February 15, 1973

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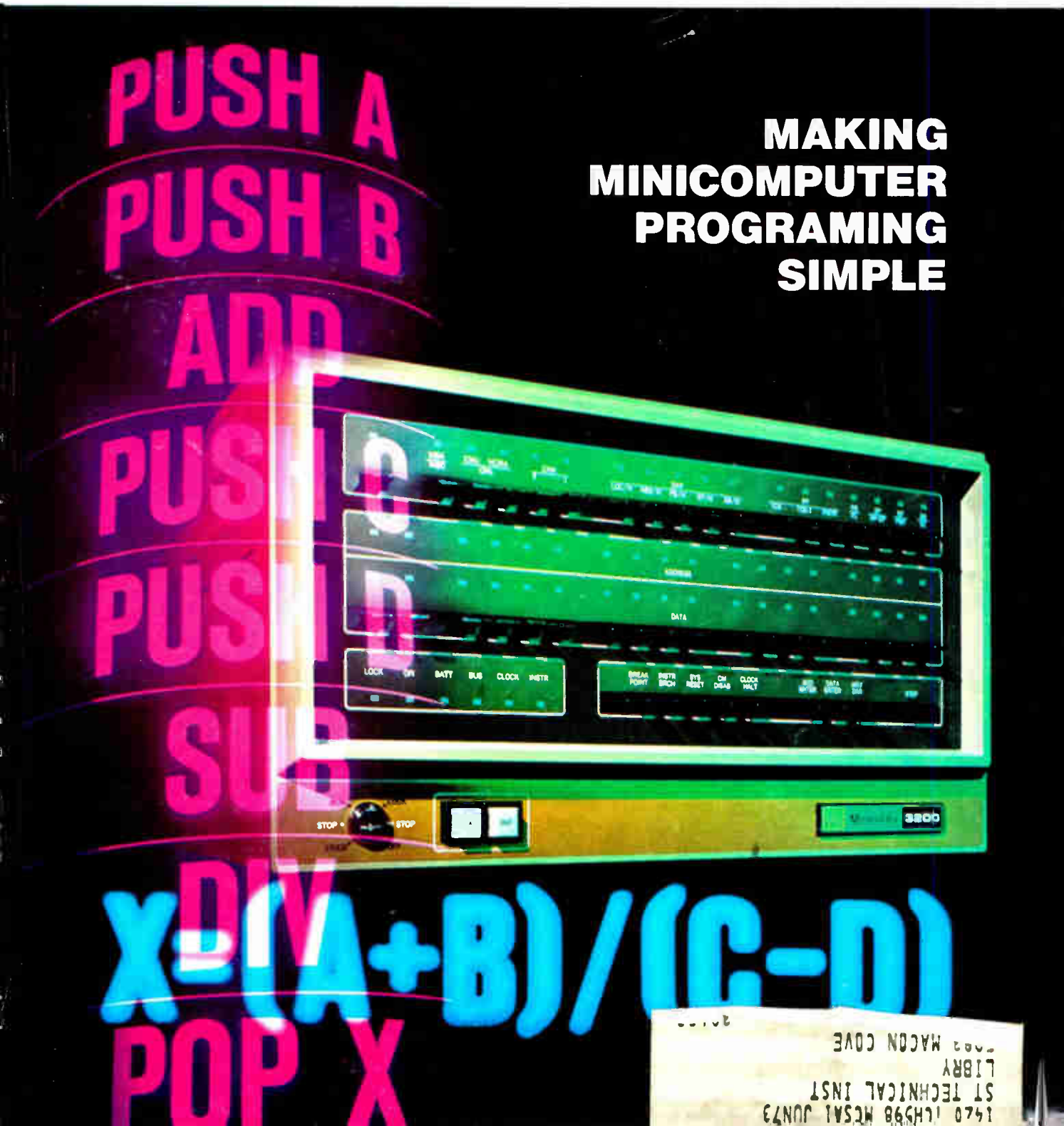
# Electronics

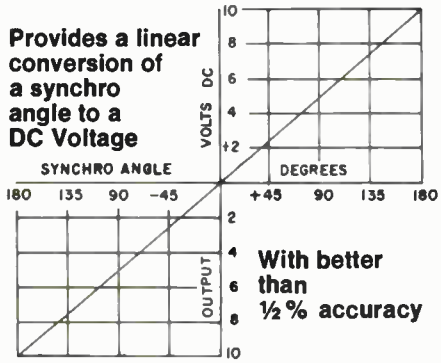


# 3 Wire Synchro to Linear D.C. Converter

**ACCURACY ½ %**

#MAC 1422-1

**Provides a linear conversion of a synchro angle to a DC Voltage**




**With better than ½ % accuracy**

- Scaled for ±10V DC output
- Operates from ±15V supplies
- No external adjustments
- Hermetically sealed
- Output short circuit protected
- Units can be altered to operate with different L-L Voltages or frequency

## *Specifications*

**Accuracy:** ±1% over temperature range
**Input:** 11.8V, 400HZ line to line 3 wire synchro voltage
**Output impedance:** less than 10 Ohms
**Input impedance:** 10K minimum line to line
**Reference:** 26V ±10% 400HZ (Unit can be altered to accommodate 115V if available at no extra cost)
**Operating temperature range:** −25°C to +85°C
**Storage temperature range:** −55°C to +100°C
**DC power:** ±15V ±1% @ 75ma (approx.)
**Case material:** High permeability Nickel Alloy
**Weight:** 6 Ozs.
**Size:** 3.6″ x 2.5″ x 0.6″

There is No Substitute for Reliability

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135 Bloomfield Avenue
Bloomfield, New Jersey 07003
(201) 743-2700

## Precision Analog Components for Signal Manipulation and Function Generation

- Radiation Hardened Analog Multipliers and Modulators
- Linear DC to Synchro Converter
- Sine-Cosine to 3 Wire Converter
- 3 Wire to Linear DC Converter
- 3 Wire to Sine-Cosine Converter
- Sine-Cosine Generators
- Precision Modulators
- Precision Analog Multipliers
- Squaring/Square Root Modules
- Precision Analog Divider
- Precision A.C. Regulators
- Demodulators
- Transformers

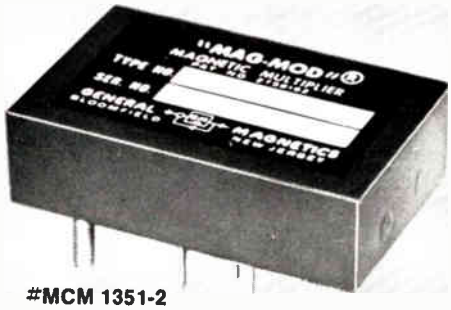
## Analog Computing Applications

- Trigonometric Manipulations
- Multiplying
- Dividing
- Squaring
- Modulating
- Automatic Gain Control
- Demodulation
- RMS Computation
- Phase Measurement
- AC Amplitude Regulation and Modulation
- Linearizing
- Square Rooting
- Power Measurement
- Ratio Measurement

## 4 Quadrant Magnetic

# Analog Multiplier

## DC x AC = AC Output



#MCM 1351-2

***Product Accuracy is ±1/2% of all readings Over Full Temperature Range of −55°C to +125°C***

- 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.
- Linearity, product accuracy, and zero point virtually unaffected by temperature changes.
- All units are hermetically sealed and completely shielded from external electric or magnetic fields.

## *Specifications Include:*

**Transfer equation:** E = XY/3
**X & Y input signal ranges:** 0 to ±3V Peak
**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
**Full scale output:** 3 VRMS
**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
**Size:** 1.8″ x 1.1″ x 0.5″

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Circle 900 on reader service card

# Here's a good reason to buy HP Modular Power Supplies

***Value Plus*** . . . at HP that means selection, performance, reliability, price! HP value plus starts with a broad selection of models and ratings in our 62000 Series. Performance? It's yours with 0.01% line and load regulation, 1mV rms/2mV p-p ripple and noise. Long a leader in the field, HP reliability means trouble-free design utilizing conservatively rated, quality components, plus built-in protective features. All this . . . and they're competitively priced (with quantity and OEM discounts).

## and another

Just as important . . . HP assures you of total program support, now and later. We have accessories to make your system designing easy, like: rack mounting trays, panels, slides and a compatible cooling unit. In fact, HP will build your entire system right to the custom front and rear panels.

## and another

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## and another

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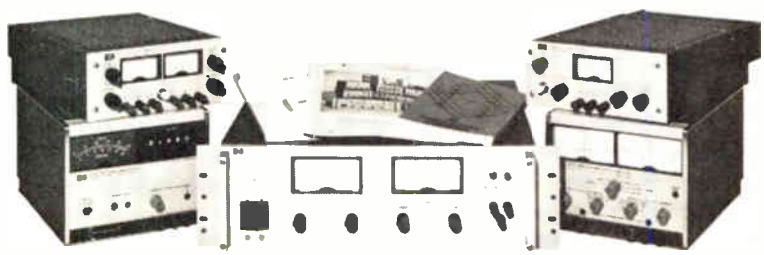

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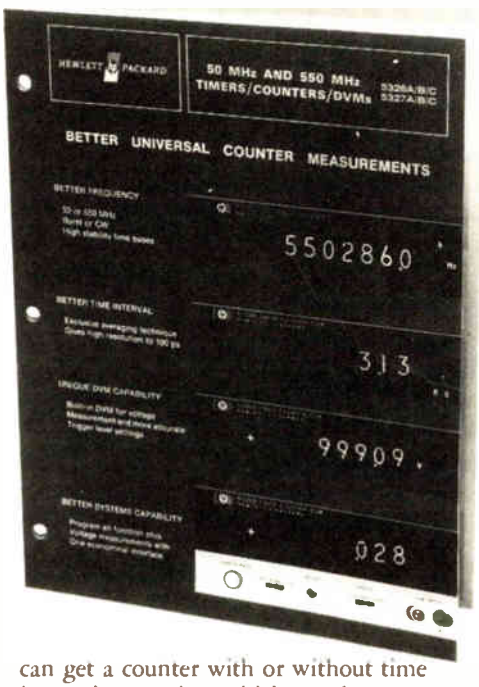
# and we'll throw the book at you.




## We'd like to send you our new booklet on how HP's high-precision universal counters can help you make better time interval and frequency measurements.

HP's 5326/5327 Series of counters offer you unmatched flexibility and versatility for a wide variety of applications. But best of all, you can get the exact counter you need without paying for a lot of extras.

For example, you can get frequency ranges to 50 MHz or to 550 MHz. You can get a counter with or without time interval averaging which can let you measure short time intervals faster and cheaper than ever before.

Or you can get a counter with or without a built-in DVM for more accurate and more convenient time interval measurements. And these counters feature a higher input sensitivity and high-accuracy time bases that have FCC-type approval.

And that's not all. HP gives you the most complete systems interface at the lowest cost. That means you can have the most ideal systems counter available anywhere. In fact, these counters are so versatile you can get almost any combination you need. Prices start as low as $995.

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Circle 2 on reader service card

Electronics
The International Magazine of Electronics Technology
Vol. 46, No. 4 ■ February 15, 1973



**Highlights**

**The battle of the budget, 68**
Nixon and Congress are struggling over who controls the purse strings, and some Federal electronics programs could get shot down. The outcome is unlikely to be cutbacks in existing contracts, but "if you are looking for big new starts, forget it," sums up one corporate analyst.

**Storage tube with silicon target has many uses, 91**
Dividing the functions of a direct-view storage tube between a CRT display and a silicon-target tube results in a storage tube of greater ruggedness and resolution and smaller size. It performs better in existing applications and attracts new applications.

**Minicomputer programing at minimal cost, 95**
Working in machine language may make the most of a minicomputer's peformance, but it also maximizes programing costs. A microprogramed minicomputer has therefore been designed from the ground up to talk a high-level language efficiently.

**Build your own multiprocessor, 123**
Bus-interconnection modules for the PDP-11 minicomputers let the user design his own computer hierarchy, network, or multiprocessor array. Such arrangements are often more economical—and more reliable— than medium-scale machines of the same capability.

**And in the next issue . . .**
The right oscilloscope probe . . . interfacing MOS chips with a gas-discharge display . . . computer decimal operation.

**The cover**
Stack architecture enables the Microdata 32/S minicomputer to translate instructions in a high-level language with unusual simplicity and speed.

# Electronics




## Publisher's letter

**In Washington,** this time of year, the Government stages the annual ritual called "Announcing the Federal Budget." At best, it's a ritual guaranteed to keep journalists up late poring over the huge budget volumes that the Government generates, as well as the special supporting documents put out by the various agencies, to extract the nuggets of information to pass on to their readers.

But, especially with this year's "austerity" budget threatening the chances for new business, it's an important story for us to cover and bring to all segments of the electronics industries. And, as in previous years, we had a team of *Electronics* editors on the spot to get it, both from the pages of the budget volumes and from the mouths of agency spokesmen, Government observers, and industry officials (see Probing the News, p. 68).

Ray Connolly, our Washington bureau chief, assisted by Bill Arnold, who covers the Washington aerospace beat, directed the coverage. In addition, Larry Curran, managing editor for news, headed a four-man New York contingent that trekked to the Capital for a concentrated week-end of work. The New York reporting team was rounded out by Howard Wolff, associate editor; Al Rosenblatt, New York bureau manager; and Lyman Hardeman, communications and microwave editor.

"The one big difference this year from previous budget expeditions," says Curran, "came in the tone of frugality set at some of the briefings given by agency spokesmen and in the combative mood perceived in Washington. That tone and that mood suggest this: despite the Administration's attempts to show economies, President Nixon's fiscal 1974 budget is probably in for more flak on Capitol Hill than any in recent memory.

"Congress is angry because many in that Democrat-controlled body think the President is trying to usurp what they regard as their most powerful constitutional weapon—the power of the purse. And the President is challenging that prerogative by refusing to spend some $8.7 billion in fiscal 1973 money appropriated by Congress.

"An adversary mood tends to surface in budget hearings on Capitol Hill. This year that mood will be sharpened by the Administration's attempt to impound funds approved by Congress last year. Also, many influential senators and congressmen regard the new budget as too lean on butter and too fat on guns, even though a hike in defense spending reflects mainly wage and price increases.

"With all this uncertainty, electronics company officials are hoping that their chances to pick up new business, albeit slim with the tight-belt budget, won't get bludgeoned as the budget items thread their way through the appropriation process."

Supporting our editorial team in presenting its findings was Fred Sklenar, our art director, who enlivened the pages with illustrations of key Administration and congressional spokesmen.


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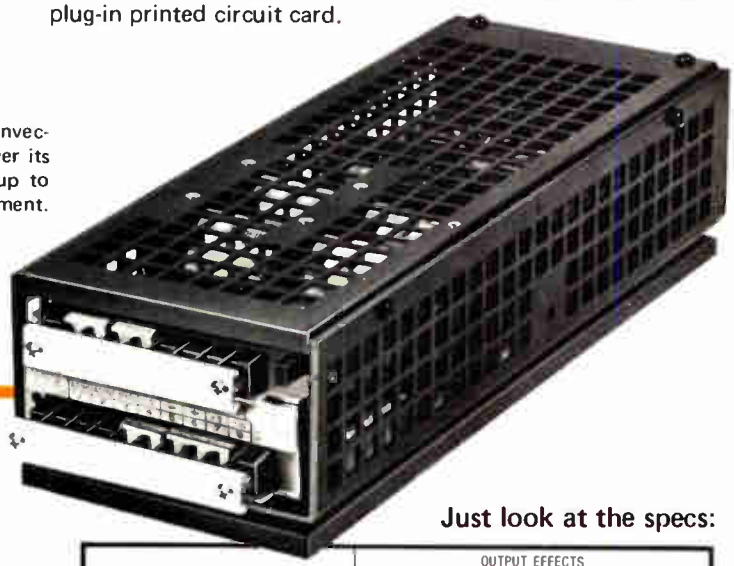
PTR is an exceptionally stable power supply module offering the convenience of automatic crossover operation for the stabilization of either voltage or current. It offers fully operational programming control of both channels—with a "flag" to tell your system which mode the combination of control and load has selected. PTR's are well built, in the Kepco tradition. All I-C's and transistors (including the power transistors) are socketed for easy maintenance. The entire circuit is contained on a plug-in printed circuit card.



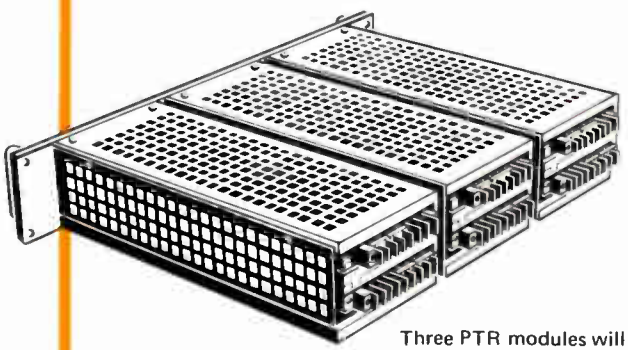
A compact 13⅞" x 5" x 3 15/32" convection-cooled package that will deliver its full current in any environment—up to 71°C. There is no derating requirement.

TM

### Just look at the specs:

| INFLUENCE QUANTITY | OUTPUT EFFECTS VOLTAGE MODE | OUTPUT EFFECTS CURRENT MODE |
|---|---|---|
| SOURCE: 105–125/210–250V a-c | <0.001% | <0.005% |
| LOAD: No load – full load | <0.005% or 0.1 mV(1) | <3.0 mA |
| TIME: 8-hour [drift] | <0.01% or 0.2 mV(1) | <0.05% or 0.1 mA(1) |
| TEMPERATURE: Per °C | <0.01% | <0.05% or 0.1 mA(1) |
| RIPPLE: [rms] | <0.1 mV | <0.5 mA |
| RIPPLE: P-P [20 Hz–10 MHz] | 2.0 mV | 2.0 mA |

(1) whichever is greater.



Three PTR modules will mount conveniently behind a 3½" x 19" panel, 4 units behind a 5¼" x 19" panel.

### Choose from six compact models:

| MODEL | d-c OUTPUT RANGE VOLTS | AMPS | PRICE (2) | SHIP WGT. lbs. | kg. |
|---|---|---|---|---|---|
| PTR 7–5.5 | 0–7 | 0–5.5 | $225.00 | 12 | 5.5 |
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| PTR 21–2.5 | 0–21 | 0–2.5 | 225.00 | 12 | 5.5 |
| PTR 40–1.4 | 0–40 | 0–1.4 | 225.00 | 12 | 5.5 |
| PTR 72–0.8 | 0–72 | 0–0.8 | 225.00 | 12 | 5.5 |
| PTR 100–0.6 | 0–100 | 0–0.6 | 225.00 | 12 | 5.5 |

(2) Optional overvoltage crowbar: $25.00.

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# Readers comment

### Microwave TV OK was earlier

**To the Editor:** Your "Electronics review section" [Dec. 4, 1972, p.44] states that "Varian Associates is presently the only manufacturer of microwave transmitters and receivers that have been type-accepted" for multipoint distribution service.

Emcee equipment has been type-accepted by the FCC for this service since Aug. 2, 1972. We are now producing transmitters for such major cities as Washington, D. C., Philadelphia, and Pittsburgh.

Steve Koppelman
Electronics, Missiles and Communications Inc.
White Haven, Pa.

### ICs on the track

**To the Editor:** Your article, "ICs help control diesel locomotive," [*Electronics*, Nov. 20, 1972, p.32], implies that Genisco's solid-state control is a first on locomotives. General Railway Signal Co. has had ICs on locomotives in a radio remote-control system since June 1968, and in 1953, we first used transistors on a New Haven Railroad locomotive. This, incidentally, was the first use of a transistor outside the communications industry.

We certainly agree that EMI is formidable, but we have worked with electric-propulsion rapid transit and mainline railroads for many years.

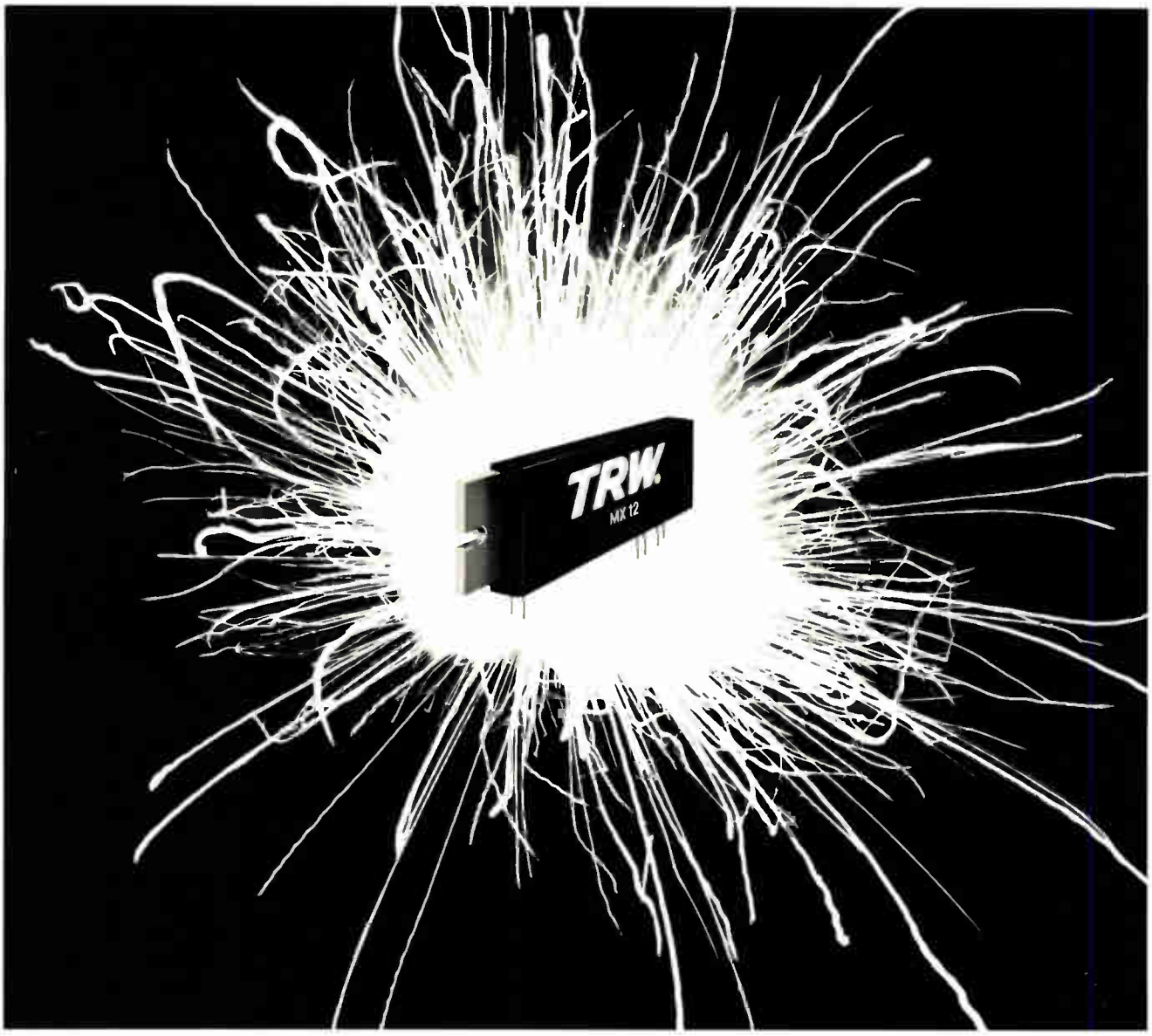
M. H. Sluis
General Railway Signal Co.
Rochester, N. Y.

### Clarifying meter supply

**To the Editor:** The story stating that our model AD2004 digital panel meter runs off a "5-volt unregulated supply" [*Electronics*, Jan. 4, p.125] may prove misleading because an unregulated supply may contain a large amount of ripple and have too high a source resistance. Besides, "unregulated" usually means that the supply voltage can vary by as much as 10% from its nominal value, while our meter can only tolerate variations of up to 5%—its power-supply voltage must be between 4.75 and 5.25 v dc.

Thomas Mealey
Analog Devices, Inc.
Norwood, Mass.

# TRW RF Power Modules. The power, the glory – and the gain!




All three are yours — with TRW RF Power Modules at work for you. You get all the gain you want, all the power you need—and at 12V. For any UHF broadband transmitter, or mobile transceiver. From 403-512 MHz.

A mere 150 mW in the MX12 — and you get 12 watts out. With the help of a few TRW JØs, 125 mW into an MX7.5 can be stepped up to 160W.

The glory comes your way when your colleagues see the ease of broadband design and manufacture, the quality and reliability of your finished product.

TRW is famous for the ruggedness of its parts, their stability and long life. These RF Power Modules give you the added assurance of knowing only TRW offers such parts with an established history of volume production.

So decide how much power, gain — and glory — you want. Then call or write Sales Manager, TRW Semiconductors, an Electronic Components Division of TRW Inc., 14520 Aviation Blvd., Lawndale, California 90260. Phone (213) 679-4561, ext. 451.

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## 40 years ago

From the pages of Electronics, February 1933

The **ventilating system** of the Roxy Theater in Radio City [New York] is distinguished by an innovation consisting of six ionization machines which provide the equivalent of mountain air in purity and vitality.

The machine consists of a series of special discharge tubes made of transparent vitreous material, containing an inner and outer electrode. These tubes are energized with a high potential electric current, supplied from a step-up transformer. Within these tubes a luminous discharge, rich in ultraviolet, is set up, while outside of the tube an intense electric field is produced and a non-luminous electric discharge takes place in the air surrounding the tube. Solarization, with ultra-violet light, of somewhat shorter wave length than is normally present in sunlight at the earth's surface, is accomplished by both the discharges within and without the tube.

**Dr. Karl Compton,** of Massachusetts Institute of Technology, did well to coin a new phrase "electrostatic engineering" as defining the new technique that is rapidly being built up employing electrostatic rather than the electro-magnetic effects that have concerned electrical engineers almost wholly so far.

Many examples of this new "electrostatic engineering" are already in evidence.

The 15,000,000-volt electrostatic generator now nearing completion at South Dartmouth, Mass., may wring new secrets from the atom and from the X-ray spectrum. Piezo-crystals are now being used as relays by direct mechanical action on contacts, providing relays that "hold in" with no current expenditure, merely shelf-loss battery charge. Condenser microphones are already familiar; condenser loudspeakers may yet fulfill the promise they inspire. Radio condensers are revising small-motor design.

Electrostatic electricity was the cynosure of Benjamin Franklin's day. It seems destined to a new ascendancy 150 years later, in the post-depression 1930's.

# New Low Cost AM/FM Function Generator Has Built In Modulation Source

EXACT'S NEW Model 129 AM/FM Function Generator lets you do it all with one box. AM internal or external. FM internal or external. Simultaneous AM-FM, sweep, single shot, tone burst. The Model 129 contains two independent function generators. One provides the carrier, while the second provides AM or FM modulating signals plus trig and gating signals in the pulse and burst modes. The two generators provide Sine, Square, Triangle and pulse waveforms. The carrier generator has a frequency range of 0.1Hz to 5MHz and the AM/FM generator 1 Hz to 1 MHz. Up to 100% modulation and double sideband suppressed carrier is provided. FM deviation up to 500:1 around a center frequency is possible. The outputs have precision attenuators, variable d-c offset and all the capabilities to make this the most versatile signal source ever offered at anywhere near the low price tag of $795. F.O.B. Hillsboro, Oregon. Circle the bingo number and we'll send you more information, or better yet, call the nearest sales office listed below and we'll rush a Model 129 over.

**Model 129 AM/FM Function Generator**

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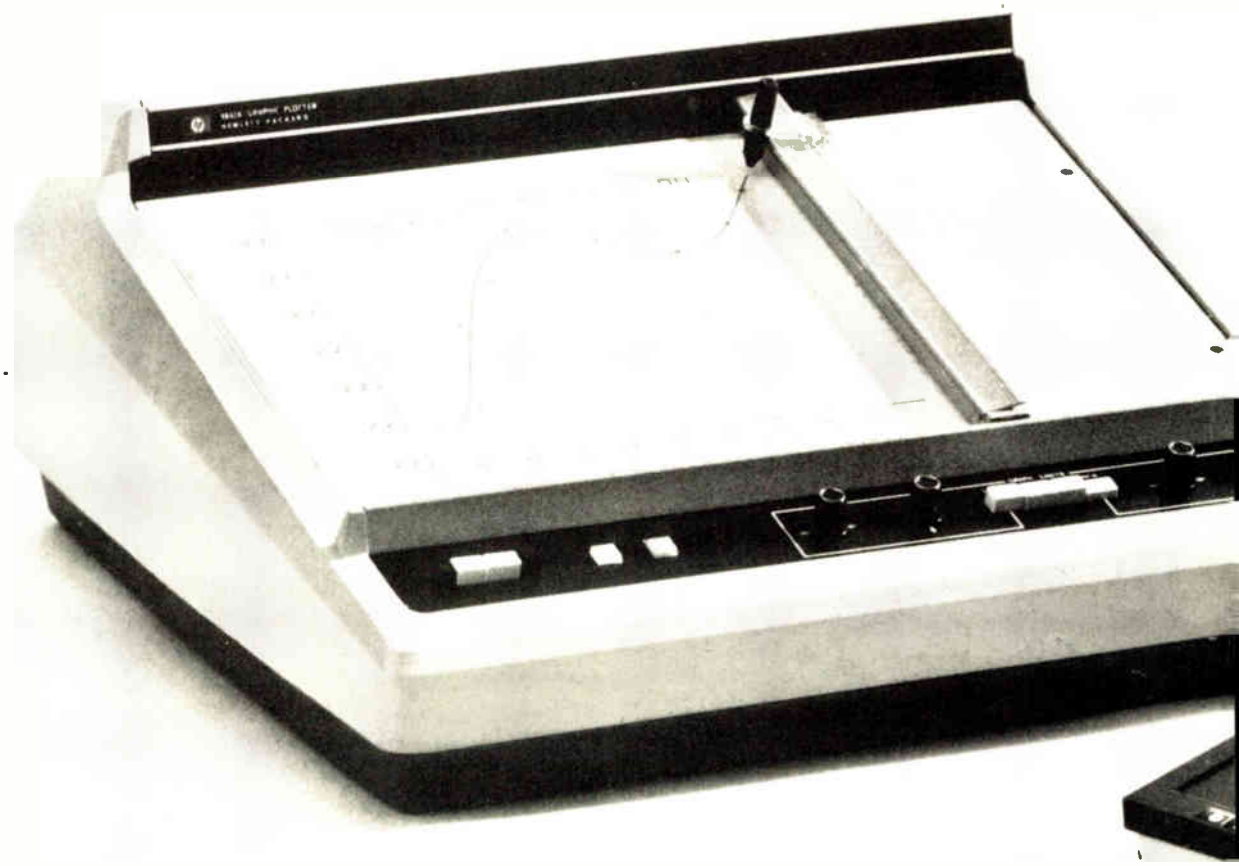

# Hewlett-Packard Series 9800 Model 30. The Name And Number Bridge The Computing Gap.

Building power into a computer isn't much trouble, these days. The task is to make that power respond to the demands of you scientists and engineers who don't pretend to be computer experts. That's a feat we've accomplished with our new Series 9800/Model 30.

It joins the accessibility and easy operation of a programmable calculator with the power and overall capability of a minicomputer. The result? Significantly reduced turn-around time for those complex research and design problems you're now sending to a programmer or outside computing service.

**Conversation guides you to the best solution.** The secret to the Model 30's problem-solving efficiency is its ability to communicate with you on a very human level. Its language is BASIC, a standard language that gives you simple, straightforward programming.

In practice, you solve a problem by setting up a dialogue with the Model 30. You talk to it through the typewriter keyboard. It talks to you through the alphanumeric display.

Once you've entered your instructions in English words and Algebraic formulas, the Model 30 does all the rest, under the automatic control of its hard-wired executive system. It'll even


show you where you've made a mistake —so you can quickly correct anything from one character to an entire block of text with just a few quick strokes on the editing keys.

**Powerful memory for solutions to big problems.** Despite its apparent simplicity and small size, the Model 30 is an extremely powerful computing tool. Significant features include the executive system software implemented by built-in ROM (read-only-memory); the large MOS-LSI read/write memory for programs and data, and the built-in tape cassette operating system for mass storage. Adding it all up, the *basic* Model 30 gives you problem-solving power equivalent to a minicomputer system with 10K sixteen-bit words of memory. And that's just for starters, because the Model 30's modular design lets you add capacity any time your usage demands.

You can add programming and systems versatility with plug-in ROMs. You can increase your data and program storage with read/write memory modules. And you can plug in up to nine additional tape cassettes for whopping mass storage.

**New Series 9800 Line Printer gives you fast formatted output.** If your work calls for formatted hard copy, you'll be happy to know you no longer need suffer the tedium and noise of slow, mechanical output writers. Our new Series 9800/Model 66 Line Printer mounts atop your Model 30 to give you a fast output of 250 lines per minute. (That's equivalent to typing 3,600 words per minute.)

**Series 9800 Peripherals let you handle data in any format.** As a member of the Series 9800, the Model 30 is fully compatible with all 15 of the Series 9800 Peripherals—ranging from high-speed Tape Readers to Instrument Interfaces. Illustrated above is our unique X-Y Plotter that not only draws histograms, linear, log-log, semi-log, or polar plots—but writes alphanumerics as well.

Put the Series 9800/Model 30 through its paces on some of your problems. We're already shipping production units. Prices start at $5,975 for the basic Model 30. Add $2,975 for the Model 66 Line Printer.

For more information or a hands-on demonstration, call one of our 172 worldwide sales offices. Or write: Hewlett-Packard, P.O. Box 301, Loveland, Colorado 80537.

093/2

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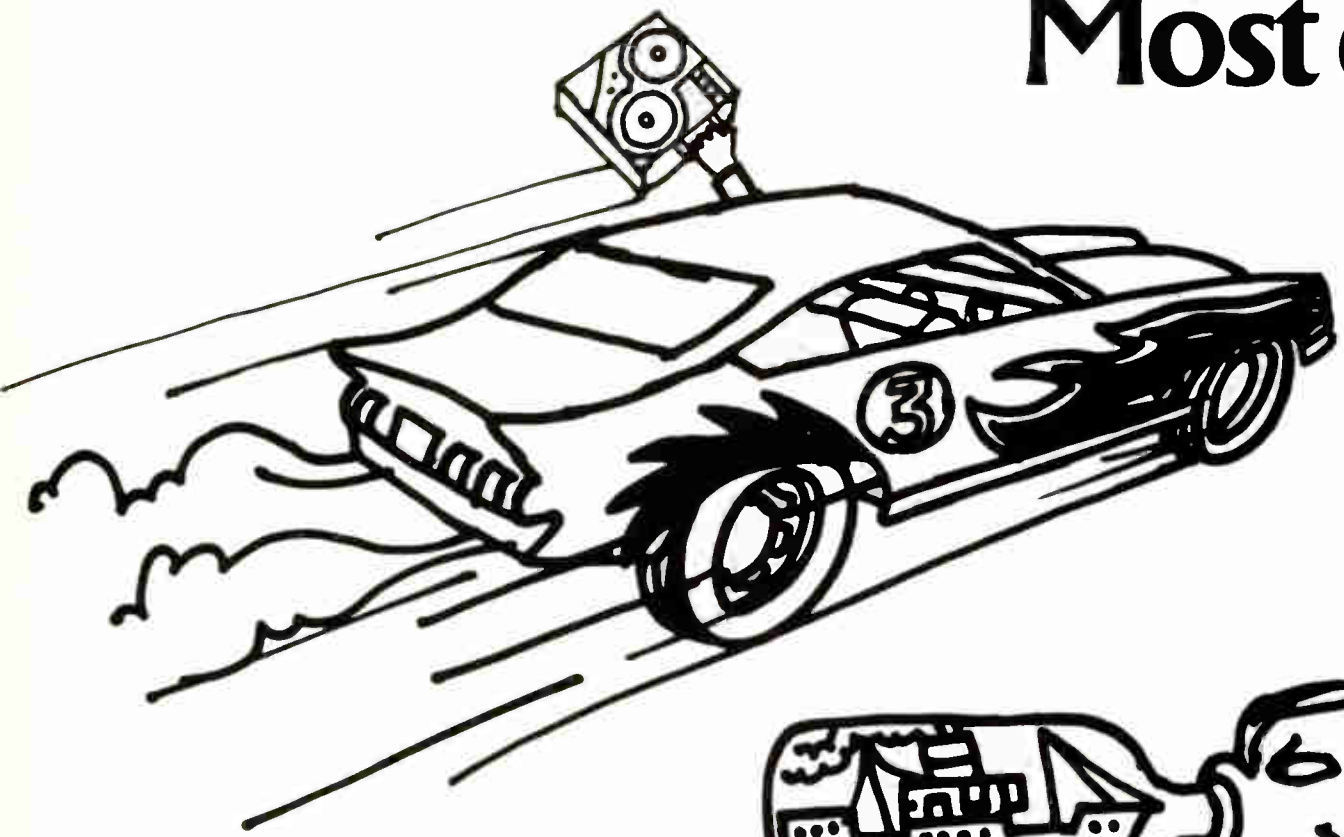
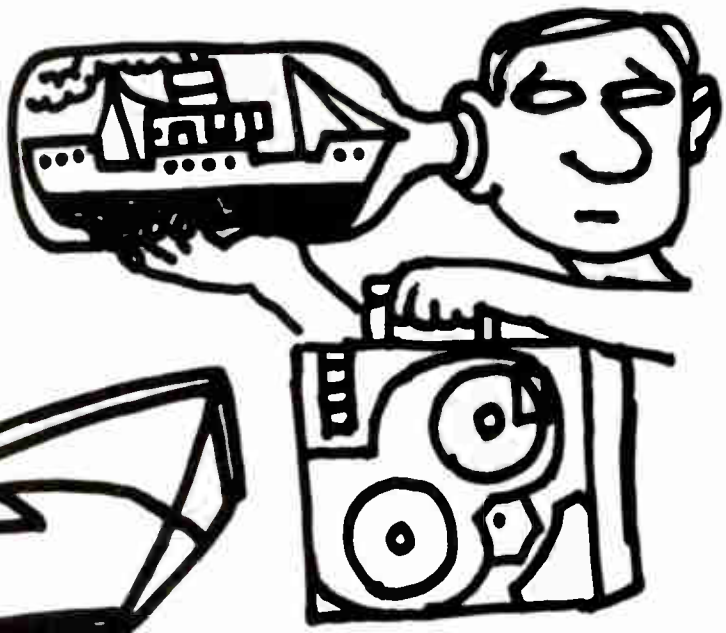
For a demonstration, circle reader service no. 11

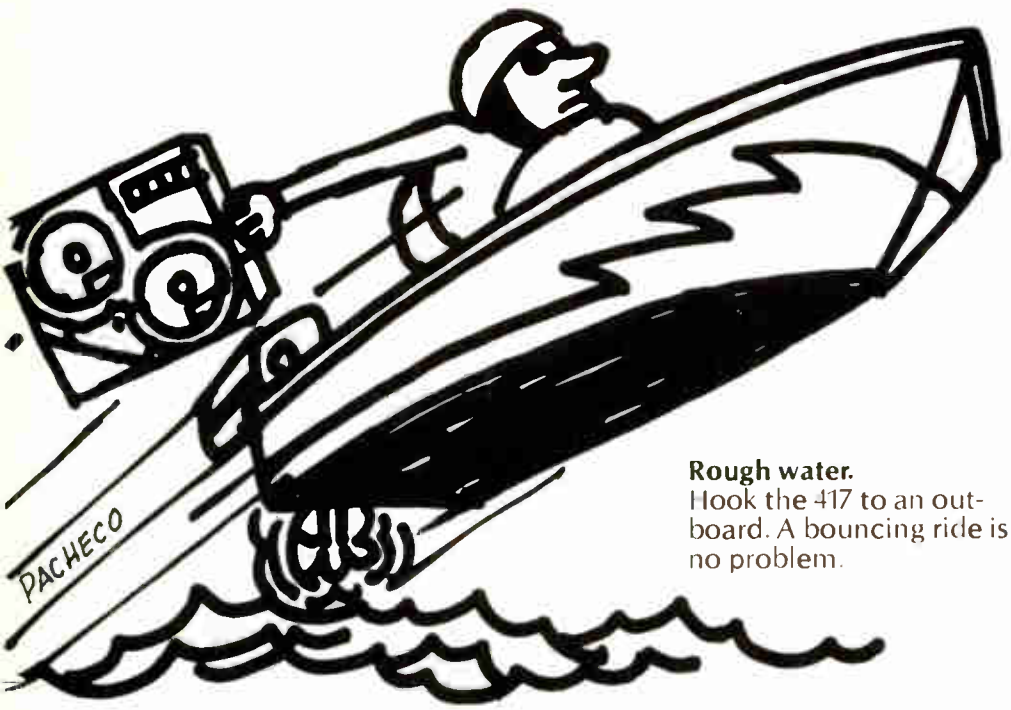
# You'll find Lockheed's 417 Most of




**Tough roads.**
The 417 shines in torture testing of autos around the world.



**Down deep.**
You can take the handy 417 to where the noise is, deep in the heart of ships.

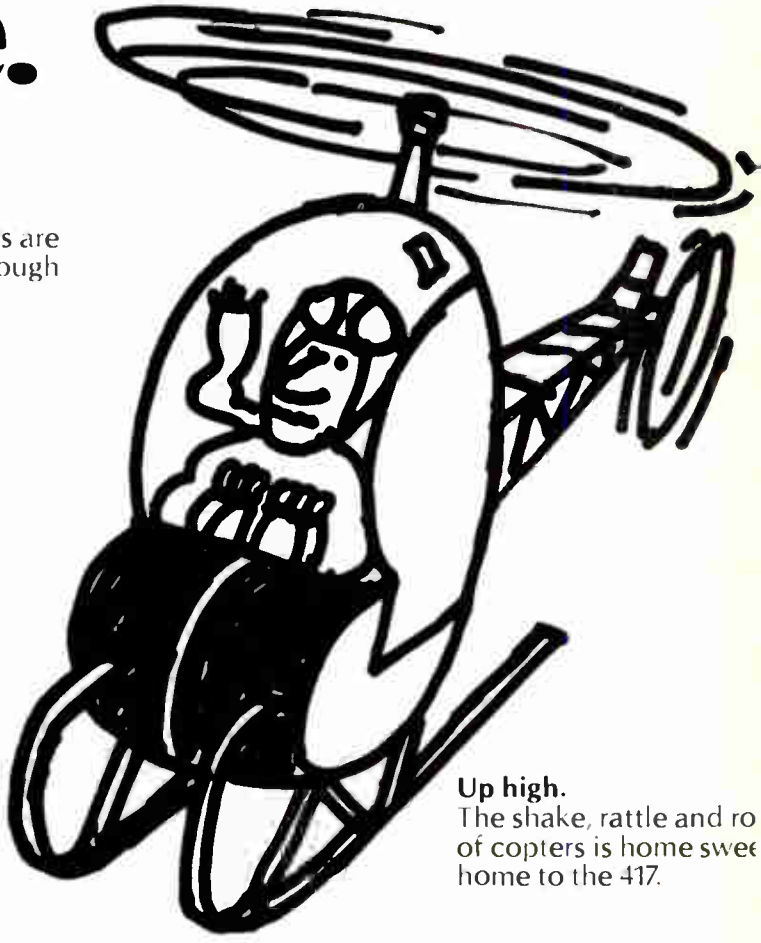



**Rough water.**
Hook the 417 to an outboard. A bouncing ride is no problem.

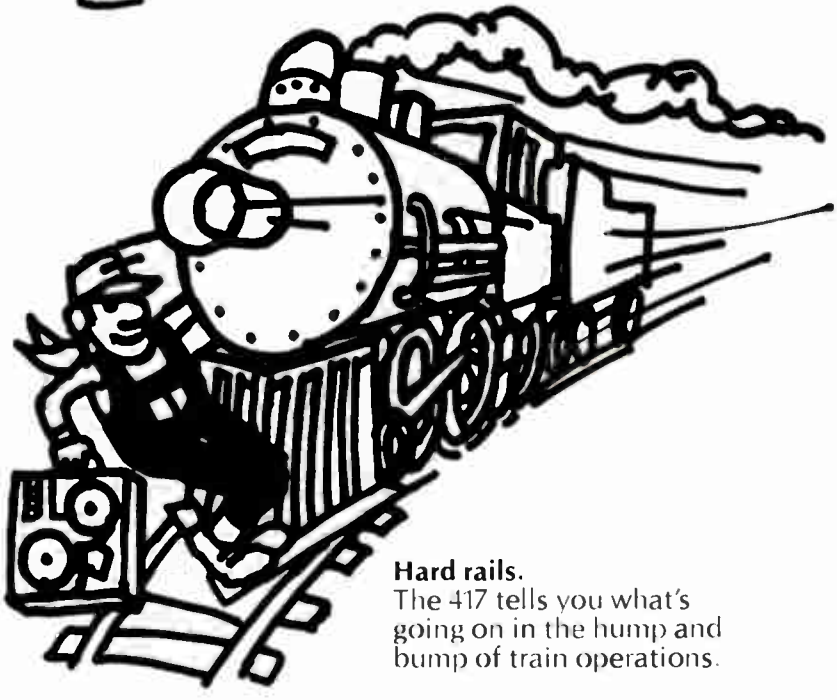
Some people bring data sources to the recorder. That makes life easy for the recorder. But if you have to take the recorder to data sources, consider the 417. It makes life easy for you. Weighs only 28 pounds, fits under an airplane seat. Wide or intermediate band, the rugged 417

# Recorder in many places. them hostile.

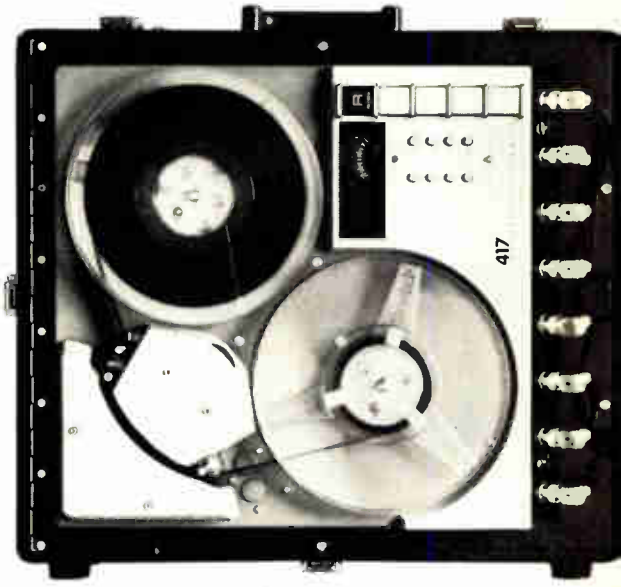
**Jittery earth.**
Seismic measurements are only one of the 417's rough terrain chores.



