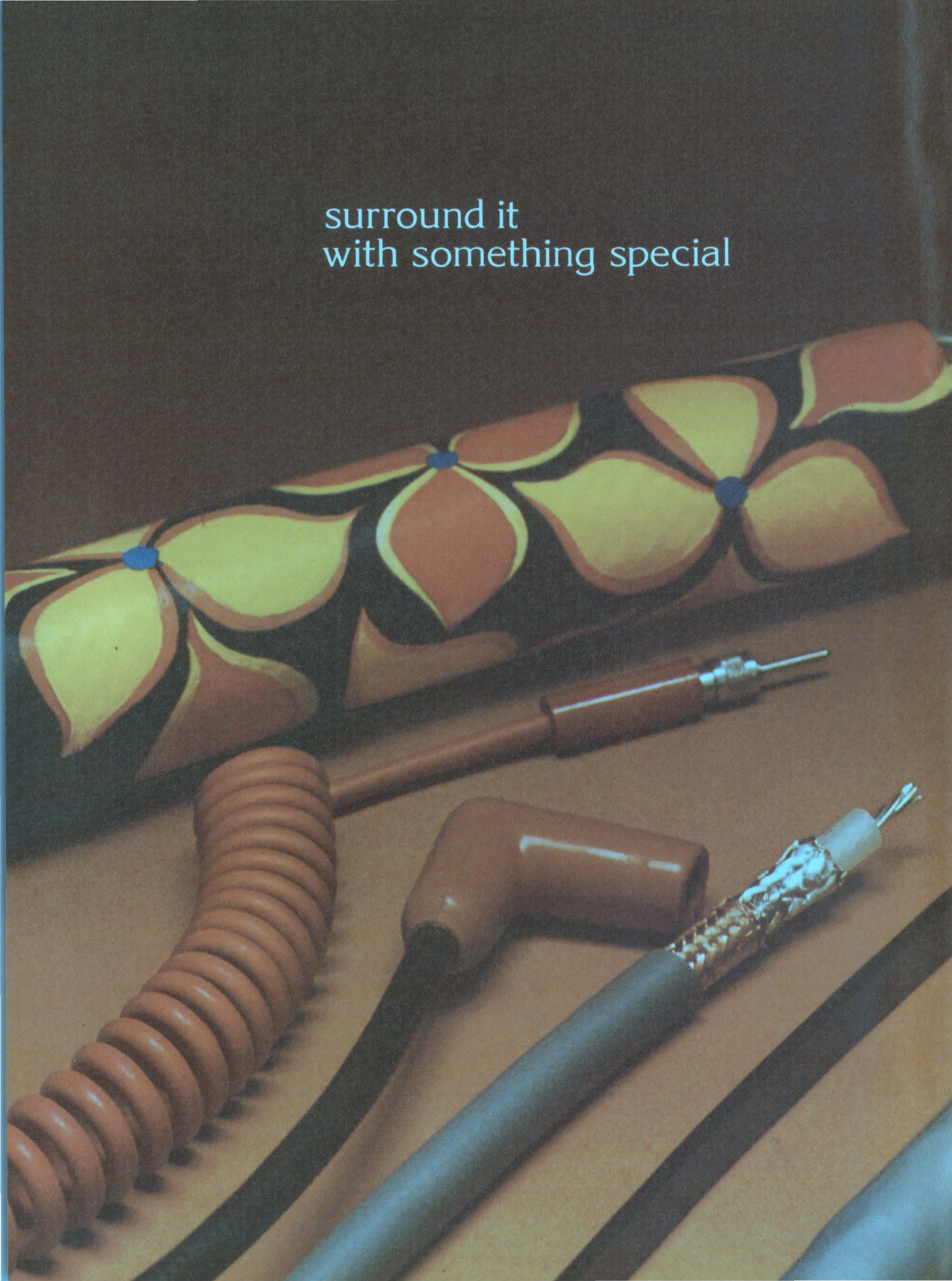
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INFORMATION RETRIEVAL NUMBER 234

ACROSS THE DESK

(continued from page 10)

A 'very well done' for pulse-gen article

The pulse-generator article in ED No. 24 was very well done. ("IC Applications Demand New Highs in Instrument Accuracy," Nov. 22, 1974, p. 90). It did an outstanding job of linking this product line to the logic testing market. I thought your coverage of the parametric and functional applications of pulse generators was very clear. This has been a point of confusion for many customers.

Jerry Murphy
Product Manager, Pulse Generators
Hewlett-Packard
1900 Garden Of The Gods Rd.
Colorado Springs, CO 80907

Simple test suggested for RTV in moisture

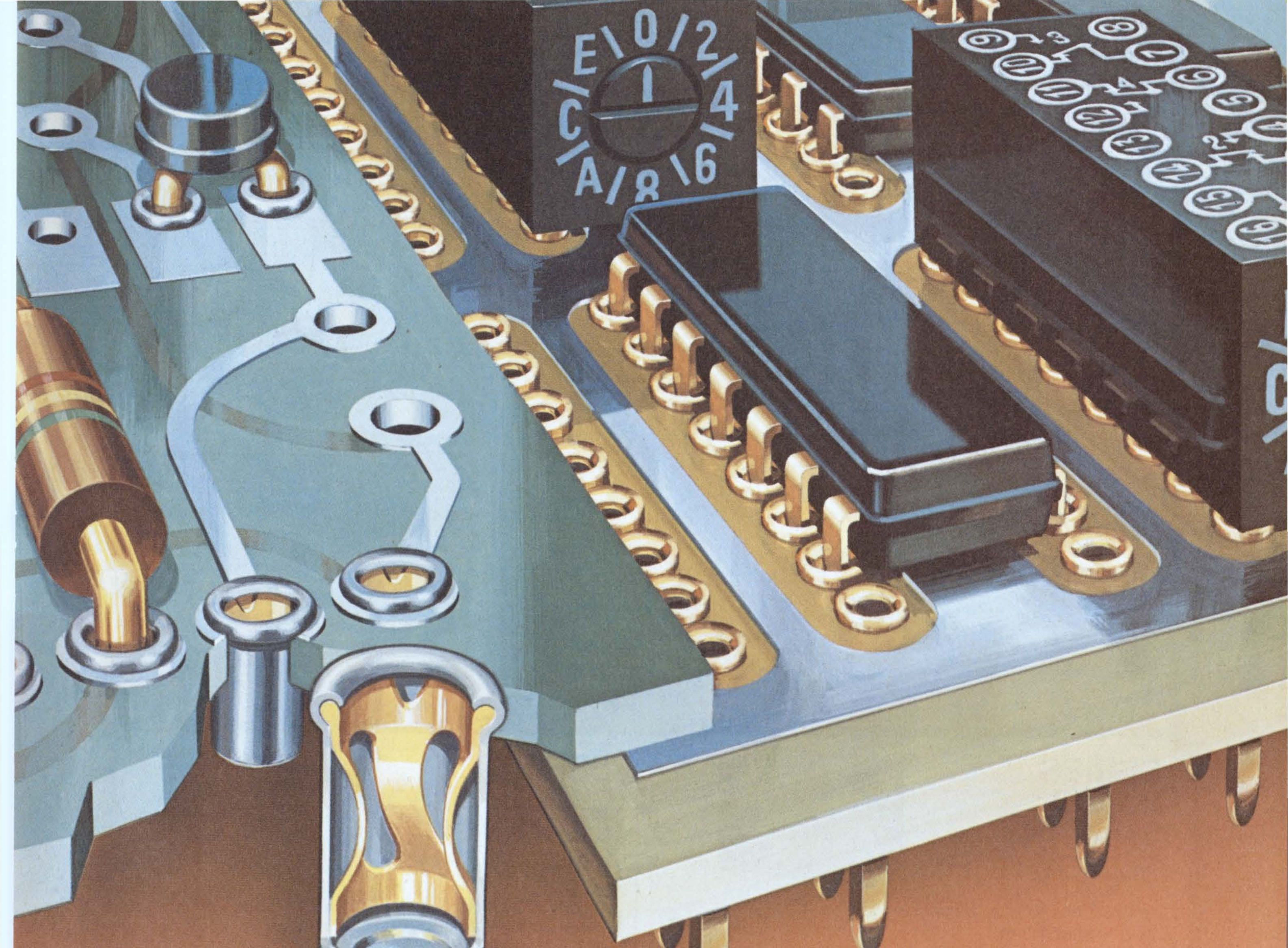
I would like to commend Morris Grossman on his excellent summary of potting and casting materials ("Today's Resins Provide a Cure for Almost Every Embedding Ill," ED No. 25, Dec. 6, 1974, p. 28). The portion devoted to RTV (room-temperature vulcanization) materials brought to mind a potential risk and proof test that an associate acquainted me with several years ago.

It seems that all RTV systems are not alike, and at least one can cause potentially serious metal-corrosion problems in an enclosed, moisture-laden atmosphere—as in marine electronics. Not wishing to become embroiled in a competitive product battle, I only suggest that designers contemplating the use of RTV make the following simple brand-comparison test:

Place a small plated steel part in a jar, add a dab or two of RTV, a couple of drops of water on absorbent paper, and cap the jar. Review the result daily.

This may sound like a non-scientific test, but at least one vendor's RTV will produce dramatic rusting within a day or two.

Bill Rich
Plant Manager
Sonagua Cientifica
P.O. Box 1253
Douglas, AZ 85607



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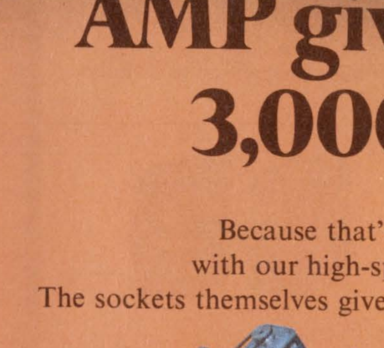

AMP sockets have closed or knockout bottoms, plus posted versions. They can take round or rectangular leads. And their low profile offers high packaging density. Gold- and tin-plated sockets are available, and all have excellent solderability.

So if you want quick, reliable loading of miniature spring sockets into dielectric panels, at low applied cost, call (717) 564-0100. Or write AMP Incorporated, Harrisburg, Pa. 17105.

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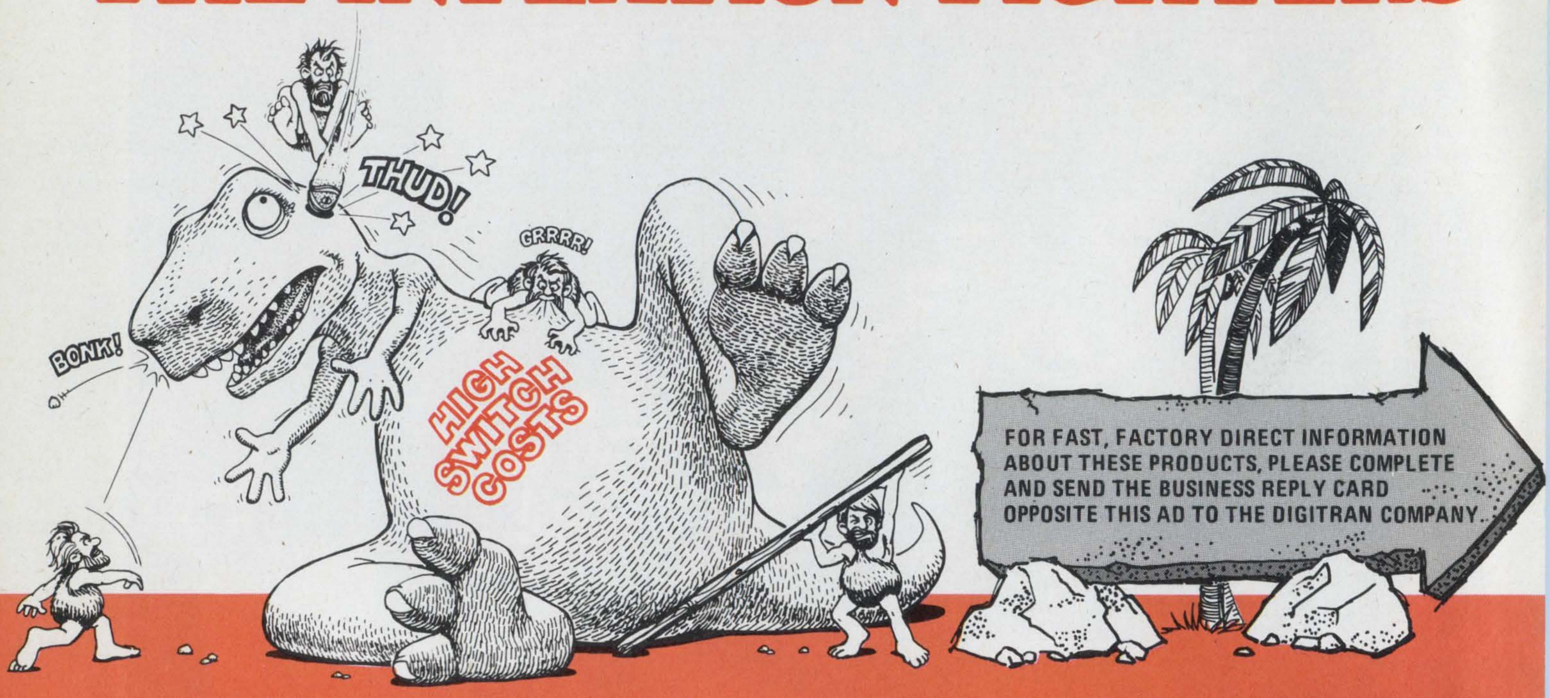
THE INFLATION FIGHTERS



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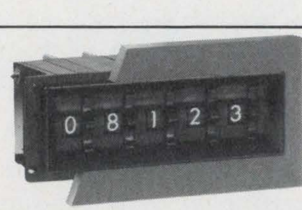

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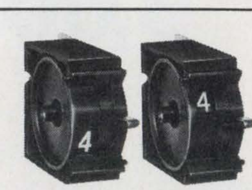

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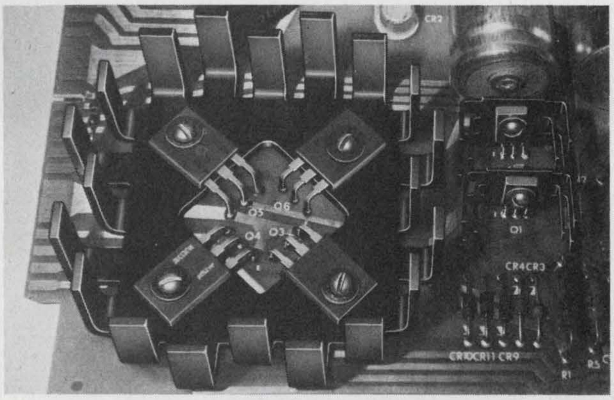
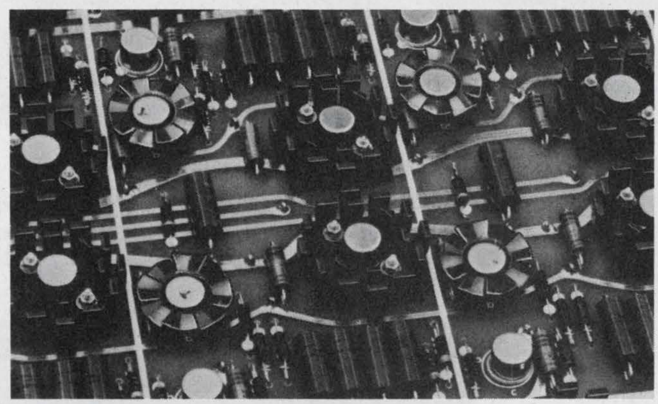
TO ORDER, CIRCLE 96

These ideas for cooling board-mounted semis could improve your circuit's performance

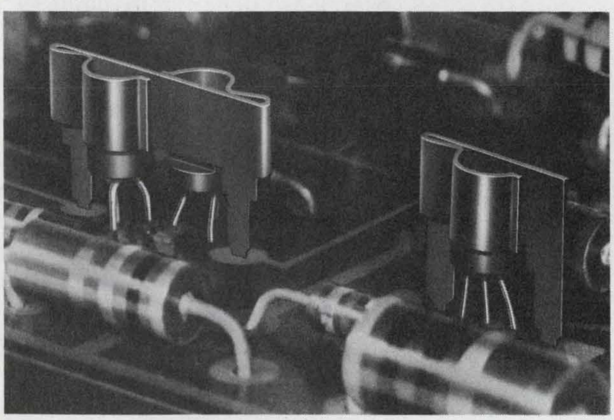
Thermal management is a highly versatile and valuable circuit design tool that can be used to increase semiconductor power, increase circuit density (or reduce the number of semiconductors), improve switching and temperature-related rise and fall characteristics, increase small signal gain and DC beta, match operating characteristics of two or more devices, improve reliability and cut costs. Here are some ways circuit designers have used IERC heat sinks/dissipators to beat printed circuit board-mounted semiconductor heat problems in order to improve their circuits, ideas that may be of help to you.



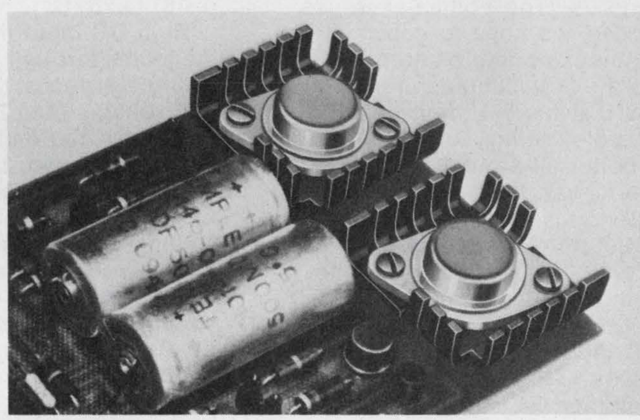
Four times the power from four power plastics took just one IERC dissipator. Bare transistors were capable of only 2 watts with 102°C substrate rise above ambient so designer used modified HP3 dissipator and got 8 watts from each at the same temperature rise. Or you could improve transistor life — roughly 7 times — by operating the devices at 2 watts and letting the same dissipator keep the substrate temperature rise to 32°.



Temperature matching at varying power levels is easy with the wide variety of IERC dissipators. On this board problem was to keep TO-5s at approximately equal case temperatures although some were operated at 2.2 watts and others at 1 watt. Press-on Fan Tops costing pennies kept 1 watters at 55°C case rise above ambient while LP dissipators held 2.2-watt devices at nearly identical case temperatures. IERC Insulube® coating permits mounting LPs directly on printed circuit lines.



Dissipators protect circuit — Designer of this TV circuit made sure dissipators would stay when D-case devices needed replacing. He designed dissipators as a part of the circuit, making it impossible to fire the circuit without them. In addition to this circuit protection the dual "Universals" gave him some other benefits: excellent retention in shock/vibration environments, good heat sinking during solder operations, and they cost just pennies.



Lower cost per unit was result of replacing four TO-3s used in this 10-watt power supply with two TO-3s in UP3 dissipators. Dissipators allow two TO-3s to operate at 5 watts each with same 65°C case rise above ambient as four devices operated at 2.5 watts each. Low profile dissipators plus TO-3s were assembled in less space allotted to four transistors. New design saved money, improved reliability.

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on heat sinks and dissipators for milliwatts to kilowatts, send for the IERC Short Form Catalog today. It covers the most complete line of thermal problem solving devices available anywhere.

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DC input voltage: Measures five ranges of DC volts from ±200mV to ±1200V.

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Accuracy and resolution: 1 μV resolution with 0.01% accuracy for 90 days over a temperature span of 18° to 28° C.

High DC input impedance: 1000 megohms through the 20 volt range. (Computer techs: you can measure any voltage up to 20 volts without loading by the multimeter.)

Offset current: Less than 15 pA on all ranges. Essential when measuring high source impedance voltages. Most other 5½ digit multimeters don't even spec it.

Maximum open circuit ohms voltage, 3.3V: Most DMM's fall into the 9 to 18 volt range. That's not good enough for measuring IC's when specs say that the measuring voltage cannot exceed 5 volts.

Overload protection: It's the best overall protection in the industry. 1200V on any AC or DC range. 250V RMS or DC on any ohms range.

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Unusually low power consumption: Just 8 watts. One reason why the 8800A is so reliable.

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Wide range of accessories: Includes high frequency probes, high voltage probe, clamp-on AC current probe.

It goes on. Our data sheet has the full details.

If you have any doubts whether the 8800A is typical of our line, just check *Electronics* Product Preference Poll (© 1974 by McGraw-Hill, Inc.). Fluke's squarely in the Number 1 spot for "Digital Voltmeters, including Multimeters"!

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INFORMATION RETRIEVAL NUMBER 141

FOR DEMONSTRATION 142

TV-compatible CCD camera ready to make the scene

A TV-compatible, charge-coupled-device camera, expected for more than a year, is finally ready for market. It is made by RCA and is scheduled to be available in April in two models, TC1150 and TC1155.

The first commercially available CCD camera was announced by Fairchild Semiconductor about a year ago, but it only has 10,000 picture elements and requires modification to be used with the standard home TV receiver.

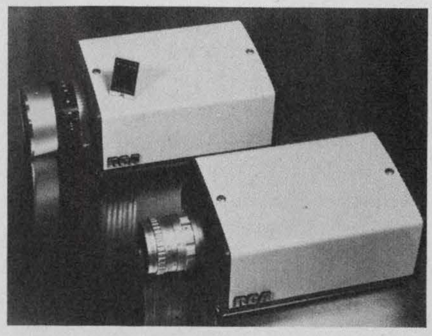
Both the RCA TC1150 and TC-1155 use a 512-by-320 element CCD imager sensor. Their capabilities include a standard 525-line video output that is compatible with commonly available monitors and accessories without modification; solid-state life and reliability; sensitivity and spectral response comparable to that of silicon-target vidicon cameras and antiblooming characteristics that control highlight overloads. The new cameras are destined to replace 2/3-inch vidicons as soon as the price comes down, RCA says.

The difference between the two CCD cameras is in the lens systems. The TC1150 has a built-in lens that is part of an automatic light-control system. Its focal length is adjustable from 14 to 38 mm. The TC1155 will accept interchangeable standard C-mount lenses.

In addition to the cameras, RCA is also offering a 163,840-element CCD image array. The array is designated SID51232 and is available in two grades: SID51232BD and SID51232AD, with the former the higher-grade device.

Either sensor may be specified when ordering a camera. If the higher-quality SID51232BD device is selected, the cameras cost $3800 each. With the SID51232AD, the price drops to $3000 each.

For OEMs who want to put together their own imaging systems, RCA is offering the chips at $2300 for the BD version and $1500 for the AD. While this is high, compared with $260 for a 2/3-inch vidicon, RCA projections indicate that by the early 1980s the sensor price could drop to $30.



Two commercial CCD TV cameras that are compatible with standard 525-line television receivers are available from RCA. A 512-by-320 CCD array (top) replaces vidicons generally used in cameras.

According to Dr. Ralph E. Simon, manager of the company's electro-optics product operations, the CCD imaging array is of the frame-transfer variety. In this type of device, half of the array is exposed to the optical imaging signal and half is used to store the signal while it is being processed into a sequential output.

Simon notes that the CCD chip is also suitable for use in a color camera. The camera can be built, he explains, with a conventional beam splitter, which divides light into its three spectral components. Each component is then directed to its own CCD image array. Signals from the three arrays are then combined to form a color video signal. Combination of the signals is made easy by the fixed geometry of the CCD arrays, which eliminates the registration problems sometimes found in tubes.

To make the CCD array easy to use RCA engineers have developed a CMOS chip that will produce all the voltage pulses to drive the imager. These include signals to control blooming and to produce the 2:1 interlace required for standard TV receivers.

While RCA has not yet announced plans for a color CCD camera, the company indicates that it has built experimental models. In addition, Simon notes that the auxiliary CMOS chip can drive three image arrays simultaneously.

CIRCLE NO. 315

Wraps come off a Naked Milli

What falls between a microcomputer and a minicomputer? The Naked Milli just introduced by Computer Automation, Irvine, CA. It is priced at $295 in single quantities, with no memory. With 8 k bytes of MOS semiconductor memory, the single-quantity price is $1060. The machine, which is contained on a 7 × 15-in. card, is a full 16-bit computer, with eight addressing modes, bit and byte processing and direct memory access.

4-k static RAM bids for memory-chip lead

The changing 4-k RAM market is about to receive a new entry: the first 4-k static RAM.

Until now, all contenders for the lion's share of the 4-k memory market have been small, dynamic memory devices that operate at high speed. But EMM Semi has announced two new devices, the 4401 and 4402, that promise to give dynamic competitors some stiff competition.

Unlike conventional static RAMs, which are generally larger and slower than their dynamic equivalents, the new 4-k devices are about the same size and a little faster than available dynamic units.

EMM Semi says the small size and low speed have resulted from use of polysilicon resistors instead of the load resistors generally used in static memory cells.

The 4402, which is the faster of the two devices, has an access time of 150 ns and cycle time of 300 ns. To get this speed, however, it is necessary to use an external sense amplifier.

The amplifier can be eliminated by the 4401 device. But this adds another 30 ns to the access time, bringing it up to 180 ns.

Power consumption of the new memory chips are 60 mW for standby operation and 300 mW when the chips are accessed.

The chips come in a 22-pin package that has the same pin-out configuration as the 4-k RAMs from Texas Instruments and Intel.

CIRCLE NO. 316

DEC develops a micro and an expanded mini

A minicomputer with midi architecture and a 16-bit microcomputer that can perform floating-point operations have been announced by Digital Equipment Corp.

The enlarged mini, the PDP-11/70, uses bipolar cache memory, independent peripheral controllers and 32-bit internal data paths to give more throughput than the next highest model, the PDP-11/45. Both the independent cache and separate data path are new to the PDP-11 line.

The microcomputer, the LSI-11, is made up of four NMOS LSI chips. It executes the PDP 11/40 instruction set faster than the 11/05 does, and it has a 16-bit parallel I/O bus.

I/O architecture similar to that in the IBM/360 line has been used to develop the PDP-11/70 from the PDP-11/45. A 2-kbyte, 240-ns bipolar cache acts as a switch and buffer between main memory and CPU. Simultaneously a separate 32-bit bus carries data between the controllers (up to four) through the 32-bit path between core and cache.

But the standard Unibus carries only commands from the CPU to the controllers, and it services only slow speed devices. Thus the controllers resemble IBM Selector channels, while the Unibus resembles the byte multiplexer channel on the PDP-11/45. The Unibus also carries data from fast peripherals.

With its TTL-Schottky logic, the processor cycles at 300 ns, and the controllers can transfer 32 bits (4 bytes) in 4 μs. The 11/70 can handle up to 63 time-sharing users under RSTS/E. With the new IAS (Interactive Application System), the computer will do concurrent batch, real-time and time-sharing.

Integral memory management allows up to 2 Mbytes of main memory (the 11/70 uses core). And the user can add up to 800 Mbytes of disc. Virtual memory is the norm on RSTS/E.

Other 11/70 features include asynchronous double-precision floating point (9 μs to divide two 60-bit numbers) as well as address the data parity check.

The LSI-11 processor consists of a data chip, control chip and two control ROMs (all custom units from Western Digital). The ROMs provide a console control program, bootstrapping and the instruction set. An optional ROM offers floating-point or communication protocol. The LSI-11's minimum instruction time is 3.6 μs (register-to-register). The unit runs PDP-11 software, is housed on a 8.5 × 10-in. board and will sell for less than $1000 equipped with a 4-k RAM.

The data bus is not a full Unibus, since data and address are multiplexed on the same 16 lines. However, the unit achieves a healthy 833-kHz DMA rate, can address 32 k words directly and provides complete interrupt vectoring (polling is not necessary to identify the interrupting device). MOS memory using Mostek's 4-k RAM, is available in units of 4 k.

CIRCLE NO. 317

2 new calculator chips offered by Rockwell

Keeping pace with the calculator industry race to pack more computing power and display circuitry into smaller space at lower cost, the Rockwell International Microelectronics Div. has developed two one-chip scientific calculator circuits.

These MOS circuits provide full scientific functions—trigonometric, logarithmic, exponential, factorial, roots and powers—which formerly required two or more chips to obtain. To minimize assembly cost, the circuits contain such internal features as direct drive of LED segments, clock and power-on circuitry. The chip consumes less than 125 mW.

One chip—the A4800—is designed for a 35-key, single-function keyboard. It has a 10-digit mantissa plus a two-digit exponent for scientific notation.

The calculator also has hyperbolic capabilities, a gradian switch as well as a radian/degree and an accumulating memory.

The second Rockwell chip—the A4802—is designed for a 25-key, double function board. Additional features include two-level nested parenthesis, a factorial key, degree/radian keys and an eight-function memory.

CIRCLE NO. 318

Bucket brigade aids word processing

A new word-processing system uses bucket-brigade devices to ensure that voice-activated recorders do not clip off the beginnings or endings of words.

Called Thought Tank System 193 by its developer, Dictaphone Corp. of Rye, NY, the dictation equipment automatically distributes the work load to speed the output of typed copy.

According to Richard Allen, an engineer at the company's plant in Norwalk, CT, the input to the system uses a charge-transfer device to provide an 82-ms analog delay.

When voice-actuated switches are used in recording systems, a delay is necessary to avoid misinterpretation of information. Most phrases, Allen says, start with consonants. Since consonants have very little energy associated with them, any voice-actuated switching system is usually inactive until a vowel, which has a high energy content, comes along. When a system switches on a vowel, however, it clips part of the word.

This is avoided in the System 193, which feeds audio information into both a 1536-bit bucket-brigade analog shift register and the transistor switch at the same time. The transistor switch waits for a vowel before it turns on. Once it does, it allows information that has been delayed 82 ms in the bucket brigade to go to the record head of the tape recorder.

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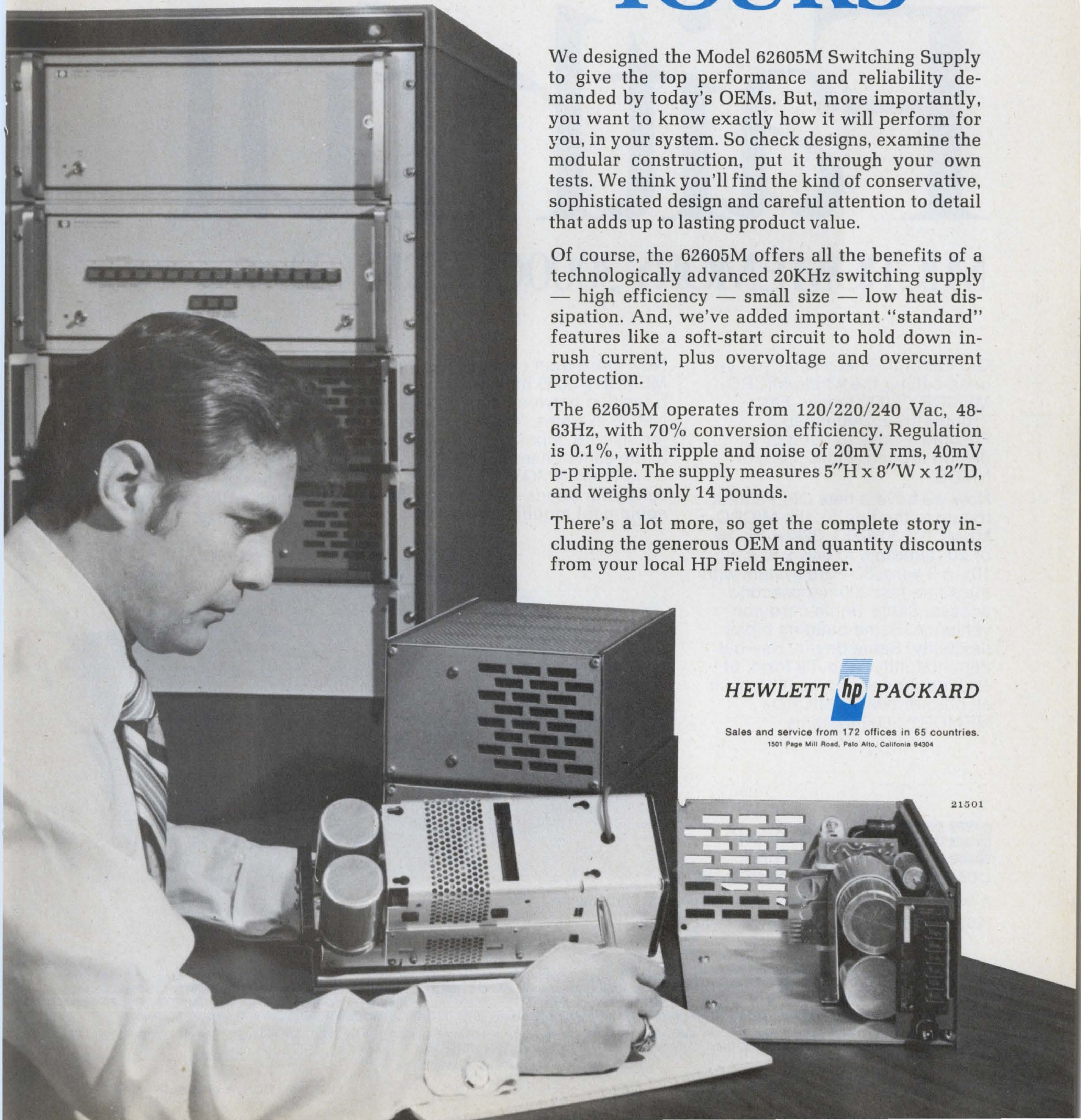

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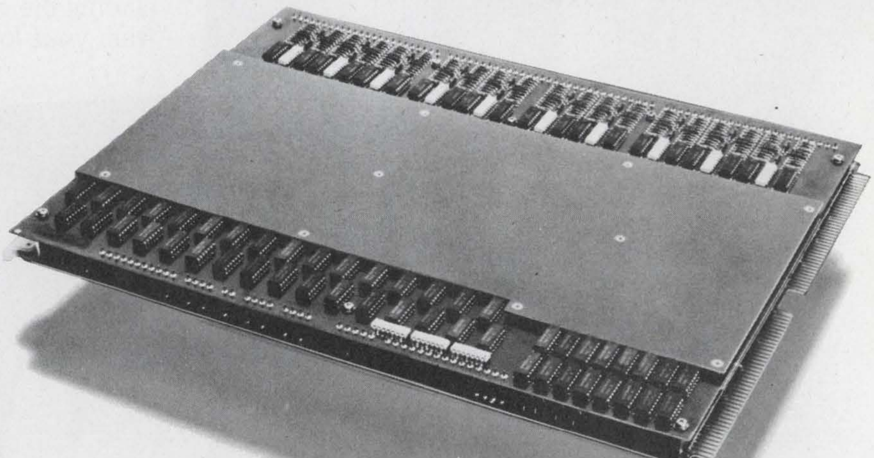

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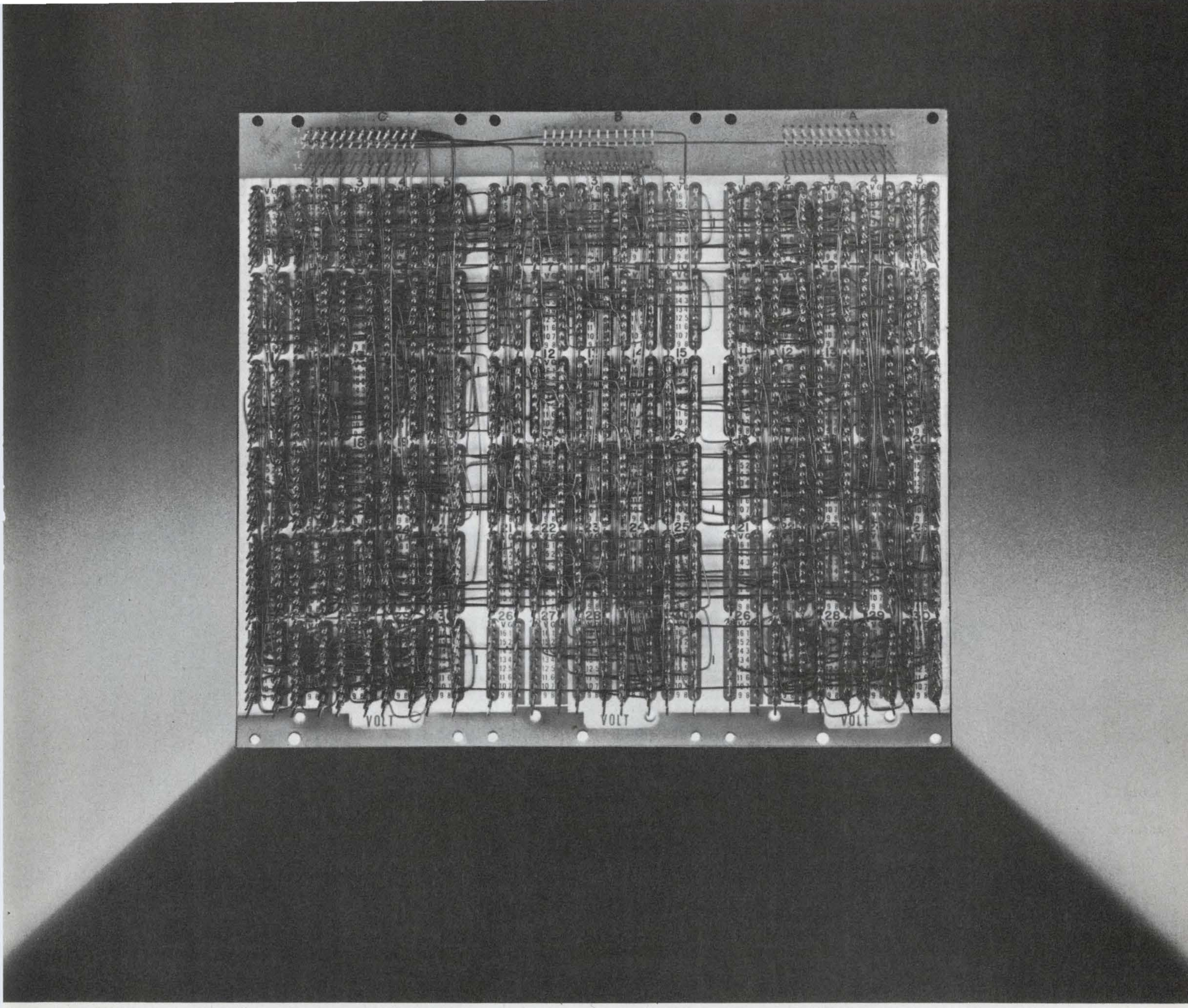


That dazzling, dizzy Disney World is run by computer

Photos by John F. Mason

Cinderella's castle is a hotbed of computers and tapes that control every move any animated attraction in Disney World makes—from dancing ghosts to space meteors.

Visitors to Disney World are filing through the portals of Space Mountain, a brand new "attraction," as such man-made phenomena are called, in the still growing fantasy world of Walt Disney, just outside Orlando, FL. They smile and even laugh. Ten minutes or so later, the same people file out, a wiser and soberer crowd.

They have taken a hair-raising ride "through space," barely missing meteors and other space vehicles. And afterwards they have a look at the home of the future as envisioned by RCA.

"THE ULTIMATE THRILL RIDE," the sign outside says. "A TRIP THROUGH SPACE."

John F. Mason
Associate Editor

"Tighten up that seat belt!"

All for psychological effects, you smile to yourself, yet you allow the pretty young girl to fasten you in.

"Remove earrings and glasses!"

Come on! Don't overdo it!

And your vehicle begins to move. You climb slowly for awhile and pause above a gaping black hole. Then, on the first of many devilish instructions from a computer, you plunge into the hole, bending, twisting and banking, up and down. The seat belt is no psychological ploy. Your vehicle zooms past other glowing capsules, through meteoric showers, special stellar and planetary effects and finally into a 75-foot-long, 10-foot-diameter tube. This is your re-entry into the earth's atmosphere.

Lights flash. Blast-off noises roar through the tube, and you are finally out. Ashen-faced, perhaps. But you are out!

How do they do it, those special effects?

Six million people a year are expected to ask that question, according to RCA officials and to Disney engineers.

Controlling the ride and assuring its safety is a Data General Nova 2 digital computer with 16-k memory. The cars race over the tortuous track at up to 28 miles an hour—fast when you're barrelling into a steeply banked horseshoe curve. And although you can't see this, because it's dark, you're shooting up and down through space six stories high. For safety, the cars must stay at least 18 seconds apart. If one car begins to

The control room for the Space Mountain thrill ride keeps tabs on the position of every car through magnets along the track and a Nova 2 computer. If cars begin to tailgate dangerously, the whole ride can be shut down.

In RCA's Home of the Future, video discs are commonplace, as are two-way closed-circuit television channels for business conferences, which can be held without having to leave home with people anywhere in the world.

Space Mountain, a new thrill ride at Disney World, is assured safety by a Nova 2 computer. Meteors, a Milky Way and re-entry sounds are provided by projectors and loudspeakers controlled by computers and tapes in Cinderella's castle.

gain on the one ahead, the tailgater is braked. And if necessary, the Nova can shut down the ride.

The Nova keeps tabs on each car's location by a block zone system of magnets using relay logic. When a metal fin extending beneath each car breaks the magnetic field of a magnet alongside the track, the information is fed to the computer. This information is gathered in parallel from the magnetic sensors, from the brakes, from the solenoids that operate the brakes and from the contactors that are used to confirm that the electrical machinery is running as it's programmed to run. The information is gathered in the relay system and sent to the computer.

The special effects are all operated from a digital animation control center, hidden away and off limits to everyone but a select few in Cinderella's castle.

The special computers in the control center were designed by Disney engineers and built by the now defunct Astrodata Corp. These are the computers that send instructions to the audio devices in Space Mountain. They release the blast-off roar in the final tunnel of the ride. They control the 40 projectors in Space Mountain that create the Milky Way, meteors and stars. And they control every movement—even the fluttering of an eyelash—of every animated creature in Disney World.

For each animated performer, an elaborate software program has been developed for its entire performance and stored on magnetic tape. These programs were made with the aid of Honeywell computers. Each creature's performance is then permanently fixed and coordinated with its fellow performers. The tapes are played over and over again, sending digital instructions by wire to the performer involved.

The actual instructions are received by a proportionate servo-control mechanism in the base of the animated figure. The control converts the digital information into linear motion. Slight movements, such as eyes closing or the movement of a finger, result when the servo control triggers a magnetic device. The movement of a leg or head, or Lincoln standing up to deliver a speech, is done by a hydraulic double-action piston.■■

Electronic music incorporating the high notes of IC technology

Electronic music, which got its start in the early vacuum-tube era, is maturing rapidly today by keeping in tune with IC development.

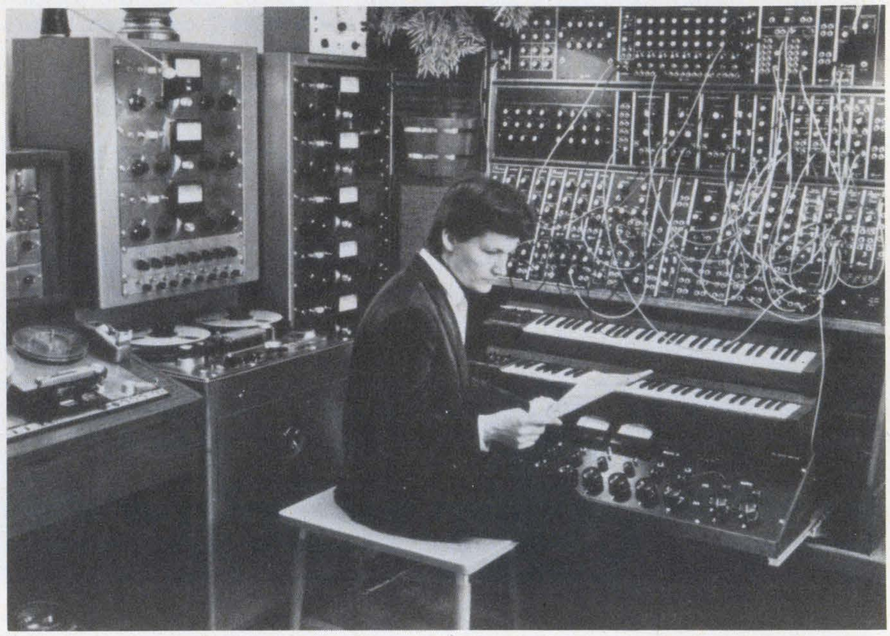
The two major types of electronic-music generators, electronic organs and synthesizers, are being upgraded with more features and less complex circuitry. And although the dollar volume of solid-state components used by these manufacturers is small by industry standards, they are taking advantage of virtually everything the IC producers offer.

Organs and synthesizers are using components that include the following:

- Silicon transistors—both small signal and power types.
- Linear ICs—op amps and other circuits being used in mixers, oscillators, modulators and active filters.
- Digital ICs—TTL and MOS used as counters, switches, frequency dividers, control circuits and even shift registers, ROMs and RAMs.
- Custom LSI—used by practically every new organ, with at least one custom circiut as a keyboard interface, rhythm generator or frequency divider.

Even the large-scale computer is being used to generate music of virtually unlimited scope. The Oberlin College Conservatory of Music in Oberlin, OH, is taking advantage of the college's IBM 360-based computer center and expects even better results with a Xerox Sigma 9 system that should go into operation this year.

Northe K. Osbrink
Western Editor



With this installation, Walter Carlos, an ex-studio recording engineer, produced the "Switched-On Bach" record in 1968—the first commercially successful synthesized recording. To the left is an eight-track recorder and to the right is his custom Moog synthesizer and mixing panel.

Waveforms describe sound

Gary Nelson, assistant professor of music and digital music project leader at Oberlin, explains: "If you translate music into its essential parts—time, frequency, and wave-envelope information—these can be inputted into a computer and manipulated, using a programming language such as Fortran. Every sound—whether produced by a single instrument or a symphony orchestra—can be described by its waveform and essentially reproduced by programming the eventual movement of a loudspeaker."

The only limitations, Nelson says, are the size and speed of the computer system and the skill of the composer—related to his musical knowledge, understanding of acoustics and his ability to use his computer "instrument."

Don Mittleman, director of the Ervin E. Houck Computing Center at Oberlin, observes: "It really does take a large computer to provide a flexible music generator. Not only is music complex with fundamentals, overtones and timing information, but the composer wants it divided into practically

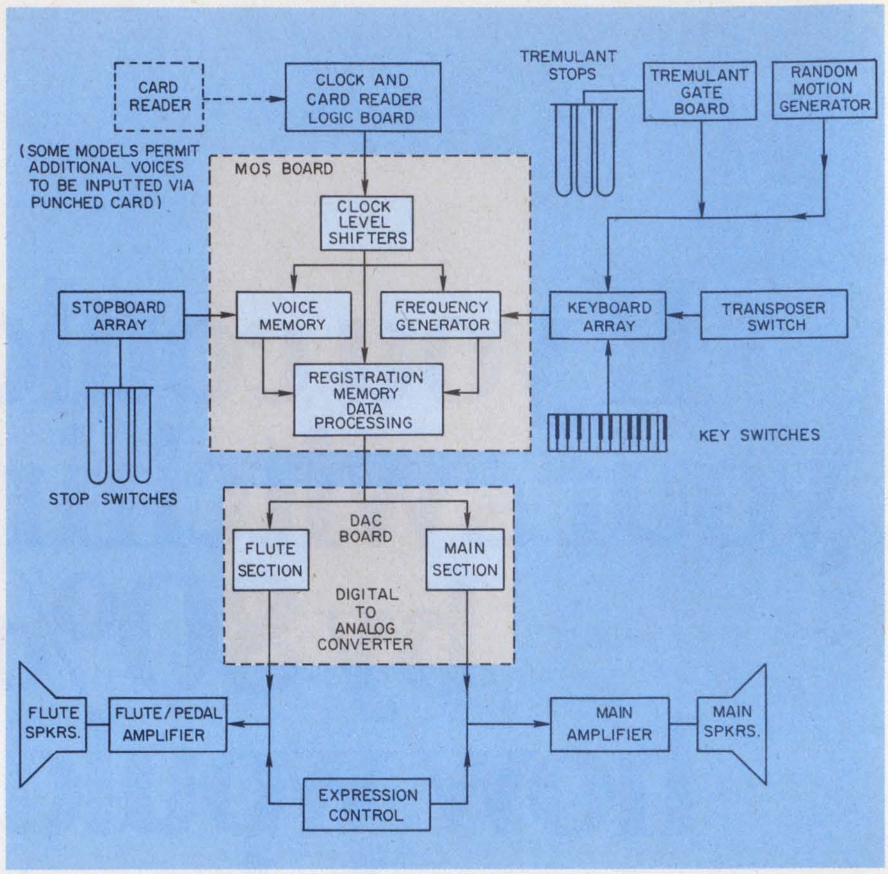
Nonconventional music

Electronic music can be defined broadly as music produced without conventional musical instruments or electromechanical devices.

It includes such experiments as "Music Concrete" of the 1940s, which used tape-recording techniques to modify natural sounds into music. It includes such instruments as a 200-ton synthesizer built in 1906, and the Theremin—which is played by motion of the hands near capacitive antennas.

In the past many electronic organs were not "purely" electronic, electromechanical devices, such as toothed disks with magnetic pickups or even vibrating reeds, to produce the fundamental tones. Others used vacuum-tube oscillators, and these led to today's solid-state organs.

The modern electronic synthesizer and the digital computer both use sophisticated technology, although each is quite different, to produce electronic music. This can range from duplicating the sounds of music played on conventional instruments to sounds limited only by the imagination and skill of the operator. ■■



To reproduce the sound quality of a musical instrument, its harmonic structure is analyzed and stored in a ROM in this Allen Digital Computer Organ. As the organ is played, the digital word representing harmonic structure is transferred to a RAM to permit two or more instrument voices to be combined. With added attack and decay information, the data are converted to an audio signal in a d/a converter.

infinitesimal time and amplitude segments, so that he can have a full range of manipulation."

