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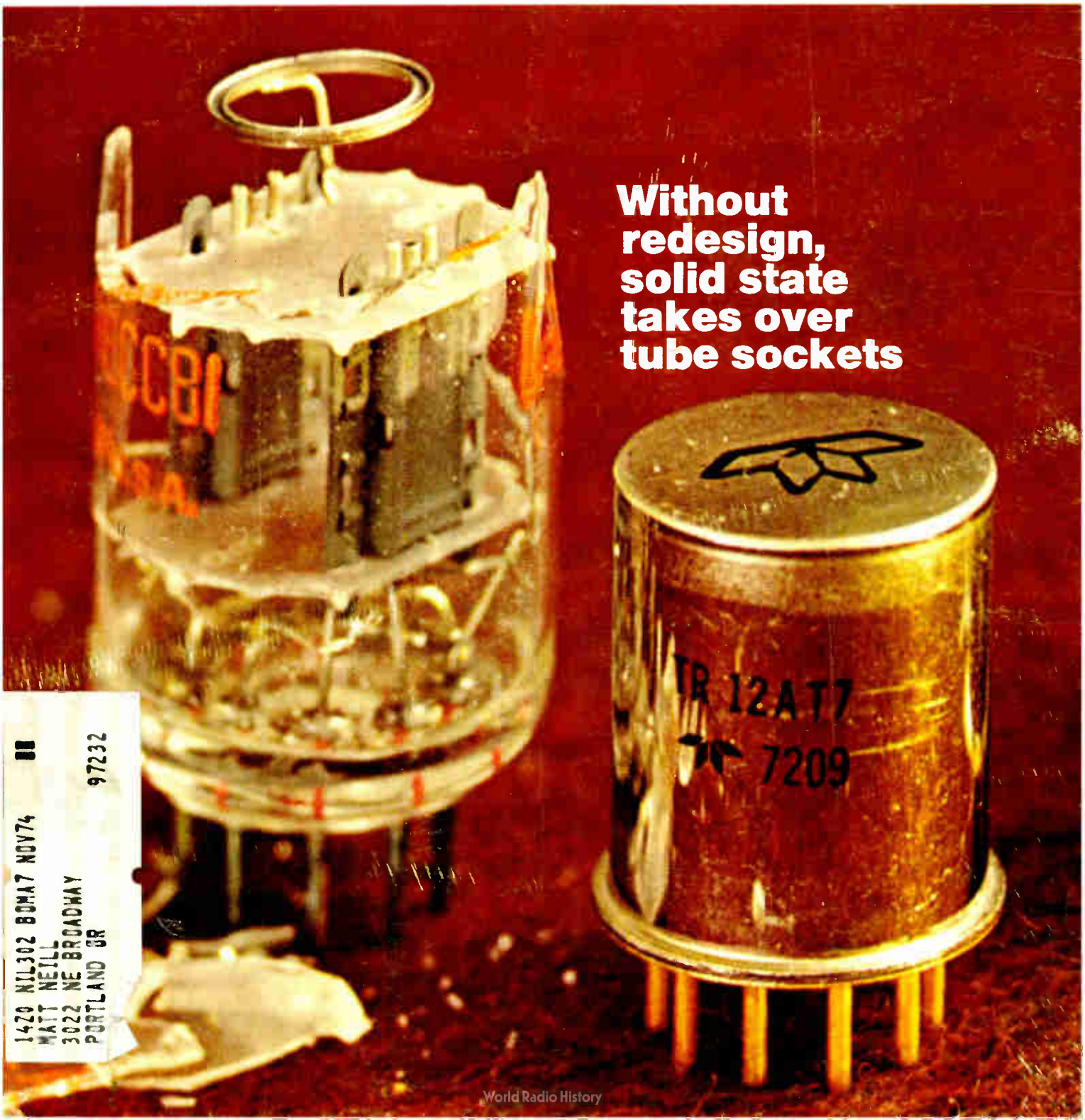
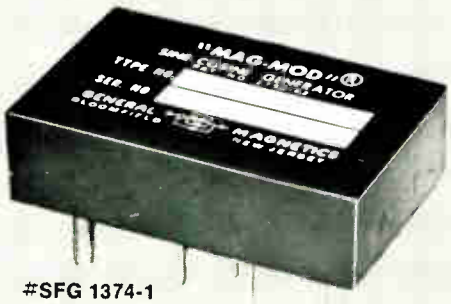
Electronics

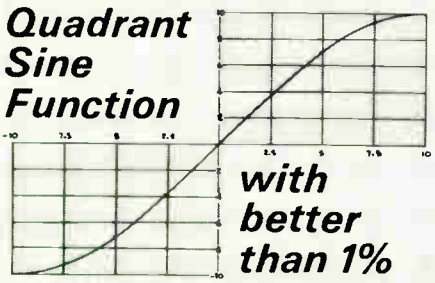


Sine-Cosine Function Generator



#SFG 1374-1

Provides A Two Quadrant Sine Function



with better than 1% Accuracy

- Scaled for ±10V input and output
- Operates from conventional ±15V power supplies
- No external offset adjustments required
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Specifications Include:

DC accuracy:
± (0.1% + 0.6% x E_{IN}/10V)

DC accuracy over the complete temperature range:
± (0.25% + 0.75% x E_{IN}/10V

Input impedance (pin 1): 9.3K Ω

Input voltage range (pin 1): ±10V DC

Rated output-voltage: ±10V DC

Rated output-current: ±5ma

Output impedance: 1 Ω

Frequency response for 1% accuracy: DC to 3kHz

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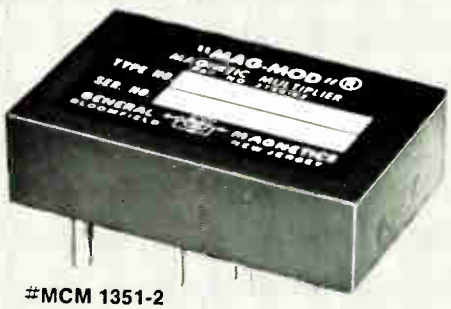

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- Product accuracy is specified in % of reading for all output analog voltage product points over the full military temperature range instead of % of full scale error giving superior results for small values.
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Maximum static and dynamic product error: ½ % of point or 2 MVRMS, whichever is greater, over entire temperature range

Input impedance: X = 10K; Y = 10K

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Minimum load resistance for full scale output: 2000 ohms

Output impedance: Less than 50 ohms

X input bandwidth:
±0.5db, 0 to 200 hertz

Y input bandwidth:
±0.5db, 20 hertz to 1000 hertz

DC power: ±15V unless otherwise required @ 20 ma

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Sample specifications of the AN2535 logic-powered meter
Accuracy 0.05%
Automatic zero – no offset
Stability 50ppm/°C
Power requirement 2.5 watts (5v from logic or battery)
Operating temperature −10° to +60°C
Floating, bipolar differential inputs
BCD output included
Separate analog and digital grounds
Input impedance 1000 megohms min.
Dimensions: 1.25"h x 3.2"w x 1.8"d (mounting surfaces)

This is the first of a series of DPM's designed for the special requirements of you, the OEM, manufactured by the largest supplier of DPM's in the world – us. We've also prepared a 28-page booklet on the theory of meter operation in general – a surprisingly useful and impartial guide for getting through the claims and counter-claims of meter makers. Just ask. Analogic Corp., Wakefield, Mass. 01880, (617) 246-0300.

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Circle 1 on reader service card

Intel's second computer on a chip!

This one's a data expert

In December Intel introduced the industry's first monolithic general-purpose CPU, a 4-bit processor oriented to arithmetic and control operations. Now Intel announces an 8-bit central processor designed especially to handle large volumes of data. Combined with any combination of Intel RAMs, ROMs and shift registers, the new Type 8008 CPU forms the MCS™-8 micro computer system, a system which can directly address and retrieve as many as 16,000 8-bit bytes stored in the memory devices.

Intel's 8008 CPU is a P-channel silicon-gate MOS chip containing an 8-bit parallel adder, six 8-bit data registers, an 8-bit accumulator, two 8-bit temporary registers, four flag bits and eight 14-bit address registers. It operates under a powerful set of 45 instructions, has interrupt capability, operates asynchronously or synchronously, and can perform as many as seven nesting subroutines.

All inputs, including clocks, are TTL compatible. All outputs are low-power TTL signals. Using standard TTL packages, the CPU may be interfaced with Intel 2048-bit ROMs (Types 1301, 1601 and 1701), with Intel 256-bit and 1024-bit RAMs (Types 1101 and 1103) and with Intel single and dual 1024-bit SRs (Types 1402, 1403, 1404, 2401 and 2405). A complete functioning computer system may be built with one CPU, one ROM and 20 standard TTL devices.

Like Intel's 4-bit Type 4004 CPU, Type 8008 CPU combines with Intel memory devices to provide complete computing and control functions for test systems, data terminals, billing machines, scientific calculators, measuring systems, numeric control systems and process control systems. Which CPU performs most efficiently depends upon the specifics of your application. We encourage you to consult Intel applications group before you make a choice.

For immediate delivery of Type 8008 phone your local Intel distributor: Cramer Electronics, Hamilton Electro Sales, Industrial Components or Electronic Marketing. In the U.S., contact your local Intel representative for technical information and literature. In Europe, contact Intel at Avenue Louise 216, B 1050 Bruxelles, Belgium. Phone 492003. In Japan, contact Intel Japan, Inc., Hanei 2nd Bldg. No. 1-1, Shinjuku-Shinjuku-ku, Tokoyo 160, Japan. Phone 03-354-8251.

Intel Corporation now produces micro computers, memory devices and memory systems at 3065 Bowers Avenue, Santa Clara, Calif. 95051. Phone (408) 246-7501.

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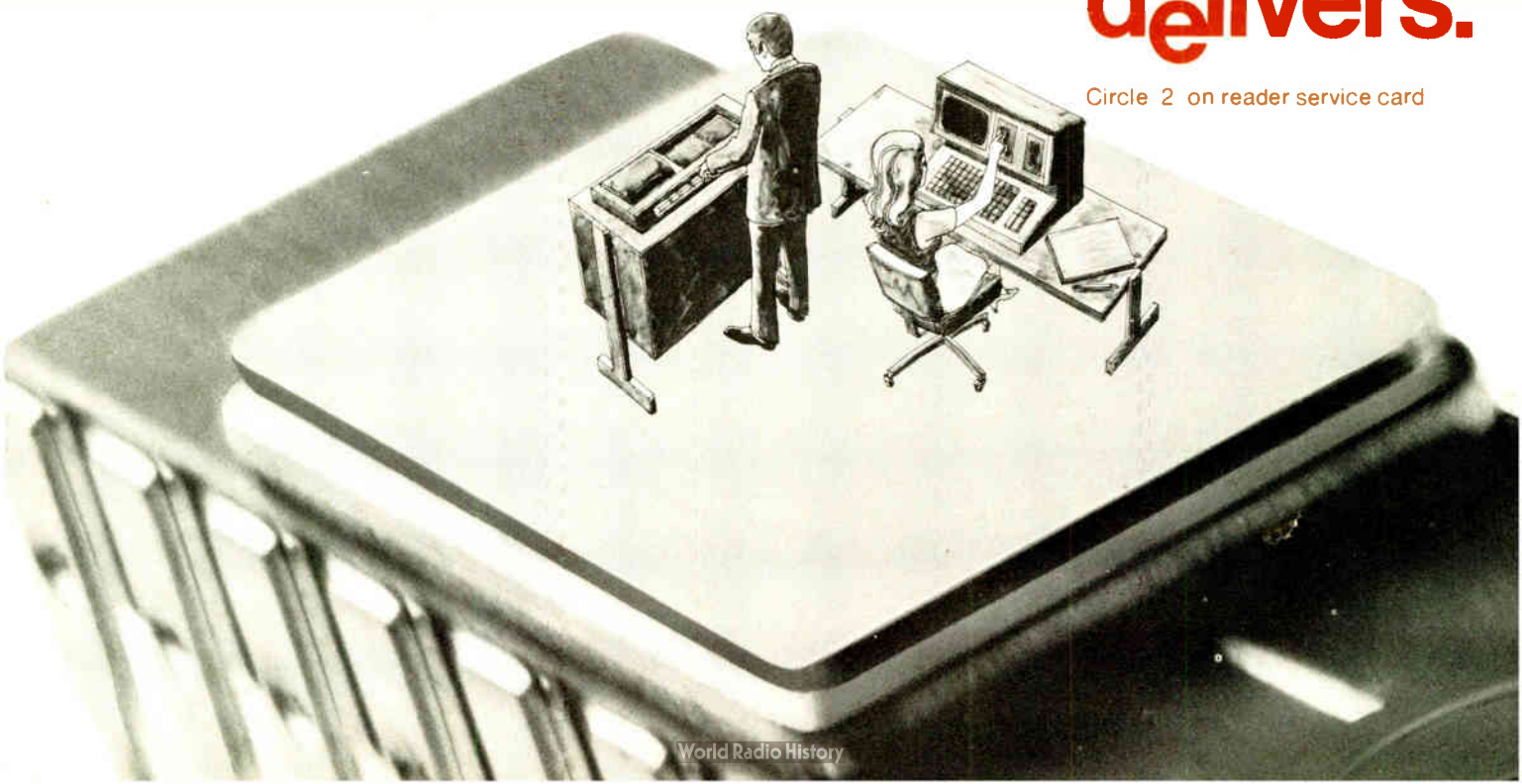

Electronics
The International Magazine of Electronics Technology
April 10, 1972

Volume No. 45, Number 8

Highlights

Navy puts $3 million into CCD R&D, 39
Touted by the Pentagon as a significant development, charge-coupled devices will be the subject of a Navy study. Goal is to find applications in optical imaging and other areas.

Electronics for the amateur sailor, 72
As boat-owners get more adventurous, they need better equipment. And as they are also getting more numerous, many new firms are jumping into the marine electronics market, estimated at up to $35 million a year.

Solid-state Fetrons plug into tube sockets, 85
One of the last strongholds of vacuum tubes is giving way before the onslaught of high-voltage JFET technology. Hybrid circuits made with such JFETs duplicate the functions of pentodes, and even outdo them in some respects. No changes are needed in the circuit.

Wristwatch features liquid crystal display, 93
Complementary MOS ICs are the basis of the electronic competitors of the mechanical watch movement. Now for the first time they have been combined with liquid crystal displays, to yield a watch that will lose or gain less than 10 seconds a month.

Special report: functional trimming, 102
Functional trimming adjusts the output of an entire hybrid circuit, and does away with the need for tight-tolerance components. It requires a different design approach—and also a sizeable investment in production equipment.

And in the next issue . . .
Another look at CATV . . . the rapid progress in n-channel technology . . . CAD applied to C/MOS

The cover
The 6AK5 tube faces being discarded and replaced by a solid-state Fetron, which plugs directly into the unaltered circuit. See article on page 85.

Electronics

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Publisher's letter

Marine electronics is riding a marketing crest that not even industry experts can see clearly. Estimates of the total market vary from $5 million to $40 million. Part of the confusion is that a lot of new companies are entering this rather nontraditional area of electronics.

When associate editor Jack Kessler started his reporting for our story on this buoyant business (see p. 72), he contacted all of the large, well-established firms in the field. He found that their success rested largely on proved designs, and that their estimates of the strength of the market were, in most cases, conservative. It was the new companies, many in the market for less than two years, that were the most optimistic and the most innovative.

A strong underlying reason for the anticipated growth in the marine electronics field is the public's increasing concern over safety, especially important now that skippers of small boats are getting less leery of sailing offshore. "I'm in the market with the rest of them," says Jack, who has a personal interest in the new gear, having started sailing a few years ago.

But the fun of adventure depends on safety, especially when children are along. "I hadn't thought much about marine radiotelephones," says Jack, "because the price was high, and even though they were small they took up too much room on my little boat. But some of today's transceivers are as small as a cigar box. Although the price is steep for the owner of a 21-foot boat, it's an important investment in safety and a real convenience. That's why so many companies see me—and many another small-boat owner—as a good customer."

Functional trimming, the subject of the seven-page report starting on page 102, is one of those production techniques whose effects are felt all the way back on the design bench. Written by our packaging and production editor Steve Scrupski, it's a good example of how closely interconnected the design and production function have become.

The time is past when the designer and the production man could work in separate compartments. Now the two must work together. Indeed, often one group has complete drawing-board-to-shipping-dock responsibility. And the design/production tradeoffs are a very real part of the engineer's daily life. And you'll be finding more and more material about those tradeoffs in our pages from now on.

For example, our new Engineer's Newsletter (see page 119) homes in on just that sort of problem. Steve Scrupski, a 10-year veteran of technical journalism and a holder of a masters in electrical engineering from Newark College of Engineering, where he taught for five years, is in charge of the newsletter. We look at it as a forum for design and application tips and news. If you have any design pointers—or any questions on recent developments the answers to which would interest other readers— pass them along to Steve.

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CPS 6–22M	0–6	0–22	$14X10^{-6}$	0.02	0.05+1	½	626.00
CPS 6–45M	0–6	0–45	$7X10^{-6}$	0.02	0.05+1	½	707.00
CPS 6–90M	0–6	0–90	$3.5X10^{-6}$	0.02	0.05+1	Full	1,065.00
CPS 15–6M	0–15	0–6	$125X10^{-6}$	0.02	0.05+1	¼	392.00
CPS 15–12M	0–15	0–12	$63X10^{-6}$	0.02	0.05+1	½	626.00
CPS 15–25M	0–15	0–25	$30X10^{-6}$	0.02	0.05+1	½	707.00
CPS 15–50M	0–15	0–50	$15X10^{-6}$	0.02	0.05+1	Full	1,065.00

♦ Price is for metered unit, deduct $30.00 for modular style.

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Readers comment

Second thoughts

To the Editor: There are several minor errors in my article ("Doubling op amp summing power" Feb. 14, p. 73). Since the gains through the inverting inputs are negative, Equations 1 should have three minus signs in them so positive values of input resistors result. The caption for Fig. 1 likewise requires a minus sign in the equation for R_{IN}. Also, four lines below Equation 2, K_{IN} should be the absolute value of the sum of quantities on the right of the equals sign. Sorry I slipped on this.

I have no connection with the Bendix offices in Los Angeles.

Raymond G. Kostanty
Bendix Corp.
Lakewood, Calif.

GE too

To the Editor: The recent article, "P/MOS chip drives liquid crystal display for digital alarm clock," by Messrs. Borden, Mingione and Nance [*Electronics*, Jan. 31, p. 66] describes a very interesting application of an MOS LSI circuit . . . an MOS LSI timing circuit was an integral part of an all-electronic am-fm digital clock radio introduced commercially by General Electric in December, 1970.

This circuit, reflecting state-of-the-art technology at the time of its design, uses a standard p-channel process, and incorporates 822 transistors on a single 112 mil × 139 mil chip mounted in a 16-lead dual in-line plastic package.

The chip was designed jointly by engineers of GE's Radio Receiver department (now the Audio Electronics Products department) and of the Integrated Circuits Center.

R. L. Pritchard
GE Corporate R&D
Schenectady, N.Y.

Correction

The equation below was omitted from Arthur G. Stephenson's article, "Digitizing multiple rf signals requires an optimum sampling rate," in the March 27 issue, and should be inserted between lines 14 and 15 of the second column on page 109:

$$K = \frac{(F_L + F_H)}{F_S} - \frac{1}{2} \qquad (4)$$

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40 years ago

From the pages of Electronics, April 1932

The greatest danger in the price war carried on by radio-set makers is the tendency to cheapen the product in the eyes of the public. Already the process has got a good start. An automobile dealer at the New York show said, "Well, a radio is just something to cut the price on, you know." A radio dealer on Long Island has discovered the best way to make a profit is to sell cheap sets as a loss and to make his money in servicing them. Within six months many sets in the lower price brackets need new condensers, resistors, or transformers. Often a half-year has seen a greater expenditure for parts and service than the original cost of the set.

The public is still mightily interested in radio. New models continued to attract eager throngs. But with the present tactics, how long can the public retain its pride of ownership in a radio set made up of a conglomeration of 10-cent-store parts that daily threatens the owner with severe service costs?

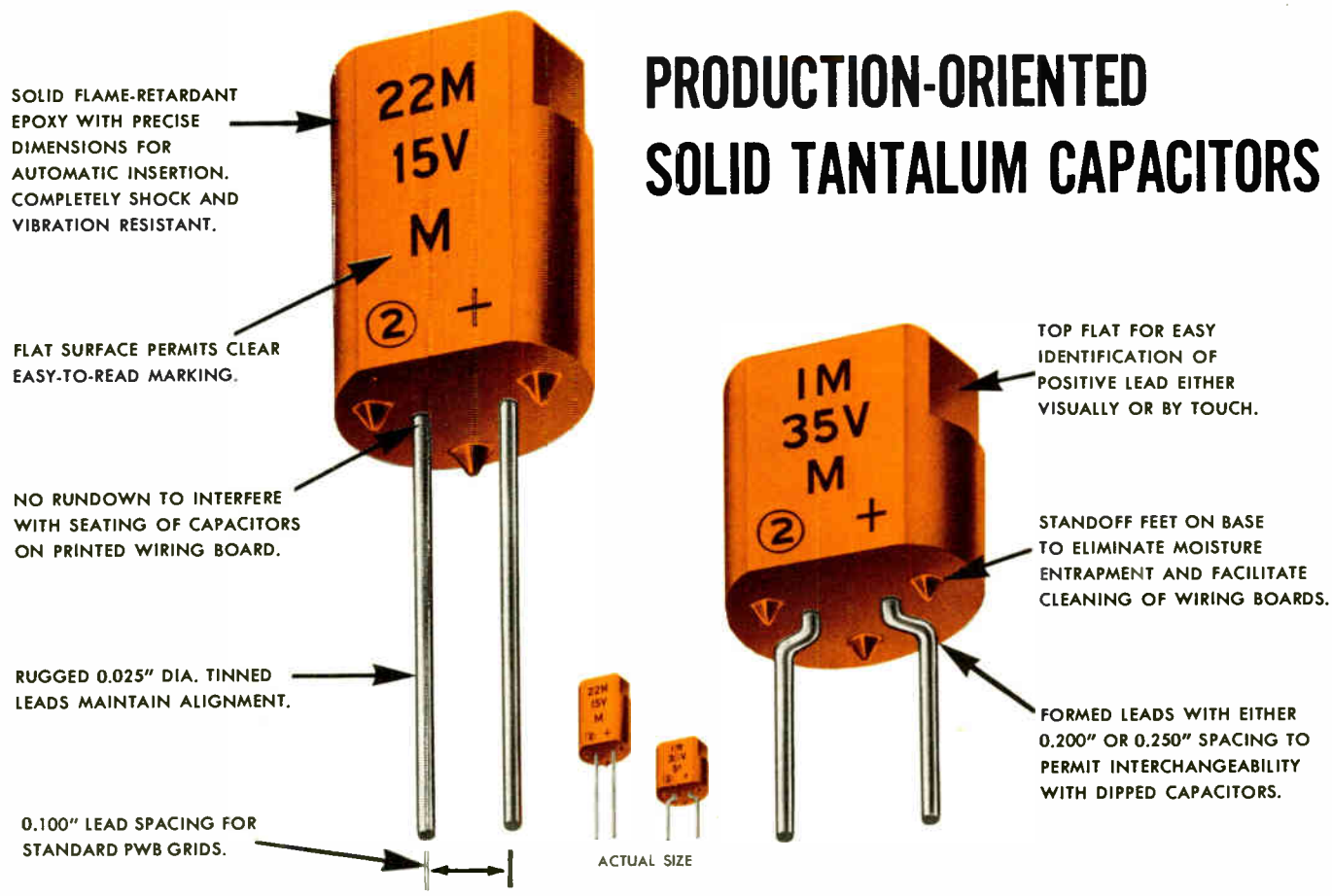
Electronic echo devices now make it possible for ships' captains to make continuous soundings of the depth of water beneath their vessels. This permits the ocean floor itself to be used for navigation.

Instead of "shooting the stars" to keep their ships on a true course, captains of transatlantic liners during the most dangerous parts of their voyage will compare readings of their echo depthfinder with a map of the bottom of the sea.

Fundamental changes of far-reaching importance are being proposed to the patents committee of the House. They are:

- Patent work should be speeded.
- Applications remaining three years open to public.
- Assignee given full right to file reissue.
- Group permitted to file as co-inventors.
- Priority of invention limited to two years before filing.
- Speeding up of patent litigation.
- Definition of status of government employees as patentees.

Another Sprague Breakthrough!



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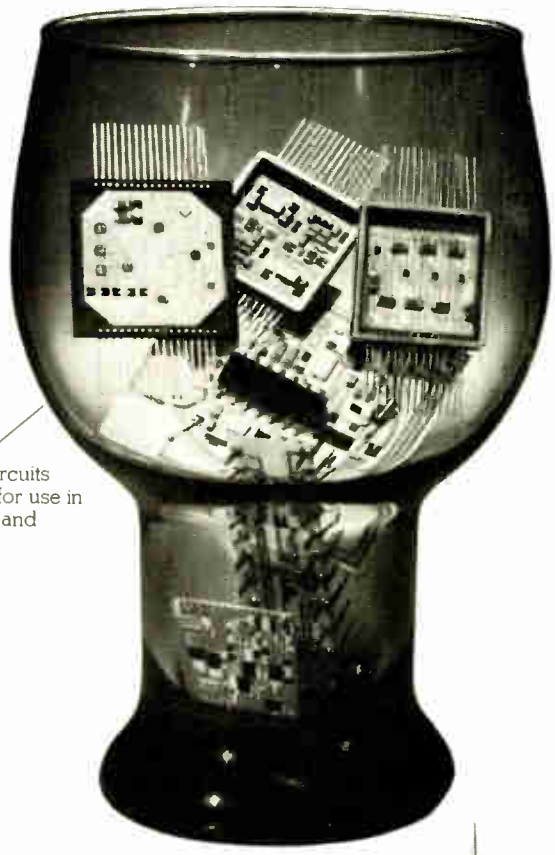
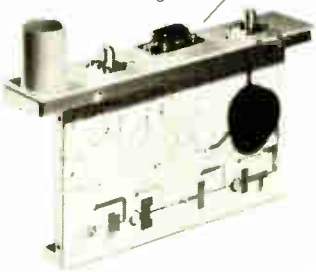
Exploring the Moon. In Houston, our Aerospace Systems Division performs myriad engineering and scientific duties as part of NASA's Apollo Support Network.

Continuous Strung Planar Array. New, high-speed memory planes with closely packed low-drive cores offer speed, cost and space savings.

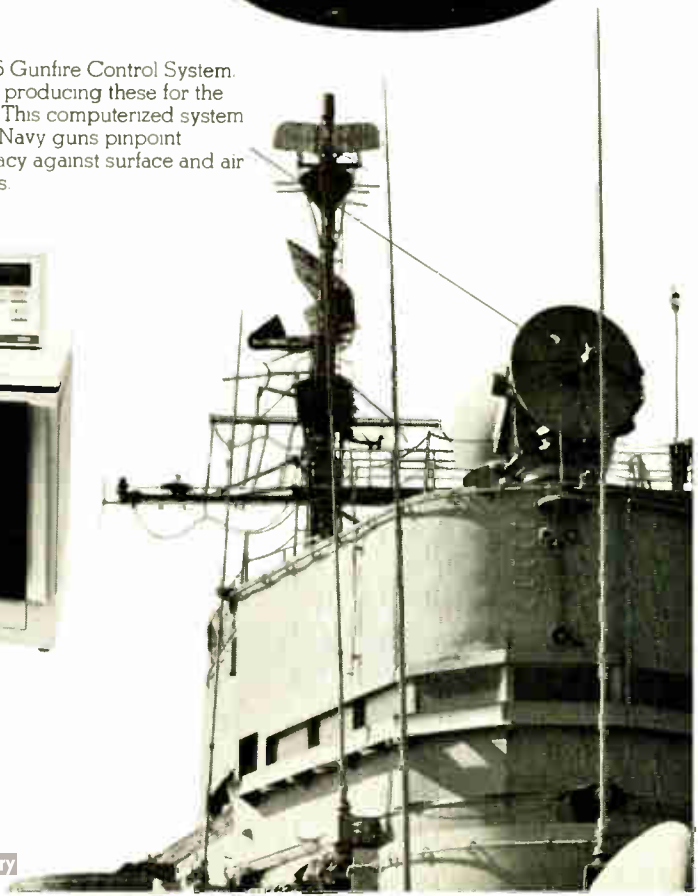


Custom-built Microcircuits Manufactured by us for use in many of our systems and subsystems

Advanced Design Radar. These high-power modules transmit at either of two frequencies. They're forerunners to multi-frequency, phased-array radar systems that will scan via electronic beam steering.



Mk 86 Gunfire Control System. We're producing these for the Navy. This computerized system gives Navy guns pinpoint accuracy against surface and air targets.



MAC 16. The Multi-Application Computer. Many are at work now. Many more are awaited by expectant customers

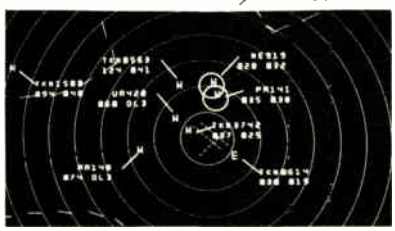
U.S. Army Electronics Proving Grounds

Electromagnetic Program. We're conducting a major engineering and technical support program in connection with the Army's electromagnetic test facility in Arizona.

than one way electronics business.

you'd like additional information, including specific product information, write: V. Vinci, LEC, Plainfield, New Jersey 07061.

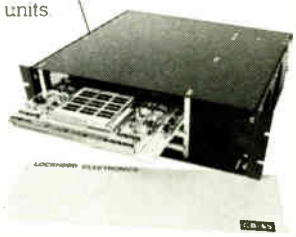
Air Traffic Control Systems. We're marketing this new ATC system on a worldwide basis. It's a unique, low-cost solution to traffic control at low-density airports.



MADAR recorder. Now being manufactured for the Air Force C-5 Galaxy's in-flight performance, analysis and recording system

Large Scale Memory Built to "simple spares logistics" demands Highly rated components can withstand extreme vibration and humidity.

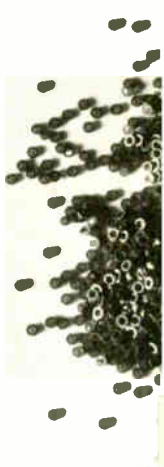
CB-65 memory system. A compact, core memory system which combines high-speed with low-cost. It can be used for minicomputers or expanded for use in large-scale mass storage units.



417 Data Recorder Now in the hands of scientific and industrial users throughout the world.

840 Centinel Fuel Registers. These ride on tank delivery trucks and produce on-the-spot, error-free invoices for fuel oil and other liquid deliveries.

Ferrite Cores. These 18-mil, low-drive cores allow close packing of cores with a 30% decrease in drive current. And that saves about 50% of the cost of conventional core systems



Mariner '71 Spacecraft. One of our space travelers along with others including ESRO, NIMBUS, ISIS, Mariner '69 and '73 and the Viking Lander.

SUE. The System User Engineered minicomputer with unequalled flexibility. SUE will be available in a galaxy of configurations.

Transaction Systems. Our LTS is the most technologically advanced self-service gas station pay system in the country.

Lockheed Electronics

A Subsidiary of Lockheed Aircraft Corporation

Circle 13 on reader service card

People

Ryan: the House is a new ballgame

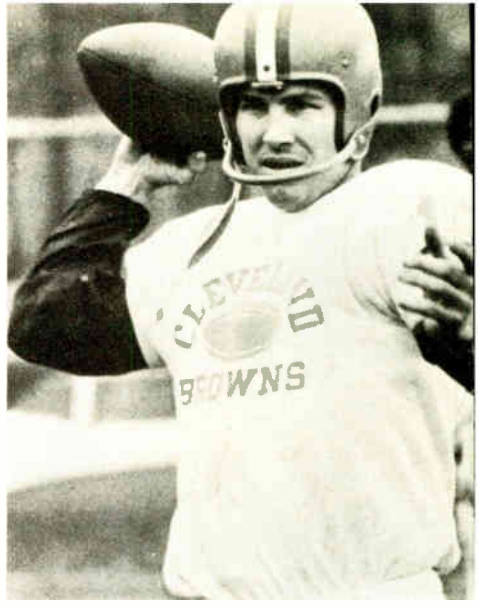
As a former National Football League quarterback, Frank B. Ryan is accustomed to sudden changes of direction. And his position in the House of Representatives should add to that experience: he was hired for one job with the Committee on Administration, but almost as soon as he sat down, the job grew into being director of information systems.

"I had never been involved in politics," Ryan relates, "but somehow or another my name got thrown into a hat for the committee job." Ryan says that when he came on board last summer, "I thought the job was to manage a small staff assisting the committee on oversight. Before I knew it, we had become an operational staff and had absorbed the (House) computer center."

Staff needed. Ryan now has $1.5 million with which to build a staff, enlarge the computer complex, and develop a number of new systems, such as automatic bill tracking, to computerize House functions [see p. 80]. "There's a tremendous load of things to do," says the Texan in his relaxed manner. Building up the staff seems of first importance. "We have 26, but we have to double that by September," he says, adding that he's looking for some "real heavyweights" to help him run the show.

At 35, Ryan already has had enough careers for several persons. While playing for the Los Angeles Rams, Cleveland Browns, and Washington Redskins, he studied off-season and won a Ph.D. in mathematics from Rice University. He was a young professor teaching at Case Western Reserve when he got word that he was being considered for the House post.

People getter. Ryan, whose dress is on the conservative side while his prematurely graying hair is longish, sees his job as "bringing people to man that staff and coordinating them." But he doesn't think his post takes special talents. "Somebody's got to do it," he says self-assuredly.



Ryan: Quarterback faces the computers.

"I've not had any political problems at all," Ryan says. For one thing, "I try to be as objective as possible," which helps in that political hothouse. For another, "I play down the concept of the computer as a cure-all; I don't push the computer for computer's sake," Ryan declares. He turned down one proposed system for the individual members' payroll because he thought the job could be done faster and cheaper on special-purpose electronic calculating machines.

Busy but happy, Ryan contrasts his job with teaching. "There was no managerial responsibility in teaching. There, the emphasis is on quiet contemplation and teaching, which is production of a sort. Here, I'm director of the whole shebang," he says. "The deadlines are unbelievable. The pace is much faster here," he says.

Wilson gives Collins that worldwide touch

When Robert C. Wilson came to Collins Radio Co. in Dallas, he brought with him what many people said the company needed most—a strong management instinct. Now, five months later, his touch is beginning to show—though not in the balance sheets.

The most obvious transformation at Collins was predictable—the management shakeup. Late last year, Wilson reorganized the company into profit centers—"almost independently-managed small busi-

Custom credo.

Our custom philosophy is pretty simple.

Sometimes you need a custom MOS/LSI or hybrid circuit to get the job done.

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So, we've expanded our very complete standard circuit design and volume production capability to include a very complete *custom* circuit design and production capability.

CUSTOM MOS/LSI We have all the processes (metal gate, silicon gate, ion implantation and C-MOS), so we can use whichever is most cost-effective for your program. We've also got the best designers, computer-aided graphics system and LSI testers available.

CUSTOM HYBRID You name it (Digital, Linear, MOS, Transistors and FETs), we've got the die capability in-house, in addition to custom chips specially designed for hybrid applications. Plus computer-controlled laser trimming of resistors and capacitors and computer-controlled final test equipment.

From us, you'll get a great custom circuit. And you'll get it fast. For specifics (including a copy of our new Custom MOS/LSI or Hybrid Capability Brochures), write on your letterhead to: National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051.

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National

People

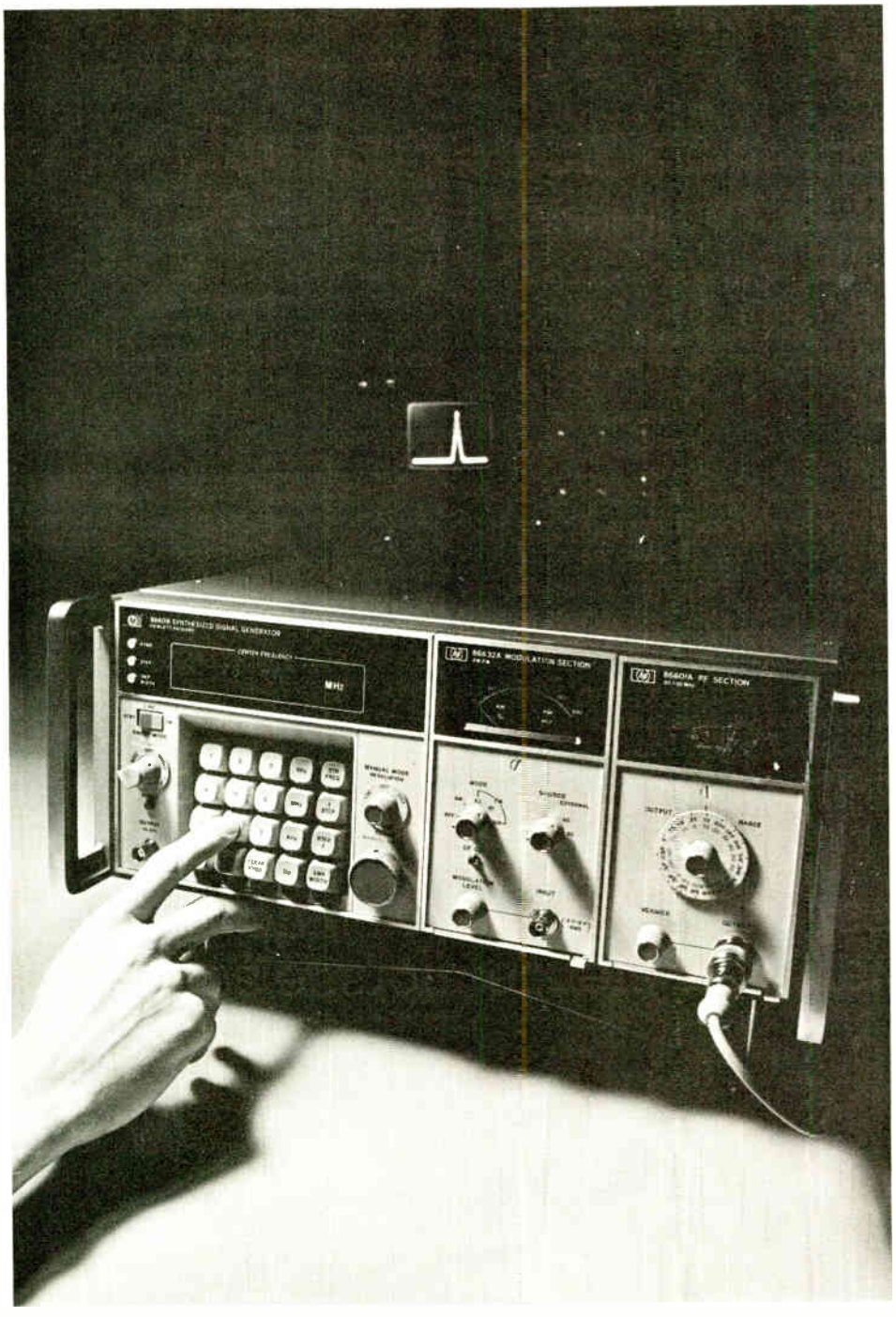
nesses within the company"—a decentralization concept that couldn't be less like the leadership of former potentate Arthur Andrew Collins, who virtually ran his company singlehanded. But besides the individual, concentrated management that the new organization should bring to the four major operating groups, "each person is being encouraged and challenged to take initiative—to think as a whole businessman."

GE alumnus. Wilson was trained at General Electric, his employer from 1941 to 1969, in the engineering, manufacturing, and marketing aspects of consumer electronics and industrial automation, and his professional business management expertise exhibits a strong international slant. He then moved to North American Rockwell and quickly became executive vice president for its electronics and industrial products groups. After 25 significant job assignments, Wilson quips that he's probably had a more diversified product line experience than anyone else in the U.S. "If you look at it that way," he says, "one of the things I should be able to contribute to Collins is perspective."

In addition, and due to Wilson's strong international management background, Collins is trying to move into the international markets faster than it would have without its new chief executive. Both of Collins' two basic markets—transportation and communications—show a strong foreign potential. "There's no question that aviation is going to grow very rapidly," he says. "But the issue is what the American participation will be in those markets."

Not quitting. Finally, despite the feelings that Collins shouldn't have diversified beyond the communications markets into computers and MOS LSI, among others, Collins is probably in those markets to stay. Recent sales of communications-oriented computer systems to American Airlines, the State of Iowa, and the American Stock Exchange have been encouraging, and "the contribution that MOS LSI can make to a great many of our products is so important that we simply must have that capability," Wilson explains.

MEASUREMENT NEWS
information for better measurement



in this issue

RF signal generator keyed for the future

An RF signal generator with synthesizer stability and spectral purity plus keyboard entry for frequency commands.

Unprecedented operator control is one of the new dimensions in RF signal generators provided by the keyboard-entry HP 8660B synthesized signal generator. All frequency commands are directly entered—not only CW, but also incremental frequency stepping and digital sweeping. Synthesized "continuous tuning" can also be achieved.

Whether you are stepping, sweeping, or tuning, the RF signal retains its synthesizer qualities: high stability, low residual FM, and low spurious content. The 8660 system also has advanced modulation capabilities (AM and FM) plus precise output level calibration and control.

(continued on page 3)

Meet HP's powerful new pocket calculator

The HP-35 is a revolutionary approach to personal computation. Our new pocket calculator has the portability of a slide rule, the ease of an adding machine, and the problem-solving power of a small computer.

This innovative "answer machine" is helpful to anyone who uses advanced math whether in science, engineering, statistics, mathematics, education or finance. The 9 oz. wonder does far more than ordinary four functions; it handles logarithms, exponents, and trigonometric functions each with one keystroke.

Enter values in either floating-point or scientific notation. The operational stack of four registers plus a solid-state memory holds intermediate solutions to problems, then later automatically brings them back for further processing. You do not have to input recurring figures over and over.

The calculating range extends from 10^{-99} to 10^{99}. And the price is within your range—only $395.

To find out how to get one, check the HP Reply Card.

This handful of solutions displays answers to ten significant digits, plus sign and two-digit exponents of 10. The decimal point is automatically positioned.

Collision avoidance role for cesium beam clock

HP's atomic frequency standards play a major role in new air collision avoidance system (CAS) successfully tested by the Air Transport Association and a commercial airline. In CAS each aircraft sends a coded message every three seconds. Time-synchronized equipment in other listening aircraft computes (a) the distance to the transmitting aircraft, (b) the closing rate, and (c) altitude difference to determine collision threat and indicate proper evasive maneuvers.

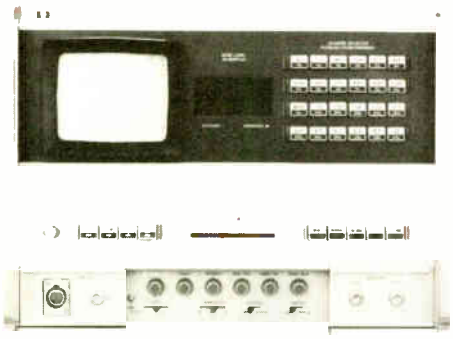
For ultra-precise CAS time-keeping, HP developed a rugged miniaturized cesium beam atomic frequency source for aircraft use. This HP 5062B "clock" is only 5 by 8 by 19½ in. (123 by 194 by 495 mm) and makes CAS independent of ground stations.

Because CAS is a navigation system, the small CAS cesium beam standard is creating interest among people involved in navigation, tracking and communication systems of other types.

The HP 5061A cesium beam standard, a larger version, has been available for eight years. Absolute accuracy is 1×10^{-11} (7×10^{-12} optional). Price: $15,500.

For more about precision frequency sources, check the HP Reply Card.

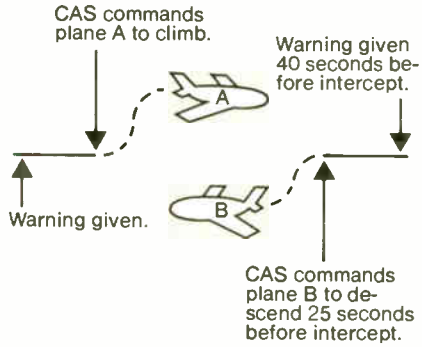
Wide dynamic range for the sight of sound



The 8064A has complete programmability built in for easy computer interface.

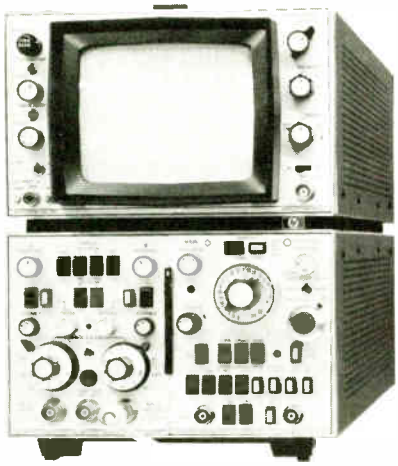
Displaying the frequency spectra of sounds as they occur, the 8064A audio spectrum analyzer operates independently or as part of an automatic data acquisition, processing or recording system. Active filters divide the spectrum into 24 third-octave channels in the 2 Hz to 40 KHz frequency range. Dynamic range is outstanding: 84 dB with 60 dB displayed. The price is $9,950.

To learn more, check the HP Reply Card.



COLLISION AVOIDANCE SYSTEM
Evasive Action Sequence

Powerful plug-in with selectable impedance



The 1805A (lower left panel) has dc offset that eliminates dc reference on logic and noise pulses yet maintains low deflection factors for maximum amplitude displays.

A new 100-MHz vertical amplifier plug-in for 180-series oscilloscopes packs more measurement capability into one plug-in than any previous unit. The dual-channel 1805A has selectable 1 megohm/50 ohm inputs, 5 mV/div deflection factors from dc to 100 MHz, up to ± 200 divisions of offset, and a vertical signal output that allows cascaded operation to 250 μV/division.

Use 1 megohm input for general purpose probing or the 50-ohm impedance for transmission-line measurements. The low capacitance doubles the frequency range over which probing can be performed without serious loading of the circuits. Price: $1400.

Check the HP Reply Card for details.

continued from page 1

The 8660B is ideally suited for the most demanding measurements; e.g., narrow-band receiver testing and crystal filter tests. In addition to keyboard control, it features 10 digit LED readout of frequency, TTL programmability and computer compatibility. And there is plug-in RF coverage, 0.01–110 MHz and 1–1300 MHz.

Prices of the 8660 systems start at less than $6000; the 8660B keyboard mainframe costs $6000.

Synthesizer for precise amplitude and frequency control

The ideal signal source should have excellent frequency accuracy and stability, precise amplitude control, a reasonable price tag, and the ability to interface easily with systems. The HP 3320 A/B frequency synthesizers have all these features, plus spectral purity of a quality RC oscillator and low signal-to-phase noise.

The 3320A adds synthesizer quality to production and design work yet does not distort your budget. The 3320B is a precision bench instrument as well as a quality programmable signal source. With amplitude accuracy, resolution and frequency response measured in a few hundredths dB over a 100 dB attenuation range, the 3320B is both a frequency standard and a very precise level generator. It is the standard low frequency source in HP's 9500 automatic test systems.

Synthesizer options include remote control, two lower frequency ranges, 75-ohm output, crystal oven, and marked card programmer.

The 3320 has the widest frequency range of any test oscillator, programmable oscillator or low cost frequency synthesizer on today's market—0.01 Hz to 13 MHz.

Prices: 3320A, $1900; 3320B, $2400.

For details, send the HP Reply Card.

How to achieve low-cost data reduction

You can interface a 9100, 9810 or 9820 calculator to the highly-diverse coupler/controller system.

Many people who could benefit by automating data collection and testing shy away from it because they believe it would be too complicated and expensive.

Not any more. HP has developed a calculator-based instrumentation system—low cost and easy to use—for on-line data acquisition and automatic testing. You can program from the keyboard within a few hours; there are no special languages to learn.

It's basically a computing system (in the form of a powerful calculator) attached to a measurement system through a versatile coupler/controller. The calculator interfaces with up to seven devices—DVMs, scanners, teletypewriters, tape punches and readers, recorders, etc. —through cards plugged into the coupler/controller. The calculator serves as the system program source and data processor. Results can be plotted simultaneously with printed, tabulated reports.

Automate your lab experiments and production testing at a fraction of the "computer price." Calculators begin at $2975; coupler/controllers start at $1275.

For all the details, send the HP Reply Card.

A first: do-it-yourself microprogramming

No extra cables or power supplies—the single Writable Control Store cards contains 256 24-bit words and all required address and read/write circuitry.

Now you can have a computer with Writable Control Store capability. You can test and debug preliminary microprograms, alter or extend the instruction set—under actual run conditions, and just as fast as operating from read-only memory.

Program execution in the 2100A is controlled by a computer within a computer. The internal computer, or microprocessor, executes microcode stored in its extendable read-only memory. With WCS, you can check this microcode before committing it permanently to ROM. You can also output, debug and alter microcode subroutines dynamically, during run time.

Specially developed software—including a micro-assembler, utility and I/O routines, drivers, and diagnostics—automatically puts your microprogram into the required form. And an optional PROM Writer commits the debugged microprograms permanently to read-only memory.

Prices: 12908A Writable Control Store, $3500; 12909 PROM Writer, $500.

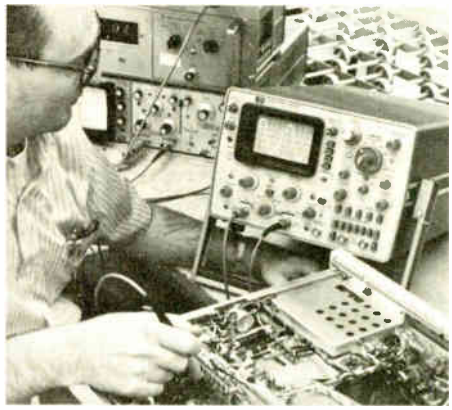
For WCS information and a copy of our "Microprogramming Guide," use the HP Reply Card.

New persistence/storage scopes that work wherever you do

Only our new 35-MHz portable oscilloscopes give you variable persistence/storage *anywhere* and *everywhere*. They are battery-powered and smaller than a suitcase. The 1703A scope has a burn-resistant CRT, along with main and delayed time base sweep speeds to 10 ns/div and a 10 mV/div deflection factor. Model 1702A is identical, but without delayed sweep.

Variable persistence lets you preserve low rep-rate signals and read the CRT display without clutter from old traces. Trace retention time is adjustable, from less than 1 second to over an hour. Use variable persistence as a pseudo-normal write mode when you need extra brilliance, or use it anytime a low sweep speed causes annoying flickering.

The storage holds single-shot phenomena or other infrequent events for over an hour. Writing speed is 100 div/ms; push the Max Write button, and the speed is 1000 div/ms.



The 1703A CRT is burn-resistant and uses P31 phosphor for excellent resolution and sharp spot size.

Both scopes operate on 11.5 to 36 Vdc, any ac outlet, or from a battery pack that fits snugly inside.

The 1703A costs $2725; the 1702A (nondelayed), $2375.

Interested? Check the HP Reply Card.

New high-speed x-y recorder especially for OEMs

Pulmonary testing is just one application for the new high-speed OEM 7041A recorder. Original equipment manufacturers also use it in correlators, Fourier analyzers, pulse-height analyzers, wave analyzers, and calculator plotters. By high-speed, we mean a minimum slewing speed of 30 in/sec and acceleration of 3000 in/sec^2 on the Y axis, 2000 in/sec^2 on the X axis.

The 7041A writing area is 10 by 15 in. (25 by 38 cm) with an autogrip for 11 by 17 in. or international A3 size paper.

This recorder is designed for OEMs who need speed and precision, but don't want costly features irrelevant to end-use. The one-piece aluminum mainframe is rugged, yet shock-resistant. The circuitry contains only ten hand-soldered connections; no expensive maintenance or special calibration is required. A new motor design lets the recorder pen be driven offscale for an indefinite period of time without noise or damage.

You select only what you need from almost 40 available options. The 7041A recorder costs $1050. OEM discounts are available.

To learn more, check the HP Reply Card.

Nifty new options for HP strip chart recorder

HP's 7123 linear motor recorder, enhanced by three new options, now writes without ink, quantifies peak areas, and has four-speed transmission.

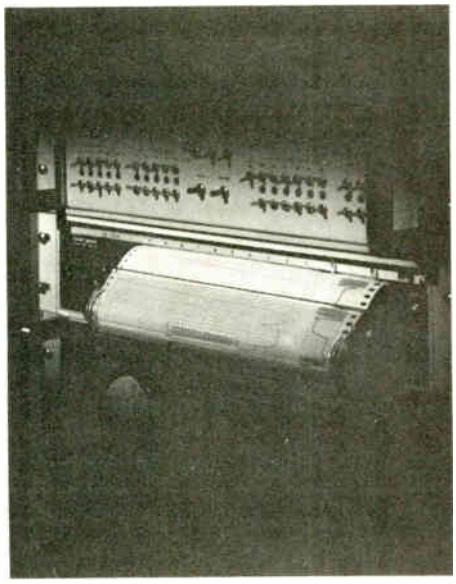
Electric Writing (Option 036) is a low voltage system that provides a clear, permanent trace on electro-sensitive paper.

The Electronic Chart Integrator (Option 035) computes complex peak area measurements and averaging. Integration is continuous; there is no lag time between main pen and integrator pen responses. Compare this with the time it takes you to read the chart, calculate mathematically, and write the results—not to mention eliminating human error, too.

Our own version of "four on the floor" is an Incremental Chart Drive (Option 045) which provides four speeds (selectable from the front panel) and an external input. Match the chart speed with other recorders, correlate it with computer output, or synchronize it with pulse output from flow meters. The 7123A costs $750. For electric writing, add $35; the integrator, $750; and the chart drive, $155.

For more details, send the HP Reply Card.

The 7123 10-in. strip chart recorder with integrator and incremental chart drive fits neatly in a spectrum analyzer.



Automatic microwave test system costs much less than you'd expect

The 8545A has the speed, accuracy and versatility you need to solve measurement problems in production test and the design lab—with visual answers on the console graphics display.

Let us surprise you with the low price and high cost-effectiveness of our new 8545A Automatic Network Analyzer. Modular in concept, a basic system can be linked to your existing timeshare facilities—for less than $50K.

Extend its frequency coverage and measurement capabilities incrementally and expand to an independent dedicated system with BASIC language software control. You can then add the high-speed interactive graphics display and enhanced operator control capability of the system console. You buy only the capability you need now, and add to the system as your needs increase.

The system measures amplitude and phase-related parameters of one- or two-port devices under automatic control in single or multiple frequency bands from 100 MHz to 12.4 GHz. Measurement accuracy difficult to achieve with manual methods is provided by system calibration and error correction techniques. The computer handles data conversions ranging from the s-h-y and z parameters of active devices to gain, loss, VSWR and impedance.

Test fixtures and adapters let you measure active and passive components: transistors, amplifiers, antennas, cables, waveguide and stripline components.

For production testing, the timeshare system provides a low-cost solution to automating those difficult tests even with small variable test runs. Timeshare allows you to store many different user-written programs that the operator can call by typing a name. These same advantages apply to your design lab. Each engineer can develop his own program series to suit his particular measurement needs.

The dedicated system gives you high-speed measurements for large test runs and built-in programming capability with HP BASIC software, together with a flexible operator interface through the use of a magnetic tape cassette unit, high-speed printing and interactive graphics display.

Interested? Send the HP Reply Card.

New capabilities in AM, FM measurements

The 5257A transfer oscillator plug-in that gives HP counters direct readout of CW or pulsed frequencies from 50 MHz to 18 GHz is the key to some more difficult measurements too; e.g., incidental FM, rms incidental FM, FM deviation, percentage AM and distortion from 50 MHz to 18 GHz. Here, the 5257A serves as an ideal down-converter since it preserves the input signal's noise, AM and FM characteristics and, in pulsed RF signals, the pulse width and repetition rate.

A wide-band sampler gives the 5257A its unique wide range, constant sensitivity, and one-dial tuning. Use it with HP's well-known 5245, 5246 and 5248 electronic counters. They accept any of 12 frequency or function-extending plug-in accessories for almost any frequency or time interval measurement you are likely to need. Their outstanding reliability is documented by 40 million hours of operating data.

Prices: $2450 for the 5257A; the counters start at $2000.

For more information on AM and FM measurements, check the HP Reply Card.

5257A Transfer Oscillator

New desktop calculator that converses in algebra

Design your own calculator. Three read-only-memory function blocks plug into the left side of the Model 20 keyboard.

Program ten times faster in algebra with a machine that speaks *your* language—the new 9820A algebraic programmable calculator. You merely enter algebraic equations at the keyboard just as they are written on paper; check expressions on the exclusive alphanumeric display; then press another key to store or execute the program.

Full editing capability lets you press a key to delete, change or insert characters, lines or statements. When a line is added or deleted, the program automatically adjusts to occupy minimum memory.

The basic 173 registers can solve 17 simultaneous linear equations with 17 unknowns. Or, expanded to 429 registers, it is capable of 36 linear equations with 36 unknowns. An optional mathematics plug-in block adds log and trig functions; a user-definable block lets you "personalize" up to 25 keys; and a peripheral control block interfaces with plotters, typewriters, and card readers.

Price: $5475, including thermal printer and magnetic card reader. Functional plug-ins cost $485 each.

For more information, check the HP Reply Card.

Now you can digitize low frequency waveforms

Two new 3480 DVM options, Sample-and- Hold and Data Storage, store up to 50 readings made on a changing input voltage. Sample-and-Hold freezes a changing input voltage at one instant in time; storage enables use of Sample-and-Hold at high speeds (1000 readings/sec) yet lets the data be printed economically on a low speed printer.

This pair of options opens up new applications including vibration analysis, servo system analysis, and ramp linearity tests. Repetitive wave shapes can be digitized or peak readings can be made. Entire wave shapes up to 410 Hz may be digitized with four-digit resolution.

Both options fit into the 3480 mainframe. Three signal conditioning plug-ins are available for the 3480, including the new 3485A scanning unit with up to 50 input channels. The 2070A Data Logger puts it all together in the form of a self-contained data acquisition system complete with printer.

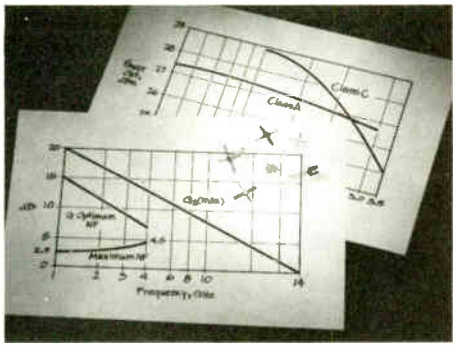
The 3480A costs $800; the 3480B, $900. For Sample-and-Hold, add $500; Data Storage, $1000. The 2070A starts at $2870.

For details, check the HP Reply Card.

Add a few options and the 3480A DVM becomes a handy data logging system.

COMPONENT NEWS

Microwave transistors: the best cost less



The sturdy HP 21, noise-quashing HP 22, and powerful HP 11 belong in your amplifier design.

Three new high frequency transistors mean you don't have to trade performance for low cost in amplifier and oscillator design. The HP 22 offers a typical noise figure of 4.0 dB at 4 GHz (with a guaranteed maximum of 4.5 dB) without relinquishing gain. At the optimum noise bias (10V, 5 mA), gain at 4 GHz is 6.5 dB. When matched for gain, this 14 GHz f_{max} device has 14.5 dB gain at 2 GHz and 9.3 dB gain at 4 GHz. Price: $75.

The HP 21 gives low cost gain with no mid-stage amplifier noise penalties. This 12 GHz f_{max} device gives a gain of 12 dB at 2 GHz with 4.2 dB NF. Characteristic of all HP transistors, it is reliable; the HP 21 has demonstrated a 10 million hour MTBF. Price: $19.

More Class A and C power per dollar is the strength of the HP 11. It features 27.5 dBm saturated, and 27.0 dBm linear power out at 2 GHz. Price: $19.

Check the HP Reply Card for complete technical information.

Small, new, low-powered LED display

Hewlett-Packard has developed a nifty five-digit LED display for designs where space and power are limited. This 5082–7405 solid-state numeric display package is 0.75 inch wide and requires only 7 mW per digit. Its compact size and low power requirements are ideal for battery-powered or hand-held multimeters, probes and miniature calculators.

This is one miniature display that is easy to read. Bright red numbers contrast against the dark lead frame. A self-magnifier enlarges each digit to 0.112 in. high, and one digit is dedicated to the decimal point for excellent display legibility.

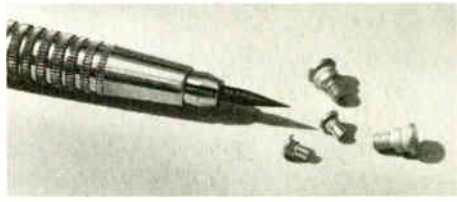
Installation is quick. Simply plug the display into a standard DIP socket or a printed circuit board.

Prices: $32.50 each (1–19), $22.50 (20–99), $17.50 (100–199) and $16 (200).

To learn more, send the HP Reply Card.

The 5082–7405 LED numeric display

New IMPATTs simplify microwave design



The 5082-0420 series silicon IMPATTs

HP's 5082-0420 series diodes are the first silicon IMPATTs to achieve microwave power levels of 1.5 W at 7 GHz and 1 W at 13.5 GHz. These silicon devices simplify the design of telecommunication repeaters, telemetry transmitters, and doppler navigational radars. Instead of costly gallium-arsenide devices or frequency multiplier chains, these silicon IMPATTs can be used as the active element in oscillators and amplifiers from C through K/μ band, when power, efficiency and reliability are critical. HP IMPATT diodes are rugged and reliable devices that meet MIL-S-19500.

Prices are $150 each (1–9), $110 each (10–99), and $75 each (100).

For complete information on our IMPATTs, check the HP Reply Card.

Counter options for high stability, sensitivity

Already they are probably the most versatile medium-priced, general-purpose counters available, but now HP's 5326/5327 universal counter-timers can have higher input sensitivity and stability. Option H60 increases sensitivity to 25 mV rms, 0° to 50°C (10–15 mV rms typical at 25°C). Long term stability becomes 3×10^{-9}/day with Option H49 and 5×10^{-10}/day with Option H50. Temperature effect is $<1 \times 10^{-8}$ total, −20° to +65°C.

Option prices: H60—$125; H49—$300; and H50—$450.

Check the HP Reply Card for details.

Now, get HP performance and reliability from 44 new modular power supplies

Three of HP's 44 new 62000-series modular power supplies.

You've undoubtedly heard of HP laboratory power supplies; now you can get the same HP quality in **modular** power supplies. Hewlett-Packard has introduced 44 new competitively-priced models for use wherever a dedicated source of dc power is required.

The 62000-series covers eleven popular voltage ratings from 3 to 48Vdc, with four output current ratings at each voltage rating. For example, at 5V there are 2.0, 4.0, 8.0, and 16.0A supplies. Intermediate output voltage ratings are also available on a special handling basis.

The units are packaged in three uniform height and depth cases which are fractions of standard 19-inch rack width: ⅛-width, ¼-width, and ½-width. Combinations of the three packages can be mounted in an accessory rack tray, or the supplies can be mounted individually on various sides.

These series-regulated supplies provide 0.01% line and load regulation, with ripple and noise of less than 1mV rms and 2mV p-p (up to 20MHz).

What makes these power supplies different? For one, they're thoroughly protected, which means you are too, even if you misapply them. If high ambient temperatures overheat the supply, a thermostat opens the fused ac line automatically. Critical loads are protected from receiving excessive output voltage if a remote sensing terminal is accidentally disconnected. Reverse voltage and current protection is also built in. Should something short the power supply output, adjustable cutback current limiting will restrict current to approximately 10% of rated output. Overvoltage protection (an internal, adjustable, overvoltage crowbar) is also available as a separate option.

This unique combination of protection features helps make HP modular supplies an exceptional value. Excellent reliability, achieved through a trouble-free design utilizing conservatively rated, high-quality components, adds even more value. And should you run into a tough applications problem, every one of HP's 172 field offices stand ready to assist you or provide service support.

Prices range from $89 to $195, depending on power output and package size. OEM and quantity discounts are available.

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Japan—Ohashi Building, 59-1, Yoyogi 1-chrome, Shibuya-ku, Tokyo 151, Japan, Ph. 03-370-2281/92.

00242

Meetings

International Symposium on Circuit Theory: IEEE, Sheraton-University Hotel, Universal City, Calif., April 19-21.

Southwestern IEEE Conf. & Exhibition (SWIEEECO): IEEE, Baker Hotel & Dallas Mem. Aud., Dallas, Texas, April 19-21.

Conf. on Computer Aided Design: IEEE, IEE, University of Southampton, Southampton, England, April 25-28.

National Telemetering Conf.: IEEE, Houston Shamrock Hilton Hotel, Houston, Texas, May 1-5.

Electrochemical Society Spring Meeting: Electrochem. Soc., Shamrock Hilton, Houston, Texas, May 5-12.

International Electronics Conf.: IEEE, AIP, OSA, APA, Queen Elizabeth Hotel, Montreal, Canada, May 7-11.

International Semiconductor Power Converter Conf.: IEEE, Lord Baltimore Hotel, Baltimore, Md., May 7-10.

Spring Joint Computer Conf.: IEEE, Convention Center, Atlantic City, N.J., May 15-18.

Aerospace Electronics Conf.: IEEE, Sheraton Dayton Hotel, Dayton, Ohio, May 15-17.

Electronic Components Conference: Electronic Industries Assn., IEEE, Statler-Hilton Hotel, Washington, D.C., May 15-17.

International Microwave Symposium: IEEE, Arlington Park Towers Hotel, Chicago, May 22-25.

Power Sources Symposium: Army Electronics Command, Shelburne Hotel, Atlantic City, May 23-25.

International Transportation Exposition/Congress of Transportation Conferences: FAA, SAE, IEEE, etc., Dulles Airport/Sheraton Park, Washington, May 27-June 4.