**Up high.**
The shake, rattle and ro
of copters is home swee
home to the 417.



**Hard rails.**
The 417 tells you what's going on in the hump and bump of train operations.




Seven channels, IRIG compatible.
Frequency response: 100 kHz direct,
10 kHz FM or 375 kHz to 100 kHz FM.

operates in any position. And is as accurate as large rack machines. Prices as low as $7,000. Write Earl Nadeau for specs and a free analysis of the 417, for your application, Dept. 413-206, Lockheed Electronics, Plainfield, N.J. 07061. Or call him collect at (201) 757-1600.

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A Subsidiary of Lockheed Aircraft Corporation

Circle 13 on reader service card

## People

### GE's Perry on top of the video boom

The new chairman of EIA's Consumer Electronics group and general manager of the General Electric Home Entertainment Business division, soft-spoken Donald E. Perry is enjoying success in both the consumer-products industry and in his own division.

Perry is satisfied with the outcome of the Consumer Electronics group's first attempt at a wintertime products show last month in Chicago. He is also pleased with the EIA's internationalization of reporting industry statistics—instead of tracking only U.S. brands, the association is now going to include total-market sales in this country.

**Four-channel push.** As for the booming consumer sales, Perry believes that U.S. manufacturers can repeat the 1972 success this year "if we can maintain the momentum into the first months." He estimates that the mid-1972 TV-replacement market accounted for 15% of all sales, and that it will increase this year. On the audio side, Perry strongly supports the sales attraction of four-channel sound, despite grumbling by some audio-equipment manufacturers that quadraphonics has caused more confusion than purchases.

Perry is also bullish about the performance of General Electric and expects his division to out-perform the industry average in television sales. On the horizon for GE is a new set with a 25-inch, 110° deflection, in-line-gun tube. (GE's TV Components department has just completed the prototype tube.) Perry expects that the 110° tube will gain acceptance in this country in large-screen sets because the space saving from the tube's shorter neck is more noticeable than with small-screen units.

**Appraisal.** General Electric has also begun market research on home video players to get a "detailed appraisal of the hardware and its sales potential." Until this study is evaluated, GE will make no moves in this volatile field and probably will not be in any rush to enter the consumer videotape recorder and video-disk market.

Concerning consumer calculators, "we've got zero interest," comments Perry. "We've never tried to pick off one end of a market. Unless we can have a full line, from hand-held to office machines, it's not worth it. Besides, our business is home entertainment."

**Don Perry** presides over the "internationalization" of EIA's CEG.

### Afips chief sees big show in New York

The world's biggest computer show will be in New York the first week in June, declares Gerard (Jerry) Van Dijk, the first full-time conference manager of the American Federation of Information Processing Societies, which is sponsoring the National Computer Conference and Exposition. "I expect a total sell-out," he affirms.

Some may call this an unusually optimistic position, considering how poorly the large, omnibus technical show—including Afips' own Fall and Spring Joint Computer Conferences—has fared in the past few years. In fact, the June 4–8 conference, to be held annually on a rotating basis in New York, Chicago and on the West Coast, replaces the two that Afips has until now sponsored

# The PHILIPS PM 3200 doesn't look like a $395 double scope...

# ...doesn't perform like one, either.

His visual

Developed and manufactured by N. V. Philips of Holland, the PM3200 looks... and performs...like an expensive, laboratory-quality instrument.

Yet it costs only $395, weighs less than 12 pounds, operates 5½ hours on its optional battery pack, is rugged enough for any kind of field work you can name and offers a wide range of professional performance capabilities, including:

- Freq response flat (—3 db) to 10 MHz
- Sensitivity of 2 mV/div
- 21 calibrated sweeps from 100 nsec/div to 0.5 sec/div
- Vertical amplifier dynamic range allows any signal to be expanded to 24 divisions, with any 8 displayed to 1 MHz
- Negligible DC drift: ¼ div/day

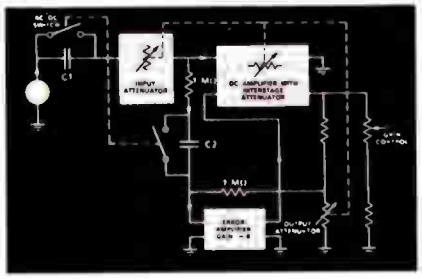
And the PM3200 is simple to operate; even semi-skilled factory workers find it easy to use it for precision test procedures. Most tests require only Y AMPL and TIME/div settings; other functions are automatic.

For instance, the PM3200 has no need for trigger-stability or continuous-level controls. Choose a trigger mode, choose a time base...and you see a stable display. Even for pulses with low duty cycles. And for TV work, a modified version of the PM3200, the PM3200X, adds automatic selection of TV frame or line sync for triggering.

PM3200 needs no DC balance control; a unique feedback circuit reduces trace drift to only ¼ div/day @ 2 mV/div and automatically compensates for DC offsets caused by attenuator tracking and by differences in AC and DC coupling.

Try the PM3200 (or the PM3200X) with no obligation. We are convinced that at $395, considering its portability, ruggedness, precision, flexibility, simplicity of operation and its Philips-of-Holland professional performance—you'll agree that it's the optimum general purpose scope for all kinds of field service organizations, production and QC departments, schools and engineering laboratories.

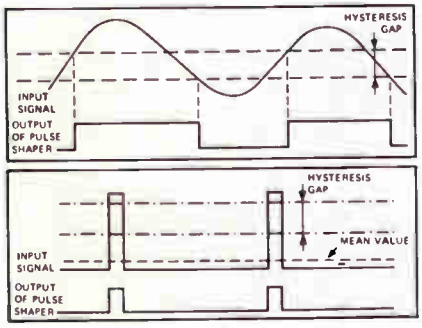
For details of our no-obligation, 15-day free trial offer and for complete descriptive literature on the PM3200 and the PM3200X, write: Test & Measuring Instruments Inc., 224 Duffy Avenue, Hicksville, N.Y. 11802. Tel: 516-433-8800.



**PM3200 IS DRIFT-FREE AND INHERENTLY DC BALANCED**

Sensitivity and DC drift are both on the order of the noise voltage.The active drift compensation loop compares vertical amplifier input to output and provides feedback to attenuate any drift voltage by a factor of 1 + ½B, where B is the feedback amplifier gain (approx. 30).

DC offsets are automatically compensated when interstage attenuators are switched, when the Y AMPL gain setting is changed, and when there is leakage around the AC coupling capacitor. Need for a DC balance control, even at 2 mV/div sensitivity is totally eliminated.

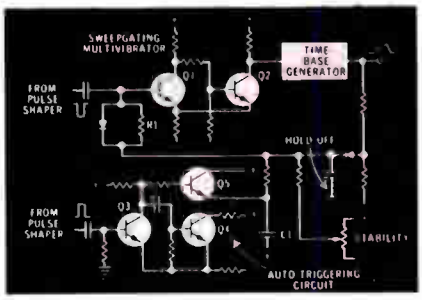



**THREE AUTOMATIC TRIGGER MODES IN PHILIPS PM3200**

Trigger mode selection allows triggering on the mean value of the AC signal, on the peak value of the signal, or on the AM component of an HF signal. Mode switches select DC level of "hysteresis gap" of pulse shaper relative to mean signal value to determine shape of switching pulses applied to time base and auto-trigger controls.

**PM3200X FOR TV SERVICE**

PM3200X offers automatic TV frame/line sync selection for convenience in TV service work. With TRIGGERING switch in TV position, setting the TIME/div control to any sweep speed up to 50 μsec/div produces frame-synchronized displays. Setting the TIME/div control to any sweep speed of 20 μsec/div or faster results in a perfectly stable TV line-synchronized display.




**PHILIPS PM3200 OFFERS AUTOMATIC TRIGGERING TO 10 MHz WITHOUT STABILITY OR CONTINUOUS-LEVEL CONTROLS.**

Time base generator is free running at TIME/div setting. Any signal produces simultaneous pulse-shaped inputs to time base control Q1, Q2 and to auto-trigger control Q3, Q4. The time base control switches the time base generator off and the auto-trigger control switches Q5 to charge C1 to the mode-set trigger level and starts the time base generator via Q3, Q4 in sync with the signal.

**PHILIPS TEST & MEASURING INSTRUMENTS INC.**

Circle 15 on reader service card

**People**

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But since ta
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way to selling all of hi
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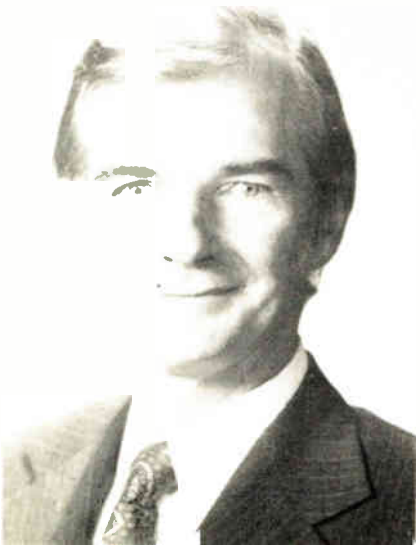
itors is buttressed by a techni
program that has been doubled i
size and geared, for the first time, Van Dijk says, to both the computer user and the high-level computer design specialist the Afips meetings generally catered to. Helping also, he admits, is the upturn in the economy and the conference's "highly visible location" in New York.

Van Dijk, 42, sees the business of organizing this conference, close to a $1 million operation, an easy extension of his 17 years of sales and marketing experience in the computer industry. Ten of those years were spent with IBM.

Tall and lanky and with a long-haired youthfulness, Van Dijk keeps in shape playing paddle tennis in winter and sailing in summer. Right now, he's building a power boat with the help of his nine-year-old son Christopher in the basement of his Larchmont, N.Y., home. (Yes, he says, it will get through the door when it's finished.) "We're sort of eyeballing it, without any plans, doing whatever we think looks good," he says and adds with a smile, "That's about the same way we're building the conference."

**Showman.** Jerry Van Dijk hopes Afips' now-annual conference will be robust.



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Our new high speed tool does it all . . . feeds a TY-RAP tie around bundle, cinches to a preset tension, locks securely and trims evenly . . . all in 8/10 of a second. There is no tool adjustment needed regardless of bundle diameter from 1/32" to 5/8".

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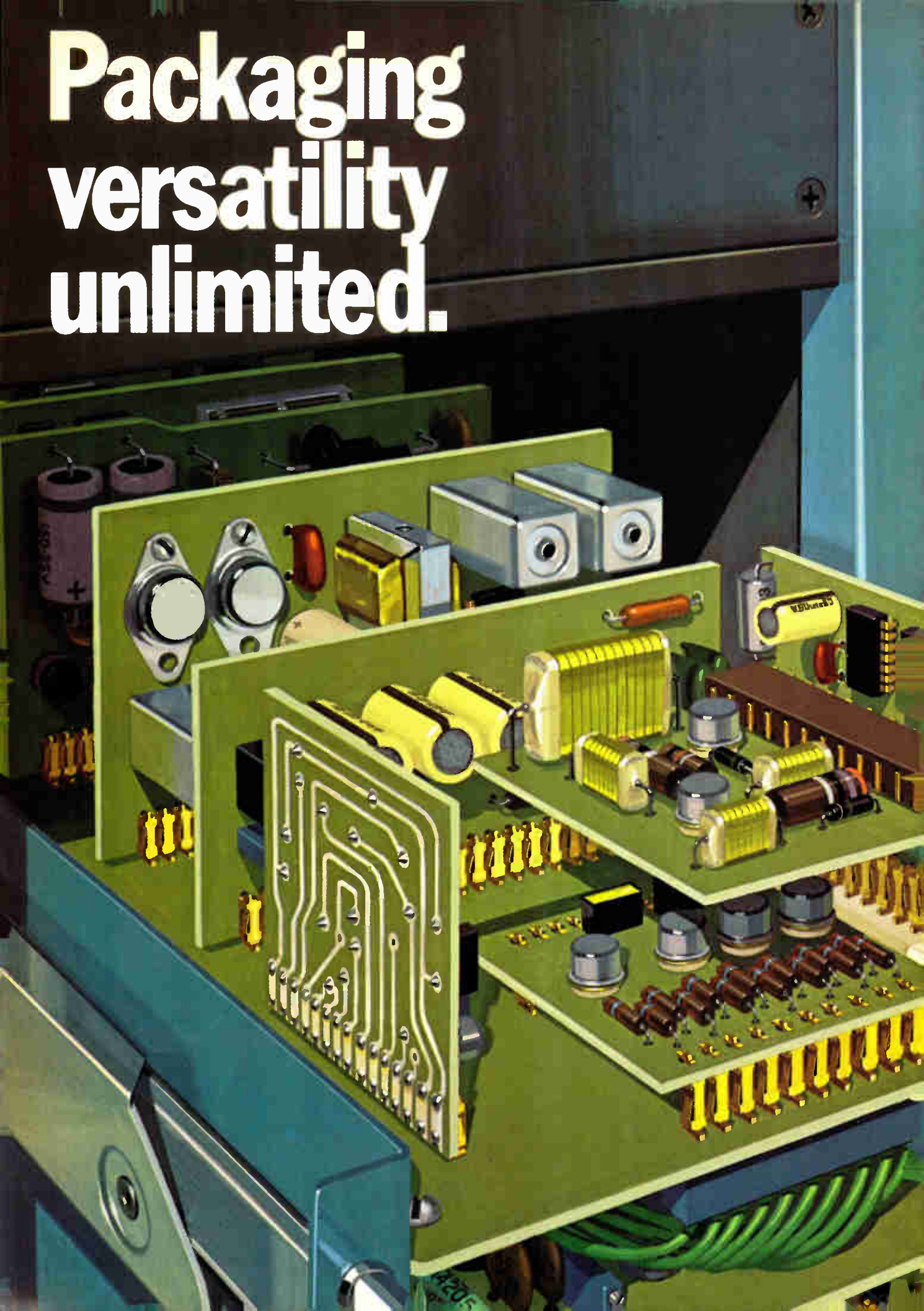
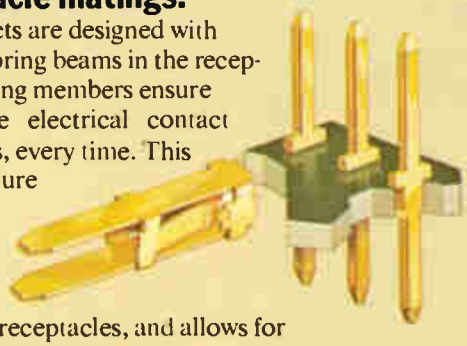
# Packaging versatility unlimited.



As electronic subassemblies become more sophisticated, the advantages of a single interconnection system to meet diverse packaging needs become more evident. If you're looking for interconnection versatility—with proven reliability—look into our AMPMODU interconnection system. Here's why.

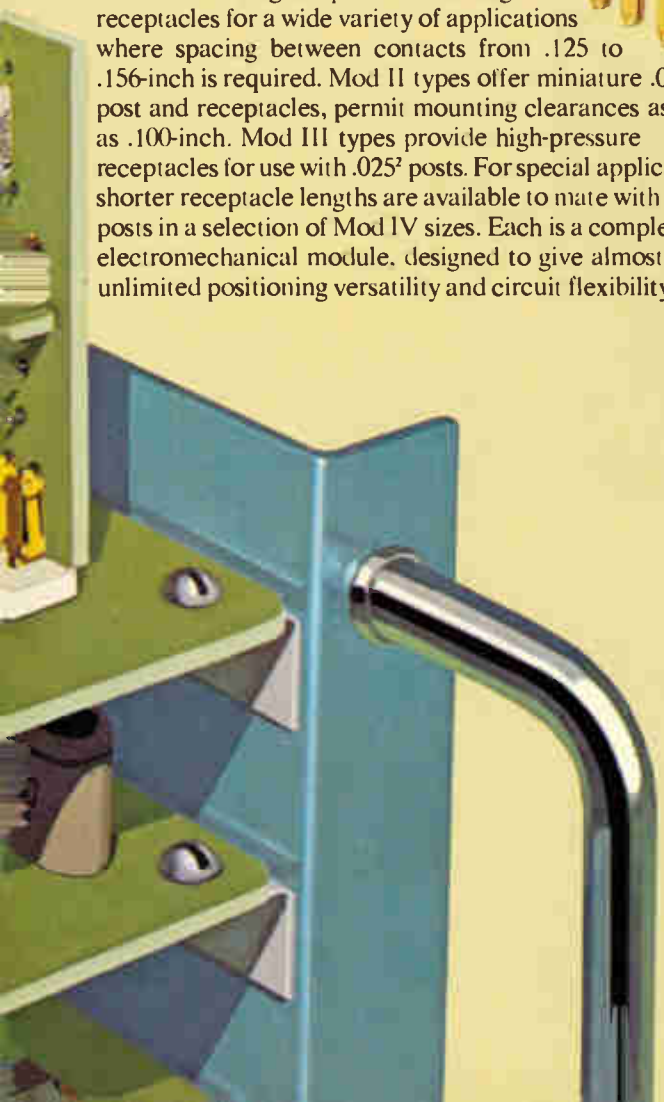
## Unique design permits repeated post/receptacle matings.

AMPMODU contacts are designed with dual cantilever spring beams in the receptacles. These spring members ensure uniform, positive electrical contact with mating posts, every time. This same design feature also compensates for misalignment of staked posts and receptacles, and allows for greater assembly tolerances.



## Wide range of types and sizes.

Four basic AMPMODU contact types provide post and receptacle size selection to meet specific packaging requirements. Mod I types, for example, combine .031 x .062-inch rectangular posts and mating receptacles for a wide variety of applications where spacing between contacts from .125 to .156-inch is required. Mod II types offer miniature .025² post and receptacles, permit mounting clearances as close as .100-inch. Mod III types provide high-pressure receptacles for use with .025² posts. For special applications, shorter receptacle lengths are available to mate with .025² posts in a selection of Mod IV sizes. Each is a complete electromechanical module, designed to give almost unlimited positioning versatility and circuit flexibility.

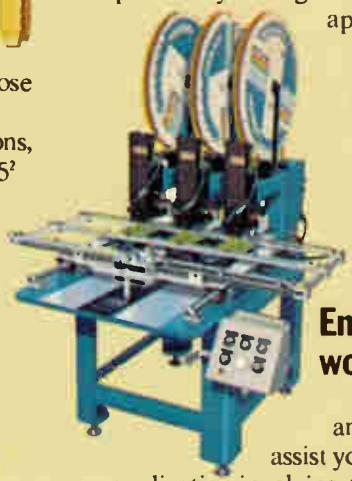


## Board-to-board, board-to-wire versatility.

Receptacles can be staked up, down or sideways, to module boards or grid panels. Receptacle designs are also available for crimping onto individual wires or for staking into flat flexible cable conductors. Others can can be used to connect coaxial wires. Terminated receptacles may also be housed in a wide range of multiple-position connector blocks for both 90° and parallel connections to boards or grid panels. AMPMODU connector posts are preassembled in insulating nylon blocks or in strip form for machine insertion. They can be wired automatically by AMP's TERMI-POINT clip point-to point method, or by wrap-type techniques.

## Staking speeds to 12,000 posts or receptacles an hour.

Our new strip-fed multi-head pantograph matches post and receptacle staking speeds to your high-volume production needs. Each applicator head stakes up to 4,000 insertions an hour, either horizontally or vertically, into pc boards from .062-inch up. Any pattern can be staked into 5 x 13-inch to 16 x 13-inch boards. AMP automatic tooling is unequalled for reducing applied interconnection costs.



## Engineering backup... worldwide.

At AMP Incorporated, more than 700 application, service and sales engineers are prepared to assist you with every design and production application involving AMPMODU interconnection systems. At your domestic manufacturing plant or wherever you use AMP products and machines throughout the world. You'll find AMP manufacturing and service facilities in 16 major international markets. In the United States, district offices are located in California, Georgia, Illinois, Massachusetts, Michigan, Minnesota, New Jersey, Ohio, Texas, and the District of Columbia.

For more information on AMPMODU connector system products, circle bingo number 10, or write AMP Industrial Division, Harrisburg, Pa. 17105.

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# Meetings

**Aerospace and Electronic Systems (Wincon):** IEEE, Biltmore, Los Angeles, Feb. 13–15.

**Annual Meeting, Association for Advancement of Medical Instrumentation:** AAMI, Washington Hilton, Washington, D.C., March 21–24.

**IEEE International Convention (Intercon):** IEEE, Coliseum and New York Hilton, March 26–29.

**Reliability Physics Symposium:** IEEE, Dunes, Las Vegas, April 3–5.

**Southwestern IEEE Conference and Exhibition (Swieeeco):** IEEE, Houston, Texas, April 4–6.

**International Symposium on Circuit Theory:** IEEE, Four Seasons Sheraton, Toronto, Canada, April 9–11.

**International Magnetics Conference (Intermag):** IEEE, Washington Hilton Hotel, Washington, D.C., April 24–27.

**Carnahan Conference on Electronic Crime Countermeasures:** IEEE, U. of Kentucky, Carnahan House, Lexington, Ky., April 25–27.

**Electron Device Techniques Conference:** IEEE, United Engineering Center, New York, May 1–2.

**National Relay Conference:** NARM, Oklahoma State U., Stillwater, Okla., May 1–2.

**Electronic Components Conference:** IEEE, EIA, Statler-Hilton, Washington, D.C., May 14–16.

**Naecon:** IEEE, Sheraton, Dayton, Ohio, May 14–16.

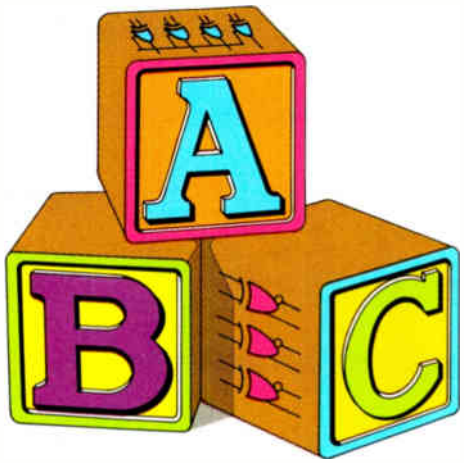
**International Symposium:** SID, Statler-Hilton, New York, May 15–17.

**Measurement and Test Instrument Conference:** IEEE, Skyline Hotel, Ottawa, Ont., Canada, May 15–17.

**Electron, Ion, and Laser Beam Technology:** MIT and IEEE, MIT, Cambridge, Mass., May 21–23.

*Continued on p. 180*

# ECL 10K: Now easy as ABC

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|---|---|---|---|---|---|
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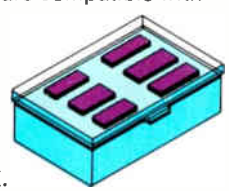
| 10102 | 10107 | 10111 | 10117 | 10121 | 10161 |
| 10105 | 10109 | 10115 | 10118 | 10130 | 10162 |

| SIGNETICS ORIGINATED FUNCTIONS | |
|---|---|
| 10112 | Dual 3-Input 1 OR/2 NOR Gate |
| 10113 | Quad Exclusive OR with enable |
| 10171 | Dual 1-of-4 Demux/Decoder (Low) |
| 10172 | Dual 1-of-4 Demux/Decoder (High) |

**Compatibility.** Pin-for-pin identical with Motorola MECL 10,000, with industry-accepted temperature coefficients and ranges (−30° to +85°C). Two in-depth, production-proven sources insure service and delivery. You can use Signetics ECL 10K in mixed systems without the subtle penalties or noise immunity reductions that occur with compensated 10K families. Switching rise/fall times are compatible with conventional system layouts.

FREE ECL 10K PARTS KIT

To introduce our new ECL 10,000 products, we're offering an Evaluation Kit: six free parts to give you first-hand experience with Signetics optimized ECL 10K.



**NEW ECL 10,000 FUNCTIONS:**

**Supergate**

10100 — Quad 3-input gate. Most useful 10K function, most reasonably priced.

**Interface**

10124/10125 — Quad differential line drivers/receivers, ECL-TTL translators. 5ns high-performance delivers density and flexibility, below the cost of any other similar devices.

**Multiplexers**

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10164/10174 — 8 to 1/dual 4 to 1. Large fan-in multiplexers, operating at 3.5ns.

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10170 — 9-plus-2 input expandable parity circuit.

**Storage**

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**Memory**

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10145* — Extremely fast 9ns RAM, 16x4 organization.

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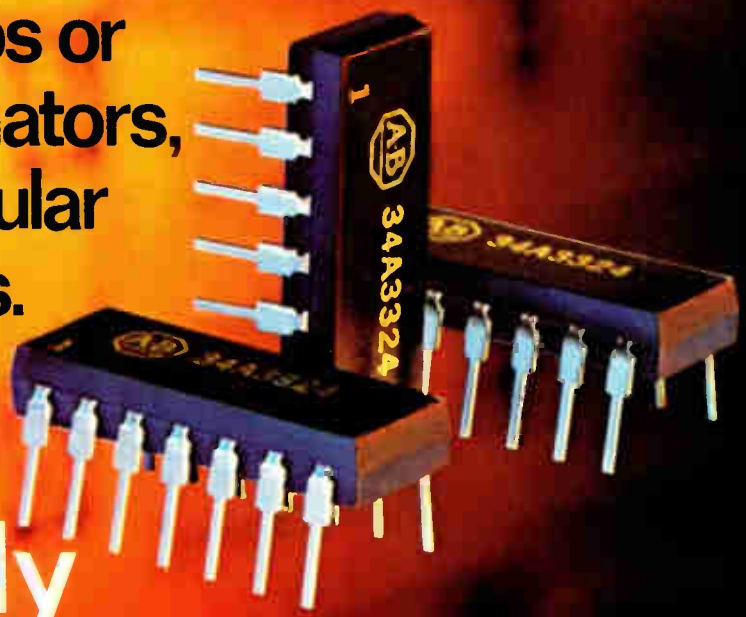


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Circle 26 on reader service card

# Electronics newsletter

## Motorola move deflates EIA's statistics bag

The Electronic Industries Association's semiconductor sales-statistics program has been dealt the coup de grace by the cessation of reporting from Motorola's Semiconductor Products division. Motorola, still an EIA member, quit supplying sales statistics to EIA Jan. 1—the last of the top three U. S. semiconductor houses to do so. Previously, Texas Instruments and Fairchild Semiconductor resigned from EIA, taking with them a huge chunk of the association's Solid State Products division's statistical base [*Electronics*, Jan. 4, p. 36].

**A Motorola source says that while he regrets the move, the division "had too much visibility as the only large company left reporting."** He adds that Motorola has proposed alternate and broader reporting categories to the EIA, suggesting that major classifications such as digital and linear ICs, silicon and germanium transistors, be broken out, rather than the scheme EIA has been using. Under the EIA plan, specific product categories have been detailed, such as TTL, ECL, p-channel MOS, and complementary MOS.

## Goldmark unveils Star Pak cable TV system

The first units of Goldmark Communications Corp.'s Star Pak, an electronic videotape cassette system for showing full-length movies on cable television [*Electronics*, Jan. 4, p. 34], have been installed in Reston, Va., Olean, N.Y., and Pottsville and Clearfield, Pa. Expected to cost less than $15,000 per unit, **the system is designed to provide programing for an entire cable-TV network by using four video cassette players to feed movies, programs, and special messages through automatically controlled preset timing.** A solid-state skew-correction device prevents picture distortion and interference, the company says. Goldmark foresees a $20 million-plus market for program-origination systems.

## IEEE Intercon threatens move to Boston

Troubled by high costs and labor problems in mounting its annual show at New York's Coliseum, IEEE has given serious thought to moving Intercon to Boston on an alternating basis. However, Donald Larson, general manager, has stated that the institute wants first "to see if we can't make New York work." **He says that threat of the move has elicited a promise of complete cooperation from the Coliseum's labor force.** But before such a move could be made, several years would be required to complete arrangements.

## Commercial LED lamp has built-in resistor

Hewlett-Packard has solved a nagging problem for users of light-emitting diodes—the need to select and assemble circuit-limiting resistors. And H-P's new LED will also save customers the bother of matching light intensity in order to get a row of LEDs with uniform brightness on a panel.

**The Palo Alto, Calif., firm has two LED lamps—one red and one with a clear diffused lens—with a built-in silicon resistor connected to the LED by a bonded wire.** The LEDs cost 60 cents each in lots of 1,000, about 25 cents more than LEDs without resistors. An H-P spokesman says that the run-of-the-mill resistor-LEDs are well-matched in intensity and that matched sets can be ordered.

# Electronics newsletter

## Military to devise test to qualify epoxy bonds

The difficulty in qualifying for military applications IC devices using epoxy to attach the chips to the substrates will probably be eased soon, thanks to a study grant awarded to Martin Marietta, Denver, Colo. The contract from Rome Air Development Center, Rome, N.Y., requires Martin to develop tests that can quickly eliminate defective devices headed for military procurement.

Up to now, epoxy has been governed by MIL-M-38510, which says that no organic materials are to be used unless specifically authorized in a contract. In effect, a manufacturer has had to obtain nonstandard approval based on test data that he submits to the Air Force.

**Epoxy is particularly attractive in hybrid fabrication because the temperature required for cure (125°C) is less than that required (370°C) in metallurgical die-attachment methods.** And degradation of devices during fabrication is accelerated by time-temperature exposure.

## Gunn diode is fastest laser switch

The Gunn diode promises to be the fastest means of switching lasers. Researchers at Bell Telephone Laboratories, Murray Hill, N.J., have used it to switch a GaAs laser with output times as fast as 200 picoseconds and fall times of 400 ps. **This is two to three times faster than such silicon devices as p-i-n diodes previously used for applications needing extremely fast switching.** The technique will be described this week at the International Solid State Circuits Conference in Philadelphia.

The Gunn device is identical to ones used for generating microwave signals. When used as a high-speed light switch, however, the Gunn diode is resistively loaded to prevent microwave oscillation and placed in series with a double heterojunction GaAs laser.

## Soviets to unveil awaited RJAD line of computers

The Soviet Union is about to reveal to the world the fruits of its long-standing effort to produce, with its Comecon partners, a line of computers ranging in size from the mini to one as large as IBM's 360/50. The series, called RJAD [*Electronics*, Sept. 25, 1972, p. 72], is to be shown May 3–June 10 at Moscow's Permanent Exhibit of Economic Achievements.

**There are to be seven models in the line, the ES-1010, 1021, 1020, 1030, 1040, 1050, and the 1060, the biggest. Memory capacity of the machines is scheduled to range from 8,000 bytes for the ES-1010 up to 256,000 to 2,048,000 for the ES-1060.**

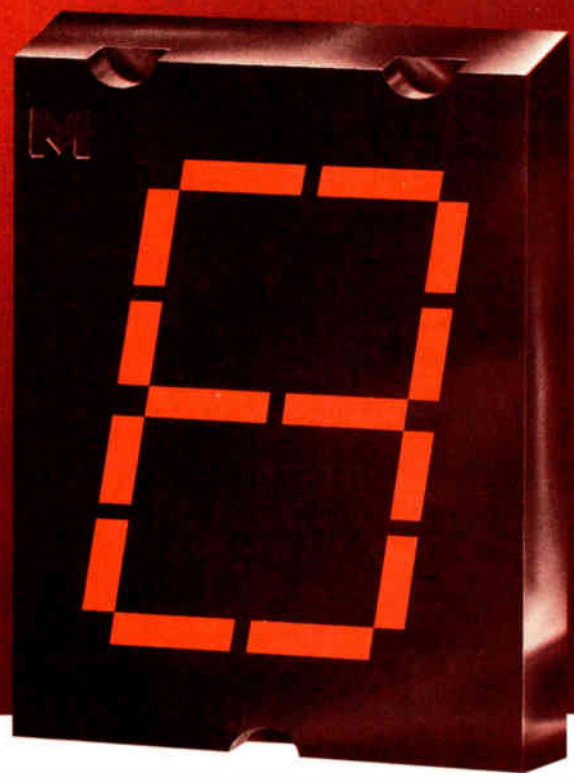
## Swedes break into the U. S. bank terminal market

Saab-Scania has broken into the U.S. computer terminal market with an order, worth $500,000, for 50 Datasaab teller terminals for the Central Savings Bank of New York City. The terminals—which include Datasaab D5/20 minicomputers, cassette tape storage, CRT displays, indicator panels, keyboards, and printout units—are similar to those the company is delivering to Nordic Savings Banks.

**This is the first bank terminal order outside Scandinavia for Datasaab, and company officials say they are aiming at at least three additional bank customers in the U.S. this year.** Saab-Scania has just named Trivex Inc., of Los Angeles as its North American agent. A maker of CRT displays, Trivex has sales and service facilities throughout the U.S.

# Putting innovation to work.


## The 40-feet-away GaAsLITE display.



Here's the MAN66A—.6" high and readable from a forty foot distance. There's also the .4-inch MAN64A. Both give you the reliability of GaAsP and both plug into an ordinary 14-pin DIP socket. You can get either in a module containing driving circuitry, too. Whether you buy components or modules, in whatever volume, you can count on Monsanto's tight process and quality controls.

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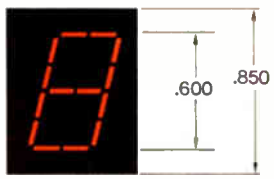
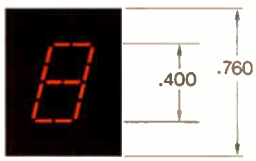



**MAN66A**—.6-inch high




**MAN64A**—.4-inch high

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GENERAL ELECTRIC

# CCD image sensors outshine vidicons, Fairchild states

Newly developed CCD cameras are moving from the laboratory into practical applications

The charge-coupled device has surpassed the vidicon tube in dynamic performance range—the ability to generate a clear video picture at widely varying levels of illumination. So say the CCD project leaders at Fairchild Camera & Instrument Corp., who see CCD image sensors moving from research into practical video camera design.

"We now have a full order of magnitude improvement over vidicons and hope for a wider dynamic range in the future," says Michael Harris, electro-optics engineering manager at Fairchild's Space and Defense Systems division in Syosset, N.Y. His statement refers to line-scanning arrays, which Fairchild's Semiconductor R&D Laboratory, Palo Alto, Calif., is making and which Harris' group has used in two mechanically scanned video cameras.

One camera, a feasibility model demonstrated to Fairchild's board of directors last fall, has generated test pictures illuminated by infrared as well as visible light. It measures about 2 by 4 by 3 inches and consumes about 2½ watts. The linear CCD array is self-scanning in the X direction and has a 625-line scan in the Y direction of about 1 second. A prototype of a military version of this camera is now being evaluated.

Moreover, Fairchild also plans to upgrade its F708 airborne reconnaissance camera with a CCD array. The F708 uses a line of 1,024 silicon photodiodes to scan lines in the X direction and aircraft forward motion for Y scanning, a mode that produces a panoramic strip picture. The company is seeking a contract from the Environmental Protection Agency to build the CCD version into an airborne camera system that would find oil spills on bodies of water.

All these camera projects are the result of progress made in buried-channel array development at the Palo Alto lab. A 500-element design, used as a test bed [*Electronics*, May 22, 1972, p. 29] has been operated successfully over a 1,000-to-1 illumination range, according to James Early, director of research. (Vidicons have about a 100-to-1 range.) In addition to operational advantages, Early emphasizes, the wide range means that much larger arrays will be practical.

The most recent tests will be exhibited at the International Solid State Circuits Conference, Philadelphia, Pa. They will consist of


**CCD eyeball.** Fairchild engineers demonstrate the first charged-coupled-device camera, which operates on 2½ watts of power and measures about 2 by 4 by 3 inches.

television test pictures made by scanning a photo mounted on a revolving drum at 2,000 lines a second (1-MHz bit rate) and feeding the signals to a conventional television monitor. The photo shows a fair-haired boy dressed in black and white—a subject that tests a sensor's ability to simultaneously detect highlights and dark shadows without washouts and loss of resolution.

**Steps.** After each scan, neutral-density filters—broadband optical attenuators—step down the image intensity from 30 to 3, 0.3 and 0.03 foot-candles. At the lowest figure, the optical energy input per line is only 15 microfoot-candle seconds. The sensors are almost saturated at 30 foot-candles. At 0.03 foot-candles, they generate about 0.1% of charge saturation. As the intensity drops, the picture on the monitor screen fades somewhat but remains clear, indicating that the buried channels can transfer very small amounts of charge with little loss.