The final step in computer music production is to feed the digital output to a d/a converter—but not necessarily in real time. The output from the computer can be recorded and then replayed at a lower speed. There may be a time expansion of 20 to 60 during the digital processing; music played in 1 s may have taken 20 to 60 s to be outputted from the computer.

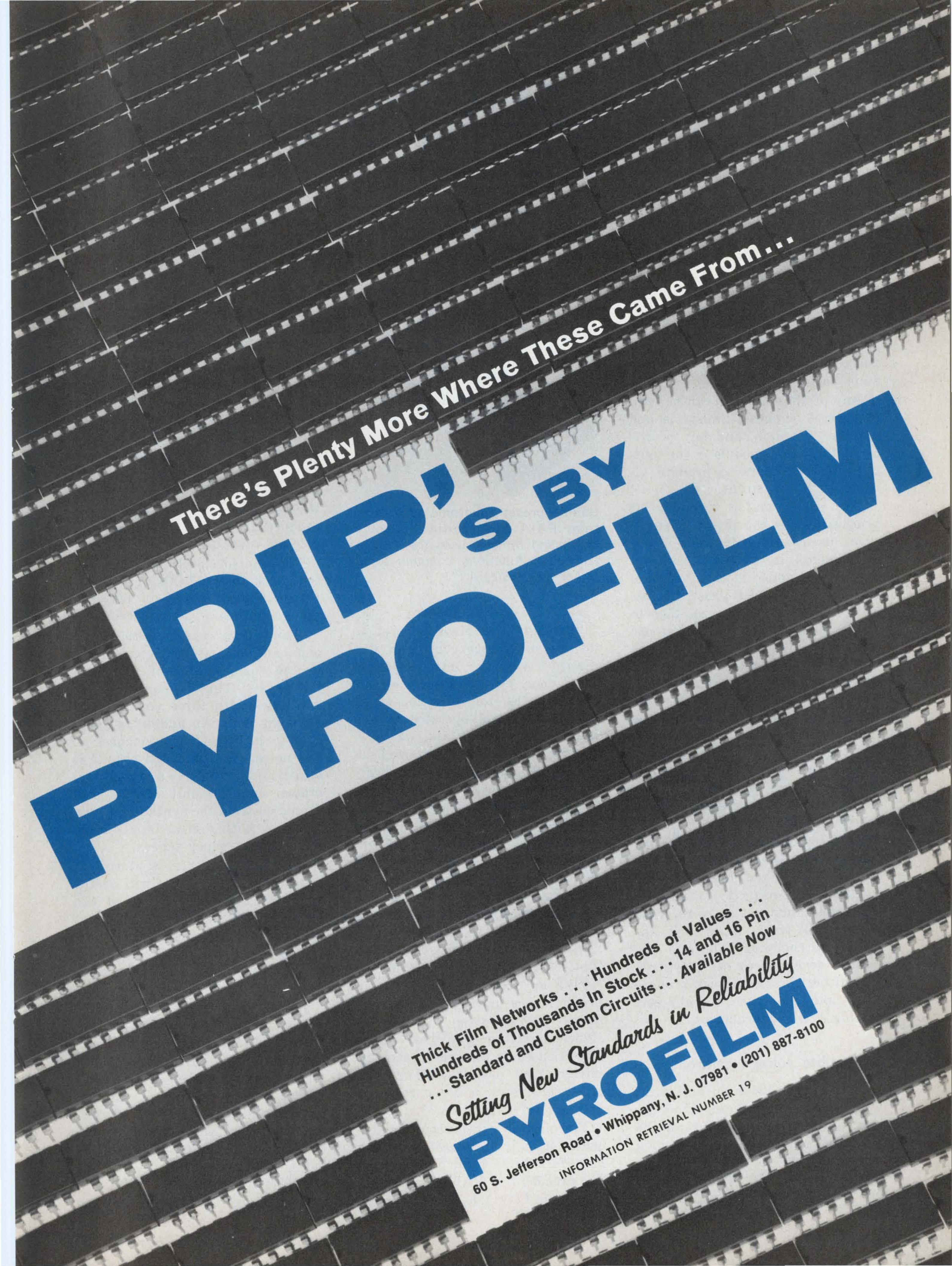
The other major method of generating music electronically is through "synthesis"—modification of the output of an audio oscillator or white noise generator with a combination of mixing, modulation, amplification and filtration to produce the desired effects. Many of the techniques are common to both the electronic music synthesizer and the electronic organ.

How a synthesizer works

In operation, a synthesizer makes use of a voltage-controlled oscillator with wide frequency range that can produce a variety of waveforms, such as sine, rectangular, triangular and pulse. Next the oscillator signal is passed through a series of high, low and band-pass filters, with voltage-variable frequency response to reshape the waveform and modify the harmonic content. The signal may also be mixed, modulated and otherwise acted upon—but whenever possible, the functions are controlled by the same range of dc voltage.

These control voltages can be programmed via a set of keyboard contacts, a linear control, a potentiometer or combination of potentiometers, such as a ball or joystick. The voltage levels can also be controlled by function generators, low-frequency oscillators and even signals generated within the other circuits. The oscillator may be replaced with a source of white noise, which can be similarly modified.

An example of a professional studio synthesizer is the Moog 55A from Moog Music Inc., Williamsville, N.Y. The complement of circuitry for this system includes one VCO capable of generating sine, sawtooth, triangular and rectangular waveforms of from 0.01 Hz to 40 KHz; seven 1 Hz-to-40 KHz VCOs and a random-noise generator. These are followed by voltage-controlled low and high-pass filters, voltage-controlled amplifiers, envelope generators (to control the rise and fall times of waveforms), mixers, signal routing and dc control facilities. The modules are con-



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nected via patch cords, with commonly used functions internally selectable by switches.

In operation, the keyboard generates a different voltage level for each key depressed and is commonly used to control the pitch of one or more oscillators. The envelope generator produces a voltage contour that is commonly applied to the amplifiers to create patterns of amplitude and rise and decay times. The sequencer produces a variety of programmed voltage steps at a rate determined either by an internal clock or external signal—a single output with up to 24 steps or three outputs of eight steps each.

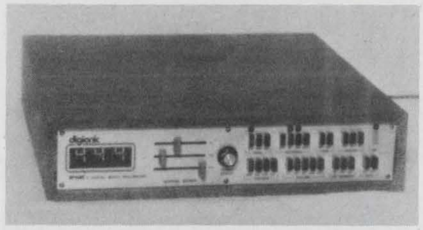
Any of these signals can be used to control loudness, timbre (sound quality) or pitch, and any of the oscillators can modulate the outputs of the others to produce vibrato, trills or sirens.

The other major category of synthesizers is the preset portable type, used primarily with other instruments in a "live" performance. An example is the Pro Soloist made by ARP Instruments, Newton MA. It has preset tabs to create 30 musical effects that are identified, like an organ, by the sounds they resemble. In addition slider controls vary volume, brilliance and portamento (or slide from note to note). Although the keyboard is used primarily to select the frequency of the note to be played, it is touch-sensitive. Added pressure on a key will activate one of six effects, such as volume level or vibrato.

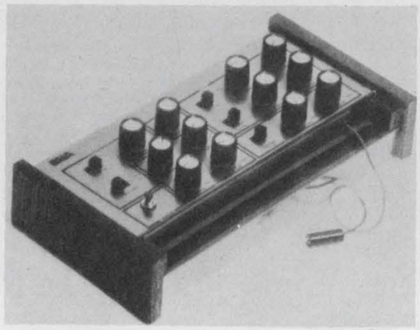
Most synthesizers are still primarily one-note-at-a-time devices. Musical chords and multipart compositions are usually produced when individual notes are recorded on multiple-track tapes and the tracks are combined. There is continuing development of "polyphonic" synthesizers, which can produce many notes at a time, thereby permitting live performances.

Compatible voltage control

In the early 1960s an important development in synthesis was compatible voltage control for all the oscillators, filters, amplifiers and special effects. A pioneer in this application was Dr. Robert Moog, who says today:



Digionic digital sequencer from Ionic Industries can memorize musical sequences up to 146 notes and modify them, as desired.



Gnome preset electronic synthesizer from PAIA Electronics, although small and limited, uses the voltage-controlled functions common to all larger synthesizers.

"Perhaps the biggest boost to the use of voltage control in synthesizers was the introduction of the silicon planar transistor. Our favorite was the 2N2926, which was inexpensive, operated over a wide voltage range and was predictable and quiet. We started doing things that were practically unfeasible with germanium transistors and tubes."

In certain circuits common to synthesizers, discrete transistors are still the rule, because of cost or performance considerations. In some cases the designer needs a discrete transistor to produce a wide-range VCO, or he uses a nonlinear portion of a transistor curve that is balanced out inside an IC.

"We are making use of ICs in nearly every part of our newest units," Dr. Moog reports. "For instance, a voltage-controlled amplifier is based on the operational amplifier—now one IC rather than five transistors, a dozen resistors and several capacitors."

Circuitry in synthesizers has become virtually standardized among manufacturers. John S. Simonton Jr., president of PAIA Electronics, Oklahoma City, OK, a manufacturer of small synthesizers and modules, explains why:

"By now, practically all synthesizers, from the simplest to the most complex, are using many of the same circuits. After all, there is usually one most cost-effective technique for designing a voltage-controlled filter using available technology. What the manufacturer wants is a way to produce an effect with ease of control, reproducability, minimum complications and least expense."

Some digital sequencing

Although the synthesizer technology is largely analog, digital interface techniques are appearing. An example is the Digionic digital music sequencer from Ionic Industries, Inc., Morristown, NJ. The device is connected to a synthesizer and receives and records the sequences of control voltages produced by the keyboard and voicing controls.

The control levels can then be sent back to the VCOs, VCAs and filter circuits—in effect, "playing" the synthesizer.

Using shift registers, the Digionic can memorize sequences of up to 146 combinations of four control levels. This is equivalent to 146 notes with three voicing voltages per note. An add-on is available to lengthen the sequences to 246 notes. An additional output is also available to drive a rythm generator, and the unit can be programmed from the synthesizer keyboard or with digital inputs from magnetic or paper tape.

Once the sequence is stored, it can be modified at the will of the operator. The sequence speed can be increased or reduced without affecting pitch, voicing can be changed or the high and low notes can be transposed. The entire composition can be inverted.

In many cases the circuit technology of modern organs is becoming more and more synthesizer-like. The major difference is that an organ is polyphonic and preset. Each key or pedal controls its own set of frequencies and waveforms. Each of the "voices" can be selected and added to other voices, but no continuous adjustments are available to the player.

Organs are carefully designed so

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the master oscillators do not vary in frequency. This keeps the organ in tune. Although the frequency of the notes may be varied for such effects as vibrato, they usually cannot be shifted at will.

Electronic organs use LSI

As the "big boys" of the electronic music field, the organ manufacturers have been using an increasing number of custom LSI circuits. The latest organ models generally have at least one custom circuit to interface the keyboard and stops to the internal circuitry. Other units have IC countdown networks for frequency division, and they are using ICs to generate such special effects as rythm.

Wurlitzer Corp. in DeKalb, IL, uses about five different custom ICs in its latest organs, as well as a number of off-the-shelf circuits. In the pedal board, a circuit known as the priority latching network plays the highest note if two pedals are depressed at once. A custom keying circuit interfaces the keyboard contacts to the frequency dividers, so that the three "ranks of pipes" can be controlled with a single contact. This replaces a much more complicated set of three contacts per key.

Other custom ICs in the master frequency generator derive the organ frequencies by counting down from a discrete component master oscillator. All timing information needed in the rythm generator comes from a single IC, although the sound of a marimba or blocks is produced with analog filters.

Finally, a custom chip is used to provide automatic chords and chord progressions, as well as to allow chords to be pulsed with rythm signals.

Off-the-shelf ICs in Wurlitzer organs include op amps—used throughout the audio system as mixers and preamps, MOS dividers, IC voltage and current regulators—and LEDs with light-dependent resistors for envelope shaping.

Organ uses digital technology

A series of organs introduced about three years ago by the Allen Organ Co., Macungie, PA still appear to be the most technologically advanced of contemporary products. The Allen Digital Computer Organs use a read-only "specification" memory to store the harmonic structure of desired voices —information which is read out at any keyboard related frequency (see diagram).

To program the memories, a desired organ voice is recorded and analyzed for its harmonic content, so its envelope can be constructed. The harmonic information is expressed as 16 words of 7 bits each; these correspond to the amplitude at 16 points along the positive half cycle of the waveform.

The negative half cycle is a mirror image, and the specification memory is divided into blocks, corresponding to the voices on the organ. Each block holds the 16 words of a positive half cycle. The blocks and each of the amplitude words are assigned a numerical address to allow the information to be retrieved on demand.

When the organ is being played and voices are selected, they are transferred to a random-access "registration" memory. This allows two or more voices to be combined digitally. As keys are played, the 16 sample points are successively read out at the correct audio rate.

The readout function is performed on a board that contains MOS circuitry. One circuit is the keyboard decoder and multiplexer, which provides an output pulse for each key depressed. These pulses are applied to the frequency generator—an action that causes the address generator to address each of the 16 sample points, then reverse and count backward for the inverted 16 points that make up the negative half cycle of the tone.

From the registration memory, the data go to a multiplication circuit, where the voice data are multiplied by the attack and decay functions retrieved from another ROM. Finally the data are converted to a conventional audio signal in a digital-to-analog converter and fed to the amplifiers and speakers. The over-all frequency of each note, as well as all the timing functions for the digital circuitry, come from a clock board with a 4-MHz master clock and counting circuitry that provides the timing pulse trains. ■■

Radar energy absorber eliminates 'ghosts'

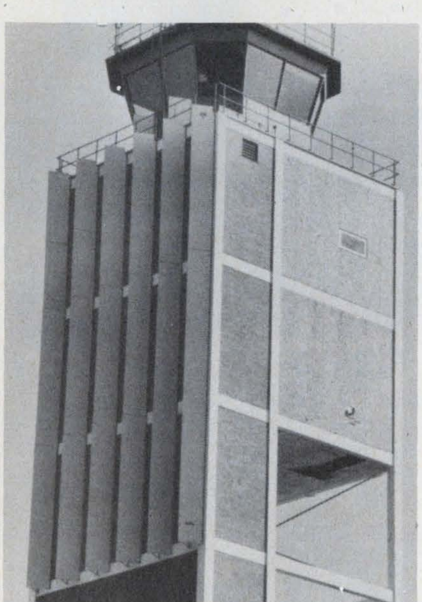
Using a new electromagnetic energy absorbing material, engineers at Rockwell International's Tulsa Div., OK, have eliminated ghosting—a problem that often plagues radar operators.

Ghosting occurs when radar signals returning from an aircraft bounce off of another object before they are reflected back to the radar antenna. This causes the radar scope to display a weaker, false image of the same aircraft.

By placing panels made of RIGEL (Rockwell International Ghost Eliminator) on the particular structure reflecting the signals, ghosting is eliminated since the panels absorb rather than reflect the signal.

The RIGEL panels contain a thin polymer film of the energy absorbing material, a honeycombed shape support structure and a wire mesh. By changing the depth of the honeycomb structure and the pattern of the energy absorbing material printed onto the thin polymer film, the absorption frequency of the ghost eliminator can be changed.

The RIGEL panels were installed at the Tulsa International Airport on the north wall of the control tower. The installation represents the first commercial use of this classified material originally developed for the Government.



Energy absorbing panels made from a new material eliminate radar ghosts.

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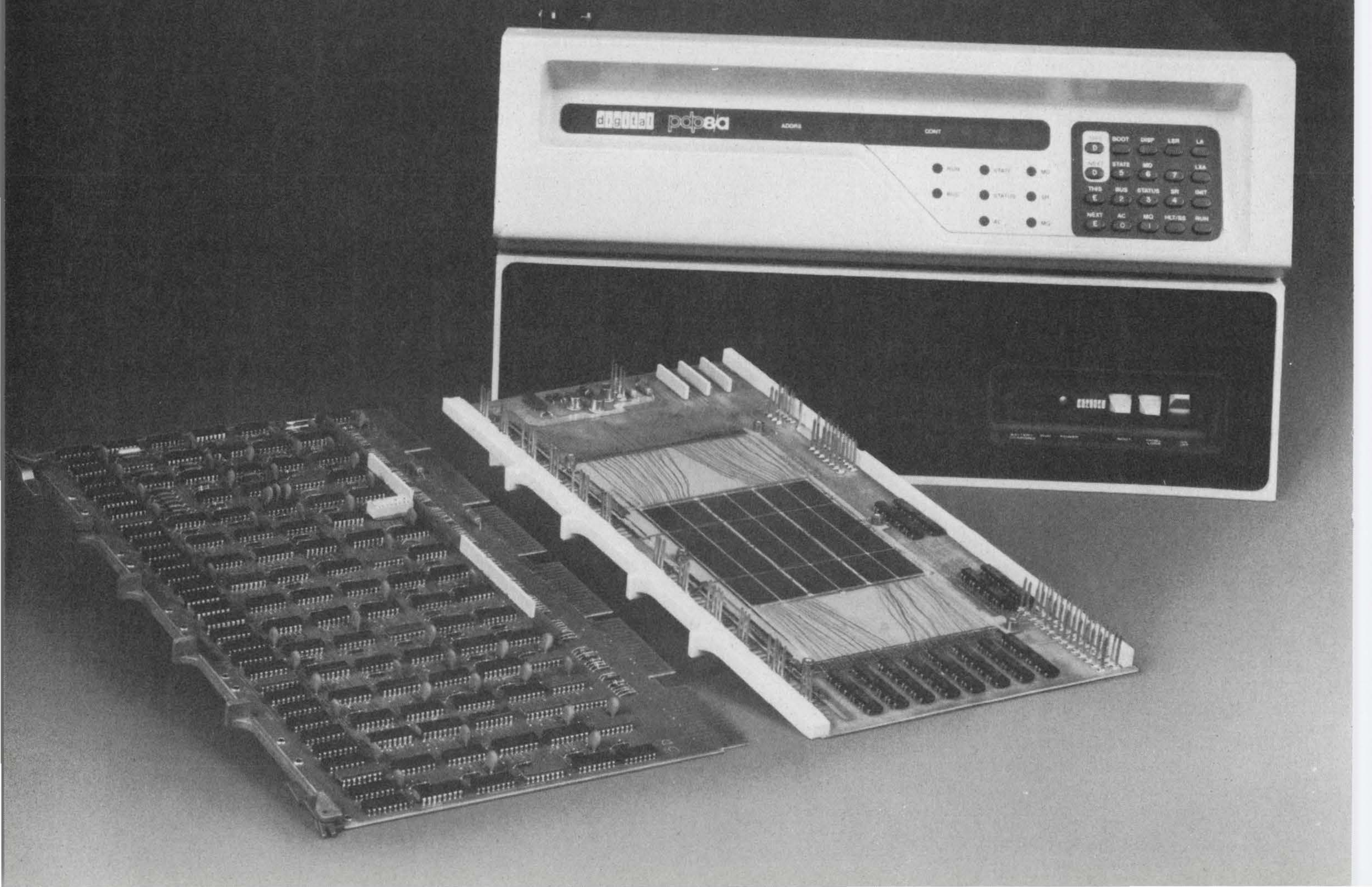

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Data General	Nova 2/4	Not Available	$2112 (CORE)	$2432	$3456
General Automation	LSI 12/16	$ 635 (Qty. 100)	$2000 (Qty. 100)	$2300 (Qty. 100) (RAM)	$3100 (Qty. 100) (RAM)
National Semiconductor	IMP-16L	$ 713	$2660	$3510 (RAM)	$5210 (RAM)

Based upon current published prices for discount level of 50 units.
Prices apply to U.S.A. and Canada only.

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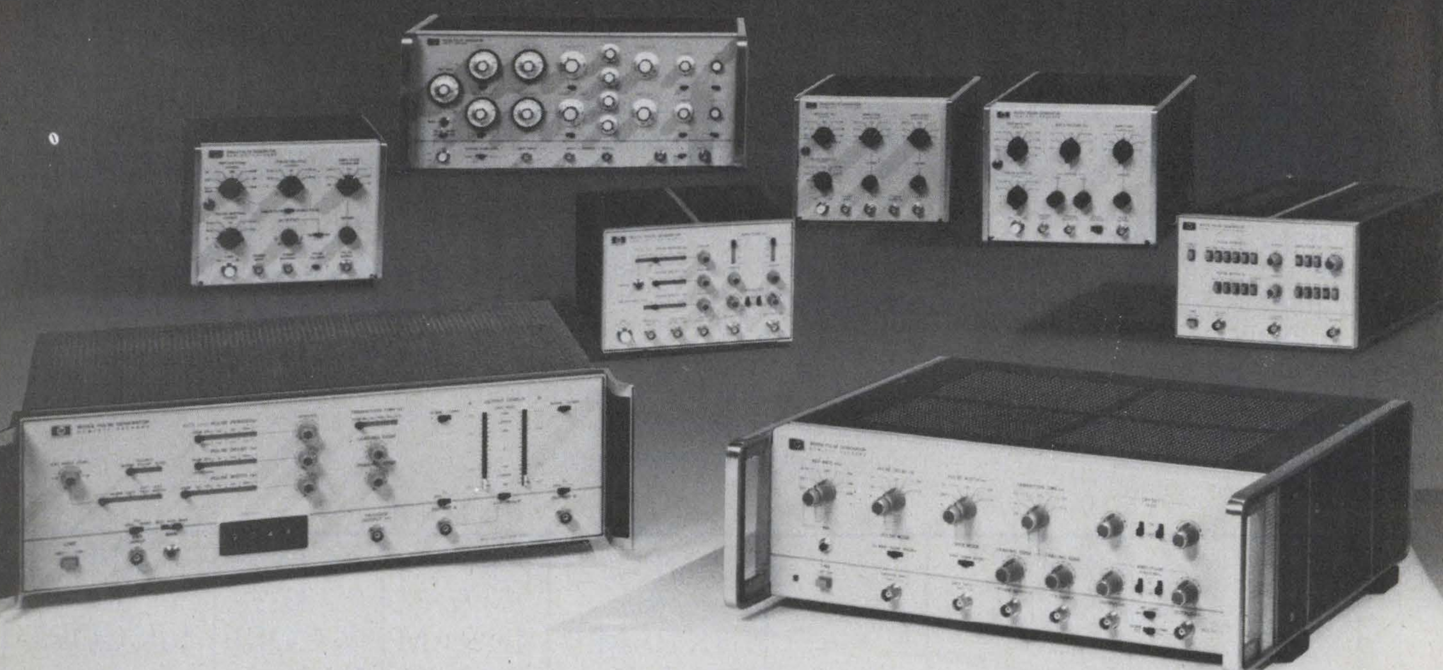

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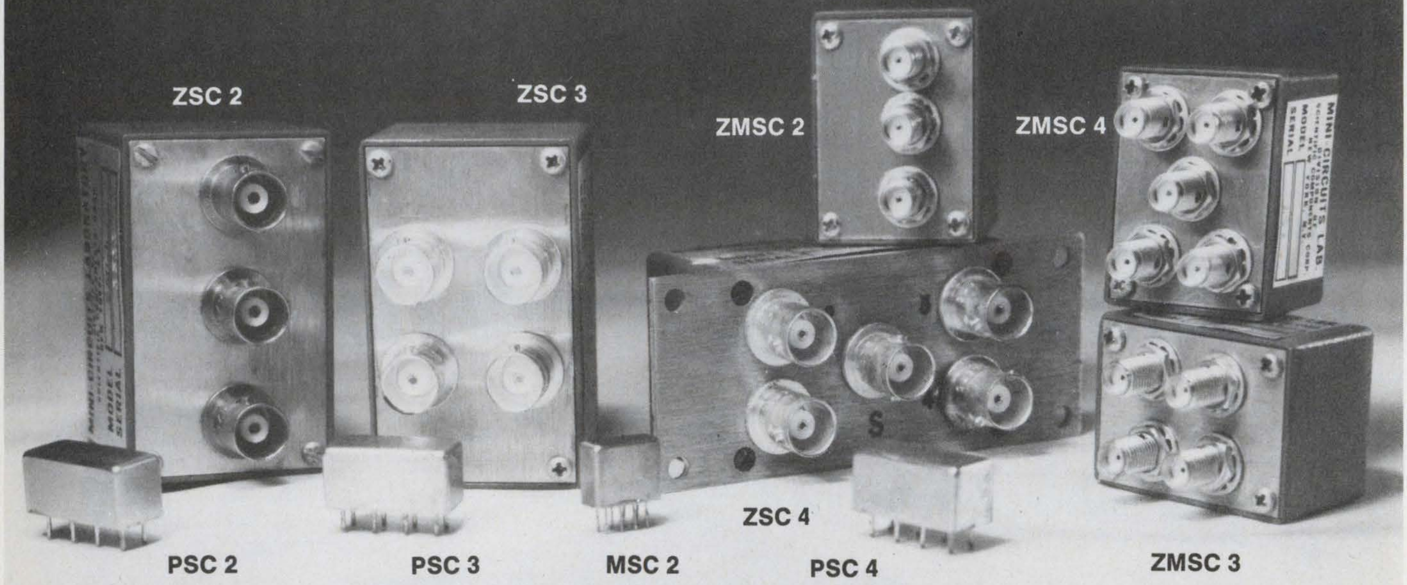

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Model No.	Freq. range (MHz)	Isolation between outputs (dB) typical	Insertion loss (dB) (typical)	Unbalance		Price (Quantity)
				φ (deg)	Amp. (dB)	
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INFORMATION RETRIEVAL NUMBER 29

washington report

F-16 fighter shapes up as a plum for electronics makers

While it's too early yet to come up with a firm figure, the Air Force F-16 fighter selection holds promise of a possible $2.85-billion market for the avionics and electronics that will go into the lightweight aircraft. Much of the avionics will be off-the-shelf, but the radar will be new. The plane will be built by General Dynamics. Hughes and Westinghouse have contracts to develop the avionics, and a flyoff on these subsystems is likely this summer.

The initial Air Force purchase of 650 aircraft will include around $490-million for the avionics. This is based on a flyaway price of $4.6-million per aircraft.

Besides the Air Force, the NATO nations are possible customers. They could buy some 350 aircraft, adding perhaps $262-million in avionics.

All told, there are possible lifetime purchases of between 3300 and 3800 aircraft. The total potential for the avionics market, in today's dollars, appears to be in the vicinity of $2.85-billion for original equipment alone —and there is always retrofitting. The F-16 program is being heralded as the plum of the century.

NASA plans for fiscal 1975 available

The National Aeronautics and Space Administration's compilation of research and technology activity for fiscal 1975 is now available as the NASA Research and Technology Operating Plan Summary (RTOP-75). Included are summary portions that spell out objectives and identify installations of primary interest. NASA officials predict the plan will be particularly helpful to small R&D companies. A copy costs $3 and can be obtained from the National Technical Information Service, Springfield, VA 22151.

U.S. moves to end procurement favoritism

New rules on Federal Government procurement by formal advertising should make it easier for sellers, tougher on buyers and stamp out favoritism. The General Services Administration says future descriptions must not specify a product that has features peculiar to a product made by one manufacturer, producer or distributor, unless the Government buyer can show the features are essential.

Nor can the specifications include either minimum or maximum restrictive dimensions, weights, materials or other salient characteristics that would tend to eliminate competition by products that are only marginally outside the restrictions—unless such restrictions are determined by the user, in writing, to be essential to the Government's requirements.

Further, descriptions must clearly and accurately describe the salient technical requirements or desired performance characteristics without including restrictions that do not significantly affect the technological requirements or performance. And, when appropriate, the buyer must describe the testing procedures that will be used to determine if the requirements or characteristics are met.

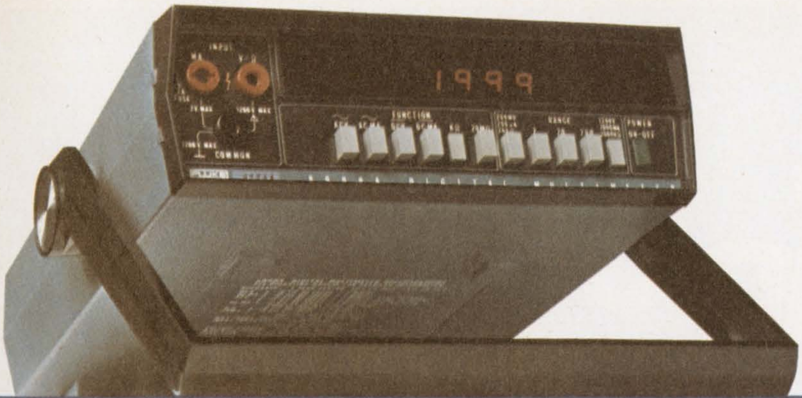
Bye-bye ERTS, hello LANDSAT

ERTS—the Earth Resources Technology Satellite—has a new and simpler name: LANDSAT. And someday it may have a companion named SEASAT. The new names were announced unexpectedly by the National Aeronautics and Space Administration. LANDSAT stands for land satellite and SEASAT—right, for sea satellite.

SEASATS are scheduled for launching in 1978, with the 2100-lb satellites circling the earth 14 times a day on a north-south orbit and sending back information on the oceans, like the LANDSATs do for land surfaces. The SEASATs will carry a compressed-pulse radar altimeter, a coherent synthetic-aperture imaging radar, a microwave wind scatterometer and an infrared radiometer. Sensors will determine wave heights, current directions, surface-wind direction and temperatures. An envisioned network would give ships sea maps of their routes twice daily.

Capital Capsules:

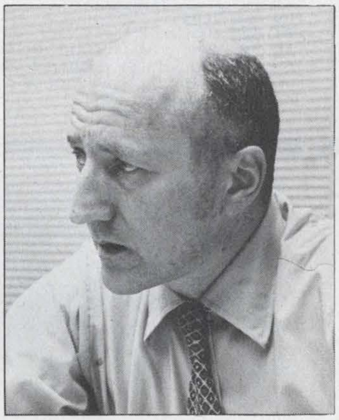
A comprehensive review of **the status of the metric system conversion program** is due in mid-February. The "Report to the Nation on the Management of Metric Implementation" will be the first annual report of the private American National Metric Council, which holds its first annual conference in Washington, March 17-19. . . . Hart, Mich., a town of 2,500 will be studied by Michigan State University **to determine if wind energy can be used economically to support the electric power needs of a small municipal utility.** Funds for the study are from a $93,400 grant from the National Science Foundation. . . . Concern in some countries with the potential environmental hazard posed by polychlorinated biphenyl (PCB), a chemical used in the manufacture of capacitor dielectrics, has prompted the Electronic Industries Association to develop **a new supplemental standard for capacitors using non-PCB oil-impregnated paper dielectrics.** The EIA says concern has led Japan and other countries to ban the manufacture, import and use of electronic equipment containing any PCB. . . The Air Force's Avionics Laboratory has announced a **need for a radiometric microstrip receiver.** Performance goals are 34-36 GHz, instantaneous bandwidth of 500 MHz and a noise figure of 5.5 dB (DSB). USAF says the receiver must be developed with hybrid microwave integrated-circuit techniques and include a self-calibrating capability. . . . A **Directory of Defense Electronic Products is available from the Electronic Industries Association.** Prime use will be to brief potential foreign customers on the capability of U.S. defense and related high technology electronic products. . . . On the horizon is **a study to verify thermal characterization models of beam-lead microcircuits.** The contractor selected by the Army will focus on microcircuits comparable in chip size, number of beams and power dissipation to MSI circuits of the 54TTL series. The power dissipation of the devices will be in the 200-to-800 mW range.



INFORMATION RETRIEVAL NUMBER 31

editorial

The foreign engineer



There's an old joke in Europe about the American fellow who had to buy a gift for his girlfriend. When someone suggested that he buy her a book, he rejected the idea with: "No, that won't do. She already has a book."

I know how that girl must have felt if she ever heard the story. Toward the conclusion of my visit with a semiconductor company in Paris, my host turned to me with: "By the way, our offices here are in the former home of a French writer of some repute." And in a tone one might use to ask a fellow if he's familiar with spoken Sanskrit, he asked, "Have you ever heard of Guy de Maupassant?" When I started quoting from some of de Maupassant's brilliant stories, my host was startled. He found it hard to believe that an American—an American engineer, at that—might have read de Maupassant, though that man ranked with the world's greatest short story writers. That's rather sad.

European engineers have great respect for American engineers—as *engineers*. But they find it hard to believe that an American engineer might read a book without equations. They can't picture an American engineer reading great literature, listening to great music or admiring great art.

Thanks largely to the efforts of electronics engineers, we've made great strides in shrinking the world with transoceanic cables, international radio and telephone, and round-the-world satellite communications, not to mention high-speed, jet aircraft. We have brought the world's people closer together. But not close enough.

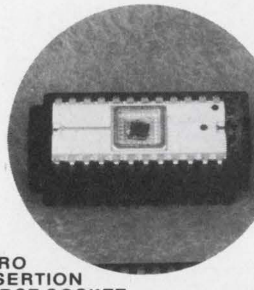
We still don't know each other. It's not too many years since Europeans, thanks to the influence of the movies, thought all Americans were millionaires or gangsters. Today many Europeans think American engineers are great engineers, but they wouldn't want to be stuck in a conversation with one. And American engineers have distinct stereotypes for French, Italian, British, German and Dutch engineers. That's unfortunate but it may point to our next step.

We have to shrink the world further. We have to make it small enough so that international communications and travel are cheap enough, quick enough and easy enough so that people of the world—not just engineers—can get to know each other better. We may find we're not shooting at each other so much.

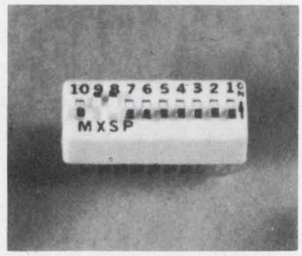
George Rostky

GEORGE ROSTKY
Editor-in-Chief

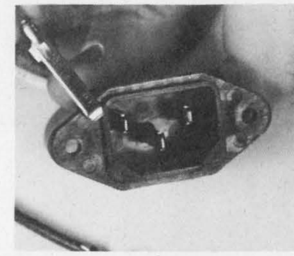
tic-tac-toe



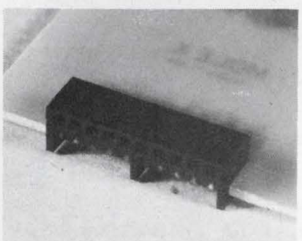
ZERO INSERTION FORCE SOCKET
40, 36, 28, and 24-position versions. Self-ejection of LSI, positive lock in the loaded position. LSI will not be damaged by repeated insertions.



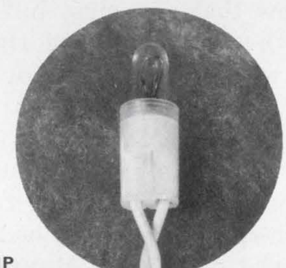
LOW PROFILE BOSS™
Our newest Boss (binary option selection switch) family member. Just .360" high for .500" board spacings. And it offers the same butting/wiping contact design.



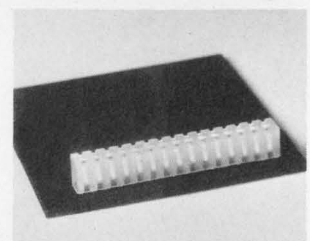
A-C RECEPTACLE
A three-pronged a-c receptacle with crimp snap-in contacts offers the lowest installed cost in the industry today. It also has a repairability feature not available on other a-c receptacles.



KK-100 PCB CONNECTOR
Right-angle, bottom-entry, and straight versions expand the possible combinations for Molex .100" interconnection systems. Reliability, low cost, and popular density are key features.

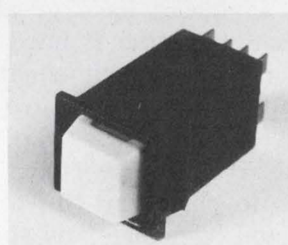


LAMP SOCKETS
A socket from which a wedge-based bulb can be easily removed. It also withstands vibration and shock. Two popular sockets that use T-3-1/4, T-5, or T-1-3/4 wedge-base lamps are now available.



CALCULATOR KEYBOARD CONNECTOR
Currently designed as a 22-circuit version, this product can be developed to connect the main logic board to the keyboard on any calculator.

MOLEX-A-MATIC
How do you make the Molex plug-in socket connector series a better buy? You assemble the terminals by machine! We are the only company that has successfully automated this operation.



NEW LIGHTED PUSHBUTTON SWITCH
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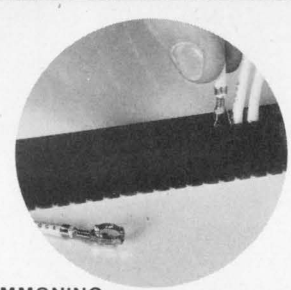

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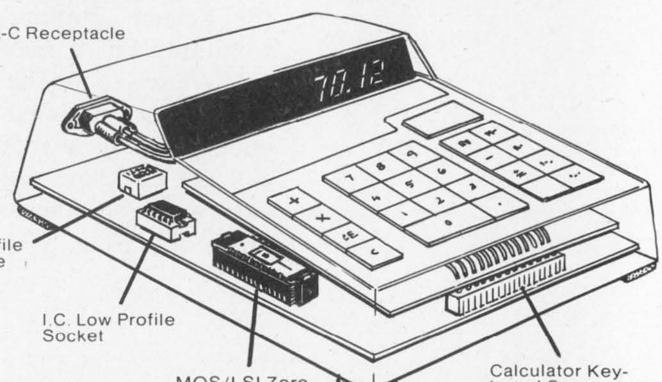
It's no game at Molex. It's serious business. In the past few months, we've developed many new products for many industries . . . computers, peripherals, radio and TV, appliances, calculators, communications, and office equipment. The nine products displayed here are the latest new products just released. There are more on the way.

Call your Molex sales representative for an update of our expanding product line. Our products are new, our prices competitive. Ask Molex to quote your next project package.

This calculator design uses several Molex components.



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INFORMATION RETRIEVAL NUMBER 33

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We call this board the Harris 3800. You'll call it reliable. Reliable because they meet the exacting demands of our own computer systems. And, they'll meet the unpredictable demands of your unpredictable needs.

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- random access
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INFORMATION RETRIEVAL NUMBER 34

FOCUS on Component sockets

Why use sockets? For the obvious reasons: You'll simplify component assembly and replacement, and you'll avoid damaging costly components with hot solder.

But, to use them, you must know something about contact reliability, allowable heat dissipation, dielectric breakdown and mechanical strength and a few new troubles before you buy.

One of the biggest socket problems, today, is posed by the ubiquitous DIP (dual-in-line package), whose skinny little leads were never meant for a socket. Add to that a very broad EIA spec on lead size, and it's a miracle that the sockets work sometimes.

However, the conventional IC DIP does use leads that have some definition of shape—the lead's cross-section is rectangular. The situation is much worse with LED displays that sport round pins mounted on DIP cases. Plug the round pin into a socket designed for rectangular leads, and the spring material deforms permanently.

To compound the confusion, there is the Occupational Health and Safety Act (OSHA), which, for component sockets, translates to an Underwriters' Laboratories spec on material flammability. Any design that involves handling at a job station—for example, CRT terminals or computer peripherals—must comply with OSHA. And the UL spec also applies to consumer equipment.

The old spec game

Naturally the manufacturer may play down these problems or introduce his own confusion. The catalogs will inundate you with contact shapes, elaborate mechanical drawings of sockets and a new language, with terms like "insertion/withdrawal force ratio" and "low profile." Specified contact resistance often is valid only on the first insertion. And words like "UL recognized" rather than the rating itself may be given when you really need something like UL 94VE2, a spec for self-extinguishing capability, or its older equivalent, SE-2. The 94VE2 spec is essential to meet OSHA requirements for work-station equipment.

Although flame retardance is just becoming an issue, the gold-tin controversy permeates almost every manufacturer's brochure. With gold hovering around $175 an ounce, most manufacturers either try to eliminate the metal or find ways to skimp on its use.

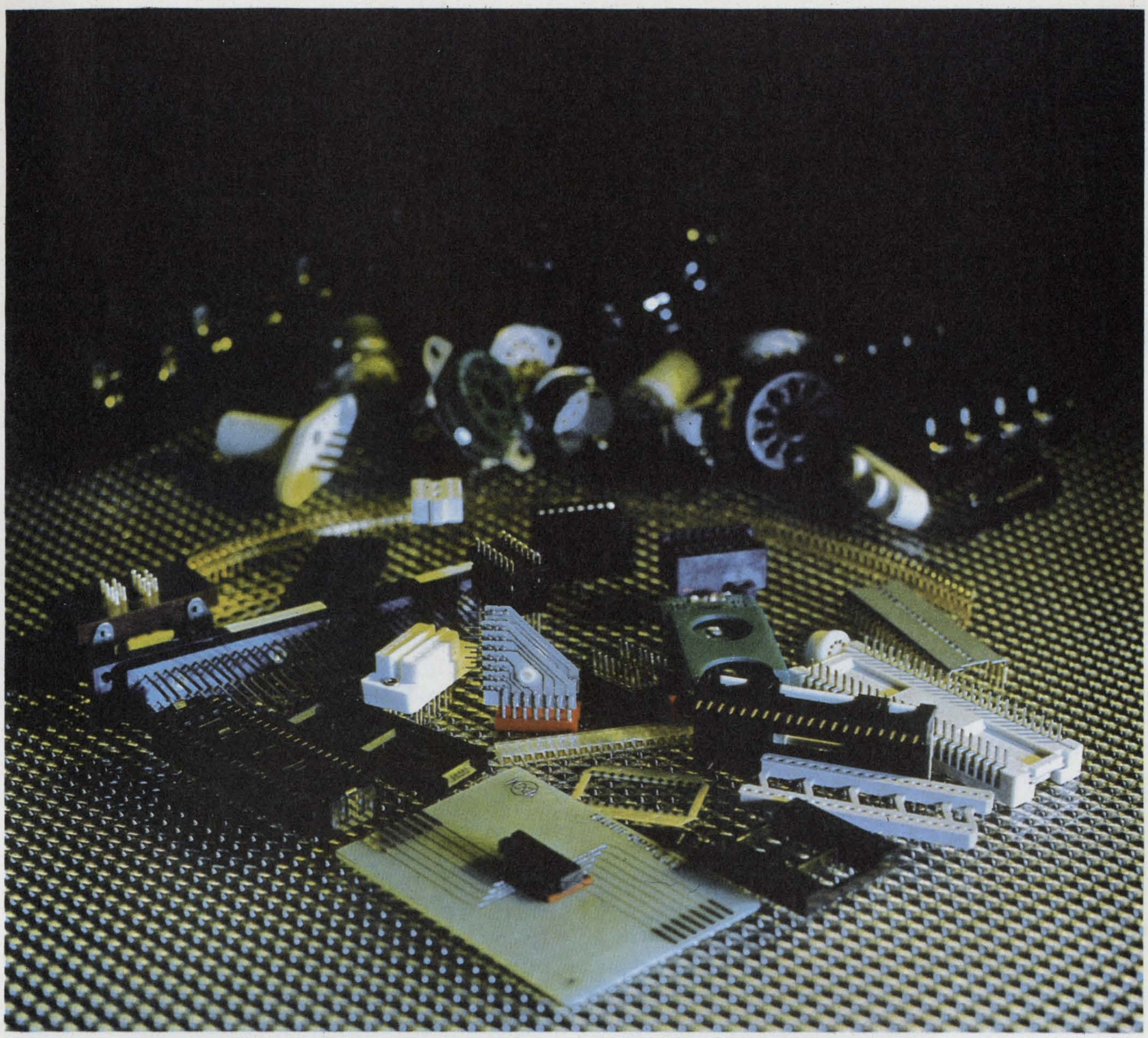
When gold prices were fixed, the military had no qualms in specifying 50 μin. of hard gold plating for reliable connections. And many computer manufacturers followed this spec rigidly. Even today, they want gold everywhere, even though tin-plated IC leads enter the socket.

Although gold-to-gold contacts offer outstanding reliability, the search for cheaper substitutes has made users think more about the real issue—good electrical contact and exactly how it should be defined.

Most manufacturers—if they supply the spec at all—give just one value of contact resistance, usually that for the first insertion. But what happens as time passes or the insertions increase? Normal force is a key parameter. If the contact material deforms, you lose force. Without force, surface films are not penetrated—poor contact results. And no one agrees on how much force is enough. With some manufacturers, the more force the better. Be sure to ask them: How do you plug in a 40-pin RAM? The answer is apt to be: "Very gingerly."

Even when the manufacturer lists such performance parameters as force and contact re-

Seymour T. Levine
Associate Editor



Component sockets run the gamut from a power relay to a leadless substrate. Contact problems once found in large relay and tube sockets can now turn up in IC units. Manufacturers such as Amphenol and H. H. Eby use large firm contacts for the bigger sockets. And the same technique is used in smaller units.

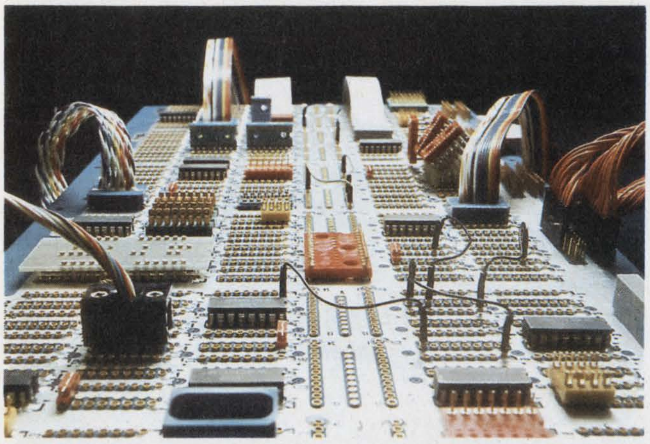
sistance, you still don't know if he tests for them, or how much they vary from unit to unit. Therefore you might ask a few questions about quality control. If your vendor acts scared, you should be too.

The EIA specifies that contact has been made if the resistance is less than 50 mΩ. But what if your vendor's socket samples have 3-σ limits between 4 and 50 mΩ, or 10 to 500? Chances are that his manufacturing process is out of control, and so is your equipment reliability. The same principle holds true on normal force. The vendor should be able to hold the force to within ±20 gm for a specific pin size and with the spring lengths used in conventional sockets.

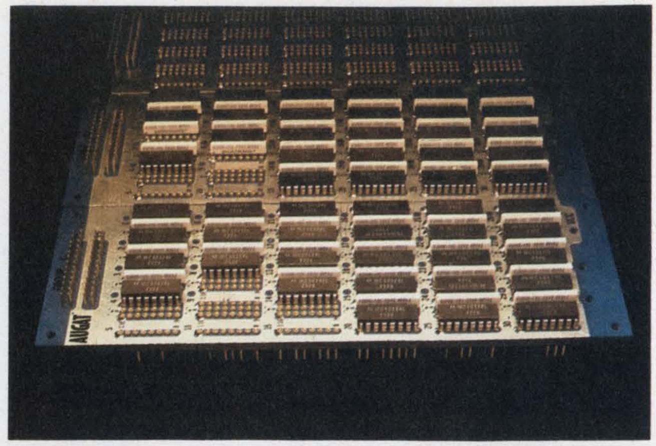
Uncontrolled force variations should warn of IC interchangeability problems. Although various manufacturers second-source ROMs, RAMs and even microprocessor ICs, their DIP pin widths vary between 0.015 and 0.021 in. And the thickness can vary between 0.07 to 0.014 in. Different manufacturers use different mean dimensions and stick pretty close to them.

The normal force on a spring is a cubic function of its deflection (and, hence, of component pin thickness). For components from three different sources, one package may be fine, the other may fall out at the slightest provocation and the third may either bend the spring open or be cracked by excessive spring force.

Some manufacturers advise you to specify normal and withdrawal forces. Watch out. Withdrawal is a game that can be played with a roughened test pin.



A new ECL packaging board offers pluggable terminating components (left). A single in-line package (SIP) holds the components and is plugged-in between the ICs. Like



Augat's older ECL boards (right) the company's new boards have three voltage planes. Note the variety of component carriers and plugs available.

Advocates of gold contacts sometimes say that this metal is chemically inert; it does not react to form halides or sulfides. Therefore really heavy force is not needed. Perhaps 200 years ago zero contact force was possible, but pollution has changed things. First, oily films and dust accumulate on gold. Also, commercial-grade gold plate has pores in which halides and sulfide films form slowly. Thus at least 15 to 29 gm of normal force is required. With tin, the force is more than 50 gm. Of course, in addition to providing poor contact, a normal force that is too low will provide poor DIP retention.

Trouble with low voltage

Early users of IC sockets found that oxide films and dry (low-voltage) circuits didn't mix. Tubes or appliance plugs worked fine—even though films were present—because the high-voltage levels broke the films down. But IC signal voltages were often on the order of millivolts. Consequently the films were not punctured, and the circuit was stopped in its tracks.

Since ICs were usually cheaper than sockets, the manufacturers soldered the DIPs directly to the board. But now sockets cost less than most LSI chips and the trend has reversed.

But with more sockets per board, the unit price of a socket becomes important. Tin plating can help reduce cost, but not without problems. The first problem is shelf life. If your tin sockets have been around for a year or more, the chances are that the leads are too corroded for good solder joints. The second problem is that you won't know how long the contact lasts once an IC is inserted.

Tin oxides are easily punctured by mechanical friction. With enough normal force, electrical contact will occur. Recent studies at Texas Instruments in Attleboro, MA, show that tin-to-tin contacts provide stable resistance at 100 C, but they show accelerating resistance change, versus time, at 125 C. In addition tin-to-tin connections with a combined plating thickness (DIP and socket contact) of 200 μin. show only slight increases in resistance from initial value at 100 C. Of course, the pitfalls here are straightforward; How well do your IC and socket manufacturers control the plating thickness? Are there areas, especially near the contact points, where the plating is too thin? When base-metal corrosion sets in, it's too late.