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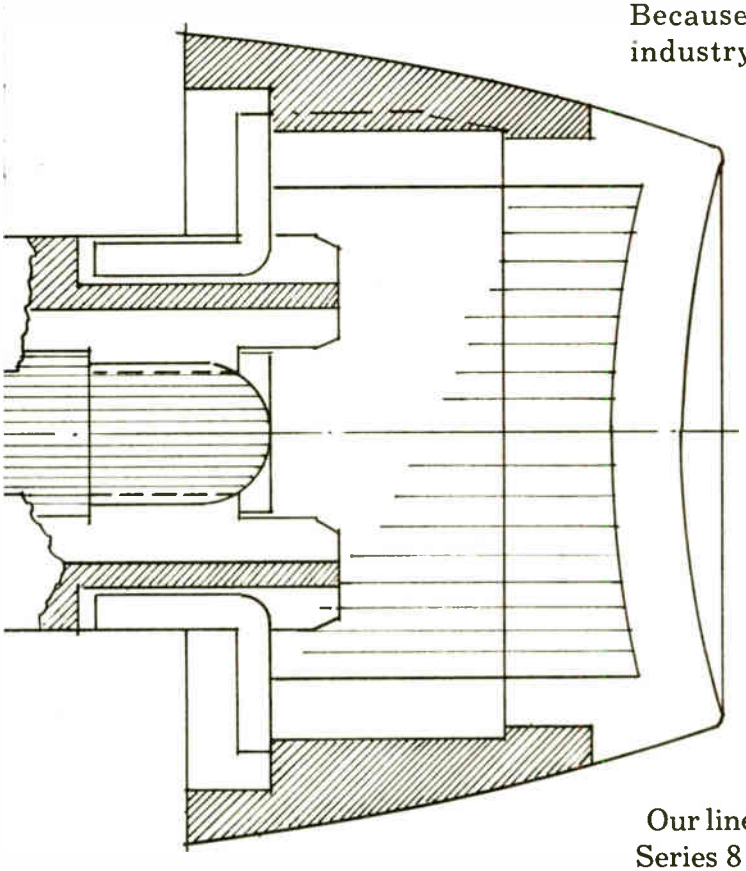

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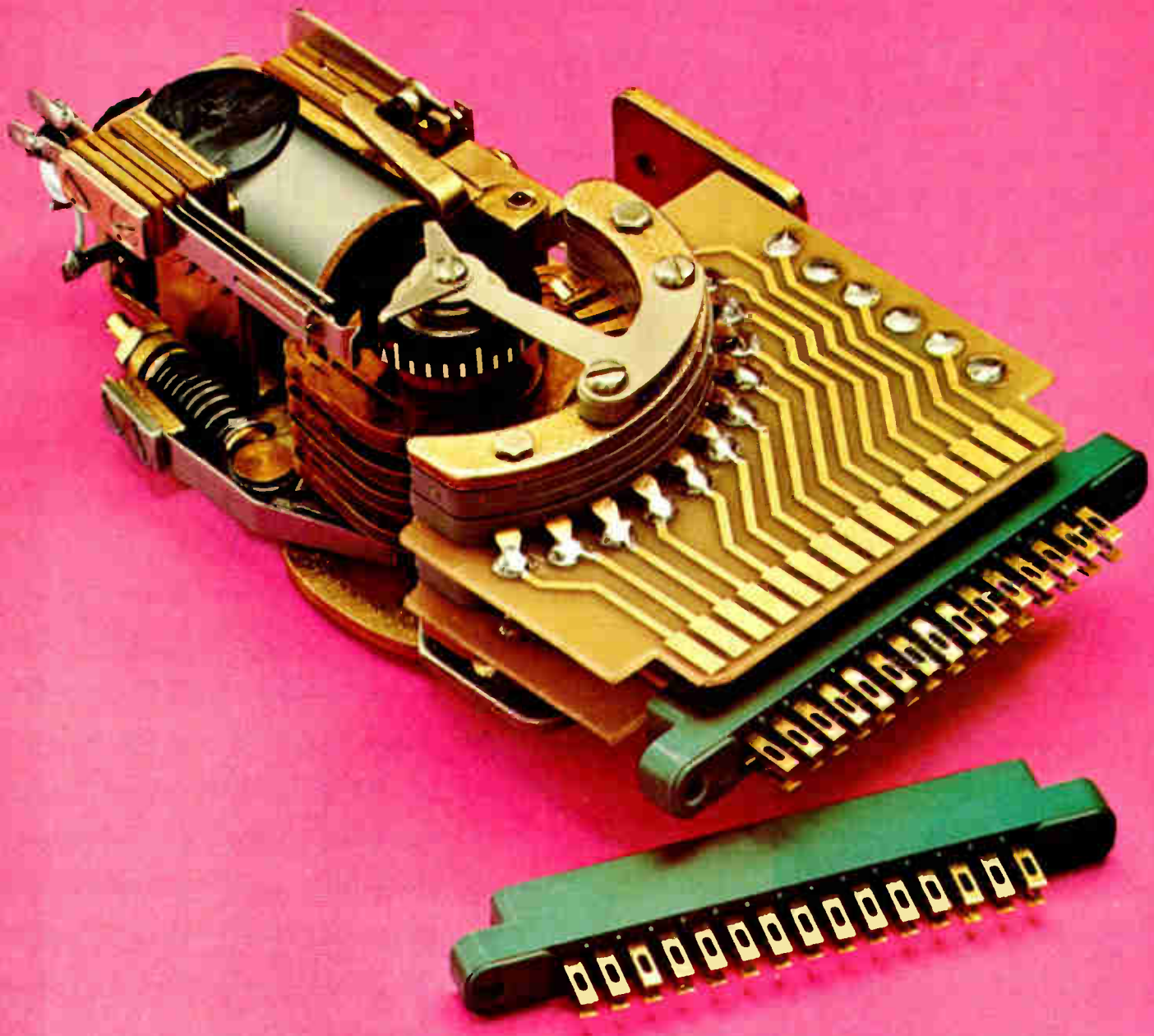

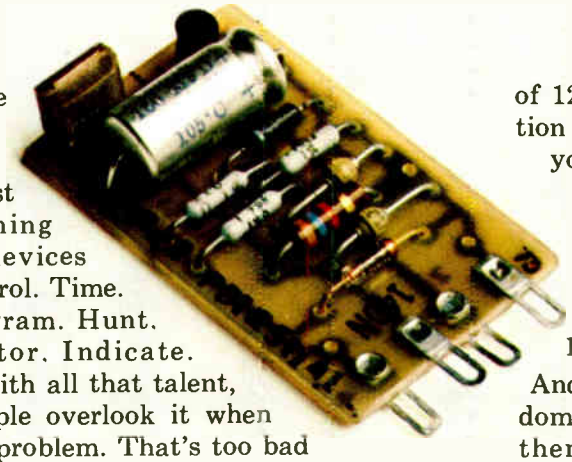

You can make a rotary stepping switch do just about anything solid state devices can do. Control. Time. Count. Program. Hunt. Test. Monitor. Indicate. Select. Yet with all that talent, a lot of people overlook it when they have a problem. That's too bad because it's often the most practical solution.

Think of the stepping switch as a time machine.

It conserves what you have the least of. Time. That's because most of the logic you need is built right in. It's part of the mechanical construction, not something you have to create. And by adding our Series 300 Time Delay module, you'll practically have a complete control system in the palm of your hand. Lots of people have created exotic solid state circuits only to discover they could have done the same thing faster and easier with a stepping switch.

Ten cents a contact.

That same exotic circuit probably costs three to five times more than a stepping switch, too. For example, a type 45 with 8 levels of 52 contacts will cost you about a dime a contact. We don't know of any switching method that costs so little.

A better memory than an elephant. And just as tough.

A stepping switch never forgets after a power outage. When the juice comes back on, it starts up right where it left off. And it shrugs off doses of 1250 volts because of inherently high insulation resistance and dielectric strength. This gives you a system reliability that can't be matched by solid state. Should the day ever come when maintenance is necessary, a plug-in style, like the type 44 in the picture, can be removed or installed in minutes.

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And maybe 10 million more. We've yanked random units off our production line and worked them to death. Many have lasted twice as long as their rated 10 million wiper sweeps across the bank. One reason is our "free floating" pawl. It can't possibly bind or overthrow because we don't use pawl or armature stops.

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If you need to switch in microseconds, or squeeze your system into a TO-5 can, forget it. But if you're looking for a simple, economical, reliable, easy-to-design solution to a switching problem, consider the stepping switch. We'll be happy to help you do it. If you want a head start, write today for a copy of our 40-page manual. GTE Automatic Electric, Industrial Sales Division, Northlake, Illinois 60164.

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Circle 31 on reader service card

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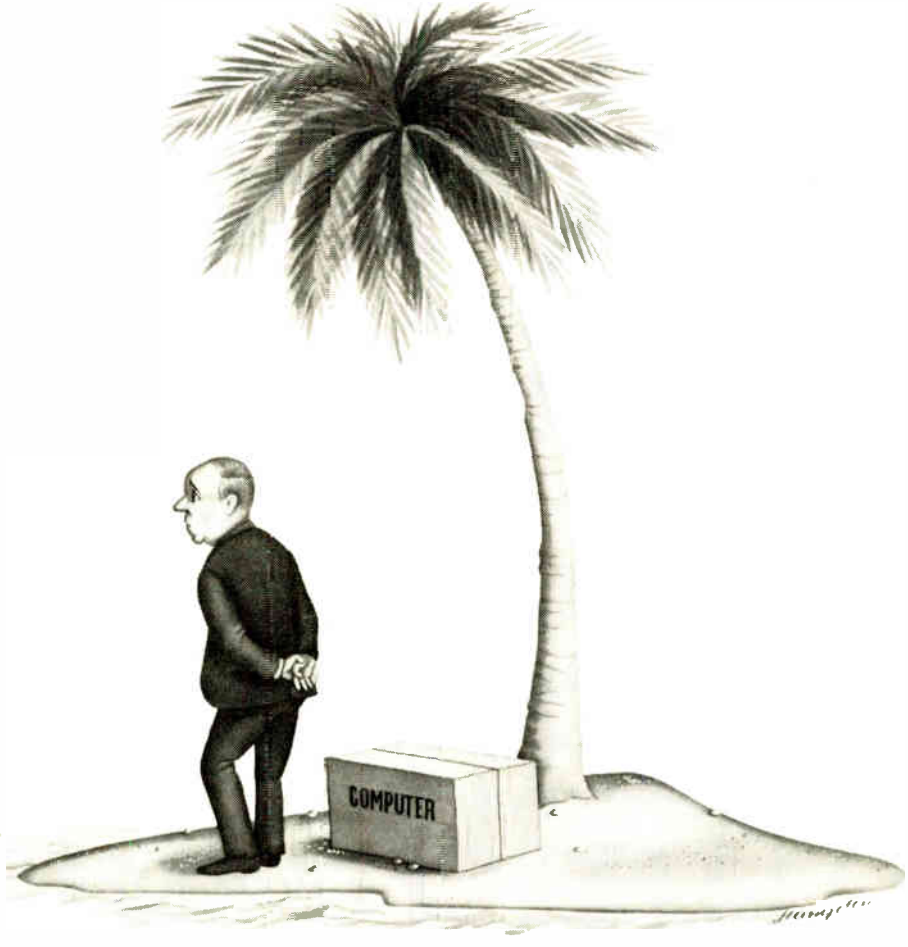
The reason most small computer companies can't give you big

computer you get When it comes time to got a problem.



We'd be happier if everybody in the world bought all their computers from us (we make and market more kinds, big, middle and small, than any other computer company in the world).

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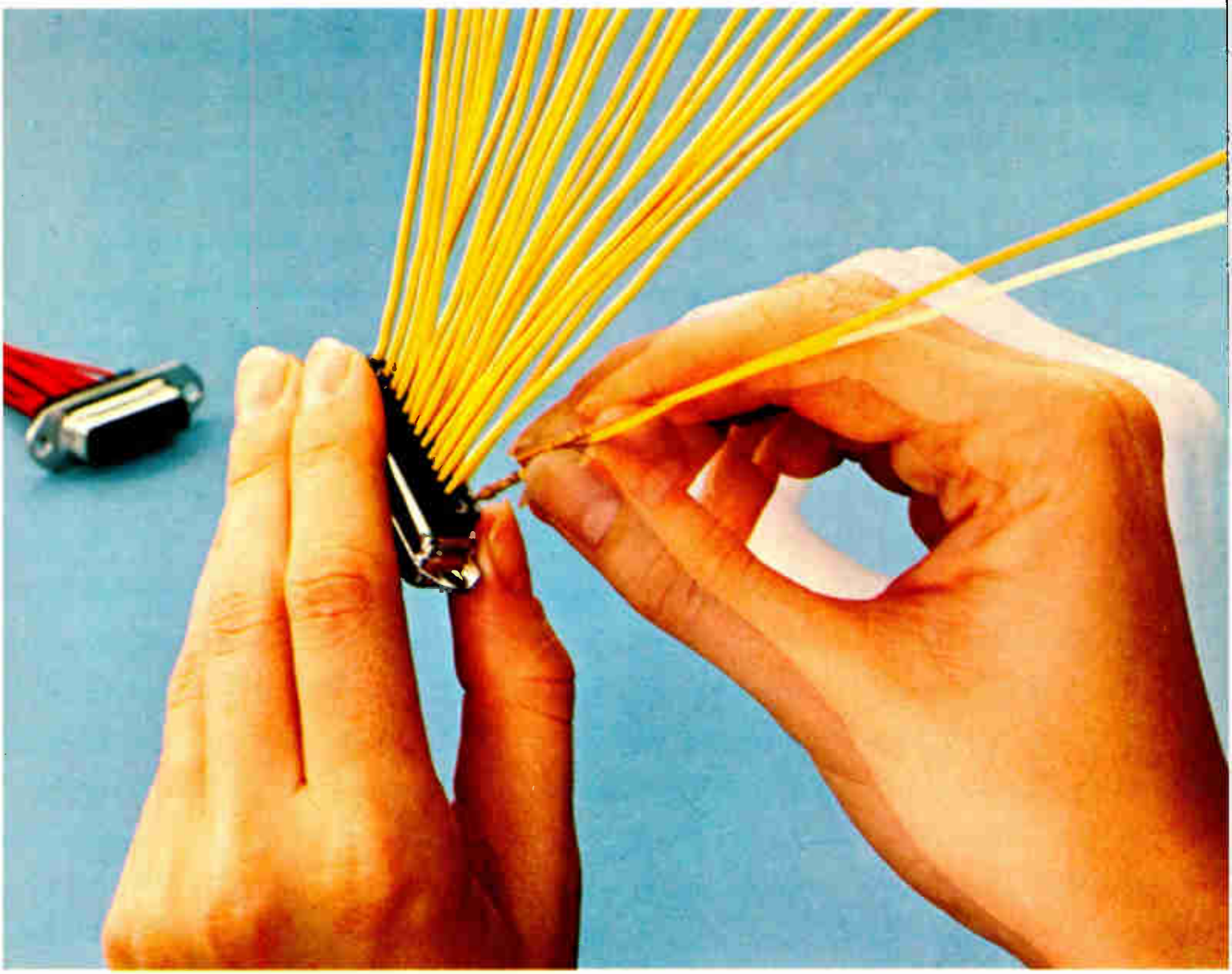

to less assembly time.

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A gentle push from the back of the connector and the contact snaps securely in place. No tools or broken fingernails, just easy fingertip assembly. And to remove the contact for fast field servicing, insert a simple plastic tool in the back of the connector and out pops the contact.

You can have a choice of screw-machine contacts in bulk packaging, or stamped and formed contacts on a carrier strip. Semi-automatic crimping or hand tools available for either type of contact.

The Min-Rac® 17 Series connectors are available in 9, 15, 25, 37, and 50 contact configurations. All meet EIA Standard RS-232C for data communications input-output connectors. And all are intermountable and intermateable with other Min-Rac 17 Series connectors as well as competitive "D" type connectors.

Find out how simple it really is. Just write Dick Colt asking for the whole story on our Min-Rac 17 Series rear-release connectors. Amphenol Industrial Division, Bunker Ramo Corporation, 1830 South 54th Avenue, Chicago, Illinois 60650.

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Circle 34 on reader service card

Electronics newsletter

Liquid crystals help measure antenna patterns

From calculator readouts to antenna measurements—that seems to be the applications range of liquid crystals. Scientists at the Raytheon Co. Missile Systems division have simplified **near-field microwave antenna pattern measurements** by using the devices and are getting more accurate results. Formerly, it was necessary to use rf probes to establish signal strength, point-by-laborious-point. Not only did this take time, it also forced engineers **to maintain near perfectly constant rf inputs to the device under test.**

Also, reflection and coupling between the probes and antenna elements, plus cross-coupling between the elements themselves, degraded accuracy. This was especially true in phased arrays where inter-element coupling must be measured and minimized to design antennas to scan without so-called blind spots. Thus, probe measurements normally were more approximate than accurate.

In Raytheon's new approach, a resistive substrate is coated with liquid crystals and placed before the antenna or device under test. The microwave energy hitting it generates heat, **which causes color patterns corresponding to rf field strength at the liquid-crystal layer.** A color photograph records the test—and it is just about that fast. Also, since the substrate is electronically nonresonant, no added coupling or reflections confuse the pattern. Though the approach is said to need refinement, it already agrees with mathematically predicted field strengths to within ±15%.

National moves into systems

National Semiconductor Corp., Santa Clara, Calif., is going into the systems business by offering memory cards—and is going to try systems marketing, too. Charles Sporck, president, says National is working with Certified Grocers Association of California on supermarket checkout system. **The association will handle marketing to its 2,500 members—but National has marketing rights outside.**

National has designed calculators and has built memory boards for testing, **but not for marketing outside.** The first memory-card offering will be a system with 4,096 words by eight or nine bits that will be on two cards—one for the storage elements and the other for timing and control functions. The basic storage element is National's MM5260, a 1,024-bit MOS random-access memory. One timing and control card will be capable of driving as many as 16 storage cards.

Telex tackles memories, eyes communications

Telex Computer Products Inc., Tulsa, Okla., which has been a supplier for some time of computer peripheral devices that are plug-to-plug compatible with IBM equipment, is branching out **with a family of semiconductor memories for the IBM System/370.** The company's previous line has included magnetic tape, disk, and printer subsystems. And in the near future, says G. Harry Ashbridge, vice president for product planning, "We're actively considering a total data communications capability."

The semiconductor memories are intended **as replacements for the ferrite-core memories IBM offers** on the model 155 and 165 and for the semiconductor memory that is standard on the 145. When leased on the conventional 30-day basis, Telex's prices are 3% to 5% less than

IBM's; on a two-year lease, there are savings of 20% to 26%. Although IBM recently has been offering long-term leases on some peripheral equipment, it has not yet done so for memories.

The new memories are direct replacements for the IBM units. Telex is not now venturing into the memory-enhancement area, which has recently stirred up some excitement [Electronics, March 27, p.70]. IBM tried to withhold maintenance on computers that had memories enhanced beyond specified capacity, but lost a court battle brought by an independent manufacturer. **The Telex units are now in the test stage,** and customer deliveries for three models for the model 155 are scheduled for the first quarter of 1973. Two models for the 145 and two for the 165 will be delivered in the second quarter.

One-chip slide rule may sell for $100

The market in electronic slide rules is beginning to heat up, though not to the same degree as calculators. **North American Rockwell Microelectronics Co., Anaheim, Calif., is working on a one-chip slide rule that is expected to sell for about $100, beginning in January 1973.** Though NRMEC will not disclose the customer, it is a mass merchandising outlet. In January, Hewlett-Packard Co. introduced a $395 unit that it is marketing by direct mail [*Electronics*, Jan. 17, p.31].

Tektronix focuses on optoelectronics

Continuing a diversification program begun several years ago, Tektronix Inc. is moving into optoelectronics. The oscilloscope firm's first entry is a portable photometer/radiometer with a digital readout using light-emitting diodes. **Manufacturers of LEDs, cathode-ray tubes, and electroluminescent panels** are considered potentially big customers for the 2½-digit instrument. In developing the unit, Tektronix drew heavily on experience gained in the manufacture and testing of CRTs and oscilloscope cameras.

Addenda

The IEEE has taken a step toward a more active role in political and economic affairs **after members indicated by more than 2 to 1 that they back such a change.** But the shift won't be implemented overnight—the next step will be a membership vote in September to amend the society's constitution . . . The National Cable Television Association's **new president will be David Foster,** who leaves Data Transmission Corp. as executive vice president. Foster, who smoothed the path of Datran's qualification as a special-service common carrier, will now have to **smooth the abrasion between large and small CATV operators** as well as advance the association's position in contests with broadcasters . . . North American Rockwell Microelectronics Co. has pinned down another of the old-line U.S. calculator companies with disclosure that **it is supplying three plastic-packaged chips** for Friden's 1101 and 1102 printing calculators, which may be sold under the corporate Singer name. The 1101 sells for only $540. One logic chip and two input/output chips are used . . . Martin Marietta's Communications and Engineering division at Orlando, Fla., has recruited George Mansur, deputy at the White House Office of Telecommunications Policy, as engineering director. Martin's move is read in industry **as a signal that the company plans to expand its efforts** in microwave and terminal communications markets outside of the Government equipment area.

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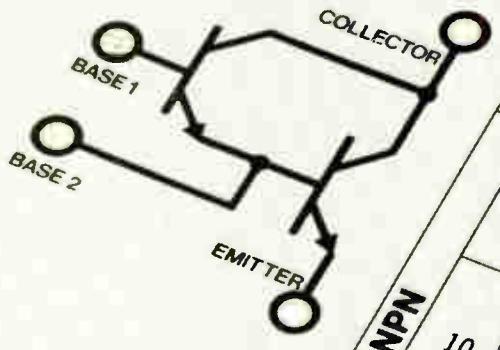
For fast action, call Sales Engineering collect at (617) 926-0404 Unitrode Corporation, Dept. 4 Y, 580 Pleasant St., Watertown, Mass. 02172

Application note U64 available on request.



C-LINE POWER DARLINGTONS

	Ic Amps	Type	Package	V_{CE} Volts	h_{FE} min	V_{sat} max	t_{on} ns	t_{off} ns
NPN	5	U2T301	TO-33	60	1000 @2A	1.5 @2A	300 @2A	1000 @2A
		U2T401	TO-66					
		U2T305	TO-33	150	1000 @2A	2.5 @2A	400 @2A	1000 @2A
		U2T405	TO-66					
	10	U2T101	TO-33	80	2000 @5A	1.5 @5A	480 @5A	1000 @5A
		U2T201	TO-66					
		U2T105	TO-33	150	1000 @5A	2.5 @5A	500 @5A	1000 @5A
		U2T205	TO-66					
	20							
PNP	5							
	10							
	20							

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1972

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D,R,Z Diode, Resistor, Zener Diode Test Instruments	Boston Paris Palo Alto	Feb. 22-25 Apr. 17-21 July 17-21
J259 IC Test System	Boston Los Angeles Paris	Jan. 25-28 June 5-9 Aug. 21-25
J263 Linear Circuit Test System	Boston Paris Palo Alto Tokyo Boston	Feb. 14-18* Mar. 6-10* May 15-19 Aug. 14-18* Nov. 27-Dec. 1
J271 Analog Circuit Test Sy	Boston Boston Boston	May 15-19* July 24-28* Nov. 6-10*
J277 MOS Clock-Rate Test Sy	Palo Alto Boston Paris Palo Alto oston	Jan. 31-Feb. 4** May 1-5** June 5-9** July 31-Aug. 4** Nov. 13-17**
J283 IC Test System ("The SLOT Machine")	Angeles on eles 	Jan. 24-28* Apr. 24-28* May 29-June 2* June 5-9* July 24-28* Nov. 6-10*
K147/K148 Relay Test Instruments	Bosto Bosto	Feb. 16, 17 Aug. 30, 31
L100 Digital Circuit-Board Test System	Paris Boston Palo Alto Paris Boston	Mar. 6-10* Apr. 24-28* pt. 11-15 23-27* 6-10*
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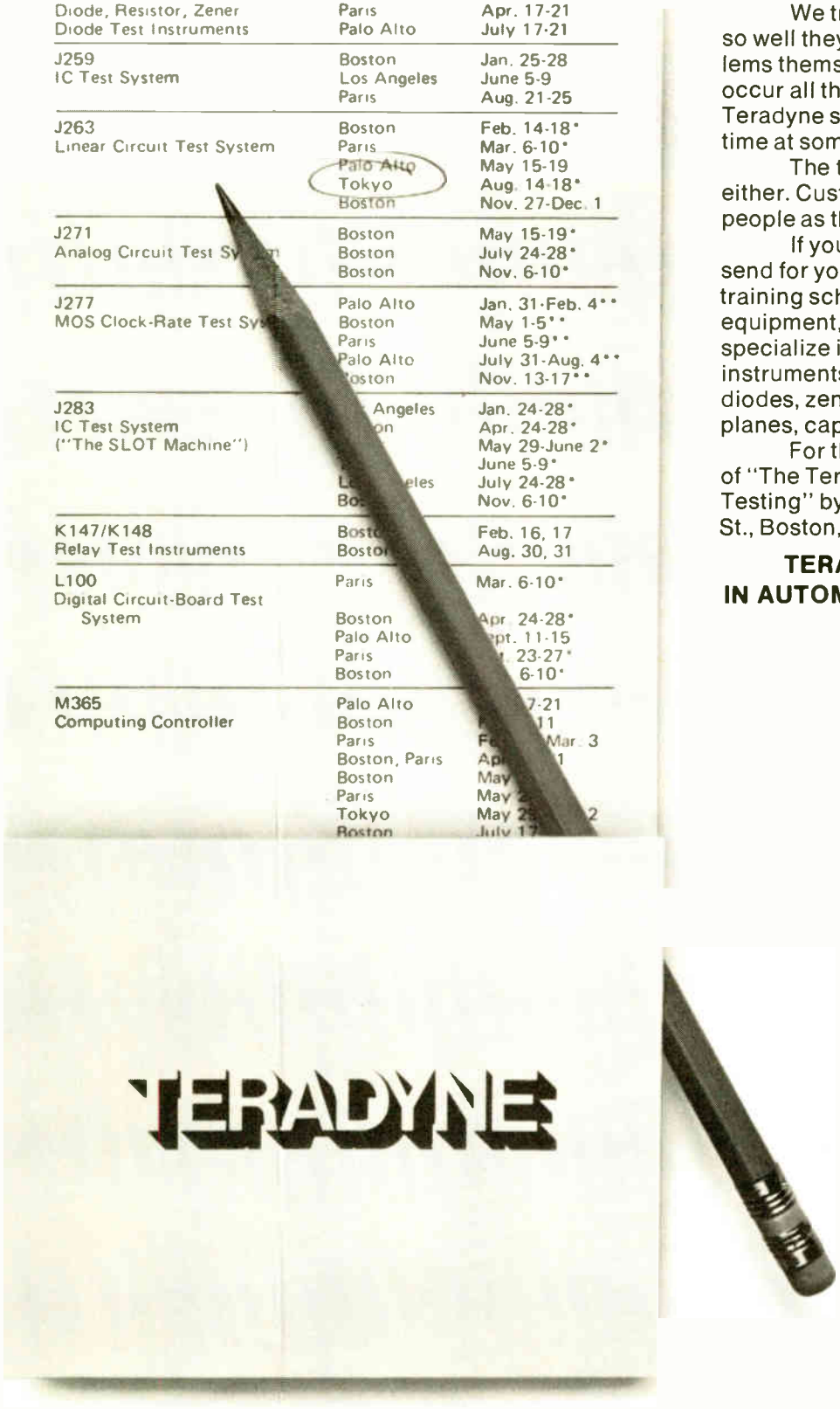


Navy to put $3 million into CCD research

Three-phase R&D program aimed primarily at replacing tubes in low-light-level TV cameras; RFPs due May 1

The Navy's interest in optical imaging is about to produce a $3 million investment with industry in charge-coupled device research and development [*Electronics*, Mar. 27, p.29]. A request for proposals by the Naval Electronics Systems Command (Navelex), scheduled for release by May 1, will spell out a three-phase program. Two contractors are expected to be funded for a total of "roughly $500,000 to $600,000 in phase one to look at the basic technology," say Navelex officials. Phases two and three, expected to concentrate on applications, will be funded at about $1.2 million each.

One of three. John S. Foster Jr., director of defense research and engineering, singled out CCDs before Congress as one of "three probably significant new electronic components demonstrated in laboratory tests." He said they "promise to simplify low-light-level television systems" by eliminating costly tube-equipped cameras. (Foster's second and third citations covered microwave acoustic devices for small, low-cost electronic warfare signal processing systems [*Electronics*, Nov. 10, 1969, p. 94] and Gunn amplifiers as traveling-wave tube replacements.)

Navelex officials suggest their approach to CCDs will not be hasty, despite industry enthusiasm and perhaps because of the visibility of the program within the Department of Defense. The achievements of Bell Laboratories in the technology are already known, as are the in-house efforts of potential Navy contractors, such as Fairchild, General Electric, RCA, and Texas Instruments. The Navy program's first phase will call for "a good understanding of the basic technology," officials say, and ask, "If we can really make these things, do they really work?" This phase should require from six to eight months after initial awards expected before the end of the fiscal year, June 30. Though the first phase "will focus on imaging, we will ask these people to look for applications in other areas," say Navelex project leaders.

Applications interest extends far beyond low-light-level TV, say program officials. "They cover quite a few optical imaging areas. For example, we will be looking into the visible portion and infrared; digital applications will also be explored. We are thinking in terms of computer memories, signal processing, correlators, and that sort of thing."

Navy thinking on CCD sizes and costs comes through this way: The device should be "about the size of a coin" compared to existing miniature tube depths of 6 inches—or 8 inches for low-light-level devices. Unit costs in volume production should drop to "$50 to a $100 for a good imaging device, compared to several hundred to several thousand dollars" for today's TV cameras. □

Look what we have

Just how does industry bring new technology to the attention of the military? In the case of charge-coupled devices, this is the chronology:

Beyond a Naval Research Laboratory effort done last year by RCA, the Navy's interest was heightened when "some time last summer, Fairchild came in with a presentation to the Chief of Naval Materiel, pointing to some real breakthrough in this area and noting that the time was ripe for some support," says an official. This led to a November 1971 meeting of the Pentagon's Advisory Group on Electron Devices under Navy sponsorship at the Institute for Defense Analyses, chaired by Bell Laboratories' optoelectronics director, Eugene Gordon. Industry representation included GE, Fairchild, RCA, and TI.

Though the Army and Air Force are monitoring the Navy effort in CCD, the initial program will be strictly a blue-water effort under the cognizance of Navelex, with technical support from NRL.

Space electronics

NASA plans four trips to Venus

Despite early indications, the $5.5 billion manned space shuttle program won't completely squeeze out unmanned explorers to other planets. Rather, by using existing spacecraft technology and spacing peak funding levels, NASA has been able to plan a few significant planetary programs that also will generate

sizeable contracts for industry.

The latest program is a projected $150–$200 million series of four spacecraft to Venus beginning in late 1976. NASA will select two industry teams August 1 for competitive $500,000 system-design studies. It plans to choose a builder for the series in late 1973 for work beginning early in 1974.

Already answering requests for proposals for system design, due May 1, are three teams. TRW Systems of Redondo Beach, Calif., has combined with Martin Marietta of Denver, Colo., Hughes Aircraft of Culver City, Calif., is with General Electric of Valley Forge, Pa., and Avco of Wilmington, Mass., has teamed with Philco-Ford of Palo Alto, Calif.

Like the recently announced economy Grand Tours [*Electronics*, March 13, p. 38], the Venus trips will be based on existing spacecraft. In this case it would be the 570-pound Pioneers F and G—built by TRW—because "Pioneer is the right size to do the missions," says Daniel H. Herman, manager of advanced programs and technology in NASA's Planetary Programs Office. "They will be spinning like Pioneer, and the communications will be like Pioneer," he says.

Launch in 1976. Present plans call for launching two entry probes during the Venus window between December 1976 and February 1977, says Herman. After those probes have defined the Venus atmosphere, an orbiter would be launched in 1978, followed by the last probe in 1980 to pinpoint any interesting anomalies that showed up in the earlier trips, he explains.

The probes would be jam-packed with instrumentation. Each would contain a fly-by craft with upper Venus atmosphere sensors; a main probe with instruments to measure pressure, density, cloud dynamics, and other phenomena; and three so-called miniprobes—measuring pressure and temperature only—that would scatter to measure the overall dynamics of the planet. The orbiter, which would circle in an eccentric orbit at 200 to 390 kilometers and in a different plane from the probe crafts, would map fields and particles.

NASA will seek congressional approval for the program to use fiscal 1974 funds. Because the peak funding costs would be only $40–$45 million a year, the outlook is favorable, Herman says. The scientific community expresses strong support also, he adds.

Besides finding out more about Venus, the probes would help earthly problems, too. "We don't have a good simulation of the earth's atmosphere," which is "thick around a rapidly spinning planet," Herman explains. "The two are coupled in a strange phenomenon, and it's hard to find the role of pollutants."

By exploring Venus, which spins slowly but has a thick atmosphere, and Mars, where conditions are the reverse, scientists can separate the variables for a simulation of the earth's atmosphere. Says Herman: "We can learn how atmospheres change and what the short- and long-range effects are when new ingredients are introduced." □

Computers

DEC builds its own core memories and opens door to system price cuts

Minicomputers are going to semiconductor memories, right? Wrong—at least in the case of Digital Equipment Corp. DEC has just entered the core memory business from the raw ferrite up, a move that has enabled the Maynard, Mass., minicomputer maker to cut basic system prices by about 20%.

The first product is new low-cost memory for DEC's PDP-11 series, both add-ons (like the self-contained ME-11L) at $5,200 and 8,192-word plug-in core modules at $4,400 to replace existing units in PDP-11s. The 19-mil cores, which are built, strung together, and integrated into their respective systems and subassemblies by DEC, run at 900 nanoseconds—50 ns faster than the core formerly used in the PDP-11 line.

Simultaneously, DEC is introducing a wholly in-house-produced disk memory system, the RK05. It is a cartridge disk system and replaces one formerly purchased outside by DEC. The RK05, says DEC, is the only such disk near its price with power supply included in its basic configuration: its cost is $5,100 in single units, compared with about $8,000 for its predecessor. Also, it is DEC's first moving-head disk. And, though it already packs 2.45 megabytes at 2,200 bits per inch along its tracks, the tracks themselves can be placed

Packing it in. DEC's Grant Savires demonstrates one of company's new ferrite core memory systems with which it expects to be able to cut system prices radically.

so accurately beneath the moving magnetic head (±50 microinches) that there is potential for much tighter data packing in future versions.

Average access time of 50 milliseconds also is faster than the market average for such low-cost disks, which normally retrieve data in 70 to 80 ms.

DEC has at least two reasons to bring out the new peripherals. Andrew Knowles, vice president and PDP-11 group manager, notes that now the company can discount its peripherals as heavily as its mainframes—20% off on 10 units and up to 30% off on 100 units sold to original equipment manufacturers. The second reason is start-to-finish engineering and quality control.

Systems discounts. With DEC formerly acting as an OEM in its own right, much of the discount potential in peripheral equipment could not be passed on to the user. But the new line should drive DEC system prices drastically downward.

The PDP-11/05 provides the simplest illustration. With 8,192 words of the old core, the 11/05 costs $7,295; with the faster, less costly core, memory accounts for only $4,400 of system price, lowering the total to $6,495.

The reductions get more impressive with more impressive systems. A PDP-11/20 with 4,096 words of memory, an LA-30 DECwriter, and a PC-11 tape reader/punch used to cost $17,245. Now it's $15,650 less discounts with the DECwriter, and only $300 less with Teletype. The DECwriter, three times faster than Teletype, formerly was $3,000 with controller, $1,500 more than Teletype.

DEC thus has applied memory price reductions against the price of the DECwriter. Knowles guesses that most users will figure that even without discounts, the triple-speed printout advantage of the DECwriter will be worth the extra $300.

With the PDP-11/20 with 16,384 words of the new core, a DECwriter, a tape reader/punch, and the new RK05 disk, DEC's asking price is $33,725 versus $43,120 using the former disk and core peripherals.

New ferromagnetic material increases magnetization rapidly

A new ferromagnetic material that increases its magnetization suddenly when subjected to an external magnetic field shows promise as the basis for a new type of coded sensor or switch. Potential applications for the material, which produces an output pulse that is independent of relative mechanical motion, include credit-card verifiers, magnetic door locks, thermostat controls, ignition systems, and other switches.

The material was developed by John Wiegand, a researcher at Com-General Corp., an independent R&D organization in Dayton, Ohio, which has dubbed the phenomenon the Wiegand Effect. The president of the company, Donald L. Roettele, says: "We are planning to negotiate with companies wanting to develop specific product lines. In addition, we are continuing basic R&D."

"The company," he adds, "wants to explore a large number of industrial and consumer-oriented opportunities through application of this new magnetic technology."

The basic mechanism works this way: a wire made of the special ferromagnetic field material is first magnetized to a certain level. The sensor consists of a static, magnetic-field-generating head and what is essentially a pick-up coil sensing head. When the wire is brought near the magnetic field, a threshold switching action takes place, and the wire's magnetization rapidly steps up to a new level. The sensing coil picks up this rapid change in magnetic field, and delivers a pulse proportional to the speed of the switching action, but not related to the speed at which the wire approaches the head. Thus, the sensing action is independent of relative motion, and can provide static switching.

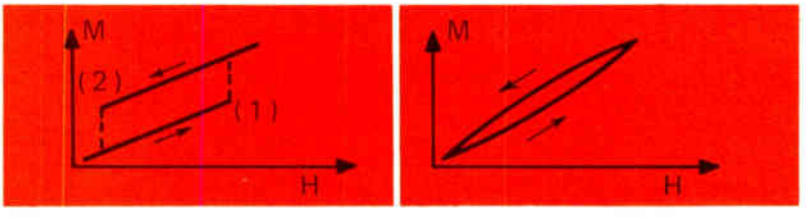
The first units deliver an output pulse of about 50 to 250 millivolts about 100 microseconds wide with a signal-to-noise ratio of 40 decibels. The material, said to be insensitive to temperature, will operate in a range extending from −95°F to +300°F.

Being independent of the activation rate, it is said to be ideal for auto ignitions, since it will deliver the same pulse regardless of engine speed. It also is insensitive to moisture, a boon to boat operators.

In a credit-card verification system, the card would have the wires laminated within the plastic. The wires would carry magnetization, and the combination of wires would be coded. When placed in a verifier containing the sensors, it would deliver an output as soon as the wires approached the sensor head, no matter how quickly or slowly the card was inserted. Thus, no motor system would be needed in the verifier to push the card at a predetermined speed. As a door lock, the wires would be embedded in the key and the sensors in the doors. Only the right combination of wires would open the lock.

Since it is a non-contact system, it will not wear out from abrasion. It will work with wide variations in head-to-wire spacing. □

Effect. As applied magnetic field is increased at determinable value (left), magnetization in wire switches very rapidly to a higher magnetization level. Then, as applied magnetic field is reduced, magnetization curve retains its slope until point (right), when it switches back to a lower level. Change is sensed by the read head.



That's a 22% price cut right off the top. And, according to Knowles, this is one of DEC's most popular PDP-11 combinations. Also, DEC discounts from that reduced price by as much as 36% to OEMs.

So DEC, by going to in-house production of core and disk peripherals and thus gaining the ability not only to engineer them to its specific needs, but also to discount them, expects to gain a significant competitive edge in systems sales prices. □

Big TI machine has wide data path

After six years of development, Texas Instruments is beginning to let the world in on what's under the hood of its Advanced Scientific Computer (ASC). The company picked last month's IEEE show as the setting to give the first detailed information from an official source about the giant computer as it moves toward its niche among other supercomputers such as Burrough's Illiac 4 and Control Data Corp.'s Star-100.

Basically, the ASC is a multiprocessor. It has eight interleaved memories, a channel processor, a peripheral processor, and the central processor. All three processors are connected to the eight memories through a full crossbar switch that permits any processor to obtain access to any memory independently of the other two. Through this switch, the memories collectively can honor requests for data once every 160 nanoseconds, delivering eight 32-bit words for each request, from each memory. This 256-bit-wide data path is among the widest, if not the widest, ever implemented. It gives the group of eight memories a bandwidth of 400 million words per second.

In the stream. Fundamental to the design of the new machine is the streaming of both instructions and data in the control processor. The ASC is actually an array of streaming units, which makes it effectively a pipeline machine, somewhat like the Star-100.

Elements of the pipeline are an instruction unit, a memory buffer, and an arithmetic and logic unit that perform both vector and scalar operations. In vector mode, it operates as an array processor, bringing to mind the Illiac 4.

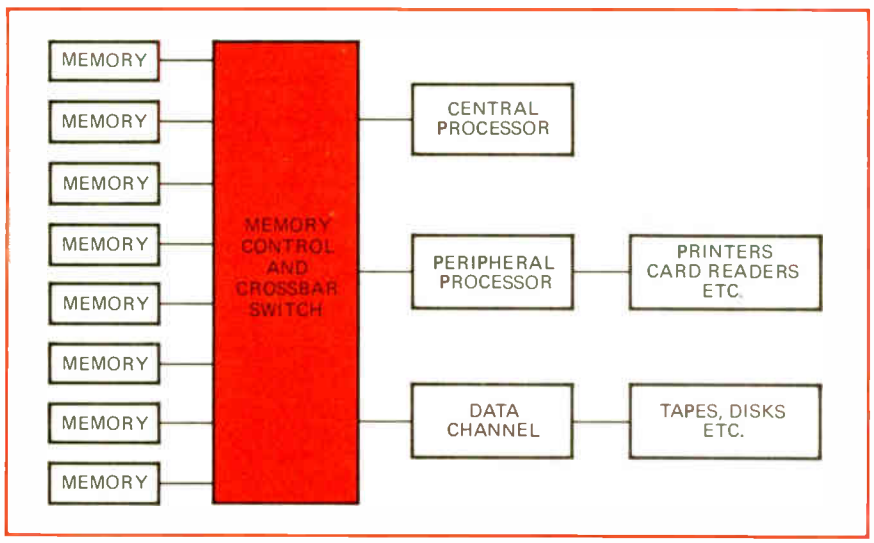
The memory buffer can transfer three 32-bit operands in 60ns–two out of memory and one into it. Since this is much less than the 400-million-word bandwidth, the memory can therefore handle additional arithmetic units if needed, plus plenty of input/output—all concurrently. The system as a whole executes a single instruction stream that contains a mixture of both vector and scalar instructions, up to 12 of which can be in process at once.

High-speed I/O equipment and data concentrators for remote terminals are controlled by the channel processor, while the peripheral processor runs slow I/O gear directly and also executes the operating-system program for the entire system. Eight virtual processors can operate independently on separate instruction streams. In this respect, the much smaller system recently introduced by Memorex Corp. [*Electronics*, March 27, p. 26] bears a startling resemblance to the ASC.

Complex board. Integrated circuits in the ASC are mounted on both sides of 17-layer printed-circuit boards—another new high in structural complexity.

One giant ASC is already processing seismic data at TI's Austin, Texas, laboratory, and another is being built for use by TI in Europe. Last January, the company announced that a third would go to the Geophysical Fluid Dynamics Laboratory in Princeton, N.J. □

Building up. Texas Instruments' new supercomputer, the Advanced Scientific Computer, has this basic structure. The machine has been under development for six years.



Displays

DOT looking at 6-color model

The promise of multicolor displays as traffic-control aids both in the air and on the ground is gaining strength. Not only is the FAA considering such displays for air traffic control, but another branch of the Department of Transportation has bought one to study its use in all types of control problems.

The DOT's think tank, the Transportation Systems Center in Cambridge, Mass., purchased the 20-inch, six-color display under a $70,000 contract with Tasker Industries of Chatsworth, Calif. Tasker also has submitted the device to the FAA for consideration [*Electronics*, Jan. 31, p. 31].

At Cambridge, it will be used

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"Not bad."

"And it's so good we've given the record head a whompin' 5,000 hour warranty."

"Well, I think we got something to work with. Anything else?"

"Yeah, those are both industry firsts from Bell & Howell."

"And?"

"Well, it has the usual 14 channels. 15/16 to 240 ips and stuff like that, in the conventional format."

"Ummm, who uses the thing?"

"R&D types mostly. It's about as sophisticated as you can get. They use it for aircraft tests. Cars. To pull down whole libraries of data from field recorders. That sort of thing."

"Sounds like a heckuva machine."

"System."

"Okay, system. So what do you call the super headed system?"

"The VR3700B."

"Wow. That really tells it like it is. Okay, we'll do an ad. But first I'll flip you for coffee. Call it."

"Heads."

"You win."

"Hey, not a bad headline for the..."

"Are you kidding? Beat it. Sheez, can you imagine."

Read about it. Bell & Howell, CEC/Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109.

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BELL & HOWELL

Circle 43 on reader service card

with conventional display-generating equipment already there, and it has much the same capabilities as the monochrome units. The color range is 6,100 to 5,400 angstroms in 100-angstrom steps, giving red, red-orange, orange, yellow, yellow-green, and green.

The cathode ray tube used is manufactured by Thomas Electronics, Wayne, N.J. Unlike conventional color TV tubes, it is a single-gun tube. Walter Weiss, display engineer at Tasker, says that the dot matrix arrangement of TV tubes provides relatively poor resolution since pure red displays, for example, use only a third of the dots on the face. "That's okay for half-inch letters and numbers, but not for the 1/16-in. ones we have to have." The Tasker display provides a 945-line resolution.

The various colors are obtained by switching the anode voltage on the tube from 5.5 kilovolts to 14 kv, a tricky problem for the drive electronics since it has to be done in only 50 microseconds. The face of the tube consists of two distinct phosphor layers, a green one close to the face, and a red one behind it. With the lower anode voltage, the electrons from the gun impinge on the red layer, but do not have the energy to go beyond it. Increasing the voltage raises the penetration, so that the phosphors give off mixtures of red and green that combine to produce the other colors.

Aside from the switching problem, a major headache was the difference in brightness between the 5- and 14-kv levels, and Weiss feels that much of Tasker's accomplishment was in compensating for these differences to provide a relatively constant brightness. □

Meetings

IEEE show booth rentals and attendance drop steeply

The IEEE show had just ended at the New York Coliseum. A $2 cab ride away, at the organization's headquarters, officials were shuffling the complaints and the kudos, searching for solutions to problems that went deeper than light attendance or a general sag in interest at all American trade shows and conventions.

The gut issue for IEEE officers and staff was simply that the number of exhibitors had slid steeply to 250 from the 426 of 1971. And, while the IEEE refuses flatly to talk about profit or loss from the 1972 edition of its tarnished extravaganza, that decrease, plus the wide open spaces on the Coliseum floors, tells its own story.

But the word came quickly from headquarters. No sooner had the show ended—possibly to head off rumors about moving out of New York, or changing the show to a regional meeting, or dropping it altogether—than an IEEE spokesman announced that the 1973 edition would again take place in New York City.

Still alive. Says William Hilty, convention and publishing services director: "All in all, we are not going to die, nor is the big-show concept. We offer specialization, and we also offer the overview that's necessary for the industry. People don't realize we are just a reflection of the industry, on the whole. We feel we have bottomed out this year."

As for those critical of New York as a convention site, Hilty points out a recent poll indicates that exhibitors still prefer New York, followed by Los Angeles and San Francisco.

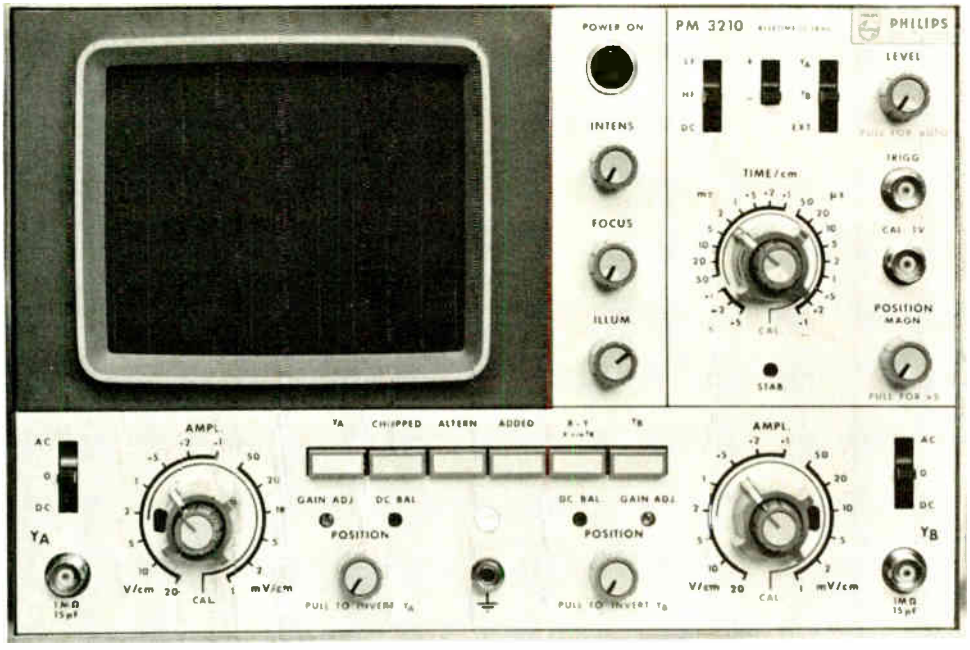
"We had thought about moving out of New York, but realized the show would die. New York is still the center of the East Coast electronics industry, and it suits our needs, just as Wescon suits the West Coast's needs, and NEREM suits Boston's needs."

Yet, one of the major complaints about New York has been the expenses for exhibitors and visitors. Hilty's answer is succinct: "About the only place that isn't expensive nowadays is Hope, Ark." However, an economy move for next year will be the rental of only a portion of the Coliseum, instead of the 100% space commitment of past years.

In the final analysis, IEEE is determined to make the show work—in New York—and to eliminate criticism, such as the interesting reactions voiced by a marketing manager and by his boss. Said the marketing man, who had made the decision to come to the show, "This is great—the best ever." But said the boss, "I don't know; we'll have to go back home and do a good deal of thinking about whether or not we'll be back next year."

Happiness. However, some exhib-

Wide open spaces. This was the scene on last day of IEEE show at New York Coliseum.



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Circle 45 on reader service card

Electronics review

Wait until next year

The IEEE show will have a completely overhauled format in 1973. A major move will be the arrangement of booths—in a mall with the focus on 10 areas of specialization. The technical program will complement the exhibition by zeroing in on the same 10 topics to be developed throughout the week in seminars. Individual meeting rooms will be assigned to each topic, with presentations of papers, workshops, and panels.

Another innovation will be a call for papers instead of invited papers, as in past years. Finally, a salute to the 25th anniversary of the transistor will be presented in a "multidimensional program" headed by Seymour Schweber, distributor of electronic components.

itors were happy about the quality of the crowds—although there were 20,000 paid admissions, compared to the previous year's 32,793—because there were more serious inquiries. Said one, "There were fewer wanderers. Everyone who visited our booth seemed to be searching for something specific."

N.S. Maxwell, director of sales promotion and advertising at North American Rockwell Microelectronics Co., Anaheim, Calif., termed the quality and quantity of visitors to his firm's booth "very satisfactory." NRMEC, the MOS LSI maker, exhibited a variety of products and capabilities, including terminal MOS LSI systems, a photodiode/shift register array, liquid crystal displays, and silicon-on-sapphire diode arrays. Visitors included company presidents and senior engineers, representing a cross section of regions of the U.S. and other countries, including India, England, Canada, and Japan. Visitors to the booth numbered in the hundreds.

Gerald B. Athey, advertising and sales promotion manager at Burr-Brown Research Corp., the Tucson, Ariz., components manufacturer, says he, too, would return with a booth if he could be assured of a similar experience next year. "I think we'll write some good business as a result of the show," Athey observes. "Our booth activity looks like it was well over 20% higher than last year. We found the quality of the leads as good as, or better than, they were at the two previous IEEE shows. It appears that we got a larger percentage of the total attendance than we did the two previous years." Athey adds quickly that he's aware that over-all attendance was down and that Burr-Brown was bucking the trend at the 1972 edition of the show. □

Consumer electronics

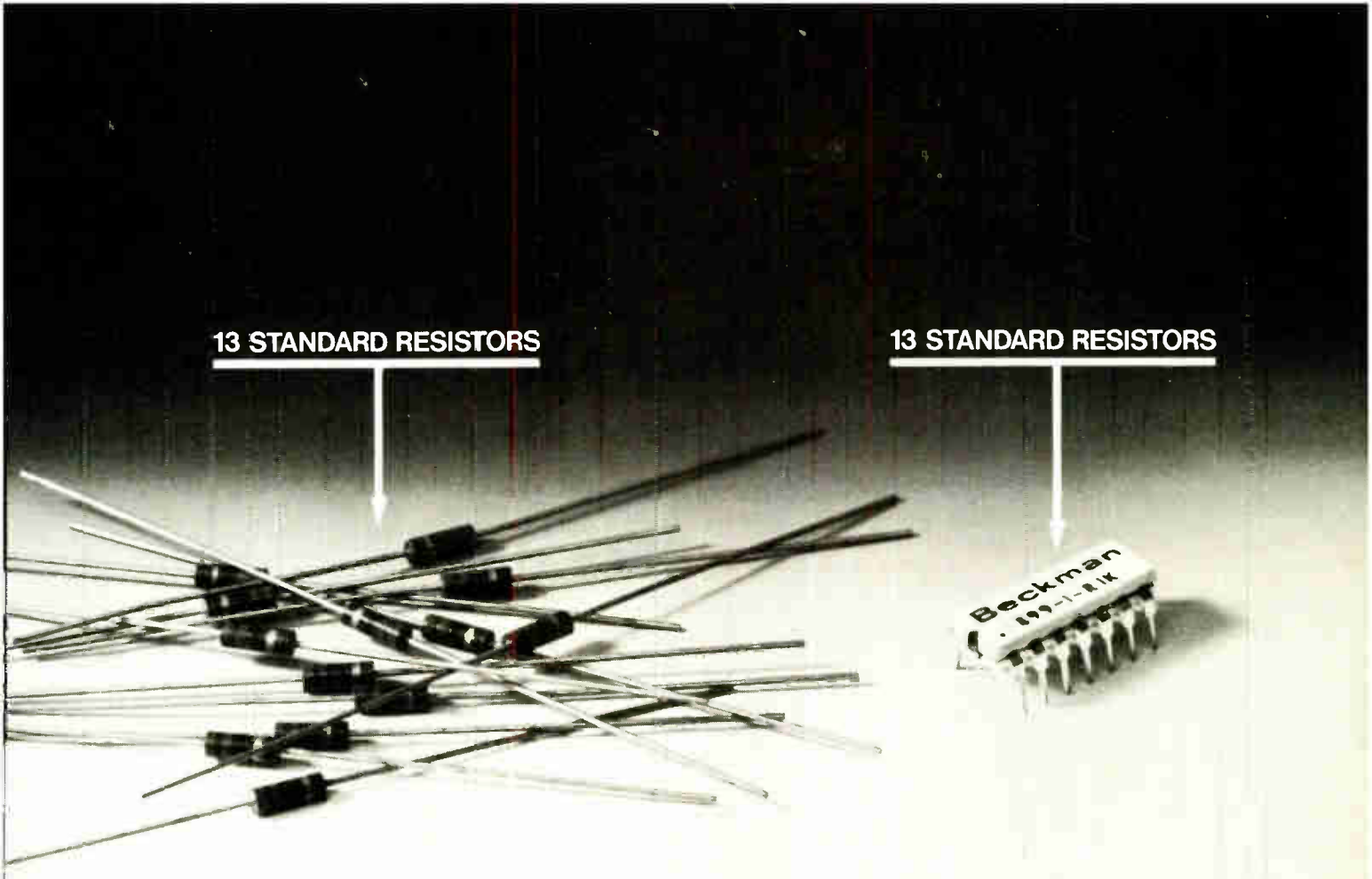
RCA's home VTR due in 1973 for $700

RCA has a message for its home-entertainment competitors. It was implicit when the company finally demonstrated a $700 home television recorder/player, a magnetic tape system that incorporates in-cartridge scanning and is scheduled for full production by late 1973. The message:

- Mighty RCA is determined to erase the head start gained by Cartridge Television Inc. of New York, with its Avco-developed Cartrivision, the only other home VTR.
- The holographic play-only technique originally called SelectaVision that has been staggering along at RCA's Sarnoff Laboratories now appears to be even further away from the market.
- The possibility of the CBS EVR system becoming a consumer product is dimmer than ever now that RCA also has cast its lot on the side of magnetic tape.

Backing its market push was the simultaneous announcement that Magnavox and Bell & Howell will be licensees for the new unit.

Competitors have been wondering, since the holographic video player ran into trouble, just what RCA would do in the meantime to



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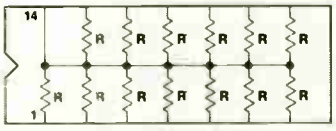
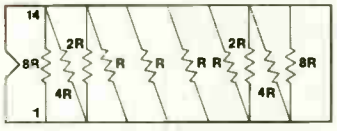


MODEL SERIES 899-1
Resistance Values (ohms): 100, 150, 220, 330, 470, 680, 1K, 1.5K, 2K, 2.2K, 3.3K, 4.7K, 6K, 6.8K, 10K, 15K, 22K.
Common Applications: Digital pulse squaring; MOS/ROM pull-up/ pull-down; "wired OR" pull-up; power driver pull-up; open collector pull-up; TTL input pull-down; TTL unused gate pull-up; high-speed parallel pull-up.
Standard Tolerance: ± 2.0%

Pricing:		
	1-99	$1.45
	100-499	1.12
	500-999	0.97



MODEL SERIES 899-2
Resistance Value (ohms): 10K
Common Applications: Inverting operational gain; potentiometric gain; differential gain; noninverting gain; gain adjustment.
Standard Tolerance: ± 2%

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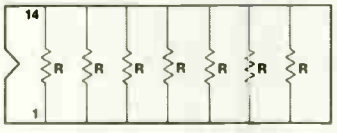
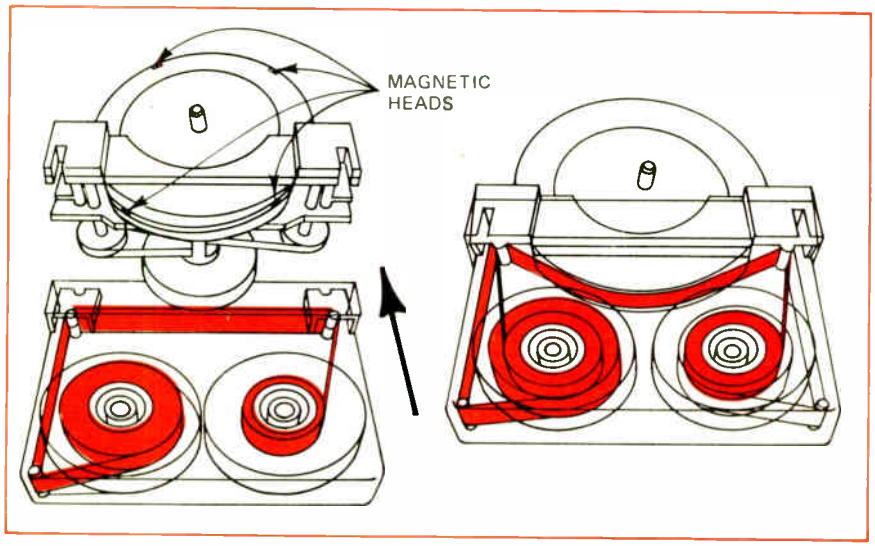
	1-99	$2.75
	100-499	2.15
	500-999	1.86



MODEL SERIES 899-3
Resistance Values (ohms): 68, 100, 110, 150, 220, 330, 470, 680, 1K, 1.5K 2.2K, 3.3K, 4.7K, 6.8K, 10K, 15K, 22K.
Common Applications: Line termination; long-line impedance balancing; power gate pull-up; ECL output pull-down resistors; LED current limiting; power driver pull-up; "wired OR" pull-up; TTL input pull-down.
Standard Tolerance: ± 2%

Pricing:		
	1-99	$1.25
	100-499	0.99
	500-999	0.86

Circle 47 on reader service card



Push, pull. That's the way cartridge is inserted in RCA's VTR home-entertainment system. A feature is in-cartridge scanning by four video heads revolving at 900 revolutions a minute.

tap the potential consumer market for home video equipment. The answer came in steps. First, there was an announcement that SelectaVision was to be a name for a family of players, not just holotape; in other words, it would be whatever RCA chose to call it. Then the company revealed that the first child in the SelectaVision family would be a standard video tape machine, not a technological breakthrough.

Four heads. Now the wraps are off. The MagTape System, as RCA calls it, has four video heads on a drum that rotates at 900 revolutions a minute. Video signal-to-noise ratio is 40 decibels. The three-quarter-inch, chromium dioxide tape is rated at 450 to 600 oersteds. It's wound into a cartridge which plays for 60 minutes, and blanks are priced at about $30. The system is designed to play and record through any current television set by connections to the antenna poles. In addition, RCA has a black-and-white camera available for home use and plans to bring out a color version later. Meanwhile, Magnavox will sell the unit with its own newly developed camera.

The in-cartridge scanning idea is the unique aspect. Because the system uses high-quality tape that must be handled carefully, the basic idea is to insert the cartridge so that it encloses the tape heads rather than pull out the tape and wrap it around the recording heads. When the cartridge is inserted, the cover is flipped open and the video magnetic heads mounted on a head-wheel come in contact with the tape in a 90° wrap that permits eased tape tension.

A simple timer makes it possible to record shows remotely, and a built-in tuner makes it possible to watch one TV show while recording another. A stop-action feature is being demonstrated, but may not be offered in production models, according to RCA engineers.

Cartrivision. By comparison, CTI, which now has six licenses, uses three video heads and half-inch iron oxide tape. A two-hour cartridge costs $35 and the recorder/player is supposed to sell for about $500 to $600—the first units due on the consumer market in June.

According to CTI, the in-cartridge principle was evaluated for Cartrivision, but rejected as too costly. The cartridge would have required more stringent mechanical controls than those in which the tape guide is part of the recording-head mechanism.

On the other hand, RCA contends that the in-cartridge approach not only improves picture quality and recording reliability, but permits design of a simpler tape transport than other recording types. The scanner module is manufactured from a single casting, which means a single setup for precision machining, fewer parts, and no aligning. Bell & Howell is making the tape transport component for RCA. □

Memories

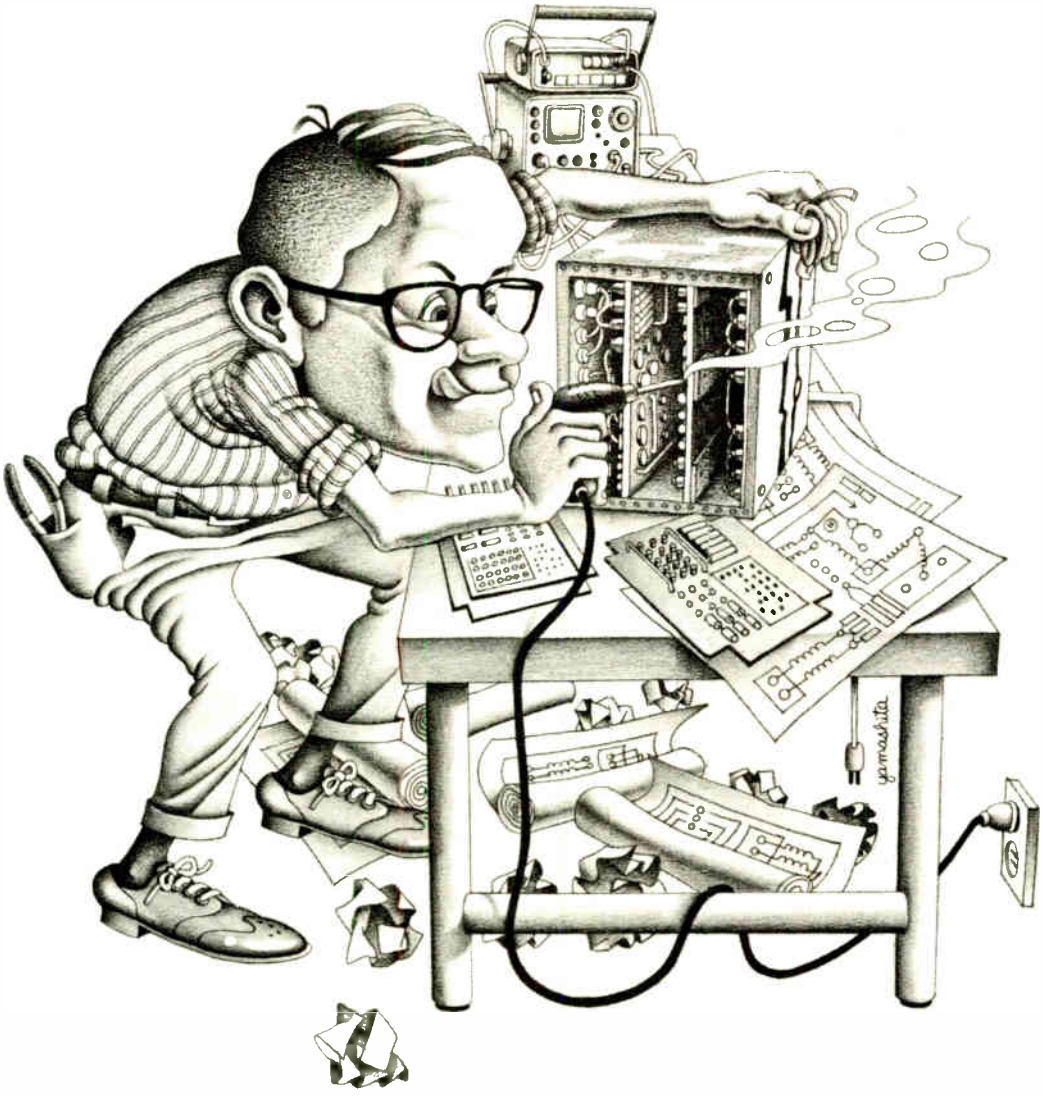
Ferroelectric film offers high yield

Semiconductor memories may have to move over if a new technology being developed by a fledgling midwestern company takes hold. The technology is based on a ferroelectric thin film, which can be used as either a read-only or a read/write memory with all the good adjectives: nondestructive, fast, high-density, and radiation-resistant. What's more, the process is inexpensive, promises high yield, and is easy to make. The company is Technovation Inc., of Grosse Ile, Mich.

The ferroelectric material is potassium nitrate (KNO_3), in its Phase III form—one of four phases in which the material can exist. Phase III doesn't normally exist at room temperature or atmospheric pressure; but in a sufficiently thin film—under 1,000 angstroms—surface tension effects stabilize the Phase III form.

Physicists have been experimenting with KNO_3 for 50 years or more. In particular, attempts to use its properties in memories go back to 1962, and much has been published on it [*Electronics*, July 25, 1966, p. 41]. But Technovation seems to be the first to have licked the Phase III stability problem and thus to have achieved high speed and high density at low cost.