Buried channels are ion-implanted donor layers in a silicon substrate. They provide charges with a relatively trap-free passage under surface traps. Bell Telephone Laboratories, Murray Hill, N.J., which first reported the technique, has used them in linear arrays up to 1,500 elements long, but researchers consider their use in X-Y area arrays problematical [*Electronics*, Jan. 18, p. 162]. □

## Materials

# Magnetic bubbles don't need crystals

Scientists at IBM's Research center, Yorktown Heights, N.Y., have found a way to make magnetic bubble memories out of a film of amorphous material. With the new material, many of the difficulties that now beset development of bubble memories seem to have been bypassed.

IBM researchers have demonstrated a 100-bit shift register, made of amorphous film 2 micrometers

# Arpanet's engineers plan civil data network

A nascent computer utility from Waltham, Mass., styles itself a new kind of carrier offering a new kind of service. Called Packet Communications Inc., the company wants to set up a national network using leased common-carrier lines. It will offer a national message-switching service that it describes as "conceptually similar" to the network of the Pentagon's Advanced Research Projects Agency (ARPA). The Arpanet now interconnects more than 40 independent computers at more than 30 sites throughout the U.S.

The alumni of that system who have founded PCI want to build a commercial network servicing "manufacturing, banking, insurance, brokerage, and real-estate industries; credit-check systems; airline reservation systems; universities; and the commercial remote-access computer industry." Those who left Bolt, Beranek and Newman, the Boston area operator of Arpanet, to form PCI include the new company's president Lee R. Talbert, operations vice president Ralph Alter, and engineering vice president Stephen B. Russell.

If PCI can obtain FCC approval of its application, it could become the first successful computer utility. PCI's illustrative tariff schedule in its filing with the commission cites monthly rates of four-tenths of a cent per 1,000-bit packet for the first 1.5 million transmitted during the day from a computer interface, scaling down to two-tenths of a cent each after the first 9 million. Night rates would be half that. PCI's application contends that in point-of-sale transactions, for example, its "value-added network" would charge $5 a day for services that Datran, Vienna, Va., a specialized common carrier, proposes to offer at $40. Moreover, Packet predicts lower error rates than Datran's.

**Issues.** In its application to the FCC, PCI points out it plans no construction of interstate or intercity exchange lines. Instead, PCI proposes leasing "existing wideband interchange lines from established carriers." The FCC must decide whether PCI requires regulation or treatment as a carrier and what to do about the apparent conflict of PCI's application with FCC rules prohibiting the resale of communications services. To preclude any disputes with the FCC, the company says it will offer a message-switching service as defined by the commission, not data-processing services such as storing, retrieving, sorting, merging, and calculating.

PCI will permit interconnection over the network of any one computer with another using specially modified minicomputers called packet-switching processors, or PSPs. Access from terminals to the computers of various customers will be by means of terminal access processors, or TAPs. Each TAP will be connected to the network through a PSP, with terminals able to access the TAP through the local direct-dial network. PCI says its network would use two network operations centers, "one in the Boston area and a second in the western part of the U.S."

**How it works.** The PSPs will subdivide and reformat messages from customer computers into 1,000-bit packets, and route them to PSPs serving the destination computer. On the receiving end, the PSPs will verify error-free transmission, remove routing and transmission codes, and pass the message on to the appropriate computers. Average round-trip communications delay for PCI users, says the company, will average about half a second for inducing end-to-end transmission, including store-and-forward functions of the several PSPs. Arpanet works in much the same way.

If PCI can get what it calls "reasonably prompt" FCC action, it forecasts starting service by mid-1974; developing a 20-city net by the end of 1975, and expanding that to 57 cities by 1978. And, if ARPA gets out of the network business—as it expects to—then PCI may find itself with an established business base on which to build, provided it can compete successfully in the bidding to take over Arpanet as a commercial service. □

**Bubbly model.** An "atom" is dropped into an amorphous "film" to show how the evaporation process stops at a point that creates a vertical field so that bubbles can be formed.

thick, which operates at a data rate of 100 kilohertz. And in thinner films, bubbles as small as 1,000 angstroms (0.1 μm) in diameter have been observed with the help of an electron microscope. This suggests that a shift register is feasible with a data rate well up into the megahertz range, and with bubbles packed as closely as a billion per square inch.

**Deposited on window glass.** Under the direction of Praveen Chaudhari, Jerome J. Cuomo, and Richard J. Gambino, films have been deposited on substrates as diverse as window glass and flexible plastic, at room temperature and without extensive advance preparation.

Until now, magnetic bubbles have generally been formed in films of single-crystal garnet materials grown epitaxially on a single-crystal substrate. Although a great deal has been learned in the few years since the inception of the technology, the single-crystal approach has not been easy.

IBM's goal was to prepare a bubble memory by evaporating the film onto an arbitrary substrate of arbitrary size, cheaply, at room temperature. They did this with an amorphous film of gadolinium-cobalt and gadolinium-iron—materials they had tried to use, without success, in crystalline form. Evaporation is a much simpler process than epitaxial growth. Surprisingly, the necessary magnetic properties, which the researchers didn't think they'd find in an amorphous material, were present at levels that, although low, were sufficient to create bubbles.

One of the most important properties is magnetic anisotropy. In an amorphous material made of two components, one would think that the axes of pairs of atoms would be aligned at random, because crystal structure is lacking. But they're not. The IBM researchers discovered that the probability that a pair axis has a component perpendicular to the film is about 1% more than the probability that it has a component parallel to the film, because of the nature of the energy relationships between the atoms. This isn't much of a difference, but it's enough to provide the anisotropy required in a bubble memory. □

## New Ruggednova comes on strong

When the first Ruggednova computers came out, that's exactly what they were—Data General Nova minicomputers repackaged by the Rolm Corp. to withstand military environments [*Electronics*, March 1, 1971, p. 61].

Rolm's new model 1602 Ruggednova is a dozen times faster than its predecessor, the model 1601, and as much as 30% faster than the Data General machines. It is Rolm's own design, a microprocessor run by instructions stored in a 4,096-word bipolar read-only memory. That memory runs at a 5-megahertz rate—five times the input rate of the basic software and five times as fast as the basic core memory.

The main-memory cycle is asynchronous, which allows semiconductor main memories to replace cores to redouble the processing speed. Another memory feature is direct addressing, which can be used to double the original memory capacity of 32,768 words to 65,536 by employing all 16, rather than 15, bits of the main instruction words. The model 1602 processes 16-bit words. The microinstruction ROM, however, uses 32-bit words to handle the program extensions.

The main reason for these and other innovations is that it opens up new military applications for off-the-shelf computers: electronic intelligence and countermeasures, priority communications-network control, and Omega and Loran.

The price with an 8,192-word core memory is $18,000. □

## Will IBM's diskette KO punched cards?

IBM's recent announcement of the 3740 data entry system—similar to but not identical with the company's European keyboard-to-disk system—could mean the beginning of the end of punched cards. An IBM spokesman insists, however, that the company is not abandoning the punched card.

The product itself uses a small magnetic "diskette" as the recording medium. (The diskette is similar to the "floppy disk" introduced by IBM in 1970 to load programs into a reloadable control memory, now available on several of the newer IBM computers.)

Each diskette can hold as much information as 3,000 standard 80-column punched cards. Data can be transferred from the diskettes directly into a computer at a rate of 3,600 records per minute—much faster than with punched-card equipment and without a significant

**Data entry.** IBM's 3740 system performs the same job as punched cards, but it's faster.

price differential between the 3740 and high-speed IBM card readers.

The system also uses a serial printer and units for transferring data from the diskettes onto computer-compatible magnetic tape, or directly into a System 370 or System 3 computer. Communications capability is also available so that the diskettes can be used remotely.

Up to now, IBM has carefully stayed out of the keyboard-to-disk and keyboard-to-tape market which was directly competitive with its punched-card mainstay. Its only nod in that direction was the model 50 magnetic-data inscriber, the performance of which is almost identical to that of an ordinary punched-card machine. Only IBM's optical character recognition machines have had a performance level significantly greater than that of punched-card equipment; and according to the International Data Corp., although IBM has maybe 60% of the installed base in OCR equipment, OCR has provided only a minor part of IBM's income. Thus the 3740 represents a significant step forward in IBM's approach to the data-entry market.

An IBM spokesman said the major market for the 3740 would be in applications that up to now have used punched cards in high volume. But small users, and in particular users of the System 3 and its 96-column punched card, will continue to find the older technology economical. □

## Communications

# Proposed safety standards for lasers draw ire of industry

Representatives of laser manufacturers and the Bureau of Radiological Health will meet Feb. 20 in a showdown over proposed laser safety standards, which, if approved, would "deal a large segment of the market a crippling blow," says one laser manufacturer. The meeting is a hearing before BRH submits the proposed standards March 26 to an advisory committee on radiation safety standards for electronic products. If that committee agrees, the proposals would be on their way to becoming law. Congress is to hold hearings on radiation problems.

At issue is the maximum power levels for class 2 lower-power continuous-wave lasers used in classrooms, demonstrations, construction, and surveying. BRH wants to limit those lasers to 1 milliwatt of power output, but the industry claims that 5 mW is safe and that the lower limit would wipe out use of lasers in classrooms and construction. If approved, the BRH standard would prohibit the sale of new class 2 lasers above 1 mW, but it will not stop the use of existing ones, assures BRH's Richard W. Peterson, electro-optics branch chief.

The BRH proposals, based on "threshold curves agreed to by ANSI (American National Standards Institute, New York City), and the bio-effects people," are needed to ensure complete safety, Peterson says. Not so, counters C. Harry Knowles, president of Metrologic Inc., Bellmawr, N.J., who argues that the dangerous levels are many times higher. The Electronics Industries Association's position is that 5 mW is a safe level," concurs Allen M. Wilson, engineering department chief. BRH would divide lasers into four classes. Class 1, those below 1 mW, would automatically be adjudged safe. The disputed class 2 would emit no more than 1 mW and carry warnings against looking at the beam. Class 3 would include all those above 1 mW, those deemed potentially dangerous to the eyes. Class 4 would endanger the eyes and skin. Both classes 3 and 4 would require use of eye shielding.

The new standard wouldn't recall lasers now in use, but EIA's Wilson says, "as we read the present standard, about 60% of existing lasers would be declared dangerous." □

## Audio electronics

# Varispeech system could aid blind

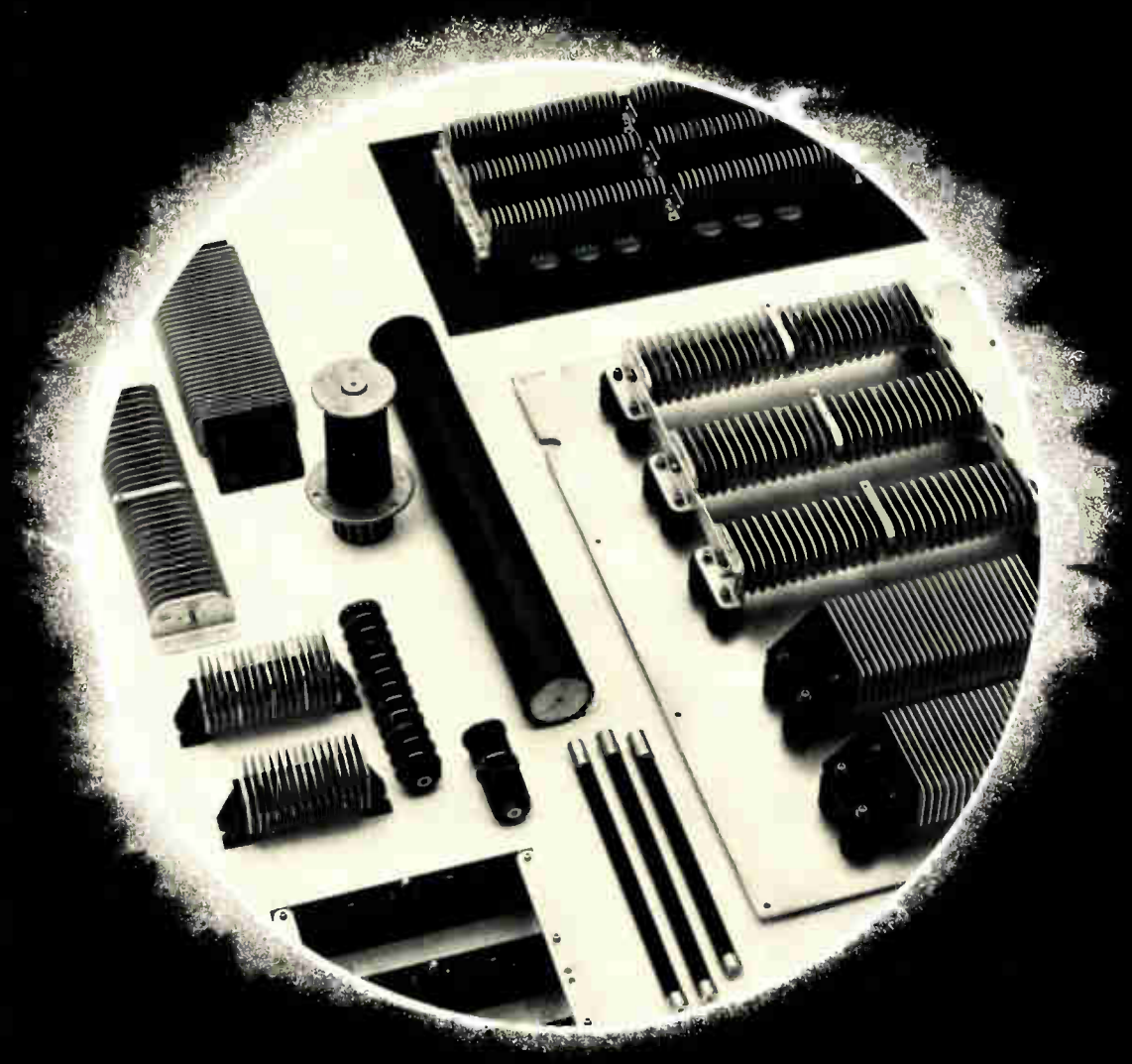
People normally speak at 100 words per minute and read three to five times that fast. Now with a technique called Varispeech, the visually handicapped have a chance to listen as quickly as some people read.

Varispeech uses digital signal-processing techniques to play back recordings with their original pitch and tonal content but at half to 2½ times the speed of the original. Thus, an hour's speech can be heard in 24 minutes, and the blind could increase their learning speeds proportionately.

Other applications might include continuing education of engineers and executives, as well as dictation. Speeches and commercial announcements could be squeezed to fit tight time spots exactly. Moreover, synchronization of film and video sound tracks would be simplified with the system's variable speed control.

There are low-speed applications, too. Short-hand instruction might begin with slow speech, and the rate steadily increased as students improve. Varispeech can also reconstitute so-called "helium speech"—the high-pitched speech, peculiar to high-pressure environments, that is a problem in undersea exploration.

Varispeech is the brainchild of



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Francis F. Lee, professor of electrical engineering at the Massachusetts Institute of Technology, Cambridge, Mass. He is selling it through his company, Lexicon Inc., Waltham, Mass.

Lee's doctoral thesis concerned text-to-audio conversion for the blind, and it earned him a faculty appointment. But construction of the hardware involved optical character-recognition techniques and multi-processors, and it would have cost several hundred thousand dollars to reproduce. "Obviously, I wasn't helping the blind with this," he says, "so I took a new approach." The new system costs $1,500.

While the Varispeech unit looks much like a standard cassette tape deck, the large variable-speed control knob atop its 13-by-14-inch case sets it apart in appearance. Playback speed is infinitely variable, and both signal processing and other key parameters are controlled through this single knob. The electronics package in the machine samples the output at the playback head, temporarily stores it in a 4,096-bit MOS random-access memory, and then reads out each sample consecutively, playing back the tape without loss of its original tonal content.

Varispeech is simpler and could prove more reliable than systems with television-like rotating multigap heads, tape loops, and other analog solutions. The system requires no more moving parts than a tape recorder and obviates the need to match the output levels of the various gaps in multigap heads.

Lee hopes eventually to be able to sell the electronics package separately for a few hundred dollars, thus broadening his sales potential into OEM markets. □

**Machine speaks fast.** Varispeech unit maintains tone, but speeds up speech.

## Commercial electronics

# Computer tells blind what they've written

An audio-response time-shared computer service (ARTS) is helping the blind to type correspondence, proofread manuscripts, solve bookkeeping problems, and even write computer programs. The system was developed by Kenneth Ingram, president of American Systems Inc. Watertown, Mass.

The first ARTS system was recently installed at the Protestant Guild for the Blind in Watertown. It takes only a few hours for a blind person to learn to use the system. When the bureau is telephoned, information is transmitted to the computer via the console; each key pressed generates a touch-tone sound that the computer recognizes. The computer responds in words, telling the user what he has typed or giving the results of commands or computations. The user receives a voice recording, braille copy, or ink-print copy of the typed information, and in addition he receives memory space to store information so he can recall it later for more changes or additional copies.

A student might use ARTS to prepare homework and type papers, and a secretary could type letters or other material, proofread them, and request printed copies on a letterhead. A programer might type in a program, using the voice to find errors. New lines could be inserted or statements corrected by typing in simple commands and then the changes. The computer would provide a punched card or printed copy of the completed program.

There are two interconnected digital computers in the ARTS bureau. An audio response unit receives the information from 16 telephone lines, transforming it into voice to be played back to the user. Speech information is stored on a magnetic disk. The audio response unit transmits information from the user to an applications computer which contains and operates the service bureau programs. Included in the applications system is a Data General Nova 800 with 16,384 words of memory, a high-speed swapping disk with 512,000 words of memory, and a moving-head disk for storage. The charge is $450 for a console with either a standard or a braille keyboard, and computer time costs an additional $1.50 an hour.

Sixteen users can now be handled simultaneously, and American Systems hopes to expand this capacity. The state of Kentucky has contracted for an ARTS system, and inquiries have come from overseas. □

# Digital thermometer uses DVM chip

One of the least likely applications for a complex one-chip digital voltmeter might seem to be replacing a simple glass thermometer, but Ivac Corp. has done just that. The San Diego company, which has been making digital-readout medical thermometers, has introduced a small portable version using a Mostek DVM chip, plus a three- or four-digit light-emitting-diode readout.

Although priced at $395, the unit is particularly useful for hospitals because readings take only 3 to 7 seconds, and sterilization is unnecessary because the probe uses disposable covers. Another bonus is the elimination of breakage, which reportedly results in 60 tons of deadly mercury pollution being washed into the environment each year.

The thermometer emits an audible signal when the reading is ready. It also stores the temperature automatically until the probe is inserted for storage.

Models are available for both fahrenheit (49.0 to 108.0 F) and celsius (34.0 to 44.0°C). Resolution for both models is 0.1°, with fahrenheit accuracy to ±0.2°, and celsius to ±0.1 . The unit also includes self-test

# Stable:

## Our phase-locked loops offer you greater V.C.O. stability, frequency range and functional capability.

**HA-2800 for guaranteed frequencies up to 25 MHz.**
For use in frequency synthesizers. As an I.F. amplifier detector for F.M. Or phase modulation receivers. Operation guaranteed up to 25 MHz. V.C.O. output: compatible with both TTL and ECL and provides improved temperature coefficient and supply regulation. Supply voltage range: 12V to 30 V.

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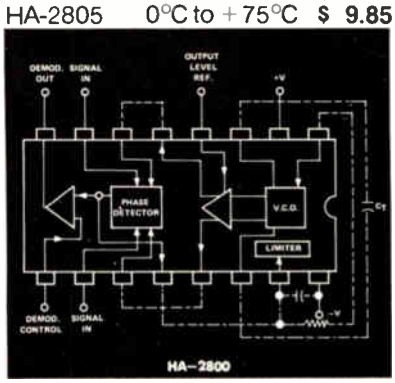

HA-2800

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**For details see your Harris distributor, representative, or write direct.**

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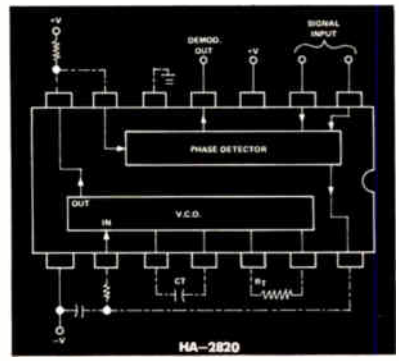
| HA-2820 | −55°C to +125°C | $13.35 |
| HA-2825 | 0°C to +75°C | $ 6.35 |



HA-2820

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capability. Power comes from rechargeable nickel-cadmium batteries, giving a battery life of eight to 10 hours between charges. The thermometer, which is 3⅜ in. wide by 5⅜ in. deep by 2⅜ in. high, weighs 12 ounces. □

## Packaging

# DIPs challenged by film-strip package

A new IC packaging technique that challenges the dual in-line package for reliability, low cost, and ease of test and assembly has been announced by AMP Inc., Harrisburg, Pa. Said to be far less expensive than ceramic packaging, the technique is similar to the MiniMod approach originated by GE, but since sold to Texas Instruments [*Electronics*, Feb. 1, 1971, p. 41]. It uses various widths of Kapton film to support plated-on lead patterns. Although some assemblies can use film strips several inches wide, most common applications would make use of films 16, 35, or 70 millimeters wide, frequently with sprocket holes like movie film for easy indexing and movement.

**Narrower.** Semiconductor chips are bonded facedown to the leads, and the film is spooled up. It can be unreeled later for test and circuit-board assembly. The technique adapts to LSI devices, discrete semiconductors, and multichip arrays; as many as 80 leads can be laid down on the Kapton with spacing between leads as small as 2 mils. According to AMP, this spacing is narrower than that possible with the MiniMod technique.

AMP spokesmen claim high potential reliability for this system, especially compared to wire-bonding techniques. First, there are no wires to bend or break, and one bonding step is completely eliminated. In addition, unlike most other facedown bonding schemes, the active area of the chip can be inspected through the transparent Kapton.

The technique is inexpensive enough that chips can be bonded to the lead patterns before electrical tests, thus removing a source of mechanical damage to chips that often cuts yields during probe tests. Also, lead and chip tests can be combined into a single step.

Packaging could be as simple as allowing a drop of epoxy to cover the chip, sealing it to the Kapton. This could simplify automated packaging, and it might cut packaging costs enough to allow competition with inexpensive offshore labor. Also, since chips so packaged have a very low profile, high component density is possible.

The system is compatible with edge-connection IC-mounting techniques and with other so-called leadless systems. But eventually, printed-circuit-board assembly of ICs using the AMP packaging technique might use reels of chips, laying down each circuit and bonding its leads to attachment points, rather like plastic postage stamps.

Unlike the MiniMod approach and Motorola's spider bonding, the technique is for sale to all comers, and the firm already claims that at least two major firms are about ready to sign. Thus the technique's challenge to the DIP could become a reality. □

# Echo triggers LEDs in depth-finder

A readout composed of a quantized linear array of 100 light-emitting diodes is featured in an all-solid-state depth-finder from a new marine electronics company. The 10-inch-wide diode array is sequentially addressed by counter-decoder combinations after transmission of a sound probe into the water. The arrival of an echo from the bottom turns on the diode addressed at that instant.

Developed by Osborne-Hoffman Inc., Point Pleasant Beach, N.J., the Quantiline Sounder distinguishes between actual sea bottom and secondary echos from objects, such as fish, between the boat hull and the bottom. It operates over three ranges, 0–20 feet, 0–100 ft, and 0–500 ft. Resolutions are ±0.1 ft, ±0.5 ft, and ±2.5 ft, respectively. For added safety in shallow water, the unit eliminates spurious echos on the 0–20-ft range and displays only the first signal received.

According to co-founder Edwin Hoffman, production units will be available in April at a suggested retail price of $150. The prototype demonstrated at the recent New York Boat Show measures 12 in. × 6 in. × 2.5 in. □

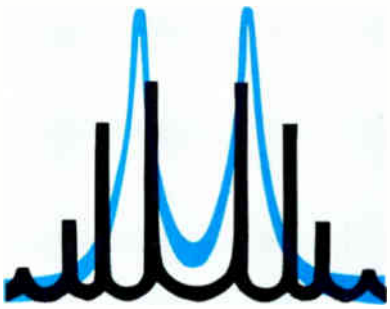
## Production

# Plating the way to inexpensive masks

Borrowing from an old technology—chemical plating—RCA's Research Laboratories, Princeton, N.J., is working on a new and inexpensive method for making the photomasks used in the manufacture of semiconductor devices. The masks are made with a cuprous oxide ($Cu_2O$) film plated on a glass substrate. Results so far are extremely encouraging, according to the project's manager, Nathan Feldstein, and should the process be used in manufacture, cost savings could be its greatest advantage. "We use a beakerful of chemicals costing only pennies," says Feldstein.

Line widths are down in the 1.5–2-micrometer region, or as good as any obtained with the silver ha-

# Near and far-sighted Spectrum Analyzer.



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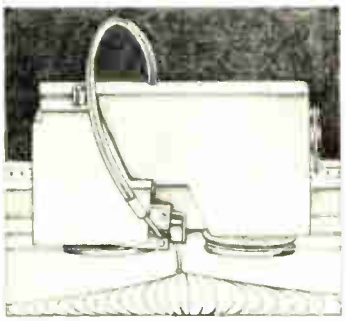
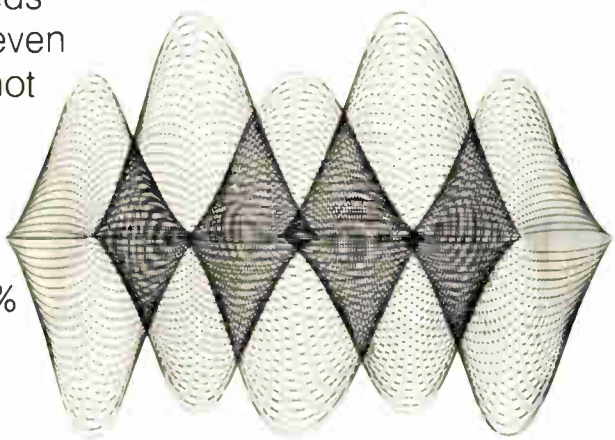
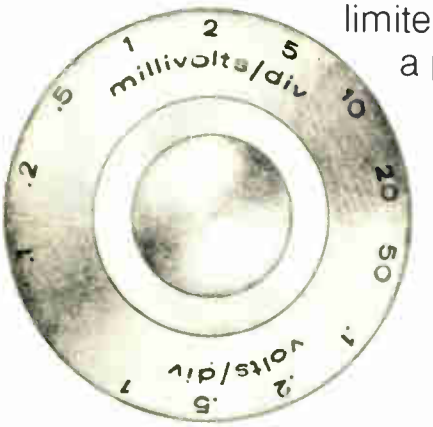




**SPEED.** The 500 does a fast 40 inches a second. Which makes it 50% or 100% faster than most anyone else's. And it accelerates at 1650 in/sec². It's a mover.

**MORE FEATURES.** Like electrostatic holddown. Easy rack mounting. Electronic limiters that eliminate collisions between pen and frame. And a price we think will please you.




For information on this excellent XY recorder with built-in preamps with a sensitivity range of 100μV/div. to 1.0 V/div., write Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Rue Van Boeckel 38, Brussels 1140, Belgium.

**BRUSH INSTRUMENTS**

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lide emulsion on glass most commonly used. And while the cuprous oxide film is opaque to the ultraviolet, the region of greatest photoresist sensitivity, it is transparent to visible light. This latter characteristic means that, unlike an emulsion mask, the new mask can be readily aligned on a semiconductor wafer by purely visual means.

Originally, the silver halide emulsions were developed to meet the precise dimensional requirements of semiconductor photomasks. Then other materials, deposited on glass substrates, were introduced that were more durable, like chromium, and also semitransparent, like iron oxide. Mask-making here requires sophisticated and expensive vapor deposition and sputtering machines, eliminated in RCA's process.

The cuprous oxide is plated on the glass strictly with wet chemical methods, and he believes it's the first time this material is handled in this manner. Initially, the glass surface is sensitized with acidic stannous solutions, then activated with acidic palladium chloride. Following this, the cuprous oxide is plated on out of an electroless plating bath of copper sulfate.

As with so many happenings in research laboratories, Feldstein hit upon the cuprous oxide material by accident. He was originally working on printing copper for printed-circuit applications and often found a deposit of an undesirable yellow material he thought "was good for nothing." Fortunately, he decided one day to run a check of its optical properties and found it would be ideal for photomasks. □

## Fairchild advances bipolar technology

While most semiconductor manufacturers are still struggling to get their first high-density bipolar processes on stream, Fairchild Semiconductor already has on tap a powerful second-generation process that promises even more speed and higher packing density than earlier bipolar memory and logic products. The new method of building digital bipolar integrated circuits is called Isoplanar II—an extension of Fairchild's original cell-shrinking Isoplanar technique that was responsible for putting high-density bipolar memories on the map.

But Isoplanar II does more. Tom Longo, vice president and general manager of Fairchild's Digital Products division, explains that the new process "reduces the silicon area of integrated-circuit transistors by 70% over conventional planar-transistor technology and 40% over the Isoplanar-transistor technology introduced by Fairchild in 1971." Not only does the new process further improve packing density, but Longo claims that Isoplanar II also provides a major reduction in junction capacitors, so that memory and logic circuits will operate faster and consume less power than those built with conventional or other passive isolation techniques.

In terms of random-access memories, using tighter line geometries could mean 2,000 bits and more on a single chip operating at access times of about 50 nanoseconds with power dissipation no greater than today's smaller bipolar RAMs. In logic, it would mean tighter ECL circuits operating at subnanosecond speeds and reduced powers per gate. Indeed, the first product Fairchild has built with Isoplanar II is an ECL circuit—a dual 5/4-input gate with current-switch inputs and emitter-follower outputs—which has typical propagation delays of 650 picoseconds for the five-input gate and 600 picoseconds for the four-input gate at 57 milliwatts per gate.

The new structure, which reduces the transistor collector-base junction area to 60% compared to that attainable by either conventional planar or the previous Isoplanar technologies, is built with an oxide walled-emitter structure. The emitter-base junction terminates at the same silicon-dioxide wall that provides isolation between adjacent transistors in the earlier Isoplanar technology.

As a result, Isoplanar II transistors not only save space, but they





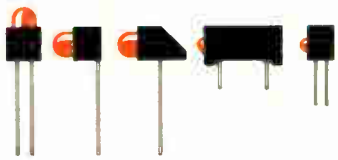
 

# Dialight sees a need:

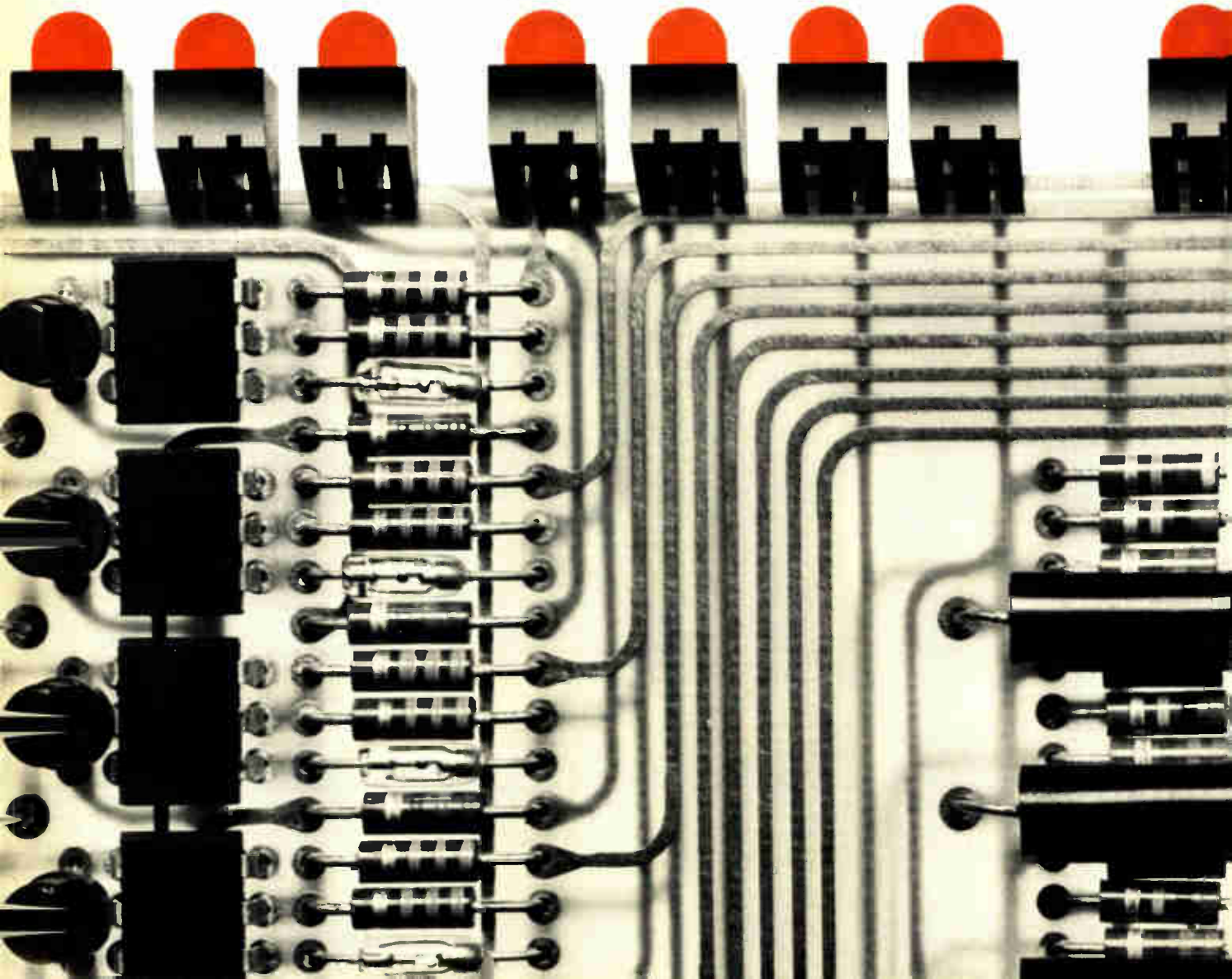
(**Need:** Find a very small fault in a very large system.)

# See Dialight.

All printed-circuit boards need a fault indicator; that's why Dialight has developed such a broad family. These tiny LED devices signal where and when a fault occurs in a complex electronic circuit — and this can reduce downtime to a minimum. With some Dialight fault indicators, you can get as many as 10 units in just 1" of space. These devices, which come in a variety of sizes, are designed to operate from 1.6 to 14 volts and are available with both axial and right angle leads. They



can be driven directly from DTL or TTL logic and can also serve as logic-state indicators, binary data displays, or just as indicators, as in this p-c board furnished by Struthers-Dunn, Inc.* But Dialight's fault finders are only a small part of their fast growing family of light-emitting diodes. Additional opto-electronic devices are extensively used in cartridges, lighted push-button switches, opto-isolators, and readouts, all supplied by Dialight. A wide variety of discrete LEDs further adds to the broad family.



have lower collector and isolation capacitances, and their dc breakdown voltages, beta, and open-base voltages are identical to those of conventional transistors made with the same diffusion levels. □

## Hearing aid IC cuts battery drain

A new linear integrated circuit that doubles battery life in hearing aids is going into production at the Raytheon Co. Semiconductor division, Mountain View, Calif. The chip, the RM8341, also cuts the RC network by more than half and provides automatic gain control. While standard hearing-aid chips, based on the Westinghouse 183 design, pull about 1 milliampere from the battery cell when quiescent, the RM8341 takes only 0.5 mA on standby. This is expected to extend battery life from a range of 60 to 100 hours to almost twice that range.

The only external components required by the RM8341 are two capacitors, a resistor, and a variable resistor with adjustable gain control or three capacitors and two fixed resistors with automatic gain control.

## News briefs

**Sapphire output to triple**

The Saphikon division of Tyco Laboratories Inc., Waltham, Mass., a major producer of sapphire substrates, has started an expansion program designed to increase the company's output from 15,000 square inches of sapphire per month to 40,000 per month by early fall. "We've made a decision to target on the electronics market, especially microelectronics," says marketing manager Frank Reed. "We have confidence that this business will take off this year." As it expands its capacity, Saphikon hopes to halve its prices from $20 for a polished 2-in. square or circle 2-in. in diameter between 10 and 15 mils thick, to sell at about $10.

Saphikon's new method of growing sapphire, a modification of the Czochralski techniques, is also a factor in its ability to lower prices. The company now can grow sapphire in ribbons, filaments, and tubes. Liquid sapphire is drawn up through capillary tubes to a predetermined shape; it spills over the shape, and crystals are grown from there in a predetermined crystal orientation.

**More test gear for Air Force avionics**

The Honeywell Inc. Government and Aeronautical Products division, Minneapolis, has won a $5.6 million award from McDonnell Douglas Corp. to build depot-level automated test equipment for the avionics aboard the Air Force's F-15 fighter. This is the second military-connected award in about a month for Honeywell's minicomputer-directed H-2600 series of test equipment, sold originally for testing avionics on commercial aircraft. [*Electronics*, Jan. 18, p. 112]. Emerson Electric Co., St. Louis, will supply the rf test equipment; Honeywell itself will build the analog, digital, and intermediate-frequency test stations. In time, and depending on how many aircraft are built, Honeywell estimates sales of the test equipment could reach $20 million.

**IBM doubles maximum memory**

Memory capacity of the multiprocessing versions of IBM's System 370 models 158, 168, and 145 have been doubled—even before the first two machines were shipped to customers. In the 158 and 168, IBM has substituted 2,048-bit MOS chips for the 1,024-bit chips that were originally specified for both machines [*Electronics*, Aug. 14, 1972, p. 40]. Memory size is increased in the model 145, announced two-and-a-half years ago as the first IBM computer with a semiconductor memory, by adding bipoplar memory chips of 1,024 bits each to the 128-bit chips used previously.

## Electronics review

To cut battery current drain, Raytheon borrowed some techniques from the operational amplifier designers. Chiefly, the company substituted pnp current sources for the passive resistors used in previous hearing aid chips, such as the Westinghouse 183.

There are four gain stages in the RM8341—three in the signal path and one in the feedback path—and an automatic gain control on the chip. The agc can be replaced by an external volume control if the agc stage is grounded. The over-all gain is 70 dB, and the acoustic power output is 150 microwatts.

The 183 has a much higher power output—3 milliwatts. However, Alan Borken, manager of linear interface marketing at Raytheon, says that about 60% of the hearing aids made today need only 150 μW. For the higher-power market, Raytheon plans to produce a 1-mW version of the RM8341.

Because of the sales appeal of longer battery life, Borken expects IC sales to climb. He estimates the total American market has been some 125,000 chips a year, which amounts to about $1 million at the typical Westinghouse 183 amplifier list price of $8, but it is actually less at the volume price of $5.

With fewer components required, Borken predicts that the RM8341 will cut into hybrid and discrete-circuit markets. He calculates that hearing-aid manufacturers now buy more than 60,000 hybrid ICs and make another 150,000 hybrids in-house. That means about one-third of all aids are still being assembled with discrete components. □

## Displays

### Silicon display being tested by AF

The first reported storage-tube refresh memory for an Eidophor projection color display is undergoing evaluation at the Rome Air Development Center, N.Y.

The color scan-converter system, developed by Princeton Electronic Products Inc., Princeton, N.J., changes a computer's digital output into a TV-type scan for Eidophor projection. The digital output is converted into three pairs of analog X-Y signals suitable for driving the deflection plates of a CRT. Each X-Y signal pair corresponds to one of the primary colors of a color-TV picture. The random X-Y scans are used to write messages onto the targets of three silicon-target, electrical-output storage tubes known as Lithocons—a trademark of Princeton Electronic Products Inc. (see p. 91). The messages are then read in a conventional TV scan mode to generate red, green, and blue video for display.