Silver-plated DIPs and gold sockets perform remarkably well, according to TI's test results, which were based on 550 to 750 μin. of silver. Even when mated to bright acid tin socket contacts, the silver DIPs performed well, but they failed when plugged into unplated sockets. Apparently the silver plate provides lubricity that reduces contact erosion.

In an SO_2 environment of 25 $\pm$5 ppm, silver plated DIPs mated to gold sockets showed a maximum resistance stability of 10 to 12% (deviation from initial value). And at elevated temperatures (125 C), the combination showed resistance value changes that were well within those measured for a gold-to-gold bond.

Watch the number of insertions

Another factor to consider is the number of insertion-withdrawal cycles. Production sockets are not test jigs for components. So don't expect hundreds of insertion/withdrawal cycles: 10 to 20 is a fair number. In fact, some manufacturers can tell you the amount of resistance change to expect after a given number of cycles. Try to specify the range of resistance you can accept and see if your vendor is willing to meet the range.

The alert reader of socket specs will soon spot subtle pitfalls in plating specs. One is the omission of nickel plating under the gold. To be effective, the gold plating must be free of pores and thick enough to prevent the diffusion of base metal. An underplate of nickel also helps prevent diffusion. Also, there are at least two types of gold—hard and soft. Soft gold can be easily galled off by rough edges, whereas hard gold cannot. Check the one used by your vendor. And too little gold is as bad as none. The porosity of the thin surface almost ensures unwanted diffusion.

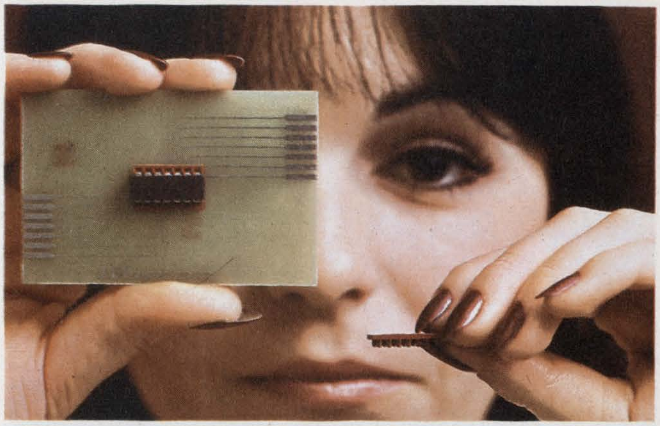
The desire to accommodate a wide variety of pin types leads to two types of DIP socket contacts: face grip and edge-grip. Actually both types perform well unless the manufacturer chooses shortcuts; then face-grip may be less risky.

Edge-grip units made with the edge of the DIP lead. Since these leads are formed with a stamping process, they are also quite ragged. Hence galling and scraping of the plating is possible. Clearly, hard gold is in order (if gold is used). A better choice is wrought gold inlay. The inlay is metallurgically bonded to the contact and is also more resistant to galling than a plated surface. In addition the gold is only where you need it; in volume, the price is competitive with tin-plated sockets. The leading advocate of this approach, Texas Instruments, is now being joined by others, such as Vector Electronic Co.

Face-grip advocates point out that they have at least one smooth face for contact (a consequence of the aforesaid stamping process) plus a redundant contact with the other face. And the universally desired contact wipe is automatic. One consequence of a face-wipe contact is slightly larger socket width, which could be a factor on tightly packed boards. Edge-grip contacts, on the other hand, expand sideways. If this expansion can break the insulation, then adjacent contacts can touch. However, most manufacturers use sufficient insulation to prevent this.

Lack of attention to plane geometry—aided and abetted by manufacturer advertising slogans—can lead to some comical configurations. The much touted slogan is "low profile," an undefined term that means sockets that allow IC DIPs to lie as close as possible to the circuit board. The "lowest" profile height above the board is determined by the lead length and where these leads attach to the package. Not infrequently the IC leads are longer than the socket height, and the IC floats well above the socket face after plug-in.

In addition to sockets that "float" ICs, "iceberg" sockets can also hamper minimum separation between boards. Some sockets that use push-in mating contacts have exceptionally low board height on one side but protrude far out on the



The elastomeric socket has such a low profile that the young woman can scarcely see it. The "Pintrap" socket from ITT Cannon Electric is a resilient part that presses the IC pins against the internal diameter of the plated-through holes. The IC rests only 0.05-in. above the board. The socket also has lead-in chamfers; many low-profile units do not.

other side, like the underwater part of an iceberg. The extra contact length is needed to provide a good spring lever.

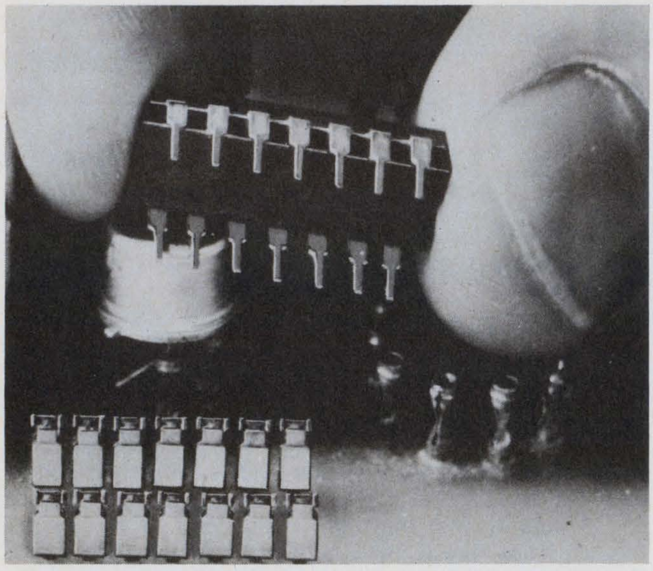
And there's the matter of spring material. Usually the choice is between phosphor bronze and beryllium copper. Beryllium copper is more expensive and has a higher yield point. Hardening and crystallization with age are low. This material is almost always needed for low-profile sockets to avoid permanent spring deformation. Phosphor bronze, on the other hand, costs about one fourth less and has good spring quality. Sometimes a third material, brass is used because it's fabricated easily. But its spring characteristics are not as good as the other two.

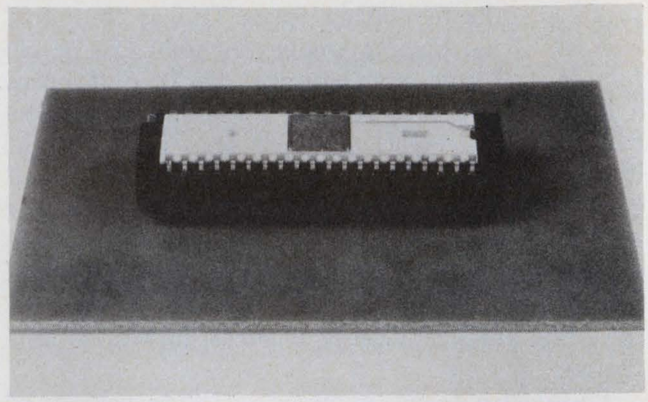
Ceramic LSI packages, such as those for some ROMs, require extra care in mounting. Most of their heat dissipation occurs on the underside of the part. Too close proximity to the board (low profile) will reduce airflow around the package and may lead to excessive operating temperatures. As a rule, low-profile sockets are those with heights of less than 0.15 in. above the component side of the PC board.

Test fixtures call for special sockets

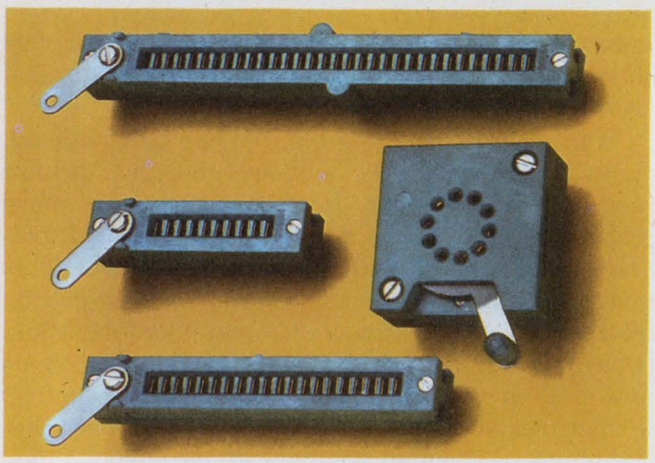
Low-profile sockets are practically never used for IC test devices where hundreds of insertion-withdrawal cycles are anticipated. The sockets used here must have long gold-plated springs to ensure that the spring doesn't bend out of shape and to get adequate normal force without galling. As a rule, avoid calling test sockets "commercial sockets"—manufacturers often interpret this as a requirement for five to 20 insertion-withdrawal cycles.

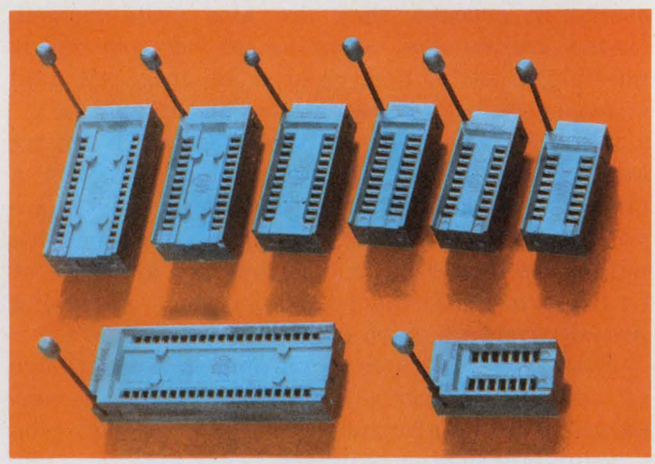
Also, many manufacturers offer zero-insertion force (ZIF) sockets. The contacts engage the





IC sockets can be as simple as precut strips, such as Molex Soldercon units (left) or complicated enough to protect delicate packages (above). The large socket, also from Molex, does not apply force on the leads until the package is pressed into position. To remove the package, simply release locking tabs on the sides.





Textool's broad line of zero-insertion-force sockets handles TO-style devices (left) as well as DIPs (right).

part when cams or screws close them mechanically. These are large, expensive sockets designed for use in testers and similar gear.

Socket installation (and removal) can pose problems for the user—though removal should seldom be necessary. Incidentally, cracking occurs on most socket removals.

Wicking is a term that describes the inadvertent flow of solder into the contact area. To prevent this, many manufacturers offer a wafer protector that can be placed onto the socket pins, or they mold the socket so that body material seals off the pin area.

Sockets without such protection, and in which the contacts do not press tightly against the body, can draw up solder by capillary action. If hand resoldering is attempted, bear in mind that the sockets are vulnerable to wicking.

Once you've socketed the IC, watch out for vibration effects. Many sockets only grip the IC lead on a single face; the other face rests against the plastic base. Given the right vibration frequency, contact bounce may occur where there aren't any pushbuttons.

Wrapped wire boards can reduce costs

The increased cost of PC board fabrication for complex devices has led to widespread use of wrapped-wire boards. Since practically no IC or display device is wrappable, extensive use is made of sockets with wrapped-wire tails. And to keep size down, manufacturers like Cambridge Thermionic, EECO, Augat Robinson-Nugent and Texas Instruments—to name a few—offer socket boards or high-density subassemblies. With many of these, discrete components are soldered to small plug-in carriers, which are later inserted into the socket rows.

Wrapped-termination boards have some stumbling blocks for designers. First, many engineers tend to specify gold for use on the wrapped-wire tails. Unless called for by contract, this gold is an unnecessary expense. Termination-wrapping

Socket-insulator characteristics

	Thermosets			Thermoplastics					
Group * comparison	Hard; brittle but mar resistant; stiff (flexure may break thin walls); resistant to heat distortion.			Wide range of impact strengths; resilient; flexible (permits snap fits); wide color spectrum					
Subgroup *	Not applicable			Crystalline			Amorphorus		
Subgroup comparison				Denser, waxy feel; more prone to warpage; more resistant to solvents.			Less deterioration of physical properties under load or elevated temperature.		
Family † properties	Epoxy	Phenolic	Diallyl (DAP)	Nylon	PTMT or PTBT**	Teflon	Polycarbonate	Polystyrene	Polysulfone
Dielectric strength	350	350	400	400	590	400	350	700	450
Thermal exposure (°C at 1000h)	225	200	170	120	120	260	250	87	130
Tensile strength (lb/in²)	8000	10,000	6000	7-13,000	8000	2-5000	13,000	6-8000	8-9500
Low-temp exposure	Good	Good	Good	Good	Good	Good	Good	Good	Fair
Fluid exposure	Good	Good	Good	Good	Exc.	Exc.	Good	Exc.	Good
Insulation resistance	Good	Good	Exc.	Good	Exc.	Exc.	Good	Exc.	Good

* Classifications and group properties courtesy of General Electric Plastics, Selkirk, NY
** Thermoplastic polyesters
† The properties of plastic vary with exact mix and treatment

machines produce sufficient pressure at the pins to provide gas-tight seals. However, this advantage is undercut if a hollow-formed pin, rather than a solid one, is provided. After a while the pin collapses under pressure from the wire joint, and the gas-tight seal fails.

A less common defect is bent pins. The wrapping machine stops whenever the pin center drifts out of alignment with the position of the chuck on the wrapping machine; operator intervention is needed then. If your board is assembled on an index table, try to use tough socket materials (avoid cheap phenolics). The large accelerations can sometimes crack the socket housing or even cause pins to pop out.

The increasing drive to miniaturization, which often leads to modularization, is being felt in component sockets for displays. Even miniature incandescent lamps have shrunk to T-1 size (0.125-in. diameter) and come with wire leads. In fact, there has been a proliferation of sizes, from T-3/4 at 0.93 in. to T-4 at 0.5-in. The numeral portion of the code is based on 1/8-in. as a standard diameter. Most engineers have little knowledge about lamp-holder size; lamp holders are not called sockets. (See accompanying table on p. 55 for a guide.)

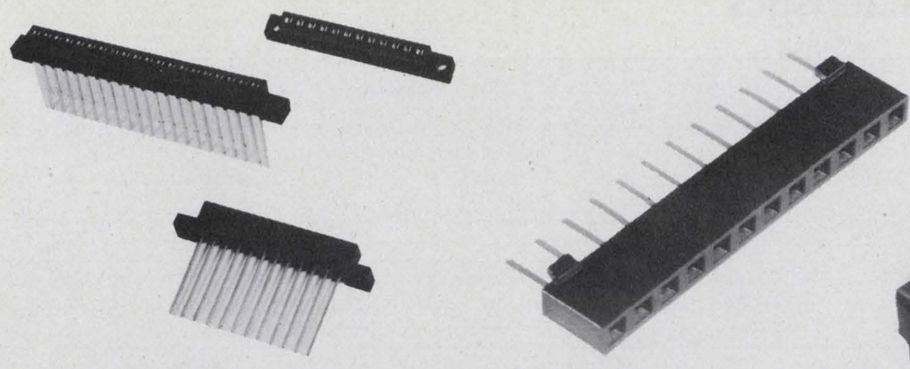
Many engineers spec the lamp holder for ac or dc current—hardly important for incandescent types. LEDs are almost always dc. But you should spell out the minimum breakdown voltage to ground, usually ac.

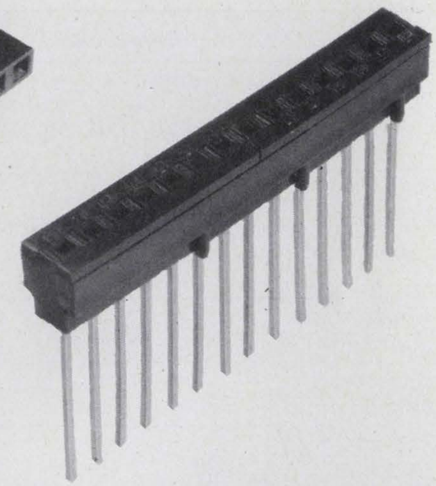
In addition to bulb dimensions, keep in mind UL standards and possibly those of the Canadian Standards Association. For example, UL specifies double the line voltage plus 1000 V, which gives 1250 V as the breakdown voltage.

For bayonet-based bulbs, which have orientation pins, make sure the filament is properly oriented when the bulb is seated in the socket. And if you need wire leads, specify the gauge, type (stranded, bonded, solid), the temperature rating of the insulation and whether the end is to be tinned. You can also use MIL-L-3661B, written especially for lamp holders and indicator lights. But lamp holders built to MIL, UL or CSA specs cost more. Holders for lamps in the "miniature" category are usually the least expensive. Larger or smaller sizes drive up the price.

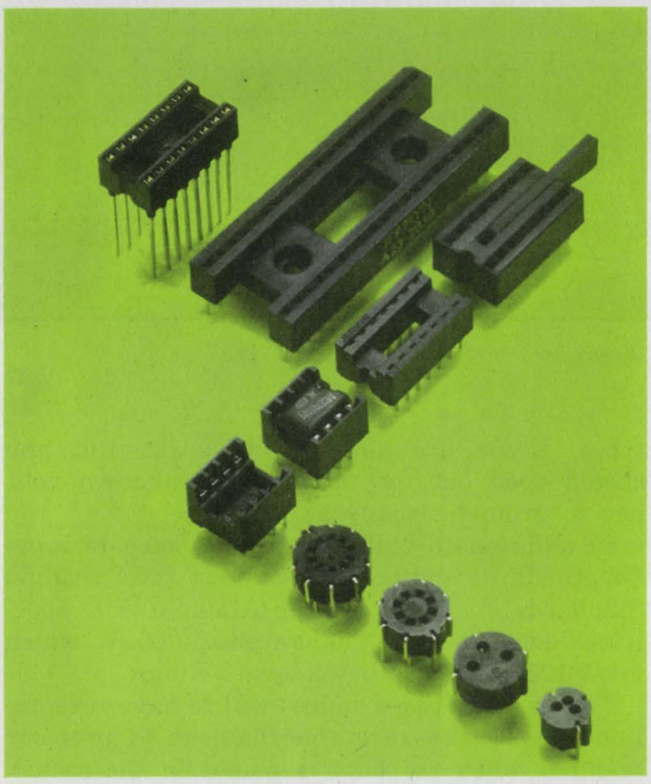
And don't forget temperature requirements and temperature rating (especially with high-intensity halogen units). The high range is 200 to 250 C, where the steel should be nickel-plated and insulation ceramic, the springs of stainless steel and the wire insulation of Teflon or glass braid over silicone.

You'll encounter some difficulty in the re-





Do unusual pin-widths bother you? Strip-sockets, such as these shown from Gibson-Egon, Jolo Industries and Scanbe, let you support almost any IC. And the space between strips can be used for discrete components.



Jermyn's broad product range covers eight to 50-pin DIP sockets as well as TO-5 style IC sockets. The 16-pin DIP socket has a built-in ejector pin, which is useful for IC test purposes.

moval of midget-grooved lens-end lamps, often used in card readers and photo sensors. The sockets are designed to provide a secure grip for good optical alignment.

Sockets designed for bi-pin lamps should have contacts that are firmly fixed in the holder. Complaints of bent pins are often the result of "floating" contacts.

A number of lamp holders designed for dead (opaque) front-panel lighting require additional attention to human factors. These use midget flange-based bulbs and are very economical—about 11 cents a lamp. The lamps must have a single common bus to all bases, and you must also have access to the rear of the panel to remove the bulbs.

Most manufacturers of DIP LED displays agree that the DIP sockets present no additional problems beyond those for the usual ICs. Lead lengths may vary from manufacturer to manufacturer, but 0.5-in. is the one most often supplied. On large orders (say, 10,000 pieces) companies like Litronix will clip the leads to a specified length. This avoids the need for specific socket heights to get the proper viewing geometry. Newer displays also have larger spacing between rows of pins—0.6-in. instead of 0.3. Circuit Assembly Corp. now provides low-cost sockets for these larger displays, for $1 or less. Previous price levels ranged from $3 to $4. IEE's Atlas series holds as many as eight display digits and snaps into a front panel.

Some users of sockets for LED displays complain of cracked pins. This happens because the body width of the display often exceeds the row spacing of the pins, and the assembler loses sight of the socket when he inserts the pins.

Liquid-crystal displays resemble circuit boards rather than DIPs, even to the terminals that are often vacuum-deposited on the edges of a glass enclosure. Insertion into PC-style connectors can chip or crack the glass, especially when the applied pressure is high. One type of mounting that bypasses the problem uses elastomeric connectors. These are layered strips of rubber filled with carbon or silver in sections alternating with plain insulators. Pressure between the display contact pads and circuit pads completes the circuit.

One of the largest suppliers, Technical Wire Products, calls this type of connector Zebra and can offer 25-Ω minimum contact resistance. AMP Corp. supplies the Elastomate connector—an elastomeric rod with parallel lines of micrometallized film. These systems are experimental but have proved very reliable in liquid-crystal watch displays and the well-known Danameter, a palm-sized DMM manufactured by Dana Labs, Irvine, CA. The main precaution is care in manufacture of the elastomer. Conductivity is quite sensitive to the fillers used, to storage time, fabrication technique and so forth. But once installed, the material shows a resistance drop (20% for Zebra), then stabilizes. There is also a nominal 20% drop in stress after installation, a decrease that then remains constant. Since pressure is needed for contact, the mounting device should provide adequate force.

Traditional components have 'enemies'

Heat, dielectric loss and voltage breakdown assume greater importance with some of the more traditional electronic components—namely, crystals, transistors, relays and tubes.

Crystal sockets have been used for about 35 years and conform to a spacing based on odd multiples of 64ths. But moisture is one of the crystal's arch enemies. It reduces the Q of the circuit and therefore the frequency stability.

Ceramics, which include steatite and porcelain, perform well. They have low rf loss, and the upper surface can be glazed and the lower surface dunked in silicone to reduce moisture effects. Nylon or other hygroscopic materials are not recommended.

Also, watch out for modular units. Many devices use a number of crystals, and it's common practice to mold an economical receptacle to hold all of them. The materials used, however, often have greater rf loss than the materials for single units.

Mechanical relays introduce arc-over problems at points other than just the contacts. Switching of reactive loads can result in sizable spikes—often two to 10 times those of the nominal supply voltage. And sockets should be rated for ac to cover the contingency. Furthermore if inadvertent arcing occurs, the flashover leaves a conductive carbon track on most phenolic materials. Diallyl phthalate (DAP) offers greater resistance to arc-over.

Another common user mistake reported by many vendors is amperage "gluttony." Engineers send ampere after ampere through a socketed relay but forget about the socketed contact ratings. Everything works fine, except that the heat that is generated produces permanent deformation of the contact springs. And it's the last time you can plug in another relay.

Small transistors generally are not a problem, except that leads may be rough enough to gall contact surfaces. But high power transistors can literally rot certain socket materials. The high-power units require sizable heat radiators, and temperatures of 100 to 150 C are not uncommon. With lower-cost phenolics, organic dissociation occurs, in which volatile materials, such as fillers, are driven out. When this happens, you won't get the rated socket lives of five to six years. Fluorocarbons such as Teflon (not molded but sintered) can outlast DAP or phenolics. Being less brittle than phenolics, these sockets won't crack when bolted to rigid frames.

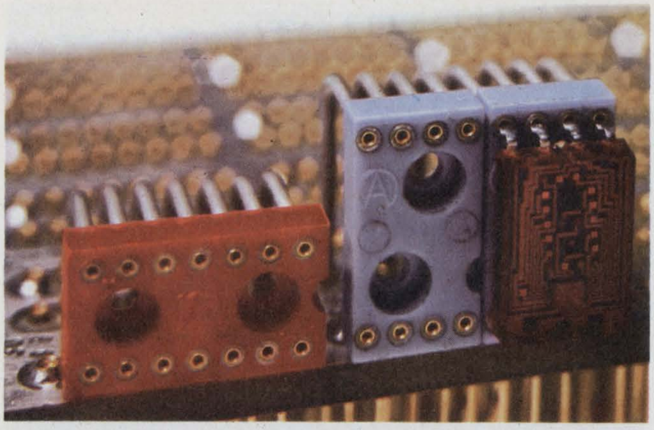
Vacuum-tube sockets share a number of contact problems with DIP sockets and some with fast IC families, such as Schottky TTL and ECL. High-power transmitter tubes are sensitive to capacitance between contacts—a factor that is

Approximate lamp sizes

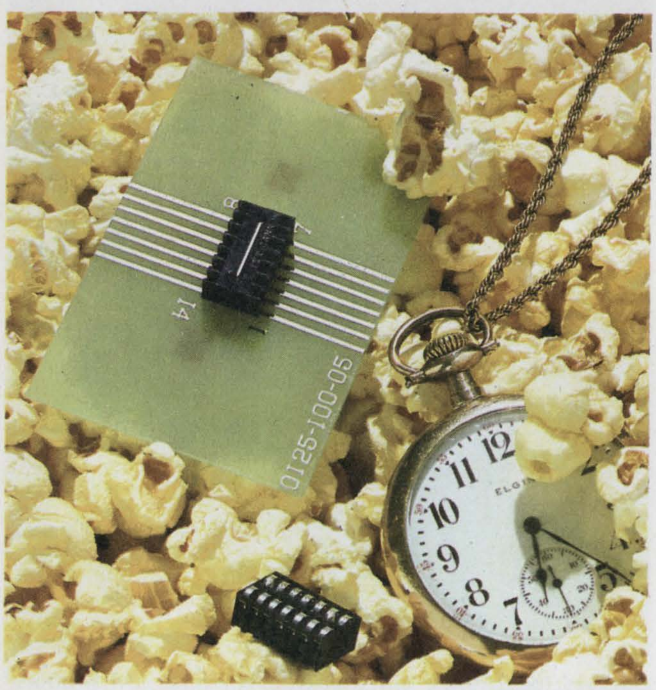
Size term used	Lamp base diameter (approx)
Sub midget	1/8 in.
Midget (Subminiature)	1/4
Miniature	3/8
Candelabra	15/32
Bayonet	19/32
Intermediate	21/32
Medium	1-1/32
Admedium	1-5/32
Mogul	1-1/2

Courtesy Drake Manufacturing Co.

Sockets for 100-kW vhf tubes do not have low profiles. The sockets are designed to direct air past the tube's filament terminals and through the anode cooling fins. Low contact resistance is required because of high rf currents. Beryllium copper, silver-plated for rf conductivity, is used. Either Teflon or Alsingmag 665 ceramic is the insulation most frequently used by EIMAC.



Sockets for LED displays handle practically any pattern, including different row spaces. The Augat units mount at right angles to the PC board.



No soldering and little drilling are characteristics that describe ITT Cannon's Popit socket. C-shaped contacts apply pressure to the IC and connect to PC traces when the socket is forced into the board. Two metal staples hold the socket.

controlled by the insulator material. For ECL logic, the important parameter is transmission-line impedance. Some companies, for example, Texas Instruments, use time-domain reflectometry to find the upper frequency limits.

In low-level amplifier circuits the finish for grid-pin contacts is as critical as it is for ICs—signal voltages in the μV region mean dry contacts. But pin forces are very high; a removal force of 25 pounds is not unusual. Accumulated data show that gold plate gives the best contact, followed by silver. But silver has been discarded in favor of nickel, because silver tarnish is more visible. But silver works best, even on low-level signals, possibly because it smears and forms a gas-tight joint—which incidentally is also the idea behind Burndy's gas-tight connection for tin-to-tin mating contacts. Once a gas-tight joint occurs, circuit integrity is ensured.

Manufacturers offer innovative products

With a little patience, the designer can buy a socket to cope with just about any design problem. Versatility and modularity are keynotes of today's products.

ITT Cannon provides the lowest possible profiles for DIPs. Its Pintrap unit has an elastomer base that forces DIP pins against plated holes. The base is a mere 0.052-in. high, yet gives 250 gms of normal force and has the all-important lead-in chamfer. EPIS Corp. plans to offer conductive elastomer buttons as IC connectors. These buttons, mounted in the PC board, would eliminate the need for plated holes.

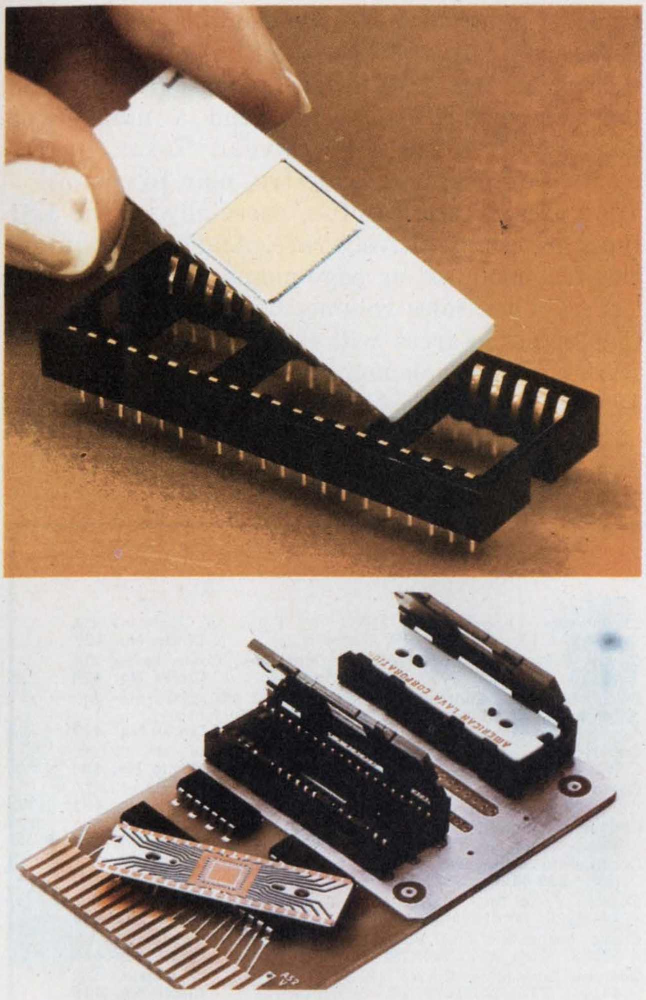
If you want to save hole-drilling charges, ITT Cannon's Popit socket seats on PC pads with the use of a simple arbor press—the board needs only two prepunched holes. The spring resembles a curled bellows that allows for wide pin-size variations and increase the effective spring length.

The wide availability of off-the-shelf sockets for up to 40-pin ICs allows low-cost mountings for most LSI and MSI components. For large numbers of pins—say, 42, 48 or 64—you can use socket strips butted end to end. These cost some 5 to 10% more per pin than fully formed sockets. TRW-Cinch provides closed-entry contact receptacles for use with socket wafers as thin as 0.113-in. The pins can be inserted in an appropriate size wafer to form sockets for just about any device, say from a TO-5 transistor case to a 44-pin LSI package.

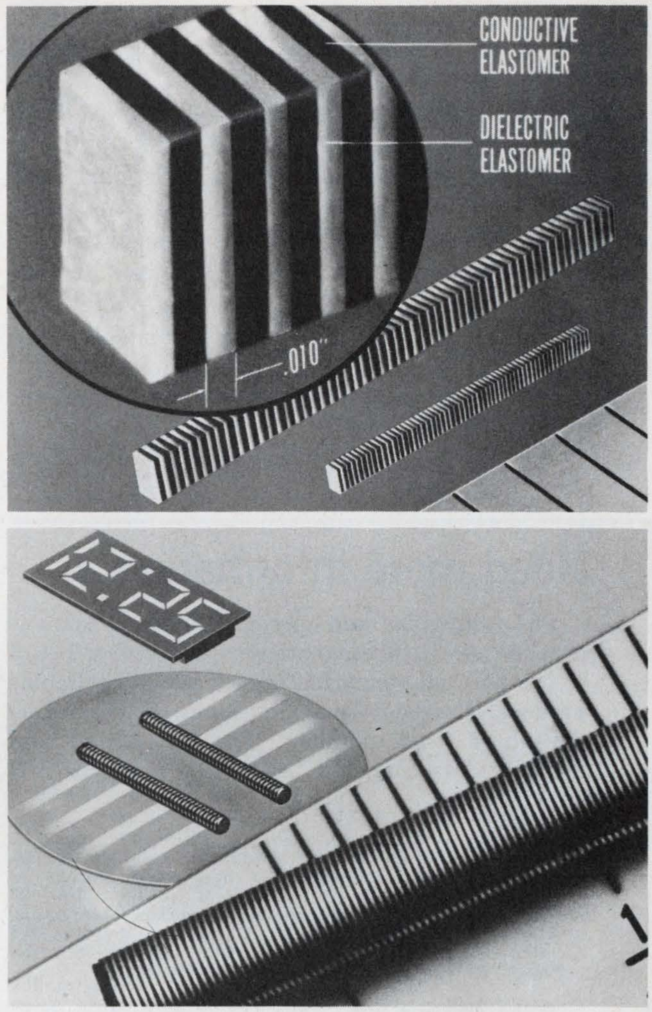
There is another choice: You can use simple pins that let you build any contact configuration. One well-known supplier, Molex, offers the Soldercon terminal for this purpose. Berg Electronics recently introduced its version, called the Minisert socket. An elastomeric seal keeps foreign matter out and remains in place for the life of the socket.

For larger ICs, there are sockets with hollow space between the pin rows. That space in the middle is available for mounting small components (if heat is not a problem). Jermyn, for example, provides such sockets for DIPs with up to 50 pins and offers strip sockets as well.

A very reliable contact, but also among the costliest, is the screw-machine pin, for which Augat is the market leader. The unit consists of a tight-tolerance pin socket with a machined, four-contact clip forced into the socket. The outside sleeve can be of tin or gold, and the inside fingers are of gold. According to Dick Grubb,



Leadless packages are plugged into this AMP receptacle (top) by someone placing the ceramic between contact rows and pressing down. The package clicks into position. A hinged plastic lid clamps the LSI package on Amphenol's PPI socket (bottom). The IC's side metalization is supposed to increase the available space for active chips.



Elastomeric devices provide reliable contact for microminiature devices when compressed. And delicate surfaces, such as on LCD displays, are not damaged. Technit's Zebra (top) accommodates contact spacings of 0.02-in. AMP's Elastomate (bottom) handles 0.025-in. spacing. These connectors also tolerate misalignment.

marketing manager of Augat, the machined sleeve is needed to provide pressure and intimate contact with the post.

The machined posts lend themselves to an almost infinite variety of contact configurations. One of Augat's products consists of these pins mounted on a disposable carrier. After the pins are soldered in, you remove the carrier, and there's your socket.

To keep packaging densities high, for wrapped-wire systems, manufacturers like Augat, MCi, Cambridge Thermionic (Cambion) and Robinson-Nugent offer DIP plugs to carry discrete components.

ECL logic has been rendered wire-wrappable as well. And increased use is forecast for high-speed computer logic—especially for arithmetic logic. ECL packaging panels with standard wrapped-wire pins allow rise times as fast as 1.5 ns with terminating resistors. Resistance value is not critical and clock rates to 100 MHz can be supported. Augat recently introduced a pluggable carrier for the terminating resistors; these resistors were formerly wrapped to posts on the board's backplane. Garry Corp. also supplies ECL boards for wrapped-wire terminations.

Even large relay sockets have quick-mounting facilities. Rundel Corp. lets you stack sockets onto a track with plastic clips as do Reed Devices Inc. and Curtis to name a few. The screw terminals on Rundel's units have wire clips that clamp the bare wire, eliminating the need for crimp-on terminals.

DIP sockets are now the subject of two specifications: the EIA RS-415 (April, 1974), and MIL-S-83734, prepared by the Defense Electronics Supply Command (DESC) at Dayton, OH. The latter spec is now awaiting approval. Both specs cover similar design areas like insertion and withdrawal force, contact retention, dimensions, contact resistance (both high and low level) and mechanical construction. The EIA standard recognizes most contact finishes whereas the MIL spec requires gold. However, the usual 50-μin. plating for MIL work has been reduced to 30-μin. except at contact engagement, where it's 50-μin.

The MIL spec is the more stringent: A flammability test is mandatory; the parts must be subjected to a corrosive sulfur atmosphere and retested for low-level resistance; the pins must withstand more bends. In addition the MIL spec requires 50 insertion-withdrawal cycles; in contrast with the 10 for EIA. For wrappable wire terminations, the MIL spec calls for solid pin cross sections. Wicking is also mentioned.

A word of advice: The MIL spec is not intended for airborne requirements.

According to the spec's author, Herman Anderson, sockets that meet the spec are a good buy for commercial users. And a number of manufacturers, including Augat, Texas Instruments, Cambion and Sealectro, plan to comply.

At present leadless ICs, especially of the LSI type, are comparatively rare. And the debate on side-face-mounted or edge-mounted contacts continues. When sales volume increases, you can bet that manufacturers will respond. In fact, AMP, Burndy and Amphenol, among others, have leadless-IC sockets in production. ■■

Need more information?

The companies and products cited in this report do not represent the manufacturer's full lines nor all manufacturers of a particular product. For additional details circle the information retrieval numbers. For data sheets and more vendors consult ELECTRONIC DESIGN'S GOLD BOOK.

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Amphenol Industrial Div., Bunker Ramo Corp., 1830 S. 54 Ave., Chicago, IL 60650. (412) 242-1000. (E. R. Lehmann). Circle No. 405

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Ledex Inc., 123 Webster St., Dayton, OH 45401. (513) 224-9891. (E. Brauner). **Circle No. 489**

Loranger Manufacturing Corp., 2715 Pennsylvania Ave. W., Warren, PA 16365. (814) 723-2250. (J. A. Loranger Jr.). **Circle No. 490**

LVC Industries Inc., 135-25 37 Ave., Flushing, NY 11354. (212) 939-9777. (N. Marino). **Circle No. 491**

Magnecraft Electric Co., 5575 N. Lynch, Chicago, IL 60630. (312) 282-5500. (A. Maag). **Circle No. 492**

MALCO A Microdot Co., 5150 W. Roosevelt Rd., Chicago, IL 60650. (312) 287-6700. (F. Racy). **Circle No. 493**

Master Electronic Controls, 1553 17 St., Santa Monica, CA 90404. (213) 393-3177. (I. Nizam). **Circle No. 494**

Methode Manufacturing Corp., 1700 Hicks Rd., Rolling Meadows, IL 60008. (312) 392-9600. (L. J. Stellmach). **Circle No. 495**

James Millen Manufacturing Co., 150 Exchange St., Malden, MA 02148. (617) 324-4108. (R. W. Caywood). **Circle No. 496**

3M Company Headquarters, Product Information Center, 3M Center, St. Paul, MN 55101. (612) 733-1110. (R. H. Herzog). **Circle No. 497**

Modular Circuitry Inc., 115 W. Bidwell St., Tecumseh, MI 49286. (313) 423-8336. (J. Cramer). **Circle No. 498**

Module Components (MCi), 115 W. Bidwell St., Tecumseh, MI 49286. (313) 423-2494. (J. Cramer). **Circle No. 499**

Waldom Molex Inc., 4625 W. 53 St., Chicago, IL 60632. (312) 585-1212. (M. Halley). **Circle No. 500**

FW Morse Co., 44 Lincoln St., Box 94, Saco, ME 04072. (207) 284-4166. (R. W. Morse). **Circle No. 501**

Mupac Corp., 646 Summer St., Brockton, MA 02402. (617) 588-6110. (A. M. Largey Jr.). **Circle No. 502**

Mycom Media Corp., 2175 Greenspring Dr., Timonium, MD 21093 (301) 252-6120. (R. W. Stow). **Circle No. 503**

North American Philips Controls Corp., Box 768, Cheshire Industrial Park, Cheshire, CT 06410. (203) 272-0301. (R. Rock). **Circle No. 504**

Omni Spectra Inc., 24600 Hallwood Ct., Farmington, MI 48024. (313) 477-1234. (R. Borden). **Circle No. 505**

Oshino Electric Lamp Works Ltd., 2-5-2 Minami-Shinagawa, Shinagawa-Ku, Tokyo, Japan 03-47 1-8548. (T. Shigemori). **Circle No. 506**

Pic Design Div., Benrus Corp., Box 335, Benrus Center, Ridgefield, CT 06877. (203) 438-0345. (C. T. Wellman). **Circle No. 507**

Pylon Company Inc., 51 Newcomb St., Attleboro, MA 02703. (617) 222-3726 (R. Pozzo). **Circle No. 508**

Qualco, 1 First St., Los Altos, CA 94022. (415) 964-7666. (M. T. Ralston). **Circle No. 509**

Reed Devices Inc., 21 W. Hill Ave., Glen Ellyn, IL 60137. (312) 858-2050. (H. J. Roeser). **Circle No. 510**

Robinson-Nugent Inc., 800 E. Eighth St., New Albany, IN 47150. (812) 945-0211. (S. M. Shine). **Circle No. 511**

Milton Ross Co., 511 Second St., Pike, Southampton, PA 18966. (215) 355-0200. (J. M. Tosta). **Circle No. 512**

Rundel Idec, 950 Charter St., Redwood City, CA 94063. (415) 365-8111. (B. Theberge). **Circle No. 513**

Scanbe Canoga Industries, 3445 Fletcher Ave., El Monte, CA 91731. (213) 579-2300. (L. Cooper). **Circle No. 514**

Schoeffel Instrument Corp., 24 Booker St., Westwood, NJ 07675. (201) 664-7263. (W. Allen). **Circle No. 515**

Sealectro Corp., 225 Hoyt St., Mamaroneck, NY 10543. (914) 698-5600. (S. A. Lescarboura). **Circle No. 516**

Shigoto Industries Ltd., 350 5 Ave., New York, NY 10001. (212) 615-0200. (M. Rubin). **Circle No. 517**

Showa Musen Kogyo Co. Ltd., No 5-5 6-chome, Togoshi Shinagawa-ku, Japan 03785 1111. (J. Takahara). **Circle No. 518**

Sigma Instruments Inc., 170 Pearl St., Braintree, MA 02185. (617) 843-5000. (J. Seppala). **Circle No. 519**

Sloan Co., 7704 San Fernando Rd., Sun Valley, CA 91352. (213) 875-1123. (G. M. Elsner). **Circle No. 520**

Herman H. Smith Inc., 812 Snediker Ave., Bklyn, NY 11207. (212) 272-9400. (S. Fleishman). **Circle No. 521**

Soderberg Manufacturing Co., 20821 Currier Rd., Walnut, CA 91789. (714) 595-1291. (L. P. Appelman). **Circle No. 522**

Spectra Strip Corp., 7100 Lampson, Garden Grove, CA 92640. (714) 892-3361. (B. Brachman). **Circle No. 523**

Standard Logic Inc., 2215 S. Standard Ave., Santa Ana, CA 92707. (717) 979-4770. (B. L. Billington). **Circle No. 524**

Stanford Applied Engineering, 340 Martin, Santa Clara, CA 95050. (408) 243-9200. (K. Dever). **Circle No. 525**

Sterling Instrument Co., 55 S. Denton Ave., New Hyde Park, NY 11040. (516) 328-3300. (H. R. Arum). **Circle No. 526**

Struthers-Dunn Inc., Lambs Rd., Pitman, NJ 08071. (609) 589-7500. (L. R. Davis). **Circle No. 527**

Sullins Electronic Corp., Rhea La., San Marcos, CA 92069. (714) 744-0125. (S. Sullins). **Circle No. 528**

Superior Electric Co., 3000 Middle St., Bristol, CT 06010. (203) 582-9561. (R. H. Bond). **Circle No. 529**

Sys Electronics Inc., 1935 W. 96 St., Cleveland, OH 44102. (216) 651-8208. (E. Bedford). **Circle No. 530**

Technical Wire Products Inc. (Tecknit), 129 Dermody St., Cranford, NJ 07016. (201) 272-5500. (R. A. Ventimiglia). **Circle No. 531**

Teradyne Components Inc., 900 Lawrence St., Lowell, MA 01852. (617) 454-9195. (H. T. Neavitt). **Circle No. 532**

Testron Inc., P.O. Box 48237, Chicago, IL 60648. (312) 775-2477. (D. Derr). **Circle No. 533**

Texas Instruments Inc., 34 Forest St., Attleboro, MA 02703. (617) 222-2800. (B. Spence). **Circle No. 534**

Textool Products Inc., 1410 Pioneer Dr., Irving, TX 75061. (214) 259-2676. (E. C. Karnavas). **Circle No. 535**

Thermalloy Inc., 2021 W. Valley View La., P. O. Box 34829, Dallas, TX 75234. (214) 243-4321. (R. Alpert). **Circle No. 536**

TRW Cinch Connectors, 1501 Morse Ave., Elk Grove Village, IL 60007. (312) 439-8800. (F. Apple). **Circle No. 537**

UID Electronics, Div. AMF Inc., 4105 Pembroke Rd., Hollywood, FL 33021. (305) 981-1211. (R. J. Stanish). **Circle No. 538**

Underwriters Safety Device Co., 7300 W. Wilson Ave., Chicago, IL 60656. (312) 867-4600. (H. R. Ege). **Circle No. 539**

UNEX Laboratories Inc., 321 Newbury St., Hathorne, MA 01937. (617) 774-3300. (J. O. Woodbridge). **Circle No. 540**

United Mineral & Chemical Corp., 129 Hudson St., New York, NY 10013. (212) 966-4330. (H. M. Rosenthal). **Circle No. 541**

Universal Relay Corp., 42 White St., New York, NY 10013. (212) 925-6900. (D. Lesser). **Circle No. 542**

Varian Associates, Electron Tube & Device Group, 611 Hansen Way, Palo Alto, CA 94303. (415) 493-4000. (C. G. Rockwood). **Circle No. 543**

Vector Electronic Co., 12460 Gladstone Ave., Sylmar, CA 91342. (213) 365-9661. (F. L. Hill). **Circle No. 544**

Vero Electronics Inc., 171 Bridge Rd., Hauppauge, NY 11787. (516) 234-0400. (B. Freifeld). **Circle No. 545**

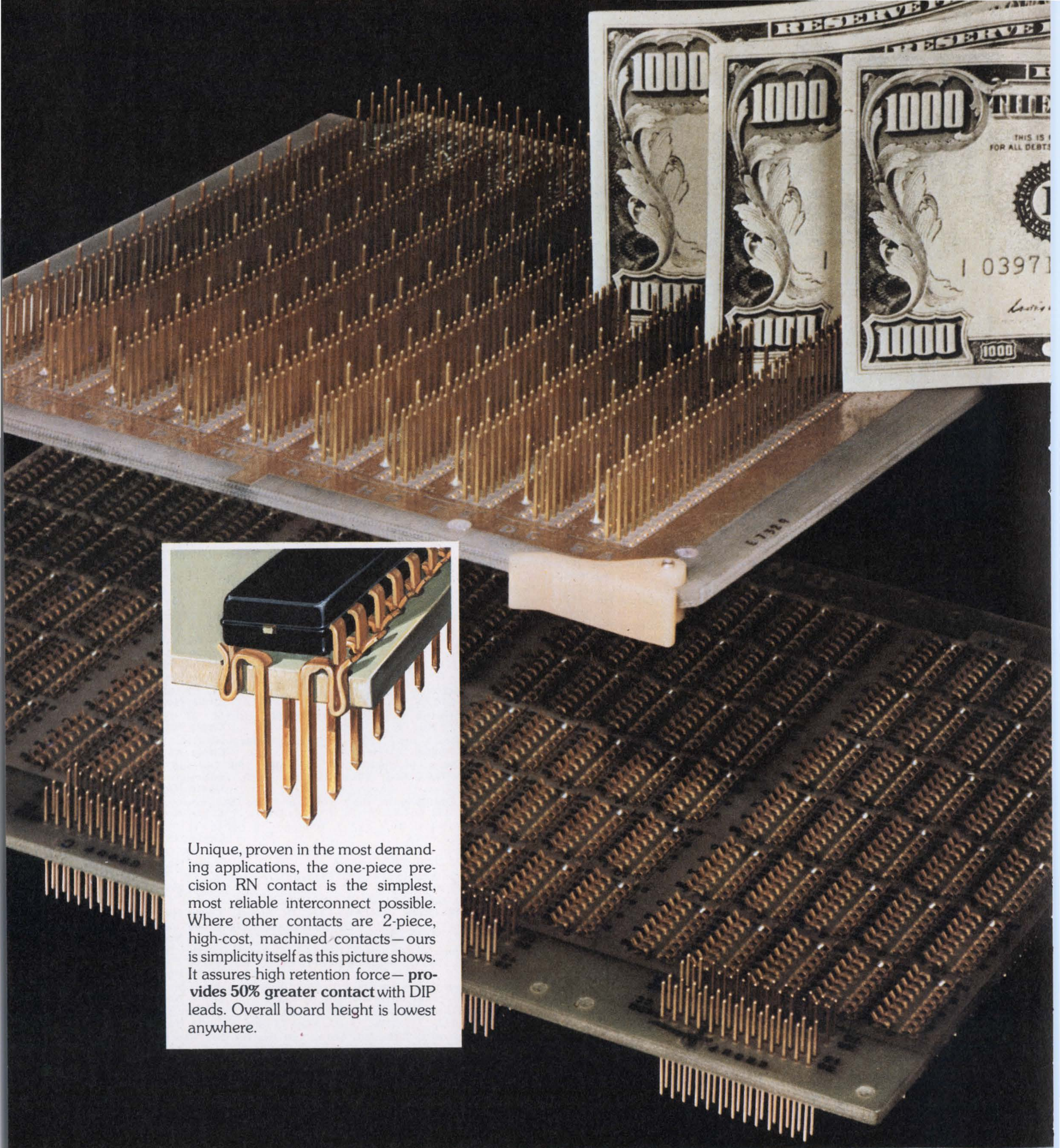
Viking Industries Inc., Standard Products Div., 21001 Nordhoff St., Chatsworth, CA 91311. (213) 341-4330. (J. J. Shields). **Circle No. 546**

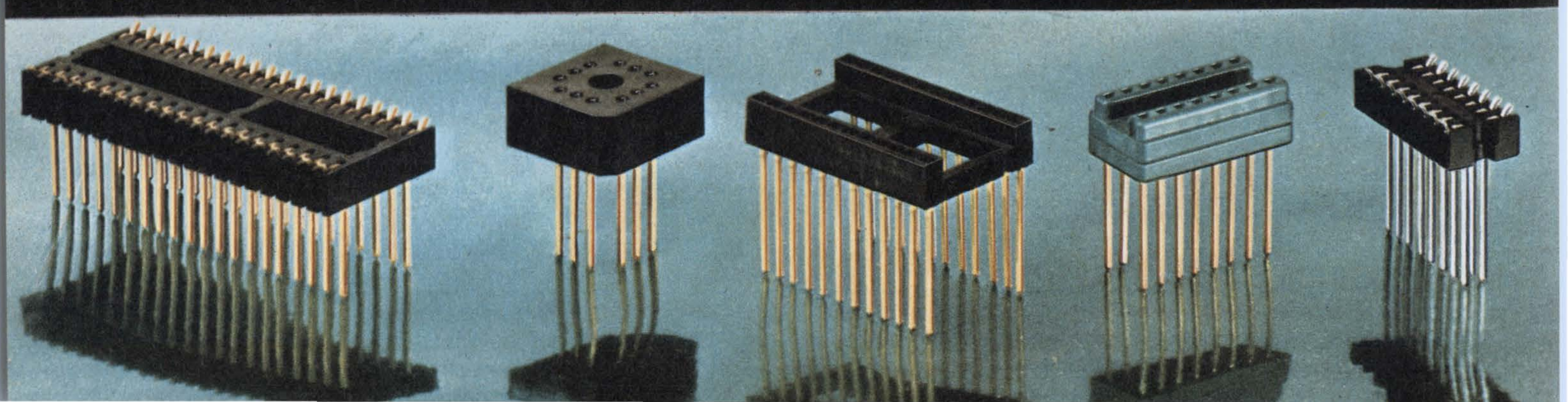
Waldom Electronic Inc., 4637 W. 53 St., Chicago, IL 60632. (312) 585-1212. (M. C. Vescovi). **Circle No. 547**

Wamco Technical Sales, 705 W. 16, Costa Mesa, CA 92627. (714) 833-9361. (J. M. Koyama). **Circle No. 548**

Western Indicator Co., Div. Dupree Inc., 9835 Dupree Street S., El Monte, CA 91733. (213) 442-4700. (J. D. Pon). **Circle 549**

Workman Electronic Products Inc., 75 Packinghouse Rd., Sarasota, FL 33578. (813) 955-4242. (J. M. Price). **Circle No. 550**





Prevent low-level amplifier problems.