Binary stores. Small crystals of Phase III KNO_3 are asymmetrical, and can be shifted to their mirror image by an external electric field; the two therefore store binary information. Applying a voltage pulse with sufficient energy switches the state of selected crystals to write new information; a pulse of lower energy disturbs the crystals enough to produce an output without



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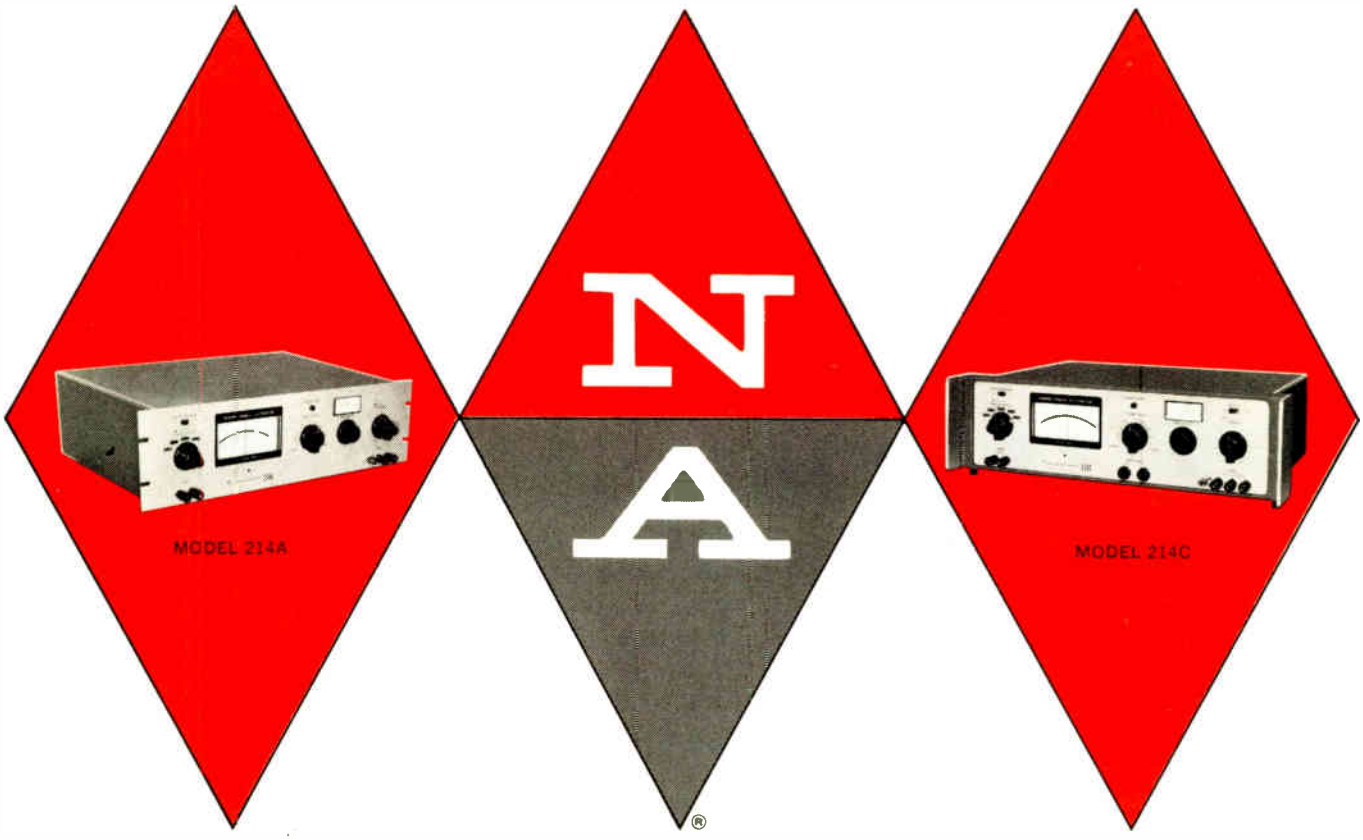

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switching their states. Since the crystals retain their states in the absence of an external field, loss of power doesn't affect the stored information.

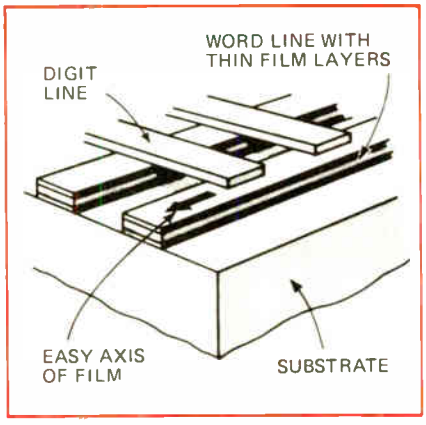
So far, arrays have been made with relatively crude techniques that yield, say, 64 one-bit cells on a film 1 centimeter square. But this enormous device nevertheless can complete a full cycle in less than a microsecond; standard micro-miniaturization should achieve densities up to a million cells per square inch that cycle at 1-nanosecond speeds or even faster. Although speed is not related solely to cell area, the latter is definitely a major factor in determining speed. And there are only three manufacturing steps, including encapsulation, leading to projections of 90% or higher yields and costs of 0.0005 cent per bit. Even multiple-bit readouts are possible if multiple-film depositions are used, for a cubic density exceeding anything previously available except through holography.

Technovation needs financial backing and has approached a number of companies who can apply their skills in semiconductor technology to the fabrication of ferroelectric thin-film elements. Some prospects have reluctantly turned aside because semiconductor technology is far more advanced, and has a better prospect of acceptance in the foreseeable future; others have expressed interest in the technology. □

Right-angle turn for plated wire

A problem with plated-wire memories, especially when the bit cells are very small and closely packed along the wire, is the cells' tendency to demagnetize themselves when the data stored in them is being read out. This tendency limits their data packing density.

But a research team in the laboratories of Honeywell Inc., Phoenix, Ariz., has built a memory that has this demagnetizing tendency to a much lesser degree than other designs. In a project that was begun when the facilities and team were part of General Electric Co., the researchers have deposited the film with its easy axis oriented axially rather than circumferentially.



Good turn. Reoriented easy axis limits demagnetization tendency in memory.

Furthermore, by constructing the memory array with planar thin film techniques rather than with the usual wire-plating equipment, the team has achieved a density of 3,500 bits per square inch—in contrast to fewer than 1,000 in conventional memories.

Tilt. Thin films are magneticially anisotropic. In conventional plated-wire structures, the easy axis of the plated film is circumferential—in one direction, say clockwise, for a binary 1, and counterclockwise for a 0. Current in a conductor at right angles to the plated wire tilts the film magnetization to one side, and the tilt generates a voltage signal in the wire under the plating; the polarity of this signal corresponds to the stored data.

The current must be strong enough to overcome the inherent anisotropy, and it tends to rotate the magnetic flux lines in the film out of closure in the circumferential direction; these combine in a way that tends to demagnetize the bit cell entirely. Furthermore, the smaller the cell (lengthwise along the wire), the easier demagnetization becomes.

But in the Honeywell approach, the "wire"—now a more or less rectangular conductor with magnetic films on its upper and lower surfaces—becomes the word line; cur-

rent in it tilts the film magnetization away from the axial position, and the tilt generates a signal in a sense/digit line at right angles to the word line. Here, although word current still must overcome the anisotropy, it tends to rotate the flux lines into closure instead of out of closure. This opposes any tendency for the word current to demagnetize the bit cell. □

Companies

RCA maps drive in hybrid circuits

Power hybrid circuits can't be considered stepchildren anymore; they need attention as a distinct product line. That's the view of Ralph S. Hartz, and as the head of a new department at RCA's Solid State Products division in Somerville, N. J., he has the opportunity to back his words with action. Moreover, the time is ripe.

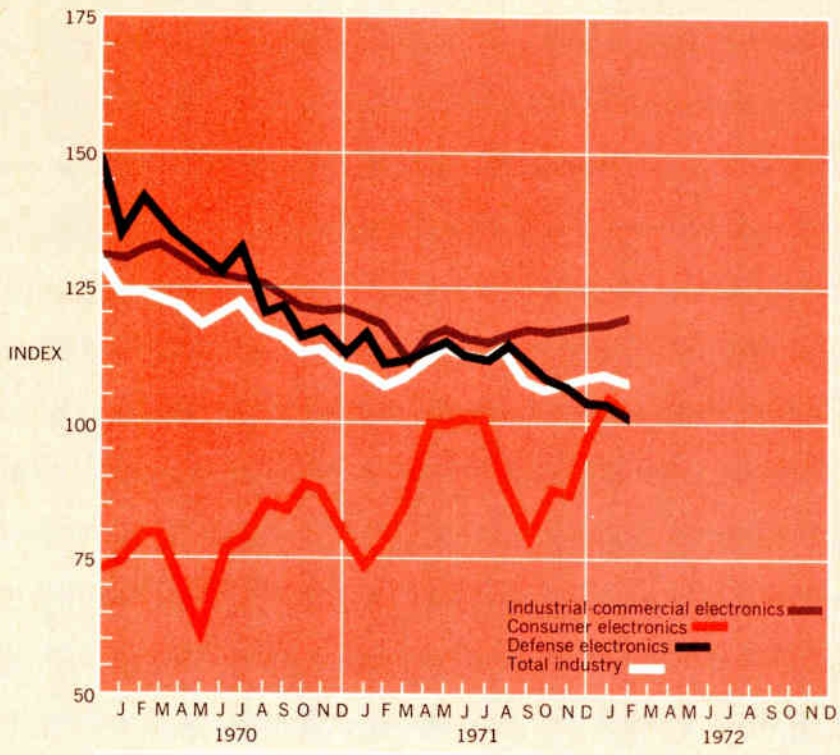
With prices declining dramatically over the past two years for its hybrids, which employ thick film resistors and attached active parts, RCA looks forward to a market that will grow substantially during the 1970's—from the "low millions" this year to $40 million in 1976 and $200 million by 1980.

Applications are turning up "across the board" for amplification and control circuits in consumer, industrial, and even military systems, Hartz says. "All kinds of customers for our discrete devices are asking us for proposals to hybridize existing systems," he explains. To meet these needs, RCA plans to continue its custom design work and to develop key off-the-shelf items. At present, these include:

- Audio frequency amplifiers ranging from a few watts to 100 w output.
- Series voltage regulators.
- Linear and Darlington amplifiers.
- Current-switching transistor arrays with outputs up to hundreds of amperes.
- Building blocks of power devices in small encapsulated packages.

Combination. In its new department, RCA has combined the functions of two groups: a power hybrid group, which concentrated on designs using RCA-produced power devices, and a custom systems group, which had relied on a broader range of components, including integrated circuits, manufactured at the Solid State Products division and elsewhere. The amalgamation allows applications to be pursued across a broader front, Hartz says.

Cost is, of course, the pacing factor in determining how attractive the hybrids are to the customer. "We're making heavy investments



Electronics Index of Activity

April 10, 1972

The total index fell 1.6% in February, its first decline in seven months, though it remained 1.1% above the February 1971 level. Only the industrial-commercial sector rose last month, inching up 0.8% to a level just 0.3% ahead of its year-ago figure.

Consumer electronics was off 2.9% for the month and defense dropped 2.5%. Of the two, only defense was below its corresponding 1971 level, down more than 5.5%.

Segment of Industry	Feb. '72	Jan. '72*	Feb. '71
Consumer electronics	102.3	105.4	79.6
Defense electronics	102.1	104.7	108.1
Industrial-commercial electronics	120.4	119.4	120.0
Total industry	107.6	109.3	106.4

Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.
* Revised.

competitive with regulators made discretely.

Power hybrids are considered by RCA as generally more than 100 W but going as low as 1 W. □

Military electronics

Gallant Hand tests electronics gear

Although Allied forces apparently halted the advance of the invading Lobobian army during the third day of fighting in Northern Marcos, the Central Theater Command (Centcom) requested additional military support from the U.S.

What it got was Secretary of Defense Melvin R. Laird, who flew into the 7,000-square-mile battle zone near the civilian hamlet of Killeen, Texas, to view the final day of Gallant Hand 72—the largest stateside workout of troops and support equipment since before the be surprised how many details are overlooked. For example, tactical teletypewriters run at 60 words per minute, while fixed ones run much faster. Engineers often must patch-in the interface in the field."

While the LES-6 synchronous satellite would normally be used to back up other voice and data channels, it was tested at Gallant Hand using backpack and jeep-mounted terminals developed by Electronic Communications Inc., St. Petersburg, Fla. □

For the record

Settlement. IBM has agreed to continue maintenance of System/360 models 22, 30, 40, 50, and 65 central processing units to which add-on memories have been attached. The agreement was reached with Itel Corp. and Advanced Memory Systems. Both had brought suit against IBM, which had indicated it would no longer maintain systems with "foreign" memories that exceed rated capacity.

SCIENCE/SCOPE

The mobile earth station that linked Peking with the world during President Nixon's historic mission was built and operated by Hughes, under contract to Western Union International. It provided capacity for one color TV channel, nine voice commentaries, and 60 two-way telephone channels for use by the Presidential party and by the press to transmit teletype, telephotos, and radio reports. The air-portable terminal was similar to those which Hughes operated in Bogota, Colombia in 1968 for Pope Paul's visit and in Iran last year for that country's 2500th anniversary.

Communications from China were received by Intelsat IV satellites built by Hughes for Comsat, manager for the 83-nation International Telecommunications Satellite Consortium. Stationed over the Pacific and the Atlantic, these satellites carried TV and all press communications from Peking and relayed them to Intelsat's worldwide satellite communications network. Each satellite can carry 5,000 phone conversations, or 12 television programs, or tens of thousands of teletype circuits.

The first 27 Maverick missiles tested by the U.S. Air Force Systems Command surpassed all contract requirements and scored a better than 90 percent success rate in flight tests, enabling USAF to reduce the missile firings by one-third and complete the tests two months ahead of schedule. Maverick also demonstrated lower maintenance requirements and faster aircraft loading time than required.

The air-to-ground missile, built by Hughes, is guided by a miniature TV camera in its nose which the pilot locks onto the target. After launch, Maverick is independently guided to the target and the pilot is free to leave the area safely.

Washington newsletter

DOD will stick with Grumman's F-14...

Defense officials believe they have no choice but to stick with the Navy's F-14 fighter even though it means a renegotiated contract at a higher price [*Electronics* Mar. 27, p.48]. Beyond confirming the earlier report, officials say **the Pentagon cannot effectively threaten Grumman with turning to McDonnell Douglas' F-15 now being developed for the Air Force, "because the Navy cannot wait** for the F-15 and it cannot carry the Phoenix" missile system, a Hughes aircraft program in which DOD already has an investment of about $500 million.

One option being considered to get around the embarrassment of rewriting the F-14 award is "to **drop the A model and go directly to the B," which will use the more powerful F-15 engine.** The Navy backed off from the B model last year, leaving the Air Force holding the bag for the F-15 engine development costs.

...but higher price means fewer planes

Suppliers of avionics, countermeasures and weapons for the F-14 are unlikely to get as much business from the program, whichever way the Navy goes. Defense officials indicate that **the number of planes ultimately bought could drop below the 313 deliveries now planned** through 1976. The figure is down from the 496 originally planned for the A and B models combined. Until the contract is rewritten, Grumman says it will accept no more orders, even under the 48-plane option which the Navy must exercise by October under the existing contract.

Europe cool to new Aerosat plans...

The White House Office of Telecommunications Policy appears to have pulled the rug out from under itself with its successful cancellation of a U.S.-European agreement on an aeronautical services satellite negotiated by the Federal Aviation Administration and the State Department [*Electronics*, Feb. 28, p.38]. Though OTP is pushing to negotiate a new Aerosat agreement under an "as soon as possible" mandate from the White House, the European Space Research Organization is extremely cool to the project following OTP's intervention in its agreement with the FAA. This being so, **U.S. hopes for a new round of final negotiations in the summer are dim.**

...but stays warm toward Pacific program

OTP continues to worry over Europe's desire to participate in the Pacific portion of the Aerosat effort, because it fears such participation might increase European commercial influence in the area. Though OTP is reassessing its bargaining position, it remains firm in its requirement that **Aerosat communications functions be operated commercially and only air traffic control functions be managed by governments.**

Comsat Labs to develop new voice compression system

A nine-month design study contract of a promising voice compression system, which could lead to new terminal equipment for satellite communications, **is expected to be let this summer by Communications Satellite Corp. Laboratories. As yet unnamed, the new technique correlates the fluctuations in live conversation with the actual bandwidth required to transmit any given sound.** It could produce a compression ratio as high as four-to-one with no degradation of voice quality.

Washington commentary

"Electronics 1985": Is show business no business?

What is "Electronics 1985"? In the opinion of its sponsor, the Electronic Industries Association, the two-day meeting that opens May 18 at Chicago's Conrad Hilton will be the first to offer an "economic, technological, political and social look ahead at the electronic industries." And those doing the looking, says EIA, will be the industry's "best informed and most influential people." With that kind of promise, the price of admission—$250 in advance or $300 at the door—seems cheap. And after one major press briefing and four mailings to excite industry interest, you would think EIA would be ready to open to a packed house.

Present outlook is poor

Unfortunately for the association, that was not the case with less than six weeks to opening day. Advance press notices have been virtually non-existent, and advance registrations through March hovered around 100. EIA's management is visibly concerned about matching its registration forecast of 800.

Part of EIA's problem lies in its decision to manage the meeting internally, rather than look for management experienced in cranking up industrial shows. One consequence of that decision is that a number of potential registrants have yet to hear of the meeting. Asked if he knew what "Electronics 1985" was, one executive responded with this question: "An anniversary issue of your magazine?"

What the critics say

In addition to just plain ignorance, a number of criticisms have been advanced by EIA members and others. "Electronics 1985," to these critics, is:

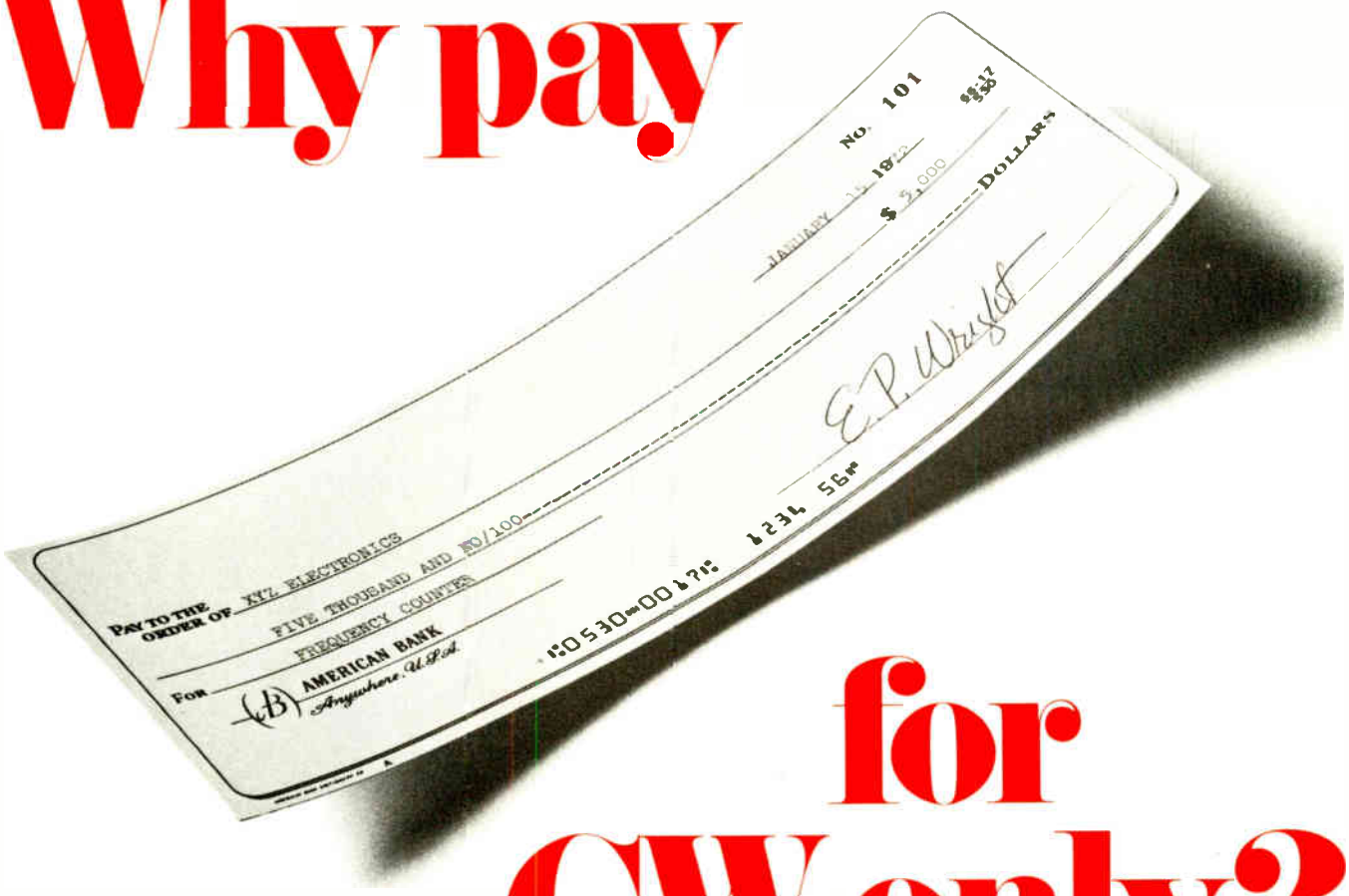
- "Incestuous" by drawing virtually all of its speakers from EIA's own member companies. The programed speakers are indeed industry's "most influential people," but, as one member said at EIA's spring conference, "They are the same old faces. I am sure I know what they are going to say."
- "Too narrow" by limiting participation to American manufacturers at a time when the United States is losing significant shares of both domestic and foreign markets to its competitors abroad, and when the 1985 electronics market is sure to be even more global in nature.
- "Too futuristic" in its attempt to guess at what will influence a market 10 to 15 years away, when many EIA members are still uncertain about the economic outcome of 1972. Forecasting the future is very tricky business in any industry, of course. Many believe it is impossible in one with a technology as volatile as electronics. "My guesses are just as good as theirs," boasted one manager after examining the program.
- "Poorly timed." This fundamental criticism of scheduling comes from producers of consumer electronics already committed to national showings of new product lines to distributors and dealers during the week of the conference. For all practical purposes, EIA's consumer electronics group has backed out of the meeting.

Point of the exercise

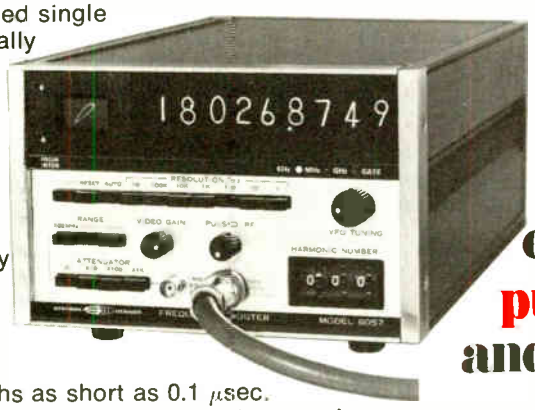
In sum, however, much of this is carping. Though "Electronics 1985" has had some obvious problems with planning and programming, it is still worth it if only as a first effort. There is not much question that the conference could be more valuable with foreign representation. With the more than 40 speakers all looking at foreign and domestic trends purely from the U.S. viewpoint, their perspectives on the state of the industry over 10 years from now will be less balanced, and their economic guesstimates will be necessarily fuzzier, than they would be with leading European and Japanese manufacturers present.

Assuredly, however, EIA will learn something about conference planning before it is through with "Electronics 1985." And assuredly, too, those who go will get their money's worth about factors likely to shape the industry, since it will be the first time that the electronic industries will have sat down to look together at their future in an increasingly competitive world market. **—Ray Connolly**

Why pay



for CW only?



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Circle 62 on reader service card

Electronics international

Cassette-based physiological data logger fits in a pocket, runs for 24 hours

To make it easier to collect detailed data on how the human body works, some bioengineering workers at Britain's Medical Research Council's Research Center at Harrow have built a six-channel digital data logger small enough to fit easily into a breast pocket.

It will run unattended for hours and is fed from a second unit of similar size that transforms body transducer signals into voltages suitable for passing to the logger. A third unit, operating on a lab bench, converts the magnetic data on the logger tape into paper tape that can be fed into a computer to produce graphs and processed readouts.

Tracks. The logger unit measures 4.5 by 2.5 by 1 inch and weighs 7 ounces. It uses a Philips tape cassette intended for small speech recorders, with tape 0.15 in. wide. Into this width are packed three data tracks and one control track—six channels are obtained by time sharing each track between two inputs. John Beatty, in charge of logger development, had to design his own four-track recording head, which is the most expensive item in the logger, at about $80.

To make a 15-minute tape last 24 hours, Beatty runs it for about 180 milliseconds at 1 minute intervals. The interval timer is an ordinary mechanical watch mechanism, wound by hand. Once a minute, the second hand breaks a tiny beam of light from a fluorescent radioactive source focused onto a cadmium photocell, triggering a bistable circuit to switch on the power. The lamp has a half-life of 20 years.

Drive. The power comes from an 8.5-volt mercury cell, which drives the tape through a tiny Swiss-made electric motor with integral gearbox. The power is on for 150 milliseconds, divided up into 50 milliseconds for accelerating the tape and 100 milliseconds for recording. Slowing down takes 30 milliseconds. To get fast acceleration, a negative resistance circuit stimulates a high surge current. To slow down quickly, a field effect transistor across the motor acts as a regenerative brake. Acceleration draws about 100 milliamperes, steady running about 20 milliamperes.

TEM Engineering Ltd. of Crawley is negotiating to make it and sell it wherever a miniature logger can be used. The logger alone probably won't cost more than about $500. The signal preprocessor is still in development; a ballpark cost figure is about $100 per channel. □

Japan

Bending improves active antenna

Higher sensitivity may be only the second most important feature of an active antenna now being built into receivers for wireless microphones by Matsushita Communication Industrial Co. Elimination of the usual whip antenna used in these 40-megahertz receivers may be even more important. Although the whip antennas are made retractable, they are prone to bending and breakage.

The active antenna is probably the world's first to use an active element along its length rather than at its base. A transistor circuit functions as both an amplifier and an impedance transformer. The inverted "L" antenna features a low profile, allowing installation entirely within the case that houses the receiver and its speaker. It also boasts two-polarization response.

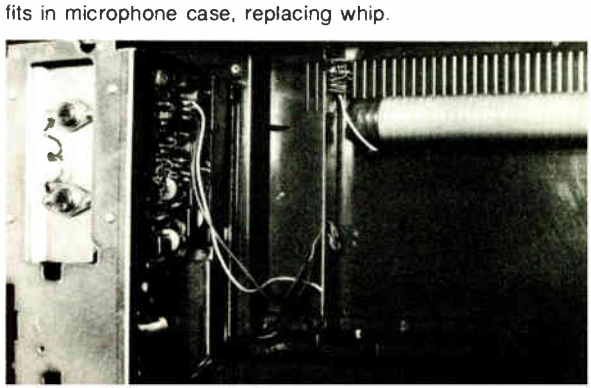
In this antenna, the vertical leg is only 15 centimeters high. With such a small antenna it is not possible to get sufficient output voltage, which results in an extremely poor match to the input impedance of the receiver. A matching circuit at the receiver antenna terminals doesn't help too much because increased loss in the matching circuit tends to waste much of the gain obtained by improved matching.

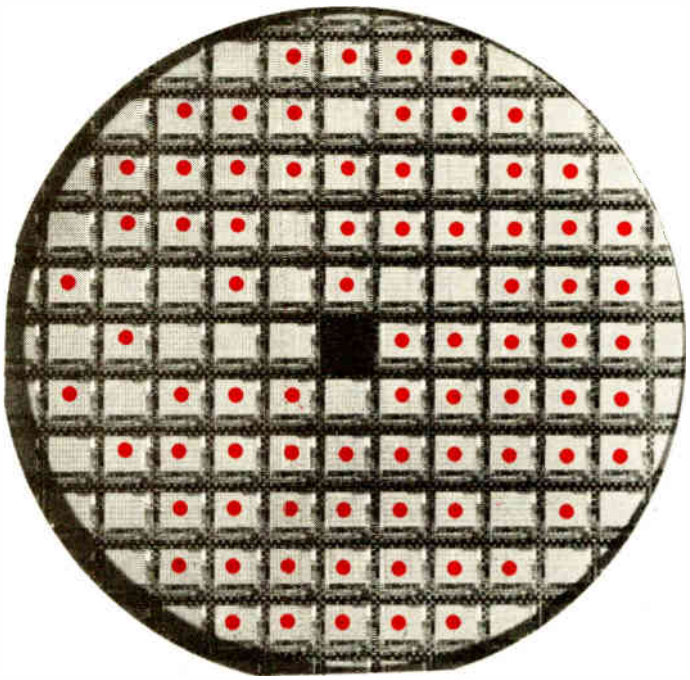
An improvement in antenna performance is obtained with a horizontal leg because the change in antenna current distribution provides improved impedance matching to receiver antenna terminals, even though the horizontal leg normally does not pick up any of the vertically polarized signal.

Peak. A helical coil 260 millimeters long by 25 mm in diameter is used for the horizontal leg. With the optimum number of turns for the frequency being received, the output of this antenna reaches about the same value as the previously used whip antenna.

A big disadvantage of such a passive antenna is its very sharp gain peak at the design frequency. The inclusion of the transistor circuit between the antenna legs both broadbands the antenna and increases the gain. What's more, the use of a transistor with a lower noise figure than that used in the receiver gives an improvement in signal-to-noise ratio of 3 or 4 dB. Overall cost of the helix, transistor circuit, and vertical leg of the antenna is approximately equal to that of the whip replaced. □

Portable. Active antenna, shaped like an L, fits in microphone case, replacing whip.





If too many chips aren't in shape to ship or assemble, maybe you need a solvent that cleans residue-free.

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International newsletter

Russians opt for French airport gear

French electronics firms active in avionics and airport equipment are in line for a windfall of new orders from Moscow as the Russians look to France for help in modernizing four of their main civilian airports. **The Soviet Union made known its need for French equipment late in March at a meeting of the Franco-Soviet economic commission.** The French also are hoping to participate in the over-all program, which **could eventually involve more than 100 airports.** The first four to be equipped with French electronics gear will be Moscow's Sheremetyevo airport, the Black Sea resort airport at Adler near Sochi, the Central Asian long-haul refueling center and tourist mecca Tashkent, and the Don River industrial city of Rostov.

France already has benefited commercially from its special political relationship with the Kremlin. **The Russians currently are installing a $1.2 million data switching network for their civil aviation fleet.** The DS-4 system is the first delivery of such sophisticated equipment ever to be cleared by Cocom, the Western Allies' watchdog committee on exports to communist countries. The DS-4 system is built by CGCT, a subsidiary of ITT.

Japanese ponder policing their European invasion

The Japanese government is considering an industry cartel, or other measures, as a tool for promoting orderly marketing of consumer electronics in Europe. At present, there is a minimum check price for television sets exported to the U. S., but nothing similar for Europe. Indeed, for Europe the problem may be more difficult because of uncertainty whether the entire European Economic Community can be treated as a single market. **On the other hand, such an approach may be more important there because the Europeans in general are more conservative, which makes the activities of the Japanese more conspicuous.**

The Japanese are considering the problem now because exports, especially color television, to Europe are rising rapidly, although they have only begun and the numbers are still small. Tape recorder exports, though, are sizeable. What's more, with calculators, which still aren't truly a consumer item, the problem is more complex. New technology is driving prices down, and the industry is fragmented. The dozen or so TV makers belong to the same industry association, but about twice that many companies make calculators, and they are based in a large number of industries.

West Germany eyes TV transmission by satellite

Under contract from Bonn's science ministry, two groups of West German aerospace/electronic firms are studying the feasibility of beaming television programs around the country by satellites. **The two consortia—AEG-Telefunken/ERNO/Dornier and Siemens/Messerschmitt-Boelkow-Blohm—are to determine system concepts for direct satellite-to-home-receiver signal transmissions and to come up with cost estimates and a time schedule.**

The studies are prompted by the difficulties and the high costs that would be involved in providing more TV channels for West Germany by conventional transmission networks. For one thing, the presently used uhf and vhf bands are too crowded for additional channels. For another, signal transmissions at the 11–14 gigahertz range, assigned to

TV at the broadcasting conference in Geneva last year would require a large number of transmitters because of the limited range at these high frequencies.

With a TV satellite, the main technical problem, besides the high power requirements, is that it must be able to concentrate the signals **into a beam no more than 1.4° at its origin if the signals are to cover an area the size of West Germany from a satellite hovering at 36,000 kilometers.**

Indium phosphide shows low-noise amplifier promise

As well as showing potential as a microwave oscillator [see page 110], indium phosphide could turn out to be a useful low-noise amplifier at higher microwave and millimeter-wave frequencies. **Experimental tests on Plessey-made InP diodes at Sheffield University have shown noise of only 7.5 decibels for gain of about 23 dB at 33 gigahertz,** using bias of 9.2 volts. This noise figure in Q-band is normally only approachable using cooled parametric amplifiers. The Sheffield researchers say that if this result proves typical, InP could be an attractive amplifier material for repeaters in guided wave communications links, and for preamplifiers in Q-band radars where, mounted in front of a conventional crystal mixer, **it could improve the overall signal-to-noise ratio by a factor of four.**

U.S. trade gain may be slow in France

The realignment of world currencies agreed upon last December is giving a boost—albeit a slow one—to U. S. exports of some electronic products. The U. S. embassy in Paris has just completed a study of the new market created by the monetary agreements, and other U. S. embassies around the world are making similar studies. **The Paris study concludes that the French are likely to buy more small computers, airborne electronics such as weather radar, and small components.** But the payoff of this new U.S. advantage may be slow in coming, the study indicates, because **France is having its own economic troubles this year.**

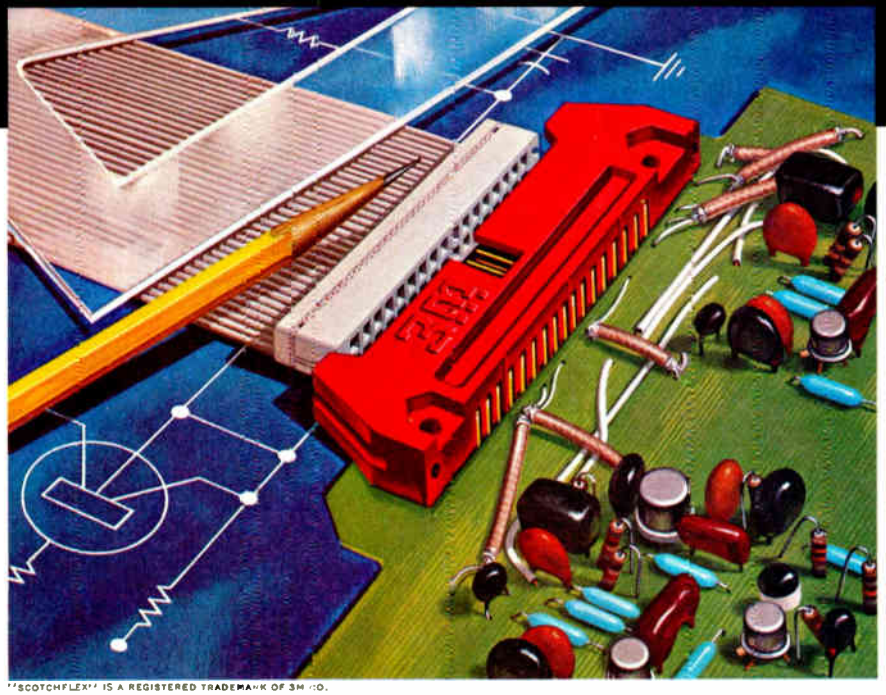
Fujitsu rents a computer to Yugoslavia

Fujitsu Ltd., has concluded an agreement to rent a Facom 230/45S computer to a construction association in Zagreb, Yugoslavia. **This marks the first time that Fujitsu has rented a computer on the international market.** However, it will be second Fujitsu computer to go to Yugoslavia. Last year, the company sent a Facom 230/15 system, worth about $230,000 at current exchange rates, there. The computer for the construction association, worth about $660,000, has on-line capability, and the system may be upgraded for on-line operation in the future.

Sweden extends its space role

Sweden officially will be in the space business under legislation proposed by its ministry of industry. **The bill—assured of passage in Sweden's parliament—would establish a state committee for space activities and a state-owned corporation to handle special projects.** The committee will be the top governmental agency for domestic and international space projects. The corporation, which will work under the committee, will handle specific projects, including operation of the Esrange, in Sweden's Lappland, which has been operated until now by ESRO. The committee and the corporation will start operating July 1.

For built-in reliability, design with "Scotchflex" Flat Cable/Connector Systems.



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For full information on the "Scotchflex" systems approach to circuitry, write to Dept. EAH-1, 3M Center, St. Paul. Minn. 55101.

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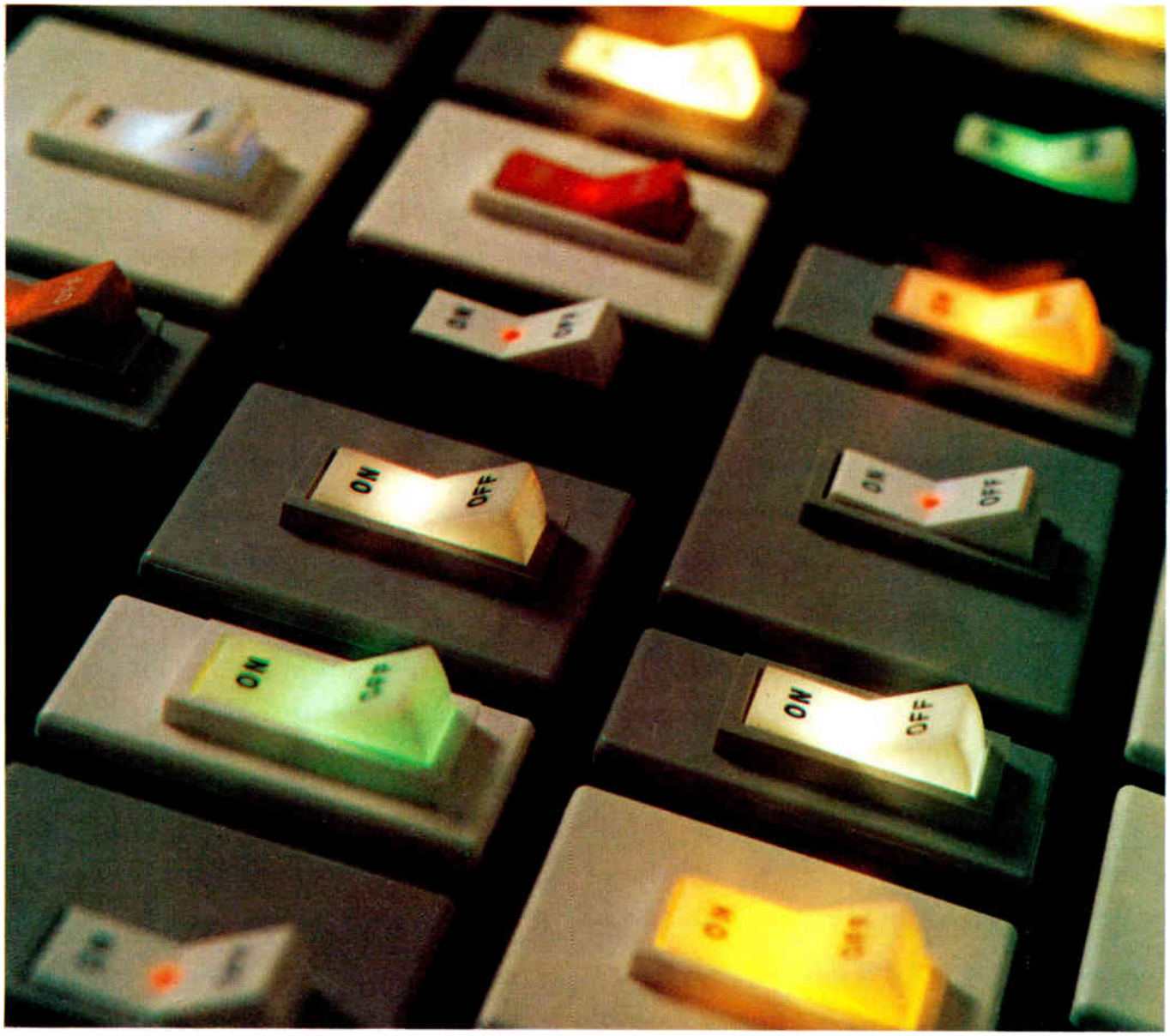

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Beam leads start to connect

With increasing military applications—and some commercial jobs in the offing—more beam-lead integrated circuits are becoming available

by Stephen E. Scrupski, Packaging and Production Editor

Slow to enter the marketplace, beam-lead devices are showing up in increasing numbers, and they appear certain to become standard components. Military and aerospace systems are becoming more beam-lead oriented, and the potential of commercial applications, while probably still a few years away, is reflected in Western Electric's use of them in telephone system gear.

However, no one now expects beam leads to be as pervasive as their proponents initially envisioned—despite their unchallenged advantages of high reliability, nonhermetic and compact packaging, and automatic handling and assembly. The major growth-inhibiting factor has been the lack of a wide variety of devices in beam-lead form. What's more, there is a capital investment decision—should manufacturers make the costly shift from wire-bonding equipment—that may prove a major obstacle.

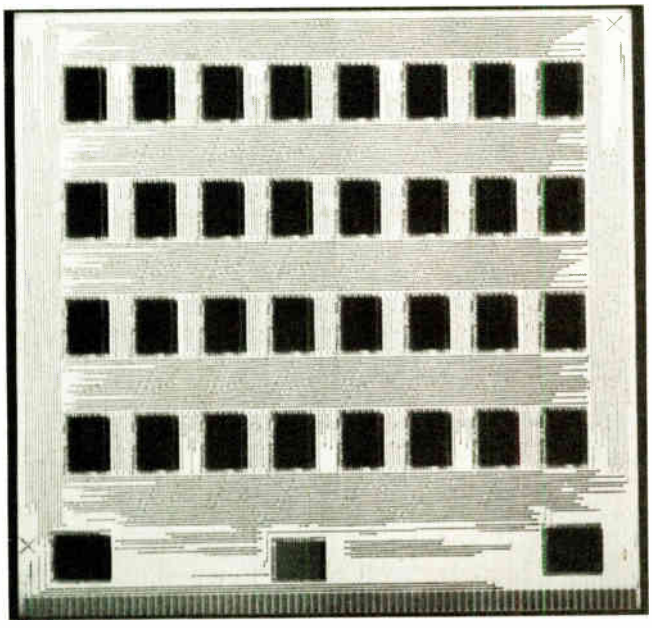
But as the repertoire of devices in beam-lead form multiplies, potential users, who once saw little advantage in mixing beam leads and wire bonds on the same substrate, are rethinking the situation. And their thoughts are being jogged by such major producers as Texas Instruments, Motorola Semiconductor, Raytheon, and RCA, who are expanding their beam-lead lines.

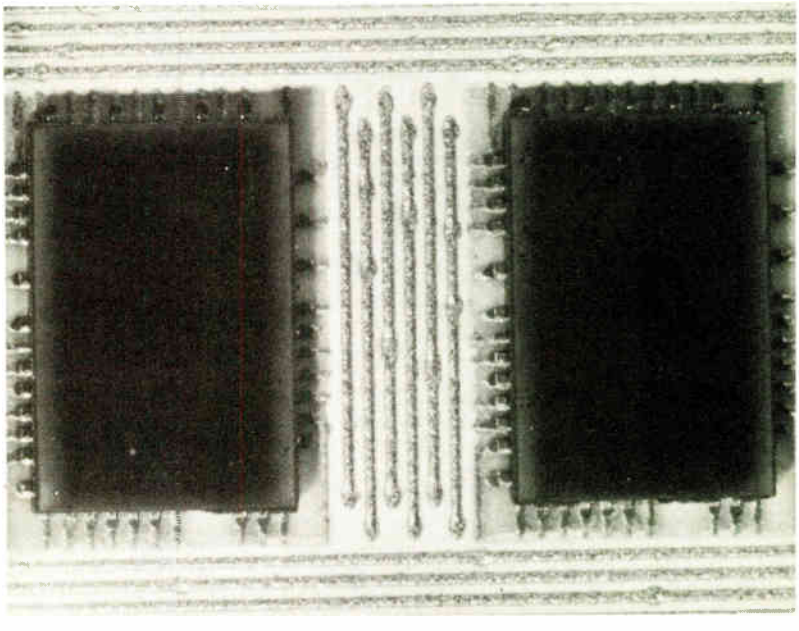
"This year should be a significant turning point for beam-lead product availability, in terms of number of beam leads that military and aerospace will use," says Larry Gast, senior project engineer in TI's special products circuits department.

Beam-lead devices are desirable for military applications, where reliability is the major criterion. Autonetics would like to use beam-lead parts in the Micron guidance system but the company just can't get all the necessary parts in beam-lead form. However, the company says it does expect many more parts in six months to a year.

The most recent large program to provide a spur to beam leads was Safeguard, for which TI and Motorola developed many devices in beam-lead form. "Now Safeguard is tapering off some, and we're going after other users," says Motorola's R. F. J. deWeeger, operations manager for beam leads and dielectrically isolated ICs. DeWeeger acknowledges, however, "The other prospective users were turned off

Golden beams. Typical of military applications for beam-lead devices is the 16-kilobit RAM developed by NRMEC and Autonetics for the Air Force with 35 beam-lead MOS chips on the two-layer ceramic substrate, which has 5-mil-wide gold conductors, 5 mils apart.





when they couldn't get the parts."

Although some devices have been available, it made little sense to users to replace only a few wire-bonded chips on a substrate. And early promises of regular, even monthly, introduction of beam-lead devices were not fulfilled, says one of those prospective users.

But things are starting to change. Strangely enough, there's only one semiconductor producer on the San Francisco peninsula that's offering beam-lead devices—Raytheon Semiconductor, Mountain View. Raytheon lists 20 bipolar transistors, eight linear circuits, as well as 13 diode-transistor logic and 29 transistor-transistor logic parts in its line-up of beam-lead circuits.

ICs available. TI now has seven beam-lead ICs in the low-power 5400 series available, with prices a little more than half those of the same devices in conventional flat-packs (for example, the BL5455Y is $1.97 in beam lead, $3.65 in flat-pack). "Our plans include a line of standard-power 5400-series ICs to be introduced by mid-year," says Gast. Also to be introduced in the second quarter are low-power Schottky devices, and in the second half of the year, Gast expects enough new beam-lead devices (such as complementary metal oxide semiconductors, linears, and memories) to double his inventory.

RCA has eight linear chips available in beam-lead form, including op amps, npn and pnp transistor arrays, differential amplifiers, dual differential amplifiers, and diode arrays. Typically, reports linear circuit marketing manager Julius Lempner, a beam-lead chip costs about 20% more than the same chip in a package and about 50% more than the same device in bare-chip form. (In quantities of 100 to 900, the CA3015L, for example, costs $1.87 in beam leads, $1.56 in a TO-5 can, and $1.25 as a bare chip.) RCA, now developing custom beam-lead chips for a commercial application, will probably have the circuit available later this year, and can convert any present circuit to beam leads.

North American Rockwell Microelectronics Co., Anaheim, Calif., will put beam leads on any of the custom MOS chips it supplies.

Motorola now supplies 20 standard 5400 parts in beam lead, plus the 709 and 741 operational amplifiers. The company will introduce two complex 5400 functions (5490 decade counter, 5493 divide-by-12 counter) and a 5472 flip-flop in late 1972, as well as 10 linear parts (1710 comparator, 1748 op amp, 1590 re/i-f amp, 1723 regulator, 1109 regulator, 1101A op amp, 1104 regulator, 1105 regulator, 1595 multiplier, and 1596 balanced modulator/demodulator).

"We will be getting into low-power Schottky TTL parts because of the demand from Raytheon for parts in its programs, but we really prefer C/MOS for low power," says deWeeger. "There's a cost differential between beam-lead chips and bare chips of about 1.5 to 2.2 times. But that doesn't mean that there's necessarily the same ratio in the selling price—that's determined by competition. But we're still high on the learning curve. The slope of beam-lead parts is steeper than that of standard parts. So the differences will be much less in two years."

We can take any chip and make it with beam leads. Delivery on a beam-lead special part would be 16 weeks, minimum."

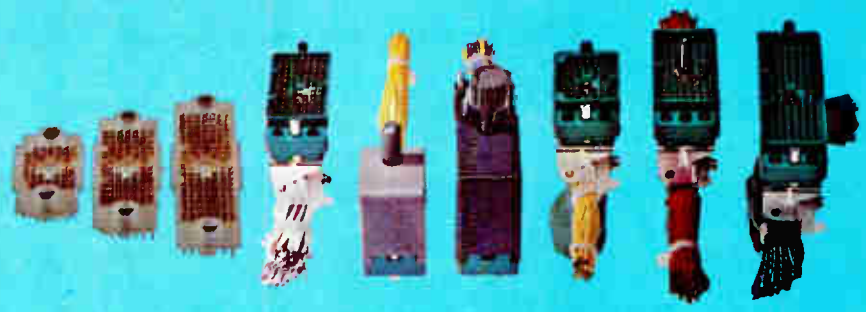
William Campbell, manager of product marketing, functional electrical circuits, Sprague Electric Co., Worcester, Mass., says sales of beam-lead devices have been very slow, on the whole. Sprague will custom-make beam-lead op amps, but business is slow on these. Sales are doing well in passive networks, both resistive and capacitive, and in tantalum nitride and nickel chromium resistors. Some capacitors with beam leads are sold to Western Electric. Right now, the market for beam-lead devices is so small that Campbell can't see expanding Sprague's product line, "but if it did take off, we might fit in things that fit our needs. Or if a Government contractor wanted it, we'd do it."

Nonbelievers. What about the semiconductor companies that haven't climbed aboard the beam-lead wagon? National Semiconductor, for one, says it just doesn't see enough market potential right now. "I'll build anything if you give me a big enough order," says Pierre Lamond, director of engineering. But "up to now, beam leads have been a limited market, aimed at only the military." Fairchild Semiconductor is not in beam leads yet, and Harris Semiconductor says it has none available commercially.

From a commercial computer company's viewpoint, beam leads are not obviously a next step. For example, Harvey Rosenberg, director of engineering of the Burroughs Corp. Components group, Detroit, doesn't foresee beam leads in his future for at least three years for a number of reasons. First of all, he says, every time he considered multichip packages, the semiconductor companies came up with an increase in circuit density that wiped out the advantage of the multichip circuit. And, like other prospective users, he points to the lack of availability—"We're just beginning to see a lot of beam-lead chips become available, but nowhere near the types and quantities that we're interested in. There are virtually no beam leads available in MOS, for example."

Rosenberg also questions the advantage in reliability for this type of circuit. Reports from field engineers, he says, show that wire-bond failures are far down the list of problem areas. After an initial period of wire-bonding failures, "we've gotten it all pretty well worked out over the last few years," he adds, "and it just hasn't been a problem."

Rosenberg's thoughts are echoed by another engineer at a computer house—John DeFalco, head engineer in advanced circuit development at Honeywell Information Systems, Framingham, Mass. The capital investment problem is the key one, says DeFalco, and he points out that other methods, such as solder bumps and even the Minimod design introduced by the General Electric Co.'s, now-defunct Integrated Circuits Product department may offer even more advantages. Since the merger of Honeywell and the GE computer operation, he says, Honeywell has had access to various GE developments, and he sees the Minimod, a scheme for reel-to-reel handling of chips mounted on a Kapton-based lead frame, as a potentially viable low-cost alternative to beam leads. □



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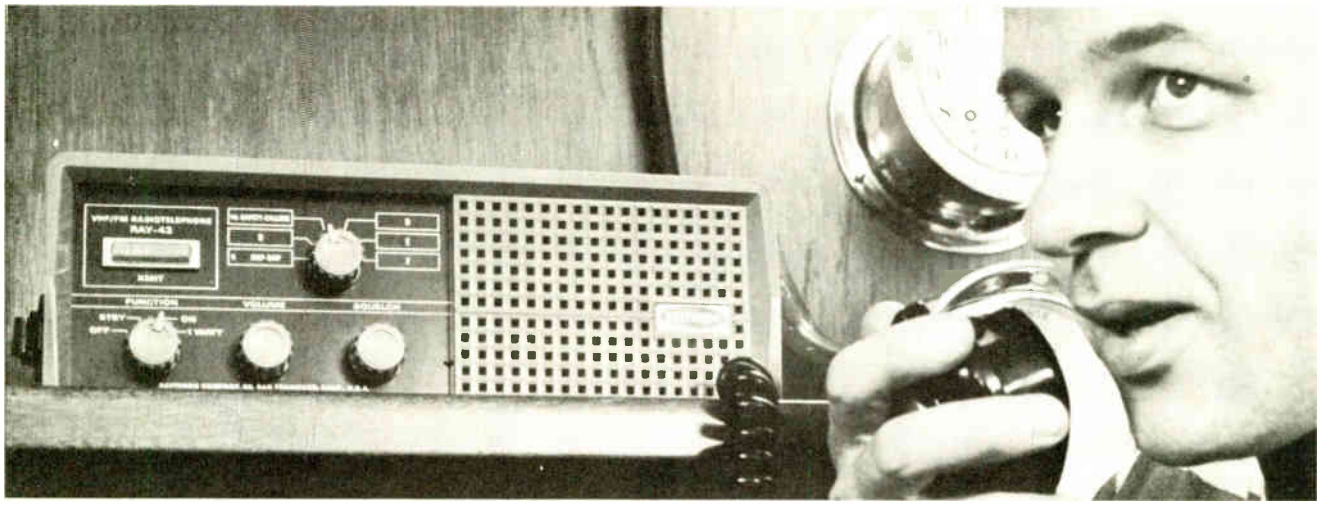
Circle 71 on reader service card



Consumer electronics

Down to the sea in chips

New companies, spurred by switch to vhf communications, join old-line producers to market high-technology radios and navigation equipment

by John N. Kessler, Associate Editor

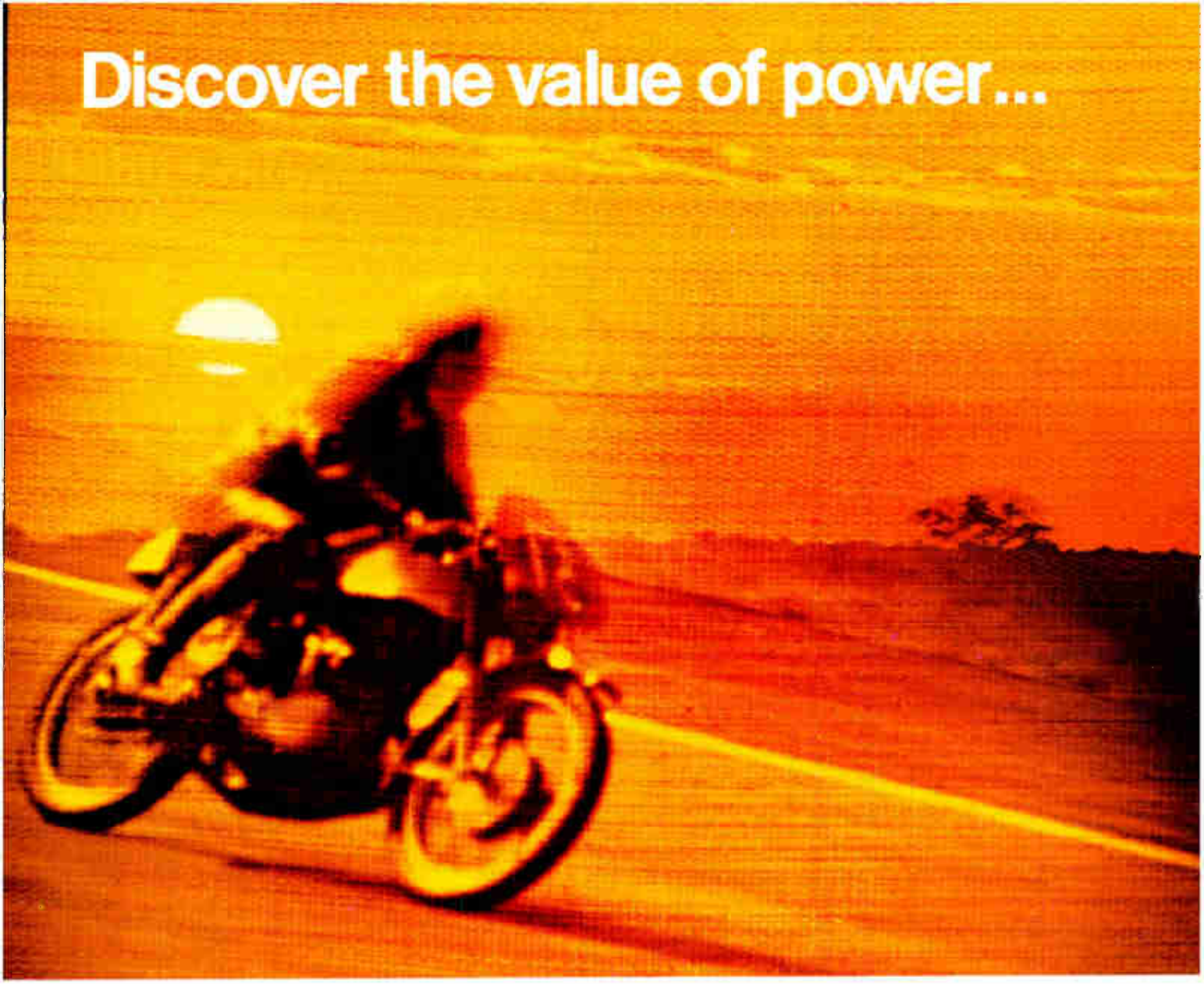
Electronics technology is keeping pace with the boom in use of pleasure craft, and the market—once dominated by four or five old-line manufacturers—is so promising that a number of new firms are jumping in with products.

Transistors have all but completely replaced tubes in marine radiotelephones, and discrete components are being replaced by integrated circuits. Light-emitting diodes are taking the place of neon bulbs. Fiber optics, power transistors, field-effect transistors, transistor-transistor logic, metal oxide semiconductors, and new circuit designs featuring frequency synthesizers and modular printed-circuit boards are boosting the performance and reliability of electronic gear for the boat owner. What's more, instruments new to pleasure craft—such as on-board computers, electronic compasses, solid state radar, and even microwave ovens—are now being aimed at the owners of the larger boats, as well as commercial vessels.

An estimated $21 million worth of marine electronics gear was shipped by manufacturers to the boating market in 1971, according to *Boating Industry* magazine, which predicts that the market will grow at the rate of 7% a year. And marine electronics manufacturers are much more optimistic. A spokesman for Raytheon puts 1971 marine electronics sales at about $35 million, with about $10 million going for radiotelephones. He estimates that the market will increase by 10% this year. Travis Marshall, vice president of Motorola's Modar Electronics Inc., says that the marine vhf market, now about $10 million, will grow at the rate of 30% to 40% over the next two years. Donald Thomas, president of Standard Communications, Wilmington, Calif., estimates that the present vhf market alone amounts to $20 million. But most marine electronic experts agree that whatever the total market may be, the big increase in marine vhf radios is coming this summer.

FCC stimulus. A major reason for the activity in marine radio transceivers is the requirement by the Federal Communications Commission that medium- and high-frequency a-m (double-sideband) equipment can no longer be sold, and that all such equipment now in service worldwide must be phased out by Jan. 1, 1977. Since the first of the year, the only radiotelephone equipment for boats that could be sold has been vhf/fm and single-sideband a-m.

Motorola had such faith in the marine electronics market that it created a new division—Modar Electronics, Schaumburg, Ill.—to serve that market. Since January, Modar has been marketing the Triton series of radiotelephones through marine dealers, a change in Motorola's traditional marketing strategy. Another new company to enter the market is Intech Inc., Santa Clara, Calif., which began manufacturing its Mariner radiotelephones 22 months ago. Walter E. Kaelin, Intech's vice president of engineering, says, "We all came from semiconductor companies. Some of us were sailors who went to the boat shows, looked at the equip-



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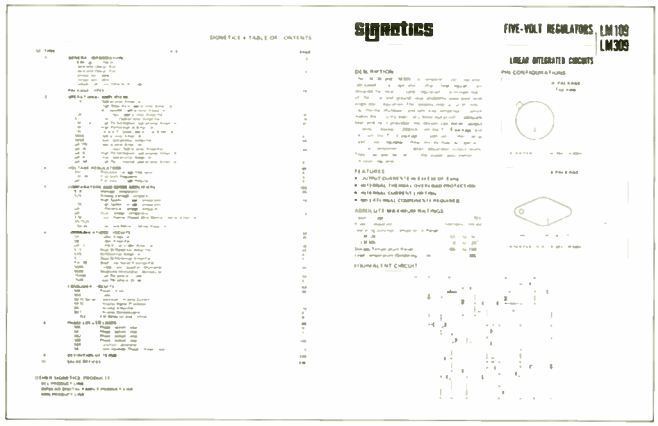
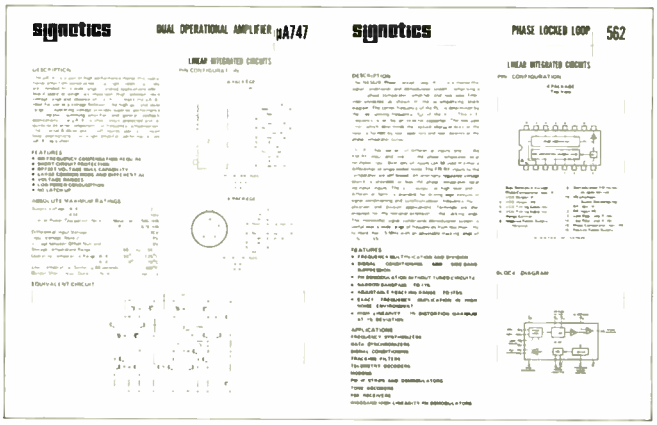
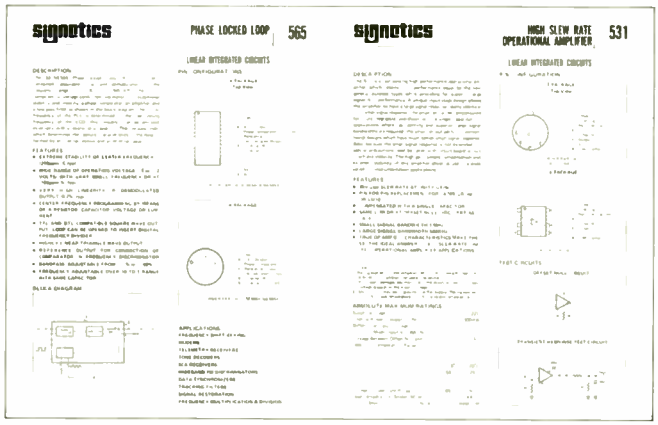
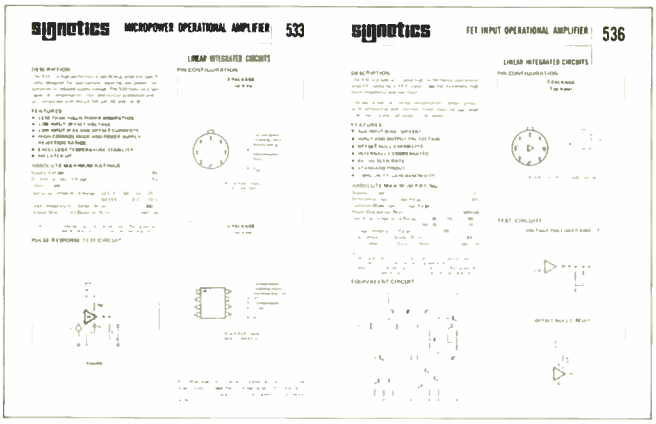
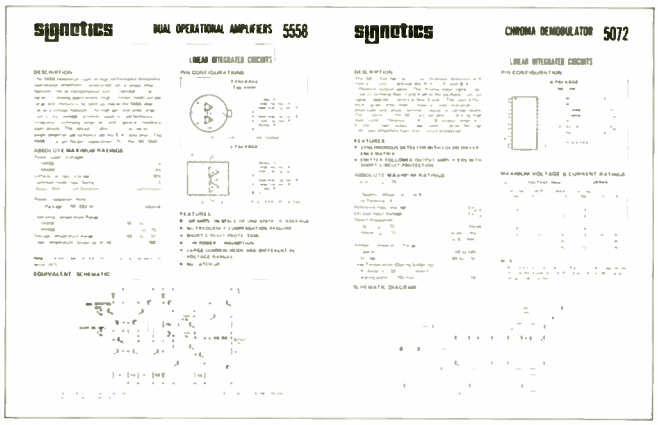
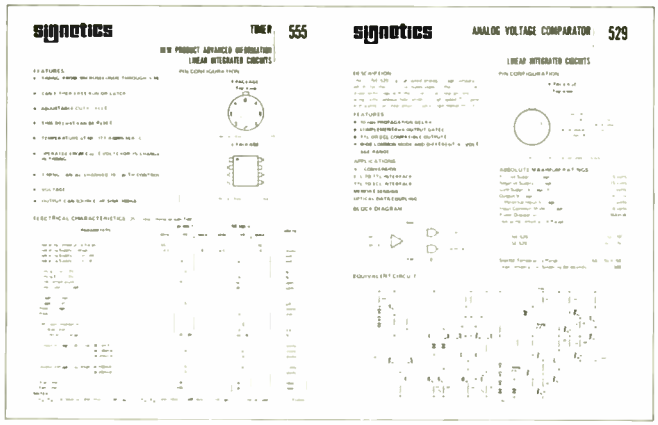












ment, and came away convinced we could do better than that with today's components."