The major advantage of the storage-tube approach is cost—a three times saving over previous all-digital methods for refreshing color displays. Also, the system is a quarter the volume of previous units. □

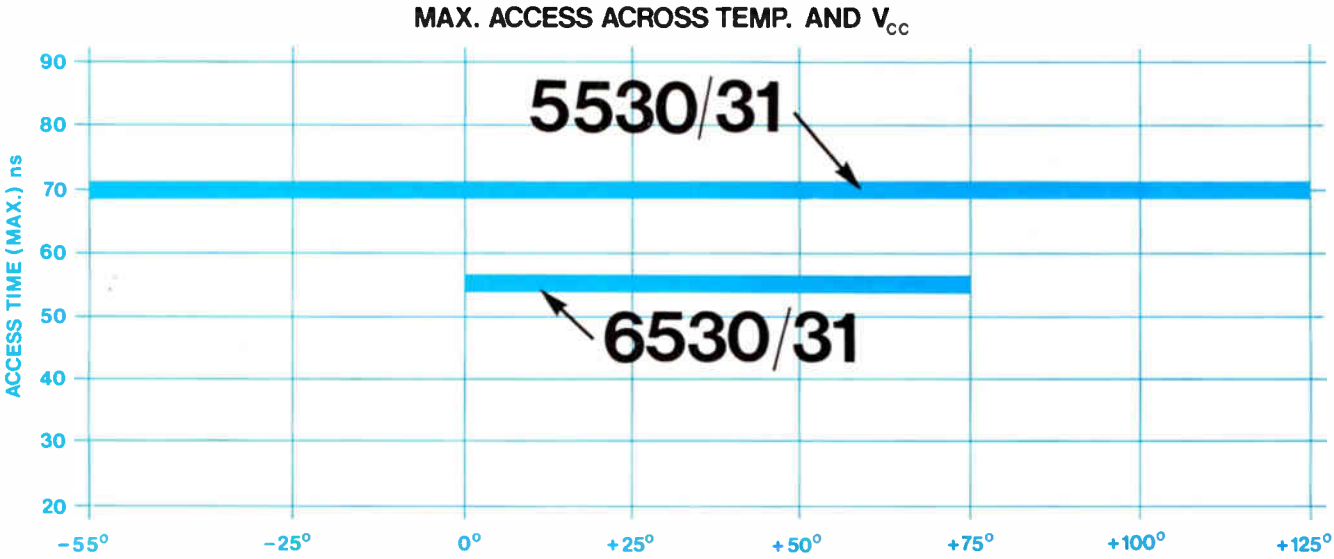
## Solid state

### Electronic watch ICs cut size and costs

Electronic watches are beginning to replace expensive mechanical time pieces for men. However, women's watches have not benefited until now because the electronic components, although tiny, have not been tiny enough for the dainty watch size. Now, Statek Corp. has demonstrated a technique that dramatically reduces the size of the electronic timing circuit, opening the way for a significant decrease in the size of today's electronic watches. Better yet, the circuitry promises to cut costs enough for finished watches to sell for $25 each, although they won't meet the highest accuracy specifications that the watch industry guarantees for its very expensive watches.

Statek combines miniature tuning-fork crystals with a complementary MOS divider chip inside a ¼-inch-square IC flatpack. The size of this assembly can be reduced even more by mounting the chip under-

# 256-Bit RAMs.

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| **FASTEST—Mil Spec 70 ns. (256 x 1) guaranteed across temp & $V_{cc}$ range** | | | | |
| **Monolithic Memories** | **5530/31** | **OC/TS** | **70 ns @ −55 to +125°C, 5.0 $V_{cc}$ ±10%** | **$52** |
| (Note: The TI 54200 and Intersil IM5533M are specified at 80 ns., but only @ +25°C, 5.0 V.) | | | | |
| Alternate sources—80 ns. devices (256 x 1) | | | | |
| **Monolithic Memories** | **6523/33** | **TS/OC** | **80 ns @ 25°C, 5.0 $V_{cc}$** | **$17** |
| Texas Instruments | 74200 | OC | 80 ns @ 25°C, 5.0 $V_{cc}$ | — |
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neath the crystal. Chip size is 85 by 90 mils, and crystal size is 25 by 180 mils. The watch also requires a trimmer, a battery, and stepping motor or digital display.

The biggest factor in reducing the size is the 32-kilohertz quartz crystal, made by batch photolithographic techniques similar to those for fabricating ICs. Statek puts a clear glass cover on the package so that the tuning fork crystal can be trimmed with a laser after air evacuation and aging.

The Orange, Calif., company is now using a standard Motorola C-MOS watch chip for demonstration purposes. □

## Mini system handles five clinical functions

Computerized medicine moved a step closer this month with the introduction, by Hewlett-Packard's Medical Electronics division, Waltham, Mass., of a multi-functional computer system called MODS, for medically oriented data system. Unlike earlier, dedicated, medical-computer equipment, MODS allows several different clinical functions to be served simultaneously by a single minicomputer, the HP2100. And, since it's a modular system, hospitals can start off small and add functions as needed. The result is lower over-all cost.

Although exact numbers are tough to nail down because no two installations are likely to be the same, Robert J. Sanzo, multi-function computer systems manager at H-P, estimates the cost of a single eight-patient monitoring station at $45,000, while a MOD system capable of handling four such stations would cost about $100,000.

The key to MODS is an operating system common to all five clinical functions it handles—electrocardiogram analysis, cardiac catheterization analysis, pulmonary testing, angiogram analysis, and patient-monitoring. A MODS accommodates up to four stations and two of these five functions simultaneously. □



## Electron imaging cures X-ray ills

X-ray techniques have significantly improved medical diagnosis and treatment since the phenomenon was discovered 77 years ago. But the technology has been seriously hampered by high incident radiation, relatively high cost, and low resolution of images because film is a poor medium for recording X rays. However, by applying a method analogous to that of electrostatic copying, a small California company has developed a technique that promises to alleviate most present flaws by merely adding a device to existing X-ray equipment.

Called electron radiography (ERG), the technique "produces sharper images at lower radiation," says Robert Carangi, assistant professor of radiology at the University of Southern California, which soon will begin two-year clinical demonstrations of the system. "We expect even better results" than those obtained through prototype testing in the last two years, he adds. Xonics Inc., Van Nuys, Calif., which began work on the process in 1970, plans to exhibit a fully automated ERG table unit later this year.

Essentially, the proprietary process converts the latent X-ray image into a latent image of electrons, and the density of the electronic charge is proportional to the incidence of X rays, explains William F. Hooker, Xonics executive vice president. The totally dry, self-contained process uses a toner to neutralize and make visible within 90 seconds the electron image on Mylar instead of X-ray film.

Unlike the conventional technique, the radiation passing through the body creates a flux of electrons in an imaging chamber. The flux is in ratio to tissue density, and it forms an image directly on plastic or paper sheet.

Xonics says that the process reduces exposure of radiation to

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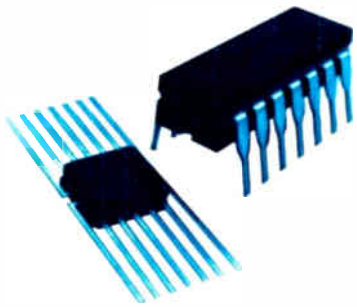

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## Electronics review

patients by 50%, and image resolution is doubled. There is also a saving of two-thirds in processing costs because plastic film is cheaper, and darkroom development is unnecessary. Carangi estimates that 20% to 30% of current radiology—especially chest X rays—could be recorded by the ERG process, which he says could replace 50% of the conventional X-ray film market within five years.

Because resolution is proportional to radiation levels, Xonics is trying to achieve the optimum balance between them. Final design of the ERG system will be determined after the clinical trial. Basic work on the idea behind the system began in the early 1960s at Siemens Research Laboratories. □

# Digital spirometer priced below $1,000

Proprietary sensing and hybrid-computer techniques have made possible a $995 respiratory-function tester with direct digital readout of eight key pulmonary signs. The spirometer, to be announced by Life Support Medical Systems Corp., has a built-in data processor.

The Woburn, Mass., firm expects to enter markets as diverse as the doctor's office, multiphasic testing, and industry—where the instrument might help spot the onset of such diseases as miner's blacklung. A back-panel BCD output also suits it to high-throughput computerized clinical applications.

The briefcase-size unit is said to be comparable with systems several times as expensive. For example, its semiconductor strain-gage transducer is accurate to 2.5% over a flow-rate range of 40 cubic centimeters per second to more than 10 liters per second, a linearity achieved only by systems priced higher than the entire life-support spirometer, the company says. Also, instead of displaying analog data, which must be interpreted, the spirometer uses a 2½-digit array to display key data in real time. □

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**National**

# Washington newsletter

## Design changes in Awacs attract critics in Congress

A major design change in the Airborne Warning and Control System **to cut an estimated $20 million from projected program cost totals** for 42 planes has caught, to the dismay of the Air Force, the attention of congressional budget-cutters. **Congress previously has challenged the need for Awacs,** the modified B-707 capped by a 30-foot-diameter "mushroom" housing a Westinghouse Electric radar. Now the Air Force says it is switching from eight GE engines with long-loiter capability for next-generation air defense to four more powerful Pratt & Whitney engines. Also, it is cutting back its test-bed aircraft program and pushing for more development avionics in the new fiscal year beginning July 1.

The changes would drop the fiscal 1974 program costs to just under $210 million, most of it for RDT&E, from $233 million this year. Congressional critics, say sources on both the Senate and House Armed Services Committees, are less impressed by the proposed economies than **the engine changes, which they suspect indicate Air Force uncertainty** about what it really wants or can achieve in the long-delayed program.

## DOT to spend millions on urban transport

The Department of Transportation plans to start a three-phase, multiyear program to provide towns and cities with transportation systems that **combine the features of communications-linked buses and automated personal rapid transit.** It intends to award **up to three $500,000 first-phase contracts in April,** when responses to its requests for proposals are due. The dual-mode systems are to use rubber-tired vehicles for 10 to 40 passengers that either ride on automated guideways or operated as buses as in DOT's experimental dial-a-ride concept.

Up to two companies would be selected for the 30-month second phase to build and test operational systems at DOT's Pueblo, Colo., test center. Phase three would use Urban Mass Transit Administration grants to enable municipalities to install working systems. Exact funding for the project is being worked out, but **a fiscal 1973 appropriation of $4 million was reduced,** says a knowledgeable source.

## AF's A-10 award to Fairchild contested; GAO investigating

A General Accounting Office investigation of **charges that political pressure influenced the selection of Fairchild Industries Inc.** to build the A-10 close-support aircraft has not affected the contract award, according to the Air Force. Nevertheless, the service **admits the contract is still "in negotiation,"** but has yet to be signed. Avco Corp.'s Lycoming division at Stratford, Conn., which made the engines in the losing Northrop Corp.'s A-9 prototype, protested the choice of Fairchild's Republic division at Farmingdale, N.Y., on grounds that New York business and political interests had been involved. Aerospace business in the Long Island area is depressed, and the A-10 represents a potential buy of 600 or more planes at $1.4 million apiece.

Interestingly, the party remaining **silent in the challenge to the Air Force is the Californian Northrop,** which is still in competition with General Dynamics for another major Air Force buy—the Lightweight Fighter, budgeted for $46.5 million in R&D for fiscal 1974, compared to $40 million this year.

# Washington commentary

## Nixonomics, Congress, and Cresco

The evidence is overwhelming that Richard Nixon holds the high cards in the developing dispute between the White House and Congress over who controls the Federal purse. One of the more important and often overlooked reasons why he does can be illustrated by relating the events that took place on April 5, 1968, at Cresco, Iowa.

Cresco is a city of about 5,000 in the northwest corner of the state not far from the Turkey River. About 50 miles to the northwest is Austin, Minn., the nearest city of any size. The business of Cresco is farming, as it is with the other communities of the region. One son of Cresco, now with an aerospace conglomerate in the Capital, recalls visiting his hometown on April 5, 1968—the day following the assassination in Memphis of civil rights leader Martin Luther King in Memphis.

"It was in the morning, about 9:30, and everyone had come to the restaurant for his 'second breakfast,' a little coffee and something to eat after the first few hours' work. The news of King's death and the riots that had broken out in Washington was on the television behind the counter, but you couldn't hear a thing. The conversation in the place was too loud." No one was paying much attention to the news from Washington and Memphis, it turns out, because the local news was overriding: the new line of John Deere tractors was being introduced to Cresco.

### Priorities and perspectives

There is a lesson there for electronics and the other industries who track events in the Capital. It is a lesson dealing with peoples' priorities and perspectives; it is a lesson that Richard Nixon knows well. How well he knows it was demonstrated when he delivered his tough $268 billion budget for fiscal 1974 to the 93rd Congress at the end of January with the message that it "fulfills my pledge to hold down Federal spending so that there will be no need for a tax increase."

President Nixon knows that "no tax increase" is as much as Cresco heard or wanted to hear. He also knows that there are literally thousands of Crescos throughout the United States. Even in the ostensibly more sophisticated urban centers of the nation, the citizenry finds the stuff of Federal budgets to be dull and undramatic. But, like the residents of Cresco, they too are taxpayers and are caught by the words "no tax increase," rather than by the reordering of specific Federal priorities through which tax stability is achieved. To its chagrin, Congress knows it, too: for every congressional district, like Iowa's 3rd in which Cresco falls, there are local considerations of far greater importance than the specifics of the Federal budget. Whether the Department of Defense gets more money next year and the Department of Health, Education, and Welfare gets less is not important as long as taxes don't go up and there is money for a new tractor, television or student tuition.

### Congressional backlash

Military and aerospace electronics contractors concerned with specific programs contemplate the congressional reaction to such cold realities with discomfort. Aware that the White House holds the upper hand in the fight to control Federal spending, an increasing number of industrialists suspect that the Democratic majority in the Congress will be unable to carry the day against the President on the fundamental issue of determining national priorities through the appropriations process. Should this be the case, Government contractors fear that a frustrated Congress will then retaliate by turning on specific military budget programs—line item by line item—and cut them back sharply.

Disturbing to both contractors and military project offices is that the President's baiting of Congress on the issue of fiscal responsibility, calling it "not responsible," appears to be asking for program cuts. One defense official, for example, noting the Navy and DOD effort to work out a satisfactory compromise with Grumman Aerospace Corp. on the stalled F-14 fighter contract, sees it this way: "We have enough problems without the President waving red flags in front of some of those bulls on the Hill. All Congress has to say is 'Oh, yes, we are responsible, Mr. President, and to prove it we're going to make the Navy hold Grumman to that contract. Period.'" And there are other programs, as well, for which the Pentagon wants more money for the post-Vietnam period, ranging from the big Trident missile submarine down to the Army's growing R&D effort to develop its Advanced Attack Helicopter.

What the Pentagon sees is that Congress perceives the lesson of Cresco, Iowa, too—the lesson that most citizens are indifferent to budgetary line items as long as the total of those items doesn't cost them. It is a lesson that is casting long shadows in Washington, unsettling shadows that are clouding some corporate futures.

**—Ray Connolly**

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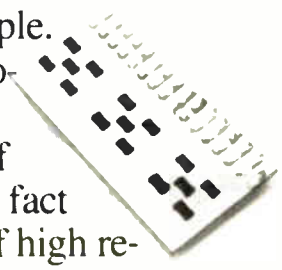

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## Tuner uses non-volatile MAOS memory to control automatic tuning

Digital technology has come to radio with an fm spectrum-scanner stereo tuner developed by Sony Corp. At first glance, the tuner looks more like a minicomputer mainframe, and it uses metal-alumina-oxide semiconductor integrated circuits and transistors for its read-mostly memory, as well as simple IC registers. The MAOS memory devices are used to store electronic display and tuning information for prolonged periods, and to maintain the information even when the power is turned off.

**Display.** One reason why the receiver resembles a minicomputer is an array of lighted front-panel buttons that replaces the dial. There are 100 buttons corresponding to the 100 U.S. fm channels, which are located at 200-kilohertz intervals in the range between 88.1 megahertz and 107.9 MHz. The buttons control the frequency-synthesizer-type local oscillator, which can tune the receiver to any one of these 100 channels only. The accuracy of the frequency setting is to 4 kHz, about one order of magnitude better than the average hi-fi tuner.

The set's new modes of operation include an automatic 5-second sweep of the fm band, after which the buttons—containing green neon bulbs—for those channels on which stations were received remain illuminated. The tabulation of channels on which stations were received is stored in a 100-bit MAOS memory and is retained until the user wishes to rewrite the information.

It is also possible to program the tuner to light buttons only for selected channels among those on which stations were received. This information is stored in a second 100-bit memory. The user can select either of the above two readouts by depressing panel buttons. A button marked "Next" causes the radio to retune to the next among the channels shown on either of the two readouts.

In line with the digital nature of the tuner panel, the signal strength indicator is also a lamp display—Sony designers thought a meter would look out of place. Other tuners often have two meters—one to balance at zero when correctly tuned to a station and the other to indicate signal strength. The new tuner has no need for tuning indication because the buttons set it almost perfectly on station frequency. Signal strength is shown on a horizontal, thermometer-type indicator with from one to five bulbs aglow according to signal strength.

The actual setting of the tuner frequency is done with a synthesizer-type local oscillator that is based mainly on frequency division. In this synthesizer, the receiver local oscillator frequency is heterodyned against a fixed crystal oscillator to translate it into a convenient lower-frequency range.

The translated lower-frequency signal then passes into a frequency divider, the output of which is compared with the frequency of a second fixed-crystal oscillator in a phase comparator. Output from the comparator is a dc voltage that is impressed on a varactor diode in the local oscillator to set it at the programed frequency. □

**West Germany**

## Scale uses MOS, optical techniques

Electronic techniques have lately found a niche in the small scales used in groceries, butcher shops, and delicatessens. With these scales, the clerk still has to enter the price of a pound of liverwurst, potato salad, and other custom-measured items, but the calculation of the selling price is handled by electronic components inside.

A new scale just introduced by a West German weighing-equipment maker combines optical and MOS techniques—the latter for the first time in a scale, the company says—to do the job more elegantly and with a lot fewer components (only two MOS ICs) than are used in the electronic scales offered thus far. This new scale system, dubbed Op Electronic 1000 comes from Bizerba-Werke Wilhelm Kraut KG, a 107-year-old family-owned enterprise in Balingen, near Stuttgart, and Europe's largest weighing-systems producer.

Mechanically, the Bizerba scale is an inclination-balance scale system The item on the scale plate causes a glass disk to rotate. The disk carries the weight coding as a combination of dots arranged in 12 tracks. With the disk illuminated from one side, the code is detected by an array of phototransistors, the output signals of which are applied to the memory circuit for temporary storage. At the same time the item's weight is shown in viewing windows to both the customer and the clerk.

After placing the item on the scale plate, the clerk punches the unit price—in Germany, the per-kilogram price—into a 10-digit keyboard. The unit price appears for both the customer and the clerk to see. The keyboard output is combined with the weight data, a process carried out about 10 times a second to insure error-free pricing. Such redundancy is one requirement of West Germany's weights and measures regulatory agency. Another requirement is that the calculator IC incorporate a parity and self-checking feature so that in case of circuit malfunction a series of zeroes is displayed. □

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# International newsletter

## British companies, eyeing good market, go to Peking

**Forty electronics manufacturers are among 350 British technology-oriented companies exhibiting in Peking from March 26 to April 7 in an effort to get a toe-hold in what could become a valuable market.** The electronics companies feel that in the foreseeable future the Chinese are most likely to buy radio-frequency communications equipment, including TV, ground and airborne avionics and avionics servicing systems for China's growing air-transport system, and specialized instruments and components. However, instrument and component makers also hope to sell many standard items while Chinese production falls short of demand.

In communications, several companies will push TV studio and transmission equipment in the belief that **the Chinese want to expand their localized monochrome network but can't make much of the equipment themselves.** They are expected to go for large-screen communal receivers, particularly if they develop color, with which they're experimenting. They already buy high-frequency, vhf, uhf, and microwave-link equipment, and it's thought they'll buy much more. Instrument purchases have been sophisticated items like dynamic performance analyzers, spectrometers, and high-quality voltmeters, apparently for use in research and design. Similarly component purchases include highly specialized items like photomultipliers—probably used in nuclear research— but also standard CRTs that probably end up in oscilloscopes and radar displays.

## No progress yet in Franco-Japanese import quota talks. . .

**Japan and France are deadlocked in their efforts to set terms for a new industry-to-industry quota agreement limiting importation** of Japanese consumer electronics products into France. The quota talks, which have dragged on in Paris since last September and included two trips of French officials to Tokyo, are aimed at updating import limitations fixed in the original Franco-Japanese agreement in 1969. That accord expires March 31. French sources say that the Japanese want to free radio and television imports entirely this time around—but the French are insisting on strict limits. **If a compromise is not forced by the expiration date, the Japanese will be freed altogether from the special French restraints.**

## . . . but Japanese companies search for French factory sites

Meanwhile two Japanese consumer electronics companies are scouting the French provinces for industrial terrain. **Matsushita Electric Industrial Co. Ltd. wants to build television sets, and Pioneer Electric Co. would make high-fidelity equipment.** Insiders say that the Japanese are being cooperative with the French provincial development agency, Datar, offering to go anywhere in the country where new industry is needed to absorb surplus manpower. Sony also has said it wants to get into manufacturing in France, probably to produce its Trinitron color-TV tube, but this is not yet an active project. French officials say that Matsushita will have trouble winning government approval for TV production, for competitive reasons, but that Pioneer should have little problem getting the go-ahead for its hi-fi plant. Both companies would be obliged to export a large portion of their production.

# International newsletter

## Philips prepares DVM price drops

**Watch for Philips Gloeilampenfabrieken to announce shortly sizeable price cuts in its standard line of digital voltmeters.** The reductions, to be made known around the middle of this month, will amount to between 15% and 20%, depending on the model and on the country where it is marketed. For example, in the Netherlands, the PM2423, one model in the Philips DVM range, will go for about $310 instead of the $390 at which it is now selling. **The reductions are made possible, Philips officials say, by the use of LSI chips in the instruments and the favorable market response** to the company's DVM line. The price cuts are seen as part of the Dutch firm's efforts to increase its already large share of the test and measuring equipment market, a market in which Philips can claim to be the world's third largest supplier, trailing only Hewlett-Packard and Tektronix.

## Yet another pocket calculator, this from West Germany, bows

Unperturbed by foreign competition, a West German company has ventured into the hotly contested pocket-calculator field with a mini-calculator that the firm says stands up well against models from Japanese and U.S. manufacturers. A product of Hamburg-based Aristo-Werke, the calculator is claimed to be the smallest ever made by a domestic company. **It is no larger than a pack of cigarettes, yet can be finger-operated,** as opposed to calculators with keys so small that some kind of peg must be used for key depression.

The aristo M-27 sells for about $145 on the German market. It can handle all standard mathematical operations, plus power-raising, and features constant-factor multiplication and a floating decimal point. Its MOS chip and eight-digit indicator are supplied by U.S. companies. The calculator is powered by five standard 1.5-volt cells, but provisions are made to incorporate yet-to-be-perfected zinc-air batteries, which will greatly extend the instrument's operating life. **What makes Aristo optimistic about strong sales of its calculators is the company's big distributor network.** Primarily a maker of slide rules and drafting equipment, Aristo has a sales outlet in nearly every large stationery store in the country and elsewhere in Europe.

## High-frequency-input ICs pay off for Plessey

**Plessey claims it has notched up sales worth half a million dollars—80% from the U.S.—for its integrated bipolar high-input-frequency divide-down devices** in the year they have been in production. Buyers are makers of frequency counters and radio-frequency synthesizers. John Hayden, commercial manager, claims that Plessey has effectively cornered the market for integrated dividers, doing so by going all out for high input frequencies—currently up to 1 gigahertz, divided internally by four, with 1.2 GHz being sampled—while U.S. makers stopped short at 500 megahertz. In fact, users want the highest frequencies possible up to about 2 GHz. In England, Racal Instruments Ltd. has just announced an eight-digit, 1-GHz counter with a Plessey chip on the input.

In Plessey's bipolar process, the epitaxial layer has been pushed down to 4 micrometers, the emitter diffusion to about 0.3 micrometers and the base diffusion to about 0.5 micrometers. Diffusion temperature is 900°C—about 150° cooler than usual—and time no more than 30 minutes. **Circuitry is emitter-coupled logic, and by year-end the company plans to second-source the full range of MECL-III circuits,** but with increased performance, using the same technology.

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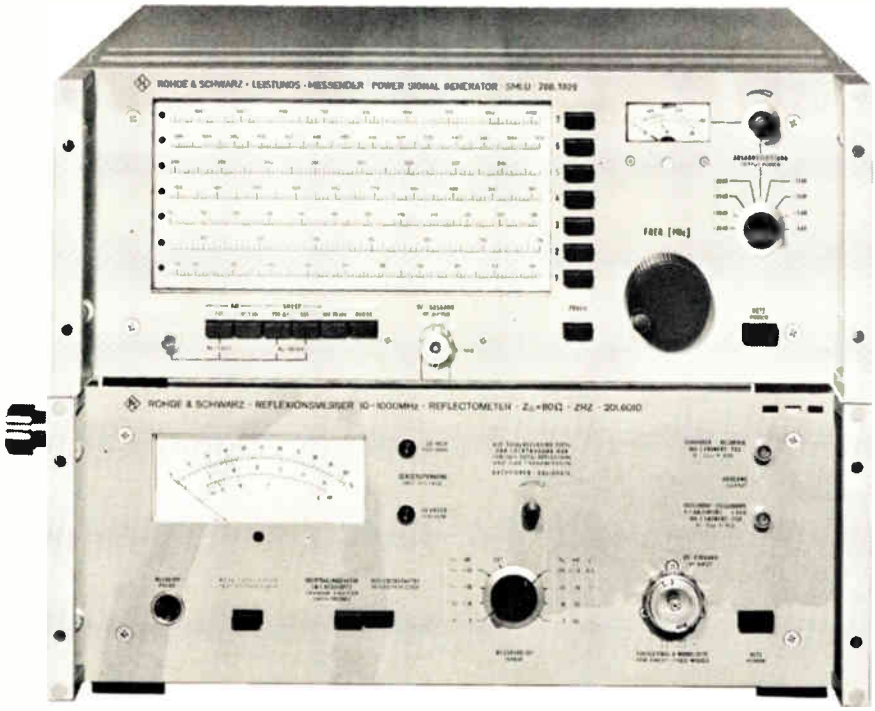

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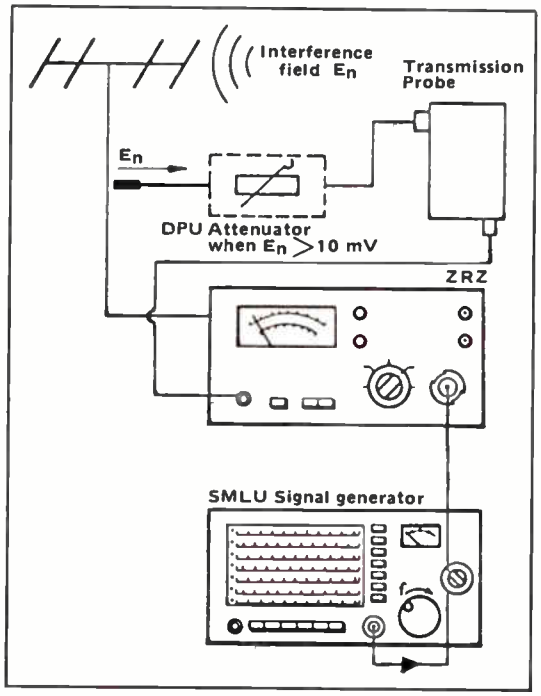


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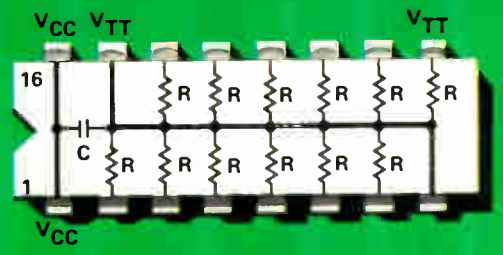


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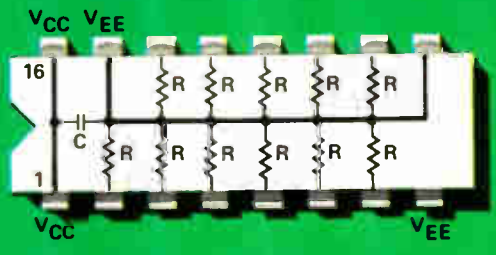
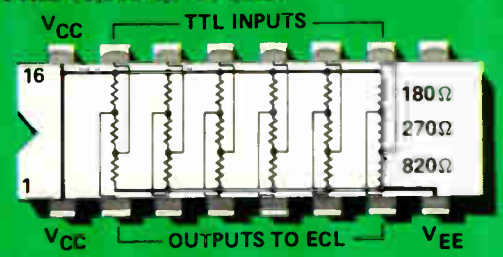


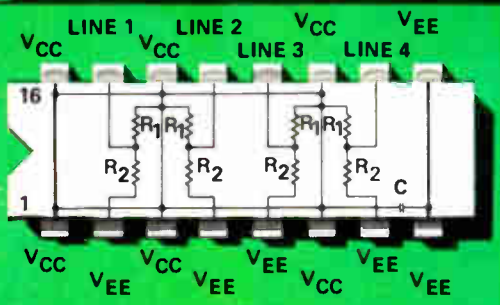

SERIES 898-42 −5.2 VOLT TERMINATORS contain twelve resistors for pull-down to the −5.2 volt bus. Each unit contains a 0.01 μF decoupling capacitor to bypass the −5.2 volt bus.
Price (1,000-4,999) $1.25




SERIES 898-45 TTL TO ECL TRANSLATOR contains six identical three-resistor sections for direct translation from TTL to ECL, both operating between a +5 volt supply and ground.
Price (1,000-4,999) $1.25

Butterfly
Diurnal insect of the order *Lepidoptera*, characterized by clubbed antenna, a slender body, and large, broad, often conspicuously marked wings. Often found fluttering about the design engineer's stomach.

# Our Bugs will get rid of your Butterflies

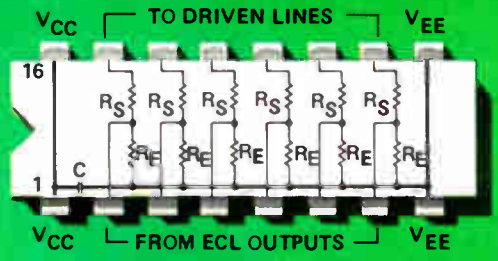



SERIES 898-43 THEVENIN EQUIVALENT TERMINATORS contain four Thevenin equivalent terminator sections. Each terminator section consists of two resistors connected as a divider from the ground bus to the −5.2 volt bus providing a Thevenin equivalent voltage of −2.0 volts. Each unit contains a 0.01 μF decoupling capacitor to bypass the −5.2 volt bus. Series 898-43 units are available with Thevenin equivalent impedances of 50, 75, and 100 ohms.

Series 898-43 $R_1$ and $R_2$ Values

| Model | $R_1$ | $R_2$ |
|---|---|---|
| 898-43-Z50 | 81Ω | 130Ω |
| 898-43-Z75 | 121Ω | 195Ω |
| 898-43-Z100 | 162Ω | 260Ω |

Price (1,000-4,999) $1.25




SERIES 898-44 SERIES LINE TERMINATORS contain six series terminator sections. Each section is designed for terminating a line at the driven end with a series resistor value equal to the line impedance minus the 7 ohm output impedance for 10,000 series ECL. The second resistor in each section is a pull-down resistor to the −5.2 volt bus. Each unit contains a 0.01 μF decoupling capacitor to bypass the −5.2 volt bus.

Series 898-44 $R_S$ and $R_E$ Values

| Model | $R_S$ | $R_E$ |
|---|---|---|
| 898-44-S43 | 43Ω | 470Ω |
| 898-44-S68 | 68Ω | 680Ω |
| 898-44-S93 | 93Ω | 910Ω |

Price (1,000-4,999) $1.25

# ECL Terminator Collection

Dependable Beckman ECL terminator networks are specifically designed for, and compatible with, the following Emitter Coupled Logic families:

- Motorola MECL 10,000 Series
- Signetics 10,000 Series ECL
- Fairchild 95K and F10K Series ECL
- Texas Instruments Series SN10000 ECL
- National Semiconductor 10,000 Series ECL

Each Beckman ECL terminator network utilizes thick film resistor materials with layouts specifically designed for low inductance and the high speed requirements of ECL systems. Where possible, the terminator networks include 0.01 μF decoupling capacitors.

Each network is capable of operating in a +85° C still air environment at standard ECL voltage levels and tolerances without heat sinking.

For complete technical data, contact your local Beckman/Helipot representative or write to Beckman Instruments, Inc., Helipot Division, 2500 Harbor Blvd., Fullerton, Calif. 92634.

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No licence agreements, no sub-contract work. From start to finish we are in control of every product that goes out to you, the customer, bearing the name Piher. We take a pride in the name. We take a pride in our products. That's why we are now a world leader in component technology.

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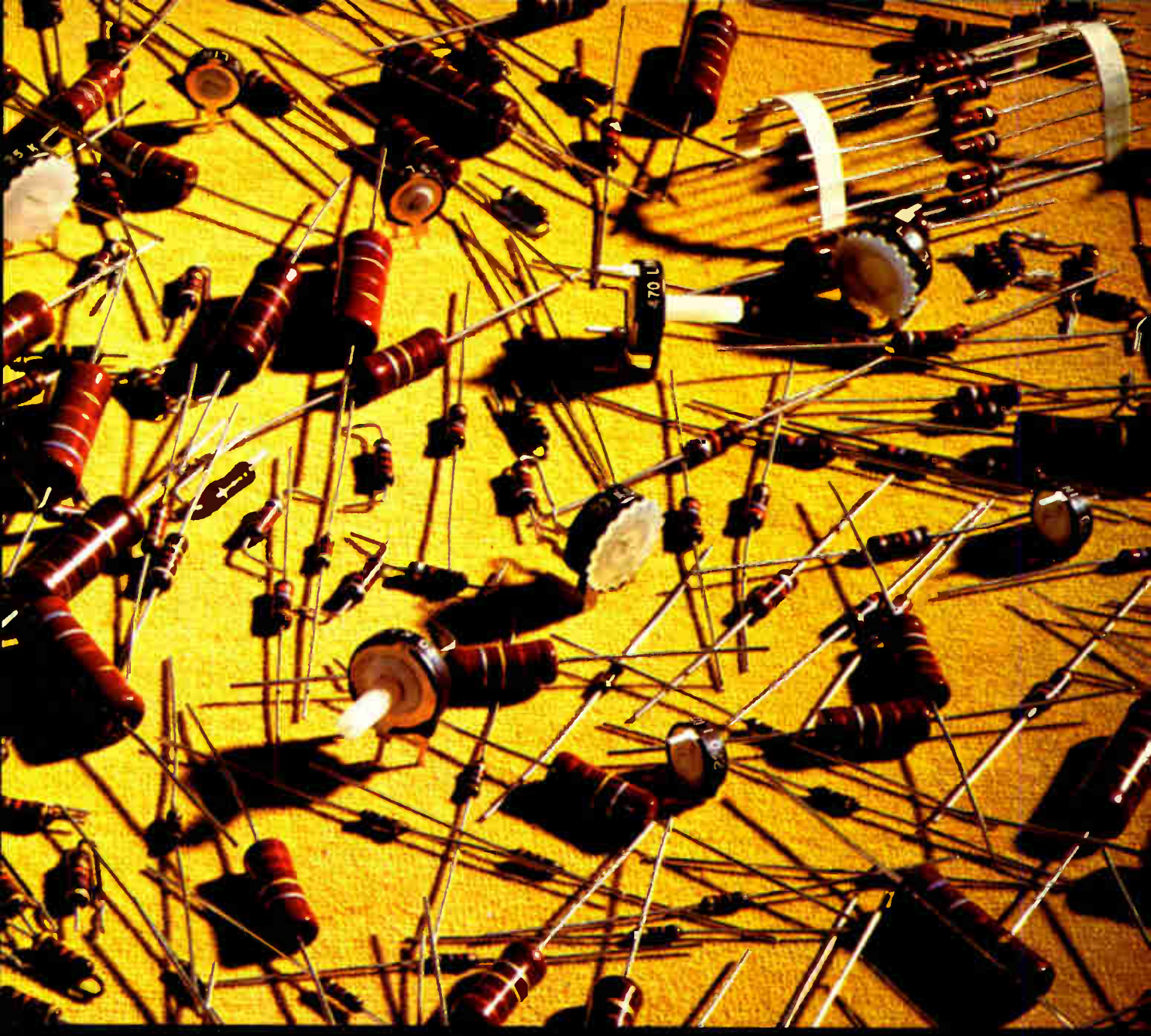

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Piher is a company that works in professional electronics, developing the best in closed circuit and professional TV, radio-telephones, etc.

And with our ferrites we are in the forefront of magnetic ceramic technology.

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Circle 63 on reader service card

**"When Foxboro changed from P.C. boards to Augat panels for FOX 2 process computer systems, we had some doubts about how much development time we would actually save.**

**"6,000 man-hours convinced us."**

Ben Franklin, Manager, Equipment Product Engineering,
Systems Operations Division, The Foxboro Company

Ben Franklin

"Augat panels provided significant savings in our overall development time, and helped us bring our new FOX 2 process computer systems to the market-place faster. And Augat's precision-machined socket contacts helped us maintain our high standards of reliability.

"Why the change from P.C. boards? P.C. boards inherently have a long development cycle, high development cost and lower initial hardware cost. In the development of the FOX 2 System, the timing was critical to get the system designed and released to the market. By selecting the Augat packaging approach, we shortened the development cycle significantly and minimized the cost of rework with no overall effect on hardware cost.

"But no one likes to gamble with new methods, so our initial evaluation of the Augat system was unusually thorough. We liked what we saw – a good, quality product and a company with lots of experience and a positive attitude towards customer service. Since our past experience with other, less-precision sockets had been comparatively unsatisfactory, we decided to try their wire-wrapped plug-in panels. The results far exceeded our expectations.

"With Augat, we achieved superior modularity, minimum down-time, easier field service, and a system that allows our logic to evolve with the technology. And all this while saving 6,000 man-hours of engineering time. That's not bad."

As you can see, Augat® offers you plug-in flexibility allowing component and wiring changes to be made in minutes (saving precious and expensive man-hours), plus tapered-entry sockets and machined contacts that offer unsurpassed reliability.

All of which just might tell you why Augat has become the world's leading producer of wire-wrapped panels and other IC interconnection products. But Augat has more to offer than just hardware. Augat's technical experience is ready to help solve your interconnection requirements.

Call or write to us today. We'll send you our free brochure and complete product information. Augat, Inc., 33 Perry Avenue, Attleboro, Massachusetts 02703. Represented and distributed internationally.

The FOX 2

**Plug into Augat. Foxboro did.**

# Think Twice:

# When is a portable really portable?

## HP's 1700 Series Portable Scopes Always Are...

They're tough go-anywhere scopes: weatherproof, dustproof, completely self-contained. Not the kind of "portable" that's gently moved from bench to bench, trailing a power cord. With a 1700 Series scope you don't worry about the rain. Or the rough ride. Or whether, when you get there, you'll find ac or dc power—or no line power.

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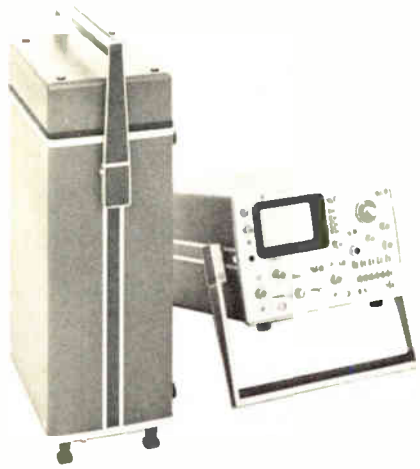
And we're just as proud of the things you don't get with a 1700 Series portable. No heat sinks. No fans. No ventilation holes to let in dust and moisture. That's because our circuits are designed for very low power consumption—and for long, trouble-free operation. And there's no challenge in servicing our portables. In fact, you can completely recalibrate some models in an hour or less, even if all the internal adjustments are misaligned. It's not very sporting, but this ease of servicing quickly adds up to impressive savings.

So before you choose a scope, check your requirements. Then think twice about costs and benefits. Remember, Hewlett-Packard portables let you make any measurement you need—and they cost from $100 to $250 less than comparable scopes. These 1700 Series portables are priced from $1475 to $2300 for non-storage models and from $2375 to $2725 for models with variable-persistence storage. For help in choosing the HP portable that's best for you, send for a free copy of our "No-Nonsense Guide to Oscilloscope Selection." Or contact your local HP field engineer. Hewlett-Packard, Palo Alto, California 94304. In Japan: Yokogawa—Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokoyo 151, Japan. In Europe: HPSA, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland.



**Scopes Are Changing; Think Twice.**

083/1

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OSCILLOSCOPE SYSTEMS

Circle 67 on reader service card


Probing the news

# Nixon, Congress battle over purse strings

Although ongoing efforts appear to be home free, big new programs are scarce for electronics companies

**With Vietnam** off his back and flushed with one of America's great political victories, a tough, confident Richard Nixon has delivered his austere fiscal 1974 budget to the 93rd Congress and guaranteed himself another battle.

Spending proposals totaling $268.7 billion for the fiscal year beginning July 1, coupled to a new $249.8 billion ceiling on outlays in the current fiscal year, promise a Federal electronics market in the coming year that will remain unchanged at best, or shrink slightly, at worst. Either way, industry forecasters in Washington see few opportunities for new business of significance, except for some new strategic military systems.

The President's proposals "suggest to me that companies with ongoing programs in-house are safe," summarizes one corporate analyst. "They will continue to get funded. But if you are looking for big new starts, forget it."

Nixon's battle with the Congress has already begun on the spending issue, specifically over the White House impoundment of $8.7 billion in appropriations for this fiscal year, ending June 30, to hold outlays to less than $250 billion. Compounding that Constitutional issue of the power of the purse are White House plans to cut back sharply on social programs started under earlier Democratic administrations to achieve economies of $17 billion and $22 billion in fiscal 1974 and 1975, respectively. Beyond these major areas of dispute, the Democratic leadership differs sharply with the President in other areas, several of which impact electronics. Among them:

- **Authority.** Roy L. Ash, director of the increasingly powerful Office of Management and Budget, is the focal point of this dispute. As OMB's role expands to the point where it can and does decide program requests from the various agencies, Congress wants its director to be subject to Senate confirmation and available to testify in the same way as other cabinet officers. The controversy surrounding selection of the former Litton Industries chief executive for the OMB job and Lit-

ton's claims against the Navy on ship contracts only serve to cloud the issue.