Commonplace components and assembly techniques can wreck performance. Here's how to maintain the precision you need.

Even though much progress in performance has been made in low-level circuit design for instrumentation and servo control, many problems cannot be countered without making careful tradeoffs. Aside from selecting the best amplifier, you must also consider the power supplies, grounding, shielding, bypassing and even the external components used.

Carefully designed amplifiers provide microvolt offset voltages, drifts down to 100 nV/°C and input bias currents of less than 1 pA. But even with first-rate specs like these, there are many ways you can unwittingly cripple performance. Among the things you must guard against:

- Haphazard selection of the power supply.
- Improper grounding of the circuit.
- Unprotected input signals.
- Poor choice of external resistors, capacitors and wiring techniques.

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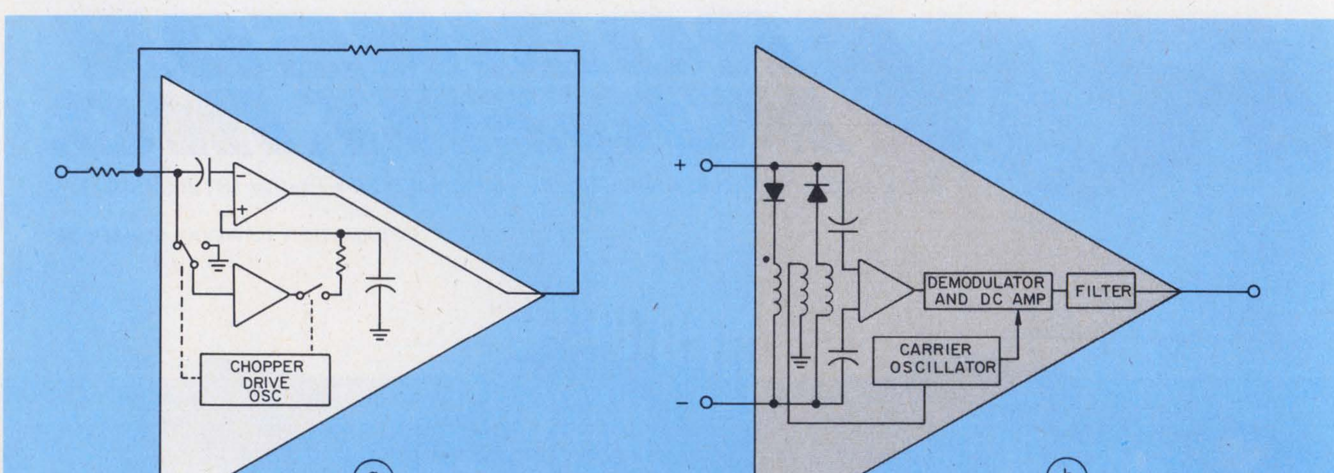
If you avoid these traps, performance can meet or surpass the manufacturer's data.

The high-stability amplifiers used in low-level circuit design are available from many manufacturers. But the variety of amplifiers presents some selection problems and calls for tradeoffs. For instance, most low-level amplifiers are limited in frequency response to a bandwidth below several kilohertz, compared with typical operational amplifiers that have responses into the megahertz region. Bandwidth vs sensitivity must be evaluated.

Two major types of low-error amplifiers are available: chopper-stabilized and varactor-bridge. Both use a carrier-modulation technique that either controls an electronic switch or excites a bridge.

A chopper-stabilized amplifier (Fig. 1a) can be built from two basic operational amplifiers. One amplifier, usually stabilized, is ac-coupled through a capacitor to the input signal to isolate the input dc offsets from an internal summing junction. The stabilized amplifier is, in turn, connected to a modulated switch that feeds the



1. **The basic chopper-stabilized amplifier** (a) contains two separate amplifiers in a servo loop that nulls any drift. The varactor-bridge amplifier (b) has a modulated bridge input that allows extremely low bias currents.

input of the second amplifier. This switch, driven by an internal oscillator, samples the offset at the summing junction and, by use of a synchronous demodulator, drives the positive input of the stabilized amplifier, thus counteracting the amplifier's dc drift. The feedback for this servo type of action is to the chopper circuit through an external feedback resistor.

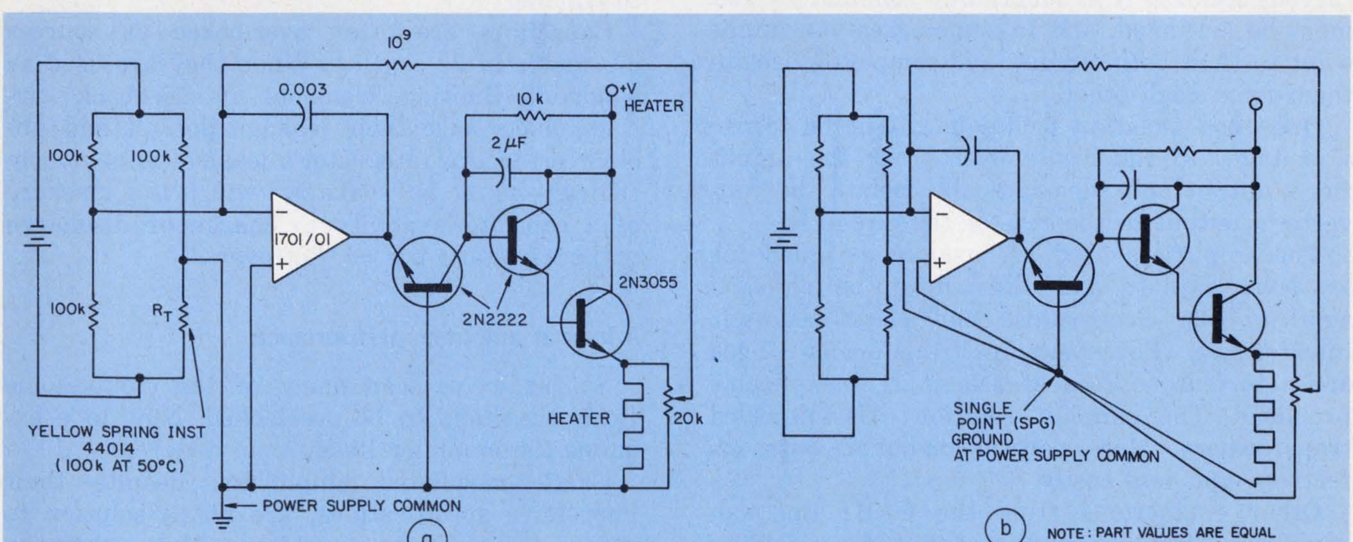
The varactor-bridge amplifier, although not chopped, uses a carrier-modulation scheme (Fig. 1b). The varactor diodes have a junction capacitance that depends upon the applied voltage. With no voltage applied, they have a high resistance in the off state. The amplifier input circuit is a floating bridge, constructed from two diodes and a modulating signal. If the inputs are precisely balanced, the diodes are equally biased and the bridge has no output. An ac input unbalance will change the diode capacitances, which in turn produces an rf output from the bridge. This signal is then amplified, synchronously demodulated and filtered to obtain a dc output signal.

Even when you have high-quality circuits, they can easily perform poorly if the components connected to them have been incorrectly selected. For instance, make sure you choose a well-regulated, low-output-impedance power supply. And watch out for these problems: Does the output of the supply overshoot when power is applied or when transients occur? Does the regulation spec include immunity to fast transients on the ac line, or do the transients feed through to the output?

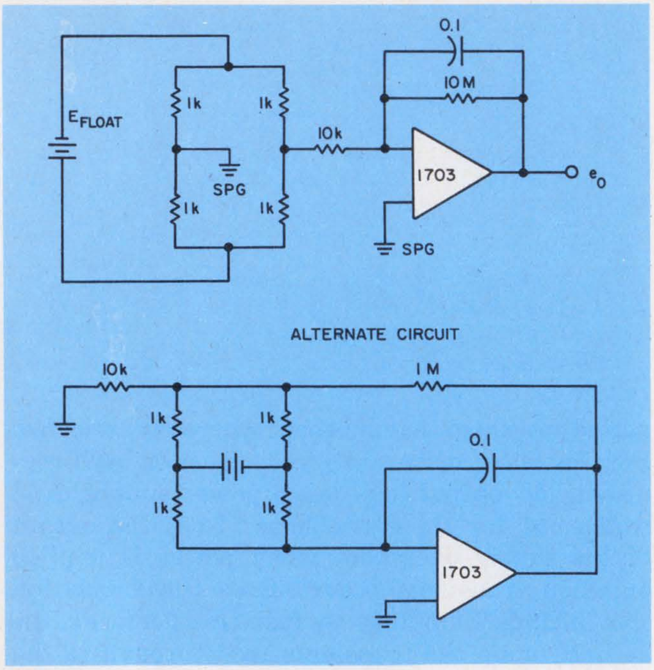
Power supplies cause problems

Series-pass, linear-regulated, power supplies are the safest choice for precision circuits; however, there are some good switching supplies. Switchers offer high efficiency and small size, but beware of the high-frequency transformer radiation—this can wreck the amplifier's input. Some switching manufacturers have solved this problem; others have not even bothered to look into it.

Some amplifier modules are equipped with internal bypass capacitors. If in doubt about the unit you have, check with the manufacturer or bypass the power-supply lines at the amplifier



2. **A precision temperature-control circuit** that has ground problems (a) uses a chopper-stabilized amplifier to provide microdegree accuracy over a predetermined range. By rearranging the ground circuit you can eliminate noise and ground loop problems (b) that can cause poor circuit operation.



3. **Single-ended chopper-stabilized amplifiers** can be connected by use of a floating-bridge circuit to perform as if they had a differential input.

with solid tantalum capacitors. Aluminum electrolytics simply do not see fast transients.

Good grounding techniques are always a must. As an example, look at the temperature-control circuit of Fig. 2. Erratic operation of this circuit can be caused by a ground bus, even when the latter is only 3 in. long and made from 12-gauge wire. Large heater currents returning through the pass transistor combined with small bridge and amplifier currents set the stage for real trouble. If heater drive comes from a separate supply, the problems become even more complex. Ground lines that have large switching currents are very noisy and usually full of fast current spiking. A nondegrading common ground must be arranged, and in some cases you might want to float both circuits and completely isolate them from each other.

One good isolation technique might be to use a voltage-to-frequency converter at the amplifier's output and then optically isolate the converter's output to the rest of the circuitry.

The amplifiers used are usually designed for low-level signals and thus must be shielded against both electrostatic and electromagnetic interference. Power-supply transformer fields are notorious sources of seemingly inexplicable problems. The simplest solution: Use shielded transformers. More careful layout is also effective—and less costly.

Other emanations from the 60-Hz line can usually be brought under control by shielding and deliberate limiting of circuit bandwidth. Battery-powered circuits, despite their "line isolation," are susceptible to 60-Hz pickup. A few picofarads of ground capacitance can seriously degrade the performace of a circuit like that in Fig. 6.

Components add unwanted headaches

Although not generally considered components, wire, solder and insulation must be considered. Certain combinations of solder, wire and binding posts can generate thermal emf's. For example, a junction of stranded wires from two different manufacturers can easily produce an emf of 200 nV/°C, or twice the input drift of an amplifier like the Teledyne Philbrick 1701/01. Amplifier sockets are fine, but a poor one can introduce contact resistance, thermal potentials or both.

With varactor amplifiers the socket choice is highly critical—10^{15}-Ω leakage from the power-supply pins to the input can provide almost 10 times the required bias current. Teflon sockets are the best choice for minimal leakage. On the circuit board, critical circuit paths should be guarded.

Precision metal-film resistors are good, but some are better than others. Certain types use "end cap" terminations and can produce pronounced thermocouple effects that swamp out a good amplifier's drift spec. High-grade wire-wound resistors offer the ultimate in low-noise performance, but they are also expensive and relatively large; save them for applications where absolute accuracy, high stability or very low temperature coefficients are musts. For example, the circuit in Fig. 2 can maintain very good stability without wire-wound resistors if you select metal-film resistors that have a 5-ppm tracking temperature coefficient.

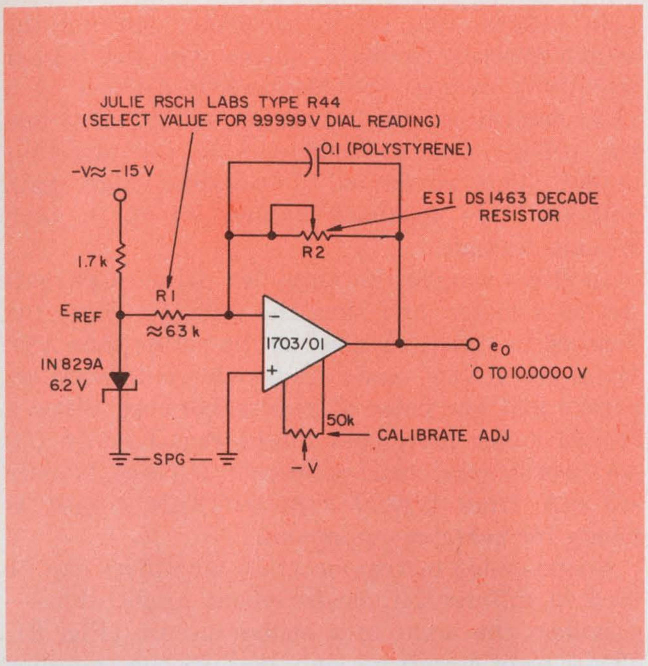
Even mixing resistor brands is an invitation to trouble.

Capacitors are often overlooked as sources of trouble in dc circuits. When they are used as bandwidth-limiting elements in feedback circuits, make sure their leakage doesn't add another error. An integrator's leakage is obviously critical—but so is "soakage," which is a measure of a capacitor's ability to charge or discharge without voltage lag or "leftovers."

A look at amplifier performance

So far we've seen many of the troublesome items that tend to be overlooked. Now let's examine the amplifier itself.

Carrier-modulated amplifiers, despite their impressive specifications, are not a solution to every measurement problem. Most chopper-stabilized amplifiers, for example, are limited in application because of their single-ended input; high-stability, differential-input op amps can



4. **Chopper-stabilized amplifiers** also form very stable voltage references. These are as stable as the zener diode used for the reference source.

more readily perform differential measurements. However, the common-mode rejection-ratio error can swamp out the amplifier's low drift. For applications where common-mode voltages are low, the differential-input amplifier is a good choice, but when common-mode voltages are high, use a chopper-stabilized amplifier with a pseudo-differential input (Fig. 3).

Chopper amplifiers have initial offset voltages down in the 10-to-20-μV region, while most premium FET or bipolar op amps have offsets in the hundreds of microvolts. And, unlike other amplifiers, choppers can be trimmed for offset without affecting $V_{os}/\Delta T_c$. This permits the amplifier's offset adjustment to be used as a calibration tweak (Fig. 4) or bucking adjustment.

High-performance op amps can come close to matching a chopper's offset temperature drift but not to equaling the chopper's power-supply rejection or time drift. All amplifiers take a "random walk" when it comes to offset voltage vs time. A differential amp may drift a few microvolts a month, but a chopper can achieve a low 5-μV-a-year offset drift. With unattended equipment, time drift can be critical.

Chopper-amplifier input bias current is usually about 50 pA, while FET input amplifiers go down to 1 pA and still maintain a 1 μV/°C offset tempco. Some FET op amps can even bias down to 0.1 pA, but at this low current you trade away offset stability. Remember, FET bias current doubles with every 10-C increase.

When bias current is the critical spec, look into the varactor-input amplifier with its femtoampere bias currents. Varactors also have high common-mode rejection—even at 100 V. Their dc drifts (10 μV/°C) are relatively poor, and their bandwidth is low (typically 40 Hz or so).

When you make a choice, don't forget to consider possible interference from residual noise in chopper-amplifier outputs, open-loop gain (choppers have typical gains of 10^7 to 10^8 vs 10^6 for differential amplifiers), power consumption and price. Generally chopped amplifiers cost a bit more than differential-input units, and FET input differentials usually cost more than bipolar-input amplifiers.

Measure some key specifications

Some of the key specifications of carrier-modulated amplifiers—or any amplifier—can be verified by a few simple tests. Measure the offset voltage and its drift vs temperature. The test set in Fig. 5a allows these measurements to be taken. Set the amplifier up for a gain of 10,000, ground the input (with S_1 open), and you get the following offset vs output relationship:

$$E_{os} = \frac{E_o}{1 + R_2/R_1}$$

The gain of 10,000 allows most instrumentation to display the 10-to-20-μV offset voltage of the amplifier without any problem. If S_1 is closed and the potentiometer is adjusted to null the offset, $V_{os}/\Delta T$ can be established. With the initial offset nulled at 25 C, place the amplifier in a controlled 70-C environment and allow enough time for the amplifier to settle. Now measure the output voltage. Next, place the amplifier in a 0-C environment and measure the settled output voltage.

The offset-vs-temperature characteristic can be calculated from the standard "butterfly" equation:

$$E_{os}/T = \frac{E_{os}/70\ C}{70 - 25\ C} \text{ or } \frac{E_{os}/0\ C}{0 - 25\ C}.$$

Stable resistors and a well-constructed test jig (good grounding, shielding, etc.) will ensure accurate results.

Time drift, measured in microvolts/year, can also be extrapolated from the same test circuit, if the amplifier is held at a constant temperature (about ±0.1 C) for one day. The long-term error can then be calculated from

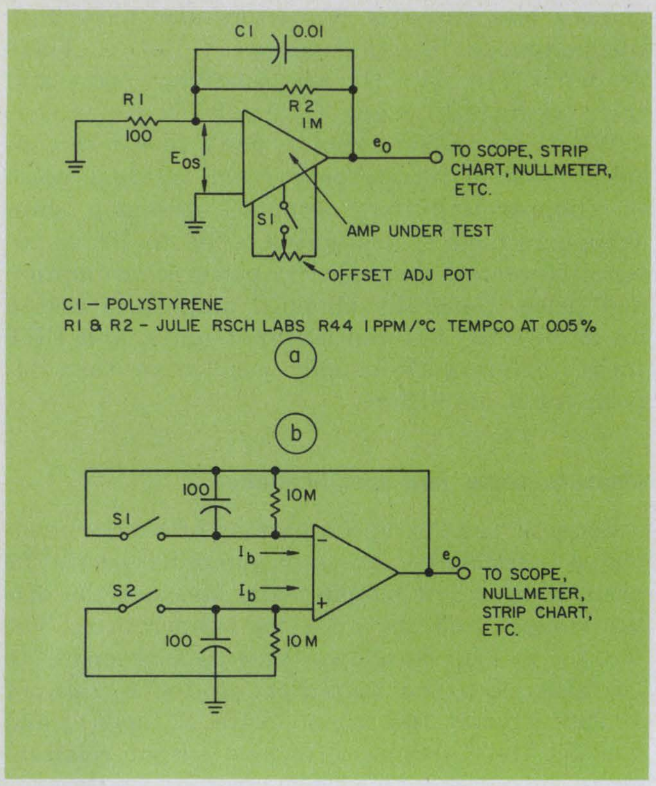
$$\Delta_{os}\ (1\ \text{year}) = \Delta_{os}\ (1\ \text{day})\ (\sqrt{365\ \text{days/year}}).$$

Another circuit (Fig. 5b) can be used to determine the amplifier's input bias current. With S_1 or S_2 closed, the output voltage is related to the bias current at the appropriate input by

$$I_b = E_o/10\ M\Omega.$$

Temperature dependence can be measured in the same way as for offset voltage.

Once you have narrowed the choice to a specific



5. **A simple test jig** to check the amplifier for offset drift (a) or input bias current (b) doesn't require too many extra components.

amplifier type, the worst is over. Let's take a look at some applications of high-stability amplifiers.

Look at some circuit examples

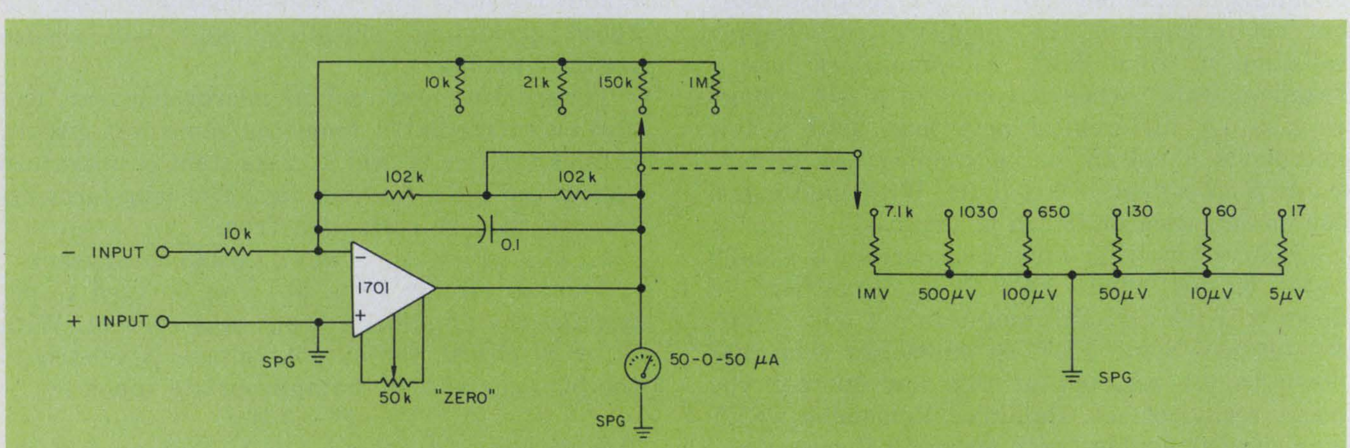
A null voltmeter/data amplifier with a 5-μV full scale sensitivity can be built with a bandwidth limited to only a few hertz if you place a 0.1-μF capacitor across the input and output terminals of the amplifier (Fig. 6). An external resistor switching circuit lets the modular amplifier cover many gain ranges. On the four lower-gain ranges, two 102-kΩ resistors parallel the switch-selected feedback values. On the higher sensitivity ranges, the feedback is divided by a ratio determined by the range switch value and the 102-kΩ resistor connected to the amplifier output. This compound T provides high gain without large feedback values, which in turn reduces leakage.

In this example the amplifier delivers an output to a meter, and thus the gain accuracy (as opposed to stability) need not be better than 1%. Metal-film RN60C resistors provide both good accuracy and low noise at reasonable cost. Since a typical meter movement might require only 100 μA, worst case, total quiescent current is only ±3 mA from typical supplies. This circuit is handy for portable equipment.

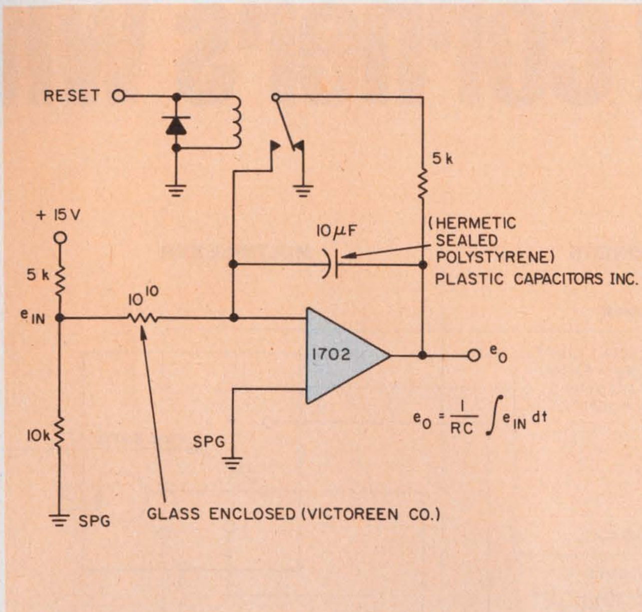
Single-ended instrumentation amplifiers can be used in differential measurement applications—just float the input in a bridge circuit (Fig. 3). This type of circuit not only permits the amplifier to extract the offset signal but, more significantly, completely eliminates the common-mode error of the differential amplifier. Even when an amplifier has a CMRR of 120 dB, the common-mode error can overshadow the input drift characteristics of a good differential amplifier. This capability is exploited by the temperature servo circuit of Fig. 2.

In this circuit the chopper's low bias current, low drift and high loop gain combine in a temperature-control system with very high performance. The true differential signal, derived from the bridge, is amplified to drive a Darlington-connected transistor pair. Thermal feedback from the heater and bridge thermistor produced a changing signal that the amplifier conditions. The potentiometer, in parallel with the heater element, should be adjusted to provide just enough feedback to prevent the main (thermal) loop from oscillating due to thermal delay.

This type of temperature-control circuit can



6. **Band-limiting of a null voltmeter** is easily accomplished if a 0.1-μF capacitor is placed across the input and output terminals to pass the high frequencies. This circuit has a 5 μV sensitivity.



7. **A long-time-constant integrator** can be formed if a high-quality capacitor is placed across a varactor input amplifier. In this case the time constant is extremely long—100,000 seconds.

hold to within microdegrees at a 50-C set point. And two such controlled ovens, one inside the other, can provide stability limited only by the thermal noise of the inner oven control thermistor.

Generate precision voltages, too

High-stability chopper amplifiers can also be used to generate precision output voltages that span six decades (Fig. 4). The output voltage from the circuit is based upon the stability of an external reference that feeds the inverting amplifier. The simple op-amp gain equation details the operation:

$$E_o = -(R_2/R_1)\, e_{ref}.$$

From this, you can see that if R_1 is carefully selected, the output voltage will be numerically identical to R_2. Thus if a multidecade precision potentiometer is used as R_2, any output voltage from 0 to 10 V can be dialed in.

Unlike direct coupled designs, a chopper-stabilized amplifier's offset tempco is independent of the offset voltage. Thus the offset potentiometer can be used as a calibration adjustment instead of a trim. The zener diode used should have a low tempco—typically 30 μV/°C or lower, since it directly determines the output stability.

The total worst-case error over a year's time under lab conditions (20 to 30 C) can be found from the following:

Diode thermal error
$= (30\ \mu V/C)\ (1.6\ \text{amp gain})\ (\pm 5\ C) = 240\ \mu V.$
Diode time error
$= (60\ \mu V/\text{year})\ (1.6\ \text{amp gain}) = 96\ \mu V$
total $= 336\ \mu V.$
Amp thermal error
$= (0.25\ \mu V)\ (1.6\ \text{amp gain})\ (\pm 5\ C) = 2\ \mu V.$
Amp time error
$= (5\ \mu V/\text{year})\ (1.6\ \text{amp gain}) = 8\ \mu V$
total $= 10\ \mu V.$
Resistor error $= 1$ ppm/year $= 10\ \mu V$
total circuit error $= 356\ \mu V.$

At 10 V full scale, that represents about a 36-ppm error, of which only 1 ppm comes from the amplifier. Zener drifts can be reduced, but the diode would still be the main error source. Thus you can reasonably expect one-year calibration intervals on an instrument that has a five-decade range.

Varactor bridge amplifiers, although not chopped, have many precision uses because of their low input bias current—about 2 fA. Only 20,000 electrons per second flow through the input of varactor amplifiers. A typical application is shown in Fig. 7, a circuit for a geophysics experiment in which a linear ramp must be generated over a 24-hour period with a maximum of 10 V.

On the ramp there are not to be any discontinuities or steps—which rules out the use of a digital-to-analog converter to form the output. The circuit acts as an integrator with a 100,000-second time constant and an accuracy that approaches 0.2%. Since the integrating resistor is $10^{10}\ \Omega$, the current available to charge the capacitor, bias the amplifier and deal with the capacitor's leakage current is given by

$$I = 10/10^{10} = 1\ \text{nA}.$$

If the capacitor has a leakage resistance of $10^{12}\ \Omega$, it will steal 10 pA of current from the input bias.

This leaves 990 pA to charge the capacitor and bias the amplifier. Since the current required by the amplifier is only 2 fA, its current drain doesn't really affect any error calculation. The capacitor's leakage, though, is the dominant error source. Humidity, radio waves, leakage paths and other interference can easily subvert the operation of this sensitive circuit.

To protect the amplifier and keep the accuracy high, the following precautions should be taken: Use a Teflon circuit board. Guard the input paths. Employ point-grounding techniques. And set up a sealed, shielded enclosure. ■■

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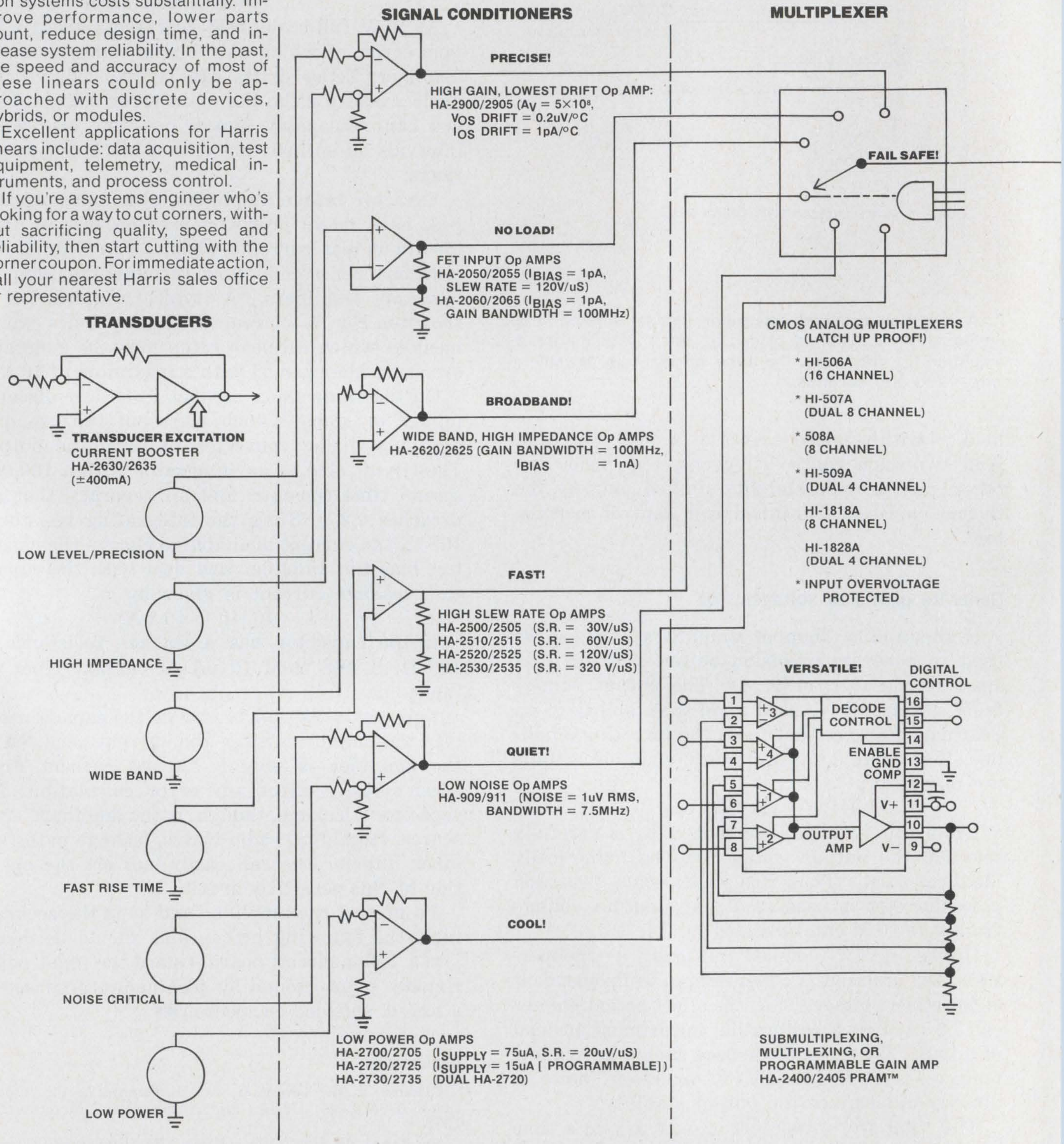

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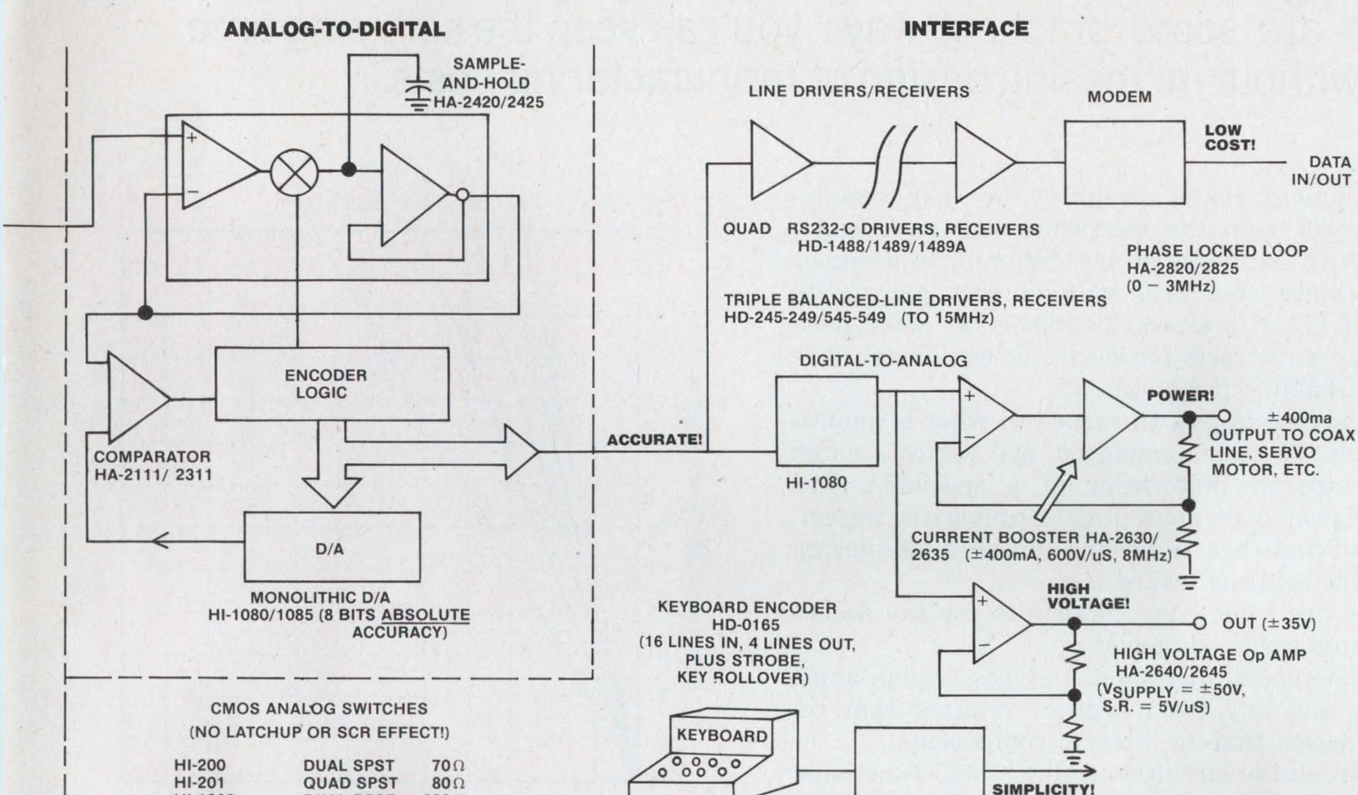

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INFORMATION RETRIEVAL NUMBER 37

Design maintainability into equipment.

Here are some practical ways you can keep the servicing time low without increasing design or manufacturing costs.

Equipment that's designed for easy maintenance will help the customer save on repairs. And, with care and proper timing, the designer can achieve this goal without cost penalty to himself. This is especially important since most of today's contracts for electronic equipment have maintainability requirements.

The specifications, in regard to what is quantified and the terms employed, are varied enough to require the knowledge of a specialist. The analysis must be done first to prepare a responsive bid and then to produce an adequate design after the contract award.

Here are some basic guidelines for the design of maintainable equipment:

1. Use quick disconnect latches, steep angle screws and any other type of retainer that reduces access time to internal components.
2. Break the circuitry up into small functional building blocks, and position test points to allow for branching.
3. Place the subsections that are most likely to fail closest to the repair openings.
4. Prefer simpler packaging to allow easy access to circuit boards, mechanical assemblies and test points.

Removing the access covers to equipment may sound like a simple job. But consider this: To remove and replace a screw takes about a minute and a half. Now add up the time to do eight or 10 screws! You can easily see that conventional screws are big time wasters.

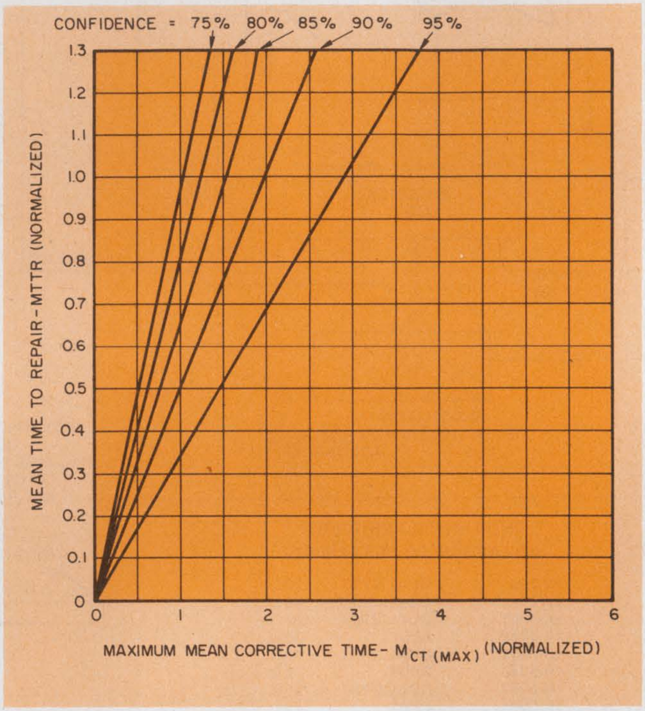
Time is of the essence

Try using quick fasteners—like quarter-turn screws, steep-pitch screws, snaps, slides, shackles. Hardware like this can cut removal and replacement time by a factor of 10.

How about sliding or hinged covers? They require only a few fasteners.

These time factors are important when you consider some contract specifications that require a mean-time-to-repair (MTTR) of only 15 minutes. Fig. 1 translates the maximum time to repair, $M_{ct(max)}$ (another often used term) into MTTR for various equipment confidence levels. A requirement for a 95% confidence level is not uncommon today.

Siegfried Goldstein, Section Head, AIL Div. of Cutler-Hammer, Deer Park, NY 11729.



1. **Both MTTR and $M_{ct(max)}$** are commonly used quantitative maintainability requirements. Thus if $M_{ct(max)}$ is 30 minutes and a 95% confidence level is needed, the MTTR read from the chart is 10.3 minutes.

After the equipment is opened, troubleshooting is the next most time-consuming job. It may involve taking measurements, checking gear trains or inspecting mechanical linkages. Typical measurements require about one minute each, two minutes if a scope is used. Automatic test equipment also takes considerable time to set up. To save time, hold down the number of test points, and be sure the test information leads to easy fault isolation.

With strictly functional packaging, few test points, other than input and output, are needed to isolate the faulty assembly. In some instances, however, functional packaging requires large subassemblies. If it does, define some subfunctions

Maintainability: We talk about it, but what is it?

Maintainability consists of many calculations, lots of statistics, and time-consuming failure-modes analysis. But, there is still some confusion about what maintainability is. It's a design consideration: to optimize equipment design so it can be repaired within the operating and support constraints specified by the customer when it fails.

An increasing number of maintainability specialists are being trained to help cope with new design and support restrictions. Unfortunately these specialists are not the engineers designing the hardware. The actual design engineers comply with the increasing complexity of hardware, greater packaging density, more stringent environmental constraints, as well as weight limitations. Yet it is the design engineer's efforts that will eventually determine the maintenance ease of the end-item.

The designer also prepares the major portion of the contract quotation. He must be concerned with time constraints, built-in test equipment, throw-away philosophy and degree of modularization.

There is rarely enough time allotted to do the analysis and prediction for a quotation, nor time to translate the contract requirements into design constraints. This leaves the designer three approaches: hope the design quoted will meet the maintainability requirements adequately, perform a quick cycle of prediction and re-evaluation, or arrive intuitively at a design.

Ideally, the design engineer should develop the major design constraints imposed by the maintainability requirements at the time of the quotation. The level of detail depends on the depth required by the quote but should, as a minimum, define: the need for built-in test circuits, whether manual or automatic; the need for peculiar test equipment compatibility; a rough idea of the quantity and type of test points; and the level of fault isolation. Most quotes don't require discussion of these points but you'll have flexibility for further detailing in the design phase.

Similarly the mechanical engineer should come up with packaging schemes that allow for special hardware or handling devices.

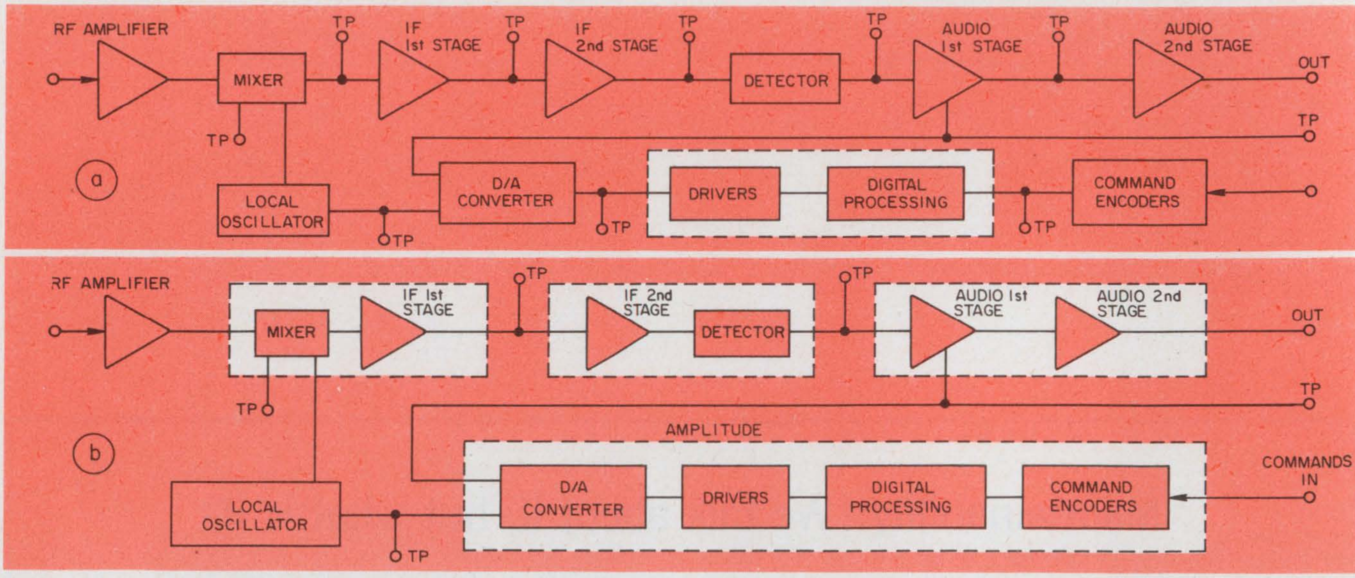
Changes become increasingly expensive as progress is made towards final drawings, and yet specifications are often so complex that designers put off interpreting them. The interpretation, done by specialists—which usually can't be funded before contract award—is a translation of the maintainability requirements into design constraints. This translation, when made by someone other than a designer, is usually biased in favor of maintainability.

Unfortunately maintainability has no immediate apparent trading value in most contracts (for example, cost incentives). For this reason the art of maintainability has to be developed in design engineers.

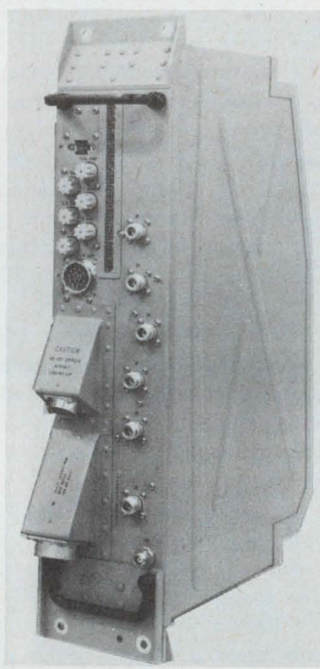
It costs no more to design maintainability into equipment with good access and useful test points than it does to have poor access and useless test points. This can be done, and the trade-off battle eliminated, if the design engineer has developed a "feel" for maintainability.

There are ways, other than experience, to develop this feeling: a course in principles, the use of design checklists, and the use of analogies to experiences with familiar equipment such as cars or televisions. There are also many texts available. Unfortunately the time and the will to study them aren't always there.

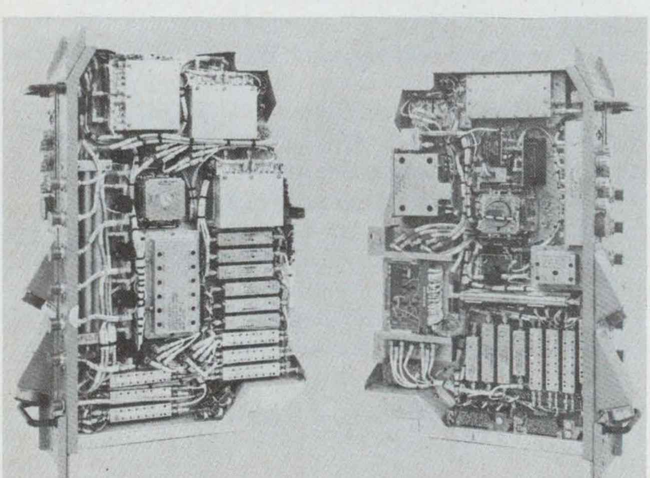
No matter what terms are used to specify maintainability, the repair time plays the major role. This time can be divided into tasks peculiar to the failure and tasks required no matter what goes wrong. These latter tasks are common to all repairs and must be added to repair times for any fault, thus making it imperative to reduce these basic times.



2. **A hypothetical digitally tuned receiver** (a) has been set up with 10 test points. Some of these points would require special buffering to prevent false readings. A redesigned receiver circuit (b) eliminates some of the test points and combines some of the small circuits into larger functional blocks.



3. **Maintainability was** considered (a) when this piece of equipment was designed (right). The internal subfunctions are modularized (b) to simplify servicing (bottom). The odd shape of the unit was dictated by the space available.



and interpose test points within each assembly. For example, Fig. 2 compares the test-point requirements for functional and random packaging.

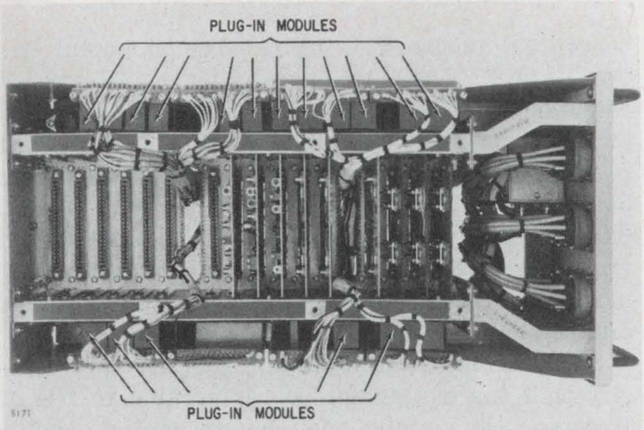
If a function is split between two or more subassemblies, this can cause troubleshooting nightmares. Such a split is more common with digital than with analog circuitry. It is not uncommon to find a single gate function split between two boards, or to discover the digital-to-analog converter on one board and its drive circuitry on another.