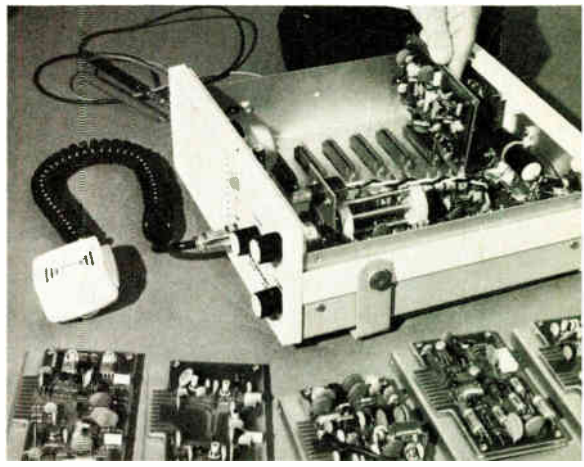
Intech engineers used their experience in building modular systems to design a modular marine transceiver. All components in the Mariner radios are mounted on interchangeable printed-circuit boards. "To keep the components count low," says Kaelin "we used two ICs for our i-f amplifier, while many other makers are using discrete components. We also use a lot of LM 301s—in the squelch amplifier and the microphone amplifier. I'm sure that the use of LM 301s [operational amplifiers] is utterly remote to someone who doesn't build modular products." In two of their models, the receiver uses light-emitting diodes for the on/off display. And in Intech's 55-channel set, a frequency synthesizer eliminates the need for crystals for each channel.

Standard Communications Corp., Wilmington, Calif., built its first marine radiotelephone in 1969. "It was marketed at $300—about half the price of everybody else's"—says Donald Thomas, Standard's president. "We sold more radios in 1969 than the entire industry had since the inception of vhf."

Enter Japan. Why the price edge? A major reason is that the equipment is made in Japan and the company is a subsidiary of Standard Radio of Japan. But Thomas also cites advanced circuit design and the use of MOSFETS to obtain high selectivity and sensitivity. "We developed electronic tuning for our radios," says Thomas.

"We use varactor diodes to tune all the front-end circuits and we switch from the low to the high frequency (from 157 to 162 MHz). This gives us, in effect, a very narrow-band receiver and still allows us to cover the two frequency ranges."

LED displays. The first to use light-emitting diodes in a flasher depth-sounder display was the Polyphase Instrument Co. Bridgeport, Pa., according to Robert H. Simmons, the company's vice president in charge of sales. "By using all-solid-state circuitry, LEDs, and fiber optics, we developed a state-of-the-art flasher that does away with two old problems—neon bulbs that burn out and corrodable slip rings (that pass the current to the bulb). This increased the reliability at least 100%," says Simmons.



Modular transceiver. With plug-in boards, accessories can be easily added to Intech's marine radiotelephone.

A unique instrument on the marine electronics market is an autopilot system for sailboats developed by Safe Flight Instrument Co., White Plains, N.Y. "The skipper decides what course he wants to sail, either to the wind or to a compass heading, sets the sails for the best wind conditions, and Wind Track maintains that set of conditions," says Joseph H. Gordon, manager of application engineering. The system uses 741 operational amplifiers in dual in-line packages in three servo loops. A small analog computer evaluates signals from the compass, wind, and rudder servos, and steers a course based on those inputs.

Digital compasses. At least two companies are marketing marine compasses with digital readouts. ElectroMarine Corp., Falmouth, Mass., developed a compass that uses magnetic sensors mounted outside the wheelhouse of a vessel to obtain heading information that is fed into the master indicator. Magnetic variation and deviation are automatically compensated for, and the digital output from the compass can be fed into a radar or autopilot system. The other compass, made by Lundy Electronic Systems Inc., Glen Head, N.Y., uses a rotating Hall-effect device to sense a magnetic null, which indicates north. The display is made of LEDs. □

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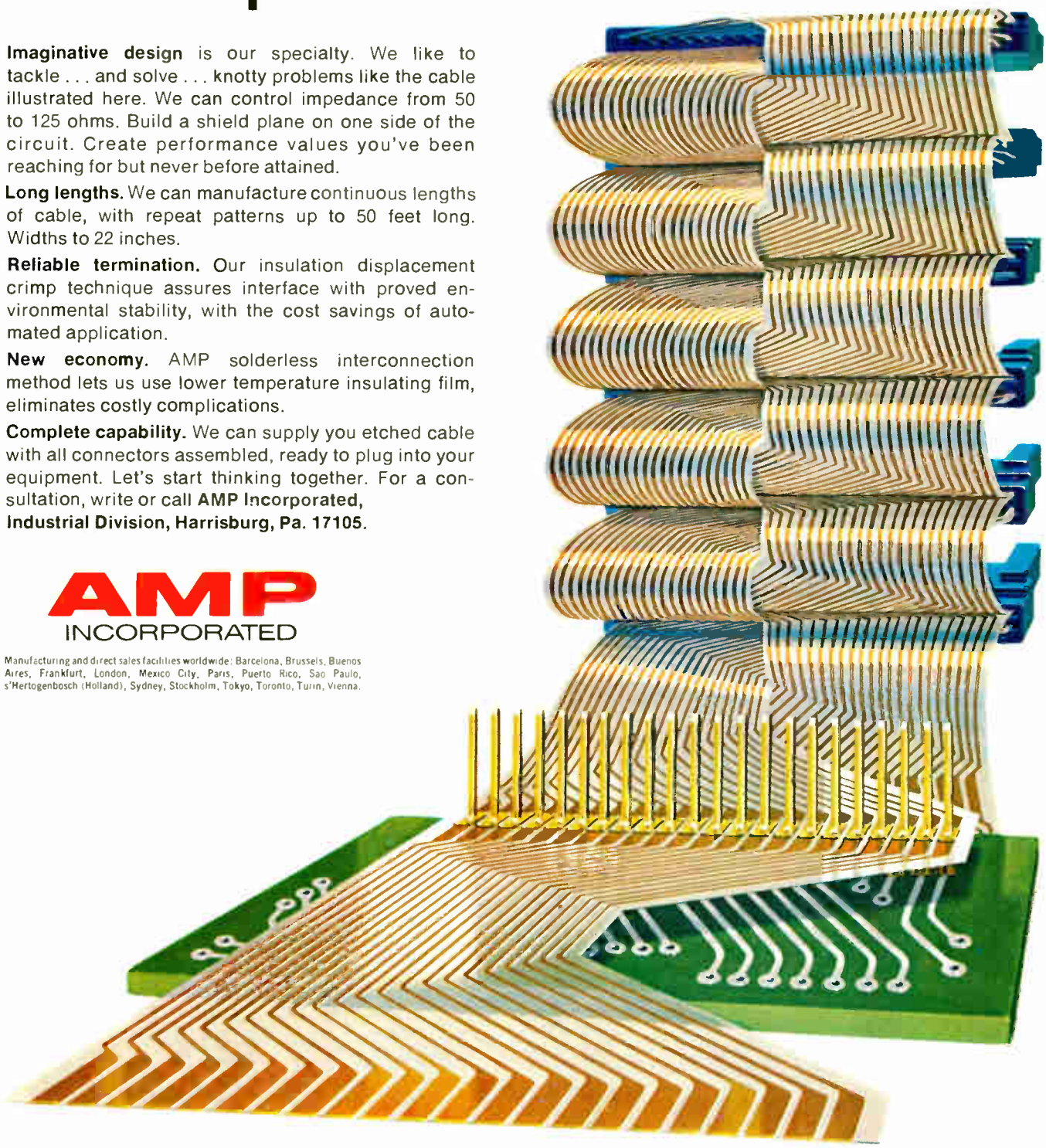

Solid State

New growth: silicon on sapphire

Technology, gaining new impetus, offers high speed, low power demand, high packing density, and high resistance to radiation

by Alfred Rosenblatt, New York bureau manager

Silicon-on-sapphire, regarded by some scientists as "the ultimate MOS technology," may soon carve out an important niche in high-speed, low-power, and radiation-resistant applications. Initially designed for such applications as digital communications, minicomputers and computer peripherals, the metal oxide semiconductor devices on electrically insulating sapphire substrates are just beginning to hit the market.

Some of the first have come from a new company, organized specifically to exploit the technology. Two weeks ago, Inselek Inc., Princeton, N. J., announced its fifth SOS product in three months. Inselek's near neighbor in Somerville, N. J., the RCA Solid State Products division, is also developing SOS devices. Within a month, the division will announce its first one—a developmental seven-stage counter. And North American Rockwell Microelectronics Corp., Anaheim, Calif., has developed SOS circuits for military applications [*Electronics*, Nov. 8, 1971, p.30].

Cheaper sapphire. And as interest and volume have picked up, prices of the still relatively expensive sapphire, an aluminum oxide, supplied mainly by Union Carbide Corp., New York, have been nudged lower. Furthermore, a new processing technology may bring prices down still more. Saphikon division of Tyco Laboratories Inc., Cambridge, Mass., says it has halved the price by extruding the sapphire in single-crystal ribbons 1-inch wide, instead of in boules. And soon the company will have 2-inch-wide ribbons to reduce the price even more.

Until now, semiconductor houses have emphasized development of other devices that showed more immediate prospects for payoffs. RCA, for example, had kept SOS on the back burner in favor of its complementary MOS devices. And Roy Pollock, vice president of Fairchild Semiconductor division, Mountain View, Calif., who had been head of integrated-circuit operations at RCA until he left, still does not consider SOS "a mainstream technology."

NRMEC, which had done the earliest SOS development work, had focused instead on MOS calculator chip technology. But NRMEC has been selling a high-density 40-by-128 SOS array and plans other commercial products soon. Hughes Research Laboratories, Newport Beach, Calif., has rekindled an SOS effort begun eight years ago. The Central Research Laboratories of Motorola's Semiconductor Products division, in Phoenix, is investigating several insulating substrates, including spinel, as well as sapphire.

Promising. The potential of SOS devices should certainly interest manufacturers. Devices in the laboratory, at least, are extremely fast—faster than TTL and nearly the speed of emitter-coupled devices. Speed is high because circuits are fabricated on a thin film of silicon, epitaxially grown on insulating sapphire. Parasitic capacitances, which slow down ordinary MOS structures, are eliminated. SOS devices can also be packed more closely than those on silicon substrates because the isolating sapphire can be narrower than the guard bands and stoppers between devices made with MOS.

Another important factor—particularly to the military—is the radiation resistance of SOS circuitry. With a sapphire—rather than silicon—substrate, relatively few hole-electron pairs are generated in the presence of bursts of radiation, thereby holding down the level of device-damaging bursts of current.

Once SOS is in production, applications could develop rapidly. "The speed of SOS parts is better than any conventional MOS and can compete with TTL," says Hans Dill, manager of solid state device research at Hughes. "Although it's more expensive than regular MOS, SOS should compete with TTL in total LSI systems." However, products are still a year away, Dill concedes.

Impact. At NRMEC, Charles Kovac, marketing vice president, predicts, "The major impact of MOS SOS will be in RAMs in the next year and a half. After that, it will also be in logic, as C/MOS."

Jack C. Haenichen, Motorola's MOS operations manager, expects important applications in commercial computers, for if "we thought it would be used only in a few military programs, we probably wouldn't devote the effort required to do it."

Inselek, relying on a "lower-power form of predominantly p-channel MOS devices" on the sapphire, has already marketed an eight-channel multiplexer, a quad linear amplifier, and memory and shift register chips. And to interest semiconductor manufacturers in the technology, Inselek has been selling high-quality SOS wafers with epitaxially grown single-crystal silicon, which some producers had found difficult to grow. Inselek's newest product is a 256-bit static shift register.

In addition, the company promises a fast 256-bit static random-access memory with 25-nanosecond access time within a week or so, a

Probing the news

"complete" even lower-power complementary MOS logic family with TTL speed early in May, and a 1,024-bit static RAM with 75-ns access time during the summer. Altogether, more than a dozen products are planned by year's end.

RCA Products. RCA's developmental seven-stage counter has a typical 25-megahertz shift rate, making the aluminum-gate C/MOS-on-sapphire device two and a half times as fast as the similar CD4004 counter in RCA's C/MOS line. Zero-count dissipation is 100 microwatts.

At least initially, RCA will produce faster versions of its standard C/MOS devices—a 256-bit static RAM may be next, says Harry Weisberg, MOS products manager. Others to be developed depend on feedback from users, he says. C/MOS-on-sapphire devices now in RCA laboratories include a shift register and a correlator operating at 50 MHz rates and a 256-bit diode read-only memory with 18-ns access time.

Prices of the SOS devices, still available only in sample quantities, are high. Inselek's 256-bit shift register is priced at $50 each in quantities of 100. However, Joseph R. Burns, Inselek president, maintains that SOS devices "could be price-competitive with MOS in six months if volume picks up." To encourage use of his devices, Burns has made them TTL-compatible.

Skepticism voiced. Other SOS device suppliers do not share Burns's cost projections. "I have my doubts costs will come down that much," says RCA's Weisberg. "SOS will sell on the basis of performance, rather than cost."

And still others believe their own developments will match SOS's potential. Paul Richman, vice president of R&D at Standard Microsystems Inc., Hauppauge, N.Y., says his firm's n-channel technology will develop even faster than SOS and have a higher packing density, to boot. Similarly, Raytheon Semiconductor's manager for advanced development, Walter Seelbach, maintains that higher speed can be attained with his company's Vertical Anisotropic Edge (V-ATE) process [*Electronics*, June 7, 1971, p. 35] □

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Computerizing Congress

Keeping track of bills—what committee is working on them and when action is due—is one job planned for computers; they'll also help in drafting laws

by William F. Arnold, Washington bureau

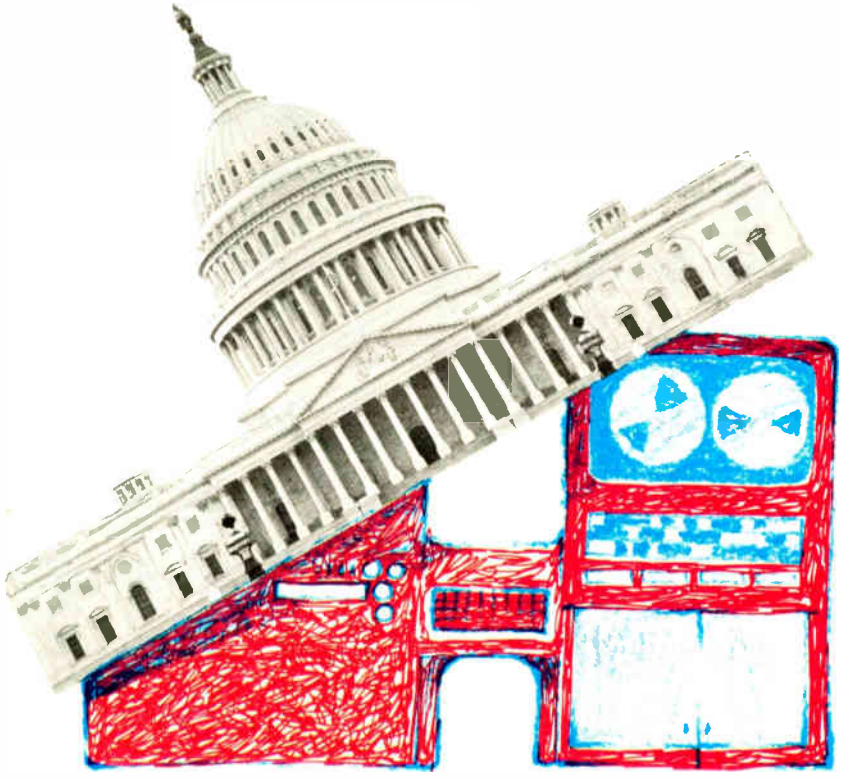
Congress, with its annual workload of some 8,500 legislative measures, has an inventory control problem. And, like the nation's corporations, both the House and the Senate are turning to computer systems to help unjam the legislative mill.

Over the next few years, the congressional computer systems will be automating such "management information" functions as:

- Bill tracking, to spot where a measure is in the intricate maze of committees.
- Bill drafting, including comparisons with existing laws.
- Codifying the rules by which the Houses are governed.
- Analyzing data for committees and their staffs.

Computers will also handle on-line payroll and personnel systems. And, still a gleam in legislators' eyes, is the day when they can go right to a terminal in a committee room and question the computer directly. That day, say the congressional overseers of computer installations, is not too far away.

Today's means of tracking legislation borders on the unwieldy. Bills don't get lost, but do get delayed. With a computer tracking bills and committee calendars, one query could quickly tell what committee has a particular bill and when action on it is due. Bill drafting would centralize the latest wording of a bill and allow automated referral to existing laws for comparison.



Once the systems become operational, Congress will still have to become adept at using them. But as experience piles up, Congress may try a lot more computerization, surmise the two directors of the systems, Frank B. Ryan of the House Information Systems and Thomas P. McGurn of the Senate Information and Computer Services. Ryan plays down "computers as a cure-all," but he does think the new systems will markedly improve things.

"They could have used this system years ago," says Ryan, for "it's an effective way of reducing costs and reducing time." Both Ryan and McGurn say they're getting "good support" from the legislators, especially their "bosses," the Committee on House Administration and the Senate Committee on Rules and Administration.

Start-up. Both computer centers use IBM 360 equipment, the Senate a model 40 and the House a model 50, backed with an NCR 100. The House also will use two Control Data Corp. 1700s for the on-going House electronic voting system, which that company is installing for September operation.

The two congressional staffs operate differently. Ryan prefers to have the development work performed in-house by his staff. McGurn says that the Senate studies are contracted out or done by experts loaned from other Government agencies "to take advantage of Government resources." Systems Development Corp., has completed a $40,000 feasibility study, and Computing and Software Inc., Alexandria, Va., is completing a $145,000 contract for the design of an on-line payroll system. Also, Ryan is direc-

Probing the news

tor of the House computer, while in the more formal Senate, McGurn goes through the Sergeant of Arms office, which operates the Senate computer with a 20-man staff.

Calendar goes computer. In the House, next month will see the committee calendar system begin to edit, update, and retrieve committee hearing and business schedules. And the precedence system—which will take about 5,000 pages of jotted notes on procedures and integrate them into the rules of the House—will also begin operation. By next January, the bill status system will become operational, followed in April 1973 by the on-line payroll and personnel system, Ryan says.

The Senate has a tight timetable for studies before it plans to implement any systems, says McGurn. Studies of legislative record keeping, payroll, analytical services, legal retrieval, and consulting services for committee chairmen will be completed by September.

Of these, McGurn sees the bill tracking system as "the biggest job for the next four to five years." Because it would include abstracts of the histories of bills, the system "would double the computing capacity we will already have." And the present Senate computer operation, which mails and addresses senatorial correspondence, as well as performs analytical studies, is not small, McGurn explains. "It's the second largest mailing and addressing operation in the country," he says. He foresees the new setup as a partitioned system since "we don't need time-sharing."

Looking forward. Ryan sees the present House schedule as "building a firm foundation" for more computerization. "Looking ahead for five years, we see a slew of projects to follow." The bill status and committee calendar systems would eventually merge into a larger facility for coordinated bill drafting and text retrieval. Ryan also foresees a mail addressing installation and an expanded data analysis system that would "really give all the committees a timely system." Here, there would be terminals like IBM 2741s in each of 21 committees. □

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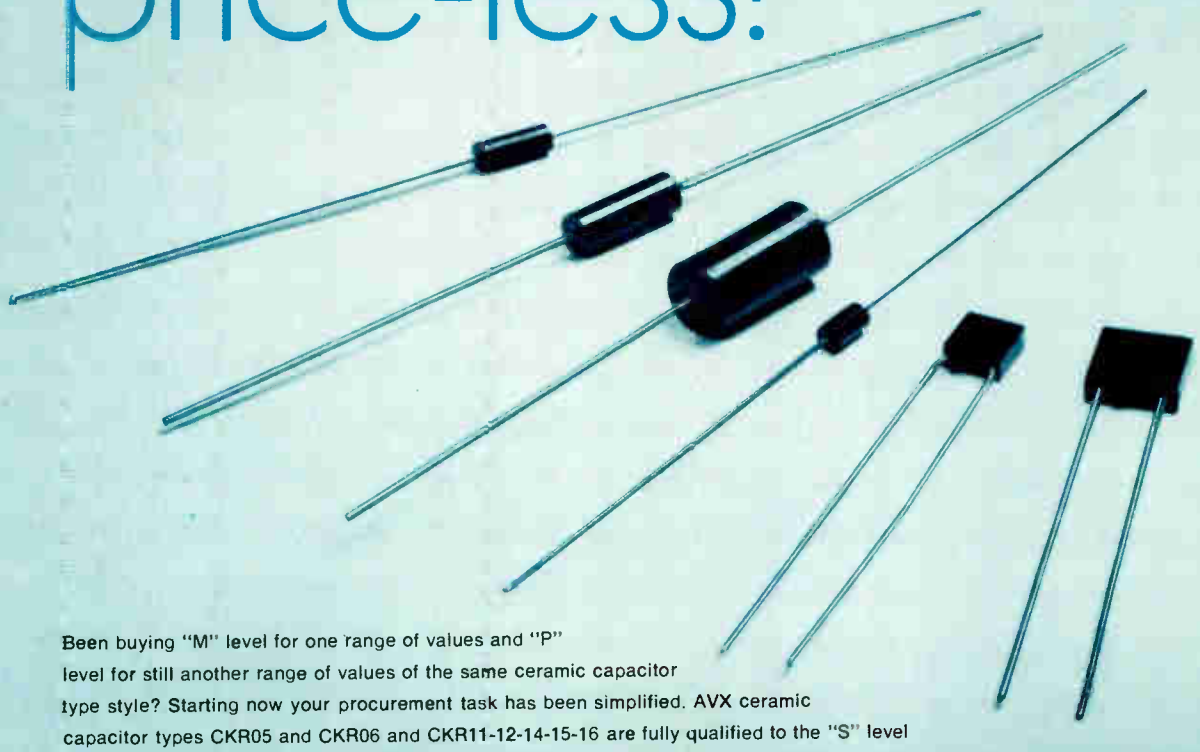

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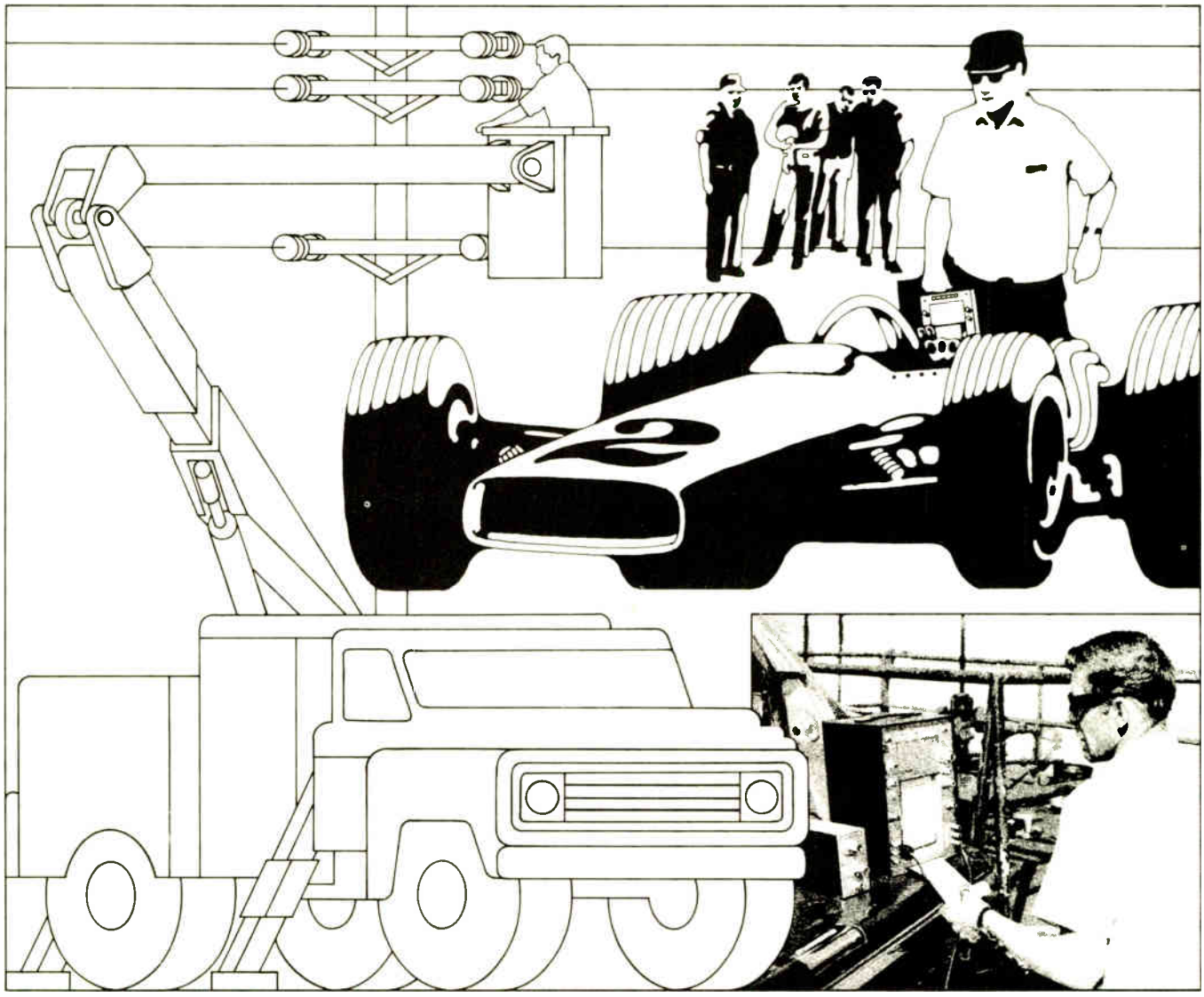

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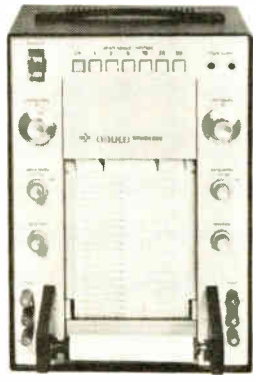

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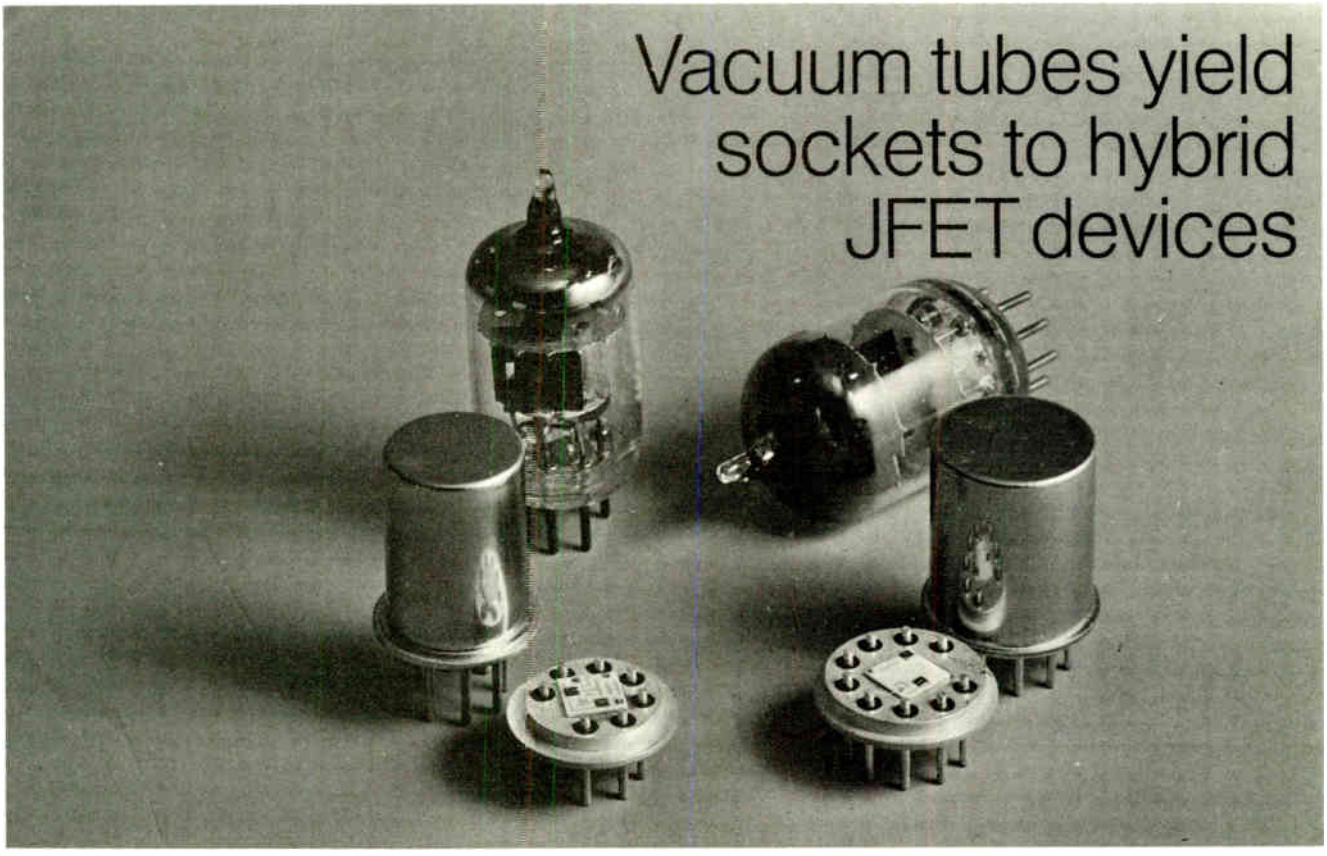
Vacuum tubes yield sockets to hybrid JFET devices



Thanks to high-voltage JFET technology, hybrid circuits called Fetrons exhibit virtually no aging, and also offer higher gain than do their vacuum tube counterparts

by Bruce Burman, *Teledyne Semiconductor, Mountain View, Calif.*

☐ A junction-field-effect device called a Fetron has been developed that replaces a vacuum tube in a circuit directly, without requiring major modifications in the circuit. To withstand the tube's high voltage supply (the B+ voltage), the device is built with the high-voltage JFET technology that was developed more than five years ago for military systems requiring breakdown voltages of 200 to 300 volts.

The Fetron package can be either a single JFET or two cascode-connected JFETs in a hybrid IC. Each kind is now being built as one-for-one replacements for such widely used tubes as the 6AK5 and 12AT7, and each goes into an oversized IC metal can that has the same pin configuration as the tube it replaces.

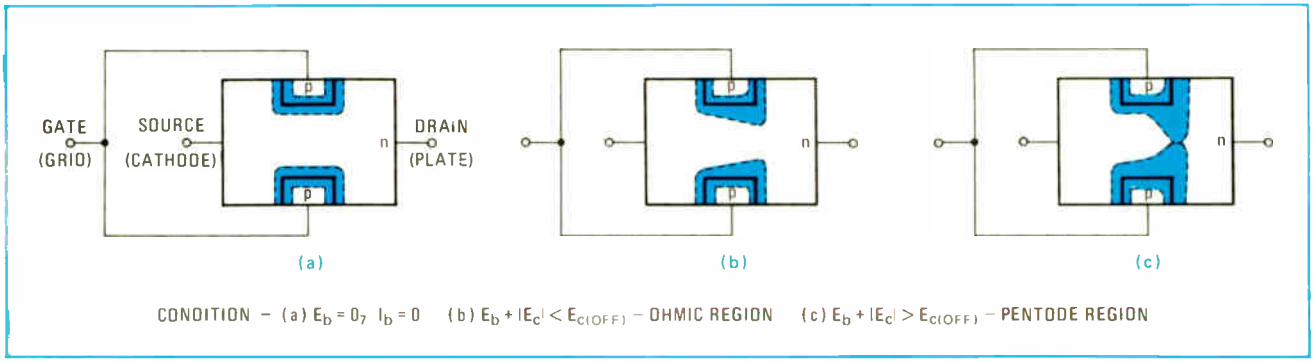
Why the factor?

From a design point of view, Fetrons make good sense as replacements for tubes in much communication equipment:

- Having no drift or aging, they can be locked in place for years, whereas the transconductance of many tubes degrades, often making monthly or quarterly adjustments and periodic replacements mandatory.
- Their improved performance includes higher amplification factors and lower noise than many tubes.
- Their low-power operation derives from the absence of heater or screen grids and the power supplies that run them. They also operate at 65 degrees centigrade, instead of the 100 C of tubes.
- The lifetimes of Fetrons are orders of magnitude longer than those of typical tubes—an estimated 30 million hours for Fetrons, 50,000 hours for tubes.
- They're physically tough, too—there's no glass to break in a metal can.

Fetrons make good sense in terms of sales, too. Billions of tubes that the Fetron could replace are still being used in communication and radar equipment. For instance, the utility telephone network in the U.S. alone contains about 150 million tubes within the Fetron's capabilities, creating approximately a $100 million-a-year market. And the maintenance bill of another major

Tubeless. Hybrid, JFET devices shown above replace tubes on one-for-one basis. Called Fetrons, they plug into unchanged circuit.



1. Brothers. JFET's elements are analogous to tube elements. The JFET source is comparable to the cathode, its drain to the plate, and gates to the grid. As the grid (plate) voltage goes negative, plate (drain) current drops. The gate's p-regions, growing into the channel, causes pinchoff, which is analogous to tube's cutoff.

telephone system's 50 million 6AK5 and 12AT7 tubes alone is estimated to be $500 million a year. Less than half that amount would be required to replace all these tubes with Fetrons once and for all. Then there are probably another 70 million pentode and triode tubes in use in other equipment that is regularly maintained and regularly tuned—from mobile radios to various types of industrial equipment. The potential market grows toward a billion dollars, without even considering consumer equipment.

Viva la similarity

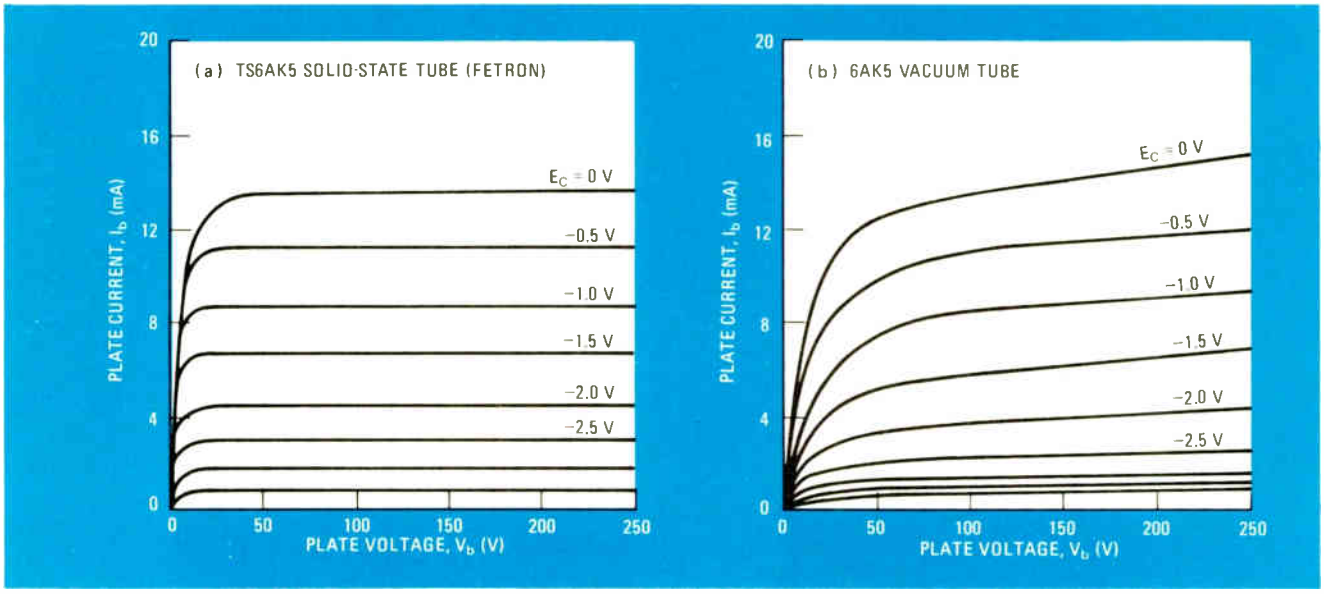
What makes the Fetron so attractive is that the JFET characteristics can be simply chosen to simulate a tube's dynamic performance. The circuit's normal trimmer components are used for tuning.

Basically, and very conveniently, a vacuum tube pentode and a JFET are brothers under the skin. Both are voltage-controlled devices and, if the differences between tube and transistor terminologies are ignored, both can be designed by using the same equations. Indeed, the operating polarities of n-channel JFETs and pentodes are identical, and they have similar output characteristics. If the JFET's drain and gate voltage are varied, the resultant family of curves will look just like the old familiar pentode plate-voltage-versus-plate-current curves at different values of control-grid voltage.

Even the current-control mechanisms of the two devices are analogous. In a tube, the grid voltage controls the number of electrons emitted from the cathode that reach the plate. In the JFET, the gate potential modulates conduction in a channel that exists between source and drain, as is shown in Fig. 1. The top and bottom gates of the JFET are comparable to the grid of the tube, its source is comparable to the tube's cathode, and its drain is comparable to the tube's plate. As the gate (grid) voltage goes negative, drain (plate) current drops because the gate (grid) p-regions grow into the n-channel region until they eventually pinch off the channel. This pinchoff is analogous to tube cutoff.

Again, the output characteristics of JFET and pentode are very similar, as can be seen in Fig. 2. But since the JFET has no elements comparable to the pentode's screen grid and suppressor grid, it is closer to the simpler triode in construction.

Since a JFET doesn't need a heater, warmup is instantaneous. Also, because of its lower inter-electrode capacitance and low channel resistivity, it can operate at



2. Equal but better. The JFET's output characteristics, although similar to those of a pentode, follow the square law more closely, and give a much cleaner on-off action, as is evident from the sharp cutoff.

much higher maximum signal frequencies than the tube, or at low frequencies with less distortion. The sharp cutoff evident in Fig. 2 gives a much cleaner on-off action, particularly in switching applications.

In short, the Fetron can be considered a better pentode than the vacuum tube pentode, because its drain output curves come much closer to the theoretical ideal.

And two JFETs are better than one

It requires two JFETs in a hybrid package to simulate the performance of one pentode. The JFET must withstand high plate voltage (see Fig. 2) to replace the tube directly. But there is no single high-voltage JFET with enough transconductance g_m to match that of the pentode tube. For example, to simulate the 6AK5 a transconductance of 3,500 to 7,500 micromhos at an operating current of 4 to 11 milliamperes is required.

Moderate g_m at high voltage is expensive to get with JFETs, since they must be physically large and of high-resistance material to yield high breakdown voltages. Then, too, the major barrier to high-frequency performance in semiconductors is the Miller effect—the gate-to-source capacitance. In an amplifier of gain A, $C'_{gs} = C_{gd}(1 + A)$. This is minimized in pentodes because of the extremely low plate-grid capacitance that exists because the control grid is shielded by the highly positive voltage screen grid.

To get a high-transconductance, high-frequency (low-Miller-effect capacitance) JFET device, it's necessary to bootstrap or cascode two of them (Fig. 3). In such a design, the input transistor is a small-signal JFET, like the 2N3823, chosen for its low capacitance and high g_m; the output device is a high-voltage JFET, such as a 2N4882. The pair is assembled as chips and packaged in cans.

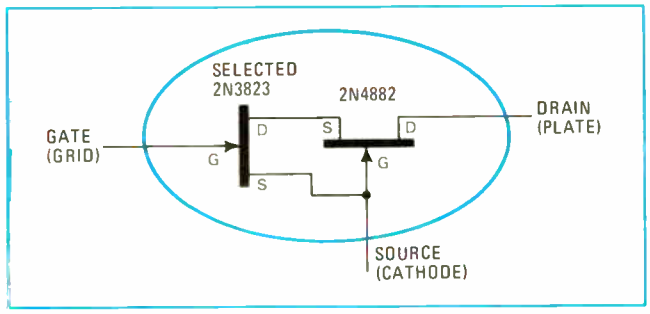
Smooth operator

The operation of the hybrid assembly is simple. The output JFET reduces the plate voltage to a safe level for the input JFET. The former JFET's drain is always connected to the high voltage—the equivalent plate connection in a Fetron—and its gate source connected to the input JFET's gate, which is tied to a low voltage or ground. With this arrangement the input capacitance of the device is just the fairly low capacitance of the input JFET, rather than the much higher capacitance associated with the large high-voltage chip.

With this arrangement assuring equal gains, the Miller-effect capacitance is equal to or lower than that of a tube pentode. The Fetron has only the 0.02-picofarad drain-to-source capacitance of the high-voltage JFET in series with the drain-to-gate capacitance of the unity-voltage-gain low-voltage input JFET. The result: less than 0.02-pF Miller-effect capacitance.

Also, the cascode arrangement boosts the effective output impedance of the Fetron about an order of magnitude above that of a pentode tube. This not only greatly improves the pentode curves, but makes the circuit gain less dependent on Fetron characteristics.

The device's input looks like a reverse-biased semiconductor junction, which provides a very high resistance that's desirable in most applications. Significantly, the effective input impedance is an order of magnitude above a vacuum tube's. This enables a circuit to operate from a high-resistance source without being loaded down.



3. Gaining with cascodes. Most Fetrons are built with two JFETs in a bootstrap or cascode connection to achieve high-gain operation. Miller-effect capacitance is minimized by using a low-capacitance, high-gain input transistor, such as the 2N3823, connected to a high-voltage 2N4881 output device.

Amplification equations

The tube equations apply when the Fetron is plugged into a typical tube biasing network, like the one shown in Fig. 4. (Heater and extra grid connections are left open on the Fetron.)

At any control grid voltage, the plate current will be

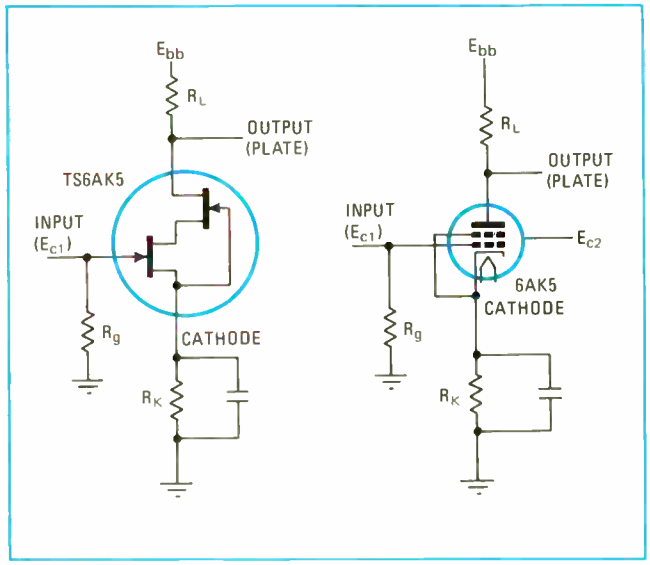
$$I_b = I_{b0}\left|1 - \frac{E_c}{E_{c(off)}}\right|^2$$

where

I_{b0} = plate current at $E_c = 0$ V
I_b = plate current at E_c voltage
E_c = control grid voltage
$E_{c(off)}$ = E_c for 1 μA of I_b

The change of plate current with grid voltage at a constant plate current gives the transconductance. By differentiating the equation for plate current with respect to control voltage:

$$g_m = \frac{\Delta I_b}{\Delta E_c}\bigg|_{E_b = K} = g_{m0}\left|1 - \frac{E_c}{E_{c(off)}}\right|$$



4. Same old circuit. A Fetron (TS6AK5, for example) can directly replace a tube (6AK5, for example) in an unaltered circuit. The heater and extra grid connections are left open on the Fetron.

where g_m = transconductance at operating E_c, and g_{m0} = transconductance at $E_c = 0$ V.

These characteristics give the solid-state device a true square-law characteristic and, because of this, very low harmonic distortion. Higher-than-second-order harmonics are virtually nonexistent.

In contrast, the vacuum tubes have a "three-halves-power" characteristic, and can generate substantially higher-order harmonics and intermodulation products. Interestingly enough, bipolar transistors have even more harmonics than the tube.

The Fetron's very high output impedance, analogous to a vacuum tube's plate resistance r_p, maximizes the voltage gain for a given load R_L. The voltage gain of an amplifier (see Fig. 4) can be expressed as:

$$A_v = \frac{\mu R_L}{r_p + R_L} = \frac{g_m r_p R_L}{r_p + R_L}$$

where $\mu = g_m r_p$ (μ is the tube amplification factor). But since r_p is much higher than R_L, the equation is simply

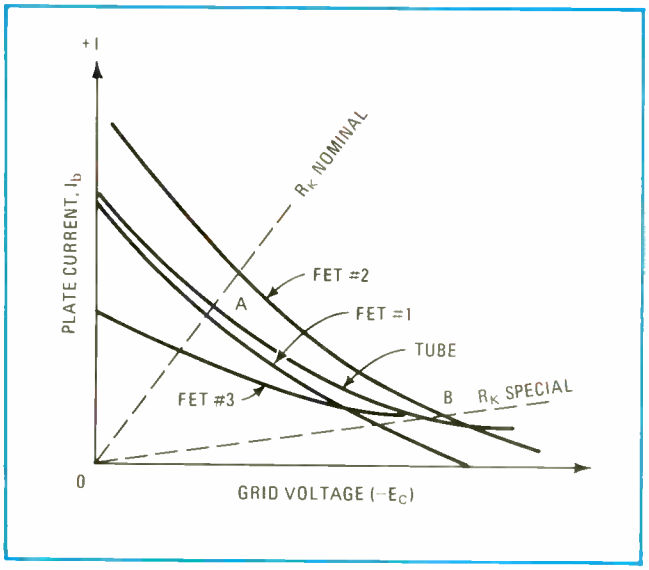
$$A_v \approx g_m R_L$$

At lower frequencies—less than a few megahertz—the simplified equation is more than 99% accurate for a Fetron.

Fitting the FETs

Versions of the device can be made for both amplifier and oscillator service. (The package for oscillator applications may include a small resistor or RC network for feedback and neutralization.) In practice, many FET characteristics are available, and single or JFET cascode pairs can be made to match the tube's current-voltage curves as shown in Fig. 5.

Although several approaches are available, about 80% of the general-purpose applications considered to date are satisfied by the simple FET = 1 approach. This type of JFET is chosen if the application is unknown or if the device must operate around some nominal operating point A (in which case, the JFET curve closely approximates the tube curve over most of the control voltage range). In large-volume applications, where the exact operating point is known, FET = 1 can be selected at the factory to coincide exactly with a point anywhere near A on the tube's curve.



5. Choosing a Fetron. Several Fetron types are available to match a tube's application. If the tube operates around a fixed point, such as A, a JFET, such as FET = 1, is chosen. To match a tube that operates beyond a FET's cutoff, FET = 2 or FET = 3 is chosen: FET = 2 for high current before cutoff, FET = 3 for low, flat current.

An operating point such as B beyond the normal FET cutoff can be matched by FET = 2 or FET = 3. FET = 2 would provide a higher current for the same control voltage, so it passes through B before cutoff. FET = 3 would have to be specially tailored for low, flat current characteristics, or for a narrow range of operation beyond the normal FET's cutoff. It would be a lower-transconductance, higher-cutoff JFET.

In simulating a tube, the dynamic characteristics as well as the operating point must be considered. Depending on the particular application, special attention must be given to transconductance, phase shift, phase margin, operating range, and neutralization requirements.

For amplifier operation, neutralization and operating range are the principle concerns. In most tube circuits, neutralization is used to nullify the effects of feedback capacitance during higher-frequency operation.

When used as an oscillator, the Fetron must provide for positive feedback between the output and input. An internal RC network within the device headers (Fig. 6) acts as a screen grid which is connected to the input to assure direct replacement.

In Fetrons designed for amplifier operations, how-

Building the high-voltage JFETs

JFETs with breakdown voltages over 300 volts can be made by standard planar processing. But to achieve this high volume, it is essential to attain the maximum breakdown field for silicon, about 30 volts per micron. Also critical is the epitaxial layer thickness and resistivity.

The channel is formed by the n-type epitaxial layer, which has a resistivity exceeding 5 ohm-cm. Since the channel region where pinchoff occurs is directly under the gate, doping levels in that region must be precisely controlled to limit spreading of the depletion region into the channel. The channel height depends on what final pinchoff voltage is desired.

The voltage from gate to source, V_{GS}, must be as large as–50 V. This V_{GS} value is required to enable the drain to withstand a voltage of up to 400 V. However, this high gate-to-source voltage can only be achieved if the spacing of the gate, source and drain is held to very close tolerances.

Another difficulty is the need to shape the diffusions so as to minimize any surface field concentrations at the chip. Breakdown should occur in the bulk silicon, not at the surface. The substrate resistivity must be fairly high for good control of depletion spreading, as well. Otherwise, the channel might get pinched off with a very small charge in V_{GS}. At high operating voltages, V_s can vary widely without any change in signal voltage, due to normal supply tolerances.

ever, the RC network is omitted and, instead, a capacitor is added to provide the necessary frequency response. Characteristics of a properly trimmed TS6AK5 Fetron and the tube it replaces are listed in Table 1. Heater voltage is not specified, because those pins are not connected in the Fetron.

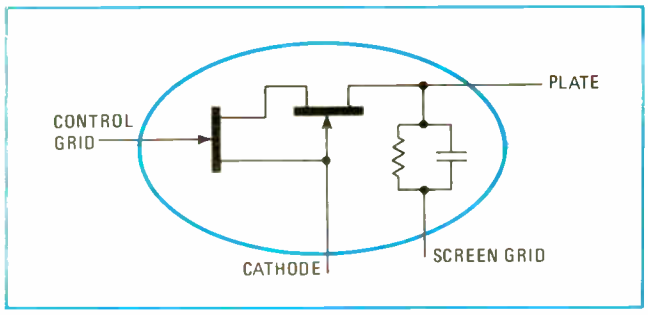
Note the great increases in amplification factor and plate resistance when Fetrons are used. The effect of these differences on the circuit is greatly improved sensitivity—about 4 to 5 decibels—resulting from the higher $m\mu$, lower noise, and low distortion.

Triode simulation

The Fetron will also perform well if configured as a triode, for the three electrodes of a single JFET directly simulate the latter's grid, cathode, and anode. But the JFET's much higher output impedance (hence higher gain) could cause an amplifier circuit to oscillate. Usually, however, the load resistance of a circuit is much smaller than r_p of the Fetron, and there is no problem.

The first Fetron triodes made were equivalents of the 12AT7 and Western Electric's 407 version, which has a 20-volt heater and slightly different pin-out. These Fetrons operate as twin triodes. Figure 7 and Table 2 show their characteristics compared to a single triode. Although the Fetron's transconductance is significantly lower (each of the triodes is a single high-voltage FET), its transconductance is the same as that of the twin triode being replaced. And the design equations given for pentode amplifiers also apply to the triode version.

True, the Fetron output characteristics approximates a pentode's, not a triode's. But it can be used to replace a twin triode—the more common triode application because two of the small inexpensive devices go easily into one glass tube envelope. It's generally not as good an electronic device as a pentode, though many circuit designers use them in cascode to get lower noise than obtainable with a pentode. Now, the Fetron triode upgrades typical circuit performance because of its excellent square-law characteristics throughout the control voltage range. Power supply regulation can also be relaxed—triodes normally require well-regulated power supplies, because triode operating current depends on operating plate voltage, whereas the Fetron's does not (see Fig. 7a).



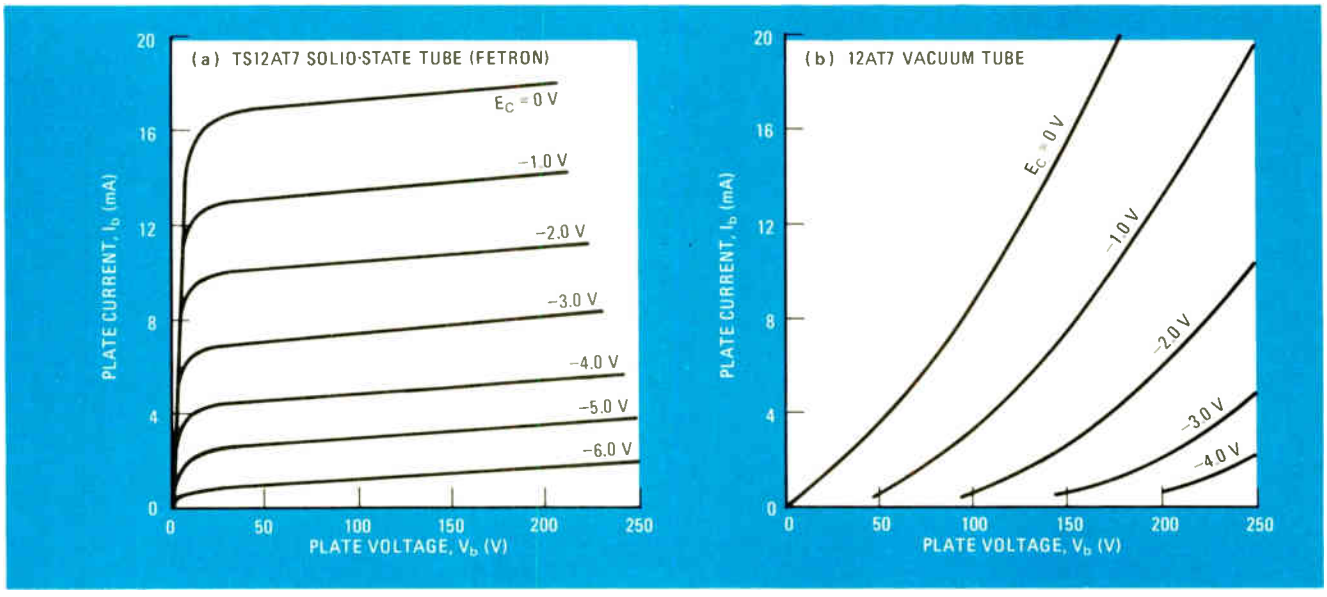
6. Farflung net. This oscillator network is used when Fetrons replace a pentode oscillator. The resistor and/or resistor-capacitor combination simulates screen-grid action. The network is included within the header, permitting 1:1 replacement.

It's dependable

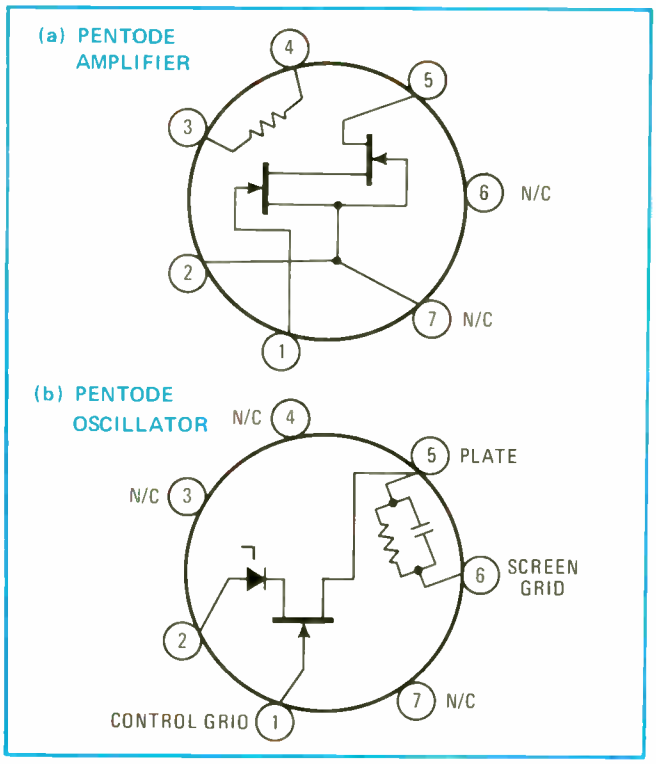
Besides replacing pentode and triode tubes, the Fetron gets higher marks in reliability than either. A high-reliability tube has a life expectance of 5×10^4 hours (63% failure point). Preliminary data from burn-in and accelerated life tests on 1,000 Fetrons indicates a life expectancy of 3×10^6 hours, or 300 years. Of the 1,000 in the sample, 787 were screened by the type of power burn-in tests generally given high-reliability tubes, and were operated for 20 hours at twice normal dissipation (1,760 milliwatts). The failure rate, or dropout, was only 3.5%, a small fraction of the tube screening dropout rate.

In addition, some 2,500 Fetrons have been shipped to telephone companies for evaluation and trial applications. Many have been in use for as long as eight months, and to date, failures or degradations reported have been statistically unimportant.

Finally, another group was put in a 170° C oven and



7. Just like a triode. Although the characteristics of a Fetron are different from those of a typical triode, they are similar to those of a triode pair and can be used wherever twin triodes are used. In fact, Fetrons were first designed to replace Western Electric's 407 twin triode.



8. Different configurations. The internal configurations depend on whether the Fetron is destined for service as a pentode amplifier (a) or oscillator (b). For oscillator use, an internal RC network provides the required feedback when the Fetron is plugged into sockets.

powered at 1.2 W, a test that keeps the junction temperature at 215 °C for 450 hours. One failed and one degraded (leaked), indicating device survival at 100 °C for 10^{11} hours.

From these destruction tests, it was found that although normal operating current is 7 mA, it generally takes a steady current above 30 mA, at 350 to 400 V, to induce failure. Surges up to 6 A can be withstood. Internal connections melt at 9 to 10 A, but fusing links can be built into the device so that if it does fail catastrophically, the circuit is protected.

Shock and other physical tests, comparable to normal IC environmental tests, have also been made. The Fetron, because of its hard metal case, is virtually unbreakable. The case is a solid, deep-drawn brass cap welded to a large header. Before welding, the case is evacuated and backfilled with dry nitrogen.

Almost every general-purpose pentode and triode tube type, and various special-purpose ones, may be simulated with Fetrons, by selecting the appropriate FET pair and varying the internal connections and networks. Figure 8 shows two versions.

Variations include:

- The standard amplifier (6AK5 with 6.3-V heater). In amplifier circuits, a cathode resistor is commonly used to adjust the operating point. At frequencies up to 30 MHz, amplifiers don't need a neutralization network. At higher frequencies, an adjustable capacitor is usually available in the circuit. If not, a 2-pF capacitor may be added internally or externally.
- The oscillator, with the screen grid simulated and feedback to input provided by the connection to pin 6.
- The low-gain single-FET pentode.
- The twin-triode amplifier, for low-noise cascoded triode circuits.
- The twin triode, with an RC network inserted for voltage regulator circuits.

The Fetron pentodes have been operated to 500 MHz, exhibit lower i-f noise than the original tubes, and do not suffer from microphonics. Elimination of heater power, and usually all screen grid power as well, cuts supply drain and reduces operating temperature from well over 100 °C for the tubes to about 650 °C for the Fetron. After some eight months of trial operation, there has been no noticeable degradation in its transconductance.

Fetron triodes will generally be used in low-frequency applications. In most of these, their sharp cutoff improves on the original circuit performance. Naturally, such triodes have the same general noise and power-saving advantages as the Fetron pentodes.

Pacific Telephone Co. recently has converted to Fetrons on a trial basis in a number of repeater lines between San Francisco and Martinez, Calif. In addition, some of the channel equipment for multiplexing and

TABLE 1: TYPICAL PENTODE DEVICE CHARACTERISTICS – R_K = 200 Ω, E_b = 120 V

PARAMETER	UNITS	6AK5 VACUUM	TS6AK5 SOLID-STATE
Plate voltage breakdown	V	350	350
Plate resistance	MΩ	0.5	5.0
Transconductance	μmhos	5,000	4,500
Plate current (R_K = 200 Ω)	mA	7.5	7.0
Grid voltage for I_b = 10 μA	V	−8.5	−5.0
Amplification factor	—	2,500	22,500
Input capacitance	pF	4.0	6.5
Output capacitance	pF	0.02	0.02
Useful frequency limit	MHz	400	600

TABLE 2: TYPICAL TRIODE DEVICE CHARACTERISTICS (EACH SIDE) – R_K = 240 Ω, E_b = 130 V			
PARAMETER	UNITS	12AT7 VACUUM	TS12AT7 SOLID-STATE
Plate voltage breakdown	V	400+	350
Plate resistance	kΩ	15	250
Transconductance	μmhos	4,000	3,000
Plate current (R_K = 240 Ω)	mA	5.0	9.0
Grid voltage for I_b = 10 μA	V	−7.0	−7.0
Amplification factor	—	60	750
Input capacitance	pF	2.2	25
Output capacitance	pF	1.5	3.5

demultiplexing in a carrier office is now equipped with Fetrons.

What next?

There are numerous tube types that can be made with the basic Fetron designs. Types such as the 6JC6 and 6EW6, which have transconductances in the vicinity of 25,000 micromhos and plate currents in the 40-mA range and which have already been made, can be combined with the 6AK5, 12AT7, and their derivatives so as to make Fetron versions of the great majority of popular tube types. Next to be tackled will be the power pentode devices, such as 6AQ5, 6V6, and remote cutoff pentodes, such as 6BA6. Indeed, with volume production and some packaging changes, the Fetron could go on to become a low-cost replacement for most tubes. □

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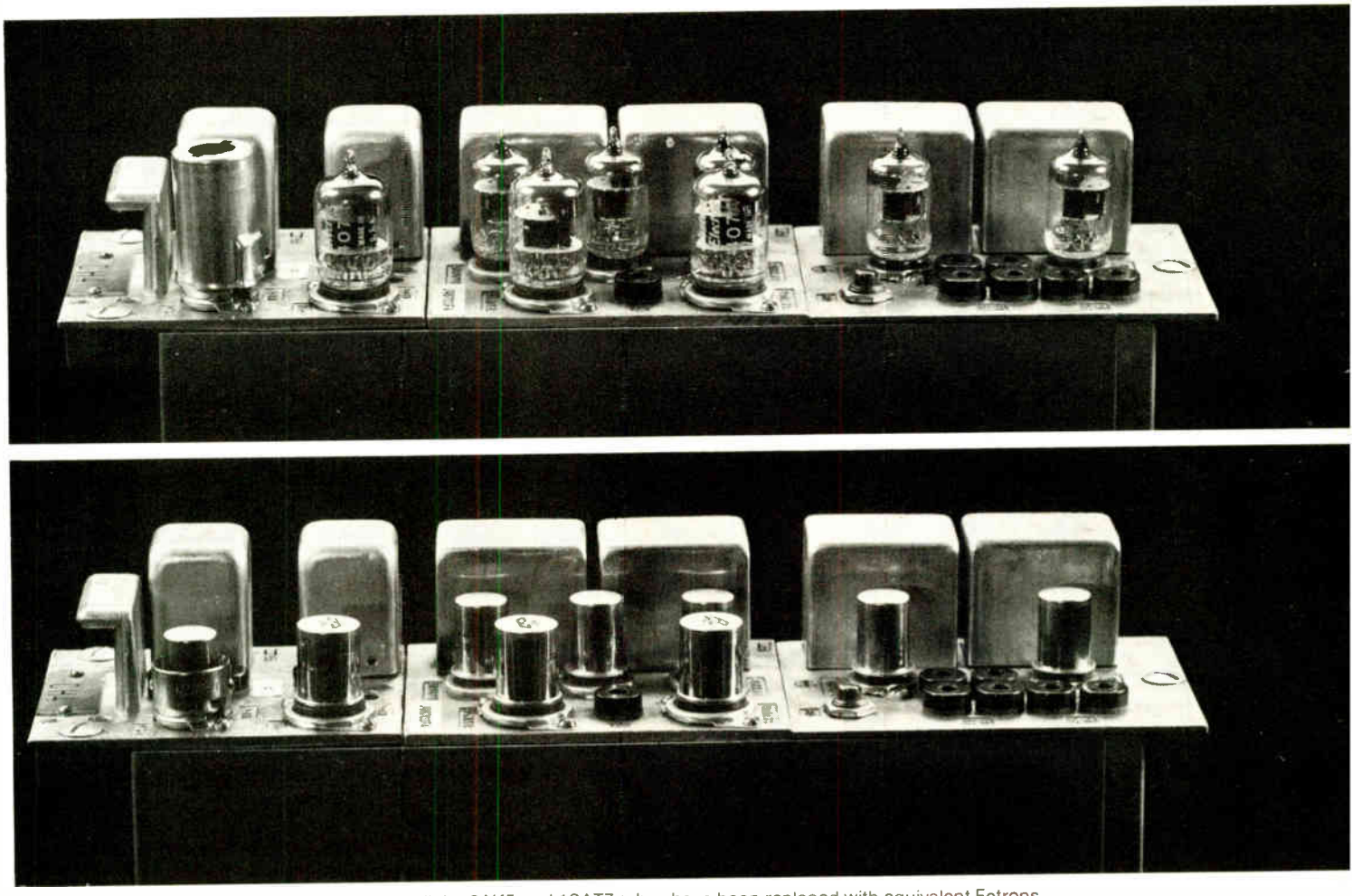
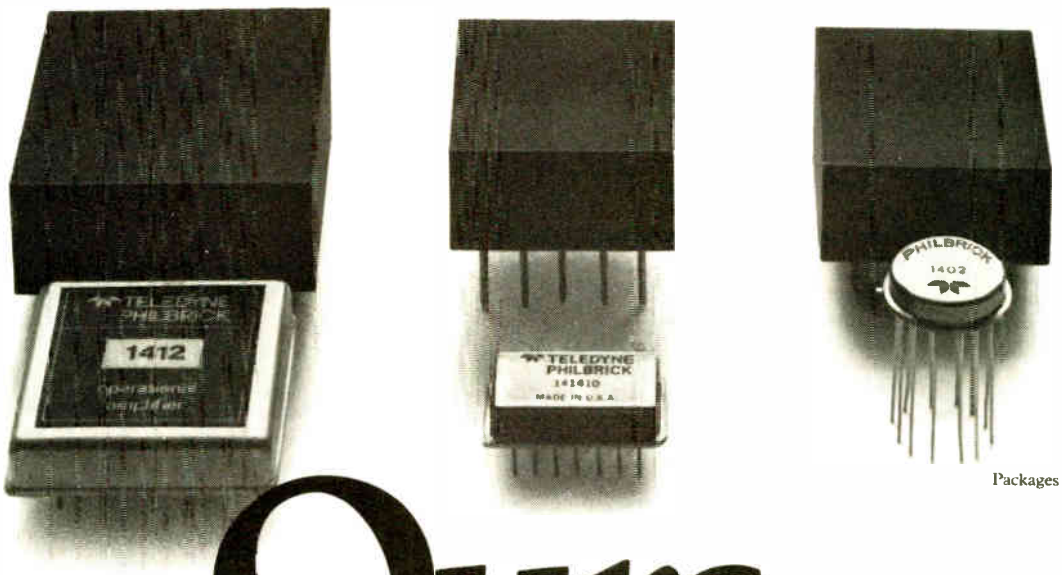
2 R L Berger, "The Direct Replacement of Pentode Vacuum Tubes with Cascode Field Effect Transistors," Mid-America Electronics Conference, Kansas City, Mo October, 1971



9. Finding their place. In the above amplifier, all the 6AK5 and 12AT7 tubes have been replaced with equivalent Fetrons.

Theirs.