Ash, an advocate of impounding, has already clashed once with Sen. Sam J. Ervin (D., N.C.), the Senate's foremost Constitutionalist, over constitutional strictures on the spending issue. Ironically, both men supported their opposing arguments with the same constitutional language, which requires the President to "take care to see that the laws are faithfully executed." Ervin, asserting that an appropriation is a law, believes Nixon must spend all of it. Ash notes that the debt ceiling passed by Congress is another law, forbidding the President to borrow—and spend—above a set limit. Impounding, he argues, is therefore "consistent with the President's constitutional duties."

Until the conflict is resolved, electronics manufacturers are edgy about the prospect that Federal funds for their contracts could become political footballs, subject to being impounded on the one hand or retaliatory cancellation by Congress on the other, particularly for military programs.

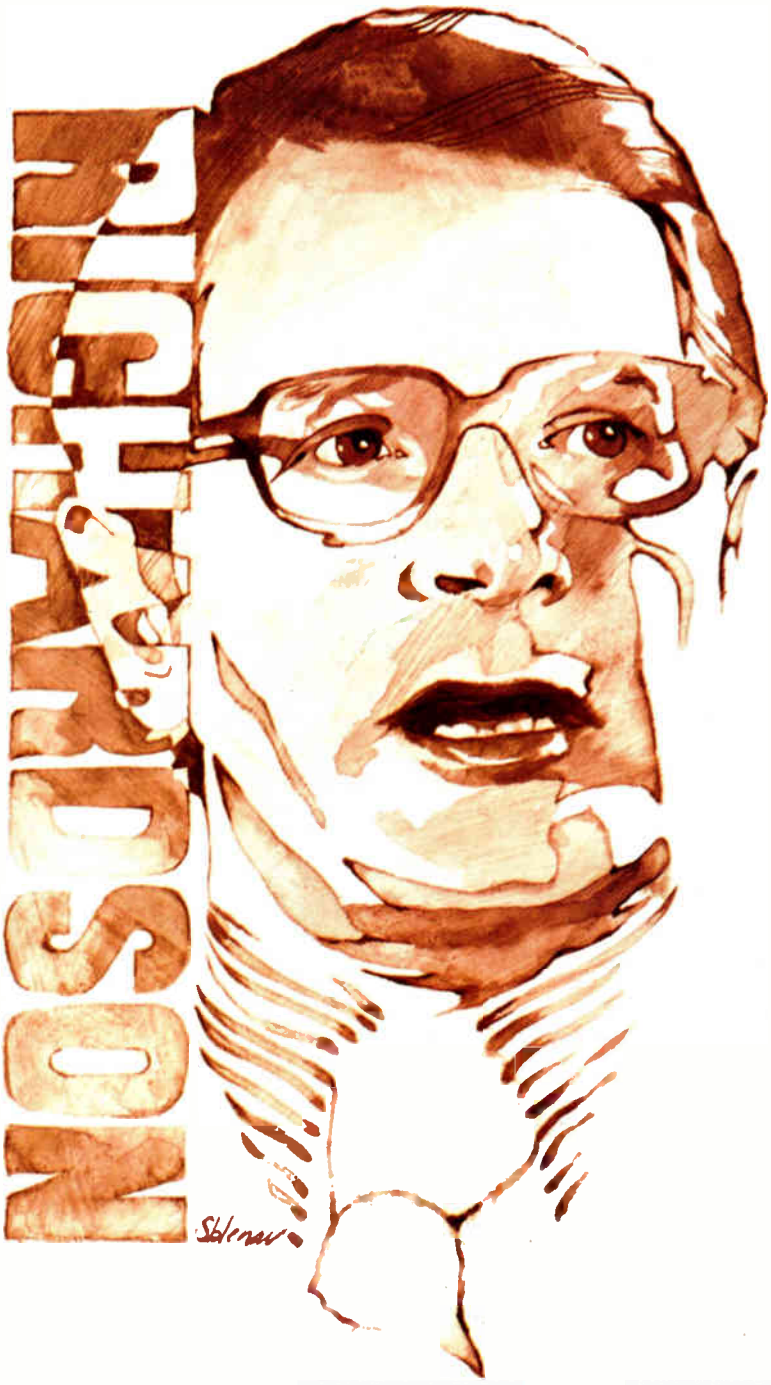
■ **Accounting.** Nixon Administration efforts to put the best public face on its budget by showing spending "increases" where it can, is at least confusing to budget readers, both in and out of Government. Its critics call the increases misleading, as in the case of the Commerce Department National Oceanic and Atmospheric Administration.

Although NOAA's electronics outlays are not seriously hurt, its overall fiscal 1974 spending plan takes a beating. Programed outlays appear to rise $55.3 million, but this is largely a paper exercise in view of OMB's refusal to spend $53.8 million in the fiscal 1973 appropriation. The "increase" shown in the new fiscal year is based on the current year's reduced level. It adds up to a net loss, since, NOAA officials say, a significant portion of the funds must be used to cover Federal pay hikes that become effective in March. Where will the money come from? "Out of the programs," says NOAA administrator Bob White. Retorts one angry and frustrated Senate staff man: "There's a lot of Mickey Mouse throughout this whole budget—more of it than you normally expect." Industry analysts tend to agree.

■ **Controllables.** This bite—funds the Government is not locked into spending by prior legislation and contract commitments—continues to get smaller. Of $268.7 billion requested for fiscal 1974, the White House estimates that only $75.2 billion—less than 28%—is controllable. This amount is $600 million below the figure for this fiscal year, when controllables accounted for 30% of a lower spending level [*Electronics*, Jan. 4, p. 70]. The uncontrollable costs of social insurance, trust funds, interest, and other open-ended programs, plus fixed costs, leave few legislative target areas for cuts.

■ **Defense.** One of those reduction areas—and the one with the largest profile by far—is defense and its associated hardware. Except for such juicy programs as the General Dynamics Corp. Trident nuclear submarine and its long-range nuclear missile under development at Lockheed—both of which are down for whopping increases—the Nixon Administration appears to have left little for a vindictive Congress to cut by way of hardware.

Beyond such highly visible programs as North American Rockwell's B-1 strategic bomber, Grumman's controversial F-14 fighter for the Navy, and the McDonnell Douglas F-15 for the Air Force, members of Congress anxious to crusade against the rising costs of the defense establishment may have



to bend their efforts to the less dramatic issue of military personnel costs—the rising ratio of support to combat troops and militiary pension and benefit programs— which now account for 56% of the defense budget.

Of the $4.1 billion increase proposed for the fiscal 1974 defense budget authority of $85 billion, Pentagon officials attribute $3.2 billion, or 78%, to pay increases for military, civilian, and retired personnel. The balance, they say, is "largely accounted for by inflation on material and services purchased."

Nevertheless, the consensus in and out of Government in Washington is that the defense appropriation could take its biggest beating in Congress since Richard Nixon took office. Though Congress is expected to try to comply with the Administration's ceiling on Federal spending in order to avoid the political responsibility for a tax increase, the 93rd is almost guaranteed also to try to juggle the Government's spending priorities by restoring social programs or creating new ones and cutting outlays for defense.

Sen. Edward M. Kennedy (D., Mass.) sounded an expected warning, calling the budget "good news for the big defense contractors and bad news for the average citizen." House Speaker Carl Albert (D., Okla.) was even more critical, calling it "a big-business budget that leaves the common man out."

The imponderable is whether or not the Democratic majority in the Congress can deliver anything more than strong statements in its struggle to reassert its power. "They couldn't do it on Vietnam when some tried to cut off funds," recalls one corporate vice-president in the capital. "I'm not sure they can do it now, especially the way the Congress is structured, with all those overlapping and ineffective committees they have."

Adds one Democrat: "If we can't pin him now, we never will."

### Defense: No electronics windfall

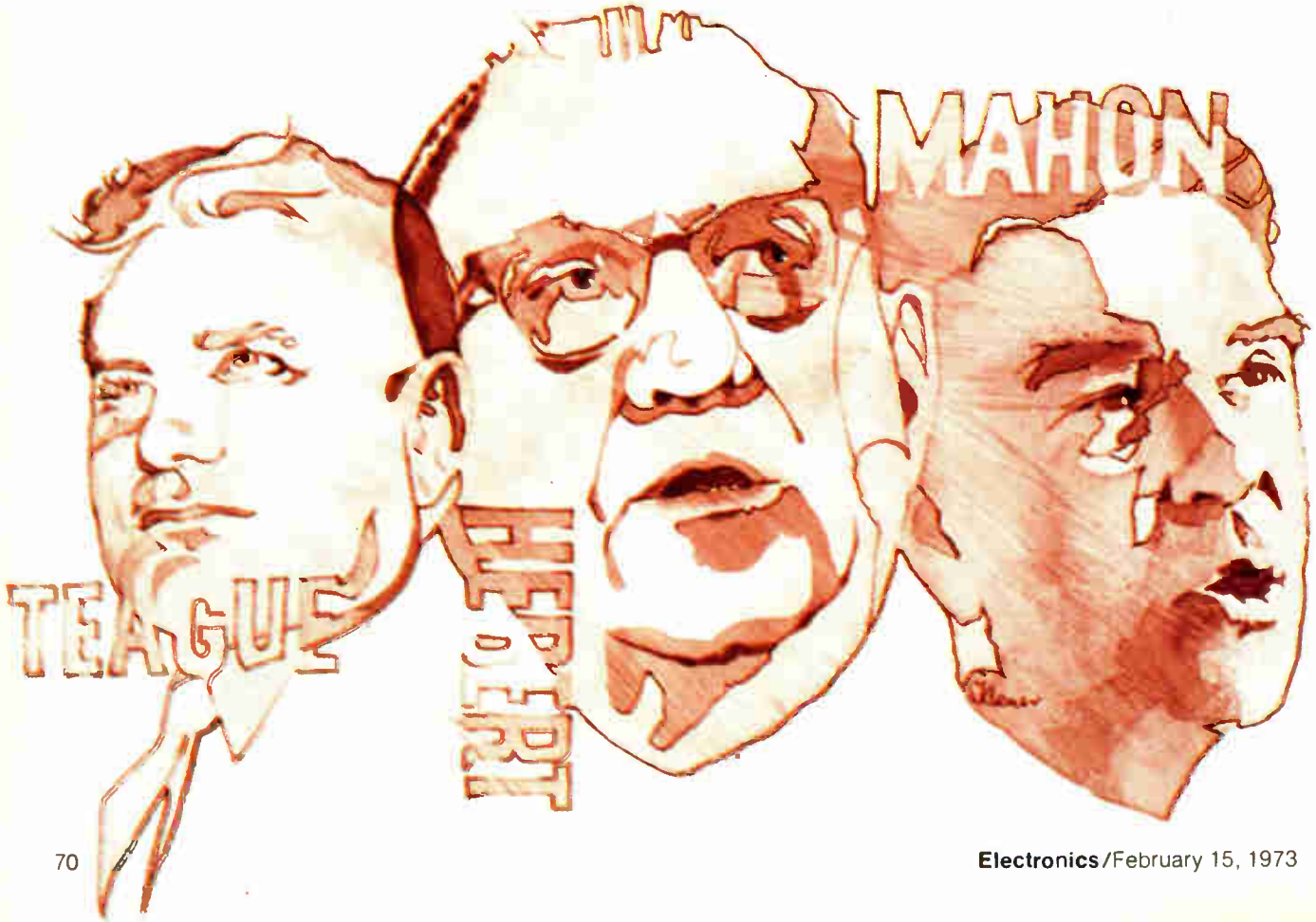
As Secretary of Defense, Melvin Laird met with the press 194 times. Just before turning that job over to Elliot Richardson, Laird received from the press corps a "game ball" marked: "Laird—194; Press—0."

Laird's relationship with the Congress was not much different. The lawmakers never dropped the Congressman-turned-cabinet-secretary for a loss.

Whether or not Elliot Richardson can do the same is open to question. In Richardson's favor is a fiscal 1974 budget request prepared and supported by the Congress-wise Laird. The $85.2 billion budget request, up $4.1 billion over fiscal 1973, calls for $79 billion in spending. The requested increase of $4.2 billion is almost matched by increases in pay and inflationary price increases laid out in the document.

While some significant increases are requested for big new strategic programs to match the Administration move toward a "hi-lo force mix." [*Electronics*, Aug. 28, 1972, p. 25], most of the money sought for new hardware is in ongoing programs. Electronics procurement essentially will be flat, with research and development outlays up fractionally from a year ago, say Defense officials.

The new Nixon budget contains a defense procurement request that's up only slightly—$184 million—over last year's figure; the new total is $18.8 billion. But substantial funds are available to avionics suppliers in a number of aircraft programs scheduled for big buys. For R&D, the President is asking for $8.5 bil-



**DEPARTMENT OF DEFENSE: WHERE RESEARCH DOLLARS GO**
(millions of dollars)

| | Defense total | | Army | Navy | Air Force | Agencies |
|---|---|---|---|---|---|---|
| | FY 1973 | FY 1974 | Fiscal Year 1974 | | | |
| Military sciences | 488 | 518 | 187 | 139 | 135 | 57 |
| Aircraft | 1,836 | 1,780 | 301 | 253 | 1,226 | – |
| Missiles | 2,095 | 2,254 | 967 | 922 | 292 | 73 |
| Military astronautics | 408 | 603 | 18 | 56 | 529 | – |
| Ships and small craft | 583 | 620 | – | 620 | – | – |
| Ordnance, vehicles, and related equipment | 350 | 414 | 241 | 50 | 123 | – |
| Other equipment | 1,630 | 1,730 | 336 | 524 | 517 | 354 |
| Programwide management and support | 629 | 636 | 58 | 146 | 390 | 42 |
| Total research, development, testing, and evaluation | 8,020 | 8,555 | 2,109 | 2,709 | 3,213 | 525 |

lion in fiscal 1974, a boost of half a billion over last year's level. Both strategic and tactical systems with electronics potential are lumped in the R&D category, such as the site-defense program for Minuteman III protection and the Air Force's A-10 close-air-support plane, for which $142.4 million is sought.

The A-10 procurement money is the first requested, moving the program out of R&D. Other pivotal programs with big procurement or R&D tickets include the Navy Trident nuclear submarine and its long-range missile, the controversial Litton-built DD-963, plus the service's cost-overrun F-14 fighter under contract to Grumman Aerospace Corp. Money is also sought to complete the USS Nimitz, as well as five more nuclear attack submarines.

For the Air Force, the more significant items are the North American Rockwell B-1 bomber and the McDonnell Douglas F-15 fighter. The Army runs the site-defense effort. It also wants to split with the Marine Corps a big buy of M-60A1 tanks, as well as $139 million more for Improved Hawk air-defense missiles from Raytheon. That company's SAM-D Hawk follow-on is down for an R&D increase to $194 million.

In a variety of big and little ways, the Pentagon is trying to cultivate the Congress and its increasingly critical Democratic leadership on key committees. Although Louisiana's F. Edward Hébert, chairman of the House Armed Services Committee, has been relatively uncritical of military programs, the role of his Senate counterpart, Missouri's Stuart Symington, is different.

Both Symington and, to a lesser degree, the man he's filling in for, Mississippi's John Stennis, had been prodding the Defense Department to bring weapons systems costs under better control. So have crusty John McClellan, of Arkansas, who takes over the chairmanship of the Senate Appropriations Committee, and George Mahon, the tough and wiry Texan who chairs the House Appropriations Committee.

The Pentagon plans to score at least a small economic point with its accession to last year's congressional consensus that a Safeguard ABM site to defend Washington is not required. No money is requested for the site in the fiscal 1974 program, although Safeguard is down for $401.5 million to complete the Grand Forks, N.D., site to protect the Minuteman ICBM fields, plus another $170.1 million for continued R&D on the site-defense option for smaller radars and missiles.

The Navy's Trident program, follow-on to the Poseidon, is down for the biggest single defense budget increase, some $917 million over the figure for this fiscal year. Of the $1.712 billion total sought, $867.8 million is budgeted for procurement of the first General Dynamics boat, plus $126 million more for RDT&E, and $536.7 million for continued RDT&E on the Lockheed missile.

The request is in for $590.9 million to buy seven more DD-963s, a dollar total more than double last year's appropriation.

That mood will also be reflected in the continuing probe of the Navy's F-14 fighter contract with Grumman, on which the contractor has refused to perform without a new and costlier contract. Although the Navy was scheduled to buy 81 of the planes in the new fiscal year under the sixth lot in the program, the service's request is for 48, the allowable minimum under the pact, at a cost of $572 million, less $40.4 million for RDT&E.

Money for the new Sea Control Ship (SCS)—a minicarrier for helicopters and V/STOL aircraft—is limited to $29.3 million for advance-procurement items, although electronics suppliers are tracking the program for potential. It is one of the few ship programs that offers any promise for the long term. Since disclosure of the new budget, the Navy has awarded the first two SCS design contracts. One for $7.5 million went to National Steel and Shipbuilding, San Diego, Calif., for system-contract design support and detail design; the other, for design support, was awarded to Lockheed Shipbuilding for $1.5 million.

Although the Pentagon highlights

its new start on a submarine-launched cruise missile (SLCM) among its programs, Navy sources indicate that the effort is still a small one being carried out in-house at the conceptual-design level. There is speculation that the SLCM program could turn to an encapsulated version of the McDonnell Douglas Harpoon antiship missile, but both programs are carried as separate line items, with Harpoon down for $85.6 million, including $19 million in the program's first procurement request.

Even though the Congress termed efforts to begin Harpoon procurement a year ago as "premature," the Navy believes the lawmakers will be ready in fiscal 1974.

Two other opportunities for avionics suppliers are embodied in the Navy's request to buy 34 more planes for the Marines. The service is seeking 24 more A-4M attack aircraft at a cost of $68.6 million, plus 10 F-4J fighters. No A-4s were bought in fiscal 1973, and the F-4J is a new version of the aircraft, for which $130.7 million is requested.

The F-15, the Air Force successor to the F-4, carries that service's biggest single procurement request—$1.14 billion to buy 77 more of the air-superiority fighters. That's 47 more planes and $240 million more money than was in last year's request, including RDT&E funds. Still in development, but also getting an increase, is the B-1 bomber; the Air Force request of $473.5 million is $29 million more than it was last year.

Tactical aircraft for close support are certain to get tough congressional scrutiny. While the Air Force is proceeding with the Fairchild A-10—an award already being investigated by the General Accounting Office, the Army wants $49.3 million for RDT&E for its Advanced Attack Helicopter, more than double this year's $20 million. The AAH, a scrubbed-down version of the canceled Cheyenne, is budgeted for a design-to-cost goal of $1.4–1.6 million each in flyaway costs and a total life cycle cost of $3.2 million each.

## Communications: Emphasis on cable TV

At a 1974 level of about $40 million, funding for the nation's communications managers—the Federal Communications Commission and the Office of Telecommunications Policy—is only a footnote in a $268 billion Federal outlay.

Nonetheless, small shifts in program activities within the FCC and OTP, which gets its technical support from the Commerce Department's Office of Telecommunications, can have major impact on the communications industry and its suppliers. The largest buildup in funding within the FCC is in the Cable Television Bureau, from $1.1 million in fiscal 1973 to $1.8 million in 1974. A bureau spokesman says that the entire increase will be used to pay for processing and licensing of cable systems under new rulings requiring certification of all cable systems by 1977. In the six years prior to the March 1972 ruling, only 600 applications were processed. However, the bureau has received 1,850 applications since then.

Most other activities at the FCC are funded in fiscal 1974 at approximately the same level or a little higher than they were this year. Appropriations for research and planning in communications technology, after a 40% gain in fiscal 1973, have leveled off in 1974 at $4.5 million. With part of these 1974 funds, the commission hopes to expand its spectrum-management task force to include a second regional center in San Francisco.

A $287,000 increase in the FCC Common Carrier Bureau's 1974 budget to $4.87 million will do "little more than maintain present levels of activity," asserts Charles Cowan, assistant bureau chief. Roughly $1 million of the new budget will go to carry on the bureau's investigation of AT&T pricing policies. Also, a small shift within the bureau staff will increase emphasis on analysis of the proposed domestic communications-satellite programs.

An increase of $280,000 in the OTP budget to $3.3 million in 1974 reflects primarily additions to outside study contracts, especially since the permanent employment positions authorized in that office are being reduced from 65 to 52 in the next fiscal year. One such study the OTP hopes to get under way is for a major hardware-demonstration program to take a look at possible new uses and cost-effectiveness for cable television. The resulting trial system is to allow an evaluation of an operating system to include both private and public users. Under present plans, the OTP would perform system management and coordination functions, with primary funding from other Government agencies and the cable-television industry. Project definition, estimated to cost up to $1 million, is expected to be carried out early in fiscal 1974, with funding from OTP in the neighborhood of several hundred thousand dollars.

**DEPARTMENT OF DEFENSE: WHAT PROCUREMENT DOLLARS BUY**
(millions of dollars)

| | Defense total | | Army | Navy | Air Force | Agencies |
|---|---|---|---|---|---|---|
| | FY 1973 | FY 1974 | Fiscal Year 1974 | | | |
| Aircraft | 5,750 | 6,052 | 181 | 2,958 | 2,913 | – |
| Missiles | 3,104 | 2,885 | 600 | 712 | 1,573 | – |
| Ships | 2,970 | 3,902 | – | 3,902 | – | – |
| Combat vehicles, weapons, and torpedoes | 561 | 562 | 253 | 309 | – | – |
| Ordnance, vehicles, and related equipment | 2,805 | 1,946 | 1,060 | 234 | 651 | 1 |
| Electronics and communications | 973 | 1,060 | 220 | 451 | 337 | 52 |
| Other procurement | 2,460 | 2,400 | 553 | 812 | 1,017 | 18 |
| Total procurement | 18,622 | 18,806 | 2,867 | 9,378 | 6,491 | 71 |

## NASA's cupboard almost bare

Although the National Aeronautics and Space Administration has managed to keep its head just above the $3-billion-budget level for the 1974 fiscal year, the true state of its funding plans is illustrated by the fact that it will start only two new programs: the Nimbus-G environmental satellite, costing approximately $50 million, and a small $2 million Lageos laser-reflector satellite.

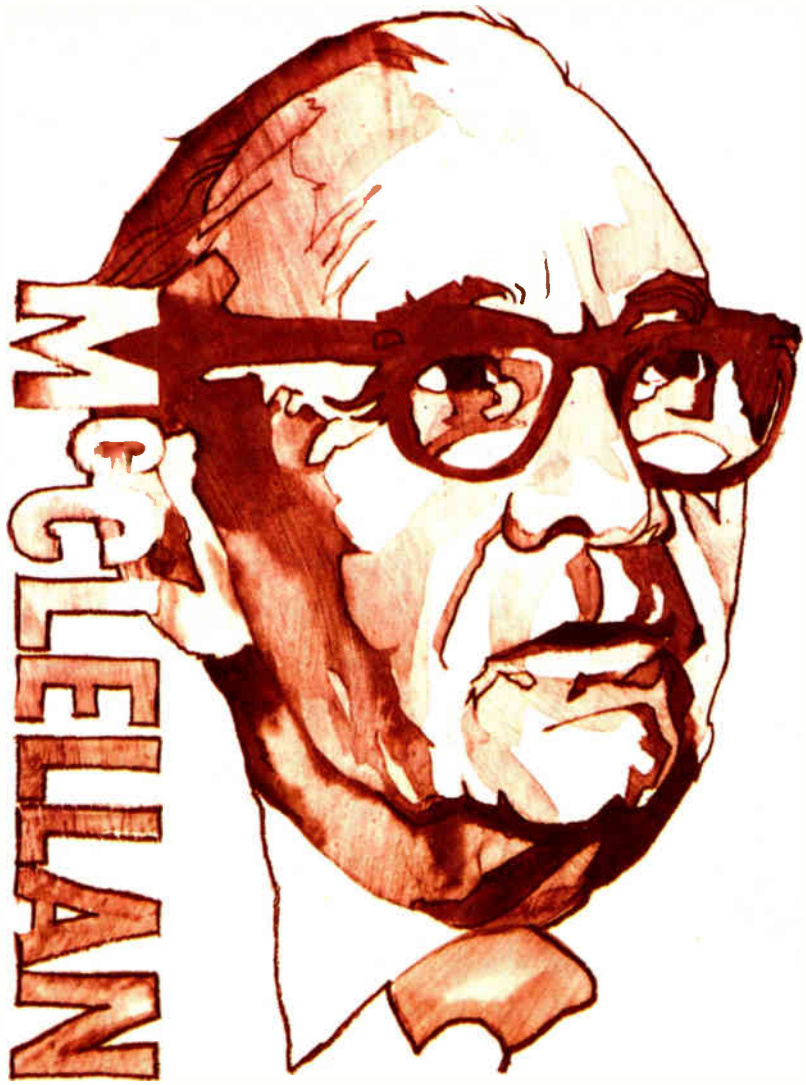
Thus, electronics contractors looking for rays of light will find NASA emphasizing three dark themes: continuing selected large programs, slipping smaller ones, and cutting back others entirely. Even the Nimbus-G program probably will go to the Nimbus series builder, General Electric Co.

There is some sunshine amid the gloom, however. NASA expects to issue requests for proposals in six to nine months for the delayed Tiros-N, a new-generation weather satellite [*Electronics*, Jan. 31, 1972, p. 79] that will cost under $50 million, says Charles W. Mathews, associate administrator for applications. But the launch date slips a year to 1977.

RFPs for some space-shuttle avionics should be out in the spring and summer with work underway by fall, predicts Dale D. Myers, associate administrator for manned space flight. March is the date for guidance and navigation equipment RFPs, and those for communications equipment are due in the summer, he says, under a philosophy of giving equipment of greater complexity longer lead times. One contract will be for an estimated $30 million central-data-processing complex of four computers sharing a central mass memory, Myers says.

Overall, NASA plans to spend $3.1 billion, including carry-over money, with manned-space operations—this year's Skylab flights, the 1975 U.S.-Russian space docking, and the later space shuttle—taking a third. Manned space is down $100 million from last year to $1.057 billion.

Space science, which falls by $95 million to $584 million, and applications, which drops $35.7 million to $153 million, show the effects of cuts NASA announced in January [*Electronics*, Jan. 18, p. 119]. For example, the High-Energy Astronomical Observatory (HEAO) with its $200 million potential under contract to TRW Inc. was scrubbed. The same fate befell Applied Technology Satellite ATS-G, the follow on to ATS-F that Fairchild industries is building. The reason: NASA has decided to leave the communications-satellite business to private industry. Administrator James C. Fletcher, saying that X-ray astronomy is of the "highest priority," announces that a new HEAO plan, probably reduced, will be ready in the "next month or two."




From past history, NASA's budget should receive a good reception from the two congressional watchdog committees, even though they are headed by new chairmen. Olin E. (Tiger) Teague (D., Texas), a space booster, leads the House Science and Astronautics Committee. Frank E. Moss (D., Utah), a freshman to the Senate Aeronautical and Space Sciences Committee, which he chairs, is promising a vigorous look at NASA operations.

Stretchouts affect Earth-Resources Technology Satellite ERTS-B, which will be delayed three years to a 1976 launch, even though ERTS-1, built by General Electric and launched last year, has been highly successful. The Orbiting Solar Observatories J and K, deferred last year, are perhaps not scrapped but deferred indefinitely.

The $5 billion space shuttle is being slipped a little to spread manpower costs, Fletcher says. Even so, shuttle costs for fiscal 1974 will more than double to $475 million as the program begins to consume more of NASA's tight money.

Funding requests for aeronautics and space technology (AST) and tracking and data acquisition remain about the same at $240 million and $250 million, respectively. AST's projects include an advanced

digital fly-by-wire system for which an RFP is expected "at the start of fiscal 1974," says Roy P. Jackson, associate administrator for AST.

Another AST project will be flight demonstration aboard a Boeing-737 of flight-control and director systems originally developed for the aborted supersonic transport "to demonstrate how these advanced flight-control systems could be used in conventional aircraft," Jackson says. A joint program with the Federal Aviation Administration, the work includes hardware installation during the next fiscal year and test flights the following year against "early models" of the FAA's upcoming microwave instrument-landing system, he says.

NASA also will choose a contractor for a $5 million remotely piloted vehicle (RPV). It's scheduled to reach the hardware stage in two years.

Downstream, the space agency promises, there are some new programs. Fletcher assures space scientists that a proposed Venus Pioneer 1977 mission is "an important new start," and that "we plan to go ahead next fiscal year, if feasible." The projected heavyweight earth observation satellite [*Electronics*, Dec. 18, 1972, p. 34] and the family of lightweight Small Applications-Technology Satellites (SATS) still are under study.

Onstream, NASA insists, is a raft of programs, many of them reaching peak funding. Among these are the second Pioneer-Jupiter (built by TRW Systems Inc.) and Mariner Venus-Mercury (Jet Propulsion Laboratory-Boeing Co.) launches slated for this year, the 1975 Viking Mars (JPL-Martin Marietta Corp.) mission, and the 1977 Mariner Jupiter-Saturn (JPL) mission. Also on target are the 1974 launches of Hughes Aircraft Co.'s Orbiting Solar Observatory OSO-I, General Electric's Nimbus-F, Fairchild Industries' ATS-F, and the 1973 and 1974 launches of Philco-Ford Corp.'s Synchronous Meteorological Satellites A and B.

### DOT: Take a flier on the FAA

Companies looking for potentially large electronics programs in the Department of Transportation requested fiscal 1974 outlays of $8.1 billion should take to the air—only the Federal Aviation Administration will spend money on major electronics projects. But sharp reconnaissance will be needed to track important programs on the FAA's projected $1.8 billion spending list.

Of that sum, the FAA plans to spend $280 million in the Airport Development Aid Program (ADAP), which will allow airport operators to buy such navigation aids as radars and instrument-landing systems along with new runways and landing lights. Another $250 million is routed for continuing improvement in the terminal and en-route traffic control systems, with a good portion charted to complete the automation upgrading already contracted for.

Despite the large FAA budget, industry reaction is that contracts for new projects will be scarce and hard to come by. "It doesn't look good," observes an executive with an electronics contractor doing business with the agency. "In air-traffic control, for example, there's so much to do, but the FAA is having a tough time finding the money to do it." He adds that "we were counting on money" for new development work, but "it doesn't look like we're going to get it."

Several awards could open new markets. The FAA will soon select up to four of the six teams competing for the second phase of the microwave instrument-landing system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(MLS) to become universal later this decade [*Electronics*, Feb. 1, p. 73]. By this summer, the agency plans to select a standard for an interim MLS, which will allow airport operators to purchase the systems with ADAP funds [*Electronics*, Jan. 4, p. 53]. Companies competing in this market include Boeing, Cutler-Hammer's AIL division, Singer-Kearfott, and Tull Aviation.

Lockheed Electronics Co. is expecting to sell its ARTS 2 advanced radar terminal systems for medium-size airports. The FAA is now evaluating the system at Wilkes-Barre/Scranton Airport. Philco-Ford could sell up to 21 electronic voice-switch systems for $78 million if the agency likes the prototype under construction [*Electronics*, Jan. 18, p. 114].

The FAA will spend some $123 million on research and development, about as much as in the previous fiscal year. Electronic projects include developing methods for transferring and processing data received from tracking radars, pilot-filed flight plans, airline dispatchers, flight-service stations, and en-route control centers. New computerized airport traffic-control systems will be developed to enable more efficient metering and spacing of terminal traffic under all weather conditions. New omnirange navigation stations also are included in the development budget.

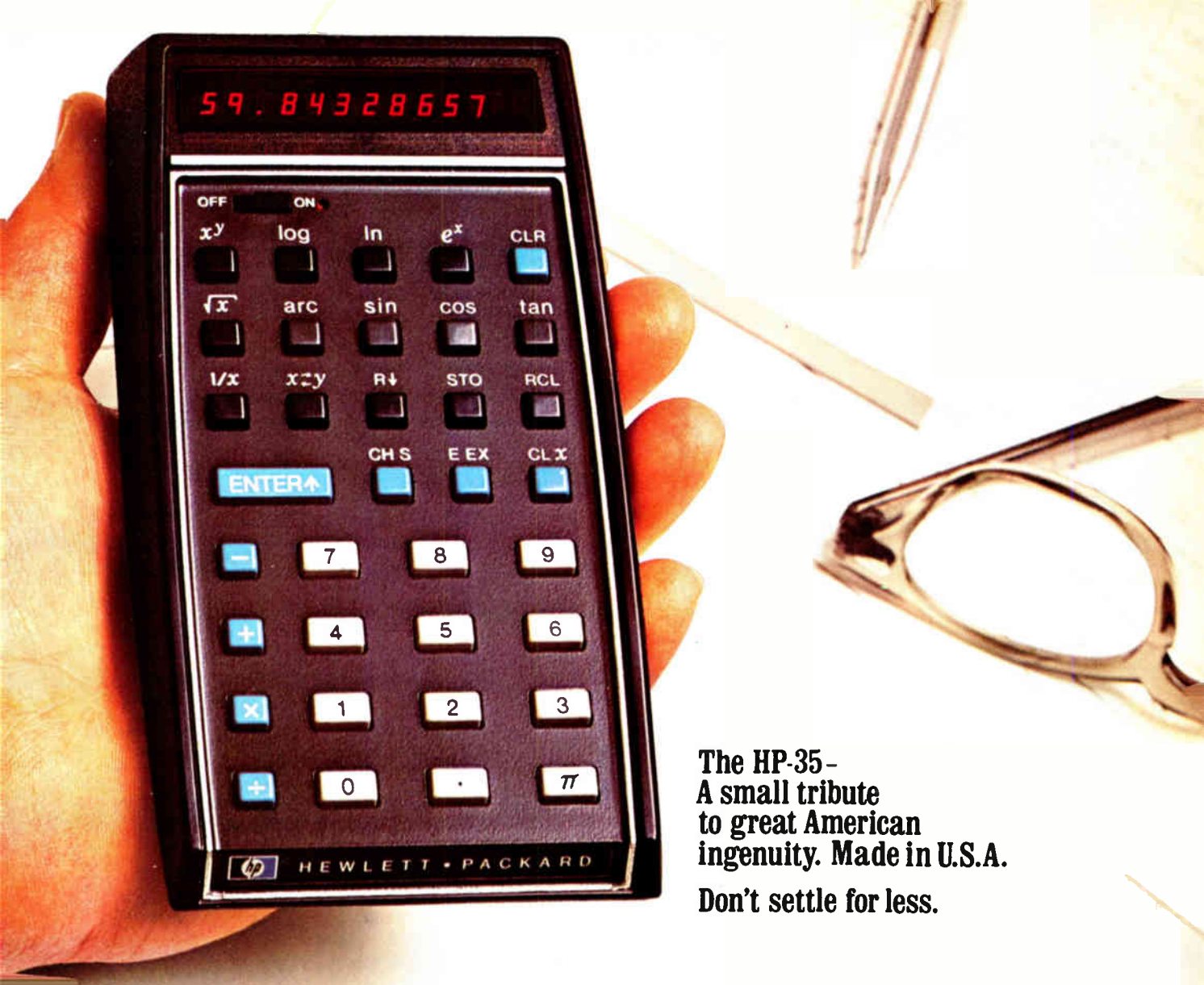
Overall, the DOT will be operating with effectively less money in fiscal 1974, since the modest $97 million increase over the previous year's amount is more than offset by inflation and salary increases. Most of the money is for asphalt and vehicle items, such as highways and buses, in which electronics only plays a supporting role.

For example, more than half of DOT's budget will go to the Federal Highway Administration, which intends to lay out nearly all of it for the Federal-aid highway program. Electronics companies could get a piece of this action if proposals pass to tap the highway trust fund for urban mass-transit projects, which would need computerized management, signaling, fare-collection, and operations systems.

At the Urban Mass Transit Administration (UMTA), whose request rose $20 million to an even $1 billion, capital outlays for new buses, commuter rail cars, and rapid-transit cars will be up slightly from the fiscal 1973 level. The new budget requests $872 million for an estimated 291 projects, up from an estimated $864 million in grants for 229 projects.

Research, development, and demonstration grants may well end up ahead of those for last year. Some $80 million is being requested, an increase of $6.7 million. However, UMTA originally requested $115 million, which Congress severely slashed. Allocation of the $80 million will be revealed when UMTA presents its exact proposals to Congress in a month or two.

Particular emphasis is being placed on developing the "state-of-the-art" commuter railroad car, now under contract to Boeing Co. The car is to include the latest innova-

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tions in electronic control systems, as well as those of suspension, ride quality, and comfort. Also, requests for proposals are to go out before June to develop a complete advanced train aimed at achieving what Boeing is doing for a single car.

However, any new funding for the type of personal rapid-transit system being constructed at Morgantown, W. Va., may be held off until fiscal 1975. UMTA wants to get some operating experience with the Morgantown system before it goes ahead elsewhere, explains James M. Beggs, outgoing DOT undersecretary. The department needs "to have a handle" on the installation, operating, and maintenance costs of such a system, he says, as well as "whether the public will ride it."

Work is also continuing on the Grumman Corp. tracked air-cushion vehicle (TACV), the 300-mph levitation machine sponsored by the Federal Railroad Administration, and on UMTA's 150-mph urban tracked air-cushion vehicle. But budgeting for the so-called dual-mode transportation vehicle—one that could ride equally well on both highways and rails—has, as one UMTA spokesman put it, "faded from sight."

The Coast Guard will be looking for some new electronics. Close to $7 million is budgeted for vessel-traffic systems to be installed in the harbors at New York, New Orleans, and Puget Sound. The final configurations of the systems will depend upon the conclusions of a study due by March.

### Social money spread out

More will be spent this year than last on social programs. As ever, just how much will go to electronics is difficult to ferret out from the budget document. And just where to find the money is harder than ever, since this year the Administration is determinedly spreading fiscal power among the state capitals and county seats, as well as Washington.

Still, law enforcement would appear to be the richest vein to be tapped this year. Other major spenders will include the Department of Health, Education, and Welfare, the Department of Commerce—especially its National Oceanic and Atmospheric Administration—and the newly prominent National Science Foundation.

At the Law Enforcement Assistance Administration (LEAA), "electronics continues to be a high-priority item" notes outgoing LEAA administrator Jerris Leonard. And makers of police-communications equipment should do particularly well. The rich agency uses about half of the Justice Department's budget, or $891.1 million, up $35.8 million from fiscal 1973, to help state and local law-enforcement agencies upgrade their crime-fighting and crime-information systems.

How big a share in these funds will go to electronics depends on what individual states request as well as what LEAA finally approves. The states will receive most of their funds through revenue-sharing provisions instead of direct grants as before. But the agency has so much money that its outlays "cut across fiscal years and aren't directly related to appropriations figures," comments associate administrator Richard W. Velde. To keep better track of its 34,000 funding grants, LEAA has just opened a computerized grants-management information system, he says.

LEAA's big Project Search may find that political considerations

## NSF takes the hand-off

The people who run the National Science Foundation, shoved suddenly stage center when President Nixon closed the White House Office of Science and Technology, manfully insist that they're ready to take on the OST's responsibilities. But some in the scientific community and the Congress aren't so sure.

H. Guyford Stever, director of the NSF and now the top scientific adviser in the Federal hierarchy, insists: "It is not the intent of the President and his staff to downgrade science, and I have the feeling we may be very effective." Stever concedes, however, that he learned of his new role only around the middle of January, even though he had discussed the possibility with former White House Science Adviser Edward E. David Jr., who resigned last month.

Under the reorganization plan, not only is the OST gone, but the post of White House science adviser has been downgraded, and the President's Science Advisory Committee has been eliminated. It leaves Stever, the very picture of a smiling, optimistic college president—which he used to be—reporting to Secretary of the Treasury George P. Shultz. His predecessor reported to the President.

What does the new setup mean? "All we can do now is conjecture how it will turn out," says Daniel W. DeSimone, a former top aide of David's. "Stever is well aware that he must develop a strong relationship with Shultz and Ash [Roy Ash, former president of Litton Industries and director of the President's Office of Management and Budget]. Working with them he can be more effective with the White House than Ed David was. If Stever can get leverage with Shultz, he'll have clout."

But that's the rub. The 4,700-member Federation of American Scientists fears that Stever won't be able to get close enough to Shultz to apply any leverage. Jeremy Stone, director of the federation, maintains that Stever will be reporting to Shultz mainly through a White House deputy, moving Stever possibly two levels away from the President.

Congressman John W. Davis (D., Ga.), a high-ranking member of the House Science and Astronautics Committee and chairman of the subcommittee that oversees the NSF, is upset by the reorganization. He says that it will, in effect, "pull the rug from under the feet of our scientists and technicians." Davis says that the NSF will have new responsibility, but it will not get more personnel. Stever confirms this, but he says that some 20 new posts will be added in the fiscal 1974 budget. These were originally planned for other purposes, but "we have very flexible bodies," says Stever.

It all boils down to whether or not Stever's flexible bodies, up to now running the NSF mainly as a mild-mannered, university-oriented agency in charge of parceling out research grants, can get in there and swing in the name of the scientific community.