Though splitting of functions might allow you to standardize subassemblies and reduce circuit cost, you'll be penalized in the long run because more test points will be required. Of course, if the contract permits, these smaller, multi-use circuits can be mounted in a larger subassembly or grouped into the next larger function. The larger function can then be replaced and repaired at a later date. Built-in test equipment (BITE) can also help in fault isolation. But this is usually not done unless required by the contract, since it adds weight, volume and cost.

Accessing faulty subassemblies for interchange or adjustment wastes time. Clever packaging can provide ready access to all the components, with none stacked or buried. Where this can't be done, the subassemblies most likely to fail or those requiring some adjustment should be the most readily accessible.

Think functional, think simple

Everybody is familiar with cars that seem to be built around the radio or those that appear to have had the engine or air-conditioner installed after the spark plugs were. Many people



4. **By packaging subfunctions into removable modules** you can increase the ease of servicing a complex piece of electronic equipment.

are capable of the hindsight to correct these annoyances, but few have the foresight to prevent them.

Just such foresight has produced electronic designs that have exceeded maintenance requirements with no compromise in performance. In one example of this (Fig. 3a), the odd shape of the case was dictated by the available space, whereas the connector angle was provided for ease of manipulation. The equipment cover is made in one piece, and it permits the chassis to be withdrawn like a drawer. The cover is held to the chassis by several screws in the rear and a peripheral lip in the front plate.

For this example, EMI shielding was a design requirement; a gasket mounted in the front panel lip provides a "foolproof" seal when the cover is fastened to the chassis.

Functional packaging of the circuits at the block-diagram phase of this design minimized the number of test points. Consequently smaller connectors and less wiring were required (Fig. 3b). Functional flow grouping and the use of a central chassis also minimized cable runs, and thus cut crosstalk and weight, while the available space inside the case increased.

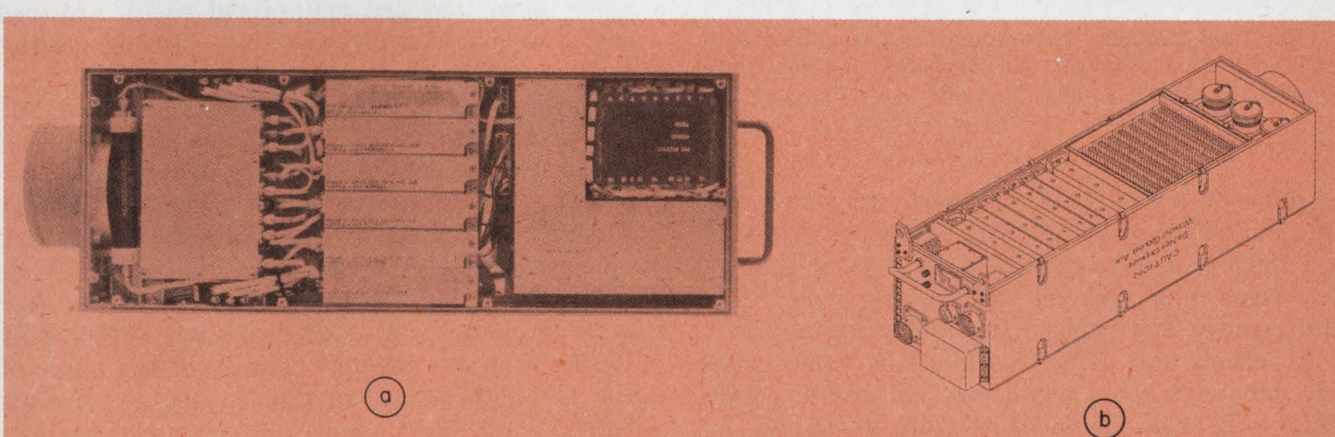
In another example (Fig. 4), functional packaging was used and the functions or subfunctions contained within the subassemblies. In this case additional cost savings resulted, since smaller subdivisions were repeated and duplicated. These smaller subfunctions were mounted on small plug-in modules that, in turn, plugged into a larger subassembly.

In the unit of Fig. 4, heat was a major problem—the density of components dictated by the space available made for minimal heat transfer. The frame that holds the circuit-board mounting slides is a heat exchanger made from honeycombed material. One side of the frame cools the slides, which, in turn, conduct heat away from the circuit boards. The other side of the frame is in contact with the circuit modules and cools them sufficiently. Again, more than adequate ease of maintenance resulted from this design.

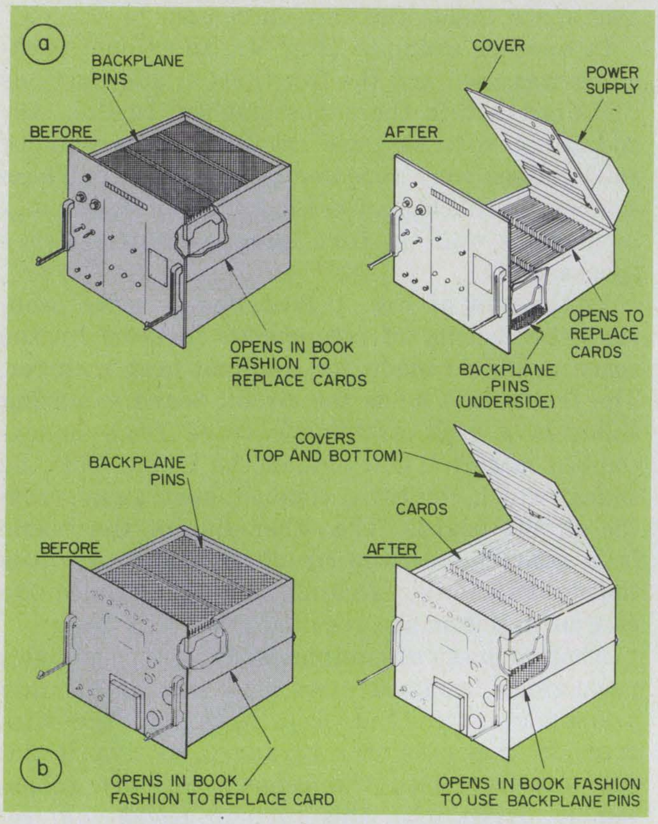
Another piece of equipment, typical of avionics packaging, crammed even more equipment into a smaller space (Fig. 5a). Note that the wire dress in this case was arranged so that it did not interfere with the removal of any subassembly. Even with this care in packaging, removal and replacement of the subassemblies is difficult. In addition the access time to the subassemblies is restricted by a conventional cover that uses many sealing screws. A redesign of the unit (Fig. 5b) used shackles so that covers could be rapidly removed to access the subassemblies.

Total equipment redesign isn't needed

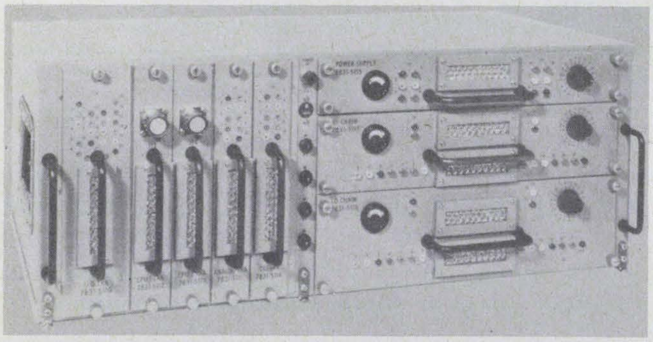
Another type of design problem (Fig. 6) had some complex constraints. One unit (Fig. 6a) had a connector plane for the circuit cards and opened like a book for access to the cards and power supply. Many identical boards were used in this unit, and fault-isolation was planned to



5. **A densely packed piece of avionics equipment** uses rigid coaxial wires to connect subfunction blocks (a). A redesigned version of the unit (b) uses shackles instead of mounting screws to hold the individual modules in the case. The shackles help reduce the interchange time considerably.



6. **By placing the circuit cards** in the lower half of the equipment case, you can reduce the amount of work needed to service this unit (a). If you flip the wiring trays, the cards are easier to reach, and you still have access to the wire terminals for measurements (b).



7. **The final product** that represents the ultimate in maintenance philosophy for in-place servicing has front-panel replaceable modules. No covers must be opened.

be done by a BITE circuit which tracked a specific fault to a group of cards. The wire terminals are then probed to determine the specific fault. The remaining problem was to access the cards and remove and replace the faulty units.

A second unit (Fig. 6b) had the same problem, but with about double the number of cards. This unit, also planned its wire terminals as test points. Good design of BITE circuits eliminates the need to use the wire terminals as test points. It thus permitted redesign during the conceptual phase of equipment development. As the figures show, the packaging that exposed the underside of the mother boards was changed so that the user could remove the small circuit boards just by opening the cover and lifting them out. A possible heat problem in the unit of Fig. 6a was solved when the power supply was moved from the bottom layer to the top. Tiltable slide mountings permitted the drawers to be extended and tilted in two directions for easy servicing.

Some avionics maintenance requirements specify that the equipment be replaceable in flight. Here you can't really open covers or disassemble equipment, so front-panel replaceable subassemblies are used. All you do is unfasten several quick disconnect screws, pull out the bad unit and plug in another (Fig. 7).

Mechanical systems can also be built for efficient maintenance. Although you may not visualize mechanical test points, items such as flow meters, temperature gauges, strain gauges, counters, etc., yield data for fault location. Functional packaging is probably the only way mechanical devices can be sectioned off for ease of assembly and test.

Access, however, is as big a problem in mechanical systems as in the complex electronic systems. It might even be more pronounced, since the subassemblies may be large and fixed. With large equipment, the need for mechanical strength and resistance to shock vibration and temperature changes may rule out the use of quick disconnect fasteners, but huge shackles may fill the bill.

Successful design of these and other black boxes sparks out enthusiasm. Unlike many other design parameters, good maintainability is apparent immediately, not at some later date when you no longer get any feedback. It can be analyzed instantly and it can be appreciated immediately when problems arise in manufacturing, testing, or debugging phases. It also pays off, since items that are maintained easily are also easier to manufacture and test, thereby cutting costs.

Clever use of slides, pins, hinges and dovetails can greatly minimize interchange time for mechanical equipment. You can probably draw upon some everyday experiences for extra insight. Chances are you've struggled with a bolt that had no wrench access or an item that couldn't be removed after it was unfastened. Have you ever tried to pour a can of oil into a car engine only to find that you couldn't because of the angle of the fill port or obstruction caused by the air filter?

All of these everyday trials, and many more, are examples you can draw from to come up with a better way. ■■

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INFORMATION RETRIEVAL NUMBER 38

Cram data through voice-grade lines

with multilevel modulation and adaptive equalization. These techniques achieve modem data rates of 4800 bit/s or more.

To design high-speed modems for voice-grade phone lines, you must reduce the source-signal bandwidth and equalize the line for amplitude attenuation and phase delay encountered over a wide frequency range. Two basic techniques are essential: Multilevel modulation will compress the transmitted-signal bandwidth. And adaptive equalization will provide the necessary reduction of phase distortion.

These design problems arise because most phone circuits offer a bandwidth of barely 2100 Hz, do not pass dc and introduce considerable phase distortion. Such factors hamper data transmission at rates above 4800 bit/s.

Fast data are clocked

Modem is an acronym for modulator-demodulator. And most modems resemble a radio transceiver. Fast modems, however, depend on data-bit timing from either an internal or external clock. With the former, the external device controls a built-in clock in the modem. With the latter, the external device supplies a clock that controls the modulation process.

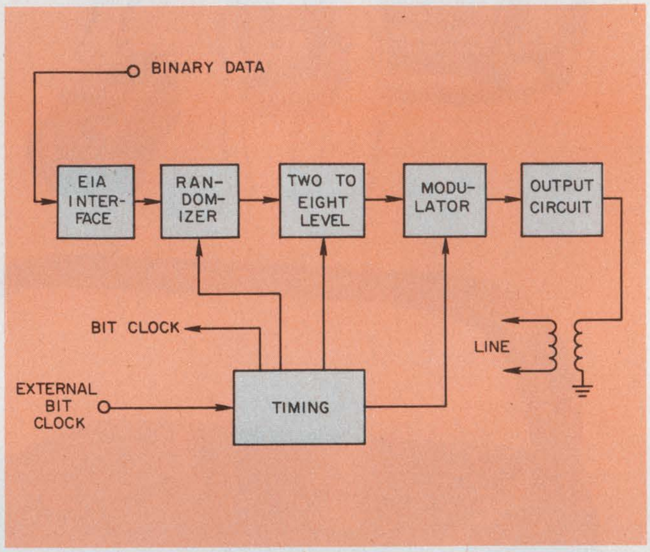
Bit-serial data arrive at the modulator (equivalent to the transmitter) through an interface circuit designed to meet EIA Spec RS-232-C (Fig. 1).

Clock signals, applied to an input shift register, control the reading rate of data into the register. The clock signal also controls the entire digital-to-analog conversion process even through carrier modulation.

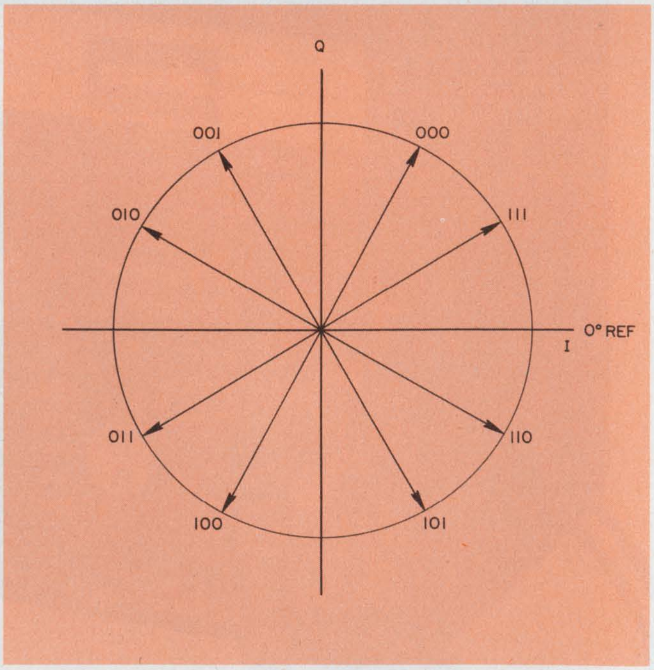
A bit randomizer encodes the serial data, then furnishes an encoded bit stream to the analog modulator. Random encoding serves these two purposes:

- It eliminates modem code sensitivity to a string comprised of a particular digit.
- It provides a learning sequence to set the adaptive equalizer at the distant receiver during initial synchronization.

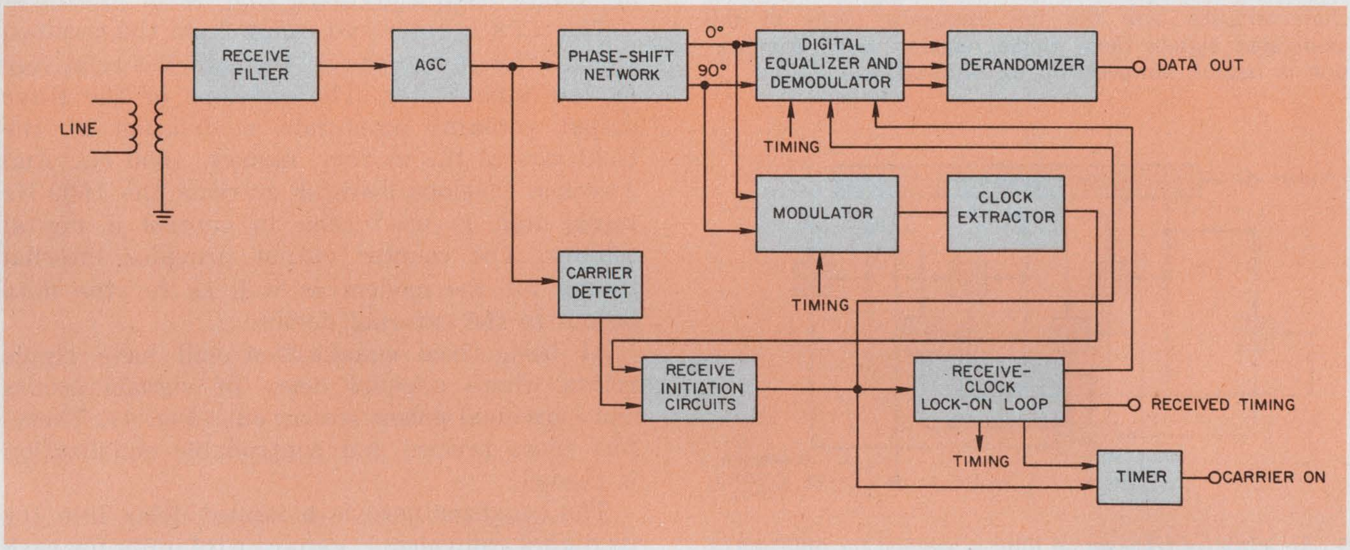
John Jurenko, Manager, Data Communication Products, Tele-Dynamics, Div. of Ambac, 525 Virginia Drive, Fort Washington, PA 19034.



1. **Modems convert digital data** to analog form for transmission over voice-grade circuits. Clock signals time the modulation process.



2. **Multilevel transmission conserves precious bandwidth.** The output of the 4800-bit/s modem is a phase-modulated waveform, which assumes one of eight phases during each baud time. One phase angle encodes three consecutive data bits.



3. **Automatic gain control levels** the received signal before demodulation. The phase-shift network furnishes in-phase and quadrature signals to the demodulator-equalizer section. Clock signals are derived from the received signal by a separate circuit, which extracts the 1600-baud signalling rate from the envelope.

Most high-speed modems use some form of phase modulation to transmit large quantities of information over a narrow bandwidth. With differential phase modulation (used here), each transmitted phase shift is referenced to the previous shift. The receiver recovers the data by storing the previous phase and comparing (or substracting) it to (from) the current phase.

To conserve bandwidth, several discrete phases are used. Each of the eight phase angles represents a particular pattern of three bits (Fig. 2). Multilevel modulation occupies the same bandwidth as simple binary modulation (two possible phases). But the number of bits transmitted in a given time interval is increased. Groups of three data bits determine the phase shifts in the modem discussed here.

Multilevel schemes are also more vulnerable to noise than binary methods. Fortunately most communication lines provide ample s/n ratios and the error rate still remains low.

Successive groups of three bits from the randomizer are converted to parallel form and applied to the phase modulator. The output from the phase modulator is either four-phase or eight-phase, depending on whether the modem is transmitting a synchronization sequence or data. The symbol or baud rate of the modulator is 1600 Hz, or 1/3 the bit rate.

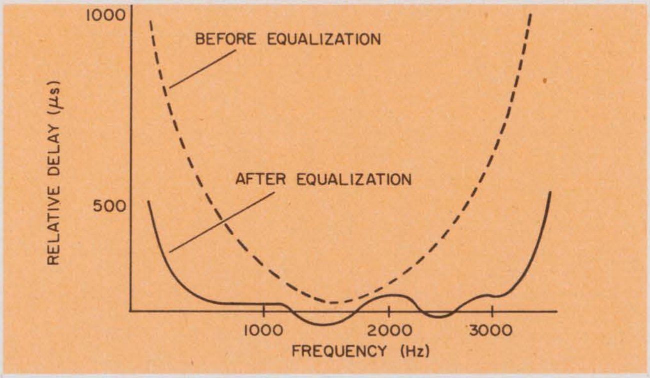
During the initialization (the first modem mode), an idle code of 12 symbols that lasts for 7.5 ms is sent. This is followed by a training sequence of 52 symbols for 32.5 ms.

A scrambled mark signal is sent then (from the randomizer) for 13 symbol periods, or 8.1 ms followed by data to be transmitted.

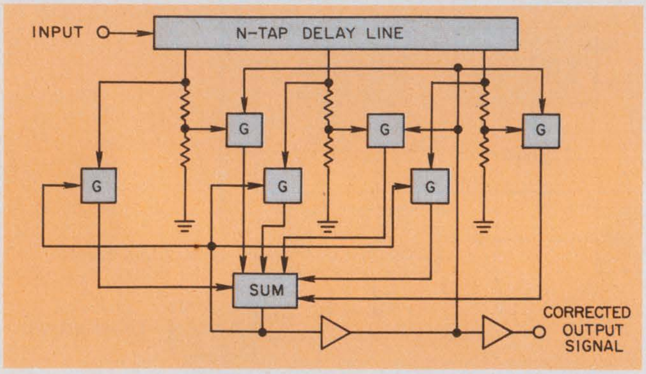
The idle code and training sequence are sent on four-phase modulation to improve the reliability of sync acquisition and to allow the receiver equalizer to train accurately and rapidly.

Delay distortion can degrade seriously the modem's transmitted signal by the time it reaches the receiver. Since phase shift is not a linear function of frequency, transmission delay (the derivation of phase with respect to frequency) is nonlinear. Inductors and capacitors used on the line are the main contributors to the distortion. Reflections due to impedance mismatches within the channel are secondary.

Low-speed modems (up to 2400 bit/s) can



4. **Factory-set equalizers** cannot compensate for line characteristics over the full frequency range of the modulated signal. Delay ripple remains. Such equalization is useful, however, up to 2400-bit/s.



5. **An adaptive transversal filter** is needed for 4800-bit/s transmission. Additional circuits (not shown) set the tap gains by cross-correlation of the median channel characteristics with symbol error. This algorithm minimizes the combined effects of noise and intersymbol interference of the channel.

operate with narrow-band analog signals, fixed equalizers or a combination of the two. But a fixed, or compromise, equalizer cannot cope with the equalization accuracy required at 4800 bit/s. Hence some form of adjustable equalization is necessary ultimately at the receiver.

Receiver unscrambles the modulation

The input signal to the receiver is filtered and sent to an automatic gain control (AGC) circuit which maintains almost constant output level for 50-dB signal variations (Fig. 3). A carrier-detect circuit, driven by the AGC output, initiates receiver action when a valid input signal occurs.

The output of the AGC circuit also drives a phase-shift network that provides 0 and 90° representations of the signal to the equalizer-demodulator section.

Analog or digital circuit techniques can demodulate the phase-modulated signal. With the analog approach, a VCO provides quadrature signals to two balanced modulators. Once the loop locks, the modulators provide the I and Q amplitude channels of the original phase-modulated signal, which is represented by

$$e(t) = I(t) \sin \omega_c t + Q(t) \cos \omega_c t.$$

In this equation

$$[I^2(t) + Q^2(t)]^{1/2} = K,$$

and the phase angle sent is given by the formula

$$\phi = \arctan (I/Q).$$

For digital demodulators, the input signal is first hard-limited and converted to a square wave. The sampled signal is demodulated then through algebraic multiplication with appropriate values from a digitized sine wave.

The clock is recovered easily from the received signal after it has passed through the relatively narrow input filter. The envelope of the filter output contains amplitude modulation at the baud rate of the modem; namely, 1600 Hz. And a simple envelope detector extracts the 1600-Hz signal that is used then to control a digital counter. The counter output provides internal timing for the modem as well as for the data output to the external device.

At best, fixed equalization will have ripple points where unequal delay of signals occurs and individual pulses spread out (Fig. 4). Therefore more precise and controllable equalization is needed.

The equalizer used is a tapped delay line (or its digital equivalent), gain-control units for each tap and a summer (Fig. 5). These three sections form a transversal filter.

The tap gains are set automatically in accordance with a suitable algorithm.

One of the previous algorithms used for phase modulation is called zero-forcing.[1] This algorithm attempts to get gain settings that constrain the channel impulse response to be zero at all sampling instants such as $-2T$, $-T$, T, $2T$, etc. The response resembles the classical sin x/x waveform which is unity for X or T = 0.

The mean-square algorithm minimizes the sum of the square of errors rather than values at the sample points.[2] One advantage is that the adjustment process will alway converge. In addition the algorithm will permit operation over marginal circuits that cause the zero-forcing algorithm to fail. Rather than force certain samples to be zero, the mean-square method requires that the circuitry examine the entire waveform on an average basis. As a result, the circuitry tends to compensate for the combined effects of noise and nonideal channel response. ■■

References:

1. Lucky, R. W., "Automatic Equalization for Digital Communications," *Bell System Technical Journal*, Vol. 44, April, 1965, pp. 447-489.

2. Chang, R. W., "Joint Equalization, Carrier Aquisition and Timing Recovery for Data Communications," *Proceedings of the 1970 IEEE International Conference on Communications,* June, 1970, pp. 28-34 to 28-43.

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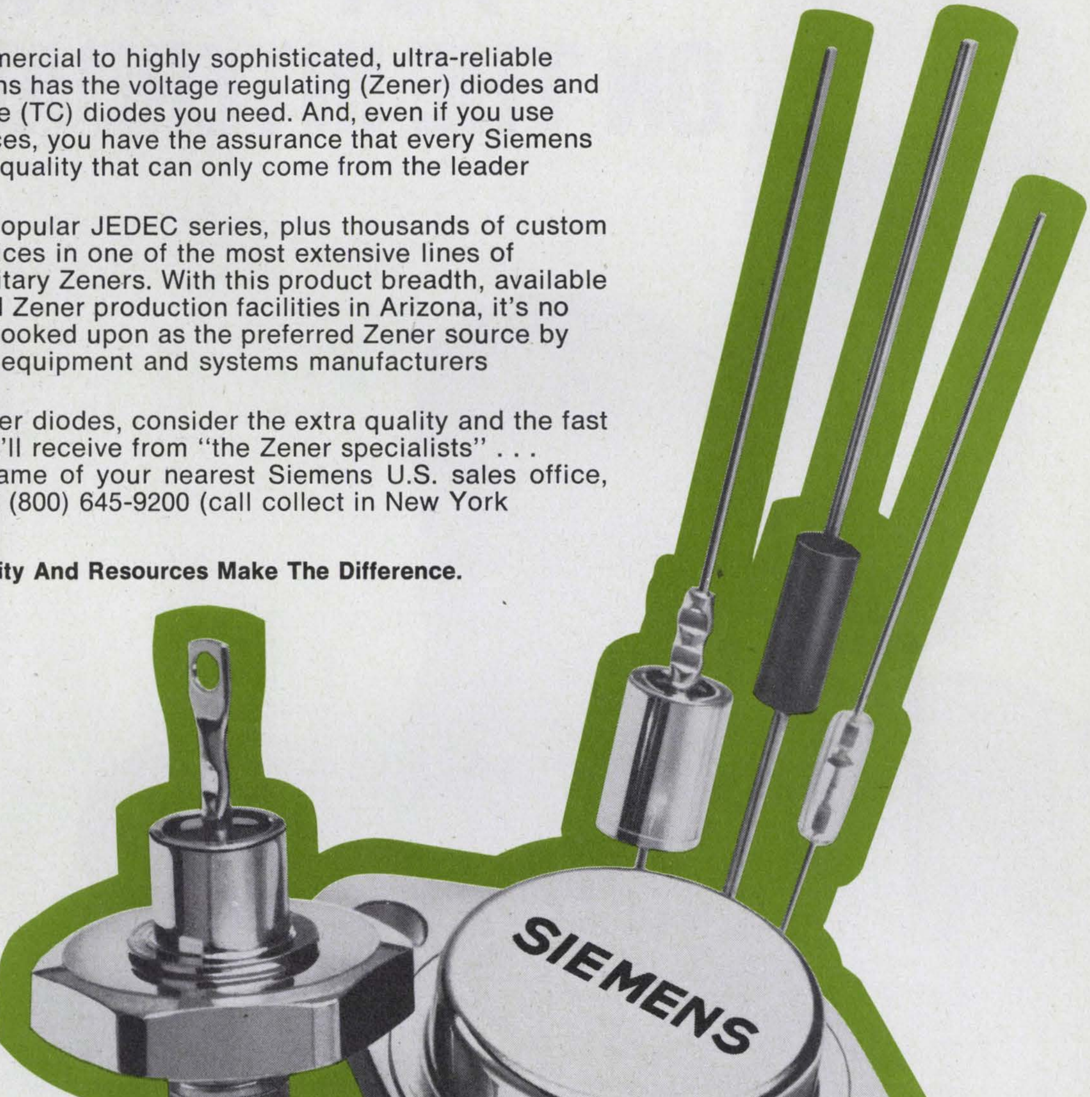

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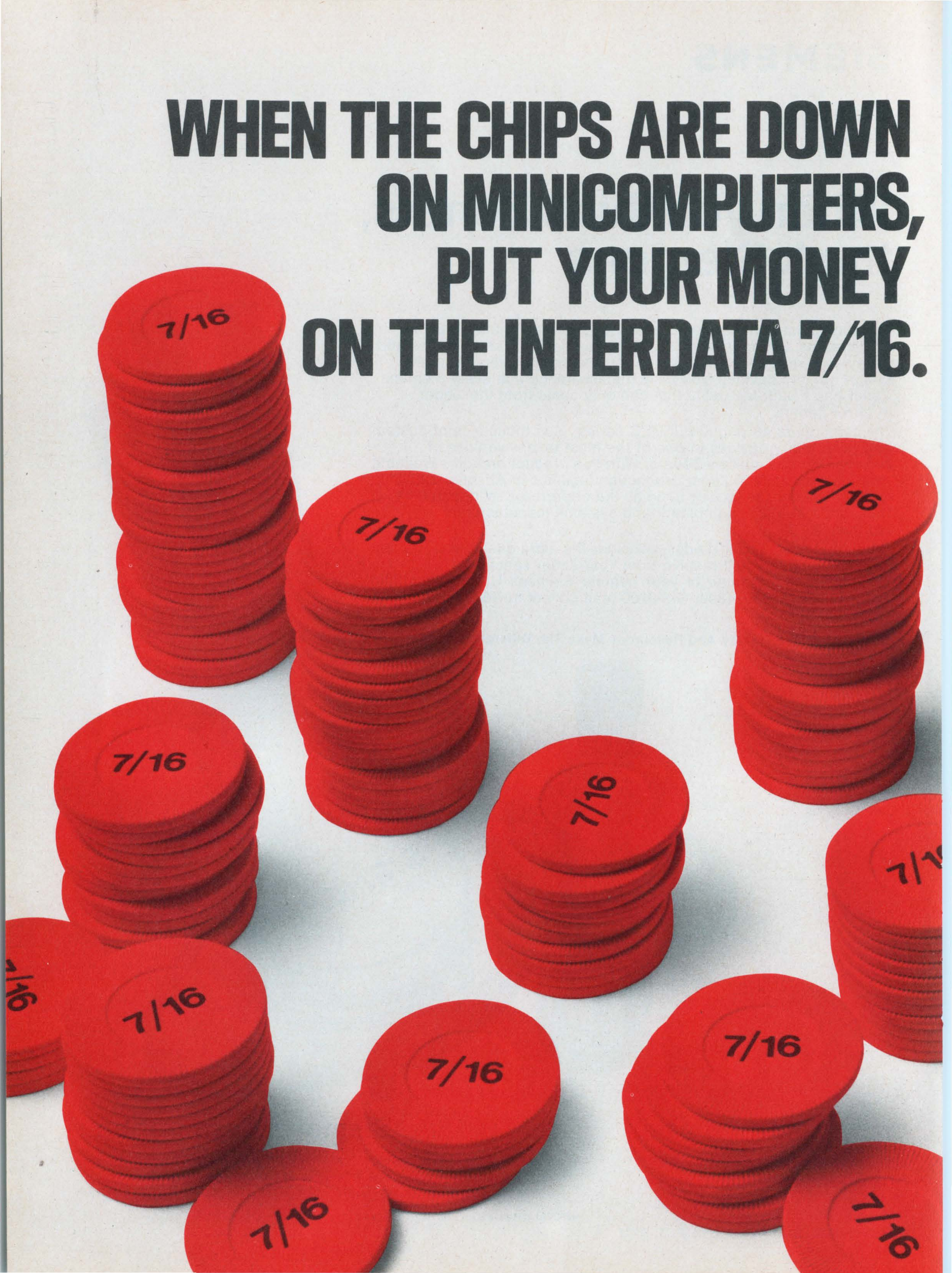
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Select pin drivers cautiously and you'll get an automatic tester that's both accurate and ready to meet future device needs.

When you evaluate an automatic tester, don't stop with the software and architecture. Take a detailed look at the system's clock-rate pin drivers. With the right decision on certain driver performance characteristics, such as output impedance, you can avoid serious problems and expense later on.

Everyone looks at architecture and software to get an over-all feel for the tester's ability to meet the requirements for the speed and scope of test. But the interface between the tester and device under test—the pin driver—represents a significant percentage of the tester's circuitry and is critical to performance. Thus it shouldn't be overlooked.

Even when the driver is evaluated, fuzzy specs often steer you to the wrong choice. Insist on the right driver, however, and you'll have confidence that you are testing fully and accurately all your devices. You'll also avoid the need for special tuning and you won't have to modify—and subsequently debug—your programs to adjust for driver inaccuracies.

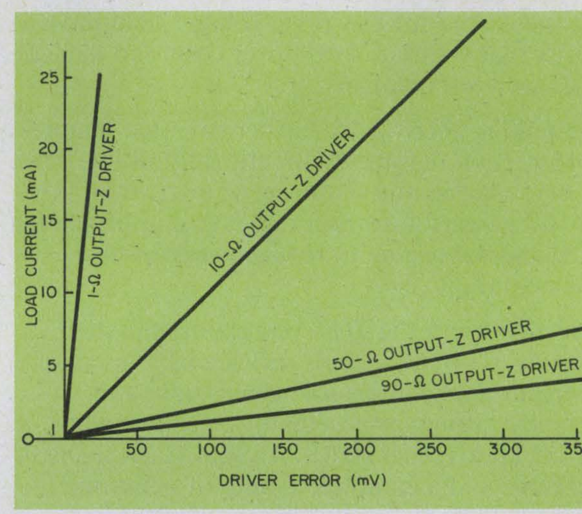
And with the right driver, you'll be ready for years of testing. Many engineers were caught short because their drivers couldn't handle both bipolar and MOS devices. With a carefully selected driver, this can't happen.

Pinning down performance

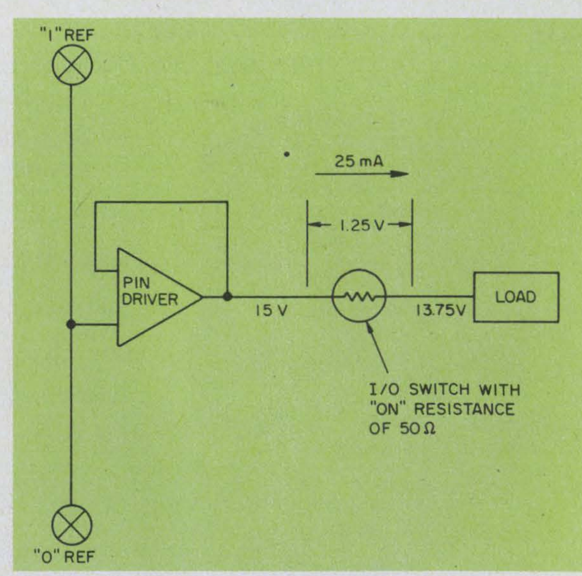
The purpose of the clock-rate pin driver, of course, is to provide accurate inputs to the devices under test at clock rates. To make accurate, time-related measurements, you need consistent, repeatable waveforms free of such perturbations as overshoot and backswing. How can you tell whether a given clock-rate pin driver can deliver this performance? It takes some analysis. But as a minimum you should satisfy these questions:

What is the output impedance of the driver? Are the rise and fall slopes linear throughout the entire range? What is the static dc current

Earl Patterson, Sales Manager, Test Systems Division, Datatron Inc., 1562 Reynolds Ave., Santa Ana, CA 92707.



1. **A pin driver's voltage error** is directly proportional to the driver's output impedance. To test both MOS and bipolar devices, it's best to keep driver impedance below 10 Ω.



2. **When the impedance of a nonintegral switch** is taken into account, voltage-drop errors can soar to 25 times the stated amount. For example, with 25 mA through a 50-Ω switch, the voltage drop, or error, is 125 V.

as applied to my application? What driver amplitude accuracy can I achieve? Is the slew rate fast enough for my test requirement?

Is the slew rate too fast? Is the input capacitance of an I/O pin too high? What crosstalk can I expect? What do the dc current ratings really mean? What is the edge current?

Frequently the answers won't be given in the manufacturer's specifications; you'll have to ask.

Perhaps the most important consideration is the output impedance of the pin driver. On the market today are drivers with output impedances of less than 1 Ω, those with output impedances of 90 Ω, and a variety of impedances in between. Since the voltage error is related directly to the impedance of the driver, it is important to select the right output impedance for your application.

If you want to test bipolar as well as MOS devices, insist upon a driver whose output impedance is no more than 10 Ω. A look at Fig. 1 will make the reason clear. For a given device and a given forcing voltage, the voltage error increases directly with the output impedance.

If the requirement is to test devices that source or sink as little as 5 mA, significant errors will be incurred if the output impedance of the driver is greater than 10 Ω. Output impedances higher than this would create errors of sufficient magnitude to invalidate the test. Another incentive to keep impedance down: Low-impedance drivers are much less sensitive to load changes.

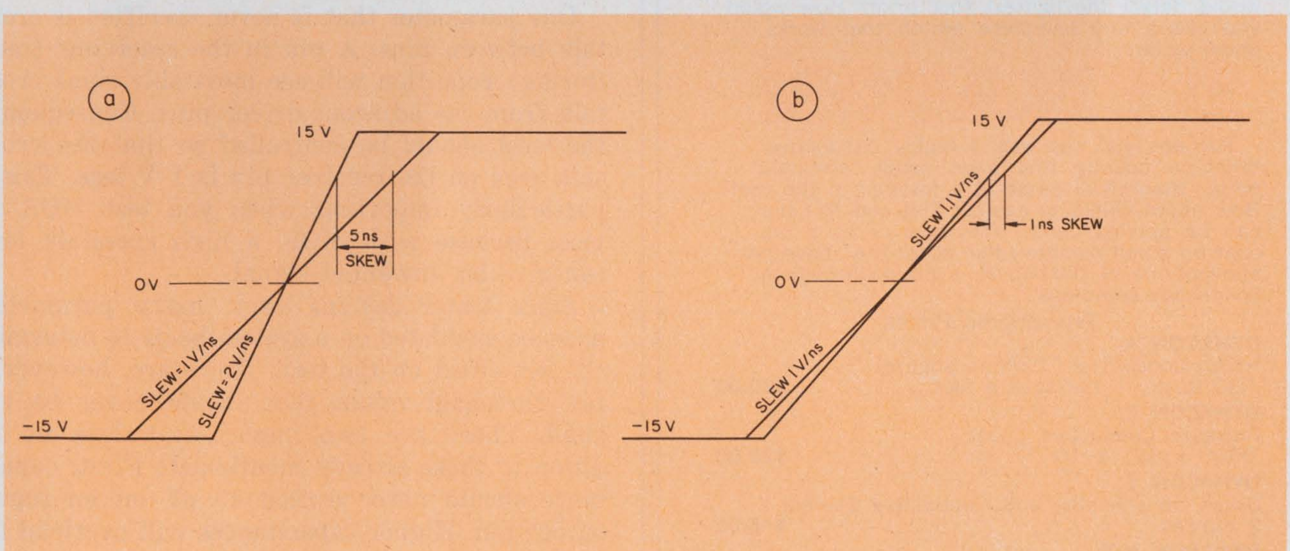
Another set of specs you'll have to sift through is the current rating of the driver. Most specs provide a value for the dc static current, but it usually isn't clear what the value really means. Does the rated dc static current imply that the driver can maintain that value at the device under test? Or does it mean that the value was measured at the output of the driver? Fig. 2 illustrates why this is important.

Degraded accuracy specs

Typically a driver does not have an integral switch; the switch is added to the line between the driver and the device under test. Suppose that the addition of the switch results in a 50-Ω resistance in the line. With a current of 25 mA through 50 Ω, the 15-V level at the driver deteriorates to 13.75 V at the device under test. In other words, the error will be 1.25 V, so a stated accuracy of ±10 to ±50 mV is meaningless.

Of course, it is preferable that the switch be integral to the driver. In any case you should obtain at least a definition of the net voltage that will be applied to the device under test.

Another parameter that should be defined is



3. **To make meaningful propagation delay** measurements, the various drivers within a system should have similar slew rates. Two dissimilar drivers with no skew at 0 V have no error at that point, but show a larger error (> 5 ns) at, say, 10 V. However, with the slew rates kept within 10% of each other, the error at 10 V drops to 1 ns. Skew is often undefined on spec sheets.

the available, or edge, current. You'll need between 200 and 300 mA of current to drive the edge at 1 V/ns. Anything less is questionable; anything much higher will result in overshoot.

Unfortunately few data sheets include edge current, so you may have to get the information another way: From a look at the slew rate into a capacitance load, you can calculate whether you can achieve 1 V/ns into 50 to 100 pF.

Another essential item is the linearity of the rise and fall times; that is, the skew across the full voltage swing. Usually you'll want a slew rate that's fast enough to test devices in the 5-to-10-MHz range—around 1 V/ns. Higher slew rates generally lead to problems—overshoot, for example. However, the absolute slew rate by itself is not the only important parameter: The variation in rates between drivers is also critical.

Watch for consistency

Since the measurements of a clock-rate tester are time-related, it is essential that the various drivers have consistent slew rates (Fig. 3). If there is a significant discrepancy (and there often is), propagation-time measurements become meaningless. At the very least, you'll have to compromise your test specification by relaxation of your timing requirements. This kind of compromise runs the risk of bad devices being allowed to pass the test.

Unfortunately few tester specs include a definition of skew, so you'll have to ask for the information. Look for a commitment such as "less than ±3-ns skew measured at any point with the same voltage swing on all pins." Just to be sure, ask also if the tester can calibrate the slew rate.

One parameter that is never specified is crosstalk between pins. A pin in the receiving (monitoring) condition will see inevitably some crosstalk from the adjacent driver pins. Consequently the level should be controlled so that the crosstalk seen on the receiver pin is 1 V less. This is particularly important when you test MOS devices because with MOS, a high crosstalk level can give an unwanted signal.

Since tester designs vary, many parameters must be evaluated on a system basis to determine the net effect on the test. There are, however, a few threshold values that should never be violated. There are two important values in addition to those already mentioned: First, capacitance should never exceed 40 pF on an input/output pin. Higher capacitances will overload the device. Second, the comparator's input impedance should be at least 10 MΩ over the full input voltage range—not just at one point.

These requirements for drivers aren't esoteric; they are readily available and should be insisted on. ■■

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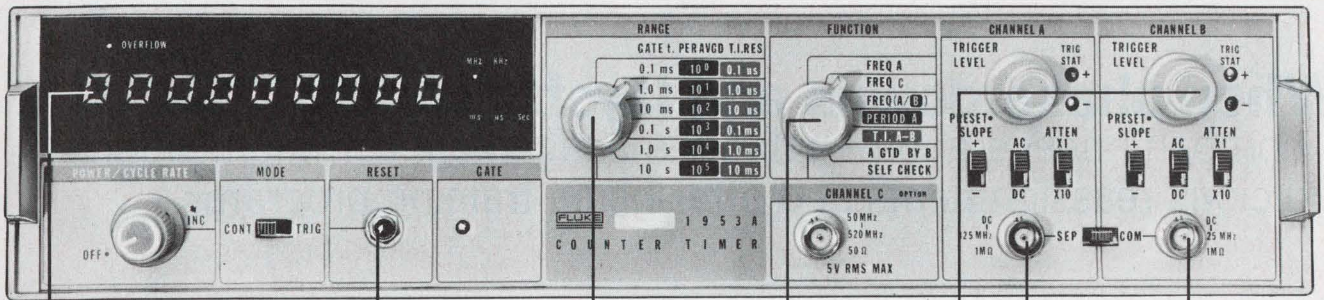

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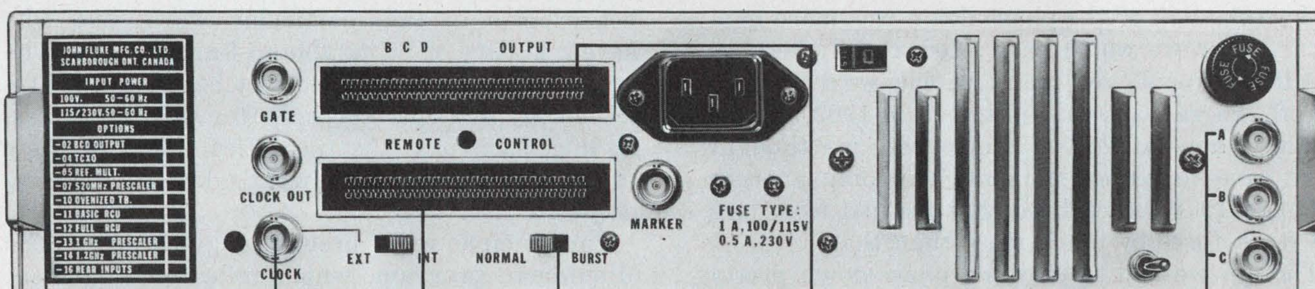

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FOR A DEMONSTRATION, CIRCLE 161 FOR MORE INFORMATION CIRCLE 162

When phase-downs and layoffs come,

a company needs good engineer-management communications, judicious reassignments and after-hours training programs.

The replacement of one or two large projects with a number of small ones has many implications for the engineering staff—from cutbacks and downgrades to the need for different capabilities.

For years, the primary business base for the Strategic Systems Div. of Rockwell International was the guidance and control system for the Minuteman ICBM and avionics for the F-111 aircraft. We phased down those projects gradually, from a total of 30,000 employees in 1964 to 7000 today.

Organization of the phase-down was more haphazard than we would have liked, mainly because we didn't know how many people we'd have to lay off. There was some optimism in 1969, for example, when, at 21,000 employees, we thought we'd have to reduce personnel by only another 10%. In 1970 we realized that we had to reduce the work force by much more than that.

Though we had to play the phase-down pretty much by ear, we were able to find cures for most of our managerial migraines caused mainly by the following four challenges:

- Convincing engineering specialists to become generalists.
- Assisting supervisors to tighten their control of project budgets.
- Training supervisors and managers to write new-business proposals.
- Coping with the over-all morale problem.

Of course, the worst problem for me was having to tell some old friends that I had to demote them or that I didn't have a job for them. I've been able to rehire only about 5% of them.

Specifying the generalists

Because there is a great need for special engineering work in large programs like Minuteman and F-111, many of our engineers spent several years working on very specific jobs. When we transitioned them from the large programs to smaller ones, I told them that they were going to have to work in broader areas of activity than they'd been used to, that they'd have to resurrect some of the engineering talent that they hadn't used in some time.

I try to structure this job change so that it's as painless as possible for the employee.

When we need someone with knowledge about a small project, often we've found an engineer who has experience in that area. We bring in other people from the larger project who are not experts in this particular work, but who have a history of being able to learn quickly. The knowledgeable lead engineer teaches them the new technology in a special class after working hours, leading them past the theoretical point of view so they can understand what's key to the new project.

For example, we've brought engineers from the Minuteman program, which relies on a conventional gyro technology, to our micro program, which relies on electrostatic suspended gyro technology. We've scheduled an after-hours course on electrostatically suspended gyros that's taught by the lead engineer, who's been active in that field for several years.

We've also conducted a series of courses on MOS LSI technology. We've managed to convert our design engineers from integrated-circuit technology to the large-scale-integration technology that MOS requires.

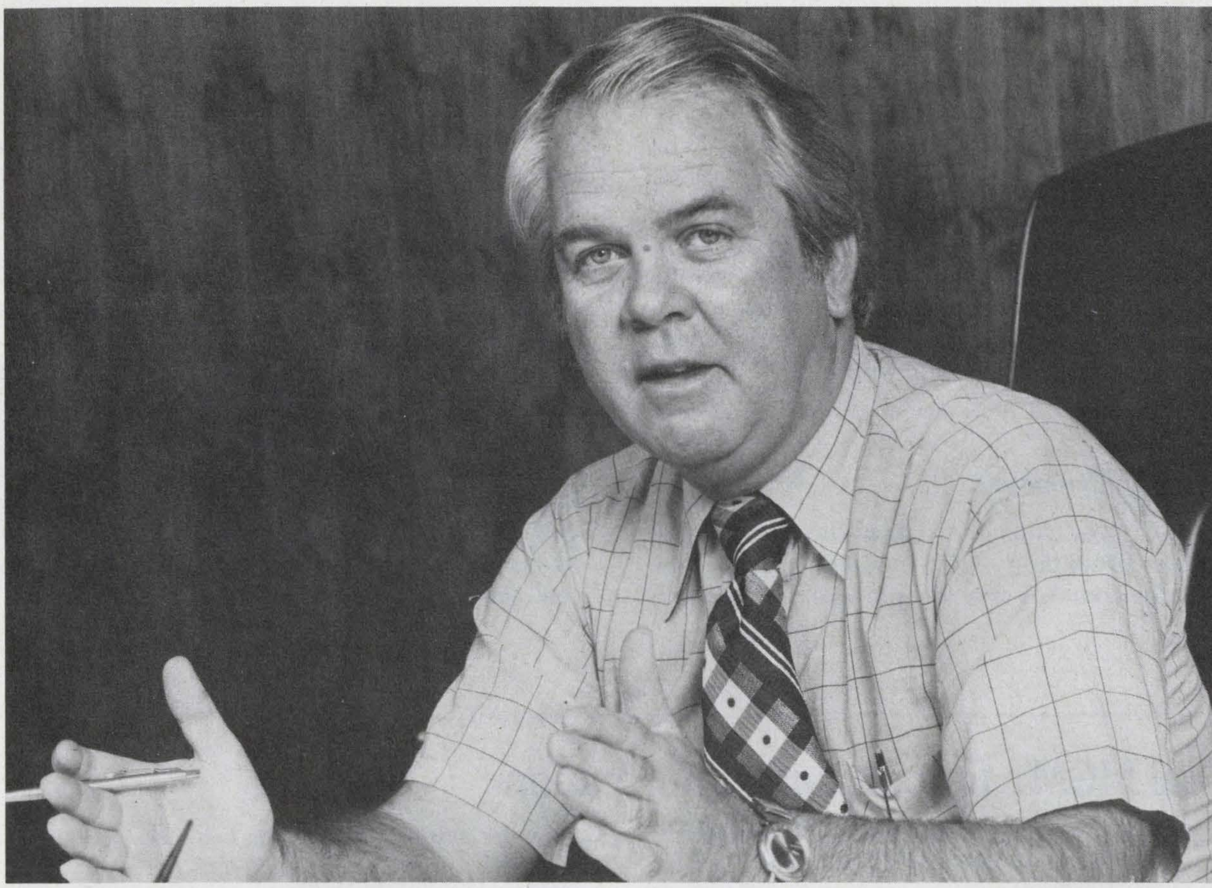
How do engineers react to shifting from one program to another and to learning a new technology? Once they stop hanging onto the feeling of security that a very large program offers, most have reacted very favorably. They find it challenging to use the skills they've never used or haven't used for a long time.