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C/MOS digital wristwatch features liquid crystal display

Used with complementary MOS, bidirectional switching found best way to drive display for power conservation and ease of manufacture; next generation also to have built-in counter and driver circuits

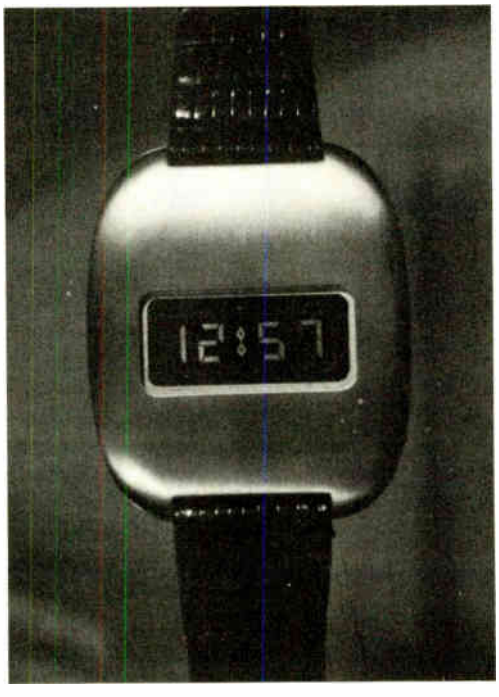
by Nunzio A. Luce, *Optel Corp., Princeton, N. J*

☐ Intense loyalities to mechanical watch movements have been built up over centuries of reliable performance and painstaking advances. But these traditional loyalties have been shaken to their foundations. The solid-state electronic watch is now a reality—at competitive prices. Virtually every watchmaker in the world is evaluating or designing electronic timepieces, and a few models already have been placed on the market.

The dramatic challenge to the time-honored and tested mechanical movements has been brought about by development of complementary MOS integrated circuits simultaneously with extremely low-power liquid crystal display technology (Fig. 1).

Once maligned as expensive curiosities, wrist computers, or portable clocks, electronic watches are now being taken dead seriously by these cautious manufacturers. One of the most dramatic examples of the change in attitude is the acceptance by a U.S. watchmaker of a digital electronic watch with a liquid crystal display.

Except for the display and a 15-volt power converter, the main components of a solid-state liquid crystal digital watch don't differ much from those of previous electronic watches—an oscillator, an MOS IC divider circuit containing about 400 transistors, a single 1.5-v battery, and an MOS counter/decoder-driver circuit with about 900 transistors.



The liquid crystal display has three and a half seven-segment units to show hours and minutes, separated by a colon. To indicate seconds count, the colon flashes at a 1-hertz rate, although on some models it is possible to have the entire display blink off the seconds. The power-to-display size tradeoff and esthetic appearance together led to the choice of a 0.123-by-0.184-in. digit with an active display length of 0.8 in. The power converter provides 15 v for the display; at this level the display has a nominal power dissipation of 15 microwatts. This provides a contrast ratio of about 10 to 1.

An important retailing feature of the watch has been the precision possible with the crystal-controlled oscillator. In general, the higher the frequency of the oscillator, the higher the accuracy that can be achieved, because in dividing down, there is greater leeway at high frequencies for slight errors that will not affect accuracy. Considerations of cost, size, availability, accuracy, and power consumption suggested an oscillator frequency of 32.768 hertz.

The quartz-crystal oscillator is set to an accuracy within 0.5 parts per million—that is, 15 seconds a year—by a trimmer capacitor in the oscillator circuit. With this adjustment made and with aging and temperature variations taken into account, the over-all deviation of the watch will be less than 10 seconds per month.

Technologies compared

It's possible to design circuits for a watch using bipolar and p-channel MOS, as well as a C/MOS technology. However, it is also important to keep in mind both power dissipation and chip size to extend battery life and keep down costs. Present bipolar technology, in general, does not lend itself to low-power operation in a small chip size because of the need to use resistors or transistors to set the high impedances needed.

P/MOS has an advantage over bipolar since a high-impedance, depletion-mode device can be used as the current source. To obtain 2 to 3 μW of power dissipation for the counter/decoder-driver chip, however, these depletion mode transistors become relatively large, increasing chip area substantially beyond that required for a C/MOS device.

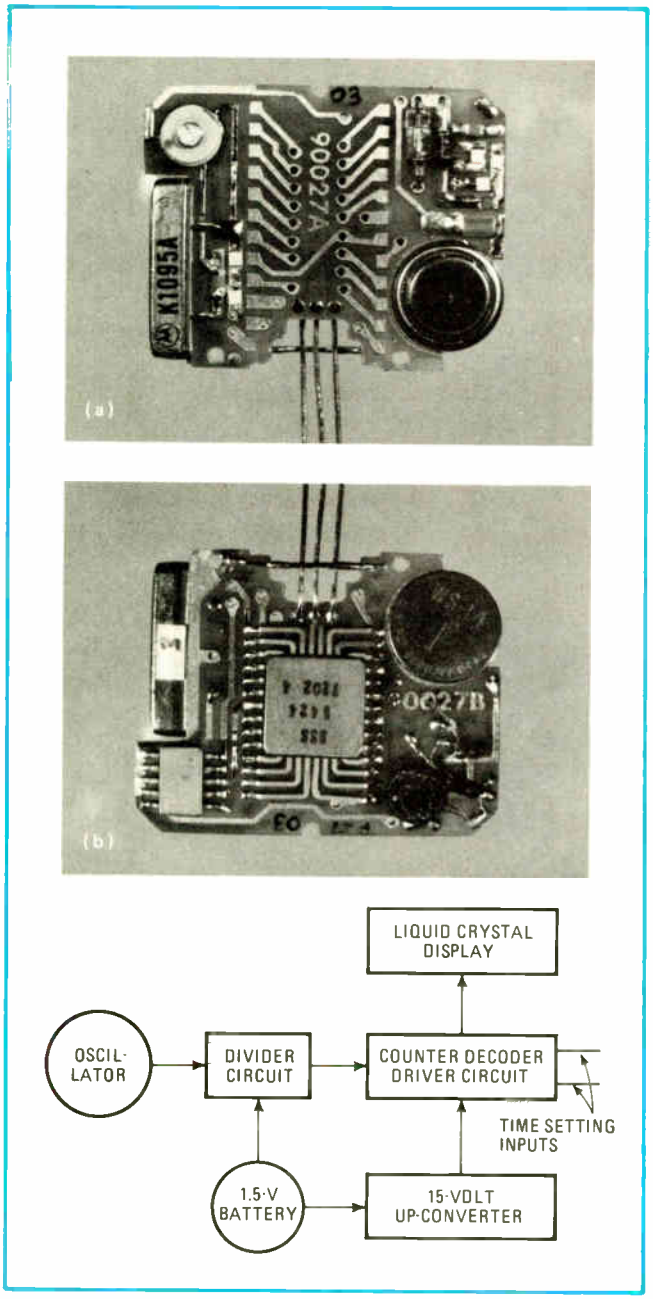
Meeting the power requirements with P/MOS is conceivable, yet more complex circuitry would be necessary than for C/MOS. Therefore, at the present state of the art, greater advantages in chip size and low power can be realized by using C/MOS chips.

A nine-stage, ripple-carry binary counter divides down the 32.768-Hz oscillator frequency to

15-microsecond pulses at 256-Hz and 64-Hz rates. Driven by a low-impedance C/MOS inverter, the 256-Hz pulses drive the up-converter. The 64-Hz output goes to an uncommitted p-channel device connected to a resistive load in the counter/decoder driver.

This uncommitted p-channel and resistive-load circuit is used to transform the 64-Hz, 1.5-V pulses to the 15-V pulses needed to drive the first counter stage in the counter/decoder-driver circuit. This circuit, the second C/MOS chip in the watch movement, contains counters for time keeping, a logic circuit for time setting, and decoder/driver circuits for the display (Fig. 2).

1. The works. Top and bottom views of the digital electronic watch movement show the major components: the crystal oscillator, variable capacitor to set oscillator frequency, power converter to boost 1.5 V to 15 V, and the 1.5-V battery (a) and the C/MOS divider circuit and counter/divider-driver circuit (b). Display is not shown.



The 15-V, 64-Hz pulses from the divider circuit are divided into seconds, minutes, and hours, with the minutes and hours accumulated in counters. The time-setting circuit, shown at the bottom of Fig. 2, uses a two-input binary coded decimal code, in which the "0" input is ground potential and a "1" input is supply potential. Both inputs are in a 0 state during normal operating condition, but they must be switched to 0-1 to change the hours setting. While held in this condition, the hours change at a 1-Hz rate, while the remainder of the counters operate without interruption.

Setting the watch

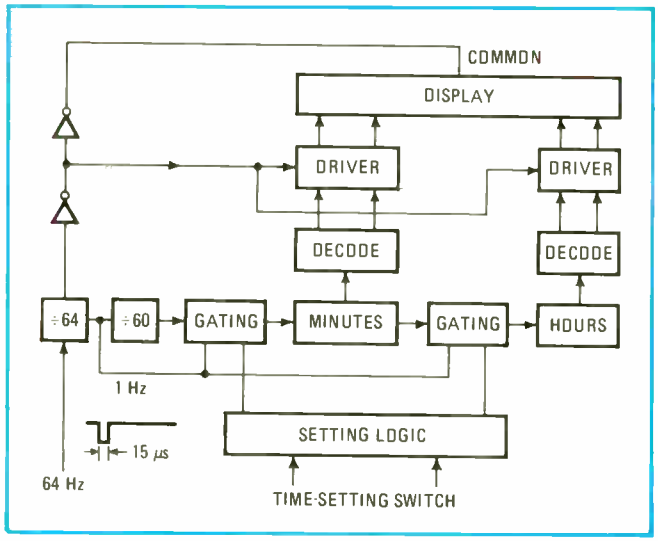
When it's necessary to change the minutes setting, the inputs are switched to the 1-1 state. In this mode, the seconds are reset to 0, and the minutes advance at a 1-Hz rate until the display reaches the correct time. Then the inputs are switched to the 1-0 state, which holds the time registered in the counters while the inputs are switched back to the normal 0-0 state.

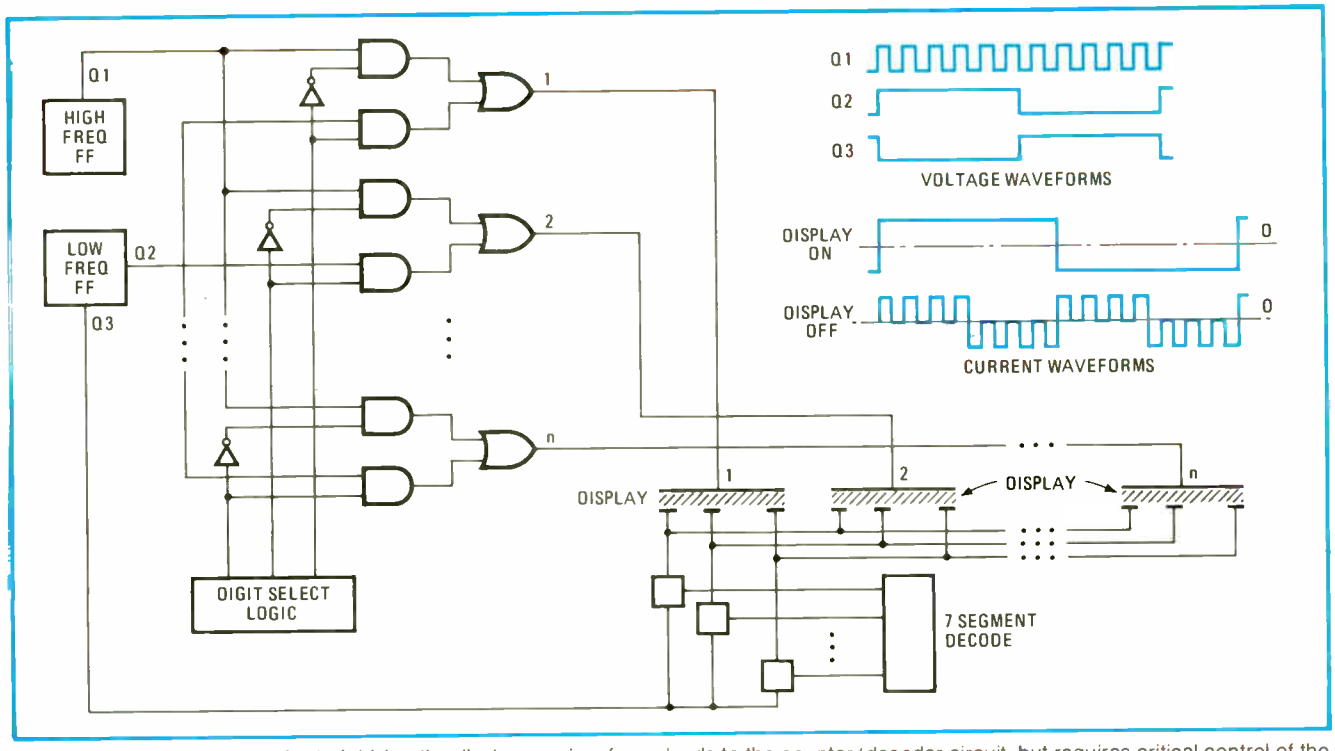
A four-position switch, constructed like the mechanical stem of a conventional watch, controls the time-setting circuit. For hours changes, the crown is rotated clockwise and held, while the hours advance until the crown is released.

For correct time setting, the crown is rotated counterclockwise to the first detent, which places the watch in a hold position. Two choices are available at this point. If the watch is running fast, this position is maintained until the correct time signal is received, then the crown is rotated back to the operating position. If the watch is running slow, rotating the crown further in the counterclockwise direction and holding it advances the minutes. Releasing the crown returns the watch movement to the hold position, and when the correct time signal is received, the crown is rotated back to the normal operating position.

The output of the minutes and hours counters is in binary coded decimal form, but must be transformed into

2. Making it not tick. The counter/decoder-driver circuit is a C/MOS chip for time keeping, time setting, and driving the display. Output of the minutes and hours counters is in binary coded decimal form, which is turned into a seven-segment code by the decoder.





3. Ac multiplexing. This method of driving the display requires fewer leads to the counter/decoder circuit, but requires critical control of the liquid crystal cutoff frequency and increased power as the drive frequency increases. The ac source comes from two synchronous flip-flops.

a seven-segment code to activate the seven segments of the display digits. A 32-Hz square wave from a flip-flop in the divide-by-64 counter drives the liquid crystal display.

Several techniques for driving the display were investigated. These included ac multiplexing, ac switching, and phasing. Also evaluated was a circuit in which the decoder drives the display directly.

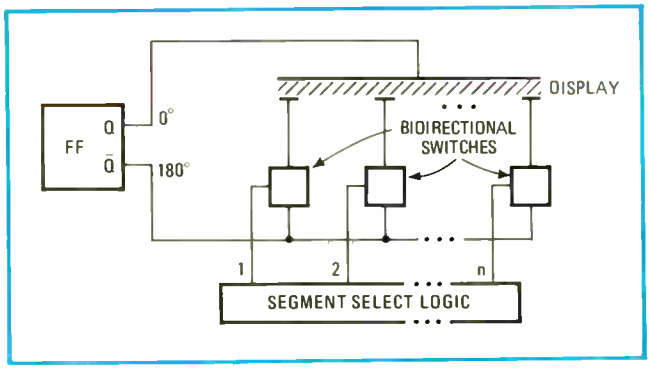
First to be investigated was ac multiplexing, on the theory that this approach would reduce the number of leads on the counter/decoder-driver circuit. Standard dc multiplexing circuits could not be used in the watch because the liquid crystal display requires an ac driving source. The main concern, however, is that when the display is driven at such a high frequency, the liquid crystal material no longer scatters light when it reaches the cutoff frequency.

Multiplexing circuit tried

To avoid this problem, the multiplexing circuit shown in Fig. 3 was tried. The ac source to drive the display comes from two synchronous flip-flops—one operating at the cutoff frequency and the other below. The digits to be displayed are selected by OR gating the high- or low-frequency drive, while bidirectional field effect transistor switches are used to turn on the digits.

The high-frequency drive prevents the "off" segments from being turned on by leakage paths. The drive is adjusted so that the frequency is at a delicate balance between the cutoff point and the point of driving off the segments completely. Since the average current is zero, there is no dc offset on the display.

However, the multiplexing approach has drawbacks. For one, the power required for the display increases as the drive frequency increases. In addition, the liquid

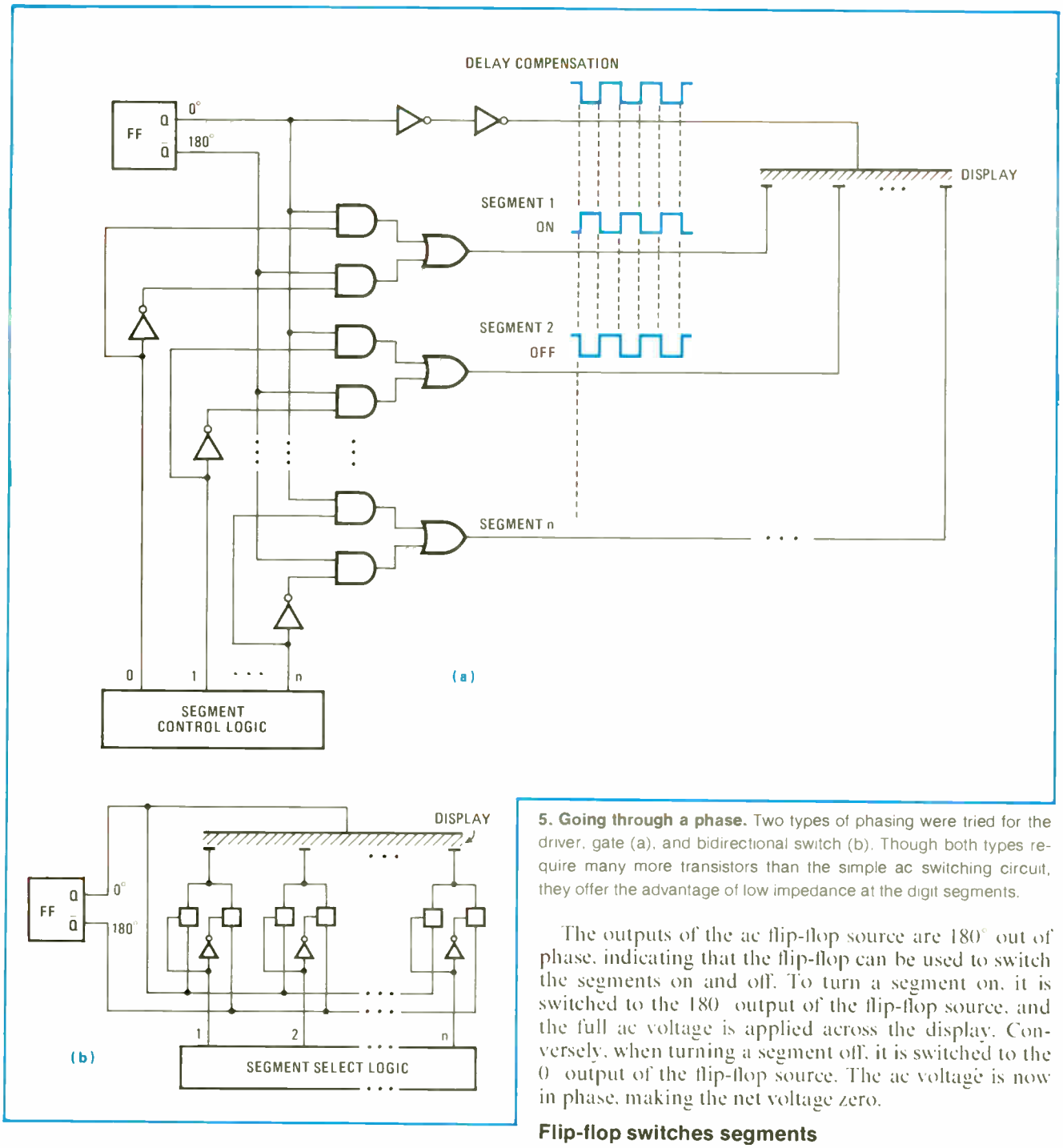


4. Ac switch method. This approach for driving the display is notable for its simplicity. The bidirectional switches consist of two FETs in parallel. When the switch is on, the current flows through the display in one direction for one half-cycle, then reverses.

crystal cutoff frequency has to be critically controlled, which gets rather costly for this application. Finally, the brightness decreases at low voltage. Even using liquid crystal materials with lower cutoff frequencies to decrease the drive power did not pan out because it was impossible to meet the design specifications of 15 μW and 15 V for the display.

After rejecting the multiplexing concept, a related approach—a simple ac switch circuit—was evaluated (Fig. 4). The bidirectional switches needed to activate digit segments consist of two field effect transistors—one a p-channel and the other n-channel—connected in parallel. The decoder outputs activate the switches. One output (Q) of the flip-flop is connected to the common side of the display. The other output $\bar{Q}$ is connected to the common side of all the switches. And the output sides of the switches drive the segments of the display.

When the switch is turned on, current flows through



5. Going through a phase. Two types of phasing were tried for the driver, gate (a), and bidirectional switch (b). Though both types require many more transistors than the simple ac switching circuit, they offer the advantage of low impedance at the digit segments.

the display in one direction and then reverses direction, thus providing an alternating current flow. Since these switches are designed to be symmetrical, there is no apparent dc offset on the display. The difficult part of designing this type of switching circuit is that the leakage current of the switch in the "off" state must be less than 10 nanoamperes because of the high impedance of the display segments. Two other methods were tried to drive the display using phasing (Fig. 5)—one with gating techniques and the other with bidirectional switching. The advantage of phasing is that the segments see a low impedance in both the "on" and "off" states, eliminating the requirement that the switches to the segments have a low leakage current.

The outputs of the ac flip-flop source are 180° out of phase, indicating that the flip-flop can be used to switch the segments on and off. To turn a segment on, it is switched to the 180° output of the flip-flop source, and the full ac voltage is applied across the display. Conversely, when turning a segment off, it is switched to the 0° output of the flip-flop source. The ac voltage is now in phase, making the net voltage zero.

Flip-flop switches segments

When using gates for phasing, all gate delays must be considered, so that no dc offset exists across the display. Using bidirectional switches for phasing has the advantage of creating no offset except for the small difference between the voltage waveforms of the Q and $\bar{Q}$ outputs of the source flip-flop. The primary drawback of either phasing circuit is that it requires many more transistors than the simple ac switching circuit described earlier.

Another possible display-driver approach is a circuit in which the decoder is connected directly to the display. Using bidirectional switches to perform the decoding function (Fig. 6), the outputs of this circuit switch the ac voltage from the source flip-flop in a manner similar to the simple ac switch circuit depicted in Fig. 4.

The direct-drive method offers the advantage of requiring few transistors, compared to the other methods, to perform both the decoding and driving function. However, the circuit still requires that the leakage current in the "off" state be under 10 nanoamperes.

Engineering prototypes of this circuit verify that the leakage-current requirement can be met. This means that the counter/decoder-driver chip could be reduced to fewer than 600 transistors. Since the 10-nA leakage requirement had to be checked under all environmental conditions, the bidirectional phasing circuit (Fig. 5b) was selected for the present watch model.

Display criteria

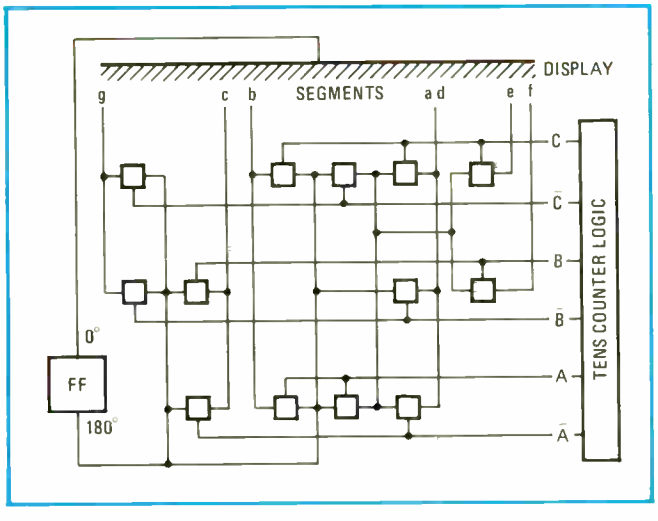
For a liquid crystal display to make the grade in a digital watch, it must operate at low power, have an attractive appearance, perform uniformly even in environmental extremes, and—most important—insure long life. This is a tall order for such a relatively new technology. To meet the low-power requirement, a material of extremely high purity was developed, which when doped operates over a wide temperature range with good speed of response and homeotropic alignment—that is, when all the liquid crystal molecules are lined up perpendicular to the display plates.

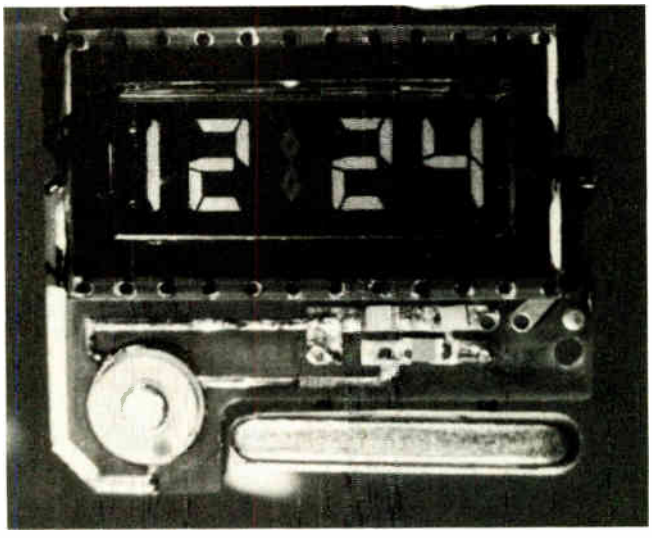
To insure long life, the material is hermetically sealed. To account for temperature expansion and contraction, the edges of the display were given a crescent or meniscus shape. This edge, a proprietary design, provides room for the material to adjust to temperature changes without breaking up.

The display requires a 15-v power source to achieve good contrast and brightness, but since compact 15-v batteries are not available in the quantities or cost required, the power converter was necessary. The power converter is an inductive charging circuit with an efficiency of about 70% to 80%. It uses a high-beta, low-saturation-voltage transistor, driven by 256-Hz, 15-μs pulses from the divider circuit.

A single 1.5-v battery can supply 30 μW of power continuously for a year, so the average power dissipation of the electronic circuits and display must be less than 30 μW. This requirement proved to be no hardship, as the power dissipation of the oscillator divider circuit is 7 μW, the counter/decoder-driver circuit is 2 μW, the liquid crystal display is 15 μW, and the up-converter is 3.4 μW for a total of 27.4 μW.

6. Direct approach. A circuit in which the decoder is used to drive the display directly requires fewer transistors than other methods to perform both the decoding and driving. It also requires a leakage current consistently under 10 nanoamperes in the "off" stage.





7. Time in. With the display mounted on the two-sided board, the liquid crystal, solid-state watch movement is complete. Total size is 1.44 in. × 1.13 in. × 0.29 in. Digits are 0.123 in. × 0.184 in.

Packaging the watch

Once the display, electronics, and power-source configurations were established, it was necessary to face the problem of how to get all the parts into an attractive case—a vital consideration to the watch company. Positioning the quartz crystal measuring 0.74 in. by 0.13 in. by 0.165 in.; the battery, 0.455 in. in diameter by 0.22 in. deep; and the display, 0.995 in. by 0.55 in. by 0.12 in. was important in determining the size of the watch.

Neither the crystal nor the battery can be mounted under the display because the watch case would be too thick to be appealing. Instead, a single, two-sided substrate was developed to permit these two components to be mounted alongside the display (Fig. 7). In addition, this mounting permits easy access when replacing these parts. The complete movement measures 1.44 in. by 1.13 in. by 0.29 in.

Second-generation digital wrist watches that incorporate the C/MOS electronics within the display itself are now under development. The first models will contain the divider and counter/decoder-driver chips with contacts on the back of the display package providing connections for voltage, oscillator, and time setting. The design goal for this complete watch movement is 1.0 in. by 0.6 in. by 0.14 in.

Later models will have provisions for mounting the entire electronics package on the display substrate. Low-voltage, field-effect, liquid crystal materials presently under development will also be used in displays. Since the only other external parts are the oscillator and the battery, manufacturing costs can be cut significantly so that digital display watches retailing for $100 are feasible. □

Unclocked logic element makes quick decisions

by Leslie K. Torok
University of Toronto, Toronto, Ont., Canada

A new kind of logic element can make logic decisions without requiring a clock for synchronization. Called Jade, this asynchronous decision element can operate at speeds as high as clocked logic blocks, offers easy debugging, and allows sequential logic systems to be mechanized directly from flow charts. Moreover, Jade will operate in clocked as well as unclocked systems.

A control signal, DO, functions much like the clock in synchronous logic, while input signal X represents the logic condition that must be decided and acted upon. The Jade element has two states—a quiescent state when signal DO is logic 0 and a decision state when DO is logic 1. There are four possible outputs: XTRUE (X is true), $\overline{\text{XTRUE}}$ (not XTRUE), XFALSE (X is false), and $\overline{\text{XFALSE}}$ (not XFALSE).

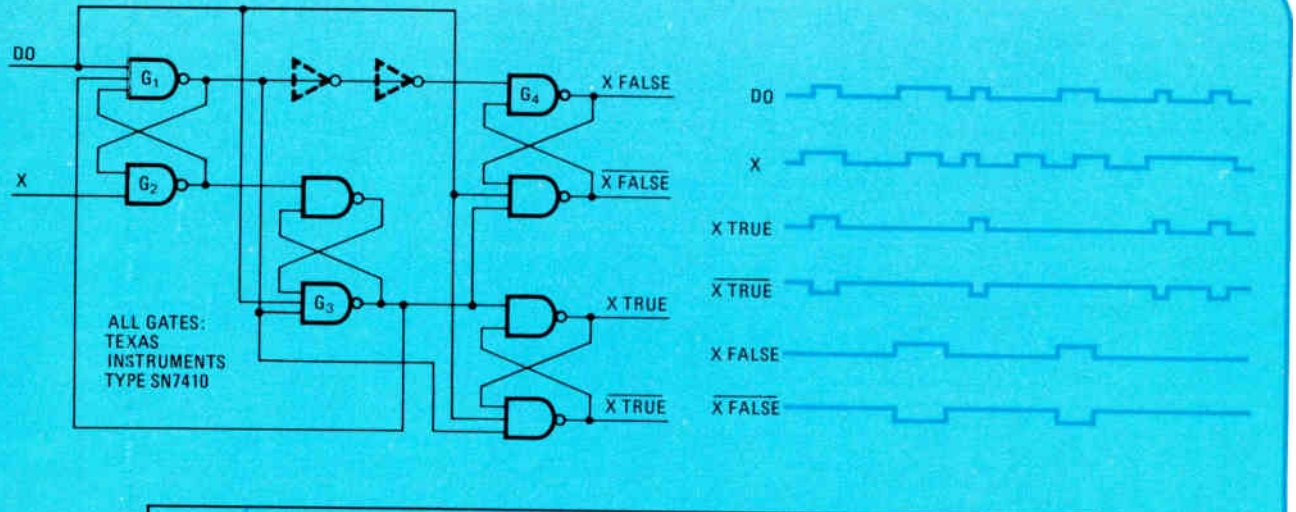
When the Jade is in its quiescent state (DO = 0), XTRUE = XFALSE = 0 and $\overline{\text{XTRUE}}$ = $\overline{\text{XFALSE}}$ = 1. For the decision state (DO = 1), Jade makes an exclusive and singular decision at the rising edge of signal DO — XTRUE = 1 and $\overline{\text{XTRUE}}$ = 0 if X = 1, or XFALSE = 1 and $\overline{\text{XFALSE}}$ = 0 if X = 0. The output decision then activates the appropriate task logic.

As long as DO = 1, further changes in X do not affect the output. Returning DO to logic 0 clears the decision, causing Jade to assume its quiescent state. It should be noted that XTRUE = XFALSE only in the quiescent state. For the decision state, XTRUE = $\overline{\text{XFALSE}}$ and $\overline{\text{XTRUE}}$ = XFALSE, since the outputs are exclusive. Those outputs that are not selected remain quiescent.

As X drops to logic 0 and DO rises, a spike may appear at the output of gate G_1 when the propagation delay of gate G_2 to a logic 1 is less than the propagation delay of gate G_3 to a logic 0. If the spike is wider than the minimum hold time of gate G_4, a double decision is made. To prevent this, two inverters can be placed between G_1 and G_4 to integrate the spike.

Jade can sort decisions at speeds of at least 10 megahertz, with signals X and DO having pulse widths of about 30 nanoseconds. □

Decisions, decisions. Asynchronous decision element named Jade uses control signal DO instead of clock to gate information signal X. When DO is logic 0, circuit is in quiescent state; when DO is logic 1, circuit is in decision state and provides single exclusive output out of four possibilities. Inverters can be added to avoid switching spike that causes erroneous double decision. Truth table shows logic characteristic.



INPUT X	DECISION STATE, DO = 1				QUIESCENT STATE, DO = 0			
	X FALSE	X FALSE	X TRUE	X TRUE	X FALSE	X FALSE	X TRUE	X TRUE
0	1	0	0	1	0	1	0	1
1	0	1	1	0	0	1	0	1

Height-to-width converter digitizes analog samples

by Roland J. Turner
RCA Corp., Missile and Surface Radar division, Moorestown, N.J.

By controlling the charge on a storage capacitor, a temperature-stabilized height-to-width converter can produce a gray code output from an analog input sample. The converter uses a differential diode-transistor arrangement to operate over a temperature range of −55°C to +65°C, and its conversion error is less than 0.15 microsecond for a full-scale output pulse width of 3.25 μs.

During the first half of the input sample, a clear pulse removes all charge from storage capacitor C_1. During the second half, a charge proportional to the sampled analog signal is placed on this same capacitor through transistors Q_1 and Q_2.

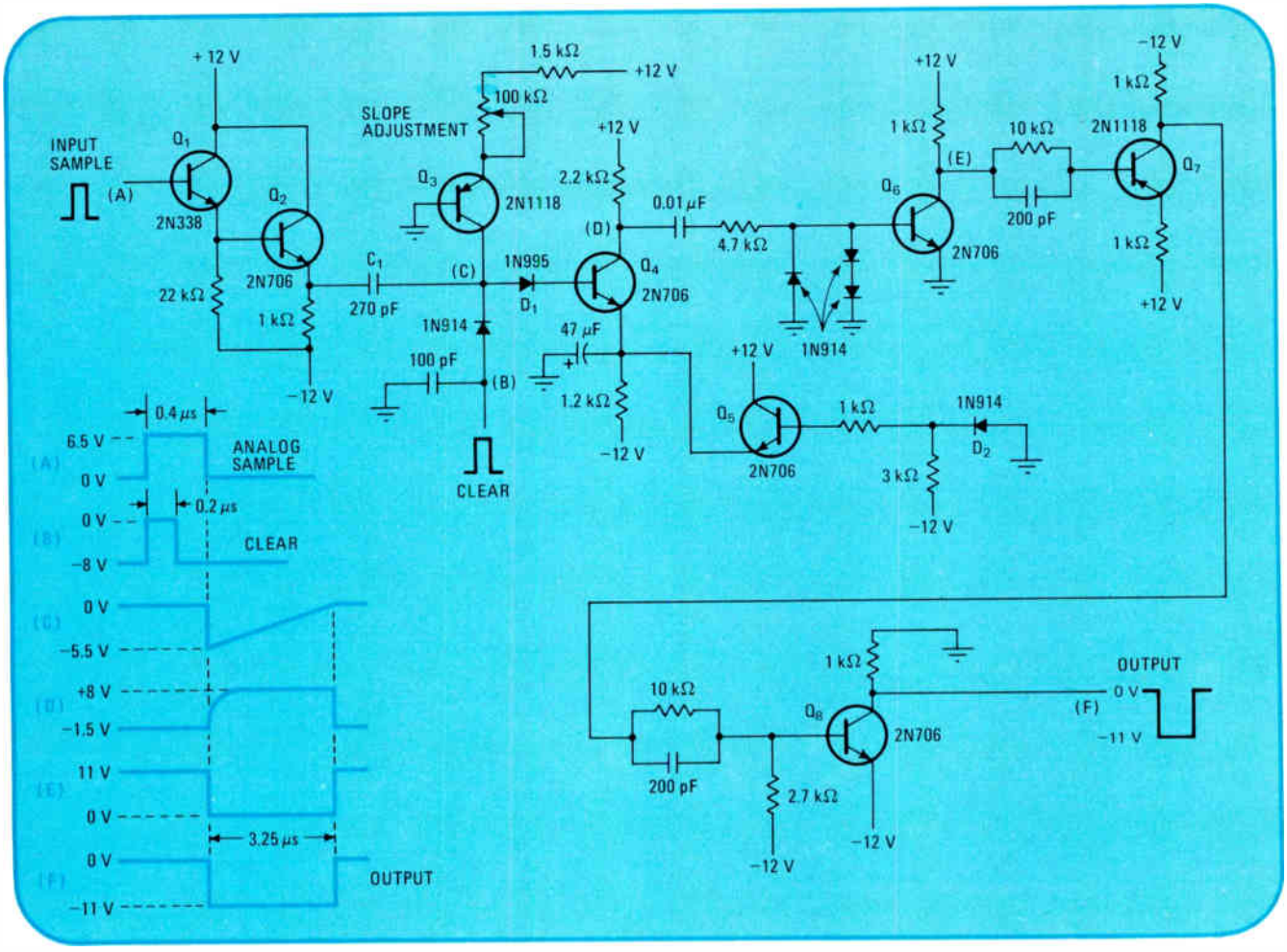
Current source Q_3 keeps diode D_1 forward-biased and transistor Q_4 fully on during the sample time. On the trailing edge of the analog sample, D_1 becomes reverse-biased by a voltage level equal to the amplitude of the analog sample before its termination. Transistor Q_4 is then cut off, and for a period of time that is proportional to the stored analog sample amplitude, a current source formed by Q_3 and the slope-control potentiomteter linearly discharges capacitor C_1.

During the time that Q_4 is off, the converter generates a pulse that has a width proportional to the amplitude of the analog sample. When the stored charge goes to zero, diode D_1 and transistor Q_4 are again turned on by the current source. After Q_4 conducts, a new sample may be processed. Transistors Q_6, Q_7, and Q_8 act as pulse shapers to yield the desired output.

Diodes D_1 and D_2 and transistors Q_4 and Q_5 are connected in a differential configuration to keep Q_4's conduction interval independent of temperature variations. The voltage drops of D_1 and D_2 and the base-emitter voltage drops of Q_4 and Q_5 track each other as temperature varies.

The converter in the diagram is designed to operate with a peak-to-peak video input level of 6.5 volts. Maximum output pulse width is determined by the slope adjustment, which is set to provide a pulse width of 3.25 μs for a an input video level of 6.5 v. The waveforms shown represent the maximum level of the gray code. □

Compensating for temperature. Differential hook-up of transistors Q_4 and Q_5 and diodes D_1 and D_2 maintains temperature stability of height-to-width converter. Amplitude of analog input sample is converted to gray code output. Second half of input sample charges capacitor C_1, then linear current ramp through transistor Q_3 discharges C_1. During discharge time, D_1 and Q_4 are off, and output pulse is produced.



Filament transformer output drops cost of 400-Hz supply

by Glen Coers
Texas Instruments, Components Group, Dallas, Texas

Power supplies with a 400-hertz output are often needed in testing servo systems and aircraft equipment, but they can be expensive to build when their output voltage must be on the order of 115 volts, root mean square. This being the equivalent of a peak-to-peak voltage of 325 V, the circuit transistors would have to have very high operating voltage ratings, and since there are no integrated amplifiers that can handle ±160 V, a discrete amplifier would be required.

Alternatively, the number of parts and component costs can both be considerably reduced by generating the 400-Hz sine wave at some low voltage level and then stepping it up with a transformer. This approach allows low-cost transistors and integrated circuit operational amplifiers to be used, yet it produces enough output power to operate small motors, servos, resolvers, and synchros. Larger output transistors and a larger transformer will, of course, increase output power.

The audio oscillator of (a) provides the sine-wave input for the amplifier of (b). The frequency-determining components for the oscillator are resistors R_1 and R_2 and capacitors C_1 and C_2. These are returned to the non-inverting input of an op amp that functions as the circuit's oscillating element.

Voltage gain for the amplifier is supplied by an op amp, while discrete transistors supply current gain. The input sine-wave frequency can vary from 60 to 400 Hz when a conventional filament transformer is used at the output. With the components shown, an output current of about 250 milliamperes is obtainable.

The amplitude of the input sine wave depends on the amount of feedback in the amplifier network. If the feedback factor is low, a small signal can drive the amplifier, but the output driving impedance becomes high, possibly causing current limiting in the output stage and therefore poor voltage regulation. If the feedback is high, a higher level of input voltage will be required, but the output driving impedance becomes lower and regulation is improved.

Here, op-amp closed-loop gain (A_{vc}) is 10, making the required drive voltage around 1 V rms. The value of feedback resistor R_f is determined by:

$$R_f = R_s(A_{vc}-1) = 9 \text{ kilohms}$$

where R_s is source resistance. Feedback factor β is set by R_f and R_s:

$$\beta = R_s/(R_s+R_f) = 0.1$$

while closed-loop output resistance R_{out} becomes:

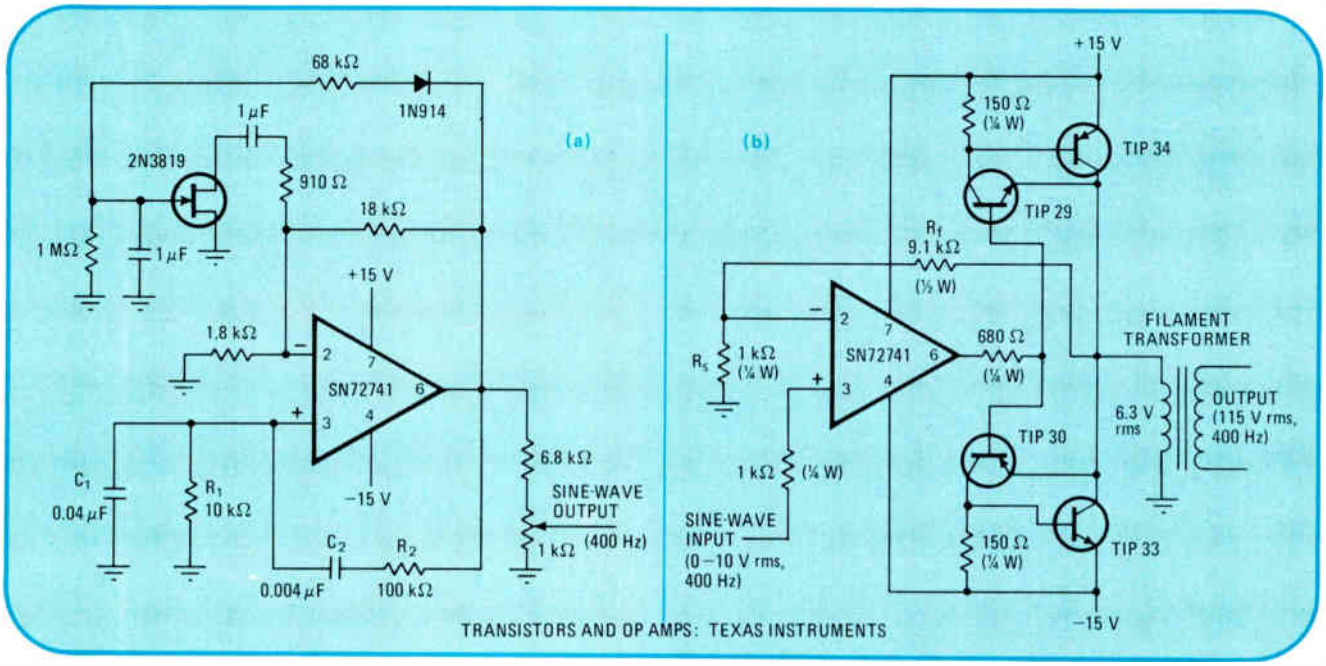
$$R_{out} = R_o/A_{vo}\beta = 0.01 \text{ ohms}$$

when open-loop output resistance R_o equals 50 ohms, and open-loop gain A_{vo} is 50,000. This last equation indicates that circuit regulation should be adequate because the effective driving impedance is much lower than the load impedance.

The output transistors are connected in a bootstrap arrangement, eliminating two base-emitter voltage drops and allowing more ac voltage to be developed. A Darlington configuration could be substituted, but there would be a 5% drop in the available output voltage. Adjusting the 400-Hz drive voltage varies output voltage between 0 and 144 V rms. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

Servo supply. Amplifying low-level high-frequency sine-wave input cuts parts and price of 400-hertz 115-volt rms power supply. Audio oscillator (a) provides 1-V rms sine wave for amplifier (b). Standard filament transformer delivers output currents of up to 250 milliamperes and voltages as high as 144 V rms. Bootstrap arrangement of amplifier's output transistors optimizes available output voltage.



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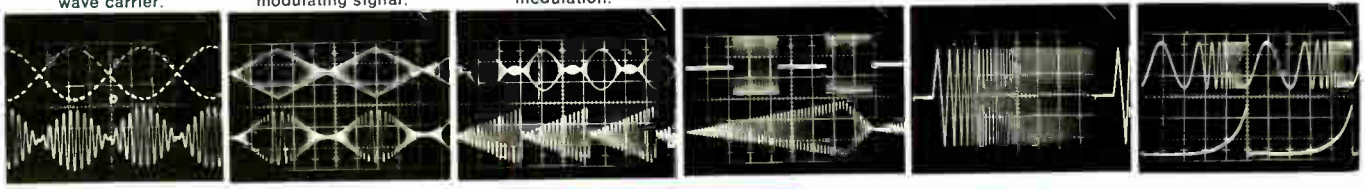
Top: 100% modulation toward suppressed carrier. Bottom: Ramp modulation.

Top: Square wave modulation. Bottom: Ramp modulation.

Gated sweep, one burst of swept waveform.

Top: Log sweep. Bottom: V:F output.



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Functional trimming gains economies for hybrid ICs

Process allows loose tolerances in circuit components, sometimes eliminating one fabrication step if circuit is, in effect, tested as it is being trimmed; however, initial equipment may be expensive

by Stephen E. Scrupski, *Packaging and Production Editor*

☐ It's possible to spend a lot of money for tight-tolerance components and still end up with a circuit that's not as good as one that uses thick-film resistors and 15-cent semiconductors. The reason? Functional trimming—a technique by which the thick-film resistors are adjusted after the circuit is completely assembled to take up the slack in the tolerances of the active devices and compensate for drifts induced by high-temperature operations during circuit assembly.

Functional trimming—sometimes called active or dynamic trimming—is becoming a way of life for many hybrid circuit producers, but on a broader front, circuit designers in many cases will have to shift from traditional tight-tolerance designs and careful accounting for errors to wide-tolerance-now, adjust-later approaches.

To set up for functional trimming, however, requires not only a new look at circuit design, but also an understanding of the economics of the production process. There are many tradeoffs in deciding whether to go directly into functional trimming from the firing furnace, or to do some pretrimming and pretesting of the substrates before the active devices are committed.

Functional trimming involves trimming resistors—either thick or thin film—not to achieve specified resistance values, but rather to achieve a specified circuit output parameter, which is primarily controlled by the value of the particular resistor that is being trimmed.

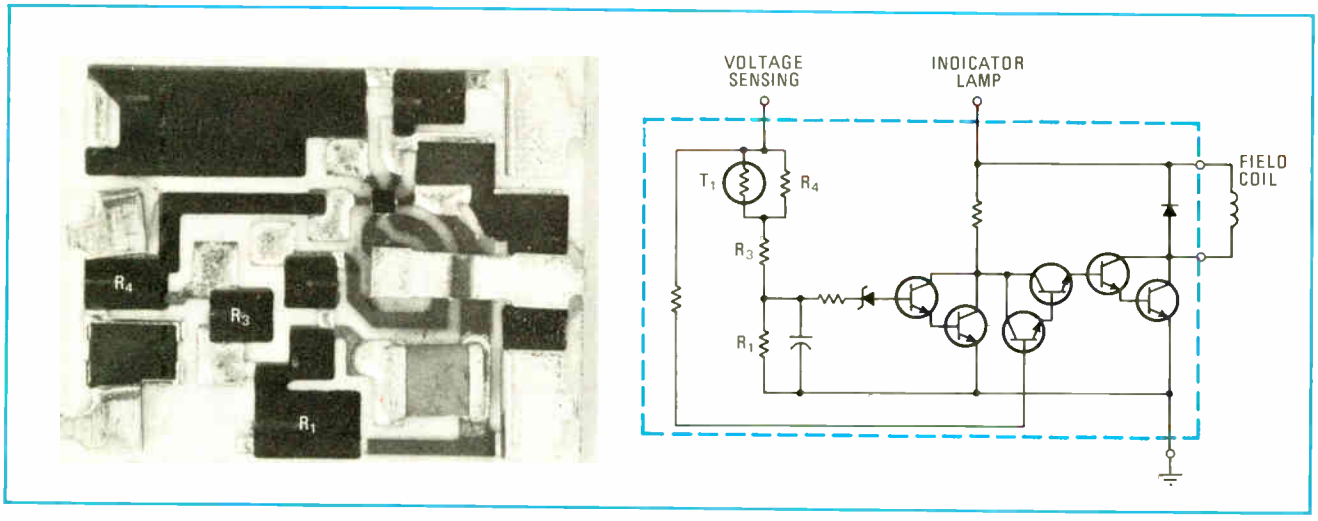
In a voltage regulator, for example, the value of a particular resistor is responsible for setting the output voltage. Thus the circuit is designed, not with a specified resistance value, but as if a potentiometer were to be used, and then it is adjusted in the final stages of production to provide the desired output. The value of resistance that results from the trimming operation thus is of no interest to the designer—he's only interested in the function that it controls.

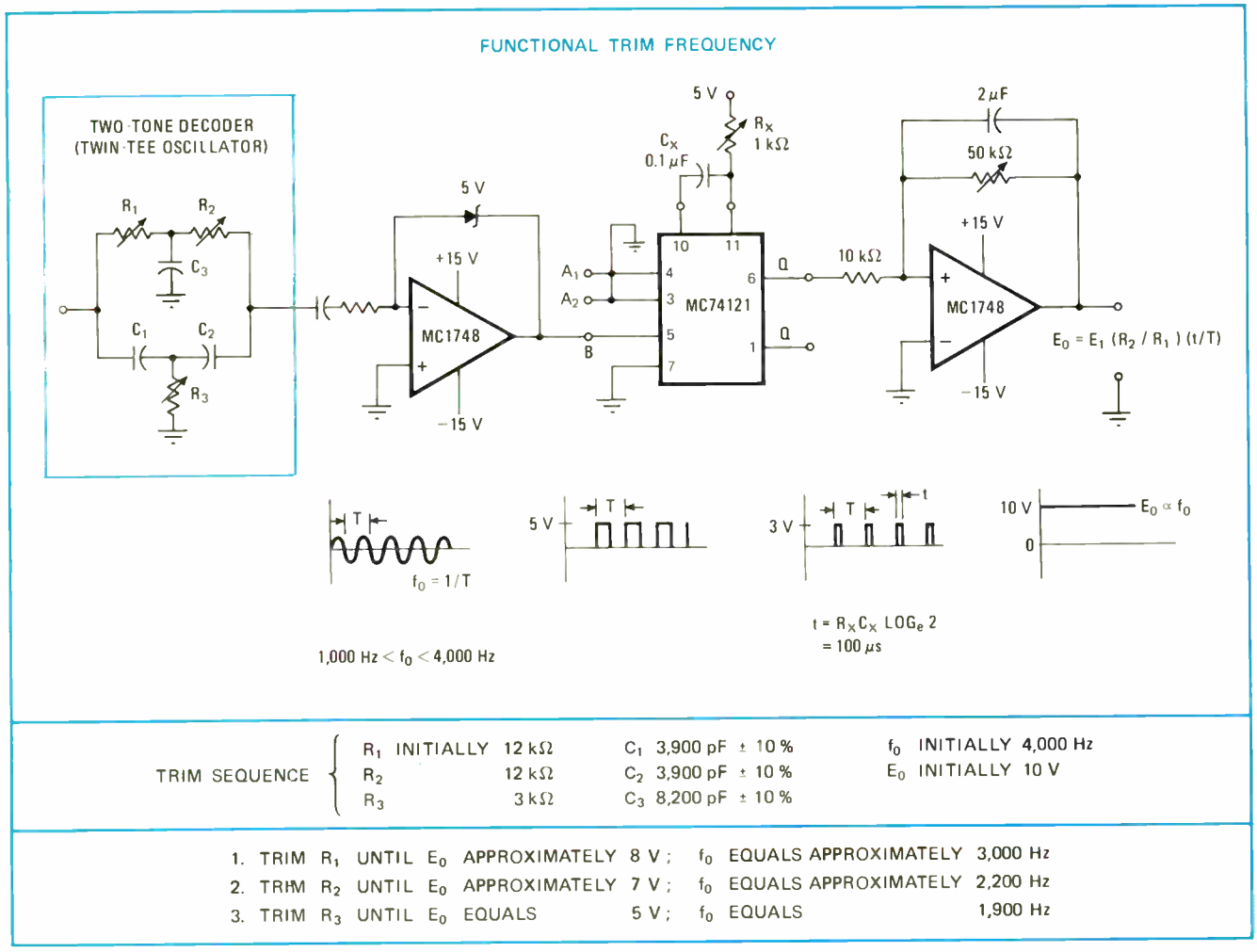
Other candidates

Other examples of resistors that are candidates for functional trimming are those that control RC time constants, an operational amplifier's offset voltage, a voltage regulator's overload cutoff point (so-called foldback point), trigger levels of comparators, and analog-output voltage in digital-to-analog converters.

The advantages of functionally trimmed resistors over resistors trimmed to value (passive trimming) are manifold: since the resistor will be adjusted to compensate for parameter tolerances in an active device or another passive device, it's possible to relax the specifications on other devices and thus reduce their costs. And often, it's the only way to achieve optimum performance without individual selection of active devices for

1. Auto supply. Voltage regulator made by Delco is functionally trimmed with a laser to temperature-compensate thermistor and to set output voltage. Thick-film regulators, automobile radios, and electronic ignitions are in mass production at Delco.





2. Set the tone. Three resistors in twin-tee network are functionally trimmed at Motorola's Mesa, Ariz., facility with a laser to set frequency of network. To eliminate process step, operation takes place immediately after addition of active components, without pretesting of substrate.

circuits built with many interactive components.

Functional trimming can also, in some cases, eliminate a step in the production process. For example, since an output parameter is monitored during functional trimming, the circuit is, in effect, being tested as it's being trimmed. Thus, essentially two operations are being performed at the same test station, saving operator time and reducing danger of damaged parts because of handling. Despite these blessings, for small hybrid shops and situations where many different prototypes are produced, functional trimming can be a problem, since each type of circuit may require its own test jig and many different measurements.

"We're taking a look at it," says Chuck DeVita, product marketing manager for integrated microsystems at Fairchild Semiconductor, Mountain View, Calif. "But up to now, we've only done it in prototype quantities." DeVita cites the special tooling and reduction in throughput, compared with automatic laser trimming, as reasons for his skepticism. "We are oriented to high-volume production of many different circuits, and we like to do automated laser trimming." Another skeptic is Robert Knittle, an engineer in the hybrid facility at Hughes Aircraft Co., Fullerton, Calif., who says that, although functional trimming is the only way he can reduce operational amplifier offset and set the bits in d-a converters, he would rather avoid it if he can, since it does require a special setup for every circuit, and most of the other circuits he deals with don't require functional trimming. However, "I suspect we will go that way," he adds, as more designers begin to take advantage of the concept.

Delco uses lasers

In "going that way," he will be following a route taken by many high-volume producers of hybrid circuits. One of the prime examples of functional trimming in a production atmosphere is in automobile voltage regulators and car radio circuits built at Delco Electronics division of General Motors Corp., Kokomo, Ind. More than two million voltage regulators built there have been trimmed with a laser. Within 2 seconds, zener voltage and thermistor resistance in the circuit are measured, the computer calculates resistance values necessary to temperature-compensate the circuit and set output voltage, and the laser then performs the trimming. Delco is actually putting out functionally trimmed circuits at the rate of about 30,000 a day, including the voltage regulators, the audio circuits of the radios, and now, electronic ignition systems for Pontiac automobiles.

More than half the circuits produced at Beckman In-

struments Helipot division, Fullerton, Calif., are functionally trimmed, says George Smith, director of research and development. Although most are trimmed for dc voltage (mainly a-d and d-a converters and dc voltage regulators), about 10% are trimmed for gain and frequency characteristics. And at Lambda Electronics Corp., Melville, N.Y., all hybrid voltage regulators are trimmed for dc output voltage and foldback current. Sprague Electric Co., North Adams, Mass. is using functional trimming to set dc bias for the transistor stage that controls symmetrical clipping in its new low-cost Ceracircuit audio power amplifiers.

"There are people who ought to be functionally trimming, but aren't—because they just haven't sat down and thought about the advantages," says Robert Gold, manager of microelectronics operations at Lambda. In Lambda's case, functional trimming is the key step in achieving the voltage regulator's specified performance, Gold points out. Although several resistors in the regulator are passively trimmed, the two resistors that control output voltage and foldback point are functionally trimmed. Thus, output voltage and foldback current are

Capacitors functionally trimmed

Most functional trimming is aimed at film resistors, but the technique can also be applied usefully to thick-film capacitors for precise adjustment of certain frequency characteristics. This is what is being done at Western Electric's North Andover, Mass., installation in the production of repeater circuits for the T-1 carrier system. In setting the frequency of an inductor-capacitor resonant circuit, the two components are connected in a circuit driven by a pulse train and the ringing frequency measured; a computer then is used to control the trimmer as the desired frequency is approached.

The trimming system is based on a commercially available abrasive trimmer that was adapted for Western Electric's use by planning engineer Z.T. Sylvester and senior test engineer T. Sveinbjornsson. In about 90 seconds, the system trims two capacitors in twin repeater circuits, matching each with its inductor to achieve a ringing frequency within 0.1% (1.5 kilohertz) of 1.544 megahertz.

Each capacitor is a multilayered ceramic that is center-tapped to provide two values: 70 picofarads, which is not critical, and 140 pF, which must be adjusted by removing some of its metalization. The T-shaped capacitor, (see drawing below) is abraded along its stem.

The computer is programed to cut off the trim at 1.5433 MHz. After shut-off, the frequency achieved usually ranges between 1.54335 and 1.54337 MHz. The cut-off frequency is deliberately undervalued slightly to allow for later processing changes, which combine to raise the frequency toward the precise design value, 1.544 MHz.

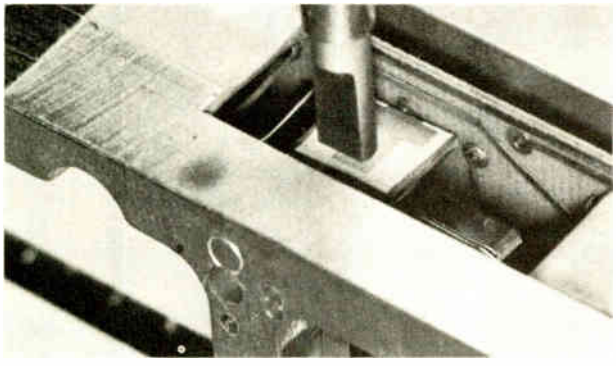
After insertion in the trimming fixture, the ringing circuit is driven by a continuous series of pulses to keep it running. Just before the computer issues a command to measure frequency, the pulse train is shut off and kept off for about 100 microseconds. The circuit then runs freely for about 70 μs while frequency is measured and fed to the computer, which controls further trimming.

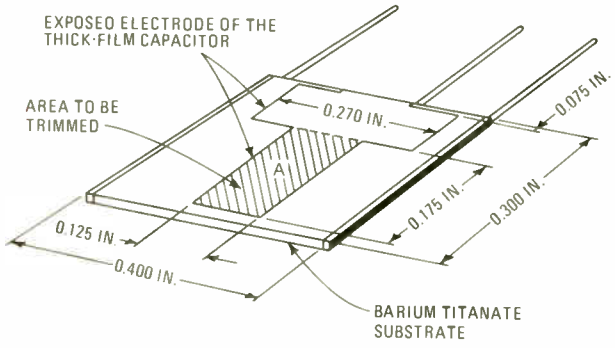
Trimming is performed in an enclosure that is continuously evacuated by a dust collector. Inlet and exhaust ports of the dust hood are placed so that swirling air picks up loose abrasive particles to assure that none comes to rest on the working circuit. Since no mechanical action can stop instantaneously, there is a small overshoot in the trimmer. However, the overshoot, constant and predictable, is readily taken into account. Another contributor to overshoot is the capacitance between the abrasion nozzle and the capacitor plate itself. This factor is less predictable than the mechanical inertia, but it, too, can be taken into account.

Lasers were tried first in this application, but were found to be unsuitable, mainly because the laser heated the barium titanate substrate, oxidizing it to barium oxide, a material that has undesirable dielectric properties. Another problem with the laser was that, because of variations in film thickness and placement of screened inks, as well as small changes in ink formulation, the laser either penetrated the substrate or did not remove enough metalization.

Between 90 and 100 capacitors can be trimmed with one pound of No. 9 Airbrasive powder supplied by the trimmer manufacturer, S.S. White Industrial Products, Pennwalt Corp., Piscataway, N.J. The powder, consisting essentially of fine glass beads, is fed into the 90-pounds-per-square-inch airstream of the trimmer at the rate of 5 grams per minute with air flow held to 0.3 to 0.5 cubic feet per minute.

The tungsten carbide nozzle, measuring 150 by 7 mils, is placed within 25 mils of the capacitor during trimming. At the end of the trim, the nozzle is pneumatically raised so that the fixture, which holds two sets of circuits, can be rotated to begin trimming on the second capacitor. In the fixture, the capacitor is held nearly perpendicular to the abrasive stream, but a slight tilt can be accommodated (which was not the case for the laser). Similarly, skewing of the printed film within reasonable limits is no problem, because the trimmer nozzle is about 25 mils wider than the metalization pattern on the capacitor.





held to "well within 1% without any difficulty," he says. For Gold, there's real significance in the fact that he no longer refers to the trimmer as such—now it's the "trim/test" system.

Since circuit test is an inherent part of functional trimming (and, in fact, test equipment often is more expensive than the trimmer), the same equipment can be used for two purposes. Since the system tests the two basic parameters of a voltage regulator, it's useful as a final test unit with the laser turned off, Gold points out, although scheduling must be worked out.

One traditional concern of trimmer manufacturers has been that as tolerances of as-fired resistors get better, the need for resistance trimming will decrease. However, functional trimming will continue to be used because it can be done at the same that circuits are being tested, says Garry Stone, president of Micronetics, an associate of General Radio in Burlington, Mass., a maker of laser trimmers.

One unusual application for functional trimming is being developed at Nova Devices Inc., Wilmington, Mass., where monolithic op amp chips with thin-film resistors deposited directly on the silicon will be functionally trimmed by a YAG laser.

Design differs

A circuit destined for functional trimming is designed differently from one aimed at passive trimming. One production man points out that there's been an about-face by hybrid processors in their advice to circuit designers. When hybrids first appeared, circuit designers were told, "Now you can design with 1% resistors because it's just as easy to trim to that as to a wider tolerance." Now the objective is to "design with wide-tolerance resistors so that we can functionally trim them after the circuit is assembled."

For functional trimming, the trick is to set up one or two resistors, the values of which determine the desired circuit output parameter, and then to establish the widest possible tolerances on these resistors so that the circuit operates, however marginally, when power is first applied before any trimming is done. A worst-case analysis, for example, might be performed on the circuit using as-fired tolerances, which may be as high as 40%, to assure that the circuit will operate.

Another important point is to try to reduce the sensitivity of the output to changes in the resistance being trimmed, says James Kent, production manufacturing manager at Bell & Howell Co. Control Products division, Bridgeport, Conn. For example, if a 10-kilohm resistor is being trimmed simply to attain a specified dc output voltage, it would be wise to use two resistors—7 kilohms and 3 kilohms, say, in series—and then trim the 3-kilohm resistor so that, as resistance changes with trimming, changes in the output occur slowly.

Also, when designing resistances for correcting offsets in an op amp, Kent suggests that care be taken to set the nominal resistance values so that compensation for either positive or negative offsets can be accomplished by trimming.

One of the key advantages of functional trimming is that it is delayed until after all high-temperature operations—die bonding, soldering, etc.—are completed. Thus, any changes in component values due to the high temperature will have already occurred and can be compensated by the final, functional trim. However, functional trimming will require some retooling of test and trimming jigs and changes in handling procedure, since the circuits are in their final packages.

Although trimming machines can be equipped with high-speed handlers, such as carousels and magazine feeds, these handlers can't be conveniently used for functional trimming, and handling packages with leads can be a little more awkward than handling flat substrates. The added time here must be balanced against what's gained in combining trimming and final testing into one operation.

One minor advantage of trimming in the package, suggests Dick Diddams, microcircuit products engineer at Motorola Semiconductor, Mesa, Ariz., is that the test equipment contacts the circuits on the package leads at the same points as those with which the actual system will eventually make contact, and thus provides accurate measurement and trim. As a side comment, Diddams adds that he has even trimmed circuits with the lid on—a sapphire lid that's transparent to the laser wavelength—and thus has further avoided any damage to fragile wire-bonds due to handling.