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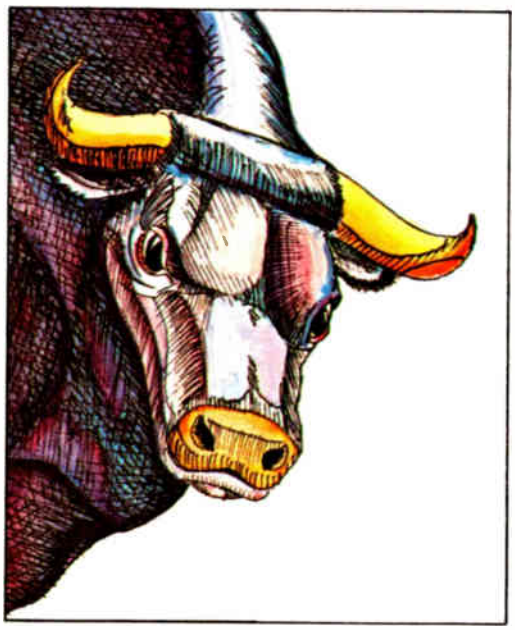

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## Probing the news

have a bigger impact than budgetary ones as "the issue of dedicated computers is slowing up" the program for establishing the crime-information system, asserts Leonard. Too many local law-enforcement people want their own computers because they confuse security with dedicated computers, he charges. "That's nonsense," he snorts. "We'll never have a nationwide system if that happens." Leonard, who says the agency is firmly behind time-shared multi-use computers among intrastate agencies, adds that some governors, in lining up behind LEAA, have told law officials to forget about wanting their own computers. Fiscal 1974 funding requests for Project Search are up $250,000 to $2 million. The funds are tagged for some other uses, such as helping states develop information systems, but just how the pot will be divided has not been decided, LEAA says.

Over at the FBI, $9,042,000 will be spent to automate fingerprint classification and matching operations. The bureau, which says it gets 24,000 sets of prints each day, will put out requests for proposals on production-model print-reading scanner equipment and related gear—including construction of a special processor to match the prints. The budget earmarks $4,478,000 for the project. North American Rockwell and Calspan Corp. (formerly Cornell Aeronautical Labs) did parallel research on such equipment, but Calspan was chosen to design and build a prototype fingerprint-identification system.

The rest of the money—some $4,564,000—will be used to rent computers to support the automation project.

As usual, the markets for electronics at the Department of Health, Education, and Welfare are scattered throughout the mazelike HEW structure. Contract awards appear to be tapering off on at least one front—computer and related equipment, called automated data processing (ADP) in Government. Following style for other Federal departments, "there's a lid on ADP expenditures this year [fiscal 1973]," says Edward A. Diephaus, director of office-management systems for HEW. "Fiscal 1974 looks worse," he adds. The fiscal 1974 ceiling, in turn, is only $124 million. This means that in recent years the growth rate in funds is decreasing to where it actually stops between 1973 and 1974, he says.

Diephaus explains that HEW originally estimated it would spend $137 million for fiscal 1973, but that the Office of Management and Budget knocked it down to $125 million. Partially "a problem of definition," he says that "there's no decision yet on how this will be spread" among hardware, support, and personnel throughout the Food and Drug Administration, Social Security Administration, and other parts of HEW.

Things look better at the National Oceanic and Atmospheric Administration and in the parent Department of Commerce, where electronics programs come out relatively well.

Under the fiscal 1974 NOAA budget request, administrator Bob White identified these changes affecting electronics:

- A $16.2 million increase in the environmental-satellite services program to $53.4 million will permit operation to begin for the two geostationary orbiting environmental-satellite systems, in addition to continuing the polar-orbiting Improved Tiros Operational Satellite (ITOS).
- An $8 million increase sought in Basic Environmental Service to $95.8 million is, in effect, a net loss, since the "increase" is achieved ad-

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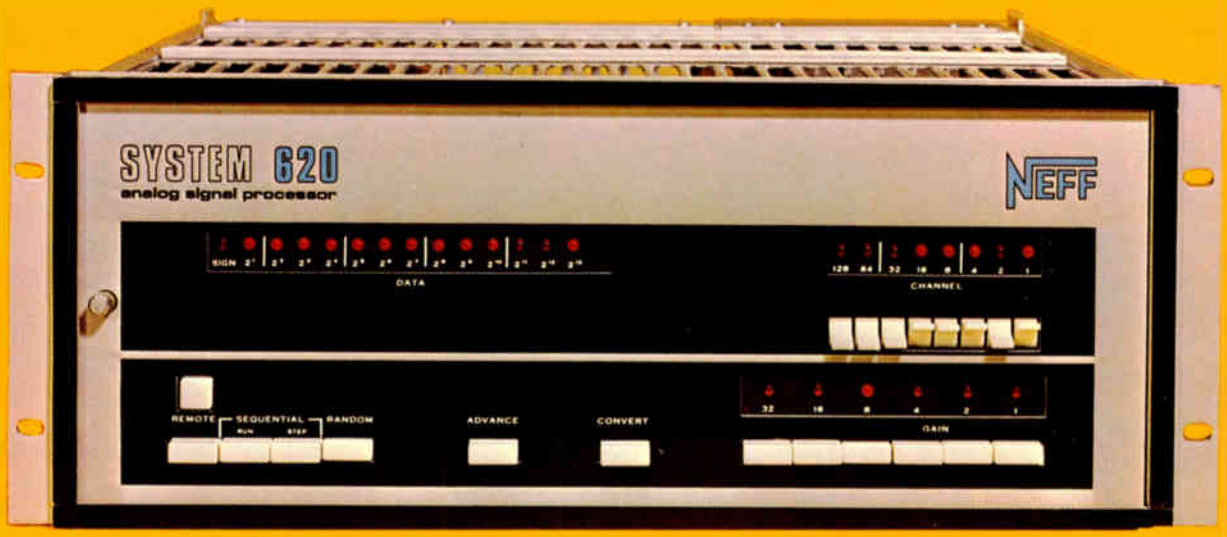


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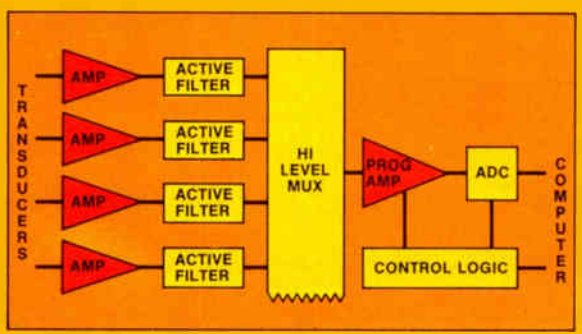


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ministratively by taking the national data-buoy program, originally scheduled to get $9.5 million, cutting it to $8 million, and transferring it to this account. The program calls for upgrading NOAA's disaster-warning system through improving use of satellite data and providing better materials for the guidance of users.

- An increase of nearly $9 million in the weather-modification program to a $12.8 million level reflects what White calls "the high priority on severe-storm modification," notably in the Pacific area.
- A $1.3 million increase in the mapping, charting, and surveying program, boosting it to the $40.2 million budget level, produces another, if smaller, opportunity for electronic instrumentation as more emphasis is put on ways to automate production of nautical charts for public, industrial, and government needs.

The National Science Foundation, which suddenly finds itself the loudest science and technology voice in the Federal Government (see "NSF takes the hand-off," p. 78), gets a total of $641.5 million. It's moving ahead with at least one big electronics program, the VLA—for very large array—a $60 million multi-antenna astronomical instrument. The Y-shaped system, to be built in the New Mexico desert, will measure 13 miles along each arm. It's destined, once partial operation starts in 1976, to be the world's most sophisticated radio-astronomy system. Funded for $3 million in this year's budget, the VLA is earmarked for $7 million in fiscal '74. The big jump is attributed to start-up cost.

Another area of interest to NSF is computer-assisted instruction (CAI), an area in which growth has been disappointing after all the hoopla of only five years ago. NSF's director, H. Guyford Stever, says his agency intends to strengthen CAI. Toward this end, adds Keith R. Kelson, acting assistant director for education, NSF will be looking at CAI matters other than computers—how to link the computers and terminals, or the advantages of interactive terminals and closed-circuit TV.

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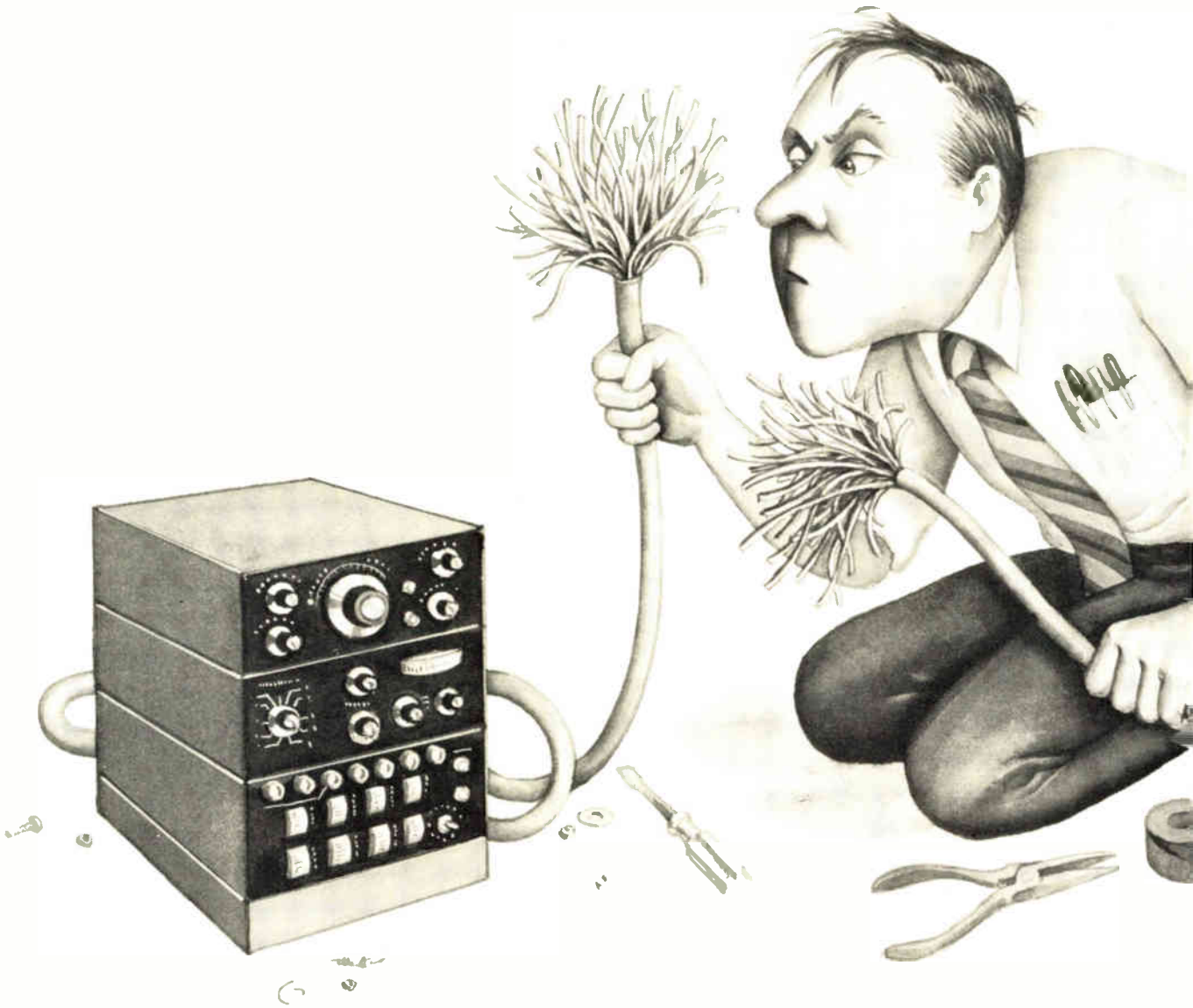

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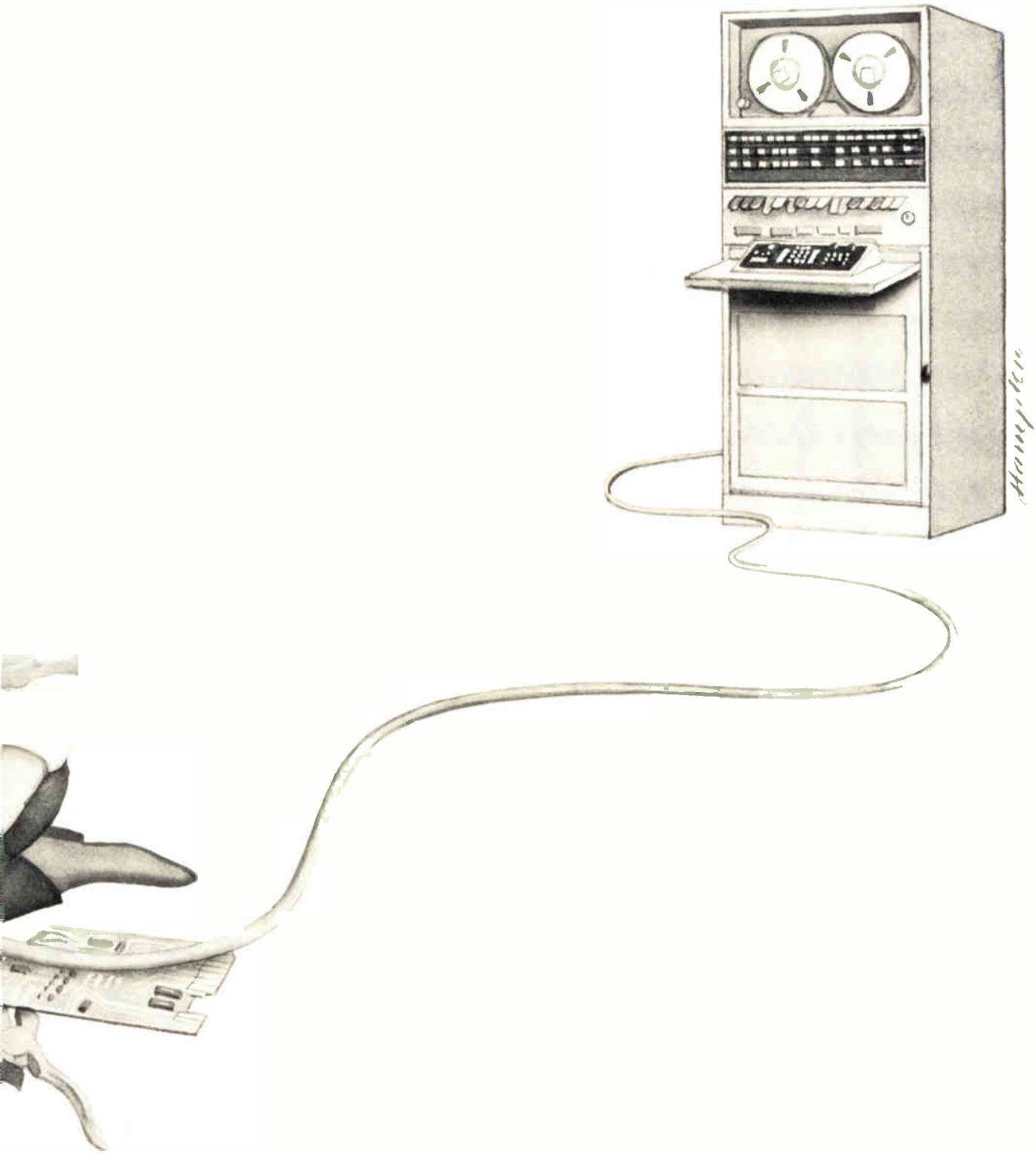


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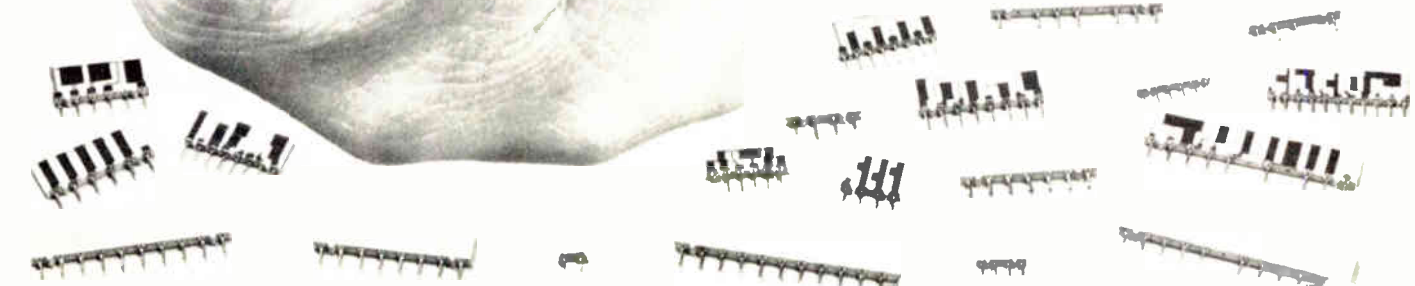

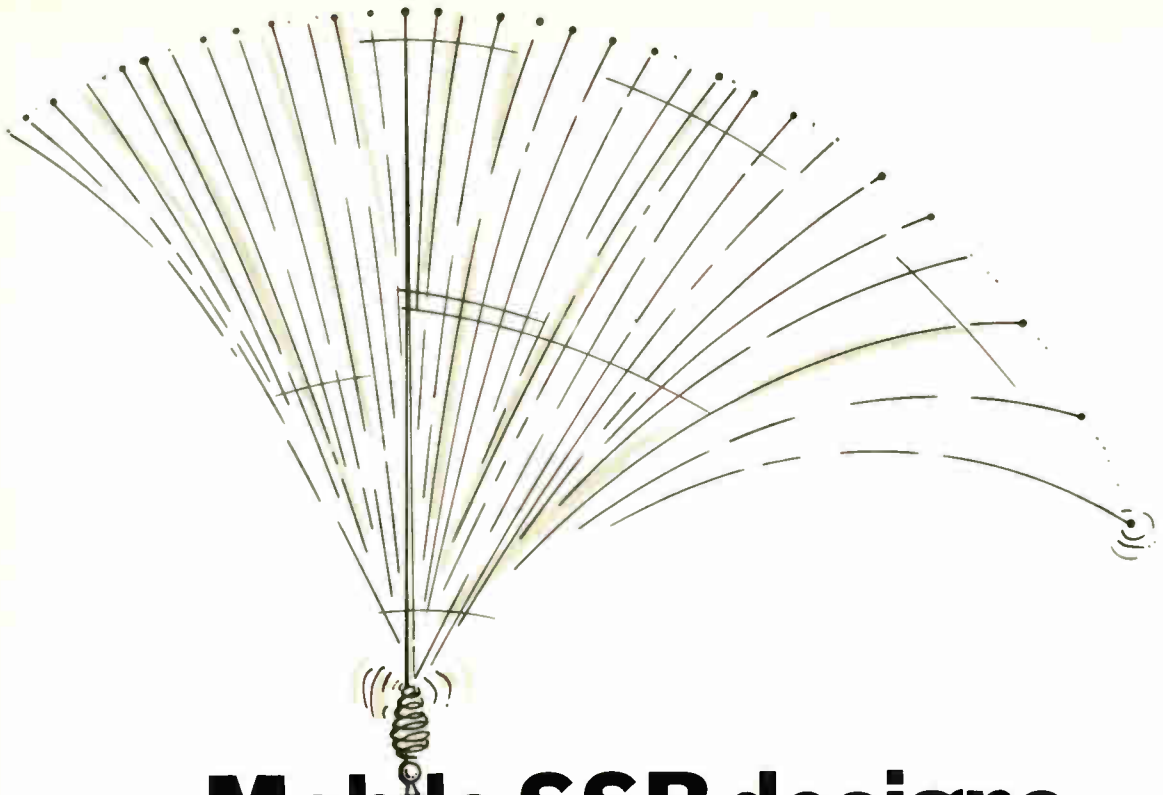

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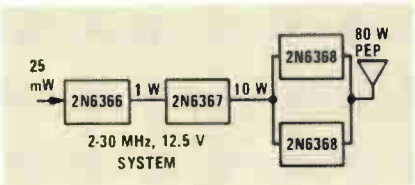
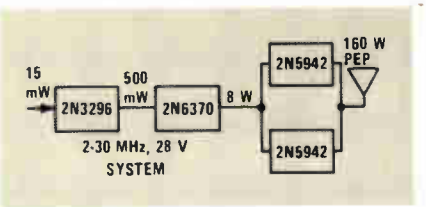
Engineering models of these designs were open and short circuit mismatched at full power — with no apparent device damage.

### . . . one if by land




All it takes to obtain 80 W PEP from a 25 mW input in a 12 V lineup is two 2N6368's in push-pull with an intermediate 2N6367 and a 2N6366 predriver. Easier one-side assembly and better thermal contact are inherent in the studless flange cases.

### . . . two if by sea




The 28 V hookup outputs 160 W from a 15 mW input . . . courtesy of a pair of 2N5942's, a 2N6367 and a 2N3296. Cooling fans aren't required since with speech operation the average power dissipation is 15 dB below peak levels.

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# Silicon-target storage tubes outdo direct-view types in versatility

Tubes that store images on a silicon target instead of a wire-mesh screen and that display them on a separate CRT achieve high resolution, ruggedness, and a good gray scale; new applications are multiplying

by Steven R. Hofstein, *Princeton Electronic Products Inc., North Brunswick, N.J.*, and William A. Rudisill, *Columbia University, N.Y., N.Y.*

☐ Imaging systems today are abandoning the old-style direct-view storage tubes in favor of silicon-target tubes for storage and standard cathode-ray tubes for viewing. From the standpoint of tube design, the requirements of storing images and displaying them are better served by separate devices. Economically, too, there is no longer any reason to double up the two functions, now that ICs have reduced the cost of the external control circuitry.

Consequently, the popularity of the image-storage tube is growing rapidly. Its most recent and commercially important application is in low-dosage X-ray systems for inspecting luggage at airports. Then, too, it has great potential in television image storage, frame-snatching, ultrasound imaging, and microfilm and microfiche retrieval.

It has several advantages over the storage/display tube. It is smaller and more rugged, storing information on a solid silicon/silicon-dioxide target instead of on a fragile wire mesh. It has higher resolution (up to 3,000 lines per diagonal), can store and display up to 10 logarithmic shades of gray, and requires lower operating voltage (700 volts or less). It can provide electronic "zoom" ratios as high as 36:1 (compared with 4:1 for conventional mesh-target tubes of the same size), and its life will typically exceed 10,000 hours.

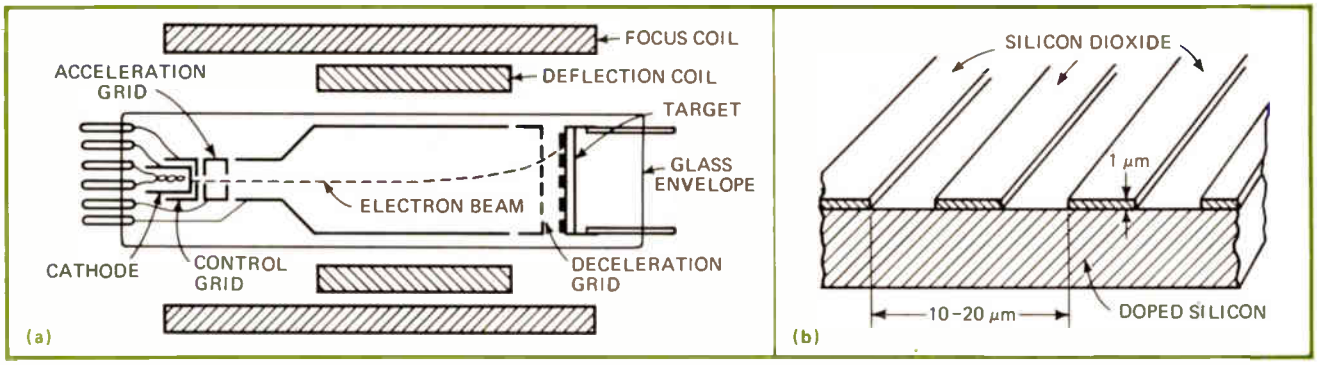
Fundamentally, the silicon storage tube consists of a triode assembly, a focus system, a deflection system, and a silicon/silicon-dioxide target (Fig. 1a). An electron beam, formed by the triode section, is focused onto the target by a focusing coil. Depending on its energy, which is controlled by the voltage of the target, the beam can write, read, or erase all or part of the image on the target.

Unlike the direct-view storage tube, which displays its output visually, the silicon-target tube has an electrical output only. This output—the beam current—is determined by the information stored on its target.

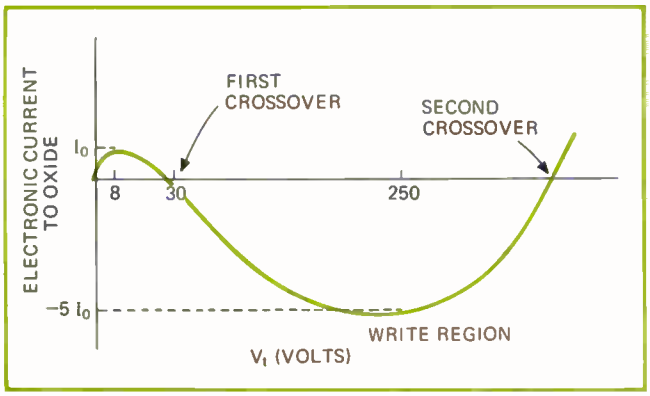
In most other storage tubes, a fine wire mesh onto which a dielectric material has been evaporated serves as the storage structure. Because it is impossible to prevent the dielectric material from being deposited across some of the grid spaces, nonuniformities occur in the mesh transmission ratio (the ratio of the open area in a given target region to the total area of that region). These nonuniformities are amplified in most cases by over an order of magnitude by the storage process, and they show up on the stored image as noise or graininess. To minimize the variation in transmission ratios, a fairly coarse mesh must be used, so that large targets have to be used for even modest levels of resolution.

By contrast, the stripes of silicon dioxide on the silicon tube target are so thin that they have virtually no

**Closing the loop.** Readers wanting to discuss this device further with one of the authors can call Steven Hofstein any time during business hours on Feb. 26 or 27 at (201) 297-4448.




**1. The Lithocon.** The world's first commercial silicon storage tube (a) is a single-ended device that uses magnetic focusing and magnetic deflection. Its target (b) consists of a heavily doped silicon substrate partially covered by stripes of a silicon dioxide dielectric.




**2. Secondary emission.** For voltages well above the first crossover point, approximately 200 V, the silicon-dioxide layer has a secondary emission ratio of about 6:1. At this energy level, an impinging beam knocks out six electrons for every one that arrives so the target charges up to a positive level and stores an image element.

effect on image resolution (Fig. 1b). Moreover, the silicon/silicon-dioxide unit has a rigidity that wire mesh lacks, plus a solidity that the mesh and screen combination cannot approach.

### Secondary emission

The storage mechanism for a silicon-target tube is based on secondary emission from the silicon dioxide. Figure 2 shows beam current entering the oxide as a function of target voltage. At the crossover points the secondary emission ratio is unity so that the net electronic current to the oxide is zero. This means that for every electron that impinges on the silicon dioxide another electron is knocked out and captured by the deceleration mesh.

The net direction of current flow may be changed by changing the target voltage ($V_t$). In the range between $V_t = 0$ and the first crossover voltage ($V_t$ about equal to 30 volts), the secondary emission ratio is less than unity. In this operating range, the number of primary electrons arriving at the target exceeds the number of secondary electrons leaving it, causing the storage surface to be charged in a negative direction.

If the beam energy level is increased to well above the first crossover point ($V_t$ about equal to 200 V), the storage surface exhibits a secondary emission ratio which is approximately six to one. In this region six times as many secondary electrons leave the oxide surface as impinge on it, so that the surface charges in the positive direction. For higher target voltages, the secondary emission ratio decreases because secondary electrons are formed deep in the oxide surface and have difficulty escaping. Eventually, beyond the second crossover point, most of the electrons impinging upon the silicon dioxide remain imbedded deeply in the layer, again charging it negatively.

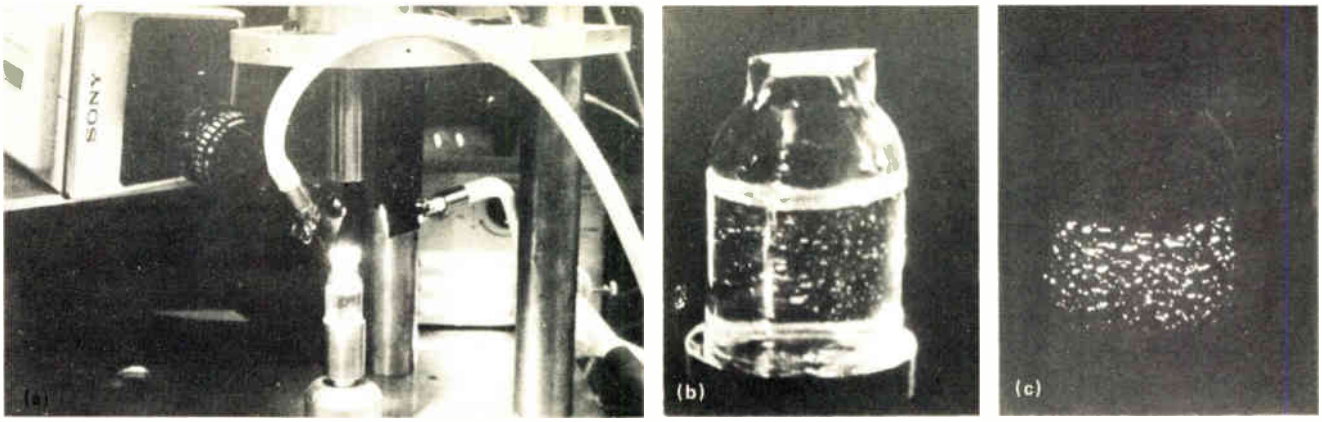
Information is stored when the oxide is charged to some positive level, which still is less positive than the silicon base. For intensity modulation, a video signal is superimposed on the control-grid bias level. The resultant variation in beam current is linearly related to the amount of positive charge deposited onto the target.

During the read cycle, the silicon base of the target is returned to a potential that sets the entire surface of the oxide negative with respect to the cathode. Unwritten sections of the silicon dioxide, corresponding to the "black" or most negative storage regions, divert the scanning beam from the surrounding silicon areas toward the deceleration mesh. Partially written sections—that is, the halftone or "gray" level, where the storage element potential is less negative than in the previous "black" condition—allow some current to flow to the silicon and return the remainder toward the deceleration mesh. Virtually all beam electrons succeed in landing in matrix sectors which are written as "white" (least negative), allowing a significant amount of current flow to the silicon. The number of beam electrons going to the target is proportional to the amount of positive charge stored during the write cycle. The point here is that the highly doped silicon is always positive and the silicon dioxide is always below cathode potential, so no electrons land on the oxide to neutralize the stored image.

To erase the stored charges, the target is raised to a positive voltage, and maximum beam current is used to charge the surface of the silicon dioxide to cathode potential. After erase, the oxide surface is below cathode potential, and the completely erased target appears black on a kinescope. No electronic current can flow to the silicon then because the oxide sends all incoming electrons back to the deceleration grid.

In addition to the fineness of target structure, the deceleration grid potential and the diameter of the electron beam are important determinants of image resolution in most video storage tubes. Insufficient bias of the deceleration grid reduces resolution by letting electrons repelled by a "black" or cutoff target region return to the more positive target regions instead of to the grid. The result is loss of contrast and a washed-out image.

**3. Bomb detection.** Lithocon-based X-ray inspection system uses pulses only 40 nanoseconds long, resulting in radiation dosages so low that they can detect guns or grenades without fogging photographic film or endangering nearby personnel.




**4. Keep it clean.** Video image differentiator checks transparent pharmaceutical preparations for visible impurities (a). By subtracting the TV image of the bottle containing moving particles (b) from a second image of the same bottle, the nonmoving background is deleted (c).

For the Lithocon storage tube that effect does not become noticeable until the deceleration grid is biased below 600 v, and so presents no problem.

In fact, electron beam diameter is the one factor that limits the silicon tube's resolution. But since it can be made quite small, the resolution of a silicon storage tube still turns out to be about four times better than that of a metal mesh device.

The techniques used to fabricate a large-resolution target produce an extremely smooth surface. Such a surface has very little target noise (caused by small random variations in the oxide spacing) and little or no shading caused by large-area target variations.

### The enduring signal

There are three other important features of a storage tube's performance. They are its reading time, storage time, and erase time.

Reading time is the maximum time over which a usable output signal is obtained during continuous read-out—that is, while the beam is on. A "usable output signal" is usually defined as one in which a normally "white" level has not decreased by more than 50% (or in which the normal "black" level has not increased to more than 50% of the "white" level).

During read-out of a silicon storage tube, the "white" charges on the target are slowly discharged by two mechanisms. First, some positive ions are generated in the region between the deceleration grid and the target and accelerated toward the more negative target, where they land and neutralize the excess electrons. The degree to which this process occurs is roughly proportional to the tube's residual gas pressure and to the reading beam current.

The second mechanism is harder to detect. Apparently, electrons are discharged throughout the silicon-dioxide layer by carriers generated in the oxide by soft X rays (of about 650 v) emitted from the grid during the read cycle. This discharge mechanism is proportional only to the reading beam current and limits the reading time in a practical system to 10 to 30 minutes.

Storage time is the maximum time during which a usable output signal may be stored without being read. For the silicon tube, it is determined by the dielectric relaxation time of silicon dioxide, which is typically greater than one month.

Erase time is the minimum time taken to reduce a fully written "white" level to 5% of its original value. It can be decreased if inter-electrode capacitances are decreased or if the oxide layer thickness is increased.

All three specifications vary depending upon the method used to store the information, potentials on the tube elements during various modes of operation, and pre-storage and post-read signal processing. Shorter writing times may be obtained with some sacrifice in resolution. Reading and storage times may be extended if only bilevel (binary) signals are recorded.

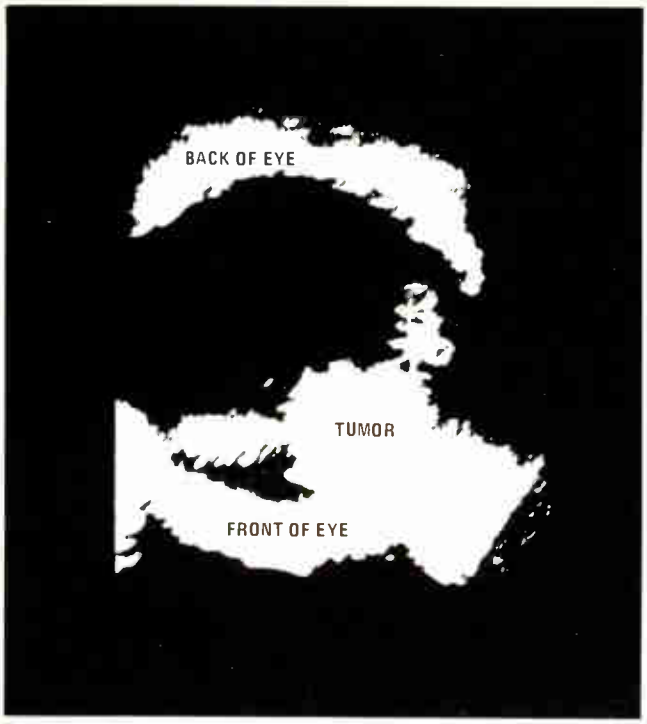
### Two new uses

The potential applications of video storage tubes in general, and the silicon-target storage tube in particular, are many and varied, ranging through ultrasound and sonar imaging, waveform monitoring, electron microscopy, and computer graphics. Two rather different examples will give a feeling for the tubes' capabilities: X-ray imaging, and the detection of visible contaminants in pharmaceutical preparations.

Pan Am's recent announcement that it will install X-ray inspection equipment at its major air terminals around the country highlights a very promising application of the silicon-target storage tube. The inspection system being bought by Pan Am is built by the Aerospace Systems division of the Bendix Corp. in Ann Arbor, Mich., and incorporates a modified version of the PEP-400, an image storage and scan conversion terminal manufactured by Princeton Electronic Products Inc., North Brunswick, N.J. The heart of the PEP-400 is a silicon-target tube called the Lithocon—a trademark of Princeton Electronic Products Inc.

The terminal operates in combination with a pulsed X-ray source and a phosphorescent screen. The X-ray pulses travel through passenger luggage to the screen, producing an image of the metal contents for a vidicon to pick up and transmit to a Lithocon. There the image is stored, scan-converted, and relayed to a standard video monitor for detailed viewing by an inspector (Fig. 3). The image can be held without loss of gray scale for up to 15 minutes. The 40-nanosecond pulses are so short they will not fog film. Also, luggage throughput is fast, for new luggage can be put in place while the inspectors are still studying the previous bag.

The other application is a novel, fully automatic sys-



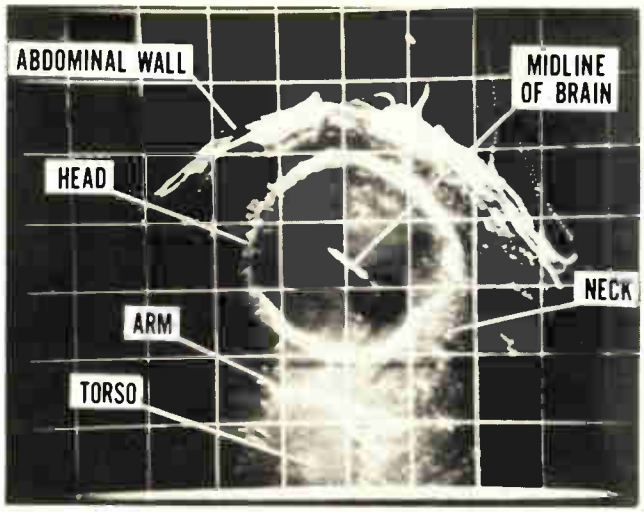

**5. Tumor detector.** This ultrasonographic display of an eye shows a tumor in the front of the eye, just behind the lens. (Photo courtesy of D. Jackson Coleman, M. D., Edward S. Harkness Eye Institute, Columbia Presbyterian Hospital, New York, N.Y.)

tem being developed by a major pharmaceutical manufacturer. Prior to the advent of the Lithocon, this manufacturer employed a line of inspectors to check transparent vials for contaminants. The vials were filled with various liquids, and an inspector would take one, hold it to a bright light for a visual check, shake it, and hold it to the light again. If he could see anything moving, or swirling around, the vial was assumed to be contaminated and was rejected. A major problem with this method, however, was eye fatigue.

The new equipment, employing special-purpose Lithocons, greatly simplifies and speeds up this process. Now, when the vial comes in, it is placed into a rotatable chuck where it is illuminated by a bright light and viewed by a vidicon (Fig. 4a). The chuck is spun for a brief period and then stopped. The image seen by the vidicon is then sent to the special-purpose Lithocon, which has the ability to subtract successive images from each other and feed only the difference between the images to a video monitor. If the liquid in the vial is clear, the successive images are identical and the differential output signal is zero. If, however, there are any visible contaminants swirling around in the vial (Fig. 4b), the successive signals are different, and the differential output shows the moving particles as white dots moving on a black background (Fig. 4c). At present, a human inspector looks at the monitor, but probably he too will ultimately be replaced by a photomultiplier system or some such electronic particle counter.

This device can be thought of as a video image differentiator. It may someday be used to detect intruders in banks and other sensitive installations.

The silicon-target tube is also particularly appropriate for ultrasound imaging, probably one of the most




**6. Safety.** This prenatal sonogram clearly shows the midline ridge of an unborn baby's brain along with the mother's abdominal wall without exposing either baby or mother to the possible hazards of X radiation. (Photo courtesy of Zenith Corp., Chicago, Ill.)

exciting applications of technology to medicine being developed today. Unlike X-ray imaging, which is better suited to high-contrast applications such as forming images of bones, ultrasound is good at producing high-contrast images within soft tissues and can carry out highly detailed examinations of such organs as the heart, liver, and kidney.

### Sound medicine

Basically, the technique is an extension of sonar—a pulse of sound energy is sent into the body, and an image is formed from the sound waves that are reflected back. In systems that use this technique, the storage tube has two functions. First, it accepts the information, which takes several minutes to be generated, and accumulates it into a clear, concise, single image. Second, it acts as an image computer, enhancing and bringing out detail from signals that would otherwise be lost in the noise from spurious echoes.

A limitation of previous imaging techniques, however, has been their inability to provide a gray scale. The images they produced were strictly black and white, and, unfortunately, much essential information needed for a diagnosis is contained within the gray scale. Thus, although ultrasound was of some value, physicians used to working with gray-scale images, such as those produced by X rays, have been hesitant about accepting the new technique.

The introduction of the Lithocon storage tube with its ability to record a full range of grays while maintaining high resolution has greatly expanded the diagnostic capabilities of the technique. According to those physicians and companies who are using silicon-target tubes in their systems, the tube may play a key role in getting ultrasound fully accepted by radiologists as a standard diagnostic tool.

The sample sonograms shown in Figs. 5 and 6 give some idea of the potential medical applications of the Lithocon in ultrasound imaging alone. Other medical uses include electrocardiogram monitoring and infrared mammography. □

# Microprograming, stack architecture ease minicomputer programer's burden

To meet the requirements of a high-level language and its compiler, a microprogramable minicomputer has been built that can adopt a stack architecture; as a result, it's inexpensive to program

by Rod Burns and Don Savitt, *Microdata Corp., Irvine, Calif.*

☐ The soaring cost of programing minicomputers could be cut by as much as 80% if high-level languages like Fortran or PL/1 could be used efficiently on them. Unfortunately, most experienced programers prefer to work directly in a minicomputer's machine language, despite the much greater time that it takes, because the available software compilers that translate high-level languages into minicomputer machine language are cumbersome and degrade performance.

The fault has lain in the architecture of minicomputers, which have not been designed with the problems of compiling a high-level language in mind. An architectural concept that does take those problems into account is the "push-down stack." This concept is at the heart of a new minicomputer, the Microdata 32/S, a firmware enhancement of the equally new 3200 microprogramable minicomputer.