Getting a handle on the budget

Another challenge that the phase-down creates for supervisors and their lead engineers is controlling the budget in smaller projects. Since the supervisor no longer has the flexibility that a

Thomas K. Shuler, Vice President and General Manager, Strategic Systems Div., Rockwell International, Anaheim, CA 92803.

Thomas K. Shuler and the Strategic Systems Division of Rockwell International



Thomas K. Shuler became vice president and general manager of the Strategic Systems Division in April, 1974. He has responsibilities for all activities from new-business proposals through design, production and logistics support of operational equipment.

Programs under his direction include guidance and control equipment for Minuteman ballistic missiles, avionics for FB-111 and F-111D aircraft and the master computer for the Short Range Attack Missiles (SRAM). In addition, he is responsible for numerous advanced studies and related hardware production with both government and commercial customers. Previously, Shuler was vice president, Strategic Systems and Special Programs for the Autonetics Division.

Shuler joined the company in 1951 as a member of the Systems Analysis unit autopilot group. Since then he has held a variety of management and engineering positions.

Before joining Rockwell he was an instructor and assistant professor of electrical engineering at Iowa State College. He received his BSEE degree from the University of Notre Dame and his MSEE degree from Iowa State.

Shuler and his wife reside in Newport Beach, California. They have three children.

large budget might have given him on a larger program, he must make sure that his entire smaller job can be done with the funds he does have. This calls for the first-line supervisor and the lead engineer to become businessmen.

In the large projects a specific group is responsible for the scheduling and the tracking of the man hours and the dollars that are being spent. On smaller programs the supervisors have to learn about accounting systems and planning and control systems.

We've assisted our supervisors through a series of training courses that explain how these business skills can apply to a whole program instead of just a part, as they'd been used to. Instructors for this series are from administration and from our program-planning and control group. The series is funded on a burden budget against each of the 793 contracts we presently have.

And then, of course, all of these programs have to be reviewed.

Management reviews in a large program are regularly scheduled and conducted by the program manager. Line supervisors do not ordinarily participate in the review. For the small programs, though, we try to conduct status reviews on a regular basis, and we require each supervisor to report his own status to management—cost, schedule and performance against the requirements. Many supervisors have probably never had the responsibility of defending their actions and reporting their goals. Their inexperience in reviewing has taken a great amount of management's time, but it has been worth it.

Writing winning proposals

The more programs there are, the greater the need for preparing new-business proposals. Periodically some of our people are taken from their regular spot on a program and asked to write these proposals. A few are natural writers; most are not. We try to train them to write better proposals by giving them direct feedback on why certain proposals have been rejected by the customer. Regularly, we tell our people what our proposal wins and losses are, in the hope that these examples will assist them in their work.

We knew the large-program customer very well. We'd dealt with him for many years, and we were able to tell him when he was wrong, without losing his business. Now we're dealing with people we don't know as well—they don't like to be told they're wrong, particularly during the proposal and contract phase.

Because of this new environment, we tell our people that we have to be more responsive to the ideas of a new customer on how the program is run. It may not be the way we ran the old large program, but we have to build mutual trust, and that takes time.

If necessary, we put on our best salesman's suit and try to get our customer to agree to our way of thinking, or if that's not possible, we try to learn to agree with his way of thinking. We feel that if we can build more mutual trust and

Dial MGMT for company information

As vice president and general manager of Rockwell International's Strategic Systems Div., Tom Shuler finds communication is a big part of the solution to problems caused by project phase-downs. Besides scheduling monthly conferences to keep his staff abreast of events, he encourages his people to use Rockwell International's employee communication system—Dial MGMT. Following is a four-point description of that system:

1. Any employee can dial "MGMT" (which stands for "management") and dictate his question into a tape recorder that is in the public-relations office of the Autonetics Group. Public relations is the central information agency for calls from the public. Since it accumulates knowledge of company organization and management-employee interface, it can readily refer questions or suggestions to the appropriate department. The agency can also promulgate answers by publishing the questions in the in-house organ or management newsletter, particularly if the questions and answers affect a substantial number of employees.

2. Questions are transcribed each workday morning. Normally they are typed onto a transmittal form, which is then addressed to the department or departments with responsibility over the subject. Exceptions are the occasional nonsense questions or comments received. Most anonymous questions, for example, are really not questions but instead pranks or comments made to "blow off steam."

3. Most employees asking a question give their name, phone extension and department identification. A number of questions are answered immediately, because they've been asked before. If there will be some delay in the reply, the public-relations department notifies the caller that his question has been received and when to expect the reply.

4. Questions are usually answered in writing. Whenever there is some doubt about the intent of a question, it is clarified by a supervisor in a personal visit to the employee seeking information.

One benefit of the MGMT system is that it encourages frank communicating. Oral communications are more spontaneous than written ones, since the caller can react on the spur of the moment and express his true feelings on an immediate problem, idea or situation. Another benefit is that the caller knows he will be heard and that someone cares, because (a) he gets a return phone call or visit and (b) the answer goes to him individually.

respect, we can be a little more blunt with him in the future.

Dealing with legitimate worries

When the company's two large programs were phased down, our engineers and managers worried about being laid off, demoted or dislocated. Today, to combat rumors about layoffs, I conduct one conference a month for 150 salaried employees at a time and present our annual operating plan.

This plan tells them where we really stand, what our outlook for business is and what contracts we'll be bidding on in the future. I want the 2000 people in my division to know first-hand what I think of the future, what I think is important, and what contracts I think we can win.

The only way I've ever found to deal with the morale problem during a layoff is to tell the people directly why we're doing what we are. Each man we lay off is told by his immediate supervisor, and often by the next manager up, why the action was taken. He is told what his shortcomings are and how he can improve in the future.

I took advantage of the phase-down to replace people who really should have been replaced even when there wasn't a phase-down. Our organization is stronger today than it was when we had 21,000 people. The people in key positions are more qualified now.

Demotions are decided by a committee made up of me, the managers who report to me, and their subordinate managers. We rate engineers and managers once a year. Ratings are based on past performance, productivity, business-like approach and success. When things get tough, like cutting back from 115 first-line supervisors to 100, we consult our rating charts, and the bottom 15 are dropped.

Job dislocation is the least of the three personnel problems. When people were losing their jobs, others were actually relieved when they were told that they weren't being let go, just being reassigned. If the reassignment means that the engineer must perform totally different work, it does present a challenge to his new manager. We don't let it become a hardship.

We haven't had any serious disorientation. My impression is that the people who are left behind on the large programs often envy the ones who are moved, because they don't get a chance to work on a new program. They worry when they're not selected. They feel that when the old program phases down, they'll be left without a job. But most of them realize that they are retained on their assignment because of special competence, and we don't intend to lose those abilities. ■■

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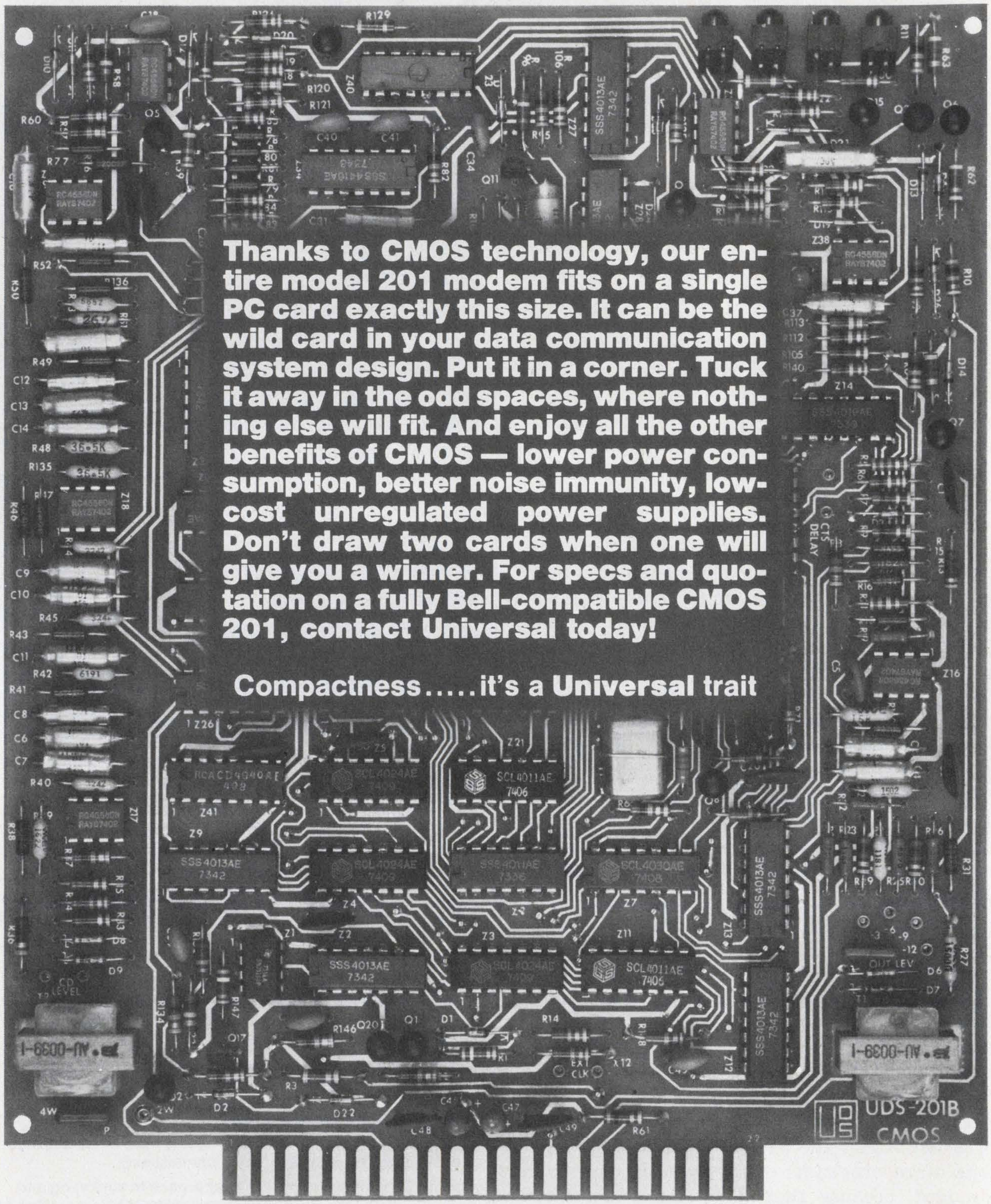

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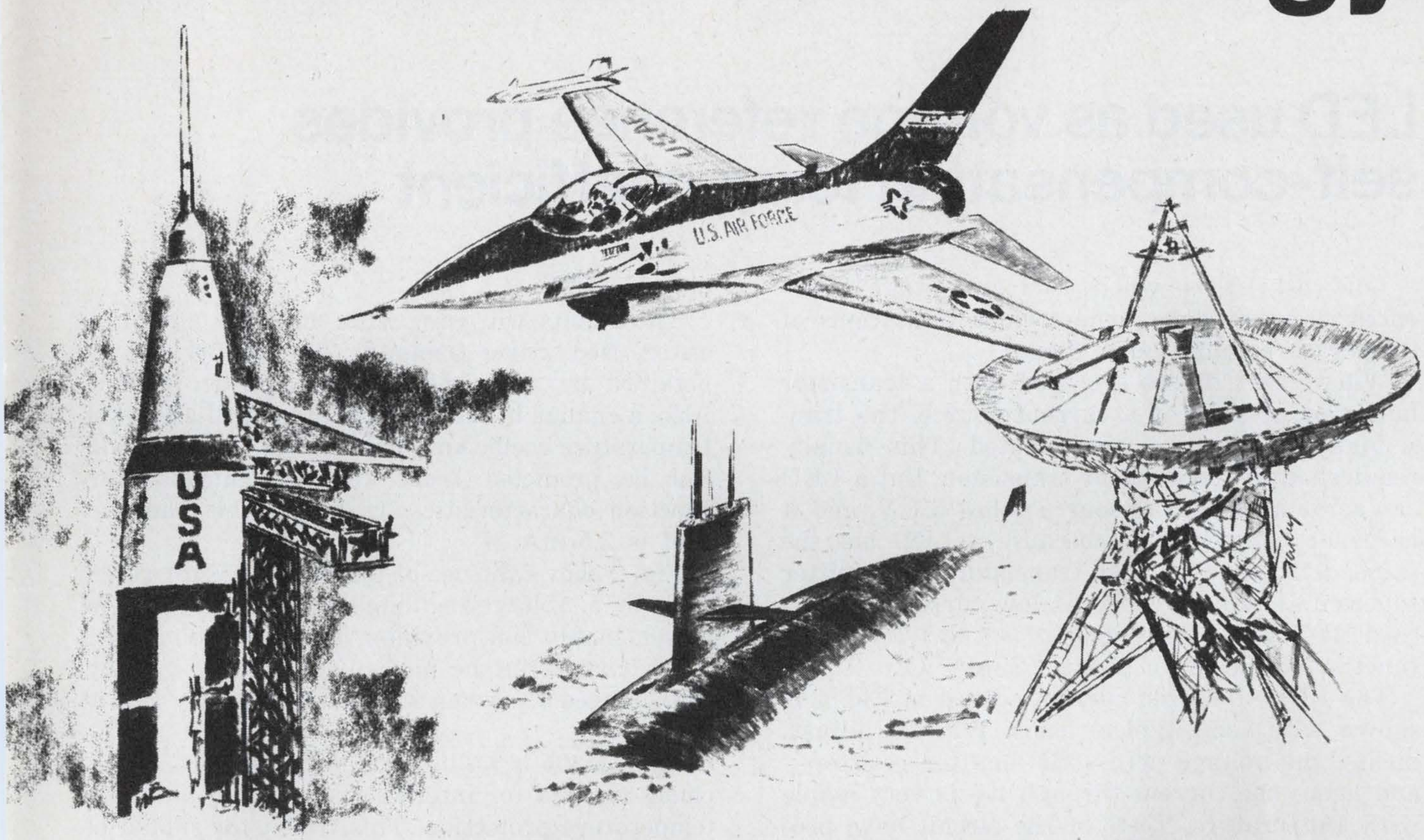

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Low-cost LEDs, when used as voltage references, can overcome some serious limitations of temperature-stable zener diodes.

When zener diodes are used with a transistor buffer or as part of a current source, the transistor's V_{be} must be compensated. This usually requires an extra diode or transistor. But a LED can serve as a voltage source below 5.1 V, and it needs no compensation, because a LED has the same drift as a typical transistor base-emitter junction already built in. At low currents a typical LED has a voltage drop of 1.4 to 1.7 V and a junction coefficient of about -2 mV/°C.

The LED-stabilized current source in Fig. 1 is shown with some typical loads. Without adjustments, the voltage across the emitter resistor—and hence the current through it—is very stable with temperature. Tests of the circuit have provided better than ±1/2% stability over the -55-to-100-C range—usually much better than needed for the type of loads shown. Other applications include coulometers, ramp generators, LED assemblies, bridges and special thermistors and other sensors.

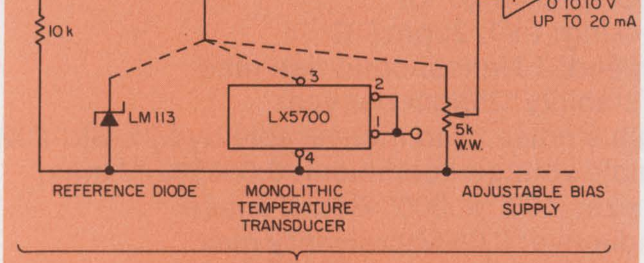
The results will vary with the LED and transistor used. Some trimming of stability can be obtained by adjustment of the 10-kΩ resistor. Also, a change in the 301-Ω resistor will affect the temperature coefficient. The change in coefficients can be predicted from known semiconductor-junction characteristics. In Fig. 1 the load current is 2.5 mA.

Fig. 2 shows the use of a LED-transistor reference in a voltage-regulated power supply. The power supply can provide over 1-A output. With a 4-V change in the unregulated input, the output changes 4% when set to 1 V and only 2% at 5 V.

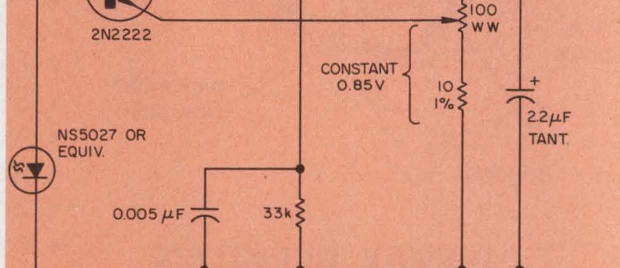
The LM395 is an integrated transistor that includes circuits for internal overcurrent and overtemperature protection. This transistor should be mounted on a heat sink for 1-A loads.

Peter A. Lefferts, National Semiconductor Corp., A.L.I.C. Dept. Bldg. C, 2900 Semiconductor Dr., Santa Clara, CA 95051.

CIRCLE NO. 311



1. **LED voltage reference** in a transistor-buffered, constant-current circuit has built-in temperature compensation.



2. **The LED is used as a voltage reference** in this temperature-compensated, voltage-regulated power supply.

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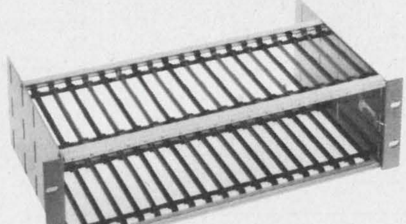

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INFORMATION RETRIEVAL NUMBER 47

Easy-to-build FM signal generator uses a phase-locked loop and an AM input

Need a simple FM signal generator that can be built fast? Try the Signetics 562 phase-locked loop (PLL) and modulate its timing-circuit voltage with an AM signal. This combination provides an FM generator with wide frequency capability and low distortion.

In the circuit, capacitor C_{10} determines the free-running frequency of the PLL's internal voltage-controlled oscillator (VCO). Audio-voltage input to point A modulates this frequency, which appears at pin 4. The values shown were chosen for FM receiver alignment at 10.7 MHz. Resistor R_{11} provides fine frequency-tuning adjustment of up to ±10% of the center frequency.

The change in the VCO free-running frequency, f_o, is a function of the voltage at point A, and the value of R_7 and R_8. This deviation can be calculated from

$$\Delta f \approx \frac{6.4 - V}{1300\ R} f_o,$$

where V is the voltage at point A and R is the resistance of R_7 in ohms.

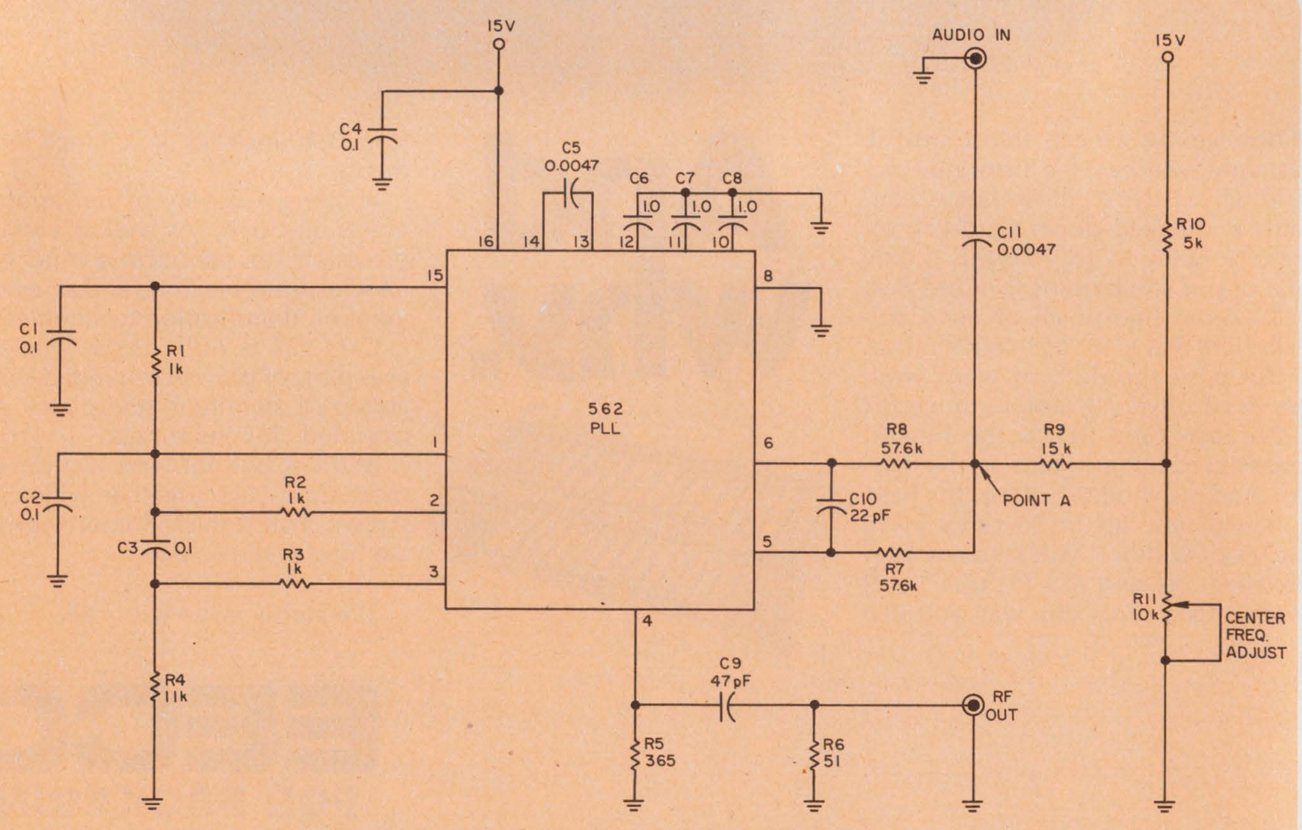
The best waveform linearity results when R_7 and R_8 are matched to within 1%. For high sensitivity or very wide frequency deviations, R_7 and R_8 can be reduced to as low as 20 kΩ.

If a range switch is used to change the values of C_{10}, a span of center frequencies from 50 kHz to 30 MHz can be obtained, although the output amplitude will vary somewhat, increasing at lower frequencies. Distortion of the output signal is typically less than 0.5% throughout the entire audio band (for a ±75-kHz deviation).

All unused inputs are taken to ac ground to ensure loop stability and low noise. If necessary, the PLL can be locked to an incoming reference signal. This reference signal can be injected into pin 12, and the resulting output signal will be as stable as the input. Since the PLL has a built-in VCO, and signal stability is voltage dependent, a well-regulated power supply should be used.

R. Marshall Jr., Sustaining Engineer, Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086.

CIRCLE NO. 312



The 562 PLL can be modulated by an AM signal to deliver a frequency-modulated, low-distortion output.

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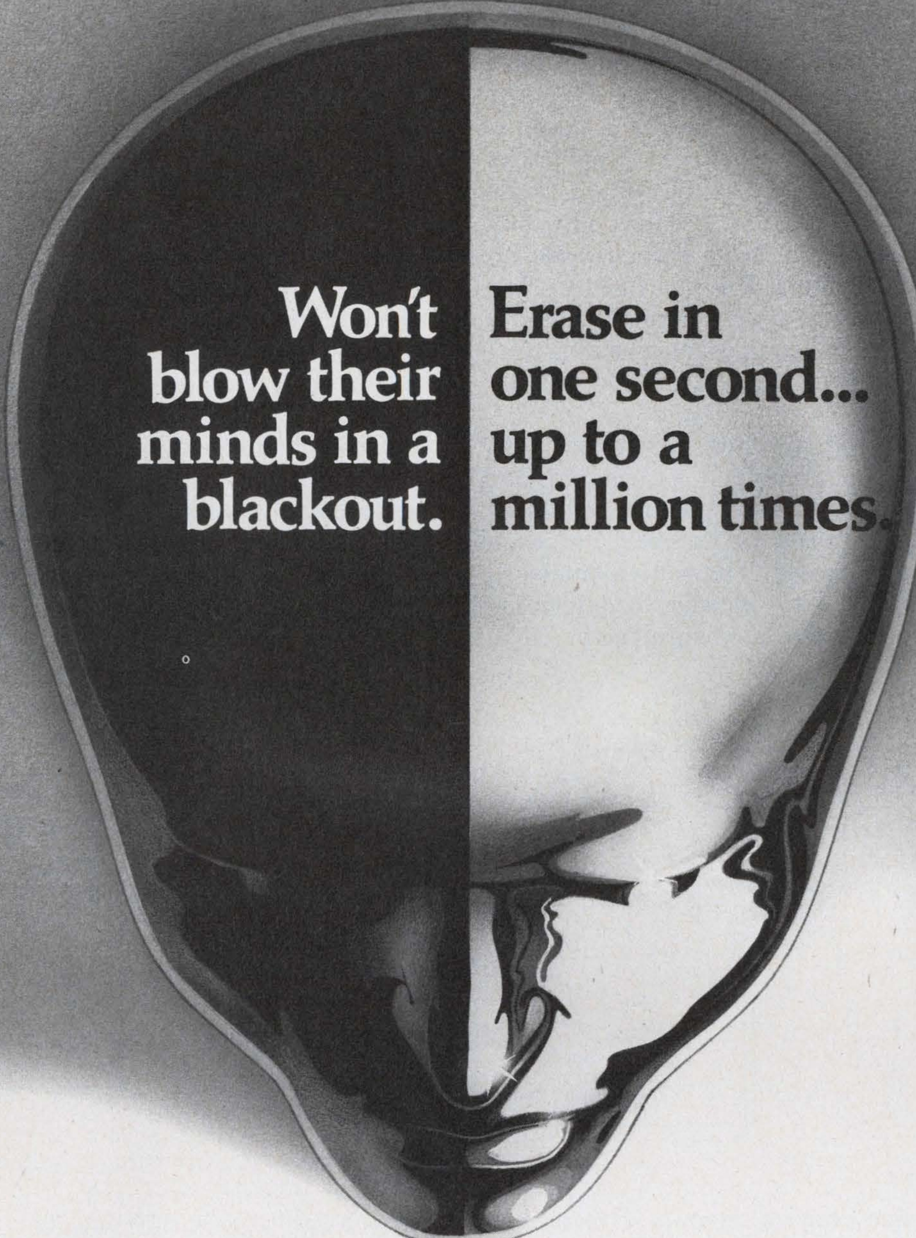

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NC7002	1024 x 1 512 x 2	±15	40 DIP	ROM Organization
NC7010	1024 x 1 512 x 2	±15	28 DIP	ROM Organization
NC7030	8 x 16	±15	18 DIP	Shift Register Stack
NIT-80C	1K x 8	±15	PC Board	8K Memory Module
NIT-80T	1K x 8	±15, +5	PC Board	8K Memory Module

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Convert 7-segment numerical code to decimal or BCD outputs

While many many MSI and LSI circuits have seven-segment numerical outputs, the designer often has a need for BCD or decimal outputs. And though BCD-to-seven-segment converters and decimal-to-seven-segment are common, those that can do the reverse are not. (A new chip that can do the job is available from Scarpa Laboratories, 46 Liberty St., Metuchen, NJ 08840.) The recoder shown converts seven-segment outputs to BCD or decimal. It requires no clocking circuitry, and the conversion time is limited only by the propagation delay of the circuit.

In the accompanying, specially arranged truth table for seven-segment numeric characters, the numbers at the bottom of each column represent the bit positions, or "priority number," of each character's equivalent word. The equivalent word feeds into a 74147 priority encoder to determine the position of the word's least-significant ONE bit. The 74147 output is an octal code, which then is translated into a 1-of-7 output from the 74138 decoder.

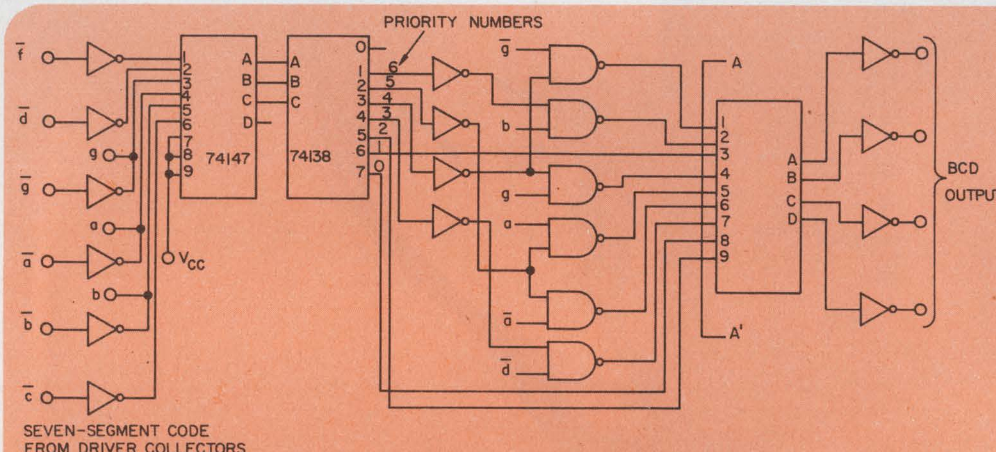
Note that the so-called priority numbers column in the table contains duplicates for 3, 4, 5 and 6. In these cases, it is also necessary to look at the state of the next least-significant bit to uniquely determine the number at the input to the circuit.

A decimal equivalent of the seven-segment input word is available at section AA′ of the figure. A second 74147 and inverters convert the decimal equivalents to positive-logic BCD.

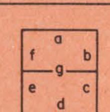
The circuit interprets a blank at the input as a zero. And it is designed to work on codes where the numbers 6 and 9 use only five segments.

David L. Howells, Western Electric, 2400 Reynolds Rd., Winston-Salem, NC 27106.

CIRCLE No. 313



EQUIV. DECIMAL NUMBER	PRIORITY	SEGMENT e	f	d	g	a	b	c
BLANK	6	1	1	1	1	1	1	1
0	3	0	0	0	1	0	0	0
1	4	1	1	1	1	1	0	0
2	6	0	1	0	0	0	0	1
3	1	1	1	0	0	0	0	0
4	4	1	0	1	0	1	0	0
5	5	1	0	0	0	0	1	0
6	5	0	0	0	0	1	1	0
7	3	1	1	1	1	0	0	0
8	0	0	0	0	0	0	0	0
9	2	1	0	1	0	0	0	0
		0	1	2	3	4	5	6



Seven-segment input code for numbers is recoded to decimal and positive-logic BCD outputs.

IFD Winner of October 11, 1974

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Microprocessor race intensifies on Continent

European computer manufacturers are racing to get their own microprocessors on the market. Olympia Werke, a West German electronics and business-machine company, has announced what it calls Europe's first microprocessor system. The 8-bit system consists of a computing/control unit, a program control unit, memory and program data unit.

Three European-based semiconductor companies cooperated in developing the microprocessor. AEG-Telefunken, General Instrument and SGS-Ates each provided a different process approach for the 15 MOS-LSI chips of the microprocessor system.

Telefunken used a metal-gate double ion-implantation technique. General Instrument relied upon a metal-gate nitride configuration. Italy's SGS-Ates used silicon-gate.

Much of the chip line is interchanegable; therefore there are no second or third-source supply problems.

Close on the heels of this announcement, Nixdorf Computer AG presented what is said to be the first European n-channel microprocessor. This is an 8-bit CPU with an integrated 32-by-8-bit RAM. The unit uses 4600 transistors on a silicon chip measuring about 0.18 × 0.16 in. and is housed in a 40-lead package. The microprocessor is TTL-compatible, requires no special clock and has separate input-output (no special circuits are necessary for microprogrammed ROMs or additional RAMs). Total delay time is 1.5 μs.

Heat shock slices optical fibers smoothly

A new method of cutting optical (glass) fibers by heat shock is reported to provide highly clean and smooth cutting surfaces. Siemens Laboratories, Munich, West Germany, is the developer.

Conventional mechanical cutting and breaking processes produce irregular fiber surfaces at the cutting plane. This results in transmission losses at interfaces between laser source or detector and optical fibers. Keeping these interface losses low is a crucial problem in optical signal-transmission systems.

The temperature-shock process uses point heating of the fiber plus light axial pull or pressure.

Tiny laser requires less pump energy

A miniature crystal laser that requires only a tenth of the pump energy previously needed while yielding the same output has been announced by the Max Planck Institute of Solid-State Physics, West Germany. The laser uses a neodymium pentaphosphate crystal measuring only fractions of a millimeter long.

The over-all length of the laser system is only a few centimeters, mirrors included. The low power requirements are a result of the relatively long life of neodymium ions in the excited state—as long as 0.1 ms. This, in turn, makes it possible to reduce the exciting energy to less than 1 mW. The researchers are aiming at an eventual exciting energy level of "about 100 μW." The light amplification efficiency of the synthetic laser crystal is now about 30%.

Other advantages cited by the developers are high temperature stability (up to 400 C), resistance to high radiation and relatively simple production. The mini laser is expected to find use in optical transmission-line repeaters.

DF system developed for small airfields

A miniature doppler direction finder for small airfields has been developed by Rhode & Schwarz, Munich, West Germany. The system operates from a 12-V battery, weighs about 67 lb and uses a frequency range of 117.5 to 136.5 MHz. Accuracy is reported better than ±2 degrees.

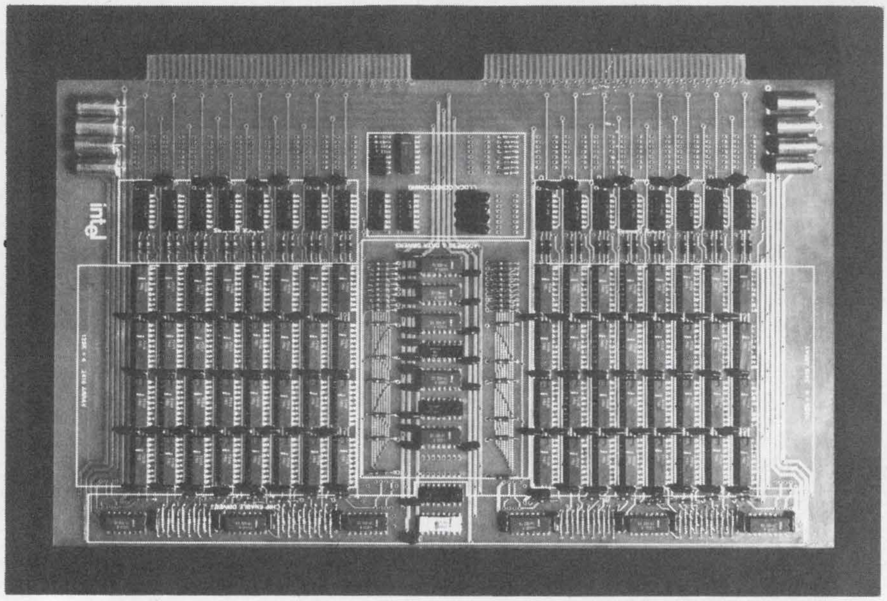
Air-pollution network relies on computers

A network of 14 air-pollution monitoring stations has been put into operation in Bavaria, West Germany. The net will be completed by the end of 1976 and will then have a total of 80 stations. Signals from the stations' sensors are fed into a PDP-11/10 computer, which sends the digital signals via telephone line to a central PDP-11/45. Here the incoming data are processed for continuous evaluation.

Laser diodes may find gas-spectrometry use

Laser diodes emitting at 5 to 8 μm and that may be useful in gas-spectrometry applications have been developed at AEG-Telefunken's Research Laboratories, Ulm, West Germany. Diodes of the PbS-PbSe type, measuring 500 × 200 × 250 μm, are mounted on a copper cooling substrate. The trigger current density is about 60 A/cm at 10 K or 1000 A/cm at 77 K. CW operation was achieved at 30 K. The devices may be fine-tuned by changes in the current that vary the diode's temperature.

CCD serial-memory capacity climbs to 16-k bits of storage



Intel, 3065 Bowers Ave., Santa Clara, CA 95051. (408) 246-7501. P&A: See text.

With the introduction of the first 16-k bit CCD memory chip—Intel's 2416—charge-coupled-device ICs become serious contenders for many mass-storage applications now filled by discs and drums.

The new memory combines a maximum serial-data rate of 2 Mbits/sec with an average access time to any bit of less than 100 μs. And compared with electromechanical storage, the CCD memory requires a fraction of the space and power.

However, Intel's CCD memory may face stiff competition from another 16-k bit chip expected shortly from Fairchild (464 Ellis St., Mountain View, CA 94042). Recently the latter company announced the first CCD memory, a 9-k bit chip, and described a 16-k CCD now being readied for introduction (see "9216-bit CCD Memory a Market Trail Blazer," ED 3, Feb. 1, 1975, p. 22). According to preliminary data, the Fairchild 16-k bit CCD is expected to have shorter access times and higher data rates than the Intel version.

CCD memories combine features of conventional shift registers and RAMs. Like a RAM, the Intel 2416 uses a 6-bit address input to select an internal memory region. However the memory region accessed on the CCD chip is organized as a shift register.

A total of 64 shift registers divide the memory's over-all capacity of 16,384 bits into equal lengths. Hence each of the randomly addressable registers is 256 bits long. And a specific bit location can be accessed, on the average, with only 128 shift operations —half the total length of a register. (Were the 2416 built as a continuous register, 8192 shift operations would be needed on the average, to access a specific bit).

Externally the silicon-gate, n-channel MOS memory requires +12 and −5-V power supplies, four-phase clock signals, address drivers, and control signals for input and output data and to provide chip enable and select.

The four-phase clocks determine the data-shift rate, which varies from about 125 kHz to over 1 MHz over the 0-to-70-C temperature range. Depending on the shift rate, the average access time to any bit ranges from less than 100 μs to 1 ms. (By comparison, rotating memories have an access of over 2/ms to more than 100/ms.) The shift registers recirculate data automatically as long as the four-phase clocks are applied continuously and no write command is applied.

Data rates can be increased to more than 2 MHz by sequential addressing of several registers between successive shift operations. This mode of operation has the advantage of decreased clock-driver power—which always exceeds the dissipation of the memory chip.

At 1-MHz, for example, the chip dissipates about 150 mW, compared with about 400 to 450 mW of capacitive dissipation for the clock drivers.

A 9 × 15-in. developmental board has a storage capacity of 1,048,576 bits, organized as 128 kilobytes (see photo). Of the total number of packages, 30% provide support circuits for the CCD memory chips. The company points out that only eight are needed for a 1-megabyte system.

With interleaving or multiplexing techniques, a board's data rates can reach a maximum of 8 megabytes per second. Maximum access time to read or write data to any location is then 128 μs.

The Intel 2416 comes in two versions. In an 18-pin plastic DIP (prefix P), the chip sells for $55 in quantities of 100 to 999. In a 22-pin ceramic DIP (prefix C), the CCD memory costs $58 at the same quantity level. Delivery is from stock.

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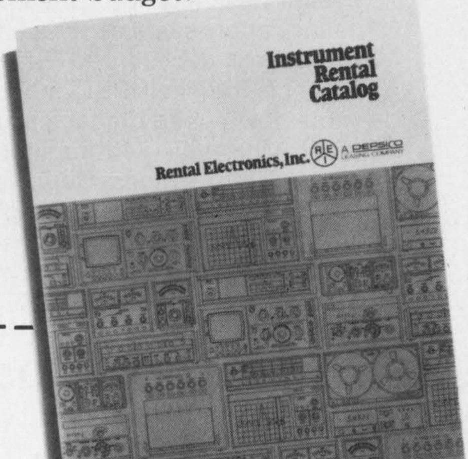

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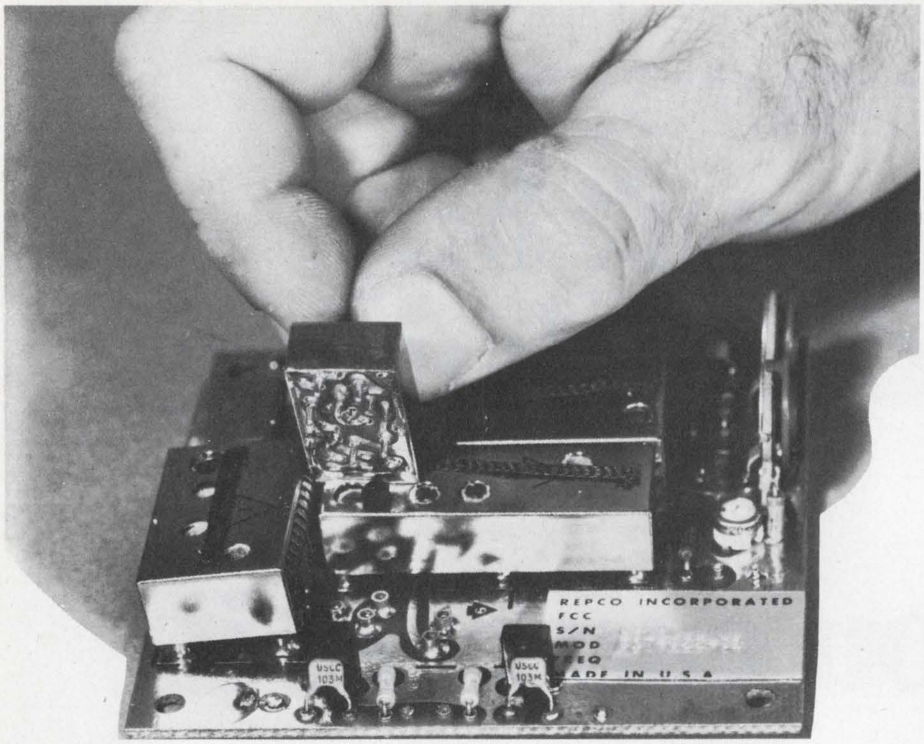
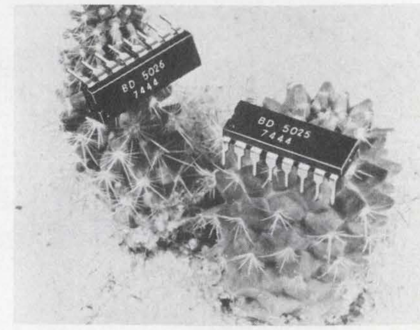


INTEGRATED CIRCUITS

9-digit LED drivers boost densities



Bowmar Arizona, Inc., 2355 W. Williams Field Rd., Chandler, AZ 85224. (602) 963-7361. $1.55 (1000); stock.

Two LED digit drivers, designed primarily for nine-digit hand-held calculators or other multidigit display applications, provide nine MOS-compatible LED digit drivers in a single 16-pin DIP. And each driver can replace two six-digit packages in most calculator applications. Called the BD5025 and 5026, the new bipolar circuits employ a five-input sequential addressing scheme. With a sequential pulsing of the five address inputs, internal logic sequentially multiplexes through all nine outputs. Hence four input lines are eliminated and the circuit is compatible with most of the industry's single-chip calculators. The two circuits are functionally identical, with the design of the BD5025 optimized for 3-to-6-V operation, and the BD5026 for 6 to 9 V. Each driver sinks up to 160 mA.

CIRCLE NO. 307

NOR functions come in CMOS gates

Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. (408) 739-7700. 47¢ (1000).

Four CMOS NOR-gate circuits are interchangeable with like-numbered RCA models. The new circuits are the N4000A dual three-input NOR gate with inverter, the N40001A quad two-input NOR gate, the N4002A dual four-input NOR gate, and the N4025A triple three-input NOR gate. Input resistance is greater than 10^{12} Ω, and input current is less than 10 pA. Fan-out to low-power TTL logic gates is two.

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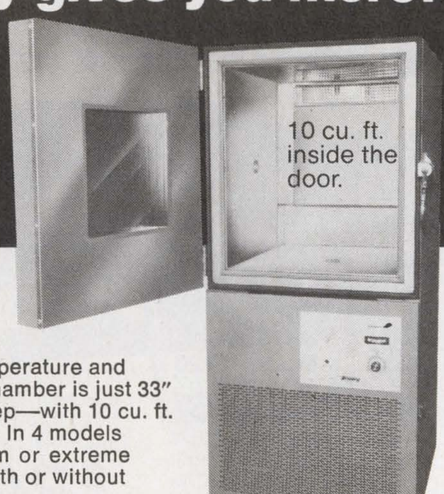

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INFORMATION RETRIEVAL NUMBER 54

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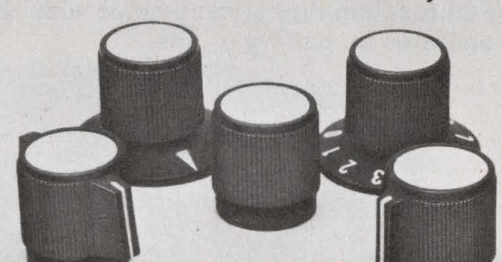

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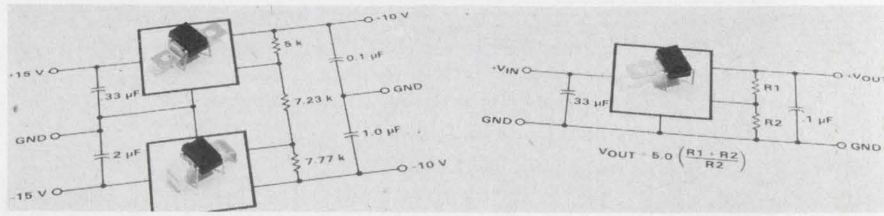
INFORMATION RETRIEVAL NUMBER 55

Programmable voltage regulators handle high power in a mini, 4-pin package

Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94049. (415) 962-2361. 100-up prices: $1.25 (78MG), $1.35 (79MG); stock.



A pair of programmable, four-terminal voltage regulators from Fairchild Semiconductor allow the simple design of fixed or variable regulators. They take advantage of a new packaging scheme that permits efficient heat transfer and easy installation.

The 78MG positive and 79MG negative regulators can be programmed, with a pair of resistors connected to a single pin, to regulate voltages from V_{ref} (5 V for the 78MG and 2.23 V for the 79MG) to approximately 35 V. Both regulators are short-circuit-proof, have thermal-overload protection and are designed for safe-area-limiting of the output transistors. They have 500-mA output current capability, with 1% line and 2% load regulation.

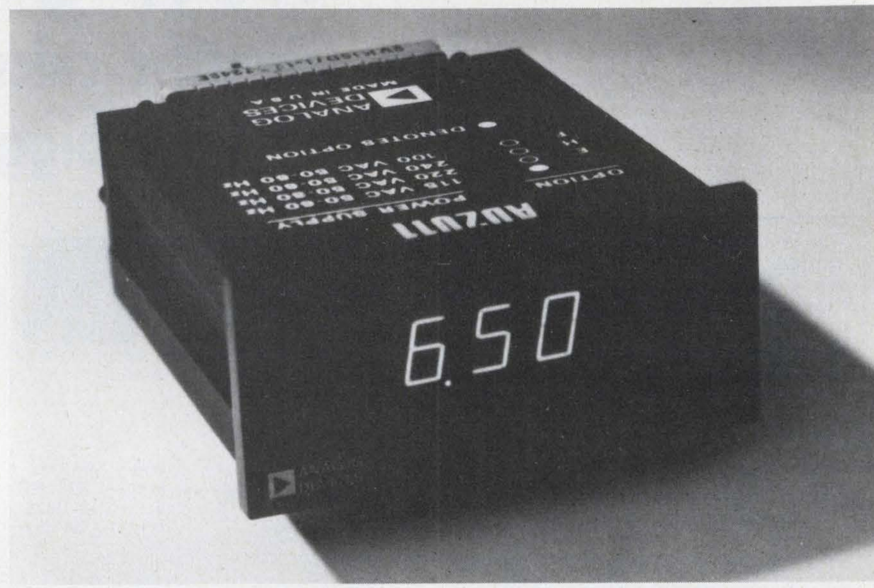
The package consists of a mini-DIP epoxy case with four pins and tinned wings. The wings are 0.24 in. wide and extend from 0.19 to 0.215 in. from the sides of the DIP, depending on bend. The wings can be bent downward (71MGTIC) or bent parallel to the package (71MGT2C). The V style is also available with a single wing.

The package is made from a proprietary epoxy material. Thermally, $\theta_{jc} = 8$ C/W and $\theta_{ja} = 70$ C/W. Power dissipation is internally limited to 6 W, operating temp is 0 to 125 C and storage temp is −55 to +125 C.

Other specifications for the 78-MG include an I_{ref} of 1 μA and an $I_{quiescent}$ of 2.5 nA. For the 79MG, the corresponding specs are 0.3 μA and 0.5 nA. Output impedance is 200 mΩ and temp coefficient 0.5 mV/°C.

CIRCLE NO. 302

3-digit DPM reads rms of complex waveforms



Analog Devices, P. O. Box 280, Route 1 Industrial Park, Norwood, MA 02062. (617) 329-4700. $295; stock.