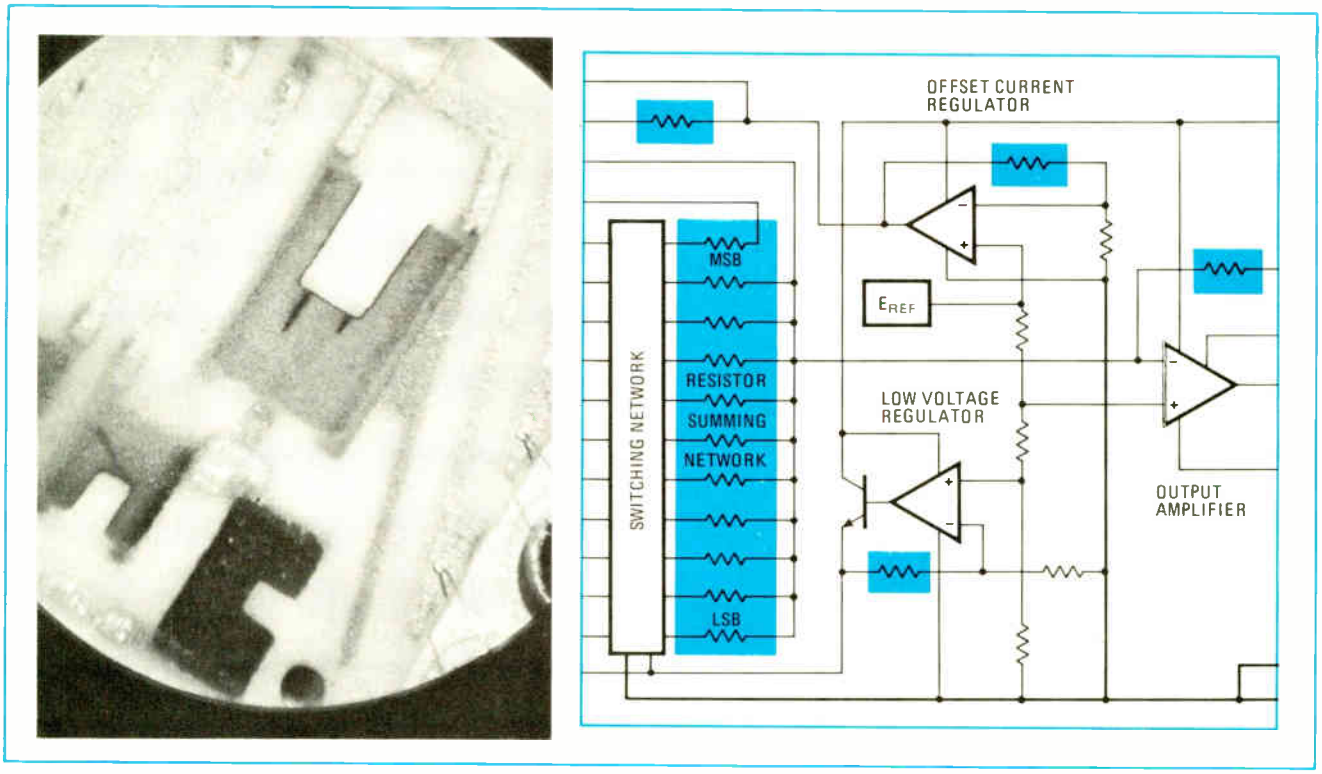
As an example of functional trimming, consider the production of a twin-tee oscillator at Motorola Semiconductor Products, Mesa, Ariz. There, a group under Nicholas Spann has converted production of many circuits from passive trimming. Spann is the manager of laser systems in the Electronic Subsystems group.

The oscillator frequency is specified to within 5% of 2,000 hertz, Spann reports. In the past, capacitors were purchased with 5% tolerances, and resistors were trimmed to about 1%. However, the capacitors tend to change value and follow an aging curve when subjected to temperatures beyond their Curie point (125°C). Spann says that if the oscillator is exactly at 2,000 Hz when the circuit is produced, it could be at 2,100 Hz after 1,000 hours, since 125°C can easily be reached during production steps after resistors have been trimmed to their design values. If the circuit is fully assembled, with capacitors and active chips in place before the resistors are trimmed, chances of subsequent exposure to temperature are less.

Spann's decision thus was "Let's eliminate passive trimming completely—right from the thick-film area. We'll bond the active devices, put the capacitors on, wire-bond them, and then we'll go into functional trimming." Before any trimming is performed, the oscillator can be as much as 100% off: for example, 4,000 Hz instead of the desired 2,000 Hz, because initially, the resistors are no closer than 40% of their design value. Functional trimming can handle this wide a variation, according to Spann.

Higher tolerance saves money

Because of functional trimming, he says, he can buy 10% variation capacitors rather than devices with 5% variation, saving about 20% of the price, which is significant, but not the only reason for functional trimming. Spann points out that with passive resistor trim-



3. Double trim. Resistors used in Beckman Instruments digital-to-analog converter are put through two trimming operations. First is abrasive trim (visible as wide cut in resistors) to set resistors near final value; second is laser trim performed functionally (narrow lines extending off wide cut). Resistors that are trimmed functionally are shown in shaded areas in circuit diagram.

ming, he had to perform a pretest operation before encapsulation. This pretest was necessary as a final step to ascertain if any rework was needed—any device failures, wire-bond failures, or the like. In fact, he adds, pretest may itself have introduced failures, since any time a part is picked up during production, there's a danger of damage from handling.

With functional trimming, the pretest is effectively eliminated—it's merged into the trimming step. Since the circuit is complete when it reaches functional trimming, it can be pretested before trimming, and if any damage is found, it can be shipped to the rework area.

If the circuit is operating, the resistors are trimmed. In the oscillator, the resistors in the tee configuration typically are about 12, 12, and 3 kilohms, respectively. Approximate final values are 24, 24, and 7 kilohms. The first resistor is trimmed to get the frequency from 4,000 Hz down to 3,000 Hz, the second trim brings it down to about 2,200 Hz, and the third one decreases frequency further to about 1,900 Hz.

The frequency is brought a little lower than the desired 2,000 Hz to allow for the aging of the capacitors, which is an inherent property of the material. However, aging will be less pronounced because temperatures are lower in the steps following functional trimming. All that remains after trimming is to encapsulate and ship the devices.

Although the functional parameter controlling the trim is an ac parameter—frequency—Spann only uses a dc test set. He points out that frequency or almost any other ac parameter can easily be converted to dc. A simple frequency-to-dc converter, for example, can be built with an operational amplifier, a transistor driver, and a few resistors along with a few capacitors.

Layout of a substrate for functional trimming depends on the type of trimming used—abrasive or laser. For abrasive functional trimming, the active devices already in place on the circuit must be protected in some way from the abrasive material. For additional device protection, Kent's advice is to avoid locating the resistors to be trimmed too close to the active devices.

Protective coatings critical

Although coatings like silicones have been used to protect active devices, Kent finds that such protective materials can introduce their own problems. Military customers won't accept components covered with epoxy or some other plastic inside the package. And trying to remove the coating after trimming can be messy—for example, trying to dissolve silicone can leave a residue on the lid-sealing surface that threatens the hermeticity of the package. The solvent often isn't "very kind to the semiconductor devices, either," he says. In commercial applications, where the coating may be left in place, expansion of the plastic can cause open wire-bonds.

Another problem with an abrasive trimmer is that more substrate real estate may be required for the circuit, since a clear area is required around the resistor. This space allows the air abrasive jet to start up before it moves to the edge of the resistor and begins cutting. At least one nozzle-diameter space is necessary, Kent has found, while overspray could add another diameter or two to the necessary clearance.

Many hybrid circuit producers, however, are satisfied with abrasives for functional trimming. At Analog Devices Inc., Norwood, Mass., resistors are first given a

passive trim on a high-throughput laser system and then functionally trimmed with an abrasive system. The laser trim is performed by an outside vendor who supplies pretrimmed substrates, and Analog adds components (semiconductors, however, are in packages and not in bare chip form) and gives a final functional trim. According to Barry Hilton, Analog director of engineering, as operators gain experience, they develop a "feel" for the process and can adjust the resistors to the right value quickly.

For functional trimming with a laser, the only restrictions on layout are the obvious ones—resistors should not be covered by a capacitor if they are to be functionally trimmed later, and should not be near or lie below a bonding wire, for example. Beyond these simple precautions, the required control of 2- or 3-mil diameter laser beams imposes no undue restrictions on layout.

However, lasers offer a different set of problems. "We tried functional trimming with a laser, and we abandoned it," says Allen Halpern, vice president of Circuit Technology Inc., Farmingdale, N.Y. Although resistors were initially trimmed to a high degree of accuracy, they proved to be unstable, he explains.

"There's no sense in setting a resistor to 0.1% accuracy if it's going to drift some 2 or 3% afterward." Halpern says that his company, a custom hybrid maker, does not do a lot of functional trimming, primarily because of the added special tooling and setup time. However, he does acknowledge that in certain applications, such as op amp offset, "it's beautiful."

Trimming on motherboards

Much of Circuit Technology's functional trimming is on motherboards—substrates to which are attached other hybrid flatpacks, where semiconductors are protected from the abrasive blast. "In places where you can use abrasive trimming, you get a resistor that is as good as anyone is capable of making," says Halpern.

Halpern's experience with a laser trimmer agrees with that of another hybrid shop manager, William Jolitz, Philco Ford Corp., aerospace and defense systems operations, Palo Alto, Calif. Jolitz says that he had installed a carbon dioxide laser for a short time, but had the manufacturer take it back after he discovered the high level of drift that occurred in the resistors. For now, he's sticking with abrasives, he says.

However, many believe they can cope with drift. Delco, of course, is using lasers on its production line. And the RCA Consumer Products division, Bloomington, Ind., also is using laser trimmers—although not for functional trimming—on its line producing thick-film modules for the XL-100 all-solid-state color TV sets. Lambda recently installed a laser trim system on its regular production line, and Nova Devices uses a laser for both thick- and thin-film circuits. Nova vice president Mitch Maidique reports no difficulty with drift so long as proper control is maintained over laser power density and repetition rate.

Many reasons have been put forth to account for drift in laser-trimmed thick-film resistors. Hilton, for example, says that drift results from not using enough power in the laser beam, which results in abrading the top surface of the resistor, rather than making a clean cut all the way through to the ceramic substrate.

Motorola's Spann maintains that the power distribution of the laser beam is the important consideration. If the laser changes modes—and thus its beam power distribution—the edges of the cut can become erratic and powder-like, leading to instability. And with the wrong repetition rate, he says, a mechanical resonance can be set up in the substrate, thereby inducing further microcracking of the resistor and substrate that further add to instability. Weekly checks of the laser setup can avoid such problems, says Spann.

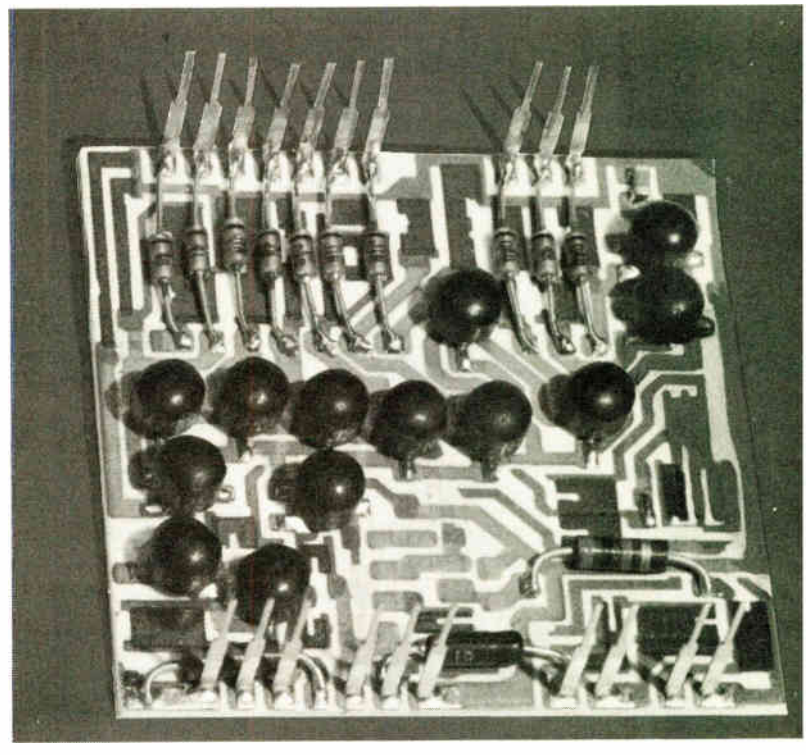
Two factors cited

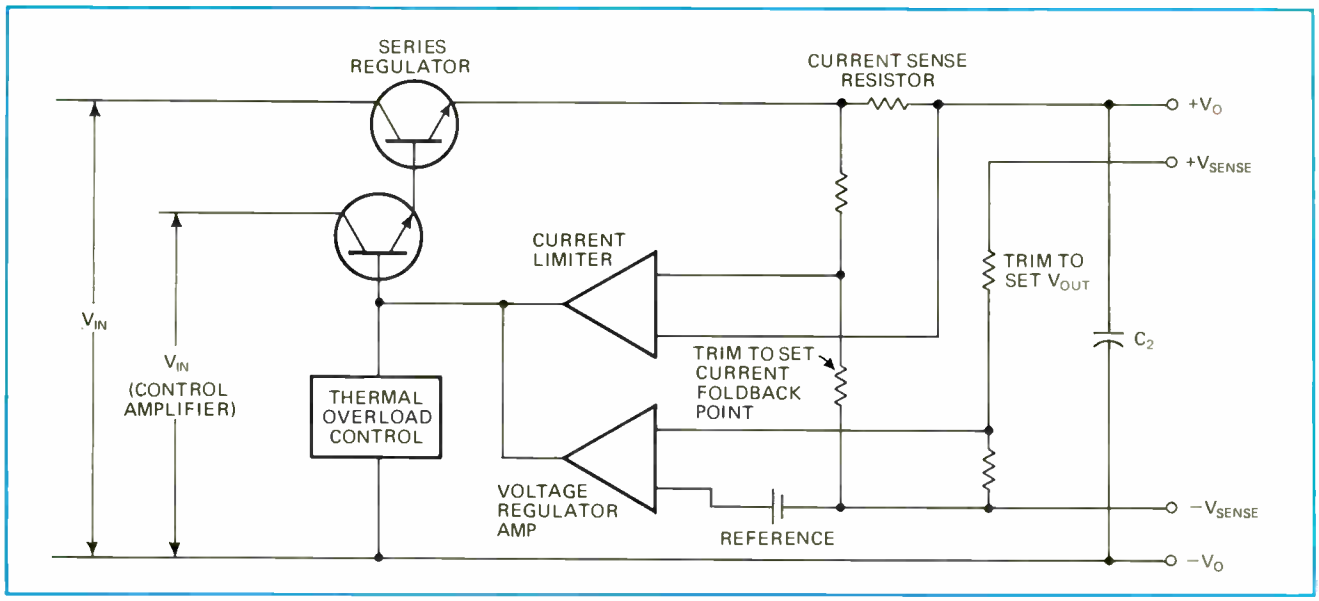
Still another view comes from George Lane, president of Electro Materials Corp. of America, Mamaroneck, N.Y., maker of thick-film pastes. Lane says that there are two factors at work to produce the problem—on one hand, the resistive inks that are being used, and on the other, the fact that hybrid producers, with better lasers and better electronic controls at their disposal, are trying to trim to tighter tolerances with the laser than they did with abrasive trimmers and are simply paying more attention to the drift.

Lane contends that the inks that best withstand laser trimming are those that use metal and glass systems designed to be fired at high temperatures—985°C, for example—rather than the 800°C common with many inks.

Beckman's Smith says that he uses a combination of abrasive and YAG laser trimming. All resistors on the substrate are first trimmed abrasively to bring them within 0.5% of final value and then those due for functional trimming are given a "vernier" cut by a laser to adjust them within 50 or 100 parts per million. A YAG

4. Setting bits. Resistors in Teledyne Philbrick d-a converters are trimmed functionally with abrasive trimmer. Note use of packaged active devices, which are protected from effects of abrasives.





5. Set and forget. Resistors are trimmed functionally in Lambda voltage regulator to set output voltage and overload point to within 1%. Previously done with an abrasive trimmer, the company now is switching over to laser functional trimming.

laser is used rather than a CO_2 because of the tendency of the ceramic substrate to absorb the 10.6-micrometer wavelength of the CO_2 and thus heat up and introduce instabilities. The 1.06-μm YAG wavelength isn't absorbed, however.

Whether or not to perform such pretrims and pretests before functional trimming is a key question that must be considered in setting up a functional trimming facility. Much of the answer depends on the application, the cost of the added components, and the ability to control the as-fired values of resistors.

Pretrimming and pretesting should only be necessary, in general, for circuits where the design is pushing the state of the art in line widths and line spacing, says Neal Thomas, manager of microcircuit engineering at Centralab division of Globe-Union Inc., Milwaukee, Wis. For consumer applications, where a few decibels of gain don't matter either way and where active devices are inexpensive, it may be worthwhile to eliminate pretrimming and commit active devices to untested substrates. However, if expensive active devices are being used, some pretesting of the substrates is probably necessary. Without it, resistors that won't come up to value may be discovered too late.

Many circuits, like the Lambda voltage regulator, are designed with resistors that are to be passively trimmed, as well as with one or two resistors requiring functional trimming. In such cases, the substrate must be run through the passive trim station anyway, so it's not much more difficult to test the resistors to be functionally trimmed. Lambda's Gold leans to pretesting before active devices are added to the substrate—in effect, he does this in the passive-trim stage—"You must have a lot of confidence in your screening and firing procedures to delay any testing until after active devices are committed," he points out.

Pretrimming advocated

At Teledyne Philbrick, Dedham, Mass., David Ludwig, director of engineering, points out that a semiautomatic resistor trimming setup brings costs-per-resistor low enough to justify trimming all resistors before active devices are added, "so it doesn't make a lot of sense to bypass the pretrim state." Typically, "we don't have too much trouble in achieving 5% as-fired values," he adds, "but even with this close tolerance, it's still worthwhile to pretrim because the substrates should be checked anyway—before adding active components.

Another argument for pretrimming is that, although functional trimming may be successful in increasing a resistor's value to an acceptable point, the resistor may have started at a value that was too far out of tolerance. Thus, too much of the resistive material may have to be removed (military standards call for removal of no more than 50% of the resistor width), and the resulting temperature coefficient may be out of specification, according to Analog's Hilton.

Of course, in the case of thin-film resistors, there's no need for pretrimming, since the deposition process produces accurate resistances to begin with. Thin-film resistors are being used for stable networks in digital-to-analog converters and are being functionally trimmed to provide correct output voltages and to correct output amplifier offset voltages. At Micro Networks Corp., Worcester, Mass., for example, a 12-bit d-a converter, built in a dual in-line package, uses thin-film Nichrome resistors deposited on silicon substrates. The resistors are laser-trimmed functionally as the final step in the production process.

One offshoot of functional trimming is the approach used by Hybrid Systems Corp., Burlington, Mass., on its converter circuits. The company uses discrete thin-film resistors purchased and tested to 0.1% tolerance, to set the critical output parameters. Each circuit is tested with a variable resistance box inserted and adjusted until the desired output parameter is reached. The required resistance value then is noted, selected from the appropriate bin, and wired into the circuit. "We believe we can get more accuracy for less cost this way," says sales manager Carl Kramer. □

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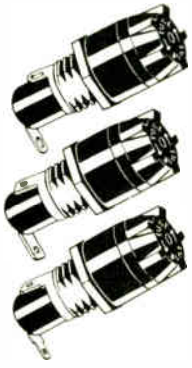

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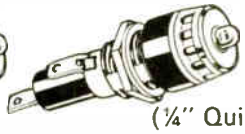

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Indium phosphide: is it practical for solid state microwave sources?

Theory says yes, and efficiencies of prototype units look favorable, but major improvements must be achieved in power output to match GaAs performance; an overview shows where we stand now

by David Colliver and Brian Prew, *Royal Radar Establishment, Malvern, Worcestershire, England*

☐ Though transferred-electron oscillators and amplifiers are gaining in popularity, they suffer from rather poor dc-to-rf conversion efficiencies. At present, they are fabricated from GaAs, though other materials could in theory provide better efficiencies.

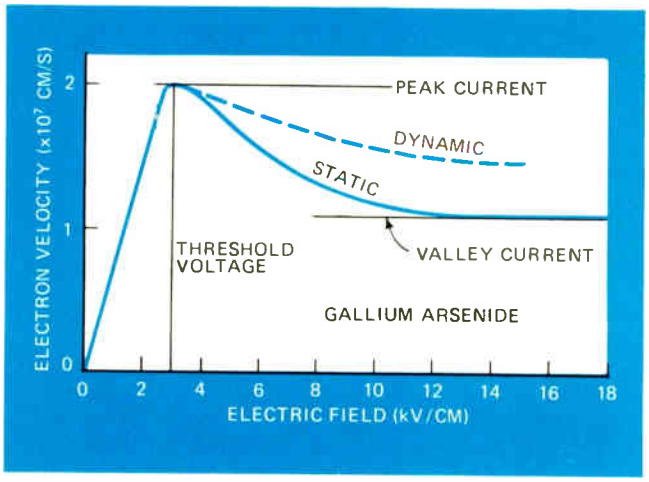
One of the possible rivals is indium phosphide, and, in a series of preliminary tests, it has already shown efficiencies as high as 20%, which compares very favorably with GaAs performance.

Practical InP diode circuits, of course, await both further development and further improvement. But they would be particularly desirable as components in such applications as phased-array antennas, where their higher efficiency would substantially reduce both prime power and heat dissipation problems. And they would also be useful in beacon transponders and radar transmitters, where pulsed power at a low duty cycle is used, and in receiver local oscillators and microwave test equipment, where low-noise continuous-wave sources are required. In fact, they should find applications just about wherever GaAs circuits now look attractive.

As for frequency range, pulsed oscillators fabricated with InP have so far been operated from 5 to 30 GHz, while continuous wave oscillators made at Plessey Co. have operated in the 20- to 35-GHz range with efficiencies up to 10%. These efficiency figures are generally on a par with those for GaAs. The output powers, however, go up only to several watts of peak power, or rather below GaAs' 100-W-and-over levels.

Still, all these figures are easy to reproduce, and ought to get much better as the present, relatively crude methods of processing and handling InP are refined. They are in any case encouraging enough for a significant development effort to be under way at the Royal Radar Establishment, working in conjunction with laboratories at Plessey and Mullard.

1. Negative resistance. Plot of electron velocity (proportional to current) as a function of electric field (proportional to voltage) for a GaAs transferred-electron device shows the region of negative resistance. Threshold field typically occurs near 3 kV/cm in GaAs.



Why InP seems good stuff

Any discussion of the difference between InP and GaAs transferred-electron devices must be preceded by a grasp of their similarities.

Both types operate in basically the same way in a circuit with dc potential applied at the electrodes. A plot of electron velocity (which is directly proportional to current) versus the applied electron field (which is directly proportional to the voltage applied across the diode) shows that a region of positive resistance occurs until a voltage threshold is reached (Fig. 1). Peak current also occurs at this point. Then, as voltage across the diode is increased, a region of negative resistance is observed which continues until a voltage level is reached where the current flow begins to increase slightly again (known as valley current).

The ratio of peak current flow to valley current flow is often used as a figure of merit in comparing transferred-electron devices. This peak-to-valley current ratio is dependent on a number of device parameters, including the uniformity and purity of the material, and type of material used. It is the main determinant of the efficiency of the device as a microwave oscillator. The higher the peak-to-valley ratio, the greater the efficiency becomes.

The peak-to-valley current ratio can be related to the material's electron energy level properties. And it is here that InP and other materials prove different from—and superior to—GaAs.

Figure 2 reveals that the key to improved performance lies in the different number of energy levels each possesses. The conduction band for GaAs, plotted as a function of momentum, shows minima at two discrete levels, the central one being known as the gamma energy level, and the upper one as the X energy level.

The conduction band for InP, however, has a third, the L energy level.

Normally, all the conduction electrons are at the Γ level. However, when a voltage is applied to GaAs, these electrons gain energy and momentum until some of them jump into the X level. Electrons at this X level have a lower mobility. Since the material's resistivity is inversely proportional to electron mobility, the region of negative resistance shown in Fig. 1 results.

In GaAs, this electron transfer process from Γ to X levels is comparatively slow. At a particular voltage above threshold, current flow consists of two contributions: one from the electrons at the X energy level, and a much larger one from the electrons which have not yet transferred from the Γ level. In GaAs, the contribution from the higher mobility Γ level electrons is quite large, a relatively low peak-to-valley current ratio results, and the negative resistance region is not very pronounced.

To increase the peak-to-valley ratio, therefore, an electron transfer is needed which proceeds rapidly as the field is increased. This can be achieved if the coupling between the Γ and X levels is weak—not strong as in GaAs. The problem with such a weakly coupled system is that some Γ electrons would acquire energies high enough to cause impact ionization, resulting in breakdown of the material at low field strengths. An additional energy loss mechanism is required to avoid this breakdown, and usually this can be provided in a third energy level.

InP is one of the semiconductors that possesses such an energy level structure, as Fig. 2b shows. Here, the Γ level is weakly coupled to the L level, but strongly coupled to the X level to prevent breakdown. Strong coupling between X and L levels and weak coupling between L and Γ levels insure that, under normal operating conditions, electrons concentrate at the L level. The improved peak-to-valley ratio of InP in Fig. 3 is to be contrasted with the plot for GaAs in Fig. 1.

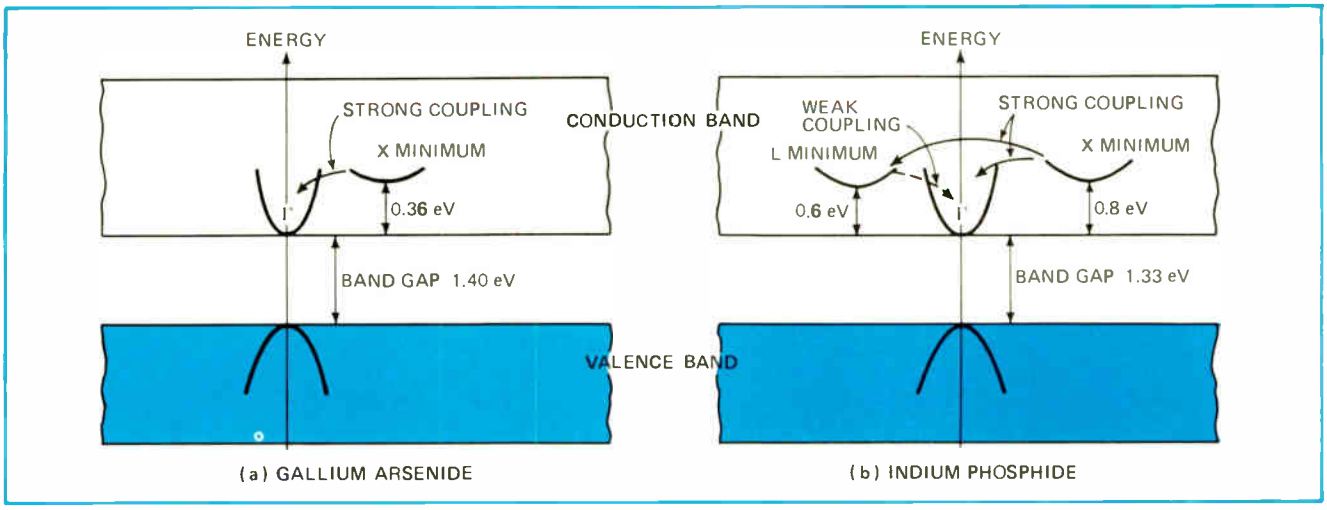
A comparison of Figs. 2a and 2b shows that the

Solid-state alternatives

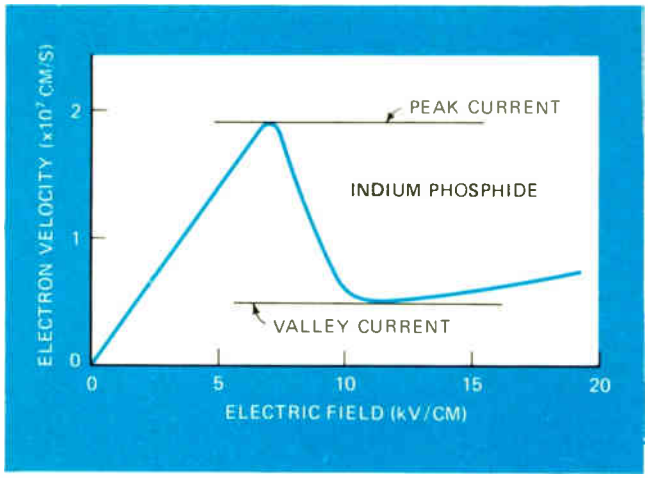
Because no one device satisfies all microwave generating requirements, several competing solid-state sources are currently in use. The four most important are transistors, varactors, avalanche diodes and transferred-electron diodes, and they line up against one another like this:

- Transistors make very efficient sources, yielding several watts of power at frequencies up to 5 GHz. They also have good noise characteristics. But they're unlikely to be competitive as power sources above 5 GHz, since frequencies above that level require impractically small geometries.
- Varactor diodes used as frequency multipliers have the advantage of being very stable and low-noise devices. But they require both driver and multiplier stages, making them comparatively bulky, expensive and complex.
- Avalanche diodes, which are usually fabricated from silicon and gallium arsenide, tend to be noisier than the transferred electron oscillator operating at the same frequency. They operate in two basic modes. The Impatt mode offers good cw power and efficiency at high frequencies, but requires bigger drive voltages than the transferred electron oscillator does. The Trapatt mode will deliver high pulsed power and efficiency, but is generally limited to frequencies below 10 GHz.
- Transferred-electron (Gunn) devices have the advantage of simplicity and low operating voltages. However, under normal operating conditions, TEDs have a low efficiency, which is still further reduced at elevated temperatures. The special mode of operation known as limited space charge accumulation (LSA) offers the possibilities of high efficiency and power, but is critically dependent on circuit control and extremely uniform material. Until recently, TEDs have been made only from GaAs.

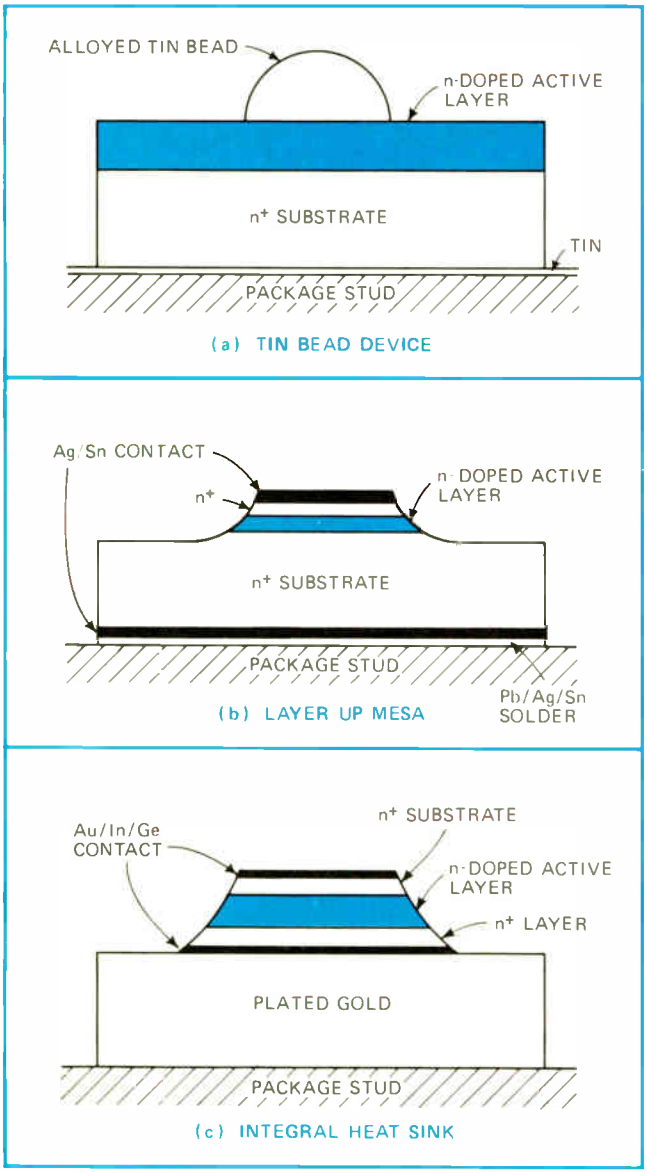
As technology progresses, both avalanche and transferred-electron devices are likely to find widespread application at frequencies above 5 GHz. At present, both are the subject of intensive research and development aimed at improving efficiency and reliability, in part by reducing noise and the effects of temperature on frequency.



2. Electron energy. Energy diagrams illustrate InP's potential advantage. Conduction electrons in GaAs (a) fall into two strongly coupled energy levels. For InP (b), three energy levels exist, resulting in greater electron mobility and improved negative resistance characteristics for the transferred-electron device in a circuit.



3. Improved efficiency. Greater electron mobility in InP gives its current-voltage curve a deeper negative resistance region, improving circuit efficiency. Compare current peak-to-valley ratio with that of GaAs (Fig. 1). Threshold field is just under 10 kV/cm. For a typical device with an active layer of 10 micrometers, a bias of 20 to 30 volts gives the best efficiency.



energy separation between the Γ and the nearest energy levels is much greater in InP than in GaAs. Consequently, the thermal excitation of electrons has less effect in InP, and degrades its peak-to-valley current ratio less. Calculations suggest the degradation is about four times less than in GaAs. This is a significant advantage since it means that a larger peak-to-valley ratio can be maintained in devices operating with high average powers or at elevated temperatures.

Operating mode determines performance

In the common oscillating mode (often called the Gunn or domain mode) for a transferred-electron device, a high-field charge domain is formed that propagates with a velocity of about 1×10^7 centimeters per second. The result is an output current waveform that is transit-time dependent.

The presence of such a domain in a device reduces the effective peak-to-valley ratio, and therefore efficiency, since the operation of the device is now governed by a dynamic characteristic (as indicated in Fig. 1). Also, the high field in the domain may lead to avalanching, with a consequent increase in noise level, and the tunability of the device is limited because of the transit-time dependence. For these reasons, an operating mode is usually sought where charge domains are not formed.

Increasing the electron diffusion coefficient—the ability of bunched electronics to disperse rapidly into neighboring regions—would hinder the growth of dipole domains. And this coefficient is increased by the stronger coupling in a three-level system like InP. So domain growth is less likely in InP than in GaAs, unless comparatively large doping fluctuations or other inhomogeneities are present.

In addition, by hindering the formation of domain modes, other higher-efficiency modes are favored, yielding oscillations which are strongly circuit-dependent and make full use of the high peak-to-valley ratio of InP. If the potential of InP can be realized, therefore, it will result in a microwave generator much nearer the ideal device—one that can be placed in a simple resonant cavity to produce strong oscillations with a frequency governed entirely by the cavity.

InP is by no means the only material to exhibit three-level transfer effects, but it is easier to grow than the rest. It has much in common with other compound semiconductors, and in many ways the development of devices has followed that of GaAs.

High-purity, n-type single crystal material is required. For use at microwave frequencies, the active length must be in the 1- to 50-micrometer range. Since no junctions are involved in these bulk-effect devices, it is convenient to grow the high-purity n-type layer epitaxially on a heavily doped n+ substrate, either by vapor-phase or by liquid-phase processes.

4. Device structures. Three device structures are commonly used. The alloyed-bead device (a) is simple and allows quick laboratory testing. A more permanent structure (b) uses metalized contacts of controlled diameter on a mesa wafer. Up to 10 W of dc power have been dissipated using copper heat sinks (c), bonded directly to chips as little as 100 micrometers in diameter.

The level of purity currently achieved is between 1 and 3 × 10^{15} atoms per cubic centimeter with a room-temperature mobility of 4,000 to 5,000 cm^2 per volt-second. Wafers are typically 1.5 cm in diameter, and have excellent surface finish, making contact definition by photolithography possible.

Several techniques are used in fabricating transferred-electron devices (Fig. 4). The simplest method is to alloy one contact—a bead of pure tin—to the exposed surface of the chip of epitaxial material. The n^+ substrate forms the other ohmic contact, and is soldered to the heat sink. This technique is ideal for rapid laboratory assessment of material and device characteristics without rigorous production processes.

An alternative is to sinter metallic contacts across the whole area of the wafer. The sintering is done in hydrogen at temperatures around 450°C to alloy the metal to the semiconductor. Contact diameters range from 50 to 200 μm. This structure is fine for low-average-power operation, but where high-power operation is required, closer attention must be paid to optimum heat sinking of the chip. To allow higher power operation a technique has been developed using integral heat sinking, where a whole wafer surface is metalized and plated. Controlled diameter contacts are then produced and individually bonded into copper heat sinks. Up to 10 watts of dc power have been dissipated in this structure with a chip diameter of only about 100 μm.

A promising start

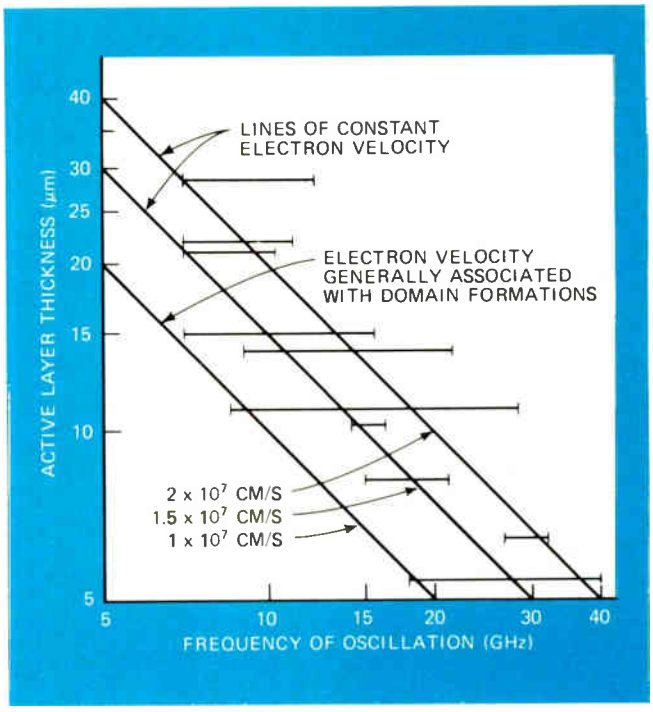
Prototype devices have been tested in both coaxial and waveguide cavities (see table). Many of these cavities are identical to those used for domain mode devices, and are essentially very simple. Normal test conditions require devices to be driven with short (300-nanosecond) pulses at a low duty cycle to avoid unwanted thermal effects in the measurement.

InP devices appear to operate both with and without the formation of charge domains. The plot of frequency as a function of active layer thickness (Fig. 5) shows operating frequency ranges for selected devices of a number of different thicknesses. In each case maximum efficiency occurs at about midband. So while they appear to have some sort of transit velocity dependence, it occurs at higher velocity than would be associated with domain mode operation. On a few epitaxial wafers, however, operation much more closely resembles domain operation, with a narrower tuning range and a transit velocity of around 10^7 cm/s.

A parameter that has not yet been assessed in the laboratory is noise. Indications are, however, that it should be at least as good as in GaAs devices.

The lack of cw results, particularly at the lower frequencies, reflects the need for higher-purity materials with higher resistivity to limit the dissipated power densities to manageable levels. Compound semiconductor materials are notoriously difficult to control in the growth process, and finding a method of growing InP of extremely high purity and homogeneity will take considerable research.

In fact, it is not yet clear where the main limitations of InP devices will lie, just because materials and device technology still have great room for improvement. □



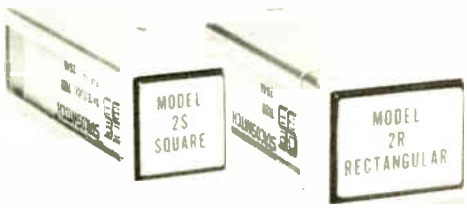
5. Tunability. Tuning over ranges larger than an octave bandwidth can be achieved in many InP devices. While rather dependent on the active-layer thickness, many of the devices operate at a electron velocity much higher than that associated with domain-mode operation. Domain-mode velocity is about 1 × 10^7cm/s.

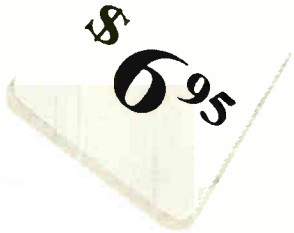
TABLE: 1972 INDIUM PHOSPHIDE PERFORMANCE

FREQUENCY (GHz)	POWER (W)	EFFICIENCY (%)	LAB
Pulsed			
5.5	3.05	14.7	Mullard
8.5	0.95	7	Plessey
10.75	1.33	12	Mullard
13	3.0	6	RRE *
15	1.13	15	Plessey
15.3	1.0	13.2	RRE
18.8	1.05	5.5	RRE
21	0.3	4.2	RRE
25	0.65	2.6	RRE
29.4	0.23	2.0	RRE
33	0.015	2.5	RRE
cw			
18	0.2	10.2	Plessey
26	0.15	6	Plessey
37	0.01	1	Plessey

* Royal Radar Establishment

LOW COST PAIR





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Choosing MOSFET bias for minimum temperature drift

by D. William Baird
Redwood City, Calif.

There's now a way—and an easy way—to calculate what gate bias voltage will keep temperature drift in MOSFETs as small as possible. The analysis applies to both saturated and triode regions of MOSFET operation, and works out the gate voltage value that minimizes any change in drain-to-source current due to small temperature excursions.

The analysis for the saturated region starts with the familiar equation for the drain current.[1]

$$I_D = -K(V_{GS} - V_T)^2$$

To this, the actual (manufacturer's, not textbook) gate and channel temperature characteristics are added. The overall gain constant K is temperature-dependent:

$$K(T) = K_1(T_0/T)^{3/2}$$

where K_1 is the gain constant that's independent of temperature and T_0 is the ambient temperature. Both T and T_0 are in degrees Kelvin. The threshold gate voltage, V_T, also is temperature-dependent:

$$V_T = V_{T_0} + K_2(T_0 - T)$$

where V_{T_0} is the threshold gate voltage at the ambient temperature, and K_2 is the temperature-dependent gate characteristic, typically 0.004 for most MOSFETs. The expression for K(T) and $V_T(T)$ is substituted into the equation for I_D. The resultant equation is differentiated with respect to temperature, and set equal to zero. This yields the two values of gate voltage that theoretically produce no change in drain current with temperature:

$$V_{GZ} = V_{T_0} + K_2 + (T_0 - T/3);$$

$$V_{GZ} = V_{T_0} + K_2(T_0 + T/9)$$

For the saturated region, there are two values of gate bias voltage which theoretically assure that $\Delta I_D/\Delta T = 0$ for small temperature excursions around ambient are:

$$V_{GZ0} = V_{T_0} + 4 \times 10^{-3}(293 - 293/3)$$

and $V_{T_0} + 4 \times 10^{-3}(293 + 293/9)$

At an ambient temperature of 20° C, $V_{GZ0} = V_{T_0} + 0.78$ and $V_{T_0} + 1.3$

The analysis for the triode region is similar:

$$V_{GZ0} = V_{T_0} + 4 \times 10^{-3}(T_0 - T/3) + V_{DS}/2$$

At $T = T_0 = 20°C$; 293 K,

$$V_{GZ0} = V_{T_0} + 4 \times 10^{-3}(293 - 293/3) + V_{DS}/2$$
$$= V_{T_0} + 0.78 + V_{DS}/2$$

where V_{DS} is the drain-to-source voltage.

These equations were used to calculate V_{GZ0} for one half of a dual MOSFET, Siliconix M108, and the results verified experimentally. The change in I_D represented by changes in V_{DS} for a resistive drain load was measured at several values of V_{GS} for small temperature changes around an ambient temperature. This was carried out for three different values of I_D (0.5 mA, 0.75 mA, and 0.93 mA) to show that V_{GZ} is not a function of I_D. So that V_{GS} wouldn't be affected by variations in I_D, the gate was grounded and a constant-voltage source connected between gate and source.

Both halves of the MOSFET match very closely, and measured threshold voltages were 2.9 V. The zero temperature gate bias voltages for the saturated case were 3.68 V and 4.2 V; for the triode condition, $3.68 + V_D/2$. The 3.68 bias point offers better signal handling range at smaller I_D currents than the other points, and remains constant for changes in V_{DS}.

Finally, differentiating V_{GZ0} with respect to temperature provides the thermal drift rate (−1.3mV/ C) so that a compensating circuit[2] can be selected. □

REFERENCES
1. R.H. Crawford, "MOSFET in Circuit Design," McGraw-Hill Book Co., New York, N.Y., 1967, p 46
2. Arthur Chace, "IC transistor array compensates for temperature," Electronics, Dec 6, 1971, p 77

Picking the right film for better oscilloscope pictures

by Robert D. Anwyl
Eastman Kodak Co., Rochester, New York

There's no need to settle for less than top-quality photographs from CRT displays. Eastman Kodak's new exposure index for recording films helps the engineer select the proper film.

The index is based on simulated CRT exposures calibrated in radiometric units for three commonly used phosphor types: P-11 (blue), P-16 (near-ultraviolet), and P-24 (green). But the difficulty in determining the precise transient output of a CRT prevents the new index values from being applicable in an absolute manner. However, they are useful for comparing the merits of several films that could be used.

In the initial film selection, it's best to match spectral sensitivity of the film as closely as possible to the spectral output of the phosphor, and to choose a resolving power higher than that indicated by spot diameter or number of scan lines. Remember that resolving power determinations must be related to the size of the display *at the film*, as reduced or magnified by the camera lens.

It's practical to design around a film, phosphor, and lens combination that results in a density of 1.0 with a typical scan rate, but that is also capable of at least a 0.1 density for capturing fast-moving transients. (Density is the log of the reciprocal of transmission.)

The resolving power of photographic materials, rated in lines/millimeter, assumes spaces between the lines equal to the line width. However, in video displays such as TV pictures, where the scan lines are usually unspaced, the number of scan lines is halved. Dividing the resultant number of "line pairs" by the picture height in millimeters yields the minimum usable resolving power. For practical considerations, the resolving power of film should be two or three times greater than the calculated value.

For oscilloscope recording of reoccuring patterns, the minimum exposure duration is the reciprocal of the sweep rate. For example, a shutter setting of 1/500 second would be required to record one complete trace, using a sweep rate of 500 hertz. Because the sweep rate may not be known exactly and the calibration of shutters is rarely precise, it is generally advisable to optimize exposure over five or ten consecutive sweeps. In this case, five sweeps of a 500-Hz display would require a shutter speed of 1/100 s.

Recording of changing or transient patterns is a bit more complicated. Generally a pulse generator is used to trigger a "brightening gate" for a single-trace cycle. All other traces are suppressed in intensity below the recording threshold of the film.

Regardless of the type of CRT display, three important steps must be taken:

- Keep ambient light away from the CRT face by shielding it with a cone of black construction paper or other suitable shroud.
- Acquaint yourself with the focus, astigmatism, and intensity controls of the scope. Make a series of trial exposures with several combinations of focus and astigmatism settings at the lowest intensity level which is readily recorded in order to produce the sharpest image. These trials should be made at the sweep rate you intend to use.
- Expose several frames of film at different intensity settings, and process the film as recommended. □

BIBLIOGRAPHY

For more detailed information, "Kodak s films for CRT recording" (P-37) is available, free of charge, from the Eastman Kodak Company, 343 State Street, Rochester N Y 14650

Engineer s Notebook is a regular feature in Electronics We invite readers to submit original and unpublished design, applications, and measurement ideas

Helpful hints

If you're having trouble getting a good picture, check out these points before readjusting equipment settings or changing the film type:

- Remove any graticules or colored filters—either may seriously modify or attenuate phosphor output.
- Check the ultraviolet transmittance characteristics of all optics in the system when photographing a phosphor in the ultraviolet or near-ultraviolet region.
- Remember the phosphorescence of phosphors. If the film is generally foggy, the CRT phosphor was probably still phosphorescent from exposure to light.
- Avoid panchromatic films except when red sensitivity is required. Otherwise cathode glow may be recorded as an out-of-focus image of the cathode. Cathode glow can be eliminated either by switching to another type of film or by using a blue or green filter with high transmittance at the phosphor's output wavelengths.

CRT EXPOSURE INDEXES FOR VARIOUS INSTRUMENTATION FILMS

Kodak Film Product	Kodak developer and development	Resolving power (lines/mm)	Spectral sensitivity	P-11 CRT E.I. at net density of 0.10	P-11 CRT E.I. at net density of 1.0	P-16 CRT E.I. at net density of 0.10	P-16 CRT E.I. at net density of 1.0	P-24 CRT E.I. at net density of 0.10	P-24 CRT E.I. at net density of 1.0
Linagraph Shellburst 2474*	8 min. D-19, 68° F	125	Ext. red	64	10	125	16	50	8
Linagraph Shellburst 2476	8 min. D-19, 68° F	125	Ext. red	50	8	100	10	40	60
2475 recording film	8 min. DK-50, 68° F	60	Ext. red	400	20	650	25	250	20
2479 RAR film	1 min. D-19, 95° F	90	Ext. red	200	20	400	32	100	10
2484 pan film	4 min. D-19, 68° F	70	Pan	320	16	500	20	250	16
	1 min. D-19, 95° F			400	12	650	12	320	8
2485 high speed recording film	1½ min. MX-857, 95°F	50	Ext. red	400	12	650	25	200	8
	2½ min. MX-857, 95° F			800	125	1,250	200	400	64
	2½ min. D-19, 95° F			650	80	1,000	125	320	40
2490, 3490 RAR films	2 min. D-19,95° F	160	Blue	32	8	80	12	25	6
2491 RAR film	2 min. D-19, 95° F	160	Blue	40	10	100	16	32	8
2495 RAR film	1½ min. D-19, 95° F	100	Ortho	200	40	400	64	160	32
2496 RAR film	1 min. D-19, 95° F	140	Ext. red	40	8	80	16	40	8
2498 RAR film	1½ min. D-19, 95° F	100	Pan	64	8	160	16	64	10
5498 RAR film	1½ min. D-19, 95° F	100	Pan	64	10	160	20	64	12
SO-200/201 recording films	2 min. D-19, 95° F	160	Blue	50	12	100	20	32	10
5374/7374**	4 min. D-19, 68° F	180	Blue	10	1.2	20	2.5	3	0.4

*Among these products, 2474 and 2490 are supplied on clear Estar base with dyed antihalation backing. Other products, which have identification numbers starting with 2 (as well as SO 200), are on Estar-AH base. 3490 and SO-201 are coated on Estar thin base. The TV recording films and 5498 use conventional triacetate supports.

**Eastman Television recording film 5374/7374 is included because it has been used as a reference product for relative CRT speeds in previous publication data.

Orthochromatic: blue and green sensitivity
Panchromatic: sensitivity to blue, green, yellow and some red
Extended red: same as panchromatic with greater red sensitivity

Exposure: Simulated P-11, P-16 and P-24 phosphors (71 microseconds, Xenon lamp with suitable filter)
Development: As indicated for exposure indexes listed
Densitometry: Diffuse transmitted density
Exposure Index: Reciprocal of the phosphor exposure in ergs/cm^2 required for net density specified

Harris' Family of Op Amps. They're a different breed. By design.

Harris op amps have always been a little bit different ever since we introduced the industry's first internally compensated op amp back in 1966.

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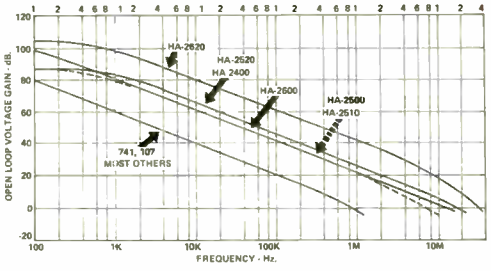

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- Superior response at higher gains.
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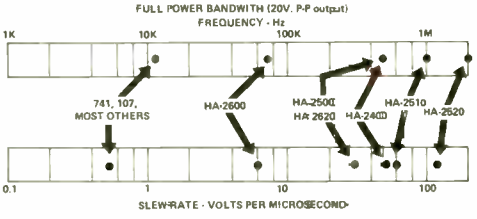

Harris high slew rate series offer:

- The only monolithic high slew rate amplifiers that are true operational amplifiers. They can be operated inverting, non-inverting, or balanced with fast settling times. In fact, they provide improved performance in virtually any standard hookup.
- The fastest settling time of any monolithic op amp. (For example, the HA-2520 settles in 250 ns to 0.1%.)
- Higher output voltage swing at high frequencies. (If you have ever tried to put a 10V peak 1MHz sine wave through a 741 type, you know what we mean.)

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HA-2101	HA-2602	HA-2622	HA-2502	HA-2522	HA-2700
HA-2107			HA-2510		HA-2400
HA-2107-3			HA-2512		

Commerical/Industrial (0°C to +70°C):

HA-2301A	HA-2207	HA-2505	HA-2525	HA-2704	HA-2404
HA-2201A	HA-2605	HA-2515	HA-2911	HA-2705	HA-2405
HA-2307					

All in standard 741 pin-compatible configuration. (Except HA-2400/2404/2405 4-channel op amp.) For details see your Harris distributor, representative, or contact us direct.

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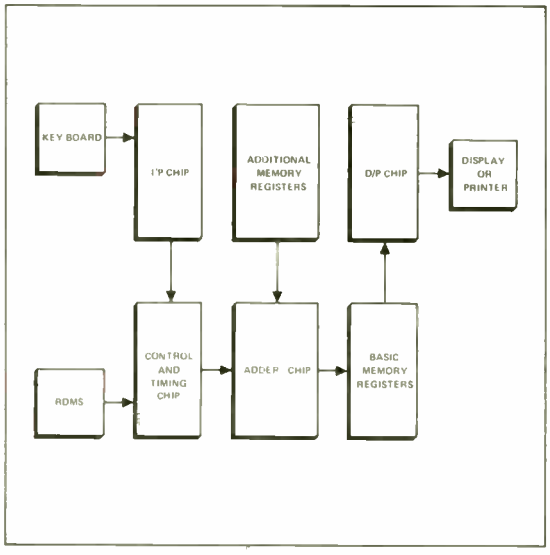
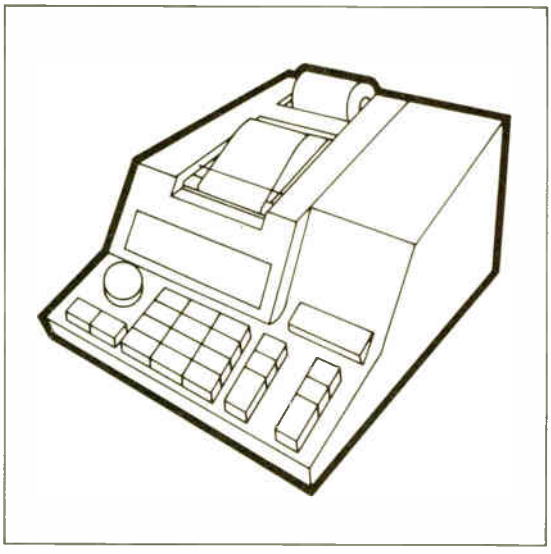
MOS Calculators





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Engineer's newsletter

First 1,024-bit bipolar RAMS may be slower but surer

Don't be surprised if the bipolar 1-kilobit RAM that's been promised by nearly every maker of semiconductors isn't based on an air or oxide isolation process; so far none of the companies developing such processes is satisfied with yields. **Instead, keep your eye on slower-speed, less-complex bipolar RAM processes.** TI's compose-masking process or Ferranti's collector-diffusion isolation process, which was first developed at Bell Labs, are good bets to come to market soon.

Plastics factor in three more design options

Progress in plastics has done as much for electronics, though not as obviously, as have circuit design and semiconductor technology. The trend continues. . . . You'll soon have a low-cost alternative to jackscrewed or clamped rectangular multicontact connectors. **An all-plastic cylindrical connector for nonmilitary applications,** now on the way from Amp Inc., has a plastic threaded ring to overcome the high insertion force. First units will be in a size 17 shell, priced at about 3 cents per contact position: a 28-position connector will therefore cost below $1.00. . . . Next, General Electric is claiming that its new Valox 310SE0 is the **first self-extinguishing thermoplastic polyester that has no glass reinforcement.** GE sees it being used in such components as connectors and coil bobbins, and in tuner mechanisms to meet new TV set safety requirements. . . . And then there's the precision-molded plastic optics for optoelectronics being made by such companies as American Optical Co. and U.S. Precision Lens in Cincinnati. **Plastic lenses cost less than precise glass optics and in most cases are equal in quality.** An added advantage is that, while molding the plastic lens, it's easy to mold in mounting flanges to simplify assembly operations.

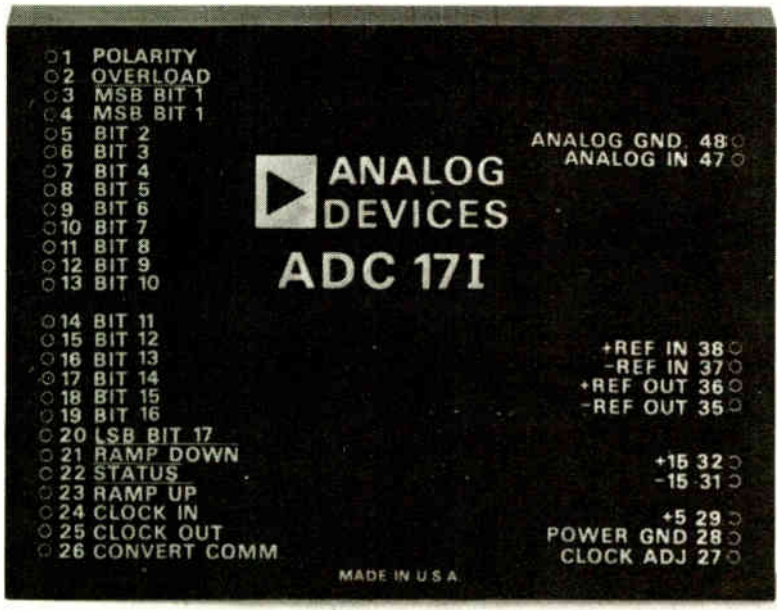
NBS offers noise figure calibrations

Make sure the guys in the calibration lab see this: for the first time, **the National Bureau of Standards in Boulder will offer calibration services for noise figure measurements.** Part of a new package of millimeter-wave services (covering 55 to 65 gigahertz), noise figure measurement is something NBS has always left to commercial labs. NBS says it now can give NF accuracy to within 0.1 dB (2.3%), with resolution of the order of 0.001 dB and precision to 0.01 dB. Other services in the package cover power, attenuation, impedance, and antenna gain.

Addenda

Here's a calculation shortcut, picked up in our travels that, if we had ever known, we'd forgotten: to determine the area in a pulse of fairly regular shape (triangle, trapezoid, rectangle, etc.), simply take the peak amplitude and multiply it by the time-width of the pulse measured at the half-peak-amplitude points. The method is exact for a sine-squared pulse and also gives close results for a sine pulse. . . . Money-saving idea: if you're designing discrete-component chopper-stabilized amplifiers for voltages below 5 V, **you may do just as well with the low-cost, general-purpose 2N2222 as with the high-priced 2N2432 chopper transistor.** You may not need the high emitter-base breakdown of the 2432, and the 2222 could give much lower offset and lower "on" resistance, our source says.

This is all there is to this high resolution dual-slope A/D converter. It can save you money.



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We're the only ones to put a complete high resolution dual-slope analog-digital converter in a single module.

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And this goes for both models of this converter. Our ADC 17I with a 4½ digit BCD output. And our ADC 14I with a 14-bit binary word output.

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ANALOG DEVICES

Circle 120 on reader service card

Chip set makes a powerful processor

MOS LSI circuits can be combined into computer-like systems for point-of-sale terminals, controllers, scientific calculators

by Stephen Wm. Fields, San Francisco Bureau Manager

The concept of employing programable sets of MOS LSI chips to implement the logic of an electronic calculator is now well proven. And some companies have taken the next step and introduced programable microprocessors [*Electronics*, March 13, p.143]. Now, National Semiconductor Corp. has gone one step further and introduced MAPS, a microprogramable arithmetic processor system—with the emphasis on "system."

MAPS is a set of MOS LSI integrated circuits that, when combined, become a powerful and yet flexible bit-serial digital processor. The set provides most of the performance features of a minicomputer controller at a fraction of the cost. But unlike a minicomputer-based controller, MAPS, once programed, is dedicated to a particular application.

A system employing MAPS, is organized like a computer, with the arithmetic unit forming the center. Connected to it are the timing and control circuit, the keyboard interface, the static data monitors, and the control read-only memory.

MAPS includes an arithmetic unit (AU), MM 5700; a register unit (RU), MM 5701; a timing and control circuit (T&C), MM 5702; control read-only memory, (CROM), MM 5703 and 5705; a keyboard interface (KI), MM 5704, and a static data monitor (SDM), MM 5706. These circuits communicate with each other over six parallel buses.

Several companies, both domestic and foreign, are designing scientific and other special-purpose calculators with MAPS. But the MAPS concept lends itself to almost any type of digital system that can operate bit-serially, and that requires data formatting and arithmetic operations without excessive speed. (At the present time, MAPS speed is about 750 kilohertz.)

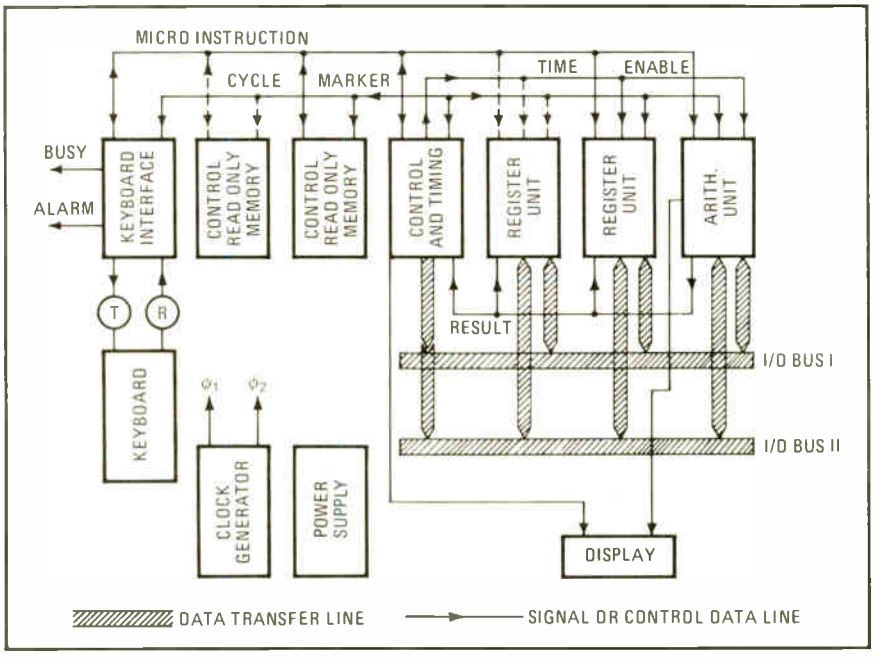
Applications include point-of-sale credit verification systems, traffic controllers, office business machines, data terminals, and general-purpose serial-data computers. Don Femling, applications engineer, says that in just about any system that requires 150 to 200 gate functions, MAPS can be employed in a cost-effective configuration.

The arithmetic unit provides the logic required for data manipulation and outputting, as well as working data storage in the form of accumulators. The register unit provides additional data storage; up to 32 register units may be connected to a system.

All basic arithmetic operations can be performed with three left-right recirculating shift registers and an adder with inputs that can be complemented. These are provided by the AU and RU, which are fully interconnected by the input/output and result buses to operate as a single data-processing subsystem. If additional working registers are required for more complex operations, additional RUs can be added.

Program manipulation logic and all general system control and timing functions are contained in the T&C chip. The actual program instructions are contained in the CROMs, with each CROM containing one page of instructions in the form

Building blocks. Diagram shows structure of a sophisticated 14-digit calculator using MAPS concept. As broken lines indicate, registers and memor es can be added to basic design.



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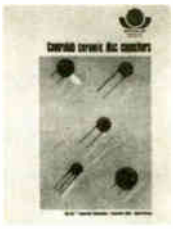

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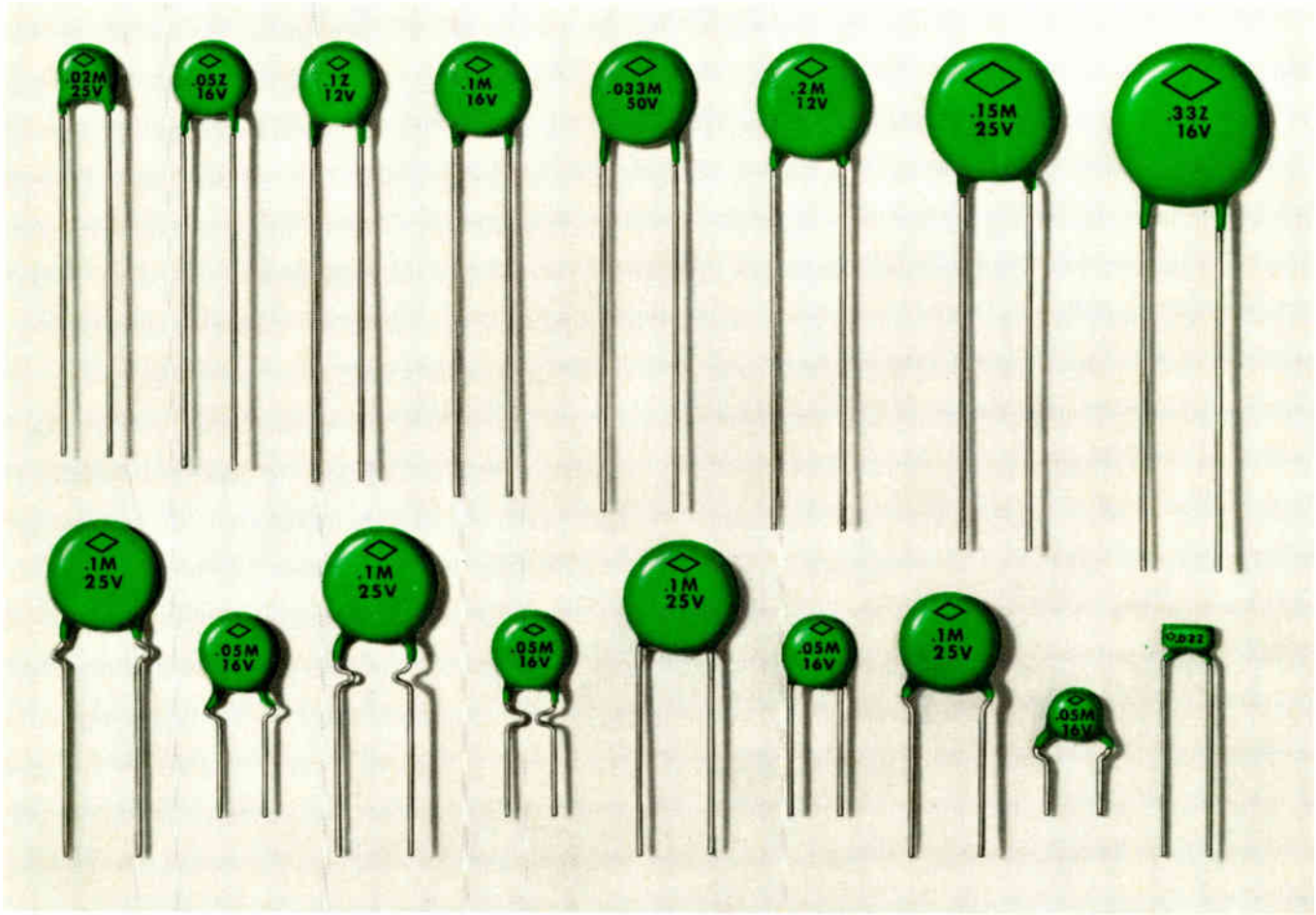

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New products

of 256 10-bit words. Up to 32 CROMs may be used in system. But Femling says that no system thus far has required more than 3 CROMs.