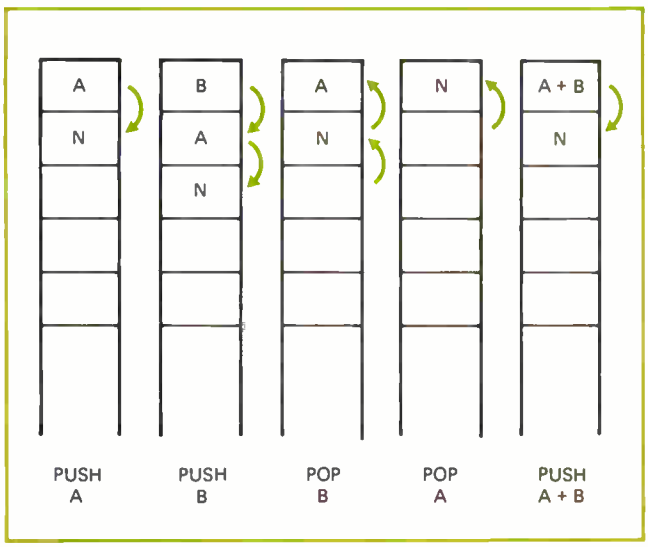
The 3200 is a general-purpose machine, microprogramable by the user to meet his own requirements. With the 32/S firmware added, the 3200 becomes a stack-architecture machine optimized to compile and execute programs written in a version of the PL/1 high-level language. The result is a low-cost, high-performance machine that is also inexpensive to program.

Microprograming was first proposed 20 years ago. For the past eight years, it has been used extensively in large computers to provide a common architecture in machines covering a wide range of cost and capability. More recently it has been used in minicomputers to customize an instruction set to a particular application.

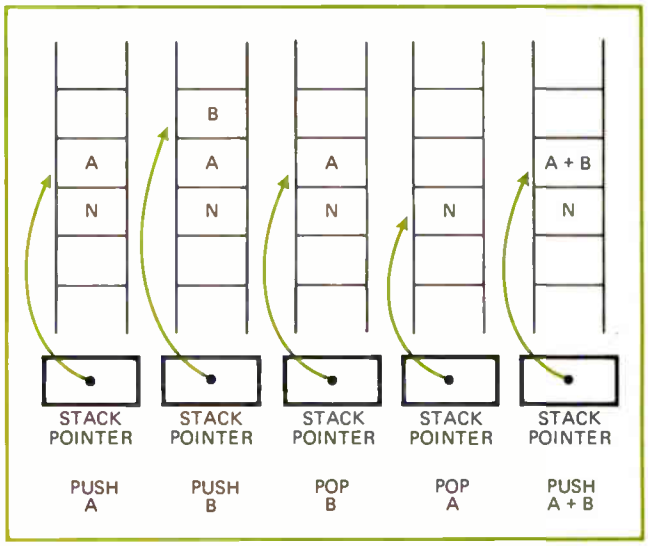
### Neither hard nor soft

Writing a microprogram is very similar to writing a problem program. But the microprogram is like the hardware control logic that would be required in a non-microprogramed computer, in that it is usually implemented in a read-only memory and is not altered after the machine has been built. Thus microprograms are sometimes called "firmware," because they are designed like software and built like hardware.

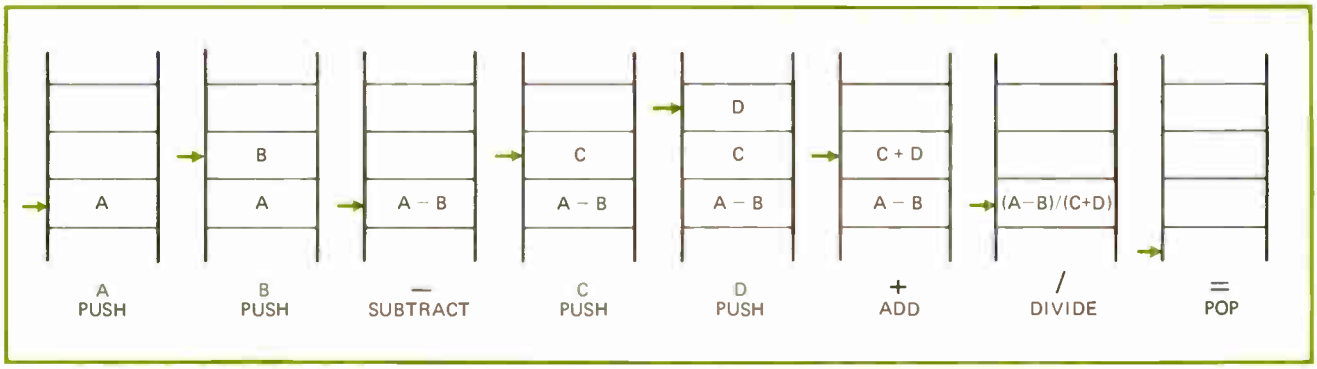
With firmware, the orientation of the minicomputer architecture can be shifted away from the constraints of hardware and toward meeting the needs of software, in two ways. First, firmware can be exploited to make minicomputers easier to program. For example, sophisticated instructions are simpler and less expensive to




**1. Push-down stack concept.** All data, shown here algebraically as A, B, N, enters stack at one end and is removed at same end. As new data enters, previously loaded data ripples downward into successive positions; as data is removed in reverse order, remaining items ripple upward until last item (first loaded) is gone.




**2. Stack implementation.** Since register-to-register rippling is physically impractical, actual stacks use an external counter as "pointer" to indicate "top" of the stack at any moment. Counter's contents always show the most recently loaded register. Registers are loaded sequentially and unloaded in the reverse sequence.




**3. Stack evaluation.** As the equation X = (A - B)/(C + D), expressed in Polish notation as A B - C D + / X =, is evaluated in a stack, the stack takes on these successive appearances. Colored arrow represents the stack pointer indicating the top of the stack.

implement in a microprogramed computer than in its hard-wired equivalent. Second, the dual nature of firmware as described in the preceding paragraph tends to shorten the traditional distance between the programer and the engineer—to get them to talk with each other.

### Language versus architecture

The standard approach to programing large computers, in both data-processing and scientific applications, is with high-level languages. These computers, having large main memories and plenty of mass storage and being heavily backed by development money, can afford multipass compilers—those which run through the input program several times, to make the best possible translation.

With minicomputers, however, it has been more efficient to use assembly language instead. (Assembly language replaces the numerical machine-language 1s-and-0s code with alphanumeric instruction and address codes one-for-one; while high-level languages, in general, replace many assembly-language instructions and their addresses with one statement.) A compiled program normally occupies just too much of the minicomputer's limited memory capacity and inserts an excessive number of extra instructions.

One reason for this inefficiency is that most minicomputer architectures minimize the execution time of common operations such as addition, or minimize the number or cost of components, without regard to the problems of compilers and high-level languages. Since high-level languages are very different from machine languages, the cost of bridging the difference is paid by the compiler, and the cost is usually very high. The solution is not to force-fit the language to the computer architecture, but to tailor the architecture to the language and its compiler.

### Push and pop

Compilers can work efficiently with computers that are designed with a "push-down stack" architecture. Conceptually, a push-down stack is a set of registers of which only one is externally accessible. Data is loaded or "pushed" into the stack through this one register; when additional data is loaded, previously loaded data moves sequentially "down" from one register to the next in the set (Fig. 1). Data is retrieved or "popped" from the same register used for loading; each such retrieval causes other data to move "up" sequentially from other registers. All data is retrieved in the reverse order from that in which it was loaded, so that the push-down stack is sometimes called a "last-in-first-out" (LIFO) buffer.

This push-down-stack concept has been used successfully in large-scale processors, notably the Burroughs 5500 and 6500. Furthermore, it is readily implemented in firmware. It's much simpler for a compiler to generate efficient programs for a push-down stack architecture than for the conventional multiregister architecture—for the simple reason that the human programer, shuttling data from register to register in a minicomputer of conventional design, can visualize what is going on, whereas the compiler can only count and catalog and sort. Therefore the compiler is likely to use the registers in a very constrained way, with many needless transfers to and from the main memory.

In addition, the stack concept is convenient for writing the compiler. Proof is that compiler writers using conventional computers create stack environments in software. Thus, from the standpoint of any user, the availability of a minicomputer with a stack architecture makes it cheaper to obtain a compiler for the particular high-level language that suits his application.

No actual push-down stack works like the conceptual model described previously. Instead, in the simplest configuration, a set of successive locations in the computer's main memory is set aside for use as a stack. Instead of data actually moving from location to location during a push or a pop, the address of the next empty location is stored in a stack pointer. This pointer is a register that can be incremented or decremented by 1 (Fig. 2), and points to the location that is currently the top of the stack.

A similar but faster-operating stack uses high-speed registers with a separate counter for the top several locations of the stack, and a stack pointer and main memory locations for lower portions. The highest register is tied directly to one input of the computer's arithmetic unit. Since most of the traffic in and out of the stack involves only the top few locations, the hardware registers reduce the number of accesses to the main memory and speed up the whole system's operation.

In an architecture based on the push-down stack, the instructions that concern the stack automatically transfer data as needed between the register stack and its extension in the main memory, so that the programer or

the compiler need not be concerned with what or how much data is in the stack. Thus a push into the register stack when it is already full is automatically preceded by a transfer of the word in the bottom register into the main memory. But, for maximum performance, the reverse is not necessarily true; a pop from the register stack is not accompanied by a transfer from the main memory stack. Only when the register stack is empty does a pop fetch data from the main memory.

### Example of stack usage

The simplest example of stack usage is the evaluation of an arithmetic expression. Working in a high-level language, a programer writes an assignment statement such as:

$X = (A - B)/(C + D)$

The compiler translates this into the format known as "reverse Polish notation," after Jan Lukasiewicz, a Polish logician:

$A\ B - C\ D + /\ X =$

This notation eliminates parentheses because each mathematical operator refers not to the two operands between which it stands, but to the two operands preceding it—or, in the case of unary operators, such as logic complementing, to only the first preceding operand.

Translating from algebraic to Polish notation is very simple, given a push-down stack to do it in. Basically, it involves juggling the variables in accordance with the notion of precedence of mathematical operations. For example, in the expression AB + CD, the sum of two products, multiplication takes precedence over addition.

Carrying out the computation after translation is also simple, because the computer can perform each mathematical operation as it encounters the operators, without backing up to see what went before or waiting to see what comes next.

To evaluate an expression in Polish notation, a compiler produces a LOAD instruction (a "push") for each variable, a mathematical instruction (such as ADD) for each operator in the expression, and a STORE instruction (or "pop") for the = sign. Mathematical instructions operate on the top one or two items in the stack and replace them with the result. The pop instruction uses the address of the dependent variable X as the location in main memory for storing the result of the evaluation. This sequence is illustrated in Fig. 3.

In comparison, if a push-down stack is not available, the compiler must create a sequence of LOAD and STORE instructions, moving data into and out of main memory or temporary registers, interspersed with the mathematical operations. The result, for a computer with a single accumulator register, and using the same example as previously, is given in Fig. 4, which also

| LOAD | A |
|---|---|
| SUBTRACT | B |
| STORE | TEMPORARY 1 |
| LOAD | C |
| ADD | D |
| STORE | TEMPORARY 2 |
| LOAD | TEMPORARY 1 |
| DIVIDE | TEMPORARY 2 |
| STORE | X |

CONVENTIONAL SINGLE REGISTER MACHINE

| PUSH | A |
|---|---|
| PUSH | B |
| SUBTRACT | |
| PUSH | C |
| PUSH | D |
| ADD | |
| DIVIDE | |
| POP | X |
| | |

STACK MACHINE

**4. Stack economy.** Simple sequence of operations and operands using stack occupies 38% less space in memory than does step-by-step sequence of conventional single-accumulator machine program, not counting two temporary storage locations.

## Hardware versus firmware

Basically, a microprogramed computer is a computer within a computer. At the hardware level, or "micro-level," is the inner computer, designed by the engineer and consisting of an arithmetic and logic unit, several registers, the main memory, and input-output buses. This computer's instruction set controls the transfer of data among these subassemblies and is stored in a control memory. These microinstructions are executed in sequence, just as in the outer computer and, also as in the outer computer, may jump out of sequence under the control of an external condition, such as the operation code of a "macroinstruction" or the occurrence of an interrupt.

Around this inner computer the microprogramer builds the outer computer, or "target-level" computer. He writes a set of routines to adapt the micro-level computer to the intended end use. Essentially he prepares one routine for each target-level instruction code, each addressing mode, and each type of interrupt. He may also prepare a routine to control the sequence of data and control transfers on the input-output buses. Since many of these routines share subroutines, the microprogramer minimizes the amount of control memory he needs by branching in and out of subroutines just like the target-level programer. The microprogram is called the computer's "firmware."

To debug firmware, the control memory may at first be implemented in a read-write memory, in which changes can easily be made. But often, when the firmware has been checked out, it will be built into a high-speed read-only memory to prevent any accidental changes.

The microprogramer must appreciate logic design far more than is required of a software programer, and he must understand the hardware engineer's constraints of circuit delays and race conditions. Conversely, the hardware engineer must understand the nature of the microprogram sequences that will control his machine; he must know the main-memory fields that will significantly affect the microprogramer's ability to design optimum data paths; and he must provide the necessary test condition signals and enough general-purpose registers for the microprogramer's work.

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**5. Microdata 3200.** New minicomputer uses firmware-controlled stack concept to run efficiently on PL/1-like high-level language.

shows the listing for a program in a stack machine. In this example, the single-accumulator computer requires 18 instructions compared to 13, or 38% more memory space. If two entire programs were compared instead of a pair of steps, and if a multi-accumulator machine were used, the stack machine might enjoy a smaller advantage in terms of the memory space the program occupies, but the task of compiling the program to an optimum level without the help of the stack would be more difficult.

Allocating registers and temporary locations in memory, a problem in conventional compiler design, is automatically solved when a stack is available. Running out of space when the stack isn't deep enough at first might seem as bad, but it's much less critical, being handled automatically by the firmware with only a time penalty—whereas the register-allocation problem must be solved with great effort ahead of time by properly designing the compiler.

### Microdata 3200

A microprogram that implements a stack-oriented computer is available in the Microdata 32/S. This is one firmware enhancement of the basic 3200 microprogramable computer.

The 3200 (Fig. 5) is a machine with a 16-bit data word length. It has a 135-nanosecond control memory for the firmware, and a main memory—an MOS semiconductor array—that cycles in 300 ns and holds 4,096 to 131,072 words of 16 bits each, addressable by 8-bit byte. The processor, the main memory, and the input-output controllers share an interface along a common asynchronous bus, the Monobus, which provides a 16-bit data path among the system components.

The processor contains three working registers, a program pointer register, and a register file of 16 general-purpose registers, optionally expandable to 32. Instructions at the machine-language level are fetched by look-ahead logic (the microprogram could perform this function, but the logic offers a substantial speed advantage). All logic in the 3200 is TTL, a small proportion being Schottky TTL.

Words in the control memory are 32 bits long and are divided into eight 4-bit encoded fields that specify various functions in the machine control. Up to 4,096 words of control memory are available.

The processor and all or part of the control memory fit on three circuit boards (Fig. 6). They are a data board, a Monobus interface board, and a control board.

The data board contains the three 16-bit working registers, which receive inputs from the F bus and drive the 16-bit arithmetic and logic unit. This unit, in turn, drives the F bus and stores machine status in the status register. The F bus also transfers data directly from the Monobus and to and from the 16 or 32 general-purpose file registers that are also on the data board. The top four file registers and one of the three working registers together form the top five locations of the 32/S push-down stack.

The Monobus interface board contains the 16-bit Monobus data register, the 18-bit Monobus address register, the 18-bit program pointer register, and the 16-bit instruction register. The two 18-bit registers require two-step loading, since only 16 bits are available in a single machine cycle; however, the Monobus address register's two high-order bits may be retained in a separate two-bit register that helps keep track of the current base address for the stack.

The processor control board holds the first 2,048 words of control memory, which must be read-only, the 32-bit control-word data register, which holds the control memory's output, and the logic for generating the control memory address. Additional control memory goes on extra boards; it can be read-only, programable read-only, or read-write memory mixed in any proportions. Inputs to the address logic come from the F bus, from fields of the current control memory word, and from external or internal interrupts; its output is the address for the control memory, whether it be entirely on the same card or partially on other cards. If additional control memory cards are used, their outputs drive the data register on the processor control board through another bus.

Each main memory board contains up to 8,192 words, of which the first 4,096 are contained on the board itself and the remainder on a secondary board that plugs into the main board (Fig. 7). The combined module fits into one connector on the backplane.

On each 8,192-word memory module are 128 dynamic MOS packages—Advanced Memory Systems' type 6002—of 1,024 bits each. Since the maximum size memory contains 131,072 words (262,144 bytes), up to 16 of the basic modules may be required; each is manually set to respond to its particular group of addresses with a 4-bit switch.

The module also contains its own timing logic, including that required for automatic refreshing. The MOS devices are refreshed every 30 microseconds during normal operation and, to conserve power, every 2 milliseconds during standby—a condition entered upon

automatically by the power supply if the primary power source is interrupted for more than 100 ms (six cycles). Standby mode can also be entered manually for idle periods or for computer servicing. Power to the processor and input-output controllers is lost during standby, and a battery provides the 21-volt level required to preserve data in the memory.

The module also contains an oscillator-rectifier circuit, which generates a 3-V bias on top of the main 21-V supply for biasing the MOS substrates—without which the memory circuits would fail. The on-card bias generator permits the module to be removed from the backplane while system power is on.

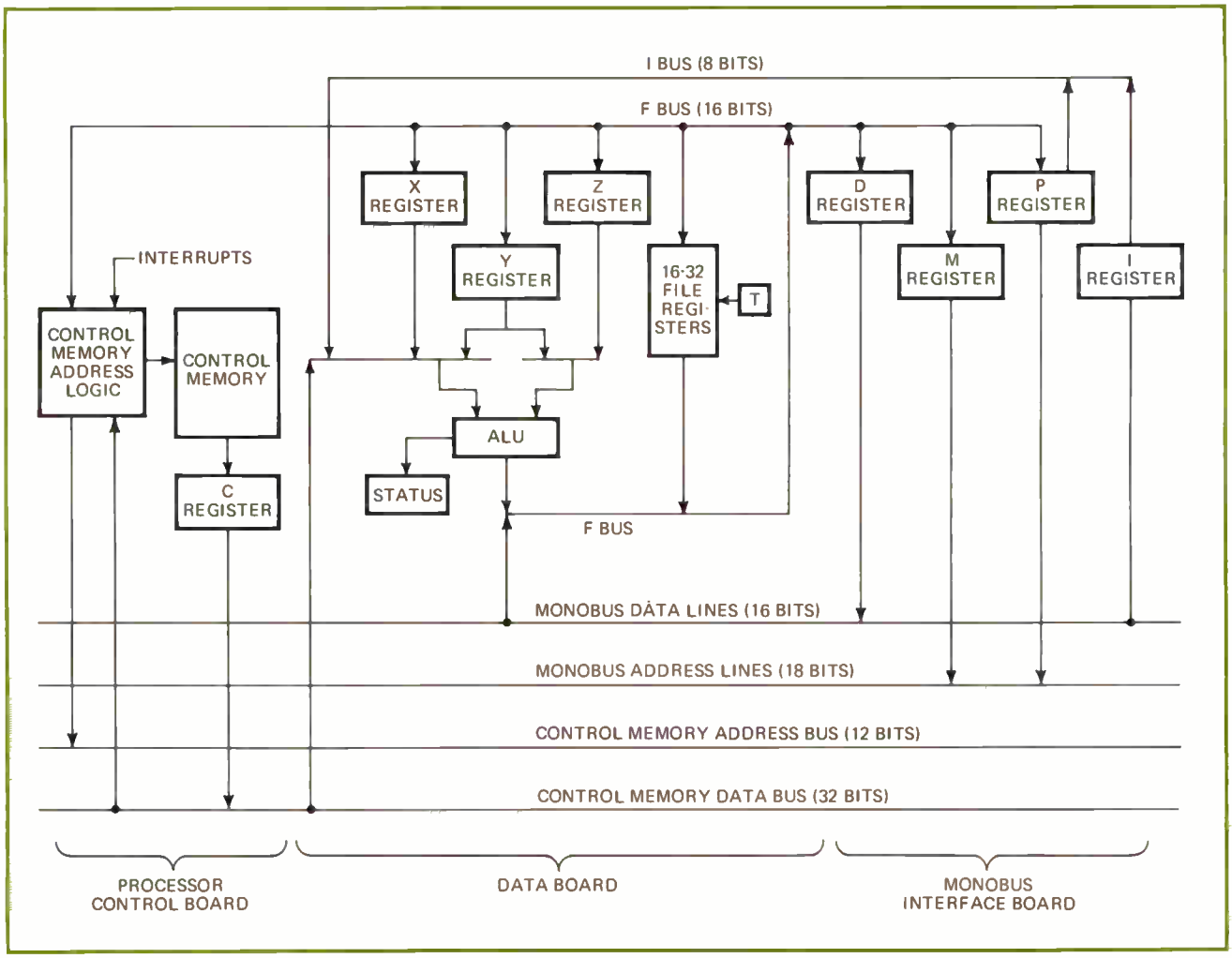
An address block of 4,096 words (8,192 bytes) is reserved for input-output controllers plugged into the Monobus; these are the highest byte addresses in the range 0 to 262,144. This range requires an 18-bit binary address, and the memory modules, with the aid of the 4-bit switch already mentioned, decode all 18 bits. Requiring the input-output controllers to decode so many bits would, however, unnecessarily complicate their logic design. They are therefore designed to decode only the 13 low-order bits, while the upper five bits are decoded in the processor and produce a separate control signal that identifies the 13 bits to the controllers as applying to them and not to a memory module.

Standard input-output controllers fit on one circuit board. Controllers for complex devices that require more than one board can be accommodated, with interconnections between boards through a flexible cable between the tops of the boards.

All boards measure 9 by 14 inches and plug vertically into a printed-circuit backplane that is the chassis floor (Fig. 8). The Monobus and five other buses are on this backplane. As a result, any board may be plugged into any backplane connector. Ordinarily the board containing logic related to the external maintenance panel plugs into the first connector, but the panel can be relocated, its board moved to another connector, and any other board plugged into its place. Thus any board can be serviced in the chassis without an extender, and with maximum cooling.

## Microdata 32/S

Although the 3200 is a general-purpose microprogramable machine, its logic design was optimized for a microprogram that defines a stack machine. When the 32/S firmware is installed, the machine becomes a general-purpose stack-oriented computer optimized to execute machine code compiled from a derivative of the PL/1 high-level language. Variations of the 32/S firmware can be designed to optimize the machine for other




**6. Three boards.** The Y register and four of the file registers form the top of the stack in the Microdata 3200; register T is the stack pointer. Lower stack positions are in main memory, reached along the Monobus. Controlling firmware (microprogram) is in control memory.

languages, such as RPG, Cobol, Basic, Fortran, or the full PL/1.

The goal in designing the 32/S was a machine in which machine-language programing would never be necessary. Accordingly, the development program began with a high-level source language and a compiler, but no assembler. This language was designed concurrently with the 32/S firmware and the 3200 hardware. The architecture of the 32/S is the result of tradeoffs between the requirements of the compiler and the cost of the control memory, containing the firmware. No 32/S instructions were included that the compiler would not use when generating machine code from the source language. With this restriction, architectural changes could be made without affecting the 3200 hardware design.

The choice of high-level language, PL/1, as a target for optimizing the 32/S firmware, is based on the belief that this language will eventually become the industry standard. A derivative of this language, designated MPL for Microdata Programing Language, was defined as the first language for which a compiler would be designed in this project.

MPL is meant to satisfy the needs of assembly-language programers who are familiar with hands-on control of the computer, while at the same time providing the advantages of a high-level language that is suitable for system and real-time programing. Since it was designed to utilize all the capabilities of the 32/S, MPL, unlike PL/1 or Fortran, is not intended to be machine-independent.

As with most high-level languages, the Microdata Programing Language employs sentence-like statements. There are two general types: assignment statements, which express arithmetic and logical operations and look like equations; and control statements, which specify branching and looping within the program. Both kinds occur in blocks, each of which defines its own variables and therefore allocates the necessary space in memory. Blocks can be nested within blocks.

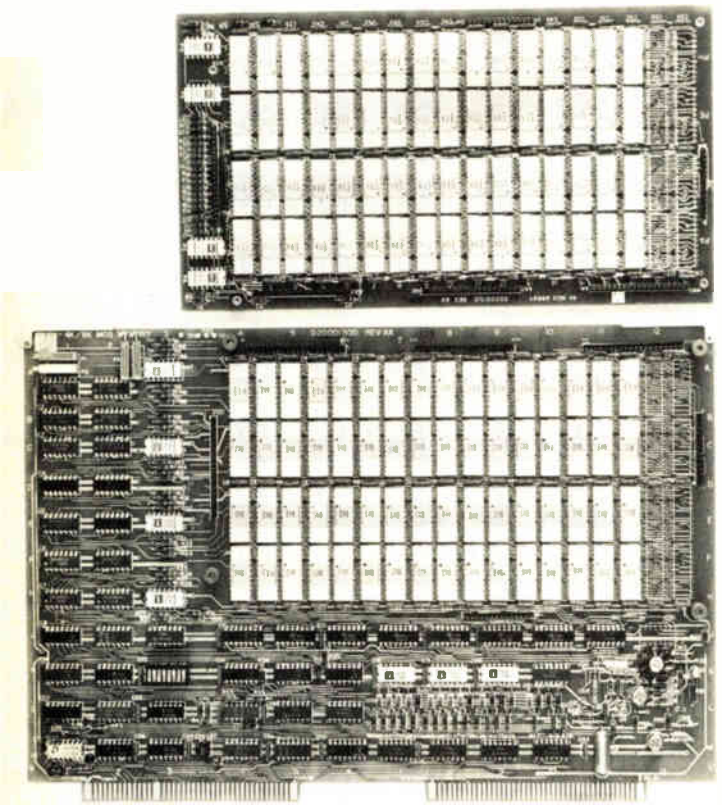
MPL is a simple language. Its power arises from the ways of combining its elements, be they arithmetic, logical, or comparison operators, symbolic data references, constants, functions, conditional expressions, and so on. Expressions may take on either an arithmetic value or a logical (true/false) value, depending on context. Compound statements—groups of simple statements—are also usable.

MPL contains no explicit input-output statements. Rather, the processor communicates with I/O controllers as if it were transferring data to or from locations in the memory. Different memory locations correspond to the registers within different controllers. The programer assigns symbolic names to these locations, and transfers data and commands to peripheral devices and tests their status by using these names in conventional MPL statements.

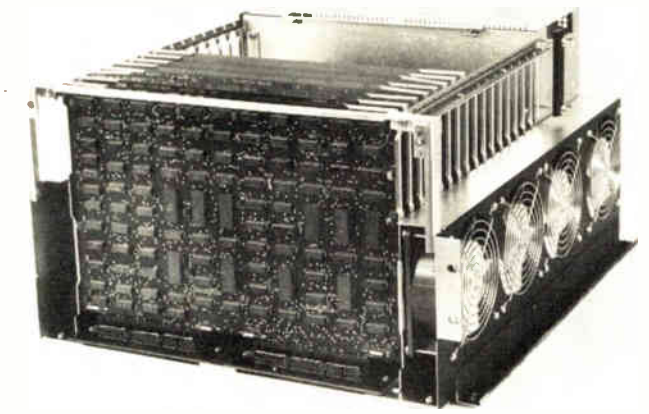
Such capabilities are in keeping with the role of MPL as a replacement for the typical minicomputer assembler language. A simple program in MPL that calculates the first 1,000 prime numbers is shown in Fig. 9, together with its flow chart.

### Extending the 32/S

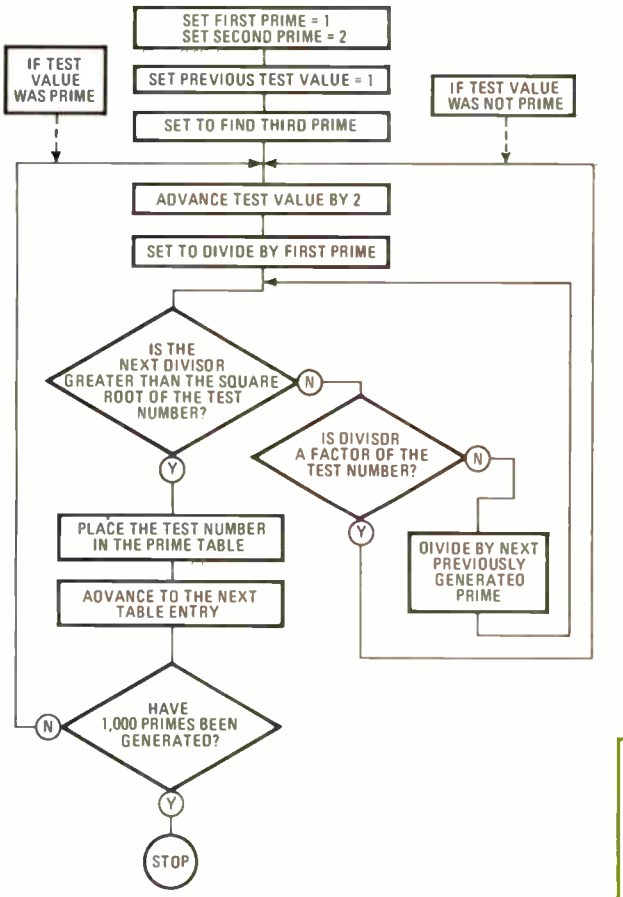
One of the outstanding advantages of a microprogramed computer is its ability to extend its instruction repertoire simply by extending its firmware—that is, simply by plugging in more control memory. MPL allows for this contingency by including provision for a statement that can cause the computer to take its next microinstruction from a specified location in the control



7. **Piggyback.** Main memory comes in 8,192-bit modules. Half the bits in each module are on a secondary board that plugs into the main board containing the other half and peripheral circuits.



8. **Easy access.** Because any board plugs into any connector, it can be brought up to the front connector for servicing. Normally the front board serves the front panel, removed in this photo.




```
PRIME:
    PROCEDURE;      /* A PROCEDURE TO CALCULATE THE
                       FIRST 1000 PRIME NUMBERS */

        DECLARE
            P(1000) WORD, /* THE ARRAY OF PRIMES */
            TEST WORD,    /* THE VALUE BEING TESTED */
            (I,J) WORD;   /* INDICIES */
        P(1)=TEST:=1; P(2)=2; /* SET INITIAL VALUES */
        DO I=3 TO 1000;   /* MAIN LOOP TO FILL THE TABLE */
L1:         TEST += 2 ;   /* INCREMENT THE TEST VALUE */
            J = 1 ;       /* INDEX FOR TRIAL DIVISORS */
            DO WHILE TEST/P(J) > = P(J) ;
            /* THIS LOOP USES ALL DIVISORS <= SQRT(TEST) */
                IF TEST MOD P(J) = 0 THEN  /* NOT PRIME, SO */
                    GO TO L1 ;  /* FOR NEXT TRIAL VALUE */
                J += 1 ;
            END ;
            P(I) = TEST ; /* TEST IS PRIME, SO STORE IT IN TABLE */
        END ;             /* END OF LOOP FOR 1000 PRIMES */
    END ;  /* OF PROCEDURE PRIME */


/* NOTE ***
   1.  THE OPERATOR ':=' SPECIFIES AN IMBEDDED
       ASSIGNMENT (WITHIN ANOTHER ASSIGNMENT STATEMENT).
       THE LEFT-HAND VALUE OF THE IMBEDDED ASSIGNMENT
       IS USED IN COMPUTING THE VALUE OF THE CONTAINING
       ASSIGNMENT STATEMENT.
   2.  THE OPERATOR '+=' SPECIFIES AN INCREMENT OPERATION.
       THAT IS, THE VARIABLE ON THE LEFT OF '+=' IS
       INCREMENTED BY THE VALUE ON THE RIGHT.
   3.  THE OPERATOR 'MOD' IS THE MODULO OPERATOR.  IT IS
       SIMILAR TO THE DIVIDE OPERATION EXCEPT THAT THE
       RESULTANT VALUE IS THE REMAINDER OF THE OPERATION
       AND NOT THE QUOTIENT.   */
```

**9. Simplicity.** Only six instructions in the MPL language are required in this simple program for generating prime numbers. Though a more efficient program would apply several tests to each trial number and thus spend less time dividing, this example illustrates the power of MPL. Other languages, in contrast, might require one or more instructions per box in the flow chart, especially at branches.

memory—what might be called a software-controlled firmware branch. Thus, as new instructions are added to the 32/S architecture, the compiler need not be modified.

To provide for a range of computers with different performance levels and corresponding prices, the 3200 computer branches to a software routine if the firmware addresses a nonexistent location. This permits the system designer to execute some functions in firmware in a higher-performance version of a machine, and in software in the lower-cost versions.

### 32/S architecture

In the architectural scheme of the 32/S, the main memory is divided into two parts: a push-down stack area, which stores program variables and maintains temporary storage as needed during program execution; and a program segment area, which stores the coded instruction sequence for one or more blocks of statements. All instructions refer to operands in the stack and leave results in the stack. Some relatively complex instructions "mark" the stack with pointer and status information when the computer enters a new block during execution of a program, and remove the mark and re-establish the previous machine environment when the computer leaves that block.

Some instructions can also retrieve data from the program area; but no instruction can modify the program area. This eliminates the possibility of designing a program that modifies itself, either deliberately or accidentally. It also reduces the number of bits required for addressing data, since the latter has its own section of memory that is smaller than the total data-plus-program memory.

When a new program segment is called into the memory from bulk storage or from an input peripheral unit, executive software decides, on the basis of the segment size and a table it keeps of available memory, where within memory it can load the segment. Having made this decision, the software assigns a base value to the segment, and stores the base address (the address of the beginning of the segment) and the length in a program library table. Then, when the execution of the segment begins, the firmware automatically refers to the program library table to obtain the base address and the length. These are placed in registers for use during the execution.

Memory locations in the data stack area are also addressed relative to individual base and stack-length registers. This makes both the program segment and data stack areas relocatable—that is, either area may be loaded or moved around without modifying the program code. The length of the program segment determines when a memory reference to the program segment has erroneously reached beyond its end into some other program—a capability required in time-sharing and sometimes referred to as memory protection. These features are conveniences for single users, and almost indispensable for multiple users in time-sharing applications. □

# Negative-resistance generator has controllable response

by Samuel E. Bigbie
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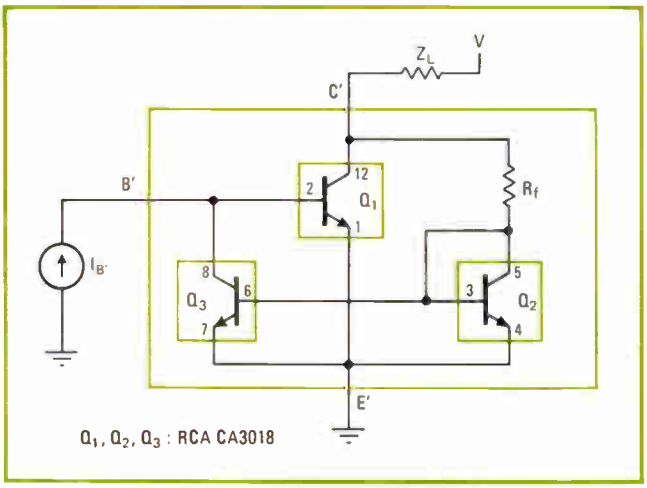
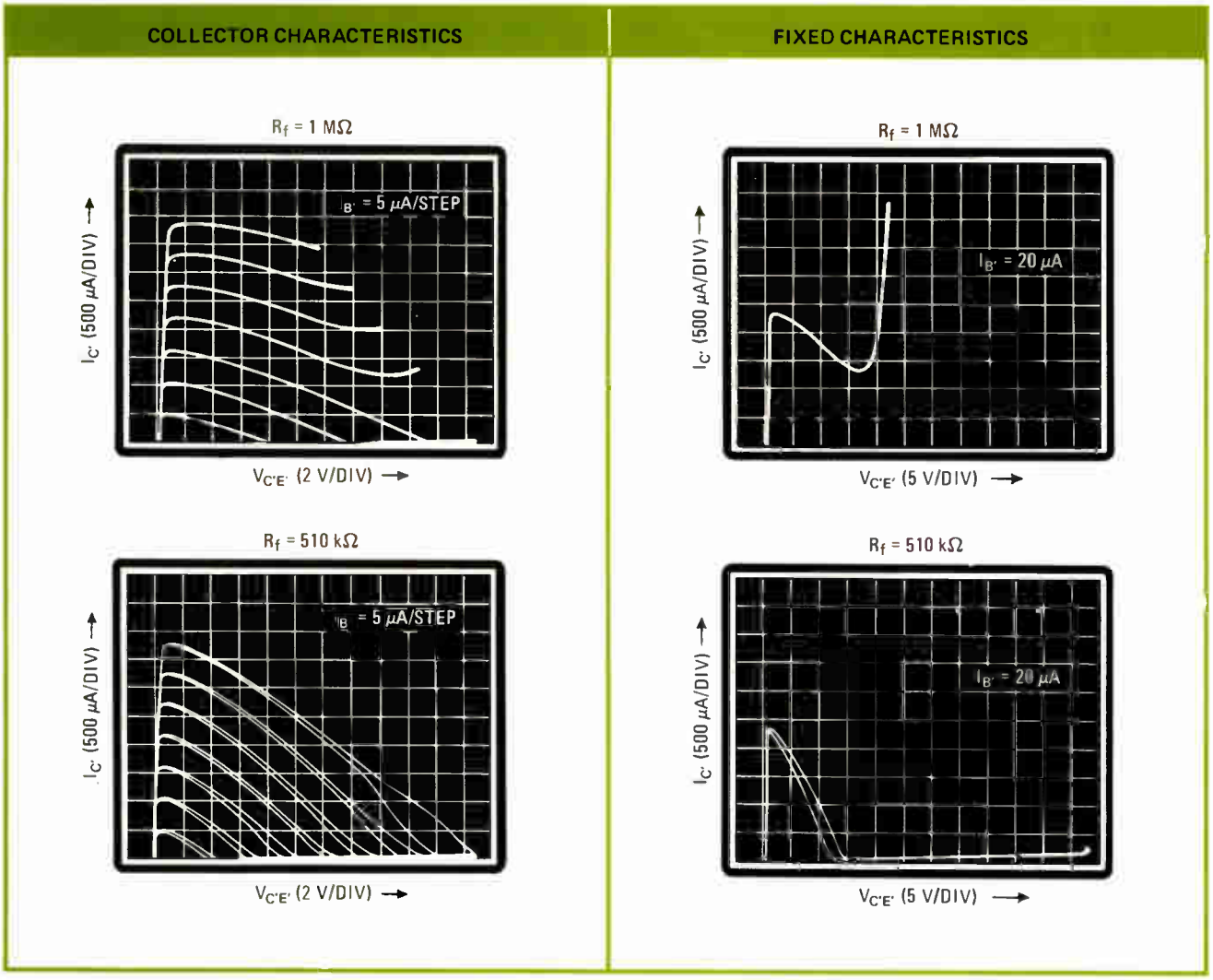
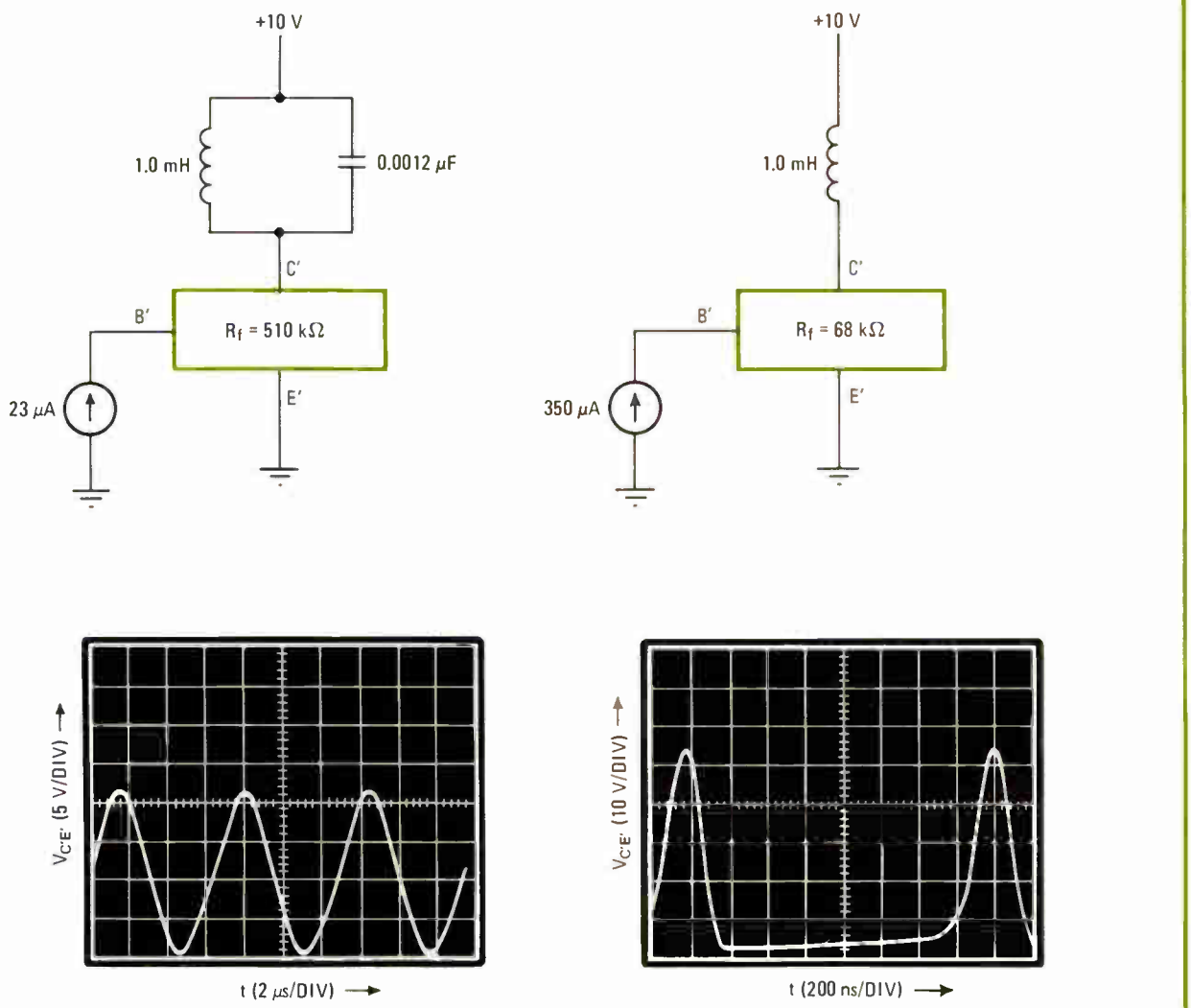
A negative-resistance generator, consisting of three matched transistors, has a current-voltage characteristic that varies with feedback resistance, but not with frequency. When driven by a current source and loaded by an LC resonant circuit, the generator can be operated as a self-starting sinusoidal oscillator. It also can be used for monostable, bistable, or astable pulse generation, as well as oscillator stabilization and switching networks.