Truth—like beauty—frequently is in the eye of the beholder. So when Analog Devices points to its 2011 DPM as the industry's first to measure the "true" rms of any ac waveform, you may well ask: Which "true"?

While the line-powered AD2011 does indeed measure and display the rms of a complex waveform, it uses a computing technique to derive the figure—rather than a thermal-input device that responds directly to the rms value. Which technique is more valid depends on whom you talk to.

Philosophical discussions aside, however, the 3-digit Analog Devices unit, which sells for $295, won't wince at pulse trains, triangles, gaussian noise, SCR-chopped sinusoids and the like—provided the crest factor, input-voltage and other limitations aren't ignored.

These limitations, and other specs, vary with the input range. To avoid use of ac attenuators, the 2011 provides four separate full-scale ranges: 1, 10, 100 and 1000 V. On the 1-V and 10-V scales, the crest factor—the ratio of rms to average value—shouldn't exceed 7 at 100% of full scale, and 10 at 25%. The numbers drop to 1.4 and 5, respectively, on the 999-V range.

The maximum safely sustained input varies from 240 V rms (340 V pk) on the lowest scale, to 1100 V rms (1555 V pk) on the highest. Common-mode voltage is limited on all ranges to 300 V rms at 60 Hz.

Since the 2011 is dc-coupled, the unit will include in the measurement any dc levels riding along with the ac waveform. How accurately the meter reads such waveforms is another story.

While the unit's 3-dB frequency response extends from 30 Hz to 300 kHz (10 kHz on the 1000-V scale), accuracy is specified for dc or for sinusoids from 45 to 1 kHz. For these, you can expect ±0.1% of reading ±0.1% fs ±1 digit on the 1-V range. The percentage-of-reading figure deteriorates to ±0.3% on the two middle scales and to ±1% on the highest.

But if you need only one range, that range can be calibrated to keep accuracy at the ±0.1% value. "Typical" errors vary from ±0.5%

(continued on page 108)

RF Microwattmeters– Analog and Digital– FS Sensitivities from 10 nW to 10 mW

MODEL 42B/42BD

Boonton rf microwattmeters offer unrivalled sensitivity: 10 nW fs to 10 mW fs; from 200 kHz to 18 GHz, at highest stability ever attained at these sensitivities. Analog (42 B) or digital (42 BD) versions, both with linear DC outputs and logic-level programmability. BCD outputs are standard on digital version, autoranging and dB display (0.01 dB resolution) optional. Boonton Electronics, Parsippany, N.J. 07054

INFORMATION RETRIEVAL NUMBER 255

Wide-Range Programmable Capacitance Meters

MODEL 72B/72BD

Boonton analog (72B) and digital (72BD) provide rapid, accurate, 3-terminal and differential measurements, at 1 MHz, from 1 pF fs. Measures semiconductor-junction capacitance at low (15 mV) test level, with provision for external DC bias. Phase-sensitive detector measures accurately even at Q=1. Logic-level range programmability and fast-tracking DC output are ideal for ATE. Model 72BD has standard BCD output and autoranging. Boonton Electronics, Parsippany, N.J. 07054

INFORMATION RETRIEVAL NUMBER 256

Direct Capacitance Bridge 0.00005 to 1000 pF and 0.01 to 1000 mho

MODEL 75D

Boonton Model 75D Direct Capacitance Bridge is designed for 1 MHz capacitance and loss measurement. Capacitance range, 0.00005 pF to 1000 pF; basic accuracy, 0.25%. Conductance range: 0.01 mho to 1,000 mho, basic accuracy, ±5%. Internal bias from -6 V to +150 V. Adjustable test level, 1 mV to 250 mV, at 1 MHz. Two modes of operation allow either conventional capacitance and loss measurements or one-control balance for capacitance only. 3-terminal input configuration. Boonton Electronics, Parsippany, N.J. 07054

INFORMATION RETRIEVAL NUMBER 257

INFORMATION RETRIEVAL NUMBER 258 ▶

Happy birthday, price-less.

Introduced just one year ago, our 102A FM/AM Signal Generator is celebrating a well-earned sales success against the HP8640B that once had the market sewn up. It's no wonder when you can save thousands of dollars and still get all you really need.

With our generator you get a well shielded, low noise source from 4.3 to 520 MHz that is both stable in frequency and accurate in level. We've shrunk warmup to 15 minutes and weight to 30 lbs.

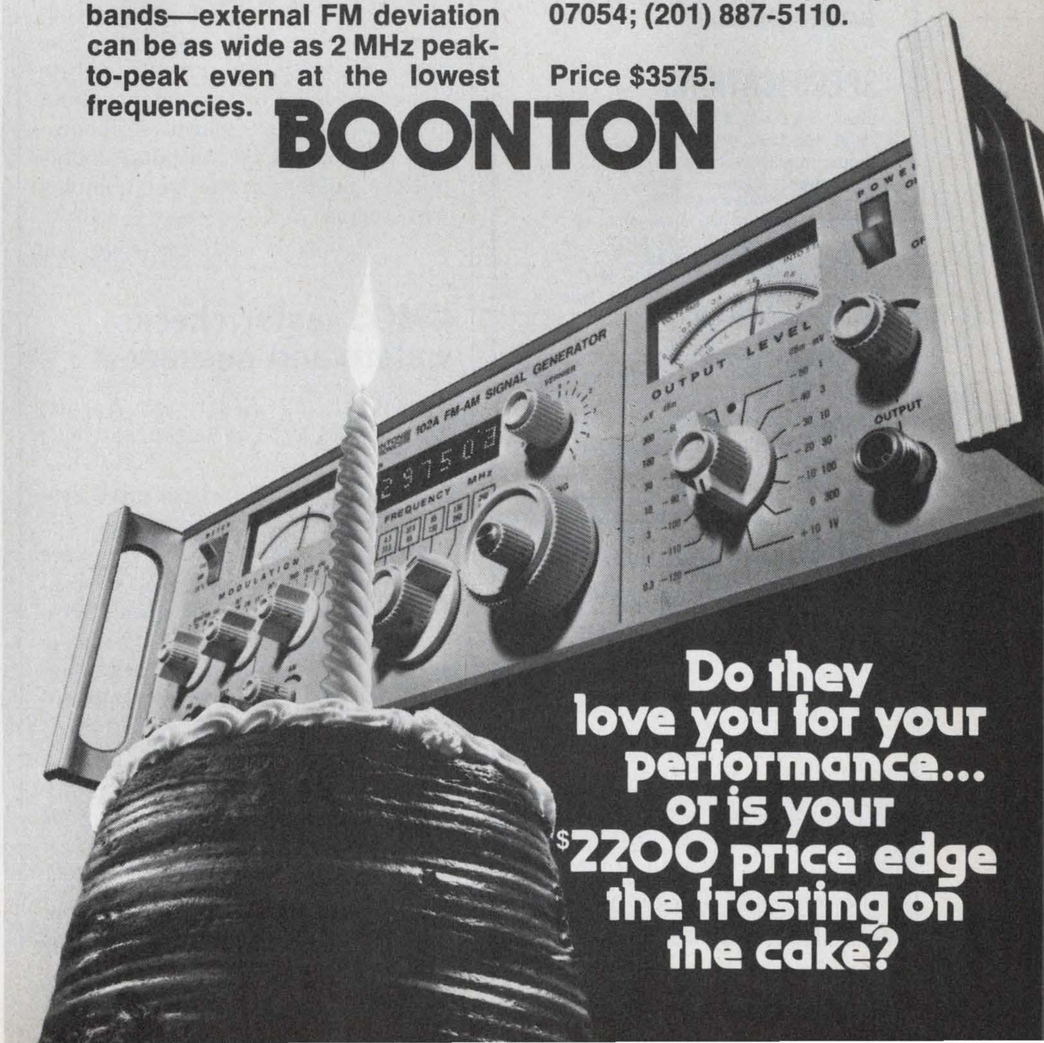
We have the best residual FM spec around: 100 Hz resolution with a 6-digit display, individual metering of modulation and RF output, true peak monitoring, and 0-300 kHz internal FM deviation on all bands—external FM deviation can be as wide as 2 MHz peak-to-peak even at the lowest frequencies.

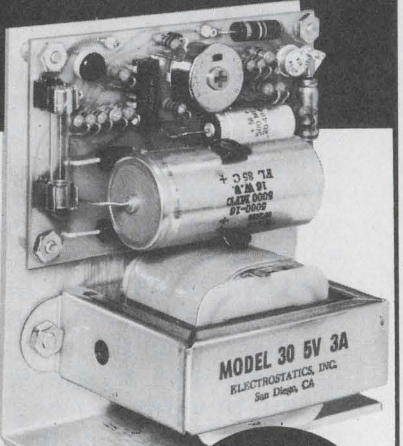
The 102A is engineered for your convenience. That's why we've designed a front panel that is easy-to-use and understand, why we have the specifications decaled on the top of the instrument in plain view, why we've added a unique adjustable "feel" main drive mechanism for easy narrow-band receiver setting, and why we have a full list of optional goodies—like a detected AM output to verify our negligible phase-shift for VHF omni-testing, fused RF output with replaceable elements, and external clock input.

Call or write today for data and/or a demo and you'll call the 102A price-less, too. Boonton Electronics Corp., Rt. 287 at Smith Rd., Parsippany, N. J. 07054; (201) 887-5110.

Price $3575.

BOONTON





INSTRUMENTATION

(continued from page 106)

for a symmetrical square wave to ±0.9% for pulse trains with 10% duty cycle and SCR-controlled waveforms fired at 90 degrees. In any case, a voltage-frequency limit of 10^6 V-Hz must be observed (10^7 V-Hz on the 1000-V scale).

Other features of the 2011 include a Beckman gas-discharge display and a floating, opto-isolated input.

CIRCLE NO. 301

Pulse/delay gen offers ±30-V offset/±30-V out

Instrument Research Co., Box 231, Lincoln, MA 01773. (617) 897-7647. $1255; 30 days.

Model 910 is a modular, multichannel pulse-delay generator that can directly drive all presently used logic families, including MOS and HTL, without interface converters. The 910 does this by providing a ±30-V offset range coupled with a ±30-V amplitude. The unit's channels (four) can operate either as delay or pulse generators, and this feature permits generation of multiphase outputs, double pulses, pulse bursts and complex waveforms.

CIRCLE NO. 308

CMOS tester checks wafers and packages

Teradyne, 183 Essex St., Boston, MA 02111. (617) 482-2700. $90,000; 20 weeks.

The J295 computer-operated system performs functional and dc parametric tests on CMOS devices at both the wafer level and in final packaged form. Two clock pulse generators are included in the basic system for use during functional testing. The pulses are programmable in amplitude, delay and width. For parametric testing, the J295 can force voltage while measuring current or force current while measuring voltage. A differential-voltage measurement capability is included.

CIRCLE NO. 309

Temperature indicator handles 6 TC types

Doric Scientific, 3883 Ruffin Rd., San Diego, CA 92123. (714) 565-4415. $799; 45 to 90 days.

The 402 digital temperature Trendicator is the third model of the company's Series 400 family. It will accept any of six thermocouple (TC) types (J, K, T, R, S or B) and will display in degrees F or C. The 1-degree-resolution unit uses six interlocking pushbuttons to select TC type and provides a 0.6-in.-high planar display in a panel mounting DIN package, 72 × 144 × 173 mm. It can be used with grounded or floating TCs. Included are dual-slope integration, auto-zero, digital linearization, and noninterfering TC break detection.

CIRCLE NO. 320

Ergonomic scope is No. 2 in new line

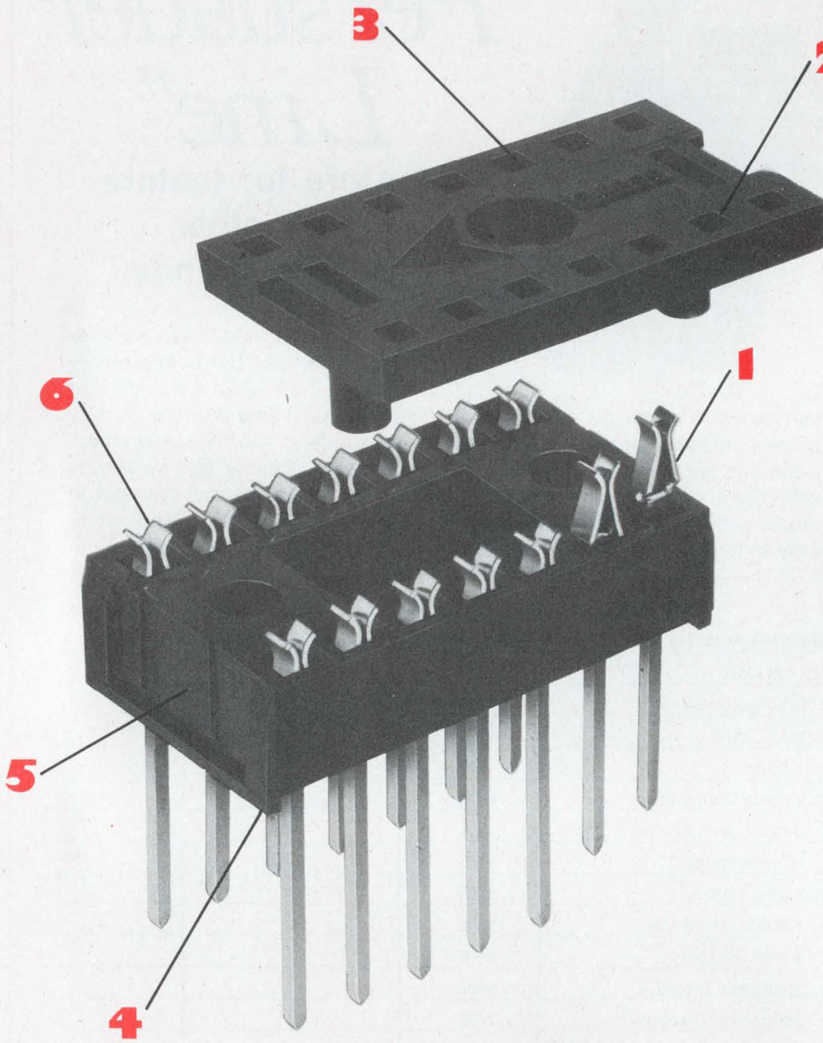
Philips, P. O. Box 523, Eindhoven, the Netherlands. $1470 w/o probes.

PM 3240 dual-beam scope offers a sensitivity of 5 mV and a bandwidth of 50 MHz. The unit belongs to the same family as the recently introduced PM 3260, a scope that stresses ergonomic design. Like the PM 3260, the new instrument has an 8 × 10-cm screen and bright trace at the highest sweep speeds. And at only 8 kg (18 lb) it weighs even less than its companion instrument. The front-panel layout is very logical, with the controls split into four vertical sections—Ya, Yb, delayed and main time base, with all the main controls on exactly the same level.

CIRCLE NO. 321

All sockets look alike, but......

While *some* socket manufacturers include *some* of the features and advantages of a Scanbe socket *some of the time*, no manufacturer can include *all* the features *all of the time*...except us.



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provide greater contact pressure.

2 CLOSED ENTRY DESIGN
accurately guides I.C. leads into contacts.

3 TAPERED ENTRY CHANNELS
insure that I.C. leads enter contacts in perfect alignment.

4 SOLDER RELIEF
keeps solder from wicking into contacts.

5 PRECISION MOLDED
cap and body assures accurately positioned and aligned pins.

6 MATERIAL
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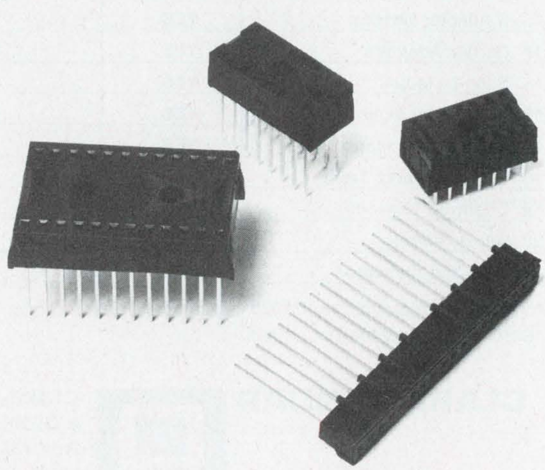
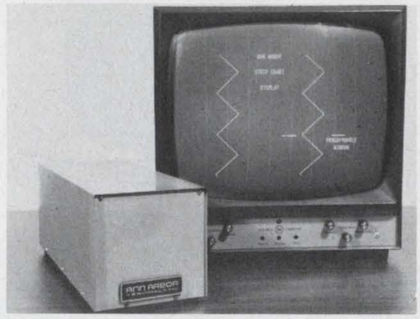


Scanbe Manufacturing Corp.
3445 Fletcher Avenue
El Monte, California 91731
Tel: (213) 579-2300

SCANBE
CANOGA INDUSTRIES

INFORMATION RETRIEVAL NUMBER 61

Controller converts monitor to strip-chart 'recorder'



Ann Arbor Terminals, Inc., 6107 Jackson Rd., Ann Arbor, MI 48103. (313) 769-0926. $1895 (single trace); 45-60 days.

Imagine a strip-chart "recorder" with no chart paper, no pen, no ink and no moving parts. Sounds impossible?

Your daydream can be realized if you change the word "recorder" to "display" and design an interface controller that sits between a computer and a standard 525-line TV monitor—as Ann Arbor Terminals did.

The company's Series 200 CRT strip-display controller converts 15-bit data to a composite video signal that produces a continuously moving, strip-chart-like trace on the CRT. The trace enters at the top of the field and spills off at the bottom, so that the vertical axis represents time; and the horizontal, amplitude.

Single trace is standard on the controller, with dual trace optional. Since amplitude excursions and "chart" speeds are under program control, speed changes are automatic and practically instantaneous. This means that there's no information loss between speeds, or error build-up to worry about over long "chart" runs.

With a graphic field (which occupies 80% of the screen) of 192 sample points and a maximum sample rate of 60 Hz, the fastest trace covers top to bottom in 3.2 s. And unlike galvanometer recorders—which restrict pen movement—traces can roam over the full field at will, and adjacent traces can overlap.

One feature that few recorders can boast—but which the Ann Arbor controller can—is alphanumerics: 64 upper-case ASCII characters in a format of 16 lines with 80 characters per line. Also under program control, the alphanumerics can indicate chart speeds, scales and other information. In some instances, Ann Arbor says, you can get a numerical readout of a bipolar signal level, similar to that of a DPM.

Both the graphic and alphanumeric fields are centered and superimposed. While both fields occupy the same height—16 character spaces, or 192 sample points—the graphic width is 4/5 that of the alphanumeric.

On top of both fields is still another: eight vertical grid lines at half brilliance that extend the full screen height. These, of course, are analogous to the X-Y grid of standard chart paper, with the X lines missing.

A programmable "window," which consists of two separated horizontal line segments, appears on the 128th sample line. The position along the horizontal and the length of the segments and gap are controllable so that a limit, or excursion, indicator can be set up.

Why buy a recorder that doesn't record? Many applications are ones of monitoring and don't need hard copy. Or perhaps you can store data more conveniently on tape rather than on stacks of paper.

But the Series 200 offers a number of advantages over electromechanical recorders: no wear, no hysteresis, operation at analog input frequencies to 30 Hz (computer-input signal), an amplitude resolution of about 0.4%, a rise time of 16.6 ms and a power drain of only 30 W.

The Ann Arbor controller is also available as a plug-in board set for OEM applications. Multidrop expansion to 16 individually addressable controllers is standard.

CIRCLE NO. 303

Microprogrammed minis are 32-bit machines

Systems Engineering Labs, 6901 W. Sunrise Blvd., Fort Lauderdale, FL 33313. (305) 587-2900. See text; stock.

The SEL 32/50 and 32/55 minicomputers mark the beginning of a 32-bit series dubbed SEL 32. Designed for OEM use, the 32/50 (about $18,000) features separate microprocessor I/O controllers that simplify interfacing. The 32/55 for end users (prices start at $25,000) has a complement of equipment that includes two floating-point processors, mass-storage and shared memory. All members of the SEL 32 Series use microprogrammed firmware and use single bus structure with throughput rates up to 26.6 Mbyte/s. All members of this series can directly address 16 Mbytes; initial models can use up to 1 Mbyte of memory.

CIRCLE NO. 322

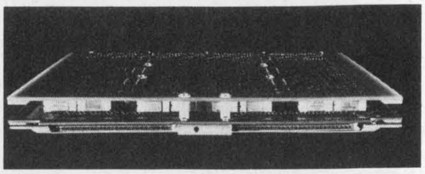
Printer uses monorail for 600 line/min speed

Data Printer Corp., 600 Memorial Dr., Cambridge, MA 02139. (617) 354-4700. $9675.

Character-links that ride on a monorail track help the CT-6644 printer provide good copy at 600 line/min. The unit prints any of 64 characters with 132-character line length. The price includes a sound-deadening enclosure plus a single-line buffer memory.

CIRCLE NO. 323

CMOS memory module meets Mil temp range



Rolm Corp., 18922 Forge Dr., Cupertino, CA 95014. (408) 257-6440. $11,000; 150 days.

An 8-k CMOS memory module is available that operates over the Mil temperature range of −55 to 95 C. The Model 2032 RAM is up to 60% faster than conventional core memory yet requires only 30% as much operating power as the same amount of core. The unit features static memory that does not need refreshing, an extremely low standby current requirement (less than 25 μW at 3 V), and plug-in installation in the Rolm computer chassis.

CIRCLE NO. 324

Software driver helps upgrade to disc OS

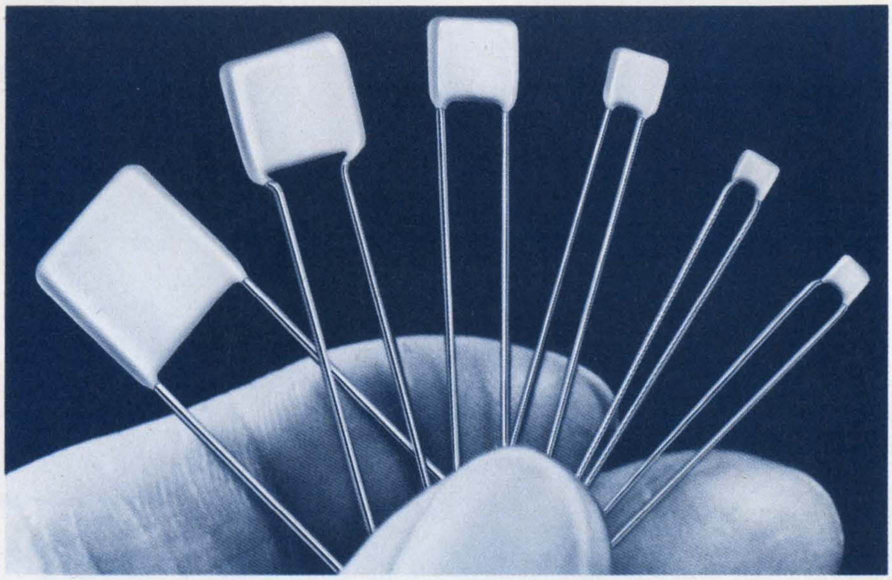
Sykes Datatronics, 375 Orchard St., Rochester, NY 14606. (716) 458-8000. See text; stock.

Software drivers can now interface the manufacturer's flexible disc memory with two DEC PDP-8 operating systems—the 4K Disc Monitor System and OS/8. As the system disc, the unit can handle all support programs such as BASIC, Fortran, assemblers, editors and utility routines. Users with 4K PDP-8 systems that have limited I/O can be upgraded to become disc operating systems. The drivers are available at a nominal cost of $50 along with the purchase of the flexible disc memory called the SYKES disc. Diskettes written on the Sykes drive are compatible and directly interchangeable at all levels with IBM 3740 systems. The disc controller automatically performs the following functions: sector search, track sequencing, record blocking, generation and check of IBM sync and CRC characters, address verification prior to reading and writing every sector, head unload, and bootstrap. The storage units are available in single and dual drive systems and a typical system sells for $3700.

CIRCLE NO. 325

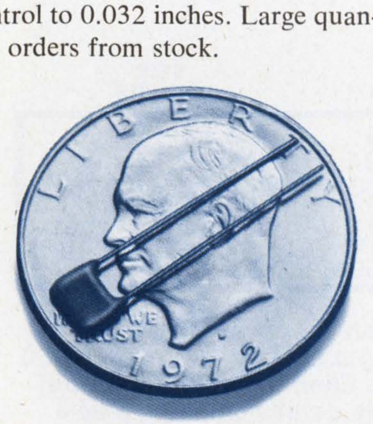
QUALITY IN VOLUME

When you achieve it, you can offer true competitive value. That's just what we're doing at USCC/Centralab for 1975. MONO-KAP™ radial, and MONO-GLASS axial monolithic ceramic capacitors are now available to volume users *from stock* to eight weeks. Our investment and "learning curves" last year guarantee competitive responsiveness – USCC will welcome your specials and non-stock orders. Here's an offer you haven't heard lately – your money is going to buy more at USCC. Cash in on the best values in monolithic ceramic capacitors.



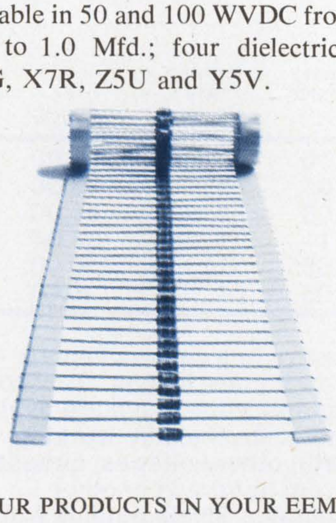
DISCRETE ASSEMBLY

MONO-KAP™ radial-leaded epoxy coated capacitors are reliable performers; they're rugged enough to work in MIL environments. 4.7 pF to 10 Mfd., 50 to 200 WVDC in 4 dielectrics, including Z5U, in a variety of case sizes featuring meniscus control to 0.032 inches. Large quantity orders from stock.



AUTOMATIC INSERTION

MONO-GLASS axials are glass encapsulated, designed for automatic PCB insertion; furnished reel-packed for high volume applications. They're available in 50 and 100 WVDC from 1 pF to 1.0 Mfd.; four dielectrics: COG, X7R, Z5U and Y5V.



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INFORMATION RETRIEVAL NUMBER 65

Calculator gains versatility with PROM

Sharp Electronics Corp., 10 Keystone Place, Paramus, NJ 07652. (201) 265-5600. $645.

A scientific calculator, the Model PC-1002, performs 15 scientific functions and has 10 built-in programs. The calculator has a special-application PROM with 256 programming steps. These can be divided into four separate program groups operated by an independent set of keys. There are four models. Each has a PROM that is programmed for different applications: statistics (providing mean, standard deviation, standard error, linear regression); mathematics (law of sines and cosines, perimeter and area); and surveying. The 15 functions of the PC-1002 include trigonometric, inverse trigonometric, hyperbolic, exponential, logarithmic, factorial, power, azimuth, and area calculations. An operator can also program the unit with up to 64 steps, apart from the PROM. The calculator has a 10-digit mantissa, two-digit exponent, and eight memory registers.

CIRCLE NO. 326

Prototyping boards now available for PPS-8

Microelectronics Div., Rockwell International, P.O. Box 3669, 3430 Miraloma Ave., Anaheim, CA 92803. (714) 632-3279. See text.

Samples of Rockwell's PPS-8 microcomputer system are now available as prototype boards. The first system, priced at $600, includes CPU, two RAMs and two general-purpose I/O chips. The second unit, priced at $700, includes CPU, two RAMs, a parallel data controller and direct-memory access unit.

CIRCLE NO. 327

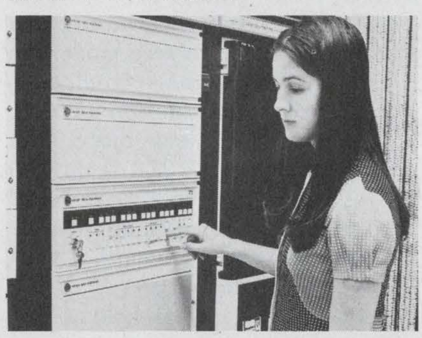
Graphics CRT designed for multi-user systems

Digital Equipment Corp., 146 Main St., Maynard, MA 01754. (617) 897-5111. $10,000; 90 days.

An interactive graphics terminal, designated the EG-11, with its 17-in. display, operates with PDP-11/40 and PDP-11/45 computer systems. It provides Fortran-IV compatible graphics capability when used with Digital's multi-user RSX-11 software. A typical RSX-11 system with 24k words of memory, can accommodate a single EG-11 terminal. A PDP-11 with 64k words of memory, 40 Mwords of disc storage and an RSX-11D or M operating system can support up to four graphics terminals along with other peripherals and consoles.

CIRCLE NO. 328

Low-cost mini added to V-70 series

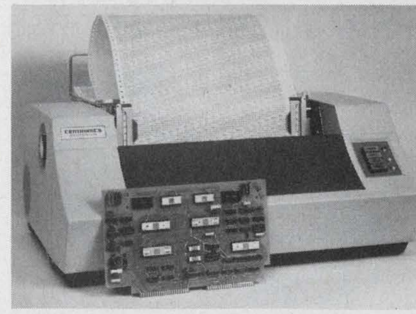


Varian Data Machines, 2722 Michelson Dr., Irvine, CA 92664 (714) 833-2400. $8000; March.

A low-cost systems computer, designated V-71, offers up to 32 kwords of memory at a cost of $8000 (qty 12). Basic V-71 computers include 16 kwords of 1200-ns core memory, I/O bus with DMA, chassis, power supply and programmer console. The V-71 is the fourth unit of the V-70 series and is priced to be the least expensive. The V-71 can be selectively expanded in terms of processor options, I/O structure and memory size. With options, the V-71 handles a comprehensive blend of hardware, systems software (including the VORTEX operating system) and extensive peripherals. Options on the V-71 include a writable control store, power fail/restart, TTY controller, automatic bootstrap loader for TTYs and a real-time clock.

CIRCLE NO. 329

Serial printer operates at 330 characters/s



Centronics, 1 Wall St., Hudson, NH 03051. (603) 883-0111. $4675; 60 days.

The Model 102AL is a 132-column serial impact printer, which uses LSI (Large Scale Integration) electronics and has a printing speed of 330 characters per second (125 lines per minute). Modular design of the electronics package on one PC board increases maintainability by minimizing parts and provides for flexible interfacing. The 102AL will produce an original plus up to four carbon copies. The last printed line is visible for immediate reading. The standard mode produces a line of elongated boldface characters on command. The printer uses the dot matrix technique for generating characters in a 9 × 7 pattern. Popular computer and communications (up to 9600 baud) interfaces are available as options.

CIRCLE NO. 330

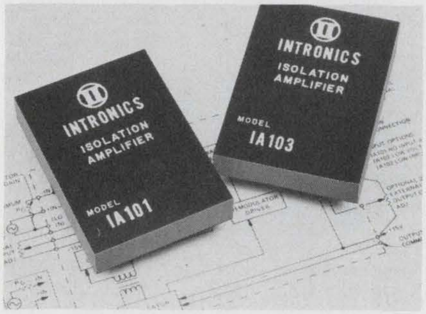
Low-cost couplers have 450 baud data rates

Omnitec Corp., 2405 S. 20th St., Phoenix, AZ 85034. (602) 258-8246. See text.

Priced well under $250 (qty), the 400 Series acoustic couplers offer 450 baud rates, RS232 (EIA) interfacing, full or half duplex operation and good sensitivity. These units are also offered as coupler kits for built-in installation.

CIRCLE NO. 331

Amplifier provides 5-kV input/output isolation

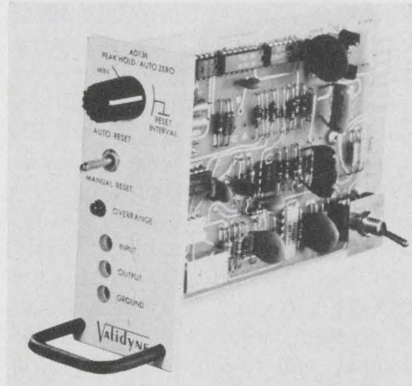


Intronics, 57 Chapel St., Newton, MA 02158. (617) 332-7350. From $125; 2 to 4 wk.

The IA100 series of isolation amplifiers provides high input impedances, good input-output isolation, high common-mode rejection rates, and good linearities. There are four models in the series, with minor component changes to optimize each in a particular area. The IA101 is a unity gain buffer; the IA102, a low drift adjustable gain model; and the IA103/104s are low input current adjustable gain amplifiers. All units have accuracies of ±0.01% and input-output isolation capability of 5000 V. The input impedance is 10^9 Ω shunted by no more than 10 pF. An additional feature of the IA100 series is a floating ±15-V supply, which is isolated from the output and can be used to power transducers that feed the amplifier. The units are packaged in 2.5 × 3.5 × 0.9 in. cases with gold-plated pins suitable for either socket or printed circuit board mounting.

CIRCLE NO. 332

Sample/hold amplifier has auto-zero feature

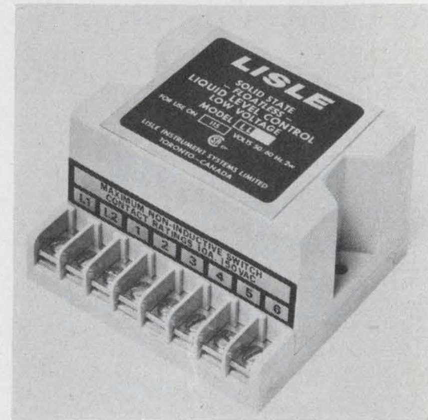


Validyne Engineering, 19414 Londelius St., Northridge, CA 91324. (213) 886-8488. $250; 4 wk.

The AD136 peak-hold/auto-zero plug-in sample-and-hold circuit is designed for use in the company's MC1 module case system. The unit has a digital counter and a digital-to-analog converter, which combined, provide extended hold times without the leakage of voltages usually associated with analog s/h circuits. In the auto-zero mode, the AD136 accepts signals from 0 to +10 V with a resolution of 0.01 V. In the peak-hold mode, the AD136 tracks any signal from 0 to +10 V, and can hold that input until a larger signal is applied, or until reset to zero. The output voltage will be within ±0.01 V of the input voltage. The peak-hold circuit will track input signals with slew rates up to 0.4 V/ms. For recurrent signals with higher slew rates, the AD136 will advance on successive cycles until the peak value is reached.

CIRCLE NO. 333

Liquid level controller has no moving parts



Lisle-Metrix Ltd., 49 Sheffield St., Toronto, Ontario, Canada. M6M-3E5. (416) 249-9151. $45 (U.S.) (unit qty.); stock.

The LL liquid level controller uses a probe to electrically sense the liquid level. This eliminates mechanical problems inherent in float type units. The unit uses very low ac voltage applied to the probe and is completely safe for use with all types of liquids in any environment. Sensitivity of the LL can be adjusted in the field, thus permitting the unit to be used with a wide variety of fluids. Internal circuitry and terminal connections have been arranged so that two models are required to perform all normally required functions, including high or low level alarm, lock-in, lock-out, or cut-off service as well as differential level pump-up or pump-down control. The controllers are housed in a chemically resistant ABS plastic enclosure.

CIRCLE NO. 334

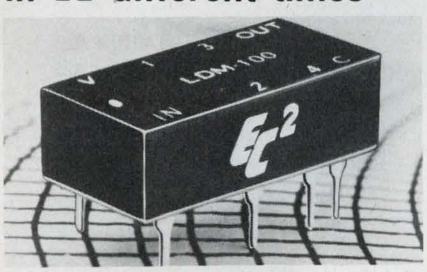
Sine wave oscillator has 10:1 tuning range

Kinetic Technology, 3393 De La Cruz Blvd., Santa Clara, CA 95050. (408) 296-9305. $19.50 (100-up); 4 to 6 wk.

The OS-550 double-DIP hybrid modules are solid-state sine wave oscillators. Frequencies to a 1% tolerance can be provided between 100 and 3000 Hz. The DIP case measures 0.82 × 0.7 × 0.225 in. The oscillator requires from ±6 to ±18 V for operation. At ±12 V, current is approximately 5 mA and output levels to 7 V rms are obtainable. No external components are required but frequency tuning over a 10 to 1 range can be achieved with an external potentiometer.

CIRCLE NO. 335

Digital delay available in 11 different times

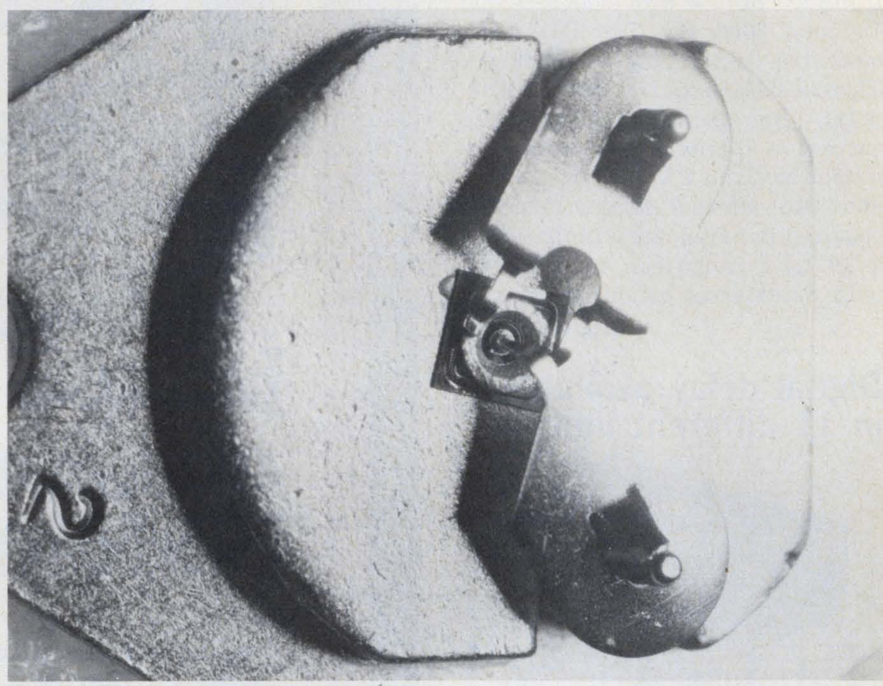


Engineered Components Co., 3580 Sacramento Dr., San Luis Obispo, CA 93401. (805) 544-3800. Under $20 (small qty.); stock.

The LDM logic delay module provides precise tapped delays with required driving and pick-off circuitry in a single DIP package. The LDM is available in 11 delays from 25 to 250 ns. Each module has taps at the 20% increment point of total delay. Tap tolerance is maintained at ±3 ns or ±5% (whichever is greater) of nominal tap delay. Tolerance on total delay is maintained at ±5%. Temperature coefficient of delay is approximately +500 ppm/°C over the operating temperature range of 0 to 70 C. Rise time for all modules is 4 ns maximum, when measured from 0.75 to 2.4 V. The DIP series of modules is packaged in a molded, flame-proof Diallyl Phthalate case per MIL-M-14, type SDG-F, and is fully encapsulated in epoxy resin. Package size is 0.4 × 0.8 × 0.25 in.

CIRCLE NO. 336

Gate turn-off SCRs handle up to 8.5 A



RCA Solid State Div., Route 202, Somerville, NJ 08876. (201) 722-3200. P&A: See text.

Can you get an SCR that doesn't need any extra turn-off circuitry? Until recently you couldn't. Now the TAG5000 series of gate turn-off (GTO) SCRs from RCA eliminates the extra circuitry. All that's required is a positive pulse on the gate for turn-on and a negative pulse for turn-off.

There are 12 SCRs in the TAG-5000 series, as shown in the table. All of them have a maximum forward dc current of 8.5 A and can operate at case temperatures of 75 C. Larger currents of up to 15 A can be controlled if the case temperature can be kept to 25 C.

For the device suffix classifications—A, B, D and M—the repetitive peak off-state voltages are 100, 200, 400 and 600 V, respectively. As a tradeoff for the high blocking voltages, you pay the price of low, repetitive-peak-reverse voltages of 70, 50 or 30 V for the 5001, 5002 and 5003 SCRs, respectively.

To turn on these SCRs, you need a positive-going, 0.7-to-1-A current pulse applied to the gate for about 3 μs or longer. The forward gate curve looks like that of a forward conduction diode with a voltage drop of about 1 V.

The GTO can be turned off by a negative-going voltage pulse applied to the gate. No reduction of the anode current is necessary to produce turn-off. The TAG5001 offers the fastest switching speed but requires a negative pulse of −70 V. Similarly, the 5002 and 5003 require −50 and −30 V, respectively, for turn-off.

The gate controlled turn-on time

100-to-999 prices for the GTO series SCRs

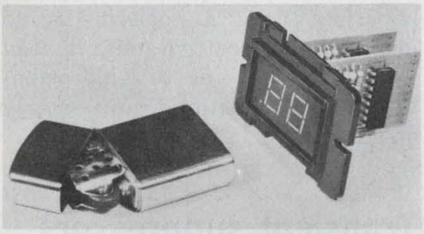
Type Number	Suffix A	Suffix B	Suffix D	Suffix M
TAG5001	$4.80	$5.76	$6.90	$8.34
TAG5002	$4.20	$5.05	$6.12	$7.44
TAG5003	$3.00	$3.60	$4.50	$6.54

ranges from 2 μs for the 5001 to 3 μs for the 5003. Turn-off times, though, range from a low of 2 μs for the 5001 to a high of 20 μs for the 5003. Test conditions for these results are as follows: for turn-on time measurements, $V_D = 100$ V, $I_T = 5$ A, $I_g = 1$ A and $T_C = 25$ C; for turn-off time, $V_D = 100$ V for all A types and 200 V for all others, $I_T = 5$ A, $Z_{GS} = 1\ \Omega$, and $T_C = 125$ C.

All of the devices are available in sample quantities from stock with TO-3 metal packages. Large production quantities will be available in late 1975. The prices for the 12 models are shown in the table for 100-to-999 quantities.

CIRCLE NO. 304

LED numeric assemblies have driver options



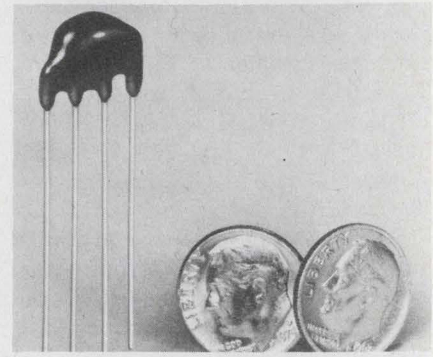
Dialight, 203 Harrison Pl., Brooklyn, NY 11237. (212) 497-7600. $37.85/3 digits (100-up); 4 to 6 wk.

The 749 series numeric LED readout assembly is available with or without decoder/drivers in a black bezel, for simplified panel mounting or multidigit groupings. The display has a character height of 0.27 in. When supplied with decoder/drivers, or latch and counter options, all components are mounted on a printed-circuit board, with terminations for automatic blanking of leading and/or trailing edge zeros, and intensity control. The user has the option of hard wiring to the board or using edge card connectors. All digits include a left-hand decimal point. A polarity overflow module is also available. The decoder/drivers, one for each character, require an 8421 BCD code. The unit also contains a lamp-test input that overrides all other inputs and can check for a possible display malfunction.

CIRCLE NO. 337

DISCRETE SEMICONDUCTORS

Bridge rectifiers made to handle 0.75 A

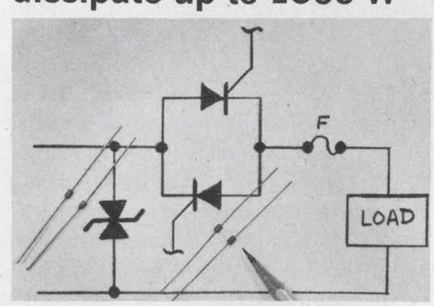


General Instrument, 600 W. John St., Hicksville, NY 11802. (800) 645-1247. 75 KBD02: $0.20 (25,000-up); 3 to 4 wk.

The 75 KBD series single-phase bridge rectifiers are miniature 0.75-A silicon units rated from 50 to 1000 V PRV. All units in the series have a peak surge overload rating of 30 A and an operating temperature range of −55 to +125 C. The miniature bridge rectifiers have a colored dot to identify the positive output lead for double-checking of unit orientation in production-line assembly operations.

CIRCLE NO. 338

Transient suppressors dissipate up to 1500 W

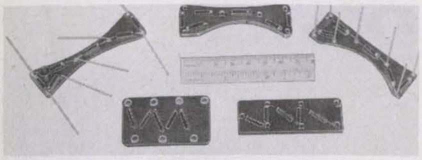


Microsemiconductor Corp., 2830 S. Fairview St., Santa Ana, CA 92704. (714) 979-8220. From $3.55 (100-up); stock to 30 day.

A line of silicon transient suppressors provides either symmetrical or unidirectional circuit protection from voltage transients. The devices dissipate peak-pulse power surges of 500 W (1 ms) in DO-35 packages or 150 W (1 ms) in DO-41 packages. Breakdown voltages range from 6 to 200 V ±10%. Dynamic impedance spans 1.5 to 175 Ω, depending on breakdown voltage.

CIRCLE NO. 339

High-voltage rectifier stacks custom designed



Electronic Devices, 21 Gray Oaks Ave., Yonkers, NY 10710. (914) 965-4400. $375 for 1000 pcs; 4 to 6 wk.

Custom tailored diode matrices facilitate the assembly of high voltage multipliers for color television and similar applications. These assemblies consist of five or six high voltage diodes cast in an epoxy with through-hole or wire lead terminations at each interconnection. Capacitors, resistors, terminals and lead wire can be easily attached.

CIRCLE NO. 340

Disc power diodes handle currents to 850 A

AEG Telefunken, D 6000 Frankfurt 70, AEG Hochhaus, West Germany.

Disc power diodes, types D280 and D480, have effective forward current ratings of 620 and 850 A, respectively. Model D280 has a maximum cyclic PIV of 1800 V and the D480 has a max of 2800 V. Pulse currents of 5300 and 7300 A can be withstood by the D280 or D480, respectively.

CIRCLE NO. 341

Optical isolator handles voltages up to 10 kV

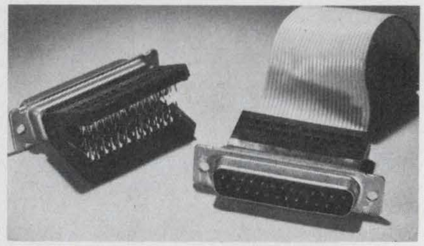
Optron, 1201 Tappan Circle, Carrollton, TX 75006. (214) 242-6571. $2.90 (1000-up); stock.

The OPI 110 high voltage opto-isolator consists of an npn phototransistor coupled with a GaAs infrared emitter mounted in a plastic package. The isolator has an input-to-output isolation voltage of 10 kV, a typical current tansfer ratio of 40% and an input current of 10 mA. Typical switching time of the OPI 110 is 4 μs. The OPI 110 is housed in a cylindrical package that has a 0.3 in. diameter and is 0.5 in. long.

CIRCLE NO. 342

PACKAGING & MATERIALS

Connector terminates cable ends en masse



AMP Inc., Harrisburg, PA 17105. (717) 564-0101. See text.

A fast, economical means of mass-terminating flat, round-conductor cable to pin and socket contacts is now available in the HD-F series of Amplimite connectors on a sample basis from AMP. Production is scheduled for early 1975. This series mates with AMP's standard HD-M and HD-P high density subminiature rectangular connectors. The insulation-piercing contacts are pre-loaded in the housing and use a special two-fork crimp design that penetrates the cable from opposite sides, interlocks and traps the conductor. The connector accommodates cable with solid or stranded conductors on 0.050-in. centers without any cable preparation other than cutting the end square. A 25-position version is now available with a 37 position to follow. Housings are thermoplastic and have integral cable guides and strain relief. Only a simple arbor press is needed to close the housing and terminate all contacts simultaneously. The current rating is 1 A and dielectric strength is 500 V. Contact life is 500 cycles.

CIRCLE NO. 343

Tool nimbly handles wafers and chips

Unitool Corp., 3740 Skypark Dr., Torrance, CA 90505. (213) 378-2323.

Chips can be picked up and aligned with Unitool's vacuum-type Roto-Pic. Wafers can be lifted from trays and boats for inspection. The tool reduces manual handling and provides positive hold and release characteristics. The unit operates on standard shop air. Easily replaced tips come in various sizes. A kit that includes a vacuum pump and hoses is available.

CIRCLE NO. 344

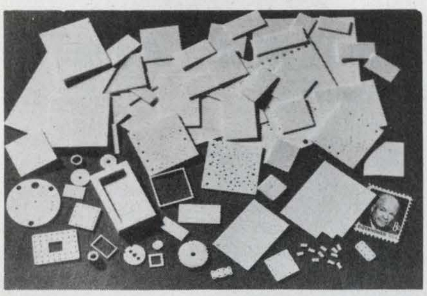
Wrought-gold contacts use little gold

Vector Electronics Co., Inc., 12460 Gladstone Ave., Sylmar, CA 91342. (213) 365-9661. R724: $1.50; R724-2: $0.88; (100-500) stock.

Vector's R724 and R724-2, 24-pin LSI sockets provide the low-contact resistance of gold-plating with a price approaching conventional nickel-plated units. The sockets use wrought-gold strips that are metallurgically bonded to copper-nickel alloy contacts. Since the gold strips are placed only where device leads contact the terminal, the amount of gold required is reduced. The smooth surface of the 50-microinch wrought inlay provides lower contact resistance than the porous surface of a conventional gold plate. The R724 sockets are standard 0.280-in. height units with 0.690-in. leads for wrapped-wire termination. The R724-2 is a low profile, 0.150-in. socket with 0.150-in. leads for solder interconnections.

CIRCLE NO. 345

Ceramic substrates in 3-week delivery



Comco Inc., 9421 Telfair Ave., Sun Valley, CA 91352. (213) 768-5450. See text.