Information is entered into MAPS via the keyboard interface and the static data monitor circuits. Each keyboard interface scans as many as 32 dynamic keys (pushbuttons) and eight static toggle switches. The circuit includes the logic for two-key rollover and three-key alarm.

As many as four units may be connected to scan up to 128 dynamic keys and 32 switches. To increase the static switch-handling capacity alone, the static data monitor can be used. It connects with up to 16 static switches, in addition to the eight of the keyboard interface.

Expandable. A serial processing mode minimizes chip area and reduces the number of buffer circuits and package pins. Bus organization further reduces the pin count and facilitates modular system expansion. Each MAPS circuit contains the housekeeping logic needed to use the bus structure.

The bus structure consists of three data buses and three control buses (see diagram). Buses $\frac{3}{8}$/OI and $\frac{3}{8}$/OII are primarily information transfer buses for the arithmetic and register units. Both are bidirectional. The use of two I/O buses allows the AU and RU to interchange words of up to 19 digits in a single cycle. The complete system is designed around a 76-bit-word cycle.

In addition, an I/O pin on T&C can be connected to one of the buses to transmit data to the AU and RU. This allows data from the T&C, such as data from the keyboard or CROM, to be transferred to the processing area.

Data on the result bus is primarily the output of the adder in the arithmetic unit, which is hard-wired to the result bus. This bus goes to the register unit for storage of data during processing and to the T&C block. The microinstruction bus is the control and input data bus. It carries CROM addresses, microinstructions, and KI-to-T&C communications. The cycle-marker bus distributes the system-synchronizing signal, and the time-enable bus controls when the arithmetic unit and register unit execute microinstructions.

To demonstrate some of the data manipulation and arithmetic capabilities of MAPS, National has designed a 14-digit, 25-key electronic calculator that contains some sophisticated features, such as three registers for calculation and two for memory. Because MAPS is expandable, special functions such as sine, cosine, tangent, and exponential functions can easily be added to the basic system simply by adding another CROM.

At National, MAPS has been interfaced to a Digital Equipment Corp. PDP-8 computer. The computer memory is used as random-access memory, replacing the normal system CROM storage (256 10-bit words for each CROM).

This allows the MAPS system to be exercised with a simulated CROM, and thus it is easy to modify the program, if necessary, by altering the program stored in the PDP-8. The final design, verified by this simulation, is then transferred via punched-paper tape to a David W. Mann Co. reticle generator, which produces the CROM masks.

TTL-compatible. All units in the present MAPS family are made by National's bipolar-compatible, low-threshold p-channel enhancement-mode technology. Standard +5 and −12-volt supplies may be used. At these levels, the inputs and outputs normally connected to external logic will operate at TTL levels and the internal bus lines at MOS levels.

A chip set, including all of the MAPS MOS LSI building blocks necessary to put the demonstrator calculator together, can be ordered from National for $85 each in quantities of 100. This kit includes one AU, two RUs, one T&C, two CROMs, and one KI chip.

In quantities of 100, the MM 5700 AU sells for $15.40 each; the MM 5701 RU for $9.70; the MM 5702 T&C for $17; the MM 5703 CROM for $9.50; the MM 5704 KI for $14.40; and the 5706 SDM for $13.50.

National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051 [338]

Multipurpose tester: ICs to radar

Front-panel controls can interconnect registers, counters, and comparator to check memories, analog circuits, systems

by James Brinton, Boston Bureau Manager

For testing delay lines, integrated circuit memories, magnetic tape and many other things, vendors or users have had two choices. Either they could build up racks and consoles of separate test devices like counters, computing counters, digital voltmeters, word, pulse, or data generators, and oscilloscopes at typical costs of from $15,000 to $35,000—or they could go the computerized system route, at perhaps hundreds of thousands of dollars.

Now there is a third route, a $6,000 tester which is said to outperform most "home-brewed" test consoles, and to approach performance levels possible before only with dedicated computerized systems. It is the S-130C system performance calculator from Tau-tron Inc.

The 130's block diagram is a simple arrangement of two so-called infinite-length shift registers, a data comparator, a clock counter, a data counter, and a four-digit light-emitting-diode display—plus a set of front panel controls which interconnect these blocks in a wide variety of combinations, thus providing many testers in one box.

With the proper use of the interconnections, the 130 can act as: a variable-length-word generator, a data generator, a variable-width and variable-delay pulse generator, an event counter, a frequency meter, a variable-period, pseudo-random-bit sequence generator, a digital encryption/decryption system, a random-noise generator (with repeatable random noise), and many other machines.

With such flexibility, the tester could replace many consoles, and perhaps even a few of the computerized systems. But is the user putting all his eggs—or instruments—into one basket? Not according to John Connolly, Tau-tron vice president: "The 130 is designed to degrade gracefully with each function on a single circuit board. Thus if one fails, while the 130 would not be able to go through its full repertory, most tests could proceed as usual." Consequently, he assumes, many costly consoles could be disassembled and their parts returned to the test equipment pool found in all major electronics firms.

Tau-tron claims more applications for the 130 than there is room to relate. It can test memories, varying from the magnetic tape to ultra-high-speed IC types. It can check out serial processors such as the digital equivalent of a signal tracer. It can act as a jitter generator (with repeatable, controllable jitter) to test high-repetition-rate radar and microwave systems or analog circuits in digital communications systems such as phase-lock loops and their clocks. And it can test these systems themselves at bit rates of 0 to 130 megabits per second.

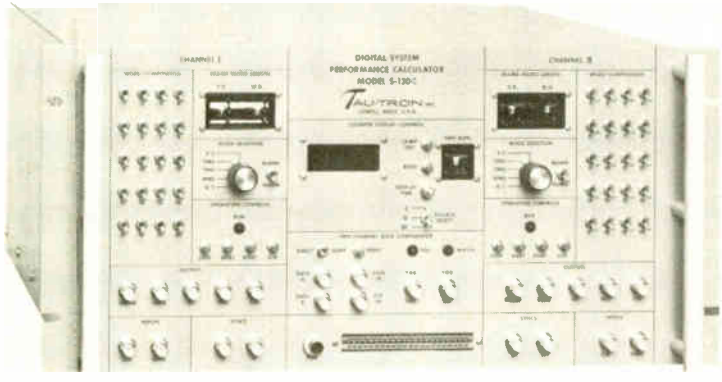
One application Tau-tron hopes will become popular is fast IC-memory testing.

Users and makers of these storage chips often are backed into corners by the limits of their test setups. Chips may be good or bad, and the test results can be the same. Common practice with chips running in the 10-nanosecond region is to dump address data, plus a string of repeating 0s and 1s from a read-only memory, into the random-access device under test. The RAM then reads out its contents through an oscilloscope and a counter. The scope should show clean square waves and, if the chip is a 1,024-bit memory, the counter will read 512, the number of 1s.

But repeated 0s or 1s can cancel one another. The counter may read 512, but it could be because the first 512 bits out were all 0s and the rest all 1s. This kind of gross error would be caught by the scope, but others might not be.

With the 130, a pseudo-random

Versatile. Controls on front panel enable user to interconnect a variety of signal and data generators for test purposes. Edge connector at bottom provides added versatility.



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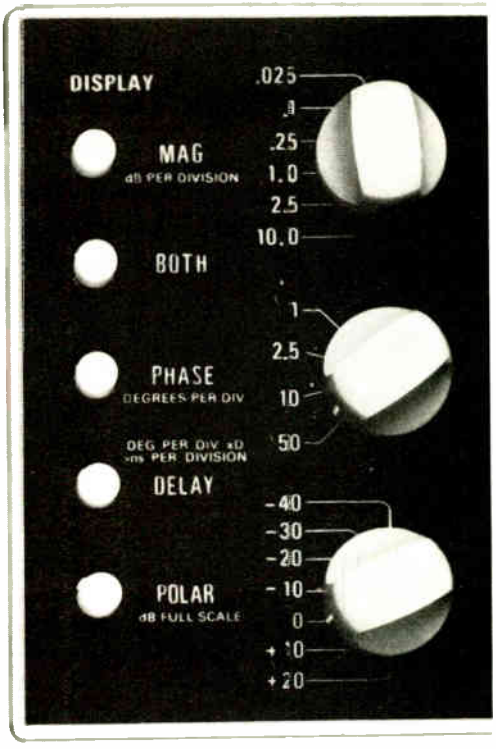

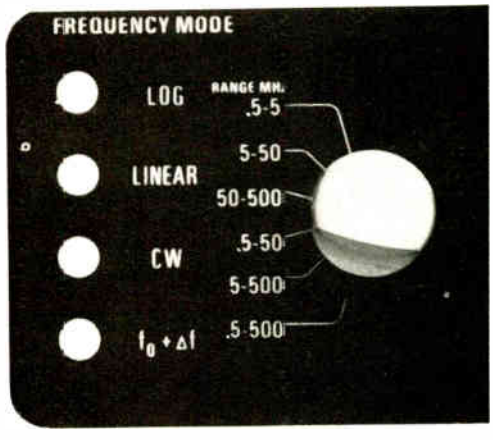

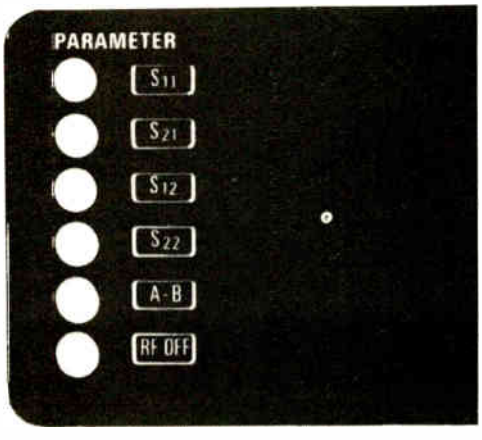

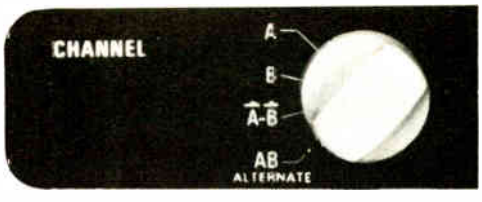

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Circle 125 on reader service card 125

bit stream is passed through the chip and read out into the tester's comparator, which spots 0s where 1s should be and vice versa. It can be set to stop the test at any point of divergence. Meanwhile the 130's counter is keeping track of clock pulses, and thus the rough location of the particular memory cell that is failing. A few minutes should be enough to isolate trouble down to the single cell level, says Connolly, claiming a much faster test rate with finer "grain" than is possible with most instruments.

In communications and data bank applications, the 130 could be used to prototype nearly breakproof encryption systems. Its two infinite-length shift registers with their controllable feedforward and feedback loops would couple their outputs to data passing through the 130, coding or decoding it any of about 10^{10} codes.

The 130 should also find several analog applications. It should at least find its way into radar labs, as engineers experiment with output pulse shapes and radar-return signal processing to gain maximum range and resolution.

There is added flexibility available through the printed-circuit board edge connector on the 130's front panel. The connector supplies all input-output channels to a plug-in board, which the user assembles himself, to add anything from crystal-controlled clocks to analog filters, IC test fixtures, multiplexer outputs, and other features to the 130. For example, a simple two-stage RC lowpass filter cuts off the upper frequency components of the 130's output and leaves the rest, say up to 10 megahertz, as white noise output, but with a difference: the white noise put out by the 130 today can be duplicated tomorrow, unlike the outputs of gas discharge tubes and other sources often used in audio, rf, and microwave research. And if the user needs a spike at some frequency within his white noise envelope, he has only to program it.

Delivery time for the S-130C is about 30 days.

Tau-tron Inc., 685 Lawrence St., Lowell, Mass. 01852 [339]

Subassemblies

Switching supply offers low rfi

Modular line challenges series-pass types; filter techniques help reduce noise

The series-pass supplies that have dominated the modular power supply field, are being challenged by a switching type made by the Raytheon Co.'s Sorensen operation. Switching-type supplies to date have not been a threat, because they have a bad reputation for putting radio- and lower-frequency hash in

their dc outputs, and even back onto the power line.

Sorensen's market development manager, Robert J. McCue, notes, however, that series-pass supplies usually are larger than the switching type, that they often dissipate a lot of their input as heat, and that such inefficiency affects the thermal performance of ICs, transistors and other parts of the system and makes heat-performance tradeoffs a way of life in series-pass design.

On the other hand, switching supplies have so far been unable to meet rfi specs, and sometimes—if their switching frequencies were low enough—these supplies could be painful to listen to.

Sorensen engineers aimed for a combination of low rfi, small size, and low cost. The result is the STM series, 10 of which now are available, with another 30 models on the way.

A team led by an R&D section head, Joseph C. Perkinson, got around the rfi problem by placing a toroidal transformer with dual windings at the line input. This yielded good common-mode cancellation of line noise, and kept dc and other noise from getting back on the ac line. Other such inductors are used throughout the supply. After the initial rectifier, a dual L-C network protects the line from switching noise and the supply from line noise; this L-C pair is optimized to damp out the second harmonic of the inverter switching frequency, 40 kilohertz. Two more L-C nets are used before the output terminals, again to damp switching noise, and also to add passive regulation. Following these are taps for the inputs of a type 741 op amp which feeds a regulating signal back into the inverter.

The inverter is the heart of a switched regulator, and Sorensen has tried to maximize efficiency here by using faster transistor switching. According to Perkinson, many switching-type supplies lose efficiency through slow rise and fall times. Raytheon switches its transistors at 20 kilohertz, and claims that the fast—but unspecified—rise and fall times allow them to work at lower junction temperatures. Thus less costly transistors can be used for a given application, and since less heat is generated in their junctions, there's less derating of the transistors used. A zener reference and the feedback from the 741 control "on" time and output, and thus regulate the system.

The STM takes up 160 cubic inches, which the company says is less than half the volume of competing series-pass types. Its efficiency is specified at 58%, and line-load regulation at 0.05%. Temperature co-efficient is 0.01%/°C. Rfi meets MilStd-461A, and stability over 24 hours is within 0.05%. Typical ripple for an SIM is about 25 millivolts, regardless of output voltage.

The first 10 STMs, offering 3 to 56 volts and 1.6 to 24 amperes in various combinations, range in price from $229 to $269, and overvoltage protection is included in the standard package. They are available off-the-shelf.

The Raytheon Co., Sorensen/Manchester Operation, 676 Island Pond Road, Manchester, N.H. 03130 [381]

Recording amplifier provides automatic gain-ranging

Anyone who's ever tried to record on tape a signal that varied as much as 70 decibels knows that the dynamic range of most recorders is much narrower than that. And while there are ways to record widely varying signals, these techniques usually depend on a manual gain-control adjustment.

But Intech Inc., Santa Clara, Calif., has developed an automatic gain-ranging amplifier that has a dynamic range from −10 to +60dB. In operation, the amplifier, model A-205, selects a gain range in 10-dB steps, and supplies an output signal along with a control signal that indicates the unit's range at the time. During playback, therefore, the tape recorder's output can be scaled to produce the proper signal. This gain-status signal varies from 0 to +1.4 volts dc, depending on which of eight ranges is being used.

Gain range for the 205 is 70 dB minimum, and gain accuracy is typically ±0.1 dB. Input impedance is 100 megohms, and input offset voltage is adjustable to 0. Gain-change response time is 300 milliseconds, and gain-change set time is 10 ms.

The amplifier is available in three versions with different dc drift levels at 60 dB. The 205, which has a maximum drift of 20 microvolts/°C, costs $355; the 206, with a 10-μV drift, costs $395; and the 207, with a drift of only 5 μV, costs $460.

Intech Inc., 1220 Coleman Ave., Santa Clara, Calif., 95050 [382]

Module eliminates distortion errors in CRT displays

A CRT geometry/focus correction module called the C101 synthesizes the correct mathematical functions

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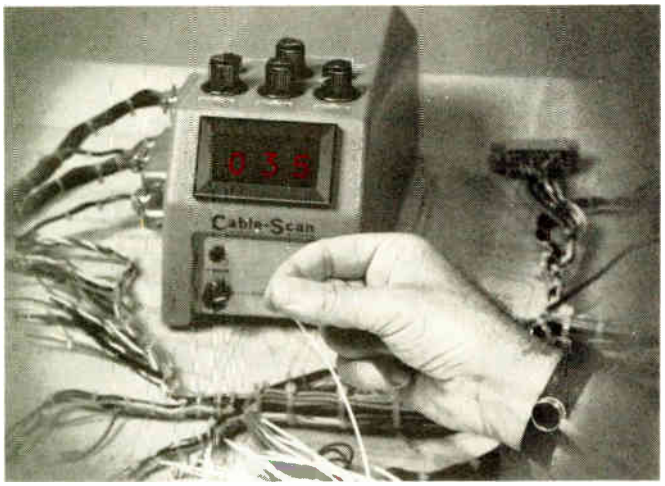

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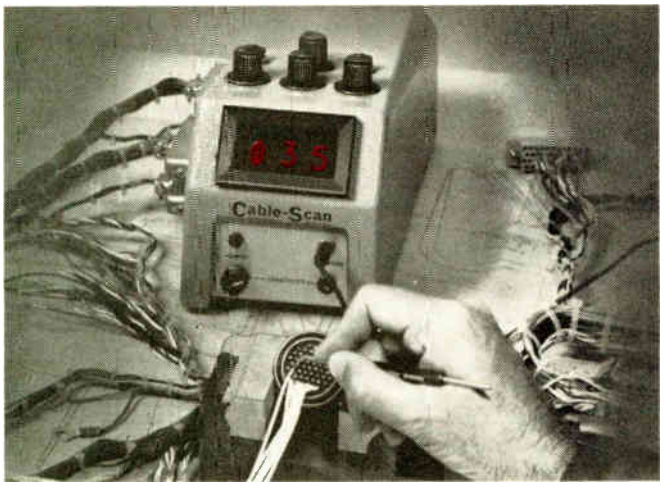

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468

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with large bandwidth to eliminate pincushion distortion errors. Correction is made by processing the deflection signal ahead of the horizontal and vertical deflection amplifiers to subtract out a correction term. This term is dependent on the magnitude of the two deflection signals. A third output produces a correction for dynamic focus. Corrected position errors are less than 0.1% for a 60° CRT and less than 0.01% for a 20° CRT. Bandwidth is 1MHz, and input/output signal range is ±5 volts. Price of the C101 module is $348. Delivery is from stock.

Intronics Inc., 57 Chapel St., Newton, Mass. 02158 [383]

Voltage-frequency converters cover from 25 Hz to 100 kHz

A series of voltage-to-frequency converters is designed for applications in analog-to-digital conversion, telemetering, integration, and process control readout systems.

Twelve modules cover full-scale frequency ranges from 25 hertz to 100 kilohertz, and linearity of the output frequency vs input signal level is within 0.01%. Input impedance exceeds 100 megohms, and zero and full-scale settings are adjustable by individual trimmers. Price is $145.

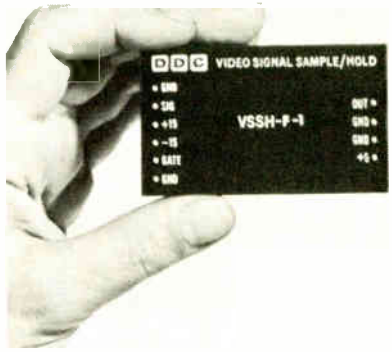
North Hills Electronics Inc., Glen Cove, N.Y. 11542 [384]

Sample-and-hold module offers fast aperture time

A high-speed sample-and-hold module operates into video frequency ranges. Aperture time is less

New products

than 300 picoseconds, and acquisition time is 20 or 50 nanoseconds, depending on the module. Output impedance is 10 megohms, and low droop rate is also featured. The unit operates over a dynamic range of ±5 volts with a linearity to within 0.1%. Applications include analog-to-digital conversion and wideband demodulation.



ILC Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801 [385]

A-d converter offers 12-bit resolution

An analog-to-digital converter designated the ADC-D series takes inputs from 0 to 10 volts or 0 to ±5 volts, and resolves up to 12 binary bits. Conversion word rate is 100 microseconds. The units incorporate monolithic and hybrid technology, and are accurate to within ±0.05% of full scale. Over-all linearity is within ±0.0125% and is monotonic over an operating range of 0° to 70 C. Price ranges from $69 to $109.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021 [386]

Miniature supply holds load regulation to 0.02%

Miniature ac-to-dc power supplies are packaged in an epoxy-cast module measuring 1 by 2 by 3 inches. Specifications include an input voltage of from 105 to 125 volts rms at 50 to 400 hertz, single output voltage of 30 V dc and dual output voltge of ±15 V dc. Accuracy is

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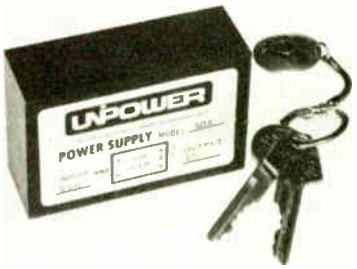


within ±0.1 V dc, and zero to full-load regulation is 0.02% maximum. The series 400 also features a line regulation of ±0.005% maximum, and input isolation of 50 megohms. Price ranges from $30 to $80.

Unipower Div., California Linear Circuits, 12741 Los Nietos Rd., Santa Fe Springs, Calif. [387]

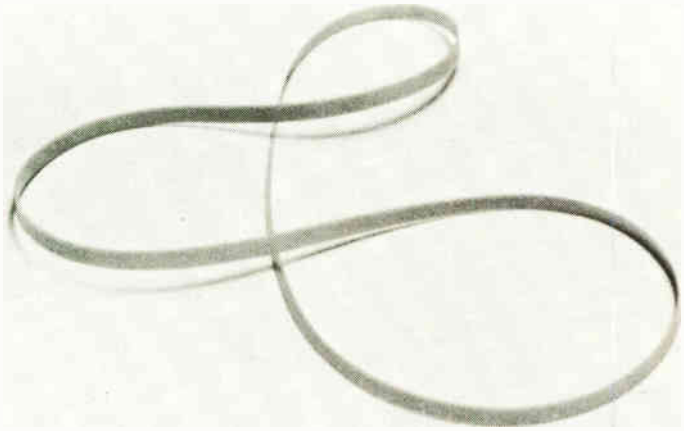
Cascadable amplifiers in TO-8 cans offer high gain

Thin-film amplifiers designated the UTO-521 and -522 are packaged in TO-8 cans, and provide 27 and 23 decibels of gain respectively from 5 to 500 megahertz. The cascadable amplifiers have minimum output powers of +6 and +12 dBm and maximum noise figures of 5.5 and

7.0 respectively. Typical applications include communications equipment, laboratory instruments, radar, ECM and navigational systems, collision avoidance and beacon sets, and telemetry and space data links. Price ranges from $110 to $195.

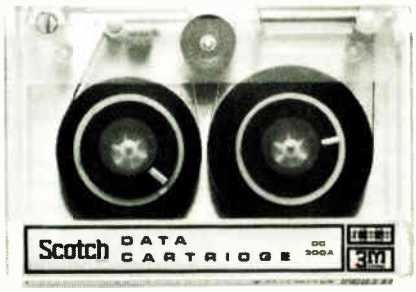
Avantek Inc., 2981 Copper Rd., Santa Clara, Calif. 95051 [388]

In the grand tradition of the paper clip:



The 3M drive band. A new concept in tape handling.

Based on an entirely different, elegantly simple drive technique, the new ¼" Scotch® Brand Data Cartridge combines reel-to-reel performance with cassette convenience and price.



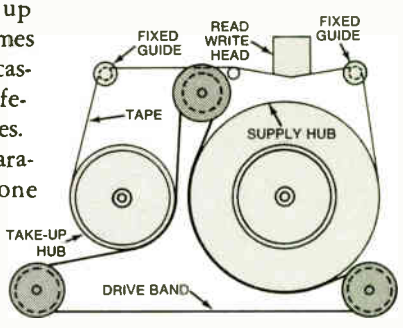
The Data Cartridge functions as its own transport and needs to be driven at only a single point.

With our new technique, tape is handled — not just driven — in the Data Cartridge. The drive band travels around three tension rollers and is wrapped partially around the tape on both hubs, making "rolling" contact with the tape. Tape wear is extremely low since the tape oxide touches nothing else except the head. Compliance in the band provides controlled tape tension at all times. No machine operation can cinch, spill, stretch or break the tape.

A single external motor powers the drive band through contact with extended hubs on one of the tension rollers. Tape motion is easily controlled by starting, stopping or reversing this motor.

Since no external guidance is required, tape/head alignment is simplified and a variety of head and data configurations may be used with consistently high data reliability.

The Data Cartridge starts and stops within 25 ms at any operating speed, shuttles at up to 180 ips, stores up to 8 times as much data as the 0.150" cassette and has an expected lifetime in excess of 5000 passes.



Add to this a cost comparable to cassettes and only one quarter that of ½" compatible tape decks, and you have a breakthrough in digital tape handling for any application.

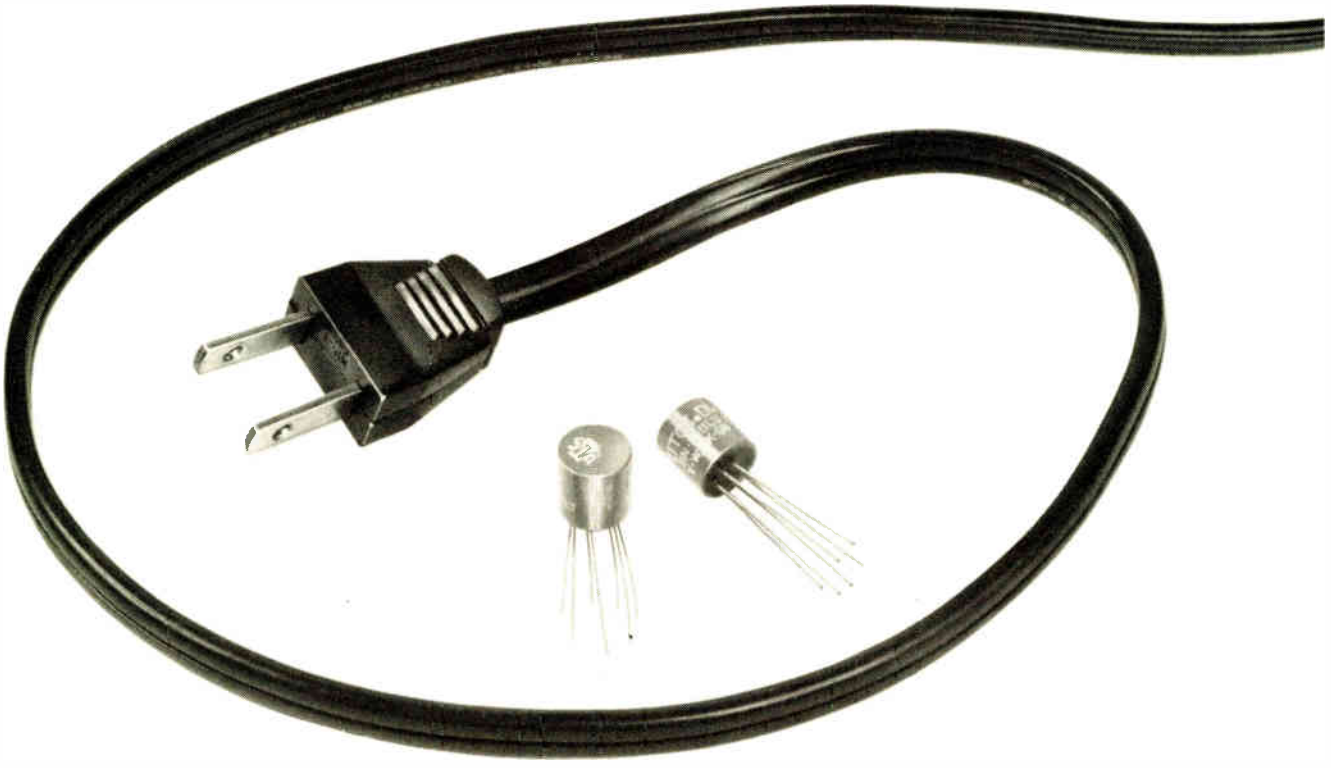
Need more data? Simple.

Contact Data Products, 3M Company, 300 S. Lewis Road, Camarillo, California 93010, Tel. (805) 482-1911, TWX 910-336-1676.

Data Products 3M COMPANY

Circle 133 on reader service card

Now the best transformers plug in



TRW/UTC I-DO-T and I-DI-T transformers now come with plug-in leads (as well as with the insulated leads introduced earlier). Plug-in units can be inserted in PC boards and wave soldered from the back. You cut labor costs as well as enjoying all the other outstanding I-DI-T and I-DO-T advantages.

A wide range of available impedances, together with the new choice of insulated or PC plug-in leads, gives you the industry's broadest and best range.

These TRW/UTC units provide unprecedented power-handling capacity and reliability, in a small package. Electrical performance parameters and areas of application exceed conventional transformer capabilities.

All units are ruggedly packaged, with a completely rigid bobbin, eliminating stress and wire movement.

Write for catalog data. TRW/UTC Transformers, an operation of TRW Electronic Components, 150 Varick Street, New York, N. Y. 10013.

TRW
UTC TRANSFORMERS

Instruments

Rf generator has calibrated fm

Signal source provides mixed a-m/fm or fm/pulse modulation up to 520 MHz

While the old-fashioned signal generator is adequate for most a-m systems testing, modern applications—such as the testing of navigational aids, fm stereo receivers, and chirp radars—require something more.

Precisely controlled carrier frequency, calibrated modulation on both a-m and fm, the ability to generate calibrated mixed-modulation signals, and fully automatic output leveling across the entire band are some of the features that a modern signal generator should have. Add to this a maximum power output of +13 decibels referred to 1 milliwatt (1 volt rms across 50 ohms), a weight of 27 pounds, a frequency range of 9.5 to 520 megahertz, and a tentative price of $2,575—and the result is a partial description of LogiMetrics' model 750 rf signal generator.

Included in the generator is a five-digit counter that measures the output frequency with a maximum error of 0.05%. Mechanical coarse tuning plus electronic fine tuning make it easy to set the output frequency to exactly the value desired.

The model 750 produces its output by heterodyning the outputs of two cavity oscillators—one fixed and one variable—and amplifying the result. All the modulation functions—a-m, fm, and pulse—are performed on the fixed oscillator only. This makes it possible to optimize the design of the modulators for operation at a single frequency and power level, independent of the actual output frequency and power level of the generator.

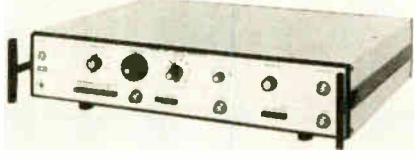
This optimized design makes possible such specifications as a maximum distortion of 1% with 30% a-m, maximum distortion in the fm mode of 0.5% at 75 kHz deviation, and a pulse modulation on/off ratio of 40 dB, minimum. The a-m can be varied from 0 to 100% with a frequency range of 20 Hz to 20 kHz. For fm, the peak deviation can be varied from 0 to 300 kHz, and the modulating rate can be varied from dc to 100 kHz. Internal modulating signals of 400 Hz and 1 kHz are supplied for both a-m and fm. For pulse modulation, an external modulating signal must be used.

Delivery time of the model 750 is 90 to 120 days.

LogiMetrics Inc., a subsidiary of Slant/Fin Corp., 100 Forest Drive, Greenvale, N. Y. 11548 [351]

Function generator digitally synthesizes waveforms

A function generator digitally synthesizes every cycle of each waveform with 1,800 bits of digital



information. A digital-to-analog converter is used to convert the digital words into a stable analog output. Typical stabilities are within 0.01% for 10 minutes and 0.02% for 24 hours. A voltage-controlled frequency input is provided for external control or frequency modulation. The model 335 operates over the frequency range of 10 microhertz to 50 kilohertz with a 1-mHz option available. Price is $1,250, and $100 for the option.

Exact Electronics Inc., 455 S.E. 2nd Ave., Box 160 Hillsboro, Ore. 97123 [353]

Portable signal analyzer comes in attaché case

A signal distortion analyzer model DTS-531 is available in a portable version. It weighs 20 pounds and measures 5 inches in height by 18

in. by 13 in. The tester identifies specific types of distortion of digital signals and the cause of the distortion accompanying the signal. The percentage of distortion is indicated by a quantitative readout. The analyzer comes in a 5-inch-high attaché case.

Communications Technology Inc., 1900 York Rd., Timonium, Md. 21093 [354]

5½-digit multimeters offer ac-line, battery operation

Portable multimeters, designated series 2500/A2, read out five and a half digits and are operable from an ac line or from rechargeable bat-

New products

teries. Both autoranging and manual range selection are available, and fundamental accuracy is within ±0.001% of full scale, ±0.007% of reading, and plus or minus the least significant digit. Price is $1,145 for the unit with dc voltage and dc ratio ranges and $1,345 for the unit with dc voltage, ac voltage, ohms, and dc ratio ranges.

Data Precision Co., Audubon Rd., Wakefield, Mass. 01880 [355]

Wide-range megohmmeter is accurate to within 2%

A megohmmeter, designated the model L-10, offers a range of measurement from 10^5 to 10^{14} ohms. Nine discrete and precise test voltages are available internally and

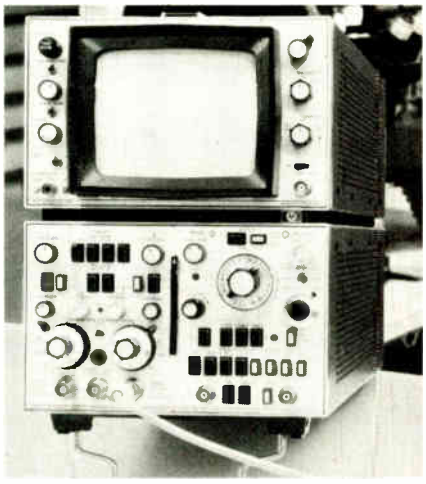
range from 10 to 1,000 volts dc with an accuracy to within ±2.0%. The infinity adjustment requires only one setting during operation, and changes in range will not disturb the accuracy of the readings. Internally, the power supply neutralizes the effects of severe power-line transients.

Beckman Instruments Inc., 89 Commerce Rd., Cedar Grove, N.J. 07009 [356]

Oscilloscope plug-in checks high speed digital circuits

A 100-megahertz vertical amplifier plug-in for Hewlett-Packard 180-series oscilloscopes offers two switchable input impedances: 50 ohms for measurements on high-speed digital circuits, and 1 megohm with 13 picofarads of capacitance for high-impedance probing

in both low- and high-frequency circuits. Voltage standing wave ratio is 1.35 on the most sensitive range and 1.1 on all other ranges. Offset voltages are provided on either or both



channels. The model 1805A is designed for transient disturbances in a power supply output or propagation delay measurements of nonsymmetrical logic circuits, where logic states are represented by two dc voltage levels. Price is $1,400.

Hewlett-Packard Co., 1601 California Ave., Palo Alto, Calif. 94304 [357]

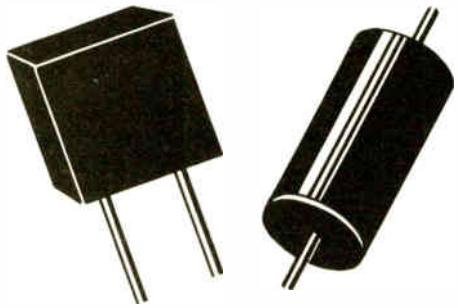
Dc power supply has line regulation to within 0.02%

Precision dc power supplies, designated the Valupower series, offer line regulation to within 0.02% or 5 millivolts and load regulation to within 0.05% or 5 mV. Ripple is less than 1 mV rms. Five models cover output ranges from 4.75–5.5 Vdc at

135 A to 26–30 Vdc at 50 A. Price of the unit is $595. A meter option is available at $50, and overvoltage protection is $80.

Systron-Donner Corp., Trygon Electronics subsidiary, 1200 Shames Dr., Westbury, N.Y. 11590 [358]

VISHAY OFFERS A WORD OF ADVICE ON PRECISION RESISTORS



First of all, they don't have to be round. As a matter of fact, the most precise unit you can buy is square (see the picture above).

Secondly, make sure you're getting all you pay for. Every manufacturer lists the basic specifications—Tolerance, Size, Wattage, etc. but very few publish *all* the specifications . . . and those missing facts can be important.

In buying precision resistors make sure you know the Temperature Coefficient (a 25 ppm/°C 10K resistor at 25°C will be 10,009 ohms when measured at 60°C)—your .01% resistor could be .1% at the operating temperature.

Make sure you are told the inductance and capacitance. (A spiraled metal film *is* inductive.) If at your frequency, the X_L is 10% of the DC resistance, the resistance shift is 5000 ppm.

Ask for stability figures under load and on the shelf (two years from now you still want the performance you designed in).

Are you told the tracking characteristics between production runs of units? And what about tracking of various values?

You should be told all these things and more if you're buying precision resistors and paying the price. Ask Vishay for the facts—we'll tell you everything, not just what we want to accentuate. We'll tell you our limitations along with our strong points. Write us today—you may not need all of our ultra-precision specifications, but you should know they are available.

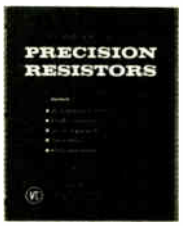
TYPICAL PERFORMANCE CHARACTERISTICS

Resistor Type	Evaporated Metal Film	Wirewound	Vishay Bulk Metal Film
Typical rise time	10-100 nanoseconds	10,000 nanoseconds	1 nanosecond
Typical TC track			
Same value	25 ppm	5 ppm	3 ppm
Value one decade	35 ppm	10 ppm	3 ppm
Value two decade	50 ppm	20 ppm	3 ppm
Typical shelf life (1 year)	500 ppm	25 ppm	25 ppm

MIL PERFORMANCE CHARACTERISTICS

PARAMETER		MIL-R-55182 Characteristic J	MIL-R-39005 Characteristic L	MIL-R-55182 Characteristic Y
Best T.C.		±25 ppm	±10 ppm	±5 ppm
Best Tolerance		0.1%	0.01%	0.01%
¼ watt size		RNR 65J	RBR 54L	RNC 90Y
Occupied board space		.188 x .625 plus lead space	.250 x .750 plus lead space	.110 x .310 no lead space
Wattage rated @		125°C	125°C	125°C
Max. ambient temperature		175°C	145°C	175°C
Maximum Permissible ΔR's	Temp. Cycling & Overload	.2%	.06%	.05%
	Dielectric withstand.	.15%	.01%	.02%
	Moisture Resistance	.4%	.1%	.05%
	Shock	.2%	.01%	.01%
	Vibration	.2%	.01%	.02%
	Low Temp. Operation	.15%	.02%	.05%
	High Temp. Exposure	.5%	.1%	.05%
	Life (2000 Hrs.)	.5%	.1%	.05%

Send for these Technical Bulletins



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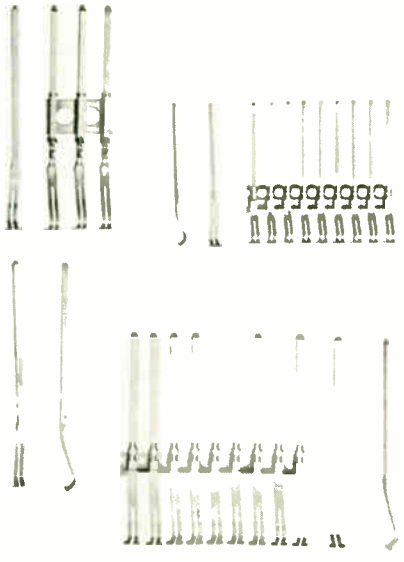
Packaging and production

Connector-pin belts cut costs

Bandolier technique permits selective gold-plating, simplifies insertion step

A new technique for aligning pins during connector assembly seems likely to cost less than processes using either bulk pins or pins stamped from metal strips. Allied Pacific Manufacturing division of Tower



Industries mounts the individual pins on a brass or steel "bandolier" that maintains proper spacing and alignment during assembly, then can be easily removed and discarded afterwards. The correct number of pins is selected simply by cutting off the proper length of bandolier.

Apart from the reduction in assembly costs, from an estimated $4.40 per thousand pins to only $1, the bandolier technique economizes on gold. According to James R. Stull, executive vice president of Tower Industries, the pins can be gold-plated selectively on the contact surfaces instead of over the whole surface, or the whole pin can be gold-plated, with an extra thickness of gold on those contacts where most wear is expected. Stull says that typical pins cost $9 per thousand, compared to the earlier $12.50 per thousand. But, he says, the more significant saving is in assembly process costs.

Other manufacturers have produced ganged pins, stamped from strips of metal, with a small strip remaining to hold them together. The main disadvantages of this approach, says Stull, are that the retaining strip must be gold-plated along with the contact, and it is relatively difficult to remove the retaining strip after assembly.

Also, the stamping process tends to create camber in the strip, with resulting misalignment (as much as ¼ inch in a 6-inch strip).

In Allied Pacific's technique, the pins are held on the bandolier by tabs accurately punched from the metal and pinched over the top of the pin. Stull says that the new technique was made possible by development of special tooling and the use of four high-speed, high-precision stamping presses.

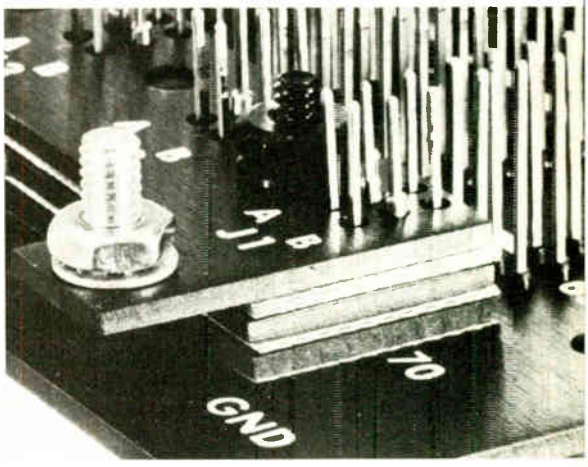
The wire for the pins (phosphor bronze, nickel silver, beryllium copper or brass) is formed to close tolerances in a 35-ton stamping press, while in a separate operation the bandolier is formed from strip brass or cold rolled steel.

The company is now making five different types of pins and is equipped to produce 6 million pins per week.

Allied Pacific Manufacturing Division of Tower Industries, 17625 South Santa Fe Ave., Compton, Calif. 90221 [391]

Aluminum back panels suppress random noise

Laminated aluminum back panels for computer, data transmission, and communications applications are designed to suppress random noise and provide low power impedance. The panels, available with segmented voltage planes, are constructed of Mylar or vinyl dielectric sandwiched between an aluminum ground plane and an aluminum voltage plane. Final thickness is typ-



ically 0.150 inch. Filtering and shielding are provided through the capacitance coupling; capacitance is rated at 50 picofarads per square inch.

Dynatech Corp., 1225 E. Wakeham Ave., Santa Ana, Calif. 92702 [395]

Socket inserter handles 3,000 units an hour

A socket-inserting machine, specifically designed to handle the Berg line of Minisert miniature sockets, inserts them into predrilled or punched holes in the printed circuit board, and up to 3,000 units per hour can be handled. With the model MS-104, which includes an

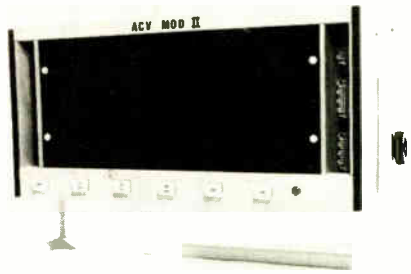
New products

adjustable working table, the operator places the board component-side down on supporting nylon spacers, and the holes are located with manually positioned pins. The pneumatic inserter is then triggered by a foot pedal.

Berg Electronics Inc., New Cumberland, Pa. 17070 [397]

Continuity verifier checks 128 points in a second

Continuity verifier model ACV MOD-II is capable of other functions that include wire sensing, wire identification, troubleshooting, string locating, and aiding in wire-list documentation. Typical applications are in Wire Wrap or Termi-point backpanel wiring, solder- or crimp-style



cabling and harnessing, and printed circuit motherboard checking. The unit, available in a range of points from 16 to 240, in multiples of 16, can check 128 points in a second. Price for a typical model with 48 accessible points is $1,200. Each additional unit of 16 points is $300.

SCI Electronics, 8330 Broadway, Houston, Texas 77017 [394]

Conveyor/dryer processes coated components

A conveyor/dryer provides controlled time-temperature processing of parts coated with photoresist, epoxies, potting compounds or thick-film slurries. Desired temperature is achieved through varied belt speed adjustment and the independent temperature setting on each modular infrared heater unit. Temperature range is from 50° to 250°F

They said no one could build and sell a computer-controlled LSI/IC test system for under $100K...

then along came Macrodata!

"Once upon a time test equipment manufacturers convinced each other that $250K wasn't too much to pay for a computer-controlled DC/IC test system. In fact, they even convinced their customers.

"Then along came Macrodata. First off, for only $200K, they built and delivered the first high-speed LSI test system, the MD-200. Then they set their sights on a system that could sell for about one-third of that price.

"No sooner said than done—they called it the MD-150. And within the first two months, many systems were purchased by leading IC manufacturers—installed and at work testing devices.

"The MD-150 is a cascaded, computer-controlled system designed to test all types of LSI/IC devices at functional speeds up to 5 MHz. It tests RAM's, ROM's, shift registers, and semiconductor memories, as well as random logic. It lets you test both MOS and bipolar devices optimally because of its unique interchangeable pin electronics and Macrodata's 'firmware' packages, and testing can be done at the wafer level and/or in the final package.

"When you buy the system, here's what you get: (1) *an MD-50 Sequencer,* which includes a computer and tape cassette that control the execution of a variety of test programs; (2) *an MD-100 Tester,* which performs functional testing and supplies control information to the device under test at 5 MHz; (3) *an MD-83 Automatic Parameter Tester,* which is capable of running a full complement of DC functional/parametric tests for single-pin or multiple-pin testing; (4) *an MD-73 Programmable Clock,* which consists of up to six, one-nanosecond, programmable 'clocks,' with rep rates of 11 MHz; (5) *an MD-44 Programmable Power Supply,* with up to nine, precision, programmable units; (6) *Pin Electronics,* with up to 42 channels, which can be configured for LSI.

"In plain talk, the MD-150 is here today, ready to work for you now. It is packed with many third-generation design features, and provides 5 MHz performance at half the price of other so-called competitive units, for as little as $60K. It requires no special software or add-on boxes, so you can launch right into a 'zero overhead testing' program immediately."

So much for Chapter II of the Macrodata Story. Look for the next exciting chapter soon. Meanwhile, for a free copy of the MD-150 brochure, use the reader service card; and if you can't wait, just call us directly.

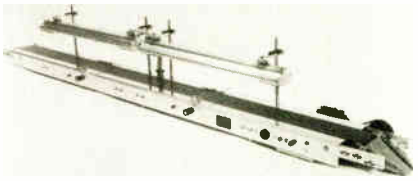
Chapter Two. The Macrodata Story.

MACRODATA™

Macrodata Company, Test Systems Division, 20440 Corisco Street, Chatsworth, California 91311, (213) 882-8880

Sales Offices: San Jose Area Tel. (408) 268-7714 • *Philadelphia Area* Tel. (609) 228-1325 Telex: 83-1496 • *New England* Tel. (617) 862-5700 • *Southeast Area* Tel. (205) 883-0140 & *Munchen 23, Bismarckstrasse 12, West Germany* Tel. 395028 Telex: 841-521-5969 • *Milan, Italy* Tel. 871988-899248 Telex (843) 34314 • *Tokyo, Japan* Tel. 03 985 5266 Telex: (781) 272-2171

New products

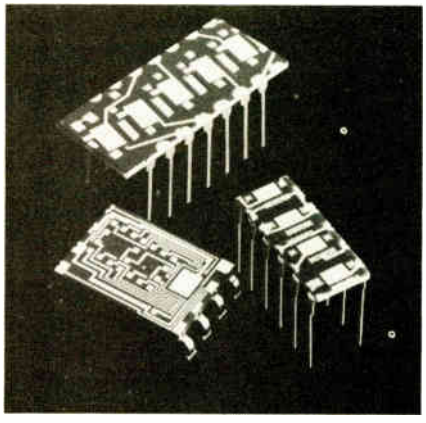


or 150° to 550°F. Price of the conveyor is $475. Each additional three-foot section is $125. The dryer is priced at $325.

Engineered Technical Products Inc., 3421 U.S. Highway 22, North Branch, Somerville, N.J. 08876 [396]

Packages for LEDs use black ceramic background

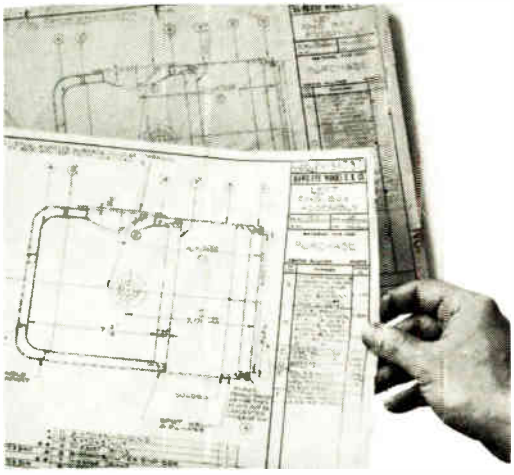
Development of a compatible black ceramic material and of a high-volume photoetch technique have led to design of a new family of packages for light-emitting-diode alphanumerics in multidigit configurations. The black alumina ceramic provides the contrast needed for LED displays and a surface suited to fine-line photoetch patterns. Cur-



rent standards of 3-mil line/3-mil spacing are readily attainable, the company says. The LED packages now in volume production include one-, five-, and six-digit configurations. The feed-through interconnection technique uses metalized vias from front to back of the basic substrate, permitting use of lower-cost brazed-on lead frames instead of pins.

Metalized Ceramics Corp., 100 Niantic Ave., Providence, R.I. 02907 [398]

"RETRACING OLD DRAWINGS IS SUCH A DRAG."



Save hours of drafting time with KODAGRAPH Films.

There's really no reason to waste time retracing those old, battered drawings. A much better way is to rejuvenate them by making sharp, clear photographic restorations on Kodagraph film.

You'll be amazed at the results. Weak lines come back strong and clear. Stains virtually disappear. And instead of gray on yellow, you've got sparkling, contrasty, black-on-white prints. Best of all, you not only eliminate drafting time, you save money, too.

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ENGINEERING DATA SYSTEMS

Kodak

Play around for a change

When was the last time you tackled a complicated design - and then plugged in a new set of variables?

And then switched the variables again?

An intricate calculation isn't something you can just whip off on a slide rule. By the time you grind through one hefty equation, you may not be fired up to try it a different way.

But now there is the Wang Design Engineer System.

At the touch of a button, this inexpensive programmable calculator/output writer combination gives you answers in seconds. Because your calculating time is slashed, you have more time for experimentation. And you get a better feel for your problems.

We can offer you a variety of programs stored on magnetic tape cassettes. Or you can program the System yourself if you prefer; it's a quick and easy process.

As your needs increase, you can add peripherals like disk storage units, X-Y plotters, micro interfaces and paper tape editors. We have a fine selection of external and internal devices and we're always developing more.

Really, you should think of the Wang Design Engineer as an inexpensive personal computing system. It can give you the design freedom you want and need.

For more information, just call Tom Courtney, collect: (617) 851-7211. Or call your local Wang sales office; you'll find us in the Yellow Pages under "Adding and Calculating Machines."

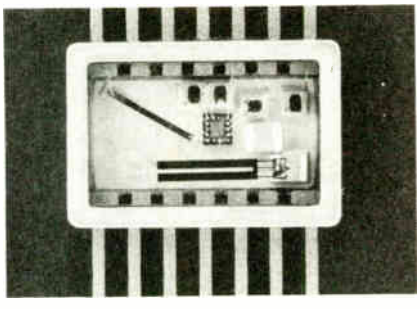
WANG

Semiconductors

Oscillators use less than 20 μW

C/MOS timing circuits with quartz crystals put out 1 Hz to 100 kHz

Watches aren't the only devices that can use subminiature micropower timing circuits. Statek Corp., a small company that makes subminiature, low-frequency crystals, says they're useful whenever space and power



are limited and rough handling is possible—in oil industry instrumentation, satellites, medical implantation, and even animal tracking.

Statek is now packaging its crystals with C/MOS oscillators and dividers in flatpacks and TO-5 cans to give what must be the smallest timers available. The oscillator units, which draw as little as 5 microamperes at 3.5 volts, can produce frequencies of 10 to 100 kHz, and up to 42 binary divider stages can be added (in slightly larger, ⅜-by-⅜-by-0.07-inch flatpacks) for pulse outputs at long intervals.

The heart of the units is the photolithographically produced tuning-fork quartz crystals developed by Juergen Staudte, president of Statek. These are batch-processed much like integrated circuits, and, in fact, Statek sells them as separate components, generally mounted in TO-5 cans. For the oscillators, the crystals are combined with a small substrate containing resistors, some chip capacitors, and a complementary MOS IC (RCA 4007) used as oscillator, squarer, and driver. This is available in a TO-5 can or ¼-by-¼-inch flatpack. For outputs down to one pulse per second, an RCA 4020 divider can also be included for divisions up to 2^{11}, the whole device being packaged in a TO-5 can or ¼-inch-by-⅜-inch flatpack. For longer intervals, divisions up to 2^{12} are possible.

The oscillators are typically calibrated within ±0.01%, and have stabilities to within 5 ppm/°C to 10 ppm. Better performance is also available. Pin connections for the units include supply voltages (3 to 15 volts), oscillator output, reset, ground, and divided outputs.

Prices vary widely. An evaluation oscillator at 32.768 kHz is available for $150, and a timer costs about $139 in quantities of 50.

Statek Corp., 1200 Alvarez Ave., Orange, Calif. 92668 [411]

Analog multiplier includes everything except pots

Until now, when a system designer had to multiply two analog signals, he has had a choice—either design a circuit from scratch, or buy an off-the-shelf monolithic multiplier, design a working circuit, and add a zener diode, operational amplifier, and a precision resistor network—a total of 18 external parts. But for the system designer who doesn't want to be a circuit designer, Intersil Inc. has developed the i-8013.

Jack Gifford, analog product marketing manager at Intersil, says, "The 8013 is a four-quadrant analog multiplier for the guy who wants to multiply two numbers and get an input. In a typical configuration, all he needs is the 8013 plus four trimming pots." The 8013 contains multiplier, op amp, and precision resistor network on a single chip. The resistors—15 of them—are thin-film devices.

Offset voltage drift is 1 millivolt/°C, and feedthrough (or output offset) is 35 mV peak-to-peak at dc and 10 kilohertz. Full power bandwidth is 700 kHz and slew rate is typically 50 V per microsecond; settling time to 1% is 0.8 μs.

In operation, feedback around the internal op amp provides level shifting and can be used to generate division and square root functions. A simple arrangement of the pots may be used to trim gain accuracy, offset voltage, and feedthrough.

Two temperature ranges—−50 to +125°C and 0 to +70°C—are available. Prices range from $32.30 to $12.75 in 100 lots.

Intersil Inc., 10900 North Tantau Ave., Cupertino, Calif. 95014 [412]

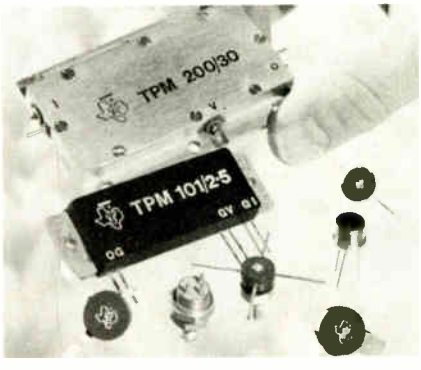
MOS receiver-transmitter's strobe rate is 200 ns

An MOS universal asynchronous receiver-transmitter subsystem called the U-ART strobes at a rate of 200 nanoseconds and has a 20-kilobaud rate. It is fabricated by a p-channel low-voltage oxide-nitride process. All inputs and outputs are directly compatible with diode-transistor-logic and transistor-transistor-logic. Tri-State output levels are also provided for those output signals that are bus-structured. Price ranges from $30 to $20.50 each, depending on quantity.

Standard Microsystems, 1101 San Antonio Rd., Mountain View, Calif. 94040 [413]

High-frequency transistors designed for communications

A line of 73 high-frequency power transistors is intended for communications applications. The units are suited for the 2- to 30-, 175-, 470-megahertz and 1-gigahertz bands. They can be used in fixed or mobile equipment with 13- or 28-volt sup-



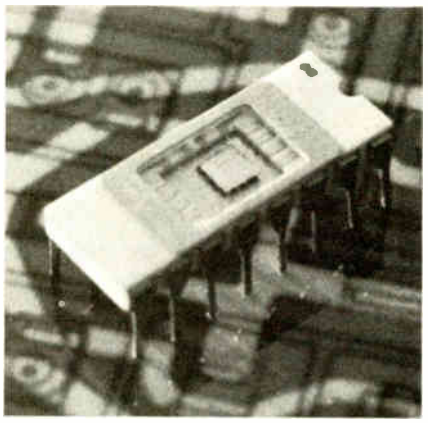
New products

plies and can withstand all voltage standing wave ratios at the output. Price in 500 to 999 quantities ranges from $1.05 to $83.50 each.

Texas Instruments Incorporated, P.O. Box 5012, MS/308, Dallas, Texas 75222 [414]

256-bit bipolar RAMs offer 35-nanosecond access time

Two 256-bit bipolar random-access-memory integrated circuits are for use in scratchpad memories, write-control stores and main memory applications. Designated the models 82S06 (three-level outputs) and the



82S07 (open-collector outputs) the RAMs have an access time of 35 nanoseconds and exhibit virtually no data setup, hold, or recovery time. The devices have protected pnp emitter-follower inputs, and require only 100 microamperes of 0-level input current. Price in 25-lots is $39.50 each.

Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086 [415]

2,048-bit MOS shift register runs on one + 5-volt supply

A 2,048-bit shift register runs on one +5-volt supply, and accepts standard transistor-transistor-logic outputs. The model 2401 is housed in a 16-lead silicon plastic dual in-line package as a dual 1,024-bit register. It is supplemented by a single 1,024-bit register, the model 2405, that has the same characteristics. The devices can be used as though they were

0.1pA I_g dual FET.

AD830 TRAK-FETS.™ Their performance is so revolutionary, we gave them a new name and came up with a new way to measure them.

This AD830 series is the newest addition to our family of monolithic dual junction FETS.

They offer gate leakage current of 0.1pA which is the lowest ever. Are optimized for 30μA operation. Have typical breakdown voltage of 80V. Excellent thermal transient rejection. And tight G_{fs} and Y_{os} matching.

Tracking linearity is so excellent, we're calling our AD830 series TRAK-FETS. And have created a new TDN spec to measure them.

TDN stands for Temperature Drift Nonlinearity. To get it we have to measure V_{GSI-2} at −55°C, +25°C, and +125°C.

Typical values of TDN are ±1μV/°C. (Max is ±5μV/°C). Which means you can routinely adjust for I to 5μV/°C performance. While paying for a 50μV/°C device.

We get this remarkable tracking without resorting to interdigitation and its common-back-gate problems. The secret is a high-quality silicon nitride process.

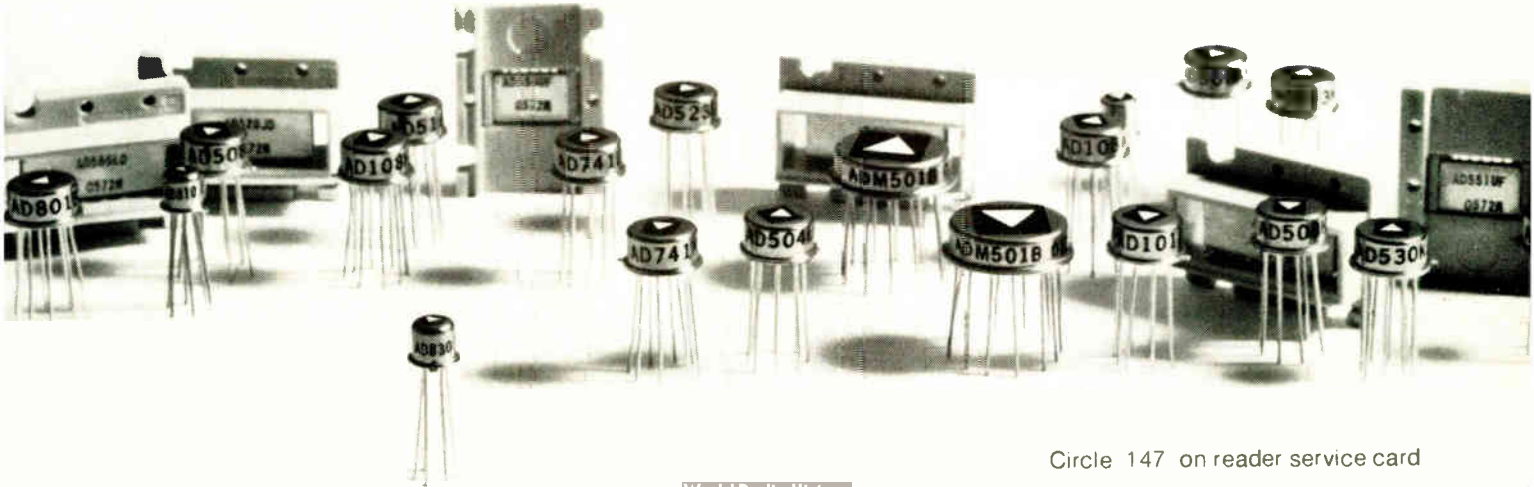
TRAK-FETS can be applied anywhere high impedance and low drift are important. In electrometers, pH meters, photo and ion current transducers, sample and holds, and low drift integrators.

Besides our AD830 series, we have AD5906 with gate leakage current of 1pA maximum. And AD3954 which are optimized for 200μA operation with I_g typical of 5 pA.

All models are ready now. And we'll be glad to send you an evaluation package of five at our hundred piece price. As well as our 1972 Product Guide which shows all the things we make to solve more of your problems better than anyone else.

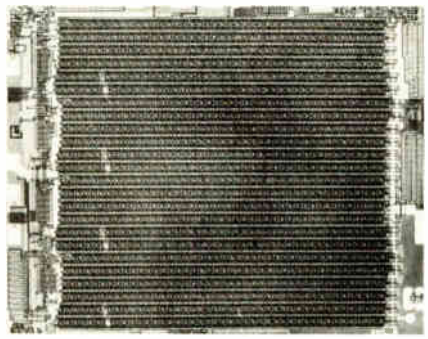
Analog Devices, Inc., Norwood, Mass. 02062. Tel. (617) 329-4700.

ANALOG DEVICES



Circle 147 on reader service card

New products

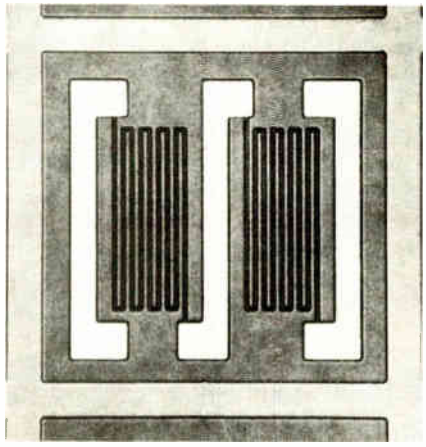


TTL circuits, and connect to TTL logic without level shifters, clock drivers, pull-up resistors, or other interfacing circuitry. Price in 100-lots is $24 each for the dual-type 2401 and $11 for the single-type 2405.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [416]

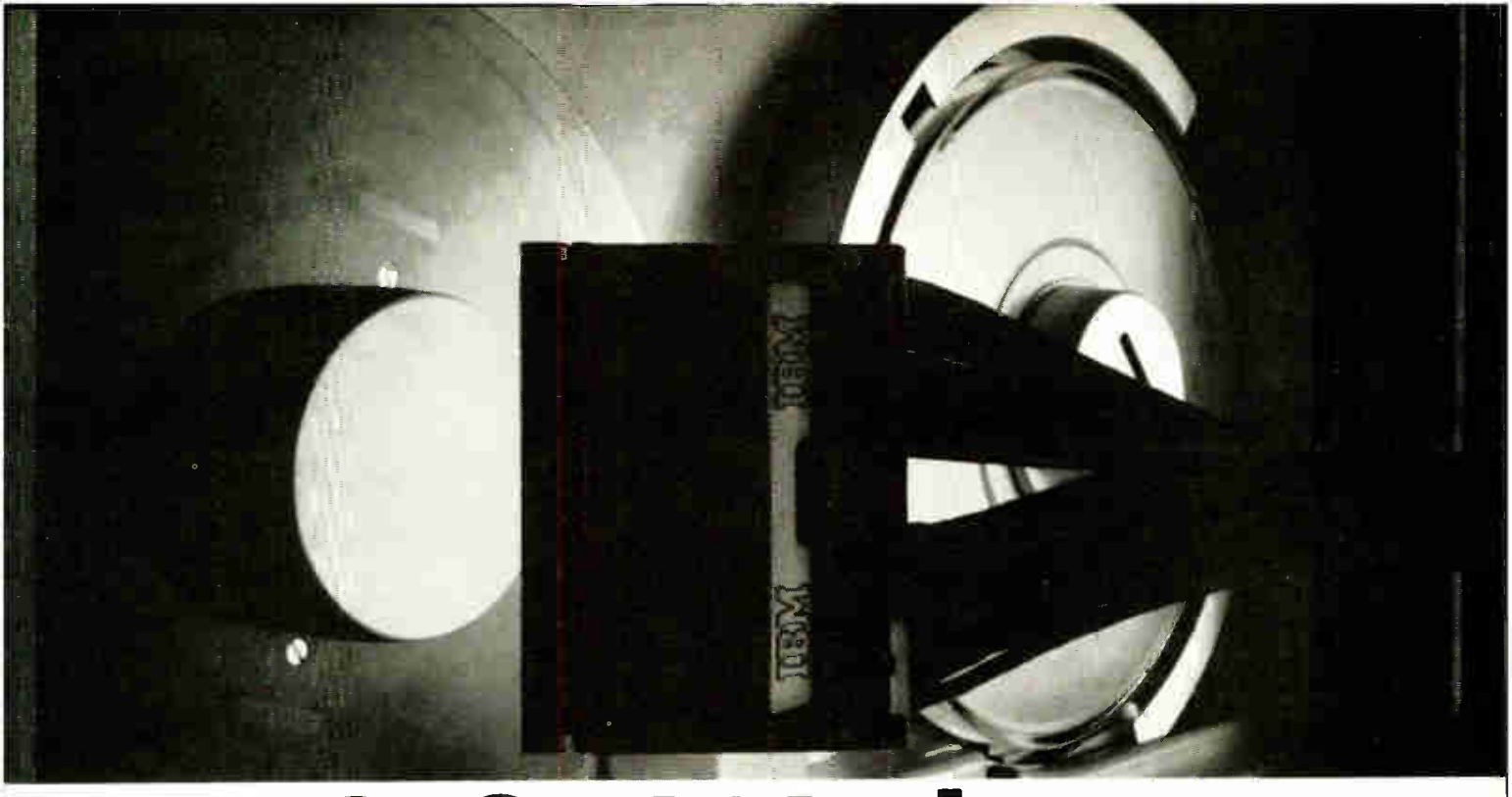
Tantalum nitride chips offer high-density resistance

Tantalum nitride chip resistors for hybrid circuit applications offer what the company describes as four times the resistance previously possible on a standard 30-mil chip. The material also makes possible increased packing densities for thin-



film chip resistor networks. The new resistors have a disipation rating of 250 milliwatts in the 30-mil size. All standard RETMA values from 4.7 ohms to 2 megohms are included in the line. Resistance tolerance is ±10%; on special order, resistance to ±0.5% can be provided.

Semi-Films Technology Corp., Box 188, West Hurley, N.Y. 12491 [417]



1962. IBM plugs CalComp into IBM.

1972. A new plug.

It happened at the Seattle World's Fair. IBM displayed an early CalComp drum plotter. Driven by their 1620 computer.

They knew a good combination even then.

What's happened since is history. A lot of people have been plugging CalComp disk drives and plotters into just about every computer IBM makes.

And because we've been in and around the computer room for a long time, you would expect us to provide you with a superior tape drive system, as well.

We just have.

Our new plug. The 1040 Tape System.

As you've come to expect, our lease prices are lower than IBM's. And our terms are more flexible.

The equipment, itself—like our disk drives and plotters—is IBM compatible, designed to grow with your needs, and fully-serviced. Everywhere.

For information about the new 1040 tape system, write California Computer Products, Inc., Dept. EM-M4-72, 2411 West La Palma Avenue, Anaheim, California 92801. Or call (714) 821-2011.

CALCOMP

New Products/materials

Molding powder, designated E-Form 7-72, is designed for encapsulation of Mylar, tantalum, and ceramic capacitors and wire-wound metal film resistors. The material is a mineral-filled, soft-flow epoxy molding compound. Storage stability is more than one year at 77°F with evidence of little or no change in flow characteristics or molding properties.

Epoxy Products, P.O. Box 1404, New Haven, Conn. 06505 [476]

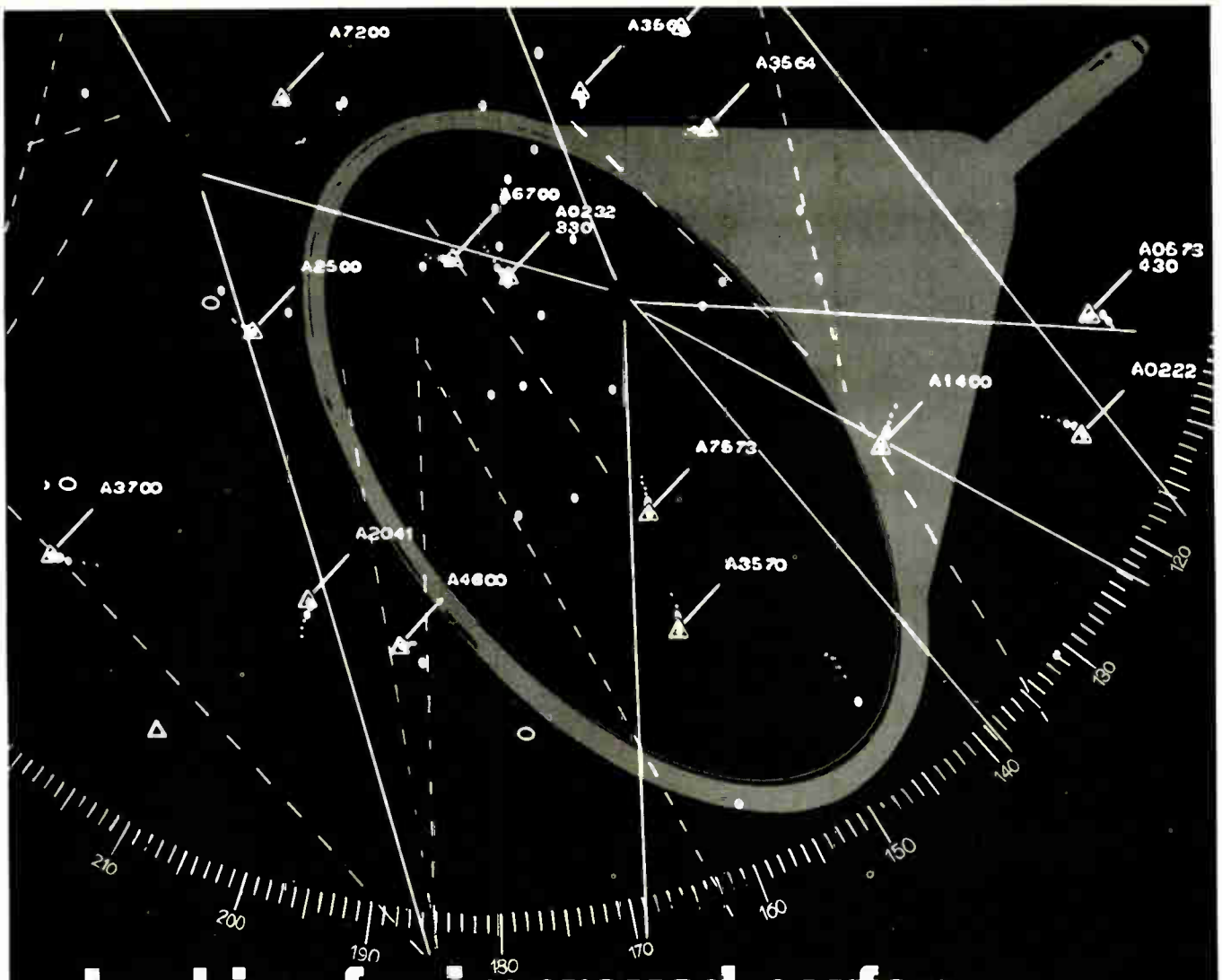
Epoxy resin system series 4130, guaranteed 100% reactive, is designed for a wide variety of applications. Three curing agents are available with varying properties, as well as a choice of room-temperature or heat-curing types.

Mereco Products, Div. of Metachem Resins Corp., 530 Wellington Ave., Cranston, R.I. 02910 [477]

Silicone rubber, called Eccosil 4952, features high thermal conductivity at a value of 7.5 BTU × in./hour × foot² × °F. Recommended applications include encapsulation of components that tend to overheat. The material, which also provides protection from vibration and shock, is priced at $3.45 per pound in 18-pound lots.

Emerson & Cuming Inc., Dielectric Materials Div., Canton, Mass. 02021 [478]

Epoxy disintegrating material, called CT 325, will selectively disintegrate many thermoset resins but will not attack molded phenolics, nylon, Teflon, linen, formvar, or metals. Applications are in the semiconductor and microelectronics industries. Four-gallon lots are priced at $19 per gallon, five-gallon bulk con-



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Our unique OME 1184 features dynamic focus which provides higher and more uniform resolution across the screen diameter, thus allowing the presentation of flight data in alpha-numeric characters as small as 0.2" x 0.3". Greatly improved readability is achieved even in highly lighted ambient conditions.

Type	Diameter	Overall length	Deflection angle
OME 1489*	22"	29"	53°
OME 1490**	22"	31"	53°
OME 1184	22"	30"	53°

* interchangeable with R 6132
** interchangeable with R 6263

For more information on these, our 16" CRT's, and our full line of radar display CRT's for air traffic control, please circle the appropriate number on the Reader Service Card, or contact us direct.

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Italy - THOMSON-CSF Tubi Elettronici SRL / Viale degli Ammiragli 69 / ROMA / Tel. 6380143
Sweden - THOMSON-CSF Elektronrör AB / Box 27080 / S 10 251 STOCKHOLM 27 / Tel. 08/6009990
United Kingdom - THOMSON-CSF Electronic Tubes Ltd / Bilton House, Uxbridge Road, Ealing / LONDON W5 2TT/Tel. 01-5791857

New products/materials

tainers cost $90, and price for a single gallon is $20.
Starnetics, P.O. Box 9308, North Hollywood, Calif. 91609 [479]

Copper-clad laminate is for printed-circuit board applications. The material, called Textolite grade PG-68, is nonbreakable and flame-resistant. The polyester-glass laminate is available in three thicknesses of 0.047, 0.055, and 0.062 inch. Standard sheet size is 36 by 48 inches, but individual pieces may be cut to customer requirements. Delivery is from stock.
General Electric Co., Laminated Products Business Dept., Coshocton, Ohio 43812 [480]

Resin foaming flux, designated type 465, is designed for the mass soldering of printed-circuit assemblies utilizing automated wave-soldering equipment. The rosin-based flux eliminates the need for thinner in most cases and has no acid content. Small samples are available at no cost.
Kenco Alloy & Chemical Co. Inc., 418 W. Belden Ave., Addison, Ill. 60101 [341]

Embedding compound, designated type 463, filled with microscopic glass spheres, is said to weigh half as much as conventionally filled resins. Good compressive strength suits the material to applications in aerospace modules, specifically for potting various types of electronic components. Price is about $15 per gallon. Quart sizes of the compound are also available.
Castall Inc., Weymouth Industrial Park, East Weymouth, Mass. 02189 [342]

Flame-retardant, noncorrosive, cross-linkable polyethelene compounds are for wire and cable applications. Called Flamolin 752 and 755, the materials conform to UL and IPCEA vertical flame tests. Flamolin, which is self-extinguishing and nondripping, gives off small amounts of light, white smoke, and noncorrosive fumes when it is ignited.
Plastics & Chemicals Div., Rauchem Corp., 300 Constitution Dr., Menlo Park, Calif. 94025 [343]

Why pay for features you can't use?

B&K INTRODUCES FOUR OSCILLOSCOPES! DC TO 10MHz, REMARKABLE PRICES!

If you use, design, test or service complex electronic equipment, B&K Precision has the oscilloscope for you at a remarkably low price. Four solid state scopes designed for production testing, incoming inspection, quality control, maintenance or engineering.

Their rugged construction, input protection and cool operation almost eliminate equipment down time. Simplified controls and built-in accuracy combine to minimize testing errors, reduce set-up and testing time. Ideal for untrained or semi-skilled operators, because they can now concentrate on the job, not the test equipment.

In fact, the 1440 and 1465 scopes can actually be used by semi-skilled people to read Peak-to-Peak voltages of waveforms. These two scopes incorporate CALI-BRAIN,® the B&K patented system that automatically lights the correct meter scale and full scale voltage (with decimal point), collapses the horizontal sweep to a vertical line, and moves the vertical line to that meter scale! CALI-BRAIN simplifies test procedures, measures voltages of complex waveforms.

All of these scopes have FET input stages for drift-free operation with 10MHz wideband frequency response; 35 n sec risetime insures high fidelity resolution. For television work, there are special sync separator and integrater circuits and sweeps corresponding to TV horizontal and vertical sync rates. Vectorscope operation is simplified with a removable CRT overlay.

B&K Precision scopes are built to test the performance of most types of electronic equipment. From the 1440 recurrent sweep scope, to the new 1470 dual trace triggered sweep scope, they cover the range of your oscilloscope requirements. But you no longer have to pay for features you can't use in order to get the durability and accuracy you need. Look again at the specifications and prices.

They're remarkable.

Sold by electronic distributors throughout the United States. For more technical data, and information on how to get a demonstration of these scopes, write Dynascan Corporation, or call your local B&K distributor.

B & K Precision Model 1440
Recurrent Sweep Oscilloscope

Vertical Amplifier: DC coupling, DC-10MHz (−3db), AC coupling, 2Hz-10MHz (−3db), Risetime 35 n sec., Sensitivity: .1, .3, 1, 3, 10, 30, 100, 300 volts full scale (16.6 mV/cm). Max. input 600 V (P-P) Horizontal Amplifier: DC-800KHz (−3db). Sweep System: AC-5Hz to 800KHz (−3db) recurrent sweep in 6 steps. Trace expansion 2 x screen diam. 6 cm x 10 cm CRT. with patented CALI-BRAIN® system.

Price **$299.95**
(with Direct/10:1 probe)

B & K Precision Model 1465
Triggered Sweep Oscilloscope

Vertical Amplifier: DC coupling, DC-10MHz (−3db), AC coupling 2Hz-10MHz (−3db), Risetime 35 n sec., 0.1 volt full scale (16.6 mV/cm) to 200 volt full scale sensitivity range in 11 attenuator steps. Max. input 600 V (P-P) Horizontal Amplifier: DC-800KHz (−3db). Sweep System: 1μsec/cm to 20μsec/cm triggered sweep in 10 steps. Vernier adj. for continuous control. Trace expansion 5 x at all speeds, 0.2μsec/cm max. 6 cm x 10 cm CRT. With patented CALI-BRAIN® system.

Price **$369.95**
(with Direct/10:1 probe)

B & K Precision Model 1460
Prof. Triggered Sweep

Vertical Amplifier: DC coupling, DC-10MHz (−3db), AC coupling 2Hz-10MHz (−3db), Risetime 35 n sec., 10mV/cm to 20V/cm sensitivity range in 11 attenuator steps. Max. input 600 V (P-P) Horizontal Amplifier: DC-800KHz (−3db). Sweep System: 0.5μsec/cm to 0.5 sec/cm triggered sweep in 19 steps plus TV-V and TV-H. Vernier adj. for continuous control. Trace expansion 5 x at all speeds. Max. 0.1μsec/cm. 8 cm x 10 cm CRT.

Price **$399.95**
(less probes)

B & K Precision Model 1470
Dual Trace Oscilloscope

Vertical Amplifier: DC coupling two channels each, DC-10MHz (−3db), Risetime 35 n sec., 10mV/cm to 20V/cm sensitivity range in 11 attenuator steps. Max. input 600 V (P-P) Horizontal Amplifier: DC-800KHz (−3db). Sweep System: 0.5μsec/cm triggered or automatic sweep in 19 steps. Vernier adj. for continuous control. Trace expansions 5 x at all speeds, Max. 0.2μsec/cm. 8 cm x 10 cm CRT. Available in March 1972.

Price **$499.95**
(less probes)

B&K Division
Dynascan Corporation
1801 W. Belle Plaine · Chicago, Illinois 60613

New literature

Software. A four-page brochure available from SofTech Inc., 391 Totten Pond Rd., Waltham, Mass. 02154, describes the company's software language capability. The brochure also discusses problem-oriented languages. Circle 421 on reader service card.

Wall chart. Ballantine Laboratories Inc., P.O. Box 97, Boonton, N.J., has published a wall chart that provides a reference source of theoretical and applications data in the instrumentation field. The 34-in.-by-22-in. chart contains tables, panels, and equations. [422]

Electrolytic capacitors. Cornell-Dubilier Electronics Div., Federal Pacific Electric, 150 Ave. L., Newark, N.J. 07101, has issued a data sheet that describes a line of single-ended type PC aluminum electrolytic capacitors for printed circuit board insertion. [423]

Miniature sockets. Berg Electronics Inc., New Cumberland, Pa. 17070, has available a bulletin describing the Minisert miniature printed-circuit board sockets, and equipment used for inserting these devices. [424]

Magnetic tape system. A four-page bulletin on magnetic tape systems is available from Microdata Corp., 644 East Young St., Santa Ana, Calif. 92705. The bulletin contains general descriptions, specifications, and a list of standard features for the models 800 and 1600. [425]

Recorders and memories. A four-page brochure from Telex Communications Div., 9600 Aldrich Ave. South, Minneapolis, Minn. 55420, describes the Termi series of digital cassette recorders and memories for point-of-sale equipment, data capture, peripheral storage, data communications, and keyboard-to-tape applications [426]

Negative thermistors. An eight-page brochure from Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830, deals with the company's line of negative temperature thermistors.

New Literature

which are designed for industrial and consumer applications ranging from temperature measurement to electrical circuit temperature compensation. [427]

Telemetering modules. A 40-page catalog is available from Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343, detailing the line of fm-fm telemetering modules that includes voltage controlled oscillators, dc amplifiers, dc signal isolators, frequency-to-dc converters, and tone oscillators. [428]

Two-channel recorder. Gould Inc., Instrument Systems Div., 3631 Perkins Ave. Cleveland, Ohio 44114. A four-page bulletin discusses the model 222 two-channel general-purpose recorder with internal battery supply. [429]

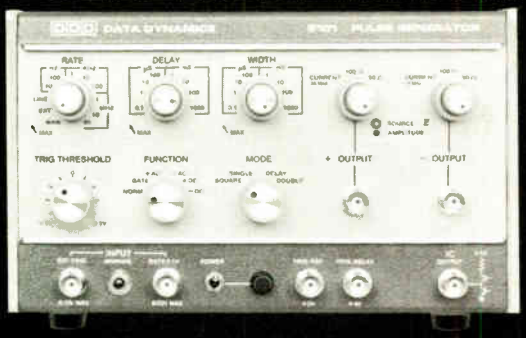
Automatic testing. Zehntel Inc., 1450 6th St., Berkeley, Calif. 94710, has published a bulletin detailing the company's automatic testing equipment, and also discusses such topics as problems and programing. [430]

Laser systems. Apollo Lasers Inc., 6365 Arizona Circle, Los Angeles, Calif. 90045, has available a data sheet on high-power laser systems with power levels to 100 joules or more. [431]

Linear applications. A linear integrated circuit applications handbook is available from National Semiconductor Corp., 2900 Semiconductor Dr., Santa Ana, Calif. 95051. The 304-page booklet provides an indexed and cross-referenced collection of linear applications using both monolithic and hybrid circuits. Product areas include op amps, comparators, analog switches, p-i-n diode drivers, and phase-locked loops. [432]

Emi filters. Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. 90221, has published a data sheet on the specifications and capabilities of the GF series of multicircuit emi filters for ground support equipment. [434]

PULSE GENERATOR



1 Hz to 50 MHz—$550.

The new Model 5101 Pulse Generator produces pulses at rates from 1 Hz to 50 MHz and includes features found only in much more expensive equipment. For example: three simultaneously operating outputs are available; Positive, Negative and Current Sinking I.C. There is a Single, Double, Delayed and Square Wave Output. The Pulse Width and Pulse Delay are variable from 10 ns to 1 second with the outputs short-circuit proof. All of these features, including a pulse Rise and Fall Time typically of 5 nanoseconds, makes the 5101 a definitely superior instrument. Send for complete specifications, or call us or your local representative for an in-plant demonstration. **Telephone: 201/567-5300**

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Circle 185 on reader service card

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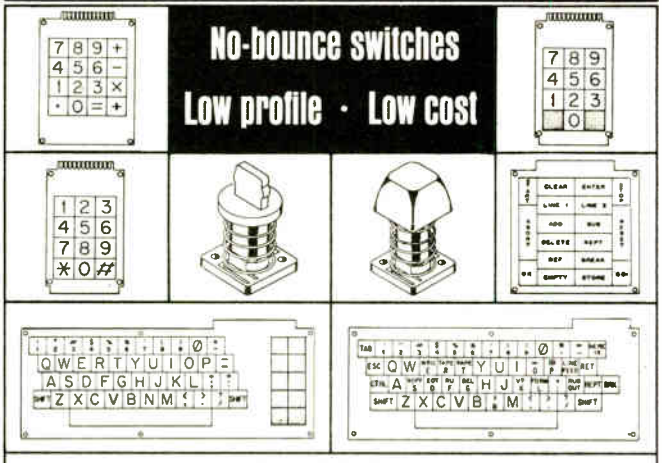

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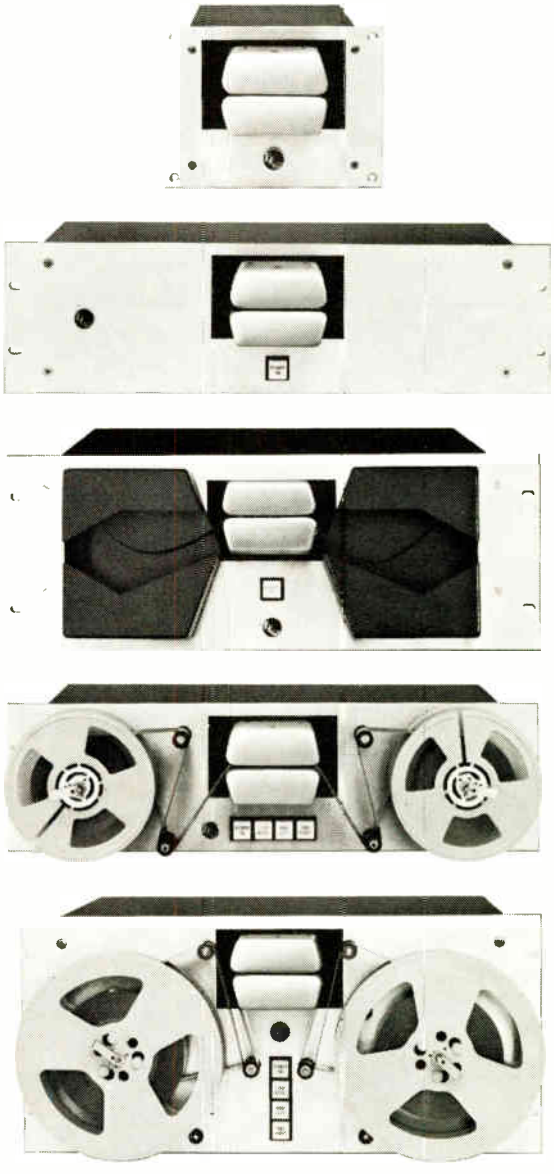

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Circle 157 on reader service card

New books

Encyclopedia of Instrumentation and Control, Douglas M. Considine, Editor-in-Chief, McGraw-Hill, 788 pp., $29.50

Douglas Considine and a team of more than 100 engineers and scientists have compiled a handy desk reference covering instrumentation and control technology. The encyclopedia reaches through all of the basic sciences and links the scientific concepts to thousands of practical industrial applications.

The book should be of value to EEs requiring basic explanations of how to use unfamiliar instruments and control devices in a wide variety of systems. After many entries, additional references are given. The coverage is fairly comprehensive and wide-ranging—including medical and biological instruments and lasers. Excellent sections are included on computers as well as space and missile-system instrumentation.

Information, Computers, Machines and Man, A.E. Karbowiak and R.M. Huey, John Wiley & Sons, Inc., 347 pp., $7.50

Electronic Circuit Analysis, Couros Ghaznavi and Arthur H. Seidman, The Macmillan Company, 526 pp., $14.95

Introduction to System Theory, Stephen W. Director and Ronald A. Rohrer, McGraw-Hill Book Company, 441 pp., $16.50

Alternating Current Bridge Methods, B. Hague. Sixth edition revised by T.R. Foord, Pitman Publishing, London, 602 pp., £7, plus handling fee

Digital Storage Systems, W. Renwick and A.J. Cole, Chapman & Hall Ltd., 309 pp., $12.75

Modern Operational Circuit Design, John I. Smith, Wiley-Interscience, 256 pp., $14.95

Electronic Engineering Materials and Devices, John Allison, McGraw-Hill Book Company, 303 pp., $13.50

A kitfull of switch sealing solutions free

Complimentary contents include: assortment of different color, size and shape environmental switch and circuit breaker seals . . . some that snap on, others that screw on. Plus a detailed catalog and a sheaf of "unexpected" design application histories. Write :

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the 304 allows free movement of personnel until a restricted area is entered

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the 304 automatically monitors status boards, meters, level guages, conveyor belts, traffic

Fire Protection
the 304 detects most types of smoke, giving added fire protection to secure areas

Indoor/Outdoor
the 304 is ideally suited for outdoor use because it does not respond to slow variations in light level

Fail Safe
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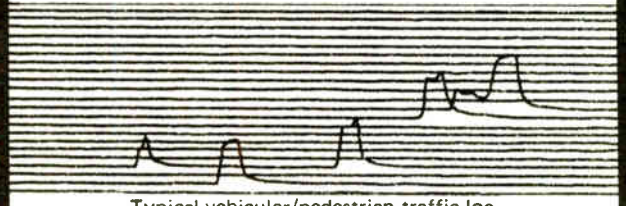

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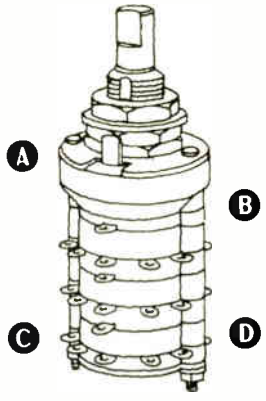

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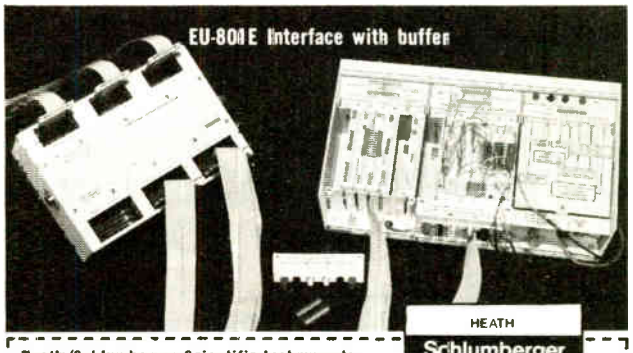

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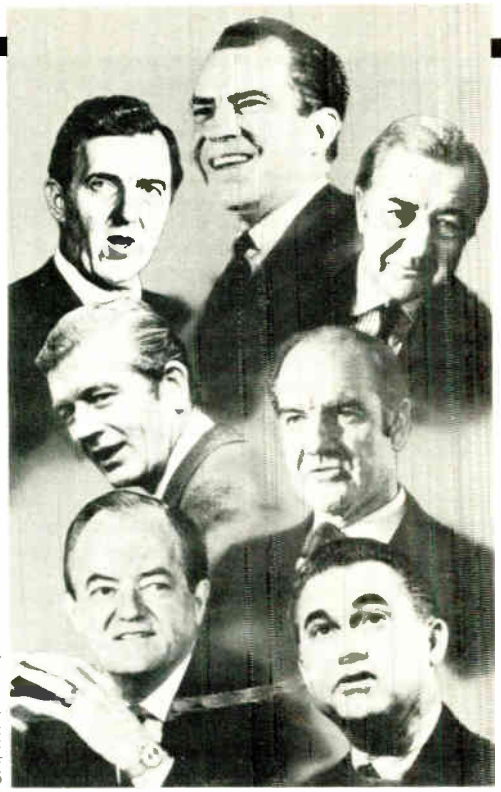

UPI, WWP, Joan Sydlow

personal business®

APRIL 1972

Political itch is easy to scratch in campaign years

Getting into politics isn't as difficult as it's cracked up to be. There is plenty of room at the bottom.

Room at the top is harder to come by, of course. Nomination to a national office such as a seat in Congress has to be relentlessly pursued, and even lower-level jobs in government rarely seek out the man. But playing the game at the bottom—as a grass roots political worker—is a snap. No candidate turns down an offer of help. "There are two things all candidates are short of," says a Washington pro who has handled a string of campaigns. "One of them is money, and the other is people's time and energy."

Anyone who has ever taken out a magazine subscription or applied for a credit card stands a good chance of getting dunned for cash by more than one candidate between now and the Nov. 7 election. Volunteering your time is just about as easy. Despite the maze of campaign committees, citizen's groups, and such, one phone call can ring a bell for a volunteer, and cut through easily:

· To the Committee for the Re-Election of the President, in Washington, for example; here (at 202 333-0920) Paul Kayser, heading up liaison with business for the President's 1972 drive, will know how a businessman can find the most useful spot on the grass roots team in his own town.

· To the Democratic National Committee (202 333-8750) where Robert Nelson, a staff director who has been working closely with the state party organizations, can similarly point the way.

· To the Washington office of any incumbent senator or representative (202 224-3121)—where a businessman's own congressman (or his administrative aid) will gladly point out the best home town political lead for activity in '72.

By now, of course, the individual presidential candidates have organizations reaching into most of the states; but a phone call to a candidate's national headquarters is still a good idea for anyone who isn't sure about whom to contact in his home town. And signing up to work for a party slate—down-the-line—is easiest of all. A call to the party's local county chairman (who will often be listed in the phone book under the party name) turns the trick. The county chairman, incidentally, is often the key political power in a city, and to insiders it matters little that he is out of the public limelight.

It is still not too late to get into the middle of the grass roots pulling and tugging. The campaign—for temporary volunteer workers—is still young. It is true that in most states the process of select-

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ing delegates to the two big national conventions (Democrats July 10, Republicans Aug. 21) is under way. But in only a few states has the routine been completed—and in some places, New York, for example, it is still possible to get on the ballot as a primary election candidate for state delegate. It's a question of rounding up the required petition signatures. True, for an outsider, this would be a brash political move; but a VIP in business might just turn the trick if he chooses.

Brash moves aside, any businessman who simply telephones and says that he wants a place in the campaign—meaning he is willing to take on some sweat and strain and contribute some cash—will be welcomed with open arms. Says a key man on the Committee for the Re-Election of the President: "We feel that businessmen want to be, and should be, involved."

Grass roots work isn't glamorous—at least, not usually—but it's important. No candidate can win without this kind of effort behind him. The main job: to get the candidate's message across .and ultimately to get his voters to the polls on election day. For the most part such efforts are peopled by volunteers who are overwhelmingly amateurs and largely short-term enlistees.

Turnover is high, partly because really working on a campaign is insatiably time-consuming. "In most suburban areas, it's rare to have even the same precinct chairman for more than one or two elections," complains an official of the Democratic National Committee. "That makes it hard to know where you're strong and where you're weak." But though turnover is a problem for political professionals, it's not bad from an eager volunteer's point of view. It means that advancement can come surprisingly fast—especially if a new recruit has something to offer besides enthusiasm.

Most businessmen have plenty to offer—organizational know-how, for one thing. Only the dullest precinct official is going to ask a business executive to stuff literature into envelopes, work the telephones making blind calls, or deliver leaflets to every door in a neighborhood. But a smart one might well ask a proven administrator to take a look at the precinct operation and see if it might be improved—or perhaps even to take it over and see that it's done right.

On a higher level, a businessman might find himself asked to organize other businessmen in his home area into a cohesive group to talk up the candidate in conversations with friends, to work on ways to get the right voters to the polls, or to plan and carry out fund-raising events. With the election more than six months away, many such slots are still unfilled on political organization charts all over the country. By and large, business groups are not well organized to carry out this sort of activity to make their voting power felt in elections. Labor, however, is superbly organized, and gets results by concentrating on voting districts that are riding on the political fence.

Obviously, such work can very nearly be a full-time job. But it's the kind of job that could be vastly important between now and November—not just in the presidential election, but in congressional races as well. In fact, a businessman might be able to have more immediate impact—and cement a warmer friendship—working in a congressional race than in the presidential campaign. He'd be more likely to come to the attention of the candidate.

The use of business contacts is touchy—but often important. Certainly, any man willing to work for a candidate is going to try to persuade his friends to vote his way. But some businessmen are strategically placed to carry the message even further. Unless he's convinced that a customer's politics are dead-set against him, a salesman, for example, might do some valuable political spadework. "These are the kind of people who are *most* welcome in any campaign," says one political manager.

Mostly, of course, the first thing a businessman will be asked for is money. As a businessman, he's supposed to have it, and no campaign—no matter how idealistic—can do without cold cash. And it's not a bad business investment. The newly-enacted income tax deduction is small—a $50 deduction or a $12.50 credit, or double that on joint returns—but the rewards can be sizable. Not that anyone will admit it publicly, but all successful candidates keep records—and some are now even computerized—of who contributed what in the course of a campaign. A common breakdown in congressional offices is to categorize contributors into groups of $1 to $99, $100 to $499, $500 to $1,000 and on up to a top category of over $5,000. The files also usually show whether a contributor worked for the candidate as well.

The hard fact is that a congressman or staff member of his will try to help any business constituent who comes asking for information or assistance on a problem relating to the government. This goes with the job. But it stands to reason, too, that a man will try harder for a friend. And in politics, friendships are proved during campaigns.

—BRUCE AGNEW

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Vehicular living: $10,000 ties up a yacht on wheels

Exploring wide-open spaces is the lure of the new, go-anywhere motor homes.

Inside, wide-open design is the criterion for comfort while living on wheels.

Americans have been living on wheels since the covered wagon was the fastest way to travel west of Chicago. Today it's being done in slicker style—in motor homes that average around $10,000 apiece. You can wheel your way over any horizon, riding on rubber while you soak up the comforts of home. With everything from color TV to hot showers aboard, the day of the rattling cook-out camper on the dusty trail is done. Motor homes are booming business.

Companies such as Winnebago, Travco, Avco, Superior and Executive are turning out so many units that by 1980 over 1-million houses-on-wheels will be traveling the highways. The motor home, incidentally, shouldn't be confused with the giant-size "mobile home" that is seen parked permanently atop cinder blocks. The motor home is a *going* unit, a de luxe traveler (pictures).

Now it's in its third generation. The grandfather was the VW camper that first became popular some 10 years ago; then came the pick-up truck unit—cumbersome, but great in its own way. The grandchild, today's modern motor home, is at least four times bigger than the VW and has everything, *including* the kitchen sink. Orthopedic beds that convert into a cocktail lounge, quadrophonics with speakers in all four corners of the living space, wall-to-wall, indoor-outdoor carpeting, roof-top sun decks, year-around weather conditioning—name it, and *for a price* it can be tucked into a deluxe motor home.

Upwards of $7,000 will buy the smallest outfit—an 18-ft. unit; top of the line measures 28 ft., and costs about $20,000. It is even possible to spend as much as $40,000 for a 28-footer that is custom-made, hand-crafted.

How does one buy? Slowly. Anybody new to the RV (recreation vehicle) business will want to shop with caution. Trade-ins are frequently obtainable as the aftermath of hasty purchases—like the man who discovered that, after all, he could use his unit but three weeks a year. A $10,000 or $15,000 motor home that isn't used frequently for weekend trips is a waste of cash and equipment. "First, make sure it's your wife's thing, too," says an old hand—and he is *so* right. One idea is to rent before you buy—not only to test out the equipment but also to discover whether yours is really a motor home family.

In any case, a buyer should see as many different makes as possible, and compare construction, inside layout, and price. (One way to do this is to visit the nearest RV or sportsman trade show.) Some units, for example, have floor plans that ignore the realities of daily family living; they strive for too much "space utilization" and end up being over-compartmentalized, cut up, and too cluttered. A family is better off with less such "efficiency" and more in the way of open interior living space. Visualize what the unit would be like on a confining rainy day—with wife and children.

Don't be smitten by fancy decor. Some of it that's on the market today—sometimes built into expensive motor homes—is as thin as veneer in quality. Open the cabinets to check on the wood finish that is not supposed to show. Examine the hardware on drawers, doors, and such—and compare it with what you have at home. And be space-conscious in your own way. Check for ample closet space, and be sure that the interior space is connected to the outdoors by sufficient vents and windows that will open wide. Be fabric-minded, too. For example, don't fall for shag rugs which are a disaster to keep clean near a beach or woods (demand indoor-outdoor carpet). And don't fall for fancy ads that show couples dressed up and dining by candlelight—who in the world really "goes formal" when they're aboard a motor home?

It's smart, of course, to talk with people who've been through a season or two of motor home living and traveling. Subscribing to some of the magazines in the field is wise, too. *Motor Home Life*, and *Woodall's Trailer Travel* are quite good—though you'll likely get more nuts-and-bolts information from motor home buffs who have lived through some of those confining rainy days. Also, write for all the company literature that is readily available. Much of it is slick material, though—so weigh it accordingly. If nothing else, it is one way to make a comparison check on prices.

It is important, too, to shop around for a good motor home dealer. Keep in mind that much more than simple auto service will be needed. You're really buying a truck-and-small-house combination, and a "tune-up" can run into all kinds of complications. Check especially on the dealer's mechanics—will they, for example, be able to repair the bottle-gas system? Or the water supply? Or the complex air-conditioning system? And get a clear understanding on whether the dealer will stand behind the warranty for each appliance. Or will he send you searching for the manufacturer?

There are more details attached to owning a motor home. For instance, it costs a bit to operate the unit on the road—eight miles per gallon is average. And tolls, overnight fees, and such, can amount to more than you might imagine. But it's impossible to be cut and dried about motor home living. It is a way of life, a mood, a means of escape. And anybody who has to analyze his feelings in terms of dollars and cents alone isn't really ready to hit the road.

—RICHARD A. WOLTERS

Taking a bite of the big deals in real estate

"The best investment on earth is earth." That adage is as deeply imbedded in the American consciousness as the Protestant ethic of hard work. In the past couple of years, however, promoters have turned it into a rallying cry for group-investment real estate deals.

First the real estate investment trust and more recently the limited partnership or broad-based syndicate have drawn hordes of investors into real estate for the first time. Wall Street, too, has joined the stampede, and many of its most prestigious houses are packaging private and public offerings in limited partnerships. The price of admission, too, has been lowered. As little as $500 will buy into H. Hentz & Co.'s American Real Estate Investors, and, while $10,000 minimum investments are still most common, several of the new Wall Street-backed syndications set minimums at $1,000 to $6,000.

Syndicating—breaking one large investment into smaller pieces—has been around for a long time, but mostly among well-heeled private investors. The tax shelters in the 1969 Tax Reform Act, designed to stimulate residential construction, are what opened the floodgates. Private capital began to pour into new residential construction. Builders such as the Larwin Group (a subsidiary of CNA Financial Corp.), Klingbeil Co. (49%-owned by Columbia Broadcasting Co.), and L.B. Nelson Corp. (10%-owned by American-Hawaiian Steamship Co.) have formed syndicates of their own.

Kaufman & Broad, Inc., biggest of the independent housing builders, operating under Section 236 of the HUD Act, buys only federally-subsidized apartment housing projects built by others for its American Housing Partners. ITT's Levitt & Sons, long the nation's largest builder of single-family homes, is now building apartments for the first time for sale to limited partnerships.

Many of the best limited partnerships are being put together by seasoned hands in the real estate business. But this type of syndication has attracted some junk dealers, too. The proliferation and uneven quality of limited partnership offerings has begun to worry both the real estate fraternity and government watchdogs, and the securities industry itself is about to crack down on some of its members. The board of governors of the National Assn. of Securities Dealers (NASD) late last year approved new rules that come down hard on such self-enriching practices as payment of real estate brokerage commissions and excessive fees to the syndicators. The Securities & Exchange Commission and various states, too, are expected to stiffen their rules.

For all the caution lights flashing, the rush to syndication shows no sign of abating. Syndicates are not only more numerous, they're bigger. In California, applications for small syndications (those with fewer than 100 investors) dropped from 166 in 1970 to only 105 in 1971. The larger syndications, however, showed no such decline. "In the last two years, they have really taken off," says Michael Broady, supervising corporation counsel in California's Department of Corporations.

Numbers alone don't tell the whole story. In California, as in many other states, there has been a marked increase in "blind pool" syndications—those to finance an unspecified group of investments rather than an individual property. Even in New York, where syndicators must comply with one of the toughest disclosure laws in the U.S., registration of limited partnerships is up sharply. Offerings of all types of real estate investments jumped from $2.8-billion in 1969 to $4-billion in 1970. Last year the New York total swelled to $7-billion, and there is another $2-billion in the pipeline. Limited partnerships account for about 35% to 40% of these offerings.

The appeal is obvious. Investors who buy into a conventionally-financed apartment project in the pre-construction state get to share in tax writeoffs from development as well as operations. New residential construction also is the only type of real estate that is now permitted to depreciate using the 200% double-declining balance method that shelters operating income in the early years. If the partnership invests in federally-subsidized (236) apartment projects, which many now do, it gets the additional advantage of interest rates as low as 1%, and a chance to avoid any current tax when it sells by using the new "roll-over" provisions—that is, putting the proceeds into other subsidized housing.

The type of partnership an investor selects should be determined by his own needs, of course. Generally, the conventional deals offer a cash return of 7% to 9% which is tax-sheltered, plus a crack at a potential profit when the property is sold at a later date. The Section 236 deals, which can be for new or rehabilitated housing, feature minimal cash flow, but plenty of tax shelter.

The rub in any of these deals, however, is not only the quality and location of the projects themselves, but the quality of the ongoing management. A study done for the U.S. Dept. of Housing & Urban Development revealed that some 60,000 trained management people would be needed by 1978, but only 1,300 per year are being turned out. Big operators like Levitt, Nelson, K & B, and Larwin, of course, are conducting their own training programs, and they offer management and maintenance contracts to the limited partnerships.

The quality of management, however, is difficult for the average investor to evaluate. As Kenneth D. Campbell, editor of Audit's Housing & Realty Investor, a respected newsletter, put it recently: "The selling methods for syndications far outstrip the sophistication of small investors to understand the real estate or the management of the funds themselves."

The novice investor must recognize, too, that he usually sacrifices some liquidity in return for income or tax-shelter. Only a handful of interstate limited partnerships can be freely traded. K & B's American Housing Partners, for one, is traded over-the-counter, and its underwriter, E.F. Hutton & Co., maintains a market in the shares.

The single most important ingredient in these deals is the syndicator. The best bet for newcomers is one of the dozen or so big names on Wall Street that have built solid expertise in real estate and have moved into limited partnerships in a big way. Investment houses such as Lazard Freres & Co., Eastman Dillon and Donaldson, Lufkin & Jenrette have been orchestrating private placements for years. White, Weld & Co. pioneered the public offering in December, 1969, and it has since been followed by Smith, Barney & Co.; E.F. Hutton; Kidder, Peabody; Paine, Webber; Merrill Lynch, and several others.

The fact that a syndicator is a member of the NASD is, however, no assurance of reliability. John McCoy, assistant director of corporate financing at NASD, estimates at least three or four dozen new members deal primarily in real estate investments, and have joined NASD mainly to qualify for marketing limited partnership units interstate.

According to Los Angeles real estate professional Allen B. Sackler, executive director of Moss & Co., a good, reliable syndicator should be easy to recognize. "He will be the one who is investing for something more than tax shelter," Sackler says, ". . . and he will be willing to back the venture with his own personal funds."

—RESA W. KING

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How to find the broker who is right for you

For one entire business day, the well-dressed elderly gentleman prowled the boardroom of E. F. Hutton & Co.'s main office in Los Angeles. More than the board itself, he watched the men behind the desks. Occasionally he noted down with whom they talked, the amount and kind of mail they handled, the location of their desks, when they arrived, when they left, and what they read. Occasionally he would stop and chat.

The next day he returned, this time to talk to the manager. He identified himself as an investor who, at 90, had been able to spend 60 years of his life abroad living on his stock dividends and profits. He asked to open an account—and he knew precisely which one of the registered representatives he wanted to handle it.

That was one investor's way of solving the tricky problem of picking a broker. Not many have the time to go about it the way he did. Few have the experience to judge good from bad, even then. But it's something every would-be investor in the stock market eventually has to do. For him, there are these words of advice:

Picking a good broker begins with picking a good firm. A good firm, first of all, is financially strong. Its service is careful and it is prompt in filling orders and delivering securities. And, since a high percentage of brokerage clients depend on their registered representatives as financial advisers, the quality of its research must be high.

Unfortunately, the financial strength of a brokerage is not easily determined. Most of their financial statements leave much to be desired—although the Securities & Exchange Commission (see below) is taking steps to repair some of the deficiencies. Few firms make public their income statement, this is now mandatory only for those that now have public stockholders.

To really know the situation, one would need, among other things, a two-column balance sheet, one column showing funds applied to the firm's accounts and needs versus funds provided by the firm's owners, and another showing funds applied to client needs versus funds provided through client sources. One would need to know the firm's history of "fails," "differences" and "shorts"—all transaction failures. And a careful reading of all auditor's footnotes, of course, would be essential.

When it comes to the brokerage balance sheet, the first point usually examined is the net capital ratio—the aggregate indebtedness of a firm divided by the net capital, as defined by the New York Stock Exchange and the SEC. The rules are constantly changing, but recently the Exchange set 15-to-1 as the maximum allowable, and put member firms on warning at 12-to-1. Naturally, the lower the figure the better, from the viewpoint of a prospective client.

In the absence of such full and accurate figures, *the best check on both a firm and its individual registered representatives is through someone who knows them from personal experience.* Somehow, a firm's general reputation gets around. If it is known as being prompt in remitting dividends, delivering securities and rendering accurate statements, its financial position is also likely to be good. A reputation for hiring—and keeping—superior personnel is a plus. The type of clientele a brokerage attracts is also indicative.

One special point for small investors: *Do not hesitate to trade up when picking a broker.* If a firm's reputation is top-drawer, don't be bashful about bringing them your business. More than one modest investor has been bowled over to learn that he has access to the account and advisory services of some of the finest and most respected houses in Wall Street.

After selecting a firm, the next step is picking the best possible individual broker or "registered rep." In the larger, busier brokerage offices a newcomer is likely to run into the "man of the day" practice common to such establishments. That is, members of the staff are automatically assigned to drop-ins, on the theory that this gives everyone a

The investors' protectors make progress—but slowly

Washington has always been reluctant to meddle too deeply in Wall Street's affairs lest it damage the delicate workings of the nation's capital markets—and brokers, a tight-knit clan, have powerful voices in the lobbies of Congress. Thus, despite recent publicity on investor-protection moves by the SEC, day-to-day control still rests largely with the brokers themselves, through their exchanges and organizations.

Probably the most important steps to protect investors will involve several major moves: automation of the entire stock transfer system, complete restructuring of the securities industry to break up monopolies of trading facilities by stock exchange members, and doing away with fixed brokerage commission rates to increase competition between firms. Congress and the SEC seem to be moving in the direction of gaining a better, more secure deal for investors. But investors should remain aware that progress will be slow.

The most substantial accomplishment to date has been the creation of the Securities Investor Protection Corp. (SIPC), which guarantees customer accounts up to $50,000 (with a $20,000 limit on cash alone) when a broker fails. Other steps have involved technical matters relating to capital requirements and to financial reports now required of brokers. To illustrate management flaws within the industry that have prompted such moves, one new rule, for example, requires brokers—for the first time—to take a quarterly physical inventory of all the securities they are supposed to have on hand.

Under the year-long regime of Chairman William J. Casey, the SEC has spewed forth a host of proposals to improve the customer's lot. While some are certain to be modified, the agency has proposed the following:

- Brokers would be required to furnish annual reports that include income statements, balance sheets, and the source and application of funds and other data.
- As of April 1, brokers are required to segregate customers' securities, and put up cash reserves for securities they have lost or failed to receive in transactions with other brokers. Further, use of customers' cash, heretofore unregulated, will be sharply restricted.
- New rules to tighten up the management of brokerage houses, including one that requires bank statements to be reconciled within two weeks after receipt. Another would increase the minimum capital required to open a brokerage business to $25,000. It may shatter the newcomer's image of the well-heeled broker, but all along the minimum has been only $5,000.

—DEXTER HUTCHINS

chance at developing new accounts. While this serves the staff, it does little to assure the investor that he is getting the best possible man for his investment needs.

A much better procedure is to ask for the manager, and explain personal needs, remembering that every brokerage office has its top man, its low man, and some in between. A manager is often likely to think of his biggest commission producer as his best man, when in fact he is simply the best salesman. The investor should take pains to determine what the man's forte really is—whether he is a market-activated type beloved by in-and-out traders, a research-sensitive type who concentrates on profitable buys, or the analytical type skilled at structuring and managing portfolios—and decide which type suits him best.

Among responsible brokers, it is unthinkable that even a new customer's interests would take second place to those of the house or its staff—a satisfied clientele, after all, simply makes good business sense. Nonetheless, it must be remembered that registered reps, whatever their talents, are still salesmen. Their individual training, on which the larger houses spend up to $20,000, focuses mainly on sales techniques. Little is spent on developing the salesman's skills in securities analysis, since the houses already spend so much on their research departments. So a customer should remember that the value of the financial advice he gets largely depends on the quality of the house's research.

As in most businesses, registered representatives are subject to temptations. There is the temptation, for instance, to push high-profit securities—certain mutual funds, special underwritings where commissions are higher, secondary offerings, over-the-counter issues, and the like. The difference to the salesman can be considerable. For instance, when an investor buys, say, 100 shares of AT&T at $45, the stock exchange commission plus the current surcharge is 1.2% of $4,500—or $56.58. The salesman gets 25% or 30% of the commission (but not the surcharge), or $12. On the other hand, on $4,500 worth of a standard mutual fund, the commission is 8½%. The fund gets 2%, the house gets 6½% and the salesman's share (40% to 50%) is about $140.

The major houses spend large sums annually policing their customer's men. Still, the SEC feels impelled to toughen its own policing of the industry. In the last analysis, the one prime quality which an investor should seek in his brokerage and its registered rep is that old-fashioned virtue, *integrity*. He looks for it much the same way he looks for it in his physician, attorney, or accountant. It is basically a matter of checking the record.

—GERALD M. LOEB

Tax scene: dollar items in the news

MIDNIGHT OIL. The much muddled office-at-home deduction has been given murky treatment by Internal Revenue and the U. S. Tax Court since the mid-1960s. Businessmen have been reading muddled information on the subject, too, sometimes ending up on the carpet at the local IRS office. To IRS, the deduction—a write-off to cover the estimated cost of maintaining a part-time "office" at home—is valid only if homework is "required" by the company. The Tax Court (once again in a liberal stance) has laid on a gentler hand and declared that such costs are deductible if the home-office is *meaningful and helpful* to the individual in his work. . . . A new Tax Court case sides with the taxpayer, again; but since court cases are often costly and time consuming, a better bet is to obtain a simple statement from the company explaining that the home-office is, in fact, required. This, to be sure, is true in most cases—executives *do* work after five o'clock, and for many it's a must, not an option. Such a statement—signed by the chief executive officer, or the division head—should put the quietus on any IRS complaint.

UNLOADING A HOUSE. It's possible to take a capital loss on the sale of a house *if* the house clearly is rental property. But the write-off may be erased if it is just a temporary rental arrangement. . . . In a new Tax Court case, a taxpayer was faced with selling his house for less than he had paid—at a sales price that was about $5,000 under a current FHA appraisal. He made the sale but let his buyer rent the house for several months so that the buyer could sell *his* old house and swing the new mortgage deal. Taxpayer then took a capital loss for his $5,000 loss measured by the FHA appraisal. Said the court: Taxpayer loses his loss—the house wasn't true rental property. . . . A *long-term lease* with option to buy might have supported the loss, according to a leading Manhattan tax specialist.

WASH-SALE WASH. Commodity traders get a clean break on wash sales. The wash-sale rule says that if an investor buys back "substantially" the same stock or other security within 30 days, he may not claim a loss on the sale of his original shares. (The danger period actually is 61 days: 30 before and 30 after the sale—plus the day of sale.) Internal Revenue is willing to agree, however, that a loss on a sale may be deducted—even with a buy-back—where the property is something besides stocks or securities. And IRS has ruled that, for this purpose, at least, commodity future contracts are *not* stocks or securities.

SPREADING COLLEGE BILLS. More colleges let a student defer his tuition cost until after graduation, and sometimes the deferral runs a lifetime. Internal Revenue now says that the student picks up no taxable income in such a deal. He gets a loan, nothing more, and interest is fully deductible. . . . IRS notes, too, that where the student borrower later repays a higher amount than the deferred tuition-plus-interest, he may treat this extra sum as deductible interest (*Personal Business, Feb. '72*). A break for the well-heeled who agree to repay their loans with payments based on a percentage of income in later years.

NURSEMAIDS. Possible benefits under the child-care provisions of the 1971 tax law revision have been widely misunderstood. The old law placed a $900 top limit on what could be deducted annually by a parent to cover child-care expenses that enabled the parent to work full-time. The top limit is now up to $4,800 a year, effective Jan. 1, 1972. Deduction can be $200 a month for one child under age 15, $300 for two children, and $400 for three or more. Full deduction is allowed where adjusted gross income is as much as $18,000; above that amount, there is a 50¢ offset, dollar for dollar. Thus, at $20,000 adjusted gross, the top deduction is $3,800. Sometimes overlooked is that this break applies not only to a working wife, but to a widower or husband whose wife is disabled. For them, too, child-care is part of the expense attached to earning a living.

TIN LIZZIE. A casualty loss is supposed to arise from a "sudden" event, but suddenness takes all sorts of odd turns (*Personal Business, Mar. '72*). In a Tax Court case, the owner of an 11-year-old car pushed the definition to the floorboard—and lost. He claimed a deduction because the motor had conked out on the highway, and stated that "metal fatigue" was the cause. This was an admitted case of slow deterioration, said the court—*not* a deductible item.

DEADLINE. A reminder to anyone who is hard put to file the 1040 by Apr. 17: A two-month filing extension is now automatically obtainable by filing form 4868; 6% will be charged on tax due, from April 17 to filing date.

Cutting costs on auto coverage

The U.S. motorist's best hope for a turnaround in automobile insurance costs may lie in so-called "no-fault" programs. Pioneered in Massachusetts, the idea of paying claimants regardless of who was responsible for an accident has already rolled back some premium rates. But, while the concept has taken hold in one form or another in Florida, Delaware, Illinois, Oregon, South Dakota and Puerto Rico (and is being pushed on a nationwide basis), the savings from no-fault are still no more than a hope for most U.S. drivers.

While they wait, however, there is something they can do to shrink their annual premiums. The secret lies in the optional deductible clauses of their auto policies. The deductibles usually apply to collision insurance and comprehensive physical damage coverage. The policyholder usually agrees to pay the first $50 or $100 of damages, and his insurance company pays the rest. By raising the deductible amount—in effect, self-insuring a larger amount of the risk—he can lower his premiums.

For example, in an area where collision insurance costs are average—such as Cincinnati, Ohio—a driver with a safe record, no youthful drivers in his family, and a moderately-priced 1971 family car will pay $92 a year for collision coverage with $50 deductible. With $100 deductible, his rate drops to $69. And if he wants to assume $250 of the risk, his premium becomes $41. Comprehensive coverage for the same car would cost $11 with a $50 deductible, and $9 with a $100 deductible.

Owners of two or more passenger cars should be aware, too, that they are eligible for a discount if both autos are insured under the same policy. For example, say the Cincinnati driver buys a second car, a 1969 sedan. Normally he would pay $15 for full comprehensive coverage; $8 with $50 deductible, and $6 with $100 deductible. Collision coverage would be $80 annually with $50 deductible; $60 with $100 deductible, and $36 with $250 deductible. If the cars are insured separately, both with $50 deductibles on comprehensive and collision coverage, annual premiums would total $191. With both cars insured under one policy, the annual bill would drop to $162—a saving of 15%.

—MARGARET DONOVAN

Why Were Bankers Warned That This "New Book Could Upset the Savings Applecart"*

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There are many things banks don't like to talk about. They don't like to talk about the fact that they do, indeed, pay interest rates of 8%, 10%, 13½%, and often more, to a select group of knowledgeable depositors!

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1. Most thrifty people in this country today are actually *losing money* on their savings. The interest they get from a regular bank account is actually *far less* than the lost purchasing power that inflation cuts right out of their savings.

This is one of the great social tragedies of our time. It means that if you are thrifty and prudent in this country today, you are penalized. Either you are driven to speculate in the stock market, where you can be wiped out overnight. Or you try to secure safety for your hard-earned capital in a bank—*and watch inflation turn your dreams of early retirement and financial independence into dust!*

2. *But you just don't have to accept these two tragic choices any longer!* Now there is a Third Way to invest your money, that gives you the absolute safety you want, plus huge guaranteed returns that you may not even have dreamed possible before.

Read What The Banking Industry Itself Says About This Startling Volume!

NEW BOOK COULD UPSET THE SAVINGS APPLECART

TIGHT MONEY, Regulation Q, and the much-touted Age of the Consumer, are key ingredients in a flammable mixture about to be ignited by a book which could explode in the face of the commercial banking industry this year. This says:

"The millions of people who have saved a few dollars in the form of savings accounts and insurance have been prevented from gaining any profit from their investment—indeed they have been forced to accept real losses—by what amounts to government agency fiat. These depositors have contributed more, perhaps, to the growth of our economy than any other group, and it is unjust that controls apply only to interest rates to depositors, while there are no controls over the inflationary wage and price increases. Conditions permitting this 20 years of discrimination should be changed."

I am quoting from a book, titled, "Don't Bank On It! How To Make Up to 13½ percent and More on Your Savings—All Fully Insured."

The book is dedicated "to the members of the median income group, those truly forgotten men whose savings deposits make banking, as we know it, possible."

"Don't Bank On It" may be coming out at an auspicious time, as the general public is becoming more aware of high interest rates, and, thanks to truth in lending, is being conditioned to look at rates of 12 or 18 percent as low. No doubt he'll soon recognize that 4 or 5 percent is peanuts.

**Bank Marketing Management, Feb., 1970.*

About the Authors

Martin J. Meyer is president of the National Depositors Cooperative Association. He also serves as Vice President and Secretary of Intercept Tele-Communications, Inc., a new international cable and telegraphic interception and forwarding organization. Mr. Meyer has written numerous magazine articles on banking, thrift, and inflation.

Dr. Joseph M. McDaniel, Jr., recently elected President of the World Health Organization, was Secretary of the Ford Foundation from 1953 until his retirement in 1967 and Dean of the School of Commerce at Northwestern University. His distinguished career includes government service with the Economic Cooperative Association.

3. It is based on one simple fact: That most depositors are *completely passive* about where and how they save their money! They never take the one or two hours that are necessary to learn the "inside workings" of the banking system. Therefore, they never even hear about the "super-savings-accounts" that can yield them *far more* than ordinary interest on their money.

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At this moment, in this entire country, out of the over one hundred million people who have savings accounts, *only about forty thousand of them use these techniques.* They are still brand-new—virtually-unknown. *Only now has a book been published that reveals them to every man and woman who is willing to risk an 8¢ stamp to learn them!*

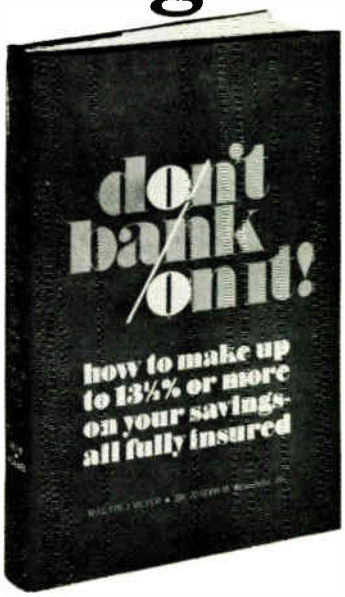
The time required to read this book from cover to cover is approximately one weekend. Or, if you wish to skip the banking background at its beginning, it will take you about an hour or two to learn these "Active Depositing" techniques themselves. *And once you learn them, from that moment on, you will be able to exploit every legal loophole in the entire banking system, including:*

How to get more than 8% interest per year as *an absolute minimum,* with hardly any more work than filling out your deposit slip in a different way. And then go from there all the way up to as much as 19% to 25% in special situations, for limited periods!

How to protect yourself against the possibility of interest rates dropping in the future. So you're *guaranteed* the high interest rates available to you today, even if tomorrow your friends find *their* return on their savings cut in half!

How to make banks pay interest to you *on money you don't really even have on deposit—on non-existent money—on money you have already spent!* (And the bank loves you for it. Because, no matter how much you make, they make more! Page 143 shows you how.)

Yes, how you can even earn high interest on *your credit card!* So that you are now earning interest on other people's money—*and spending it at exactly the same time!*



Special Warning Section: Two common mistakes, that unknowingly trap thousands of depositors every year, *that could completely destroy your savings!*

And how to defer income tax on the interest you get. Two plans that offer marvelous tax-sheltered advantages.

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1798 U. S. silver dollar jingles to the tune of $425

Coin investors are finding a golden jingle in old U. S. mintages. While the ranks of serious investors have increased, the number of collectable coins has quite naturally declined—and market prices have spun upward 20% a year. Investors today particularly eye early American coins, and, of course, rarity primarily determines worth. For example, an 1856 quarter eagle ($2.50) minted in Dahlonega, Georgia, and rated in "uncirculated" condition, is listed today at $4,500. Only 874 were coined; what's more, uncirculated condition is the second-from-top rating, below "proof" and one cut above "extra fine".

"The real interest today," notes Norman Stack of New York's Stack Coin Co., "is in gold coins. Collectors have increased 10 times in the past few years." Partly responsible is the steady rise in the value of gold. In the dollar devaluation of last winter, the official U. S. gold price rose to $38 an oz.— meantime, the world market was over $45. Some seers of the gold scene look for a 10% appreciation in the world price in 1972. . . . Gold bullion is unlawful to hold, but coins minted prior to 1934 are fair game. Some, including U. S. coins, are available at close to their intrinsic worth. Donald J. Hoppe's *How to Invest in Gold Coins* (Arlington House) is a first-rate guidebook. . . . Rising interest in coins as an investment has sparked a type of investor service similar to some security industry offerings. One such is First Coinvestors, Inc., Albertson, N. Y.; for a minimum of $50 a month, you buy several coins out of a selection, and are guided in building a "portfolio".

Cash-flow: money for college, land deals, annuities

It simply isn't so that a $15,000 income is the cut-off for college scholarship aid. Sometimes a family's income can be much higher than that. . . . A firm called Scholarship Search/IMS has come up with a list of 14,000 sources offering 150,000 grants to students. "And a surprising number have nothing to do with need or ability," says William Dahlman, head of the firm. Awards hinge on the student's hobbies, ambitions, even the father's vocation. A student fills in a comprehensive questionnaire and IMS's computer spins out a list of potential sources of aid. The tab is $20, and the guarantee is that 10 leads will be turned up, or money back (IMS, 120 E. 56th St., New York 10022).

Picking up a piece of rural real estate could be a profitable idea. At least, it's a way to give your springtime drives in the country something to center on. Along these lines, anybody who hasn't seen Irving Price's *Buying Country Property* would do well to set aside an evening or two. Price gets down to earth; he has tips that only a savvy country realty man could come up with. For example, on mortgages: "The difference in down payment requirements from just one county to the next—maybe only a few miles apart—can be as much as 20% or 30%." So, investigate. The pitfalls are many, says Price; like poison ivy, they should be recognized and avoided (Harper & Row, $5.95).

An *investment annuity* lets you move your nest egg from one investment vehicle to another with no tax consequences. Offered by First Investment Annuity Co. of America, it works this way: Money paid is deposited in the investor's personal annuity account, with a bank as custodian. Funds are invested in many ways. Depending on market conditions, the individual can go for stocks, bonds, mutual funds, etc., or a combination. FIAC provides an annuity tax shelter and mails monthly checks—for a fee of about 2% to 8% of the annuity investment, depending on dollar amount (FIAC, 1845 Walnut St., Philadelphia, 19103).

The good life

PB's restaurant-of-the-month is Bratskeller on Westwood Blvd. near UCLA in Los Angeles. Their shrimp-and-beer is a must. Boil a big mess of unshelled shrimp with some celery and bay leaf. When done, drain, rinse, and peel. Then simmer 3 cans of beer—and put the shrimp in for 3 min. Serve cold with a moderately hot cocktail sauce, with garlic bread on the side.

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LZS-10	5	450	$35
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2½" x 3½" x 1¼"

MODEL	VOLTAGE VDC	CURRENT mA	PRICE
*LZD-20	12 or 15	268 or 300	$55
*LZD-22	24	73	40
*LZD-23	24	129	55
*LZD-22	28	84	40
*LZD-23	28	143	55

*Single output ratings for dual output models connected in series

LZ-30 SERIES SINGLE OUTPUT MODELS
2½" x 3½" x 1⅞"

MODEL	VOLTAGE VDC	CURRENT mA	PRICE
LZS-30	5	900	$65
LZS-33	12 or 15	336 or 400	65
*LZD-32	24 or 28	186 or 208	65

*Single output ratings for dual output models connected in series

LZ-20 SERIES DUAL TRACKING OUTPUT MODELS
2½" x 3½" x 1¼"

MODEL	VOLTAGE VDC	CURRENT mA	PRICE
LZD-21	±5	300	$55
LZD-22	±12	73	40
LZD-23	±12	129	55
LZD-22	±15	90	40
LZD-23	±15	150	55

LZ-30 SERIES DUAL TRACKING OUTPUT MODELS
2½" x 3½" x 1⅞"

MODEL	VOLTAGE VDC	CURRENT mA	PRICE
LZD-31	±5	500	$65
LZD-32	±12 or 15	186 or 220	65

OVERVOLTAGE PROTECTOR ACCESSORIES

MODEL	FIXED VOLT RANGE VDC	FOR USE WITH	PRICE
LZ-OV-13	6.8±10%	All 5V units*	$10
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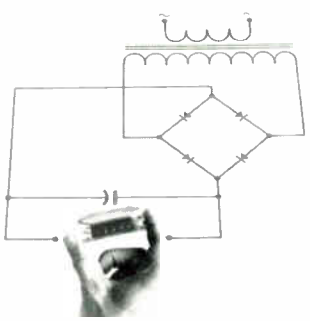
*LZ dual units require 1 overvoltage accessory for each output



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