Comco offers 3-wk deliveries for both black and white custom ceramic substrates. There is no tooling charge for square or rectangular substrates and extremely low tooling costs for other designs, according to Comco. Product capabilities include 96% alumina and microsurface 99.5%, Al_2O_3 substrates. The microsurface substrates provide surface finishes of 4 micro-in., or better, as fired. All types are available in an almost infinite variety of custom sizes, shapes and hole patterns. Scored True-Snap substrates provide exceptionally clean breaks regardless of the number of firing cycles.

CIRCLE NO. 346

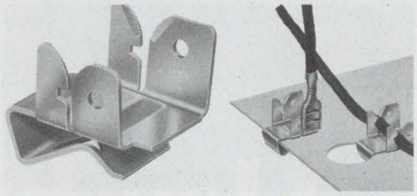
Label printer makes king-sized labels

Diamond Engineering Corp., 3655 150th N.E., Redmond, WA 98052. (206) 883-1071.

An automatic label printer produces king-sized labels with variable-sized letters and numerals. The labels are fed from a perforated, continuous roll. Label width can be 4-3/8 to 14-7/8 in. A variety of adhesives, including self-adhesive stock, can be employed in the printer. The printer can produce four-lines of characters in about 15 s. Input methods can vary from a simple typewriter keyboard to on-line computer inputs.

CIRCLE NO. 347

Grounding clip cuts through wire insulation

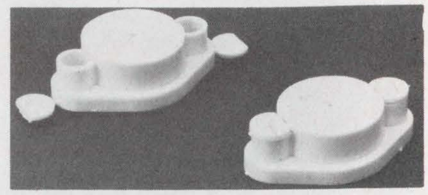


Fastex, Div. of Illinois Tool Works Inc., 195 Algonquin Rd., Des Plaines, IL 60016. (312) 292-2222.

The Blade grounding clip cuts grounding wire insulation and costs. The clip eliminates the need to measure wires, cut them to length, strip insulation and attach terminals. The clip slips easily over a panel edge or the edge of any hole having a 1/2-in. minimum diameter. There are two sizes available: one accommodates a panel thickness range from 0.020 to 0.078 in. and the other from 0.078 to 0.125 in. The Blade clip accepts wires from 18 through 12 gauge. It can also serve as a male contact for either 3/16 or 1/4-in. female quick-connect wire terminals.

CIRCLE NO. 348

Nylon cover protects TO-3 devices



Thermalloy Inc., 2021 W. Valley View Ln., P.O. Box 34829, Dallas, TX 75234. (214) 243-4321. $0.12 (100 up); stock.

A molded cover for TO-3 devices in black or white nylon eliminates the possibility of short circuits to an exposed TO-3 case. The cover provides for electrical connection of the collector case to the mounting screws with two No. 6 lock washers and at the same time protects against contact with the screws themselves. Breakaway insulating covers for the screws are shipped attached to the cover, so that they are readily available on the production line. A hole in the center of the cover allows access for a test probe.

CIRCLE NO. 349

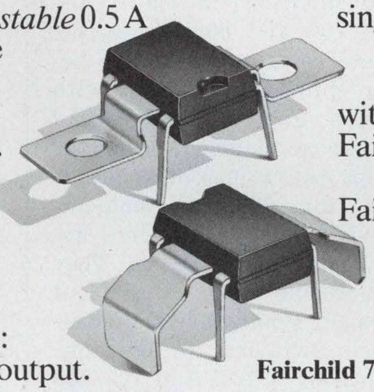
Two new adjustable 4-terminal voltage regulators.

Fairchild's unique new *adjustable* 0.5 A voltage regulators are available either way you want them:

Positive (78MG Series).

Or, *negative* (79MG Series).

They both come in our unique power mini-DIP with integral heat sinks.



And talk about versatile. These adjustable devices are ideal for applications requiring:

1. Continuously adjustable output.
2. Constant output with 4% (worst case) tolerances.
3. Output levels unavailable from standard fixed devices.

Of course, adjustable or fixed, no one gives you a selection of voltage regulators like Fairchild with our broad line of 100mA-to-5A positive 7800 Series fixed devices.

Plus, our new negative 7900 Series for complementary applications.

Five extra reasons Fairchild 7800/7900 Series Voltage Regulators can be a lot easier to use.

No matter which Fairchild device you choose, remember:

1. They're *all* there. Variable or fixed—one resource for every application.
2. They're *complete.* Self-contained. One chip in one package. So you can use them where you want them—with no expensive design time.
3. They're *reliable.* Featuring thermal shutdown, short circuit protection, safe area compensation and automatic recovery when the fault condition's relieved.
4. They're *inexpensive.* Because low-labor, single-unit installation simply costs a lot less.
5. And of course, they're *in stock* now.

For samples and data sheets complete with application information, call your Fairchild Distributor or Sales Office today.

Semiconductor Components Group,
Fairchild Camera & Instrument Corp.,
464 Ellis St., Mountain View, CA 94040.
Tel. (415) 962-5011. TWX: 910-379-6435.

Fairchild 7800/7900 Series Voltage Regulators

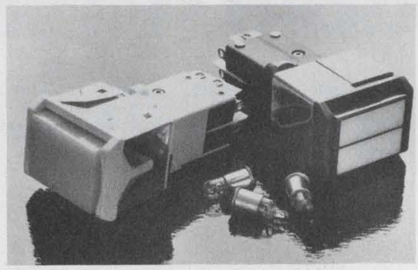
	OUTPUT VOLTAGE	FIXED 5A TO-3 & TO-220	FIXED 1A TO-39 & TO-220	FIXED 500 mA TO-39 & TO-220	FIXED 100 mA TO-92 & TO-39	ADJUSTABLE
POSITIVE	2.5				78L02	NEW 78MG POS 500 mA
	5	78H05	7805	78M05	78L05	
	6		7806	78M06	78L06 (6.2V)	
	8		7808	78M08	78L08	
	12		7812	78M12	78L12	
	15		7815	78M15	78L15	
	18		7818			
	20			78M20		
	24		7824	78M24		
NEGATIVE	5			79M05		NEW 79MG NEG 500 mA
	6			79M06		
	8			79M08		
	12			79M12		
	15			79M15		
	18					
	20			79M20		
	24			79M24		

Note: μA723 is also available in positive or negative.

MADE IN FAIRCHILD

INFORMATION RETRIEVAL NUMBER 241

Pushbuttons provide split-legend displays



Illuminated Products Inc., 207 S. Helena St., P.O. Box 4011, Anaheim, CA 92803. (714) 535-6037.

A line of five standard illuminated pushbutton switches, the Presslite 700 and 800 Series, offers panel designers a choice between a split-legend design with two lamps and a single-legend model that accommodates one or two lamps. A variety of colors is available for different ambient-light environments. The lamps are T-1-3/4 midget-flange types. They are replaceable from the front of the panel. Momentary and alternate-action switches are available. Contact rating is 10.5 A at 125/250 V ac or 28 V dc.

CIRCLE NO. 350

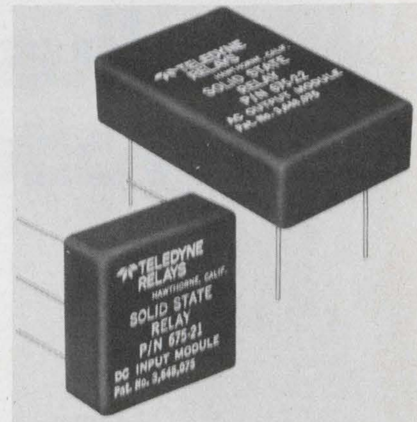
Alarm unit yelps 85-dB sound at 10 ft

Kolin Industries Inc., Box 357, Bronxville, NY 10708. (914) -561-5056.

The Kolin Mini Earsplitter, Model ES-250, emits a yelping sound, similar to emergency vehicles, which demand attention instantly. The unit is weatherproof for outdoor use. It is completely transistorized and has no moving parts to wear out. The ES-250 works on from 6 to 12 V dc and draws 100 mA at 6 V and 175 mA at 12 V.

CIRCLE NO. 351

Optically coupled relays made for PC mounting



Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, CA 90250. (213) 973-4545. From $9.90 (1000-up); stock to 6 wk.

The series 675 optically isolated relays are designed for direct PC board mounting. There are five models in the series and all offer 1500 V rms isolation and different input/output capabilities. The 675-1 accepts ac inputs from 95 to 130 V and can control logic-level voltages (5 V dc). The 675-4 and 675-5 relays control ac load voltages of 20 to 250 V under input control signals of 4 to 10 or 10 to 32 V dc, respectively. Model 765-21 accepts 10 to 55 V dc control signals and controls logic voltage levels (5 V). And, the 675-22 operates under control signals of 4 to 10 V dc and can control heavy duty loads of 4 to 55 V dc. The three dc output models 675-1, -21 and -22 handle currents of 16 mA, 16 mA and 3 A, respectively. The two ac output units can handle 3 A rms. All units are housed in 0.5 in. high epoxy cases. The other case measurements are 1.25 × 1.25 in. for all units except the 675-22 which measures 1.25 × 2 in.

CIRCLE NO. 352

Snap-action switch sealed against moisture

Cherry Electrical Products Corp., P.O. Box 718, Waukegan, IL 60085. (312) 689-7702. $1.36 (2000 up).

A new sealed snap-action switch, the E72-40A, is immune to moisture or even immersion in water. The switch is UL listed and CSA approved for ac use. It is rated at 10 A, 1/4 hp at 115/250 V ac. Operating force is 230-g maximum.

CIRCLE NO. 353

application notes

Crystal oscillators

"How to Specify Crystal Oscillators" covers clock oscillators, TCXOs and oven-controlled oscillators. A comparison of these types and a discussion specifically for timing applications are included. Vectron Laboratories, Norwalk, CT

CIRCLE NO. 354

Etching substrates

Procedures for etching thin-film coated substrates are outlined in a four-page application note. These procedures apply to three-film nichrome-nickel-gold and two-film nichrome-gold substrates. Analog Devices, Norwood, MA

CIRCLE NO. 355

Gunn-effect devices

Theory and practical circuit design of Gunn-effect devices can be found in a 28-page booklet. Amperex Electronic, Hicksville, NY

CIRCLE NO. 356

Thermistor curve manual

A 20-page Thermistor Curve Manual presents a complete story on the use of thermistors in the self-heat mode and is complemented with detailed graphs, charts, working tables and practical problems with solutions and/or answers. Fenwal Electronics, Framingham, MA

CIRCLE NO. 357

Power supplies

Application data for single-output power supplies include schematics, parts list and outline and mounting drawings. A troubleshooting guide is included along with rating tables, series/parallel operation and resistor values. Power-One, Camarillo, CA

CIRCLE NO. 358

Phase and gain matching

Specifying phase and gain matched microwave and i-f components is covered in a two-page bulletin. A composite block diagram illustrates a two-channel monopulse receiver, using phase and gain matched mixer preamps and i-f limiters. RHG Electronics Laboratory, Deer Park, NY

CIRCLE NO. 359

High-voltage power supplies

"Standard Test Procedures for High-Voltage Power Supplies" describes loading methods for both constant and changing load; test setups and procedures for voltage calibration; and test setups and methods for both static and dynamic output voltage regulation. It also contains instructions for checking output current regulation, ripple, tempco and stability. Spellman High Voltage Electronics, Bronx, NY

CIRCLE NO. 360

Linear power amplifiers

"Add Power to Your Network Analyzer" demonstrates how linear power amplifiers permit network analyzers to measure complex impedance of high power components over the 100-MHz-to-12-GHz frequency range. Microwave Power Devices, Plainview, NY

CIRCLE NO. 361

Extend sig gen freq range

With a do-it-yourself circuit, described in an application note, the Model 8640A and 8640B signal generators' frequency range may be extended downward to dc. The instruments' standard range is 450 kHz to 1100 MHz. The note shows how to build a simple external heterodyne circuit with common stock parts to do the job. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 362

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For computer applications,
business machines . . . or
a custom design to fit your
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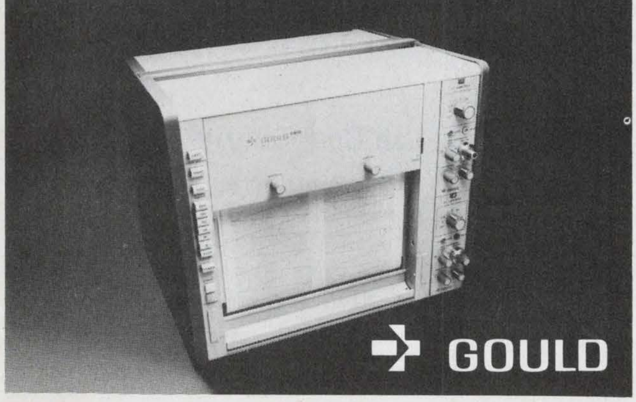
INFORMATION RETRIEVAL NUMBER 82

The New Brush 2400: the best performing, most versatile wide channel recorder you can buy.

It is available in 2, 3 and 4 channel configurations utilizing combinations of 50 mm and 100 mm channels totalling 200 mm. It had a 99.65% linearity over the full 100 mm channel. Its frequency response is an outstanding 30 Hz at 100 mm, 50 Hz at 50 mm and up to 125 Hz less than 3dB down. It has a full range of plug-in signal conditioners for just about any industrial-scientific-medical application.

For full details on why the new Gould 2400 is the best performing direct writing recorder you can buy, write Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Kouterveldstraat 13, B 1920 Diegem, Belgium.



GOULD

INFORMATION RETRIEVAL NUMBER 83

You buy more when you buy Data Precision

Today, more than ever before, Data Precision instruments are the smartest buy in the industry. Model for model they offer performance, flexibility and reliability at appreciably less cost than comparable competitive instruments.

Model 245 $295

Model 245 is the only truly portable 4-1/2 digit _full_ function multimeter available. With a basic accuracy of ±0.05% its performance far exceeds other alternative portables. Compare its cost and 4-1/2 digit performance with any 3-1/2 digit instrument.

Model 2440 $675

By far the most accurate autoranging _full_ function 4-1/2 digit multimeter available. It has DCV accuracy of ±0.007% rdg. ±1LSD/6 months, autoranging and autozeroing, remote ranging and triggering and isolated BCD output, all included in one basic price.

Model 1450 $325

Our newest 4-1/2 digit _full_ function, 21 range multimeter features a basic accuracy of ±0.02% of rdg. ±0.01% f.s., big bright 1/2 inch planar display and 100% overranging.

Contact your Data Precision representative or Data Precision directly. You may be surprised just how much more instrument you can buy, when you buy Data Precision.

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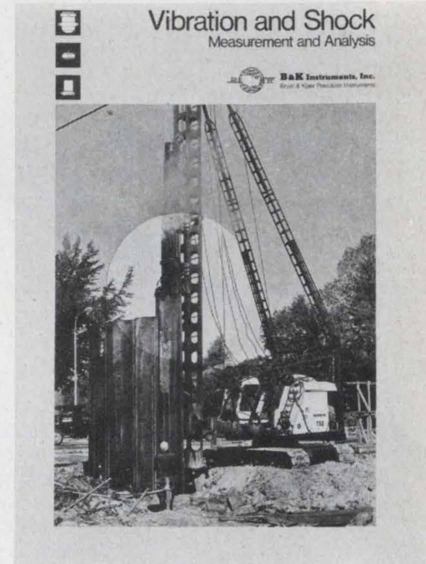
Phone (617) 246-1600

INFORMATION RETRIEVAL NUMBER 84

new literature



Vibration measurement

A 24-page brochure explains how to characterize and measure vibration using amplitude measurement, frequency analysis and motion analysis. Features and application suggestions are given for force and acceleration sensors, vibration preamplifiers, real-time frequency analyzers, portable analyzers and tape recorders. B&K Instruments, Cleveland, OH

CIRCLE NO. 363

Solid-state switch drivers

High-speed solid-state switch drivers are covered in a six-page bulletin. LRC, Hudson, NH

CIRCLE NO. 364

5-1/2-digit multimeter

An eight-page brochure describes the Model 3500 5-1/2-digit multimeter, which uses a Tri-Phasic a/d conversion technique, Isopolar reference system and Ratiohmic resistance measuring. Data Precision, Wakefield, MA

CIRCLE NO. 365

Lab Coat Courier

The aim of this newspaper is to disseminate information in technical fields related to data handling, temperature control, dielectric analysis and laboratory presses. Tetrahedron Associates, San Diego, CA

CIRCLE NO. 366

Molded plastic parts

Power transistor mounts and covers, capacitor mounts, machine screw insulators, finishing washers and beaded ties are described in a catalog. The catalog includes part numbers, materials, dimensions and prices. Micro Plastics, Arlington Heights, IL

CIRCLE NO. 367

PC connectors

An 84-page printed board connector catalog covers printed circuit and tape cable applications. Complete electrical and mechanical specifications, illustrations, outline drawings and ordering information are included. Continental Connector, Woodside, NY

CIRCLE NO. 368

Pots and switches

A two-color, 12-page catalog pictures and describes the capabilities of 53 types of cermet, carbon and wirewound trimmers and pots, 36 choices of rotary selector switches and an additional 20 miniature selector switches. It also covers six or eight-lead single-in-line resistor networks, 14 or 16-lead DIP resistor networks and seven DIP programmable switches. CTS Corp., Elkhart, IN

CIRCLE NO. 369

Monolithic ICs

Monolithic integrated circuits for gas discharge displays and power interfaces in dual in-line packages are illustrated in a short-form catalog. The catalog lists 14 display/interface and transistor arrays for the digital decade. Sprague Electric, North Adams, MA

CIRCLE NO. 370

Optical encyclopedia

Volume I of the 1975 Optical Industry & Systems Directory contains over 900 categories of products and services, which are completely indexed. Volume II contains a series of short tutorial articles describing the principles and applications of optical/electro-optical/laser technology. The cost of both volumes is $32. The Optical Publishing Co., Seven North St., Pittsfield, MA 01201

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In just a few months, the first issue of *Electronic Design's* GOLD BOOK has become the leader among all directories used in this industry. Engineers have responded enthusiastically throughout the U.S. and from all over the world — especially in Europe where they've never seen anything like it before. The GOLD BOOK has become number one almost overnight.

HERE'S HOW YOUR FELLOW ENGINEERS RATE THE INDUSTRY ANNUALS

	Annuals Consulted Within Past Month	**Annuals Preferred**
Electronic Design's GOLD BOOK	85%	60%
Electronic Engineer Master (EEM)	63%	42%
Electronic Buyer's Guide (EBG)	32%	8%
Thomas Register	16%	7%
Conover-Mast Purchasing Directory	2%	1%

SOURCE: Study by Dr. Eugene D. Jaffe, Associate Professor of Marketing, St. John's University, Nov. 1974. Base: respondents using directories. Totals exceed 100% due to multiple mentions.

The GOLD BOOK has revolutionized directory use patterns in this industry. Here's why: The GOLD BOOK is by far the largest, most complete one-step electronics purchasing and reference tool ever produced. And it's far easier to use. Look at these comparisons:

COMPARISON OF ELECTRONICS INDUSTRY DIRECTORIES
(1974-75 editions)

	EBG ELECTRONICS BUYERS' GUIDE	**EEM ELECTRONIC ENGINEERS MASTER**	**ELECTRONIC DESIGN'S GOLD BOOK**
Number of manufacturers listed	5,800	3,165	**7,528**
Total number of products listed	4,267	3,235	**4,799**
Number of direct products listed	2,479	2,250	**2,925**
Number of cross-reference products listed	1,788	985	**1,874**
Number of distributors listed in Distributors Directory — Alphabetic	0	1,720	**5,780**
Number of distributors listed in Distributors Directory — Geographic	0	1,720	**5,780**
Is complete mailing address given each time a company is listed in product directory?	No	No	**Yes**
Is telephone number given for each company listed in product directory?	No	No	**Yes**
Are distributors listed for each manufacturer?	No	Partial[1]	**Yes**
Does manufacturers listing include FSCM numbers?	No	No	**Yes**
Does manufacturers listing include facsimile equipment by make and call number?	No	No	**Yes**
Total Circulation	30,017[3]	89,169[3]	**Over 90,000**
Overseas Circulation[2]	1,339[3]	0[3]	**13,200**
Number of ad pages	590[4]	2,752	**2,820**

[1] Paid listings only
[2] Includes Canada
[3] Standard Rate & Data; Oct. 24, 1974
[4] Includes fractionals

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MAIL TO: ELECTRONIC DESIGN Circulation Dept. Hayden Publishing Co., Inc., 50 Essex Street, Rochelle Park, NJ 07662

IC chip

The CD-4 demodulator system, which allows demodulation of discrete disc recordings manufactured in this format, is described in a six-page data sheet. Matsushita Industrial Div., New York, NY

CIRCLE NO. 371

Linear modules

Oscillators, f/v and v/f converters, panel frequency meters, expanded scale freqmeters, frequency transducers, log amplifiers, pressure-to-frequency converters, tone encoders and decoders, choppers, transformers and telemeters are covered in a 32-page catalog. Solid State Electronics, Sepulveda, CA

CIRCLE NO. 372

Optocomponents

Optoelectronic components are covered in a catalog. It includes three infrared diodes, three phototransistors, one photo-Darlington, four optocouplers, two gap detectors and one reflex detector. ASEA-HAFO, Fack, Sweden

CIRCLE NO. 373

Components

A 530-page catalog contains one of the largest selections of electromechanical components. Designed as a quick-reference handbook, it details parts with schematic drawings, specifications and prices for each stock number. Allied Devices, Baldwin, NY

CIRCLE NO. 374

Mil-Spec components

A bulletin lists specifications for basic, hermetic, interlock, pushbutton and toggle switches, indicators and switchlites. Control Switch, Folcroft, PA

CIRCLE NO. 375

Electronic enclosures

A colorful 16-page catalog features electronic enclosures. Ample photographs, dimensional drawings, specifications and a color selector chart fill out the book. Premier Metal Products, Bronx, NY

CIRCLE NO. 376

bulletin board

Practically any type of technical drawing can be produced with the aid of a new **British computer software package** based on plain English or, alternatively, on any other international language. The package is EUCLID II (Easily Used Computer Language for Illustrations and Drawings), developed by **D-A Computer Services** from a grant by the British National Computer Center under the British Government Software Development Scheme.

CIRCLE NO. 377

A computer-aided software test program (Fairtest) for digital logic subassemblies is available from the **Systems Technology Div. of Fairchild.** With an IBM 360 or 370 computer, Fairtest can simulate digital networks with up to 10,000 nodes, generate test programs in Factor (Fairchild's Sentry test system language) and provide a fault isolation dictionary. A compiler is available for use on the computer that assembles the Factor program and translates it to Sentry 600 code.

CIRCLE NO. 378

Applied Materials has announced a 10% across-the-board increase on all **CVD reactor systems,** except the recently introduced Series 6000.

CIRCLE NO. 379

The Singer Co.'s Kearfott Div. is now marketing **vortex-type, single-stage blowers.** Pressures or vacuums of up to 34 inches of water are possible with free deliveries of 60 cfm. This performance is achieved at 3350 rpm without positive displacement of the air.

CIRCLE NO. 380

MRI Systems has released a **CDC version of the report writer** feature for data management SYSTEM 2000. The report writer, which operates in either a batch or interactive mode, allows the user to generate highly detailed reports in a sophisticated format without having to use a procedural language.

CIRCLE NO. 381

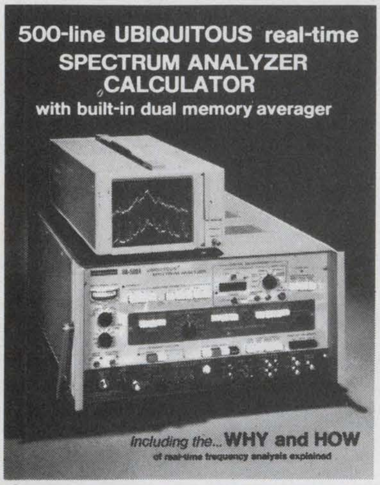
INFORMATION RETRIEVAL NUMBER 90

INFORMATION RETRIEVAL NUMBER 91

Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card
(Advertisement)

"THE HOW AND WHY OF REAL-TIME SPECTRUM ANALYSIS OF NOISE AND VIBRATION"



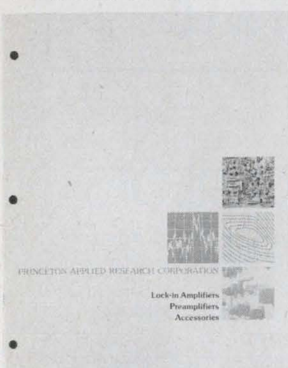
New 16-page brochure on latest Ubiquitous® 500-line Real-Time Spectrum Analyzer/Calculator UA-500A-1 contains complete application data & a "how to" section. The "why" explains the need for resolution, real time, & averaging. The "how to" section solves typical analysis problems: "how to be sure correct data is being analyzed," "how to analyze transients," "how to interface to a computer," "how to cancel background noise," "how to analyze rotating machinery."

Model UA-500A-1 is specifically designed to simplify machine diagnosis, rotating machine analysis, noise source identification, mechanical signature comparisons, underwater signal analysis, & noise reduction. Includes such features as automatic harmonic identification, direct digital readout in RPM, & the ability to make relative amplitude & frequency measurements digitally.

Demo, circle 171
Lit., circle 172

Nicolet Scientific Corp. (formerly Federal Scientific)
245 Livingston Street, Northvale, New Jersey 07647
(201) 767-7100. TWX: 710-991-9619

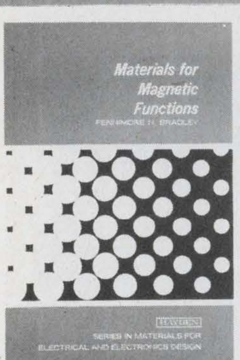
VERSATILE VECTOR VOLTMETER



The Princeton Applied Research Model 129A Two Phase Lock-in/Vector Voltmeter permits simultaneous measurement of magnitude and phase angle even if the signal is masked by background noise. Flip a switch and measure the I and Q components of the vector; independent output expansion, offsetting, and filtering of each component are also provided. Full scale sensitivity ranges from 1 microvolt to 0.25 volts and is extendable to 25 volts with the optional compensated attenuator. Model 186/41. The Model 129A reference channel has fully automatic reference tracking capability and is phase matched to the signal channel over the operating range 0.5 Hz to 100 kHz. Complete specifications are contained in our Lock-in Amplifier Catalog No. T218.

CIRCLE NO. 173

Princeton Applied Research Corporation
P.O. Box 2565, Princeton, New Jersey 08540
609/452-2111.



MATERIALS FOR MAGNETIC FUNCTIONS

by Fennimore N. Bradley

This valuable reference provides a thorough background as well as practical design techniques for the materials needed for magnetic functions. Included in its exhaustive coverage is detailed treatment of key parameters of about 30 classes of ferrite materials relating processing to costs and design trade-offs . . . and equally thorough coverage of about 40 classes of both conventional and exotic magnetic metals and processes. The book focuses on design problems encountered in a wide range of permanent-magnet applications . . . pinpoints design problems in nearly 30 categories of electromagnetic devices . . . and concludes with coverage of environmental influences such as corrosion, magnetic field, temperature, stress, etc. 360 pp., 6 x 9, illus., cloth, $17.20. **Circle the reader-service number to order a 15-day examination copy.**

CIRCLE NO. 174

HAYDEN BOOK COMPANY, INC., 50 Essex St., Rochelle Park, N.J. 07662

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ELECTRONIC DESIGN's function is:

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- To provide a central source of timely electronics information.
- To promote communication among members of the electronics engineering community.

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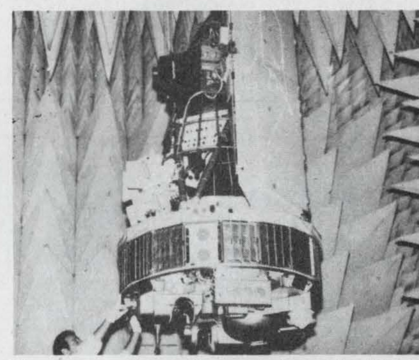
(Advertisement)

GUIDE TO DIELECTRIC MATERIALS

Short form catalog is a useful illustrated guide to product lines and literature. Eighteen different product lines are described. Useful applications and outstanding properties are listed. The catalog contains a reader service card for requesting more detailed information on specific product lines.

INFORMATION RETRIEVAL NUMBER 273

ECCOSORB® ANECHOIC CHAMBERS



The most advanced anechoic and shielded chambers . . . used worldwide for antenna pattern, radar cross-section, VSWR and RF compatibility measurements. Send for data.

INFORMATION RETRIEVAL NUMBER 274

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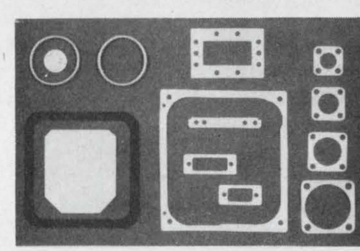

Eccoshield® SV is the flexible, compressible plastic with the conductivity of metal—available in many physical forms—for RF and hermetic seals. Insertion loss has exceeded 100 db.

INFORMATION RETRIEVAL NUMBER 275

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quick ads

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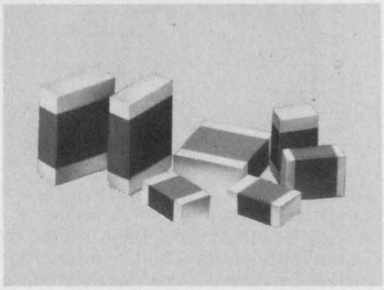
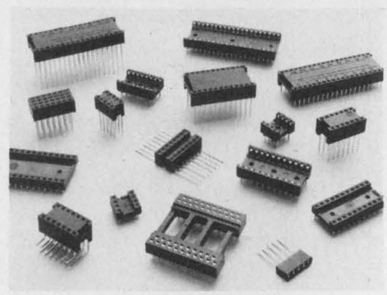


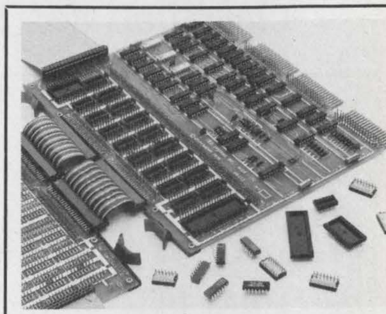
HIGH Q MULTILAYER CAPACITORS feature very high quality factors at microwave frequencies. Offered in three standard sizes: .050 x .040, .080 x .050, .125 x .095. Capacitance values from 0.1 pf to 1000 pf with close tolerance and voltages to 1000 VDCW. Johanson/Monolithic Dielectrics Div., Box 6456, Burbank, Ca. 91510, (213) 848-4465.

INFORMATION RETRIEVAL NUMBER 601



DIP Sockets—New, full color Catalog describes CA's extensive DIP Socket line: 8 thru 42-pins; .200", .300" & .400" centers; four different contact lengths; gold over nickel or bright tin plating; high density; low profile; flat pack calculator chip types. Circuit Assembly Corp. 3169 Red Hill Ave., Costa Mesa, Calif. 92626. Ph (714) 540-5490.

INFORMATION RETRIEVAL NUMBER 604



PDP-11 General Purpose Interface. The MDB-11C provides all features of a DEC DR11C plus additional 16 bit register, 4 selectable interrupt control levels, 16 decoded device addresses, takes only one quad slot, has maximum Unibus load of 1. Also, 20 wirewrap positions are provided. $390. MDB Systems, Inc., 981 N. Main Street, Orange, CA 92667.

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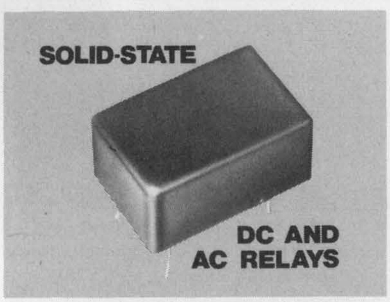

For computer peripherals and other high-speed, high-reliability switching jobs, with either DC or AC loads up to 6 amp, these transformer-coupled Heinemann relays offer highest sensitivity, isolation, accuracy for TTL and other low-level control signals. Heinemann Electric Company, Trenton, NJ 08602.

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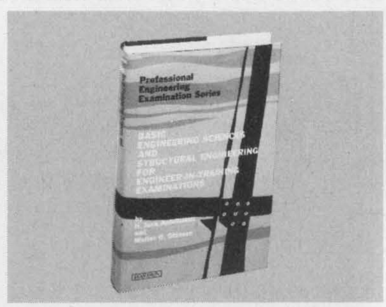

Basic Engineering Sciences & Structural Engineering for E-I-T Exams. Sampling for test problems makes the best preparation yet for exams. #5712-1, 424 pp., $17.20. Circle the Info Retrieval No. to order 15-day exam copy. When billed, remit or return book with no obligation. Hayden Book Co., 50 Essex St., Rochelle Pk., N.J. 07662

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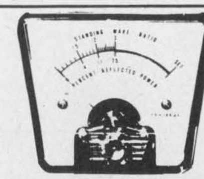

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813 2nd St., Ronkonkoma, N.Y. 11779
(516) 981-3434

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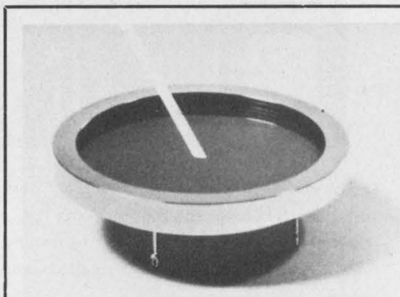


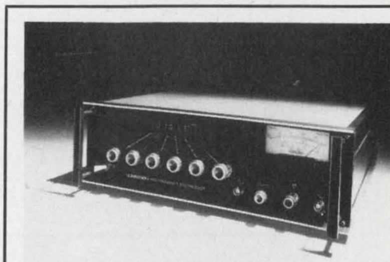
Silicon photodiodes for high resolution position sensing. UDT offers a wide variety of single and dual axis silicon photodiodes for light spot position sensing. Continuous lengths to 9" and areas to 1.4" in diameter with precision resolution to better than 10^{-5} inches. United Detector Technology, 2644 30th St., Santa Monica, CA 90405 (213) 396-3175.

INFORMATION RETRIEVAL NUMBER 603

MICRO-MINIATURE DC/DC CONVERTERS

1.35 Watt DC/DC Converters in 24 pin dip: 1.245" x .795" x .375" from 5Vdc input with 3 std outputs: 5, ±12 or ±15Vdc. Effie, up to 90%, power foldback & no derating thru 71°C. The "UD" Series offers isolated power for logic op-amps etc. Del. stk - 2 wks priced 1-9 from $26.95. Semiconductor Circuits Inc 306 River St. Haverhill MA 01830 617-373-9104

INFORMATION RETRIEVAL NUMBER 606

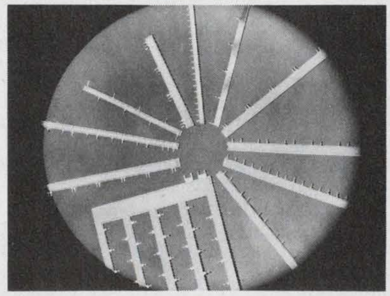


Comstron's 1013 costs only $1595. It's a 5 digit, 0.1Hz to 13MHz Frequency Synthesizer for bench & systems applications. A metered, leveled output, up to 3V RMS, with a precision output attenuator adjustable in 10db steps with continuous level control, low phase noise & low harmonic distortion ensures signal purity. Comstron Corp, 120-30 Jamaica Ave, Richmond Hill, NY 11418 (212) 441-3200.

INFORMATION RETRIEVAL NUMBER 609

Free catalog of 34,500 power supplies from the worlds largest manufacturer of quality Power Supplies. New '74 catalog covers over 34,500 D.C. Power Supplies for every application. All units are UL approved, and meet most military and commercial specs for industrial and computer uses. Power Mate Corp. (201) 343-6294.

INFORMATION RETRIEVAL NUMBER 610



Mini/Bus® Evaluation Kit, $25, in stock. Lets you try Rogers' low-cost, noise attenuating, high packaging density power distribution system for PC boards. Millions in use. Standard parts on 2 weeks delivery, or less! Customer parts 4 to 6 weeks delivery. Rogers Corporation, Chandler, Ariz. 85224. Phone (602) 963-4584

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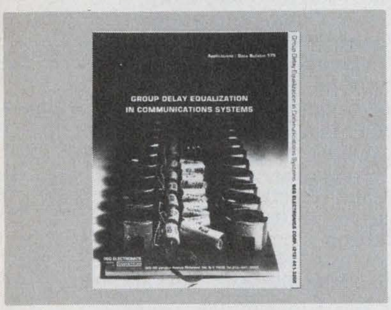
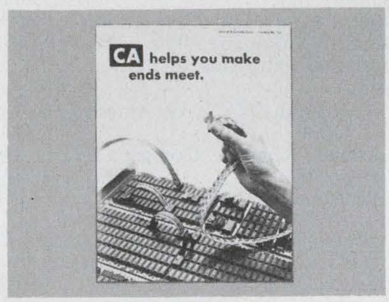


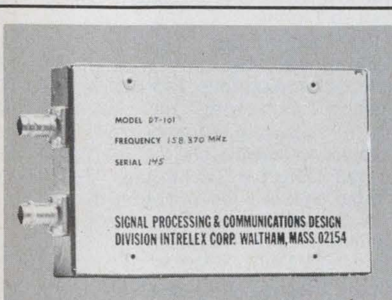
Free Applications Booklet—"Group Delay Equalization In Communications Systems". This comprehensive manual, prepared by SEG's Equalizer Design Dept., features useful applications information as well as a tutorial look at the design of equalizers and their functions. SEG Electronics Corp. 120-30 Jamaica Ave., Richmond Hill, N.Y. 11418 (212) 441-3200.

INFORMATION RETRIEVAL NUMBER 611



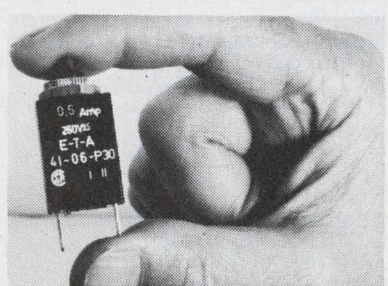
Free—Short-Form Catalog Describes Circuit Assembly Corp.'s major product lines in full color. This new catalog shows CA's extensive DIP Socket line, Plugs, Modules, and Interconnects plus Contact Stampings, Signal Transmission Interfaces, and Custom Components. Circuit Assembly Corp., 3169 Red Hill Ave., Costa Mesa, Ca 92626. Ph (714) 540-5490.

INFORMATION RETRIEVAL NUMBER 614



Wideband 145-175 MHz 1W/2W Transmitter for use in FM, voice or digital data transmission (ICW keying to 10 KHz). 10ppm stability over −30°C to +60°C and +12.5 ±2.5 volts supply variation. Features high DC to RF conversion efficiency, RF output leveling, and up to 5 remotely switched channels. Intrelex Corp. 34 Middlesex Circle, Waltham, MA 02154

INFORMATION RETRIEVAL NUMBER 612



Overcurrent Protector, manual reset eliminates fuse replacement. Convenient panel mounting. 15 fractional ratings from 0.1 to 3 amp. Other models up to 400 amp. Trip-free and fool-proof, UL and CSA approved. High quality, low cost $1.29 ea. in 1000 lots. E-T-A Products Co. of America, 7400 N. Croname Rd., Chicago, Ill. 60648. Tel: (312) 647-8303. Telex: 253780.

INFORMATION RETRIEVAL NUMBER 615

Advertisers wishing to reserve Quick Ad units should note the following mechanical requirements: Specs—Supply glossy photo of product and approximately 40 words which will set no more than 10 lines of 34 characters each. AFTER SUBMISSION NO COPY CHANGES CAN BE ACCEPTED. Quick Ads cost only $300 per insertion, less for frequency advertisers.

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advertiser's index

***Advertisers in non-U.S. Edition.**

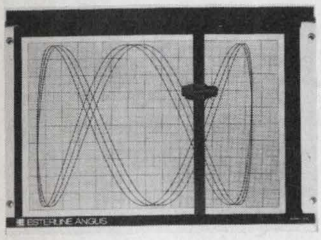
product index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

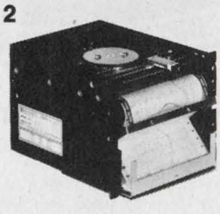
Build recorders into your products?

3

1



2



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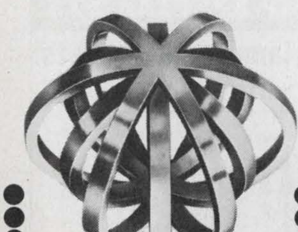

8291 users of electronic components for aeronautics and space in 1974.

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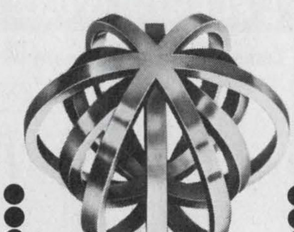

57 077 visitors from 88 countries in 1974

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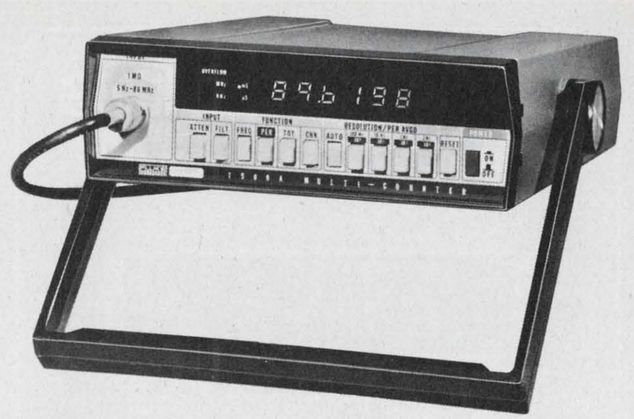

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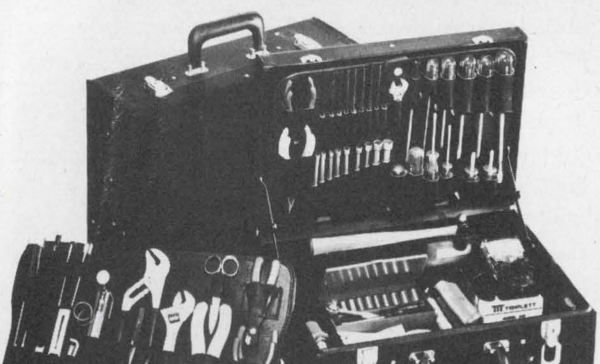

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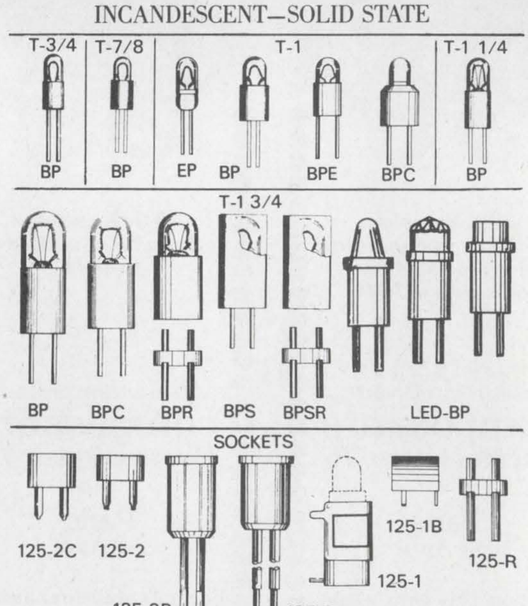

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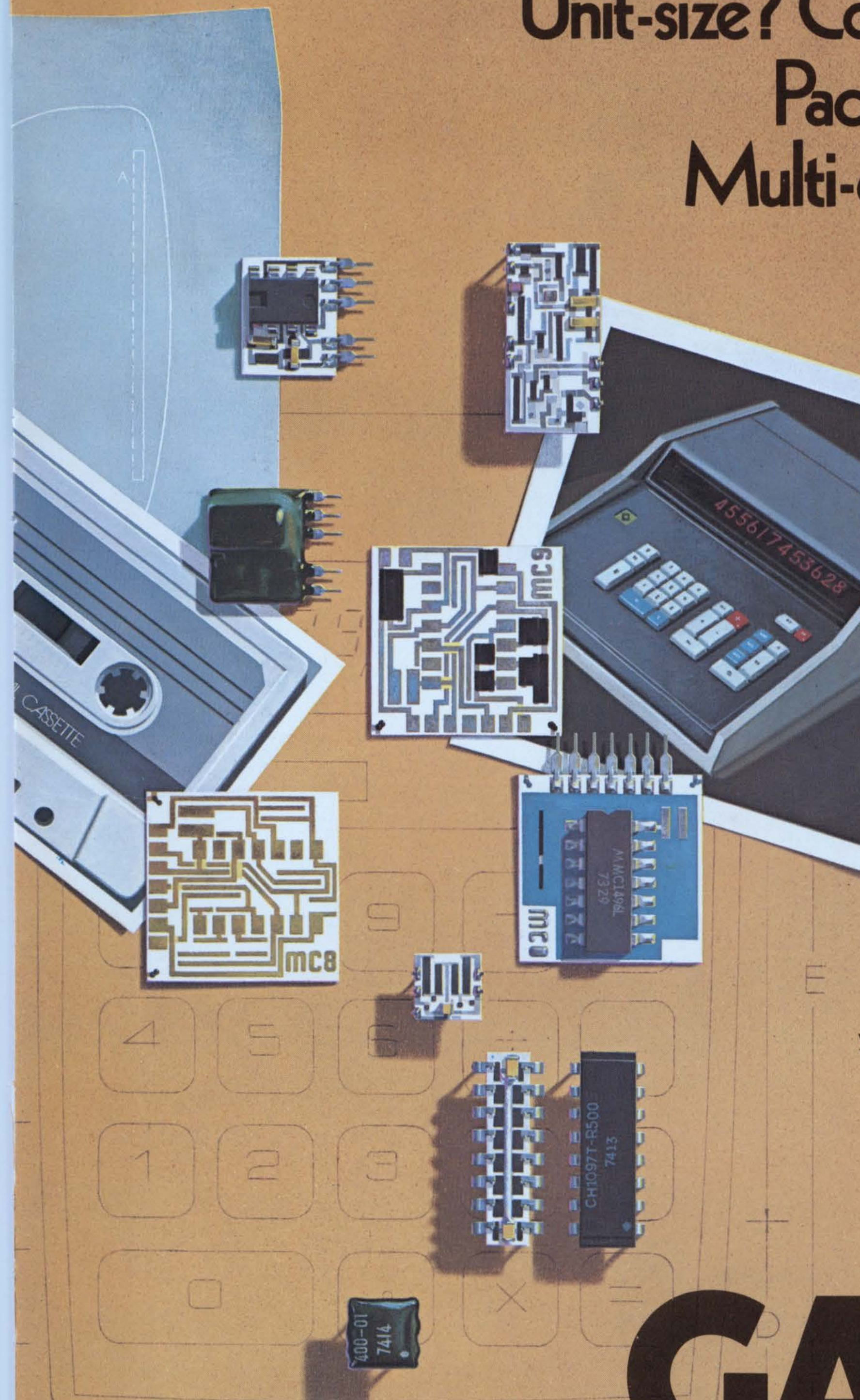

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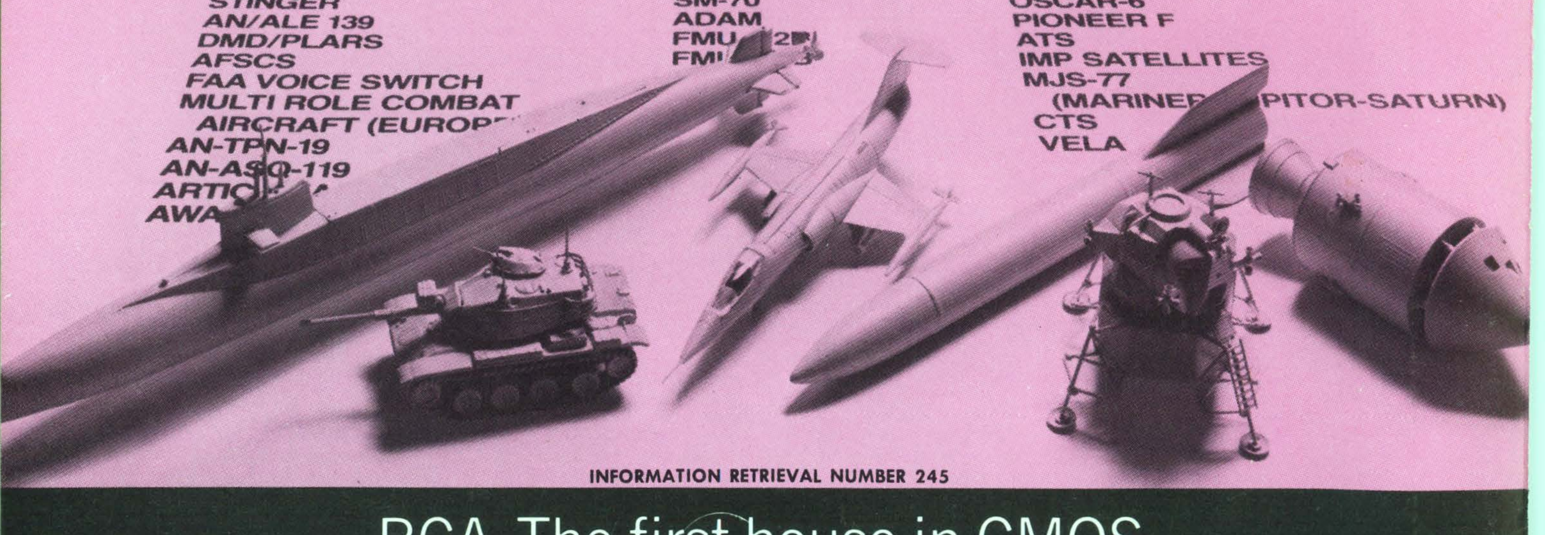

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