The maximum collector current of transistor $Q_1$ depends on the amount of bias current available at its base terminal. Feedback resistor $R_f$, along with transistors $Q_2$ and $Q_3$, make up a voltage-to-current converter that decreases the base drive of transistor $Q_1$ when this




**Positively negative.** Three matched transistors form negative-resistance generator with stable, predictable operating characteristics. Circuit can be treated as transistor that develops negative impedance at terminal C'. Transistors $Q_2$ and $Q_3$ and resistor $R_f$ decrease base current of transistor $Q_1$ whenever $Q_1$'s collector voltage increases. Circuit makes dependable oscillator or pulse generator.






device's collector voltage is increasing.

The negative resistance appearing at $Q_1$'s collector is present at frequencies from dc to several megahertz. The upper frequency limit is determined by the frequency response of both transistor $Q_1$ and the voltage-to-current converter.

The generator circuit is effectively a three-terminal transistor (with pins labeled B′, C′, and E′). An input current source provides the base current for transistor $Q_1$, while resistor $R_f$ determines the amount of current fed back to $Q_1$'s base. Because transistors $Q_2$ and $Q_3$ are a matched pair and their bases are connected in common, their collector currents will be nearly equal.

As the base current supplied to transistor $Q_1$ increases, the voltage drop across load impedance $Z_L$ also increases, lowering the potential at $Q_1$'s collector. This lowered potential decreases the collector current through transistors $Q_2$ and $Q_3$. The reduced collector current through transistor $Q_3$ represents an increased impedance at $Q_1$'s base terminal. (A decrease in $Q_1$'s base current has the opposite effect, since $Q_3$'s collector current will be reduced.)

The circuit's operating characteristics are illustrated by the scope traces showing generator performance for two different values of resistor $R_f$, and for both a fixed and changing bias current. As can be seen, the negative-resistance slope becomes steeper as the value of $R_f$ decreases, from 1 megohm to 510 kilohms, in this instance.

When the load impedance is a parallel LC tank circuit, the negative resistance generator acts as a sinusoidal oscillator, as shown in the figure. Using only an inductor as the load impedance yields an astable pulse generator, which has an output pulse amplitude that equals the breakdown voltage of the combined transistors between terminals C′ and E′. □

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# Low-distortion modulator tests hi-fi a-m tuners

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Most commercially available signal generators do not hold distortion to a level that is low enough to test the frequency response and distortion characteristics of the a-m tuners found in today's high-fidelity equipment. The amplitude modulator shown, however, supplies amplitude-modulated rf signals at a distortion level of less than 0.15%.

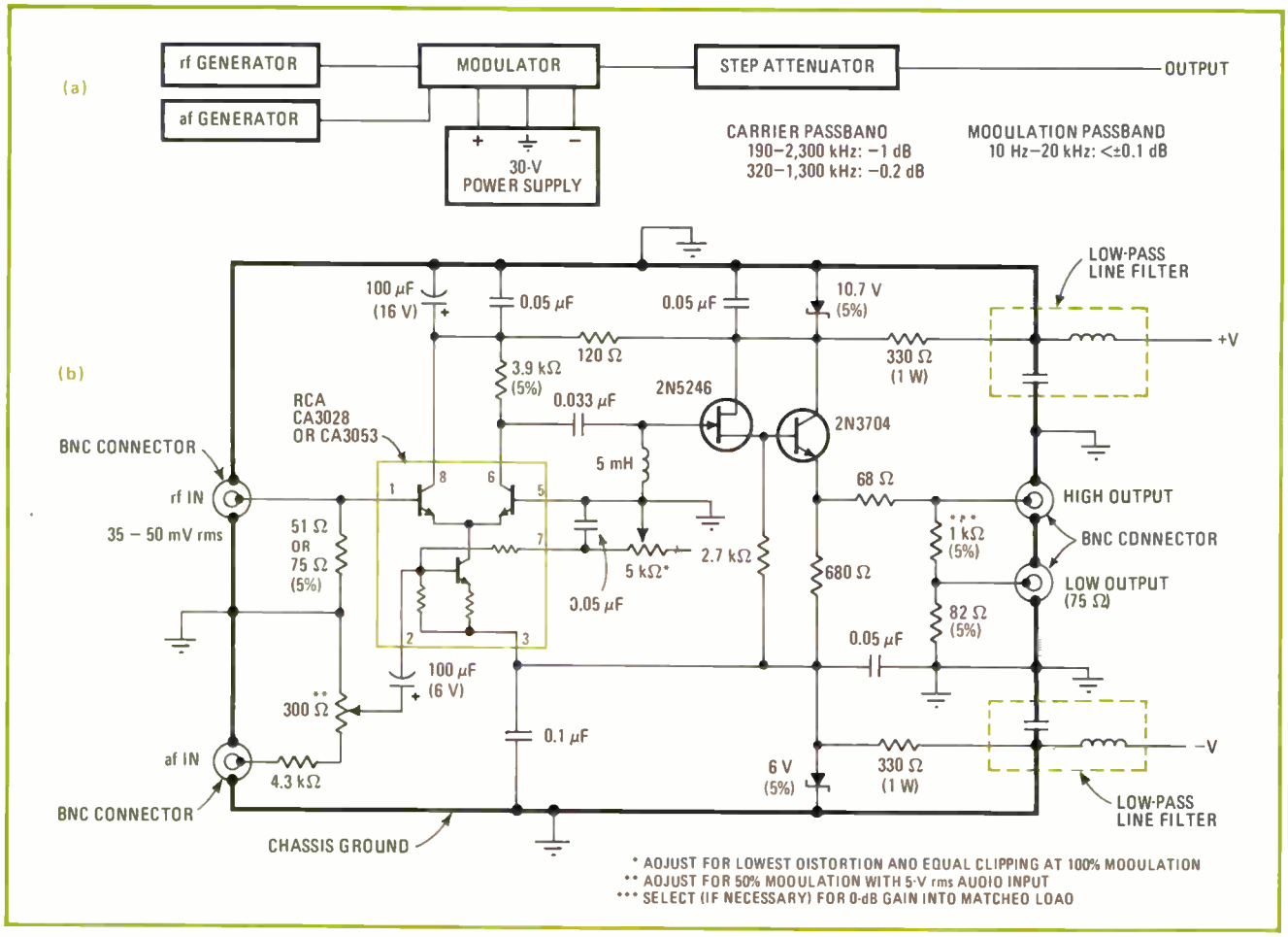
As indicated in the block diagram (a), the modulator (b) is used in conjunction with standard radio-frequency and audio-frequency signal sources. The output level of the over-all test system can be adjusted exactly with the step attenuator that follows the modulator and the vernier level control that is generally included on the rf generator. Also, the modulator gain (for the low-impedance output) can be set at 0 decibels into a matched load, allowing the absolute value of the system's output level to be easily read out from the step attenuator setting and the rf-generator setting.

The rf carrier, which has a root-mean-square amplitude of 35 to 50 millivolts, is applied to the differential input of the IC differential cascode amplifier. And the af signal drives the current-source transistor for this IC's differential transistor pair. Since the current-source transistor controls the gain of the differential pair, the af signal can vary the instantaneous gain of these two transistors, producing up to 100% amplitude modulation of the carrier signal.

The modulated carrier is coupled to the source-follower/emitter-follower combination through a high-pass filter, so that just the carrier and sidebands appear at the circuit's output. The source-follower/emitter-follower combination is essentially an impedance transformer that provides a large current gain for driving low-impedance loads.

The modulator's low output has an impedance of 75 ohms, which can easily be changed to 50 ohms. The circuit's input impedance can also be either 50 or 75 ohms, depending on the value chosen for the input resistor. The high output can drive a low-distortion detector for adjusting or evaluating modulator performance.

Output percent modulation can be indicated by the output-level setting of the af generator (a Krohn-Hite 4100A, in this case) by calibrating the circuit. Although the IC amplifier requires only a 400-mV input for 100% modulation, the modulator can be calibrated with the




**Checking out a-m tuners.** Amplitude modulator produces less than 0.15% total harmonic distortion. Equipment setup (a) shows that modulator (b) requires only one power supply. Integrated differential cascode amplifier accepts rf carrier input, as well as af modulation input, giving modulated carrier at its output. Combination source-follower/emitter-follower provides high current gain for driving low-impedance loads.

300-ohm potentiometer. Here, the circuit produces 10% modulation per volt rms of the af input.

The modulator exhibits only 0.11% total harmonic distortion when providing 30% modulation for a 400-hertz af input and a 1-megahertz rf carrier having an amplitude of 50-mV rms. Only a single 30-volt power supply is needed—neither its positive nor negative terminals is grounded. □

# Programable multivibrator is four-in-one circuit

by Edward Beach
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One inexpensive transistor-transistor-logic quad dual-input NAND gate and a few other components make up a multivibrator that can be programed for four functions—a simple latch, a monostable multivibrator, an astable multivibrator, or a retriggerable monostable multivibrator. The circuit employs a discrete timing circuit, rather than a conventional TTL timer, to allow a wide range of values to be used for timing components.

The table summarizes the operation of the circuit. With input A held low (to ground), gate $G_1$ shorts out timing capacitor $C_t$ through diode $D_1$, and gates $G_2$ and $G_3$ operate as a simple reset-set latch. When input A is held high, the circuit becomes a monostable multivibrator. A negative-going trigger (B) sets the latch, removing the short from the capacitor. Now capacitor $C_t$ charges toward the supply voltage (5 v) through resistor $R_t$ until point 1 reaches approximately 3.2 v. The regenerative switch formed by transistors $Q_1$ and $Q_2$ then rapidly discharges capacitor $C_t$, resetting the latch.

The circuit's output pulse duration (T), which equals approximately $1.3R_tC_t$, can be adjusted from about 280 nanoseconds to well over several hours in length. For the longest period, requiring timing component values of 10 megohms and 1,000 microfarads, a very low-leakage capacitor must be used.

Input C acts as a direct clear for all circuit functions. Bringing C to ground potential clears the monostable by discharging capacitor $C_t$ so that the circuit is ready for another input signal.

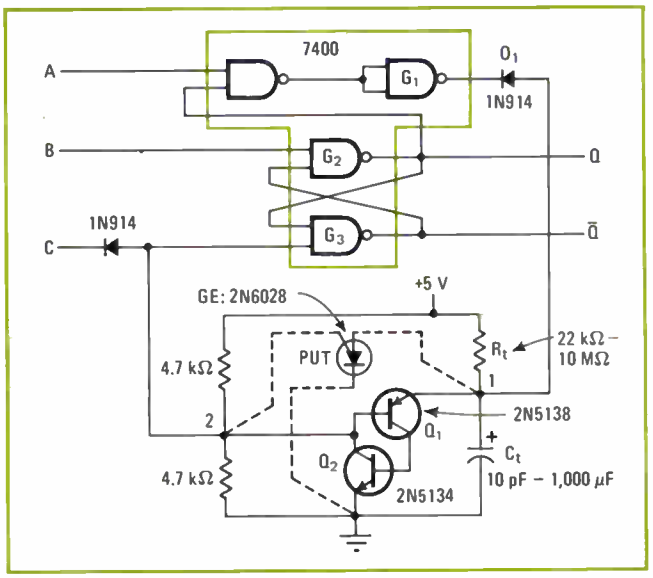
Tying inputs A and B together produces the retriggerable monostable multivibrator. Its timing period begins at the end of a negative-going trigger input. If the circuit has not timed out before the arrival of another trigger, capacitor $C_t$ is discharged, and the timing cycle is started again.

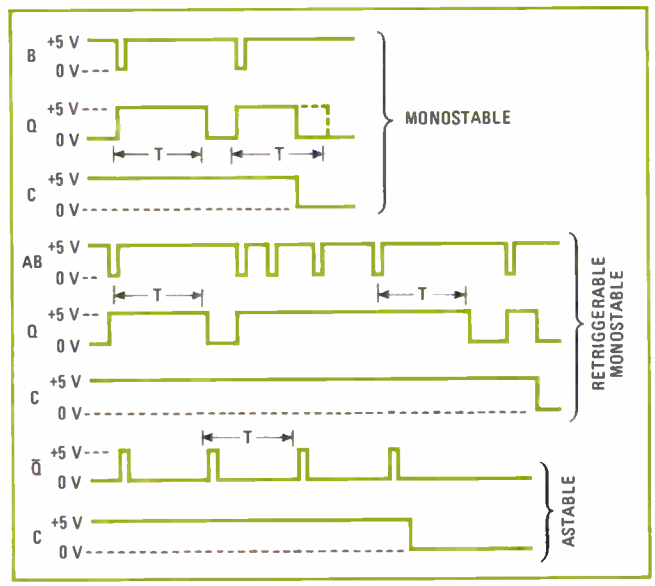
Grounding input B while holding inputs A and C high allows the circuit to act as an astable multivibrator, producing positive pulses at its $\overline{Q}$ output. Negative-going pulses could be taken from point 2, if desired.

A programable unijunction transistor (PUT) can be used instead of transistors $Q_1$ and $Q_2$. It is connected as shown in the schematic. □

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.

| CIRCUIT FUNCTION | | | |
|---|---|---|---|
| A | B | C | OPERATING MODE |
| LOW | SET | RESET | R-S LATCH: B = SET, C = CLEAR |
| HIGH | ⊓ | HIGH | MONOSTABLE: T = 1.3 $R_tC_t$, C = CLEAR |
| HIGH | LOW | HIGH | ASTABLE: $\overline{Q}$ = OUTPUT, C = CONTROL |
| A TIED TO B | | HIGH | RETRIGGERABLE MONOSTABLE: C = CLEAR |




**Versatile multivibrator.** Input signals determine operating mode of four-function multivibrator, which can be a reset-set latch, a monostable multi, an astable multi, or a retriggerable one-shot. Discrete devices in the timing network permit output pulse period to range from 280 nanoseconds to more than several hours. The programable unijunction transistor (PUT) can be used to replace transistors $Q_1$ and $Q_2$.

# Two-IC digital filter varies passband easily

by Andrew M. Volk
*University of Wisconsin, Madison, Wis.*

Only two integrated circuits—a dual monostable and a three-input NAND gate—are needed to build a digital filter that offers completely adjustable cutoff frequencies as well as excellent frequency stability. The bandpass filter is also independent of the duty cycle of the input waveform. It can be used in a variety of circuits, for instance, in tone-controlled devices or for fm demodulation of digital codes.

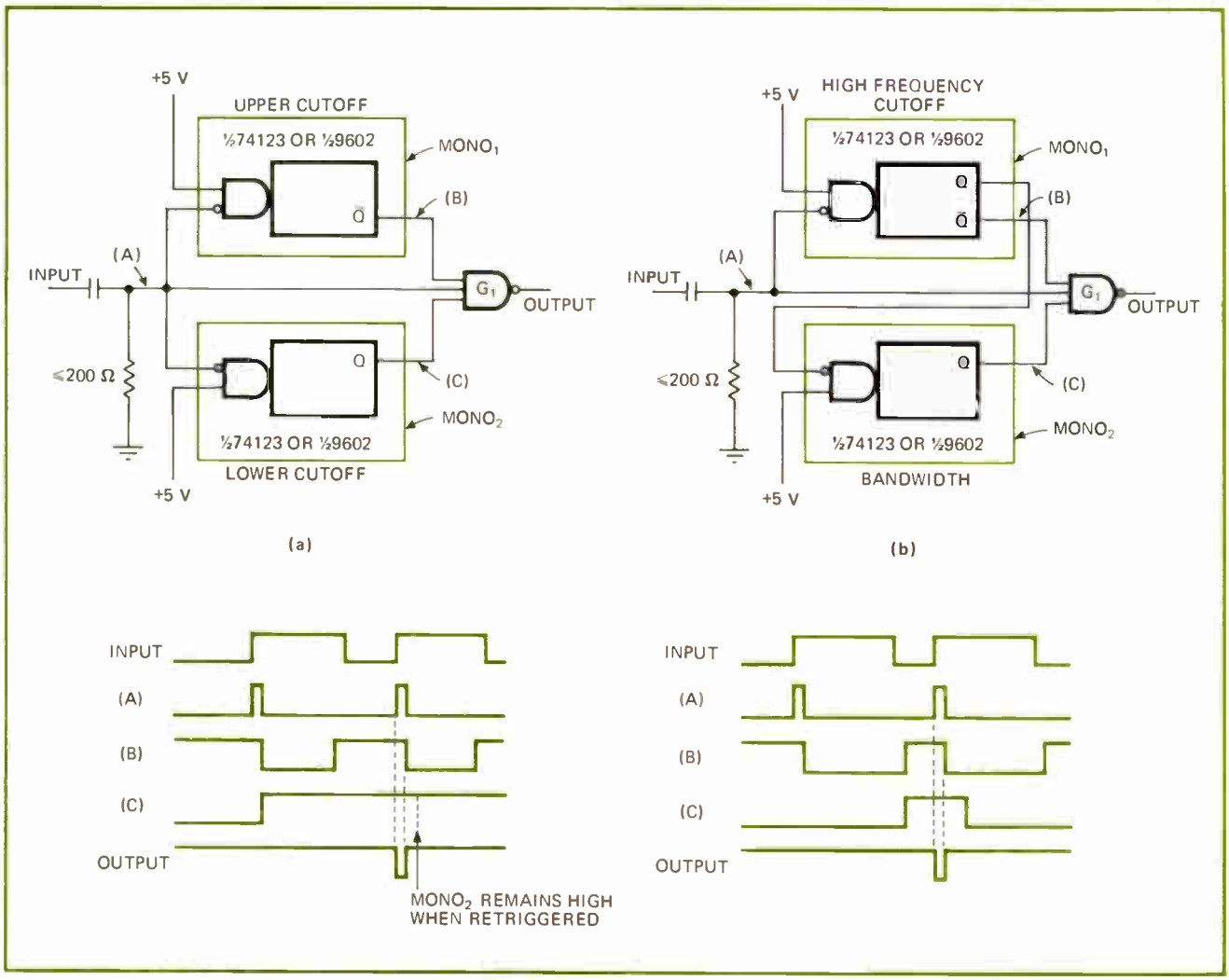
The input RC differentiator makes the filter independent of the duty cycle of the input. In (a), the lower and upper cutoff frequencies of the filter's passband are determined by the retriggerable monostable multivibrators. The output pulse length of the first monostable ($MONO_1$) is set to the period of the highest frequency of interest, while the output pulse length of the second ($MONO_2$) is set for the lowest frequency wanted.

If an input pulse appears after $MONO_1$ times out but while $MONO_2$ is still high, there will be a pulse at the output of gate $G_1$. When the input frequency exceeds the upper cutoff, $MONO_1$ stays triggered (its $\bar{Q}$ output remains low). When the input frequency is below the lower cutoff, $MONO_2$ times out (its Q output goes low). This prevents input pulses from passing through the output gate.

For the circuit in (b), $MONO_1$ sets the high-frequency cutoff, and $MONO_2$ sets the filter bandwidth. As in circuit (a), the input pulse reaches the output when $MONO_1$ has timed out and $MONO_2$ is high.

To obtain a constant output level when the input frequency is within the filter's passband, a retriggerable monostable that has its pulse length set for $1/f_{min}$ can be placed at the output. The monostable will remain triggered as long as there are output pulses from gate $G_1$. However, there will be a time lag in the filter's response of $1/f_{in}$ for pickup and $1/f_{min}$ for dropout.

For particularly critical applications or for high-speed operation, the input differentiator, made up of the passive RC network, should be replaced with a regular monostable, like a 74121-type or a 9603-type. □




**Digital frequency selection.** Bandpass digital filter built with two ICs is easily adjusted for lower and upper passband cutoffs. In (a), output pulse width of retriggerable monostable $MONO_1$ sets high-frequency cutoff, while $MONO_2$'s output pulse width sets low-frequency cutoff. In l(b), $MONO_1$ determines upper cutoff frequency and $MONO_2$ determines bandwidth. The RC network differentiates all input waveforms.

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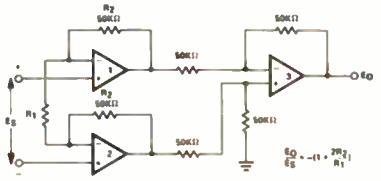

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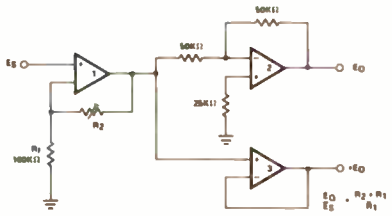

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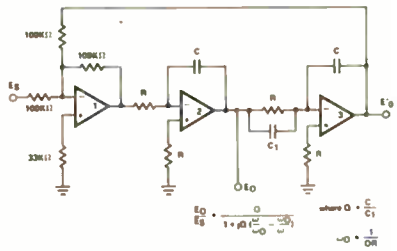

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# Dual-polarity IC regulators aid design and packaging

Mounted in cans or dual in-line packages, voltage regulators that provide both positive and negative outputs from single monolithic chips use little pc-board area, yet they give many electrical options

by Robert A. Mammano, *Silicon General Inc., Westminster, Calif.*

☐ Electronic systems using analog integrated circuits have been considerably enhanced by dual-polarity voltage regulators, now available as single monolithic chips. In addition to mounting handily on the printed-circuit boards along with the ICs they are to control, several regulators can be driven from a single remote unregulated power supply. The dual-polarity regulator provides simultaneous positive and negative voltages, with one of the two regulated voltages automatically compensating for fluctuations in the other.

When linear integrated-circuit packages first became available, they permitted the designer to build rather large and complex analog functions on one small printed-circuit board. But energizing several pc boards from one central, but remote, voltage-regulated power supply can create operational problems because of lead inductance and decoupling, and particularly from the voltage drop through leads and connectors. To eliminate these problems, an on-board IC voltage regulator was fed from a separate unregulated power supply. In this way, regulation occurred close to the load.

Initially, these IC regulators could handle voltages of only one polarity, either positive or negative, but two regulators could not be fabricated on the same monolithic chip. However, since most analog circuits require simultaneous positive and negative voltages, single-polarity regulators seemed to beg the question, since each board needed two regulators. Furthermore, two independent regulators still did not meet another basic requirement—that the two regulated voltages match, or track, each other.

Thus, the increasing use of linear integrated circuits created a demand for a dual-polarity voltage regulator built on one monolithic chip so that the adjustment of the voltage of one polarity could automatically adjust the other polarity by the same amount. This tracking capability was achieved by incorporating a single reference diode to regulate one polarity and using that output for the other polarity.

The available dual-polarity voltage regulators are Silicon General's SG1501, SG1501A, and SG1502, Motorola's MC1568, and—recently—Raytheon's RC4195. The SG1501, the first such device, features 100-milliampere output current, ±30-V input, factory-set output of ±15 V, and a sensitivity to full-range load or line variations of typically less than 2 mV. Although the output voltages can be adjusted over a range of ±8 V to ±23 V, this is done with some degradation in temperature stability.

Motorola's MC1568 and Raytheon's RC4195 are substantially the same as the SG1501. All such regulators can be combined with external pass transistors to regulate currents to about 2 A.

The SG1501A handles up to 200 mA of load current, and also it includes a circuit for automatic shutdown when the chip junction temperature exceeds a safe limit. The input voltage has been increased to ±35 V.

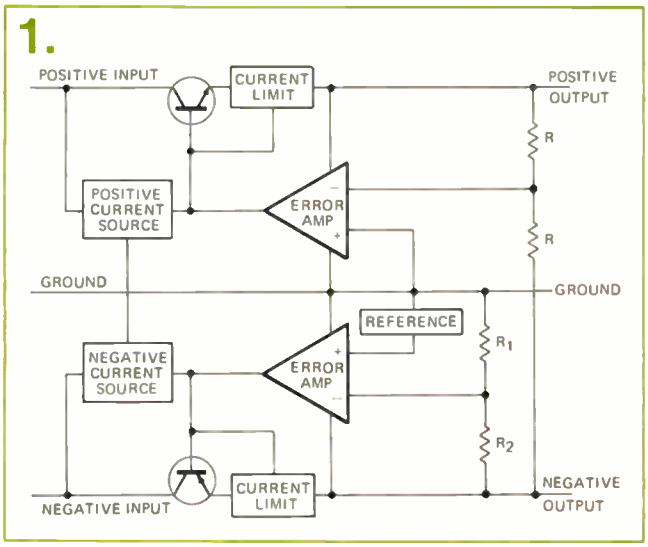
The SG1502 employs the same basic circuit as the SG1501, but it includes two additional features. User-supplied external voltage-setting resistors with small temperature coefficients permit output levels to be adjusted from ±8 V to ±28 V while maintaining excellent temperature stability. And instead of limiting the current to some maximum value, the SG1502 includes the capability for foldback circuitry, which actually reduces the short-circuit current to less than the maximum rated load current, thereby limiting internal power dissipation of the pass transistors to a safe value.

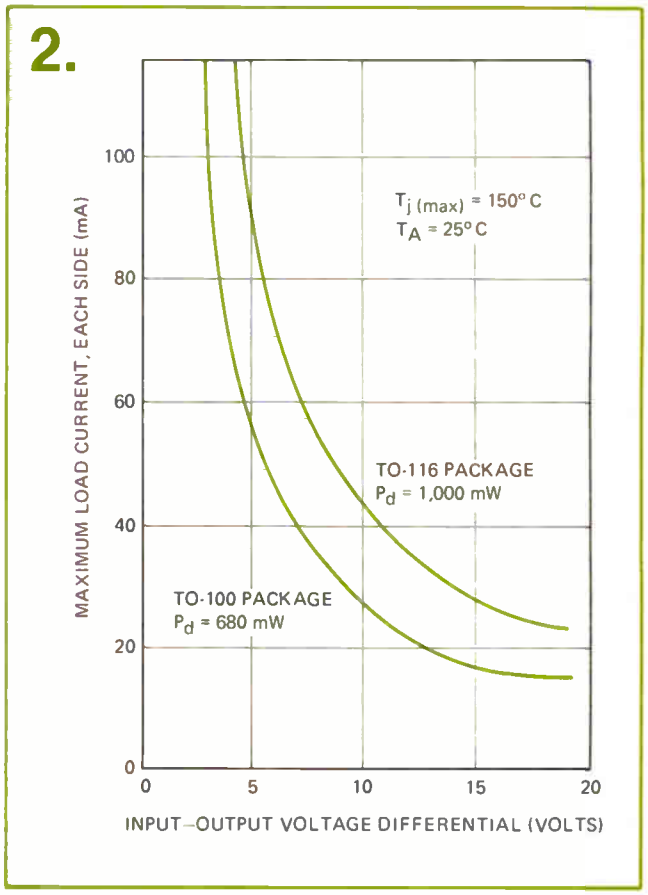
Successful applications of these dual-polarity regulators is in the hands of designers, since it is up to them to make sure that the devices do not dissipate enough power to raise internal temperature above allowable limits. The panels that follow discuss regulator operation and detail power-dissipation control by heat-sinking, by current-limiting, and by foldback circuitry.

## 1. The tracking regulator

In this basic circuit for all dual-polarity regulators on single monolithic chips, the constant voltage developed by a zener diode is applied to one input of the negative error amplifier. The other input comes from the tap between $R_1$, and $R_2$, the negative voltage divider, which thus sets the negative output voltage. Because of the closed-loop connection, the output voltage will remain fixed over a wide range of load currents and input voltages.

The reference input to the positive error amplifier is grounded, or zero. Two equal resistances span the negative and positive outputs. The tap between these two resistors goes to the other input of the positive error amplifier. In the steady state, the tap must have a potential equal to zero volts. If it does not, the positive output




voltage will increase or decrease until the input is zero. When this happens, the positive output is equal in magnitude but opposite in polarity to the negative output voltage. (Motorola's MC1568 operates similarly, except the zener reference controls the positive side.)

Any change in the setting of the negative voltage divider will provide exactly the same percentage of change in the positive output voltage. This tracking will hold within 0.5% from slightly above the reference voltage, which is 6.2 v, to about 2 v less than the input supply voltage.

## 2. Power dissipation

In maintaining a constant output voltage, despite changes in input voltage and output current, the regulator acts like an automatically variable resistance. The power dissipated by this "resistance" is the product of the voltage drop across the regulator and the load current, plus standby power. Standby power, about 10% of maximum power, is dissipated, even when no load current flows.

The maximum total dissipated power cannot allow the junction temperature of any of the many transistors on the chip to exceed 170°C. For maximum reliability, this temperature is usually derated to 150°C.

Determining the maximum power-handling capability and the resulting maximum current is a function of the difference between input and output voltages. The allowable maximum junction temperature rise, $\Delta T/j$, is:

$$\Delta T_j = 150°C - T_{a\,(max)}$$

where $T_{a\,(max)}$ is the maximum ambient temperature. The power that can be dissipated, $P_d$, is:

$$P_d = T_j/\Theta_{ja}$$

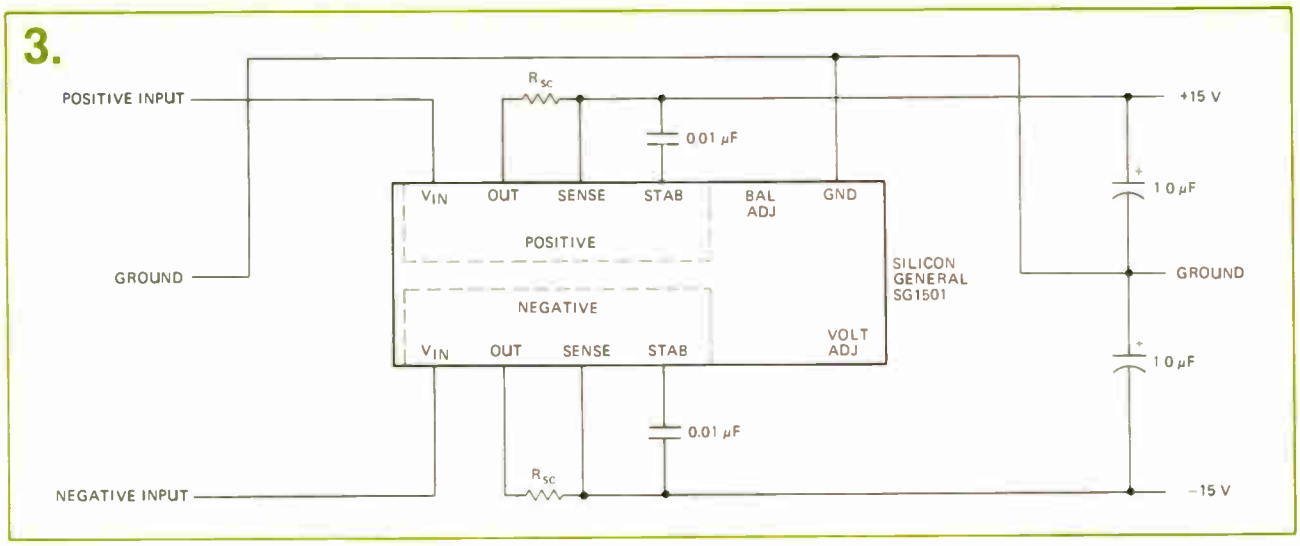
where $\Theta_{ja}$ is the thermal resistance between the junction and the ambient. The thermal resistance depends on the amount of cooling provided by convection currents, forced air, or heat-sinking. As examples, for a regulator mounted in a TO-100 metal can in open, still air, the thermal resistance is 185°C/w; for a TO-116 ceramic dual in-line package, it's 125°C/w. A heat radiator will significantly reduce these values. For example, an IERC model TXFB-032-025 top-hat radiator mounted on a TO-100 can brings the thermal resistance down to 130°C/w. A model LIC-214A-2B radiator on the TO-116 reduces the thermal resistance to 50°C/w.

The standby power, $P_{sb}$, is then subtracted from $P_d$. The remainder is the amount of power due to the product of load current and input-output voltage differential, for each side, that can be safely dissipated in the regulator. The illustration shows the maximum load current for each side, as a function of a symmetrical voltage differential, for two typical regulator packages.

## 3. Current limiting

In this simple application of an SG1501 dual-polarity regulator, the device delivers ±15 v at the output. For the designer, the main concern is to limit the maximum load current to a value that will not raise junction temperatures above a safe value. Heat-sinking can increase dissipation and hence allowable maximum current.

Each side of the regulator contains a series transistor, through which the load current passes. Current limiting is obtained by diverting, at some prescribed value of load current, the drive signal from the pass transistor. This is accomplished by another transistor which is normally held off, or nonconducting, by an external base-to-emitter resistance, shown as $R_{sc}$ in this circuit. To turn on the current-limit transistor requires a voltage between its base and emitter of about 0.6 v at a junction




temperature of 25°C, decreasing to about 0.4 v at 125°C. The load current flowing through $R_{sc}$ develops the sense voltage. Normally, the allowable short-circuit current—the limit—is taken as 150% of maximum operating load current.

Thus the value of the sense resistance is:

$$R_{sc} = \frac{\text{Sense voltage at maximum } T_j}{\text{Allowable short-circuit current}}$$

Because the sense voltage depends on junction temperature, increasing the dissipation within the regulator lowers the value of current at which limiting occurs.

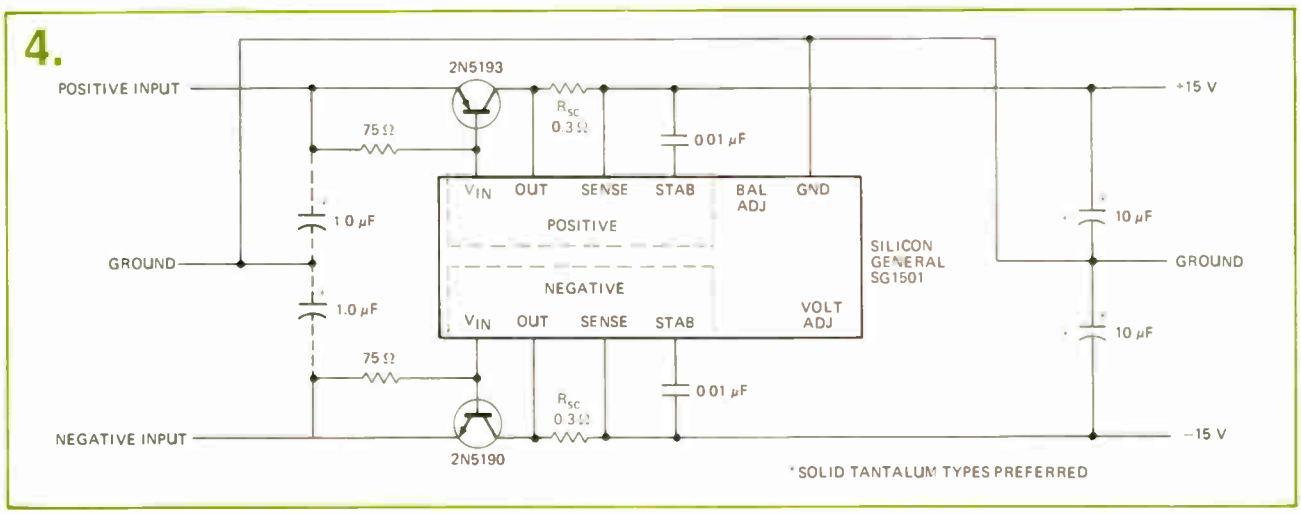
## 4. Adding extra power

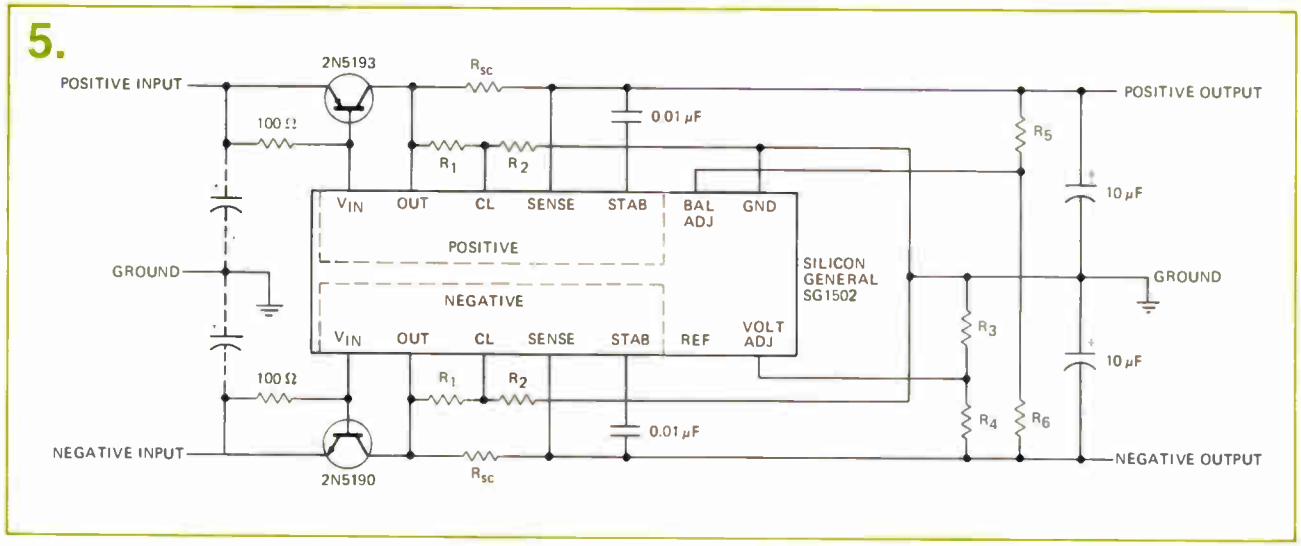
When the regulator itself cannot handle the required load current, external power transistors can be added on either or both sides. These transistors are selected basically on current and voltage capability and on mechanical requirements for heat-sinking. However, low-frequency transistors are preferred to reduce risk of oscillation. Capacitors marked by an * should be of solid tantalum because they have lower equivalent series resistance, particularly at high frequencies, than do common electrolytic capacitors. The 75-ohm base-to-emitter resistors provide a path for the dual-polarity regulator standby current under no-load conditions.

The power dissipated in these external pass transistors under short-circuit conditions can be two or three times more than normal maximum operating levels. Thus, these external transistors may need high-capacity heat sinking. Even the SG1501A, which has an internal circuit for thermal shutdown, cannot help these external pass transistors, since the thermal-shutdown circuit senses internal temperature of the chip, rather than the temperature of the power transistors. To eliminate the need for excessive short-circuit heat-sinking, the SG1502, with its foldback current capability can be used, as discussed in the next panel.

## 5. Foldback current limiting

An important added feature in dual-polarity regulators is the inclusion of foldback, the ability to reduce the output current due to a short, to less than normal or maximum operating level. That is, as the output voltage goes to zero with a short circuit—which maximizes input-output voltage differential—the output current is reduced to decrease






power consumption.

Therefore, the use of additional heat-sinking capacity to handle current overloads is not required. Using the SG1502, resistances $R_1$ and $R_2$ divide the output voltage, $V_o$, to essentially increase, or bias, the amount of sense voltage required to turn on the current-limiting transistor.

The values of $R_1$ and $R_2$ are determined approximately from an iterative solution of the equations for computing the maximum load current and the short-circuit current;

$$\text{Max load current} = [\text{Sense voltage} + (R_1 V_o / R_2)]/R_{sc}$$
$$\text{Short-circuit current} = \text{Sense voltage}/R_{sc}$$

Inspection of the first equation for normal operation shows that when a short circuit occurs, $V_o$ drops to zero, resulting in the second equation. Hence, foldback reduces the short-circuit current to less than maximum operating current. The larger the voltage drop across the sense resistance, $R_{sc}$, the larger is the amount of foldback.

Besides limiting foldback current, the SG1502 can also provide output voltages that differ substantially from the normal ±15 V. Two resistance-divider circuits on the outputs of the regulator allow each side to be set to its own value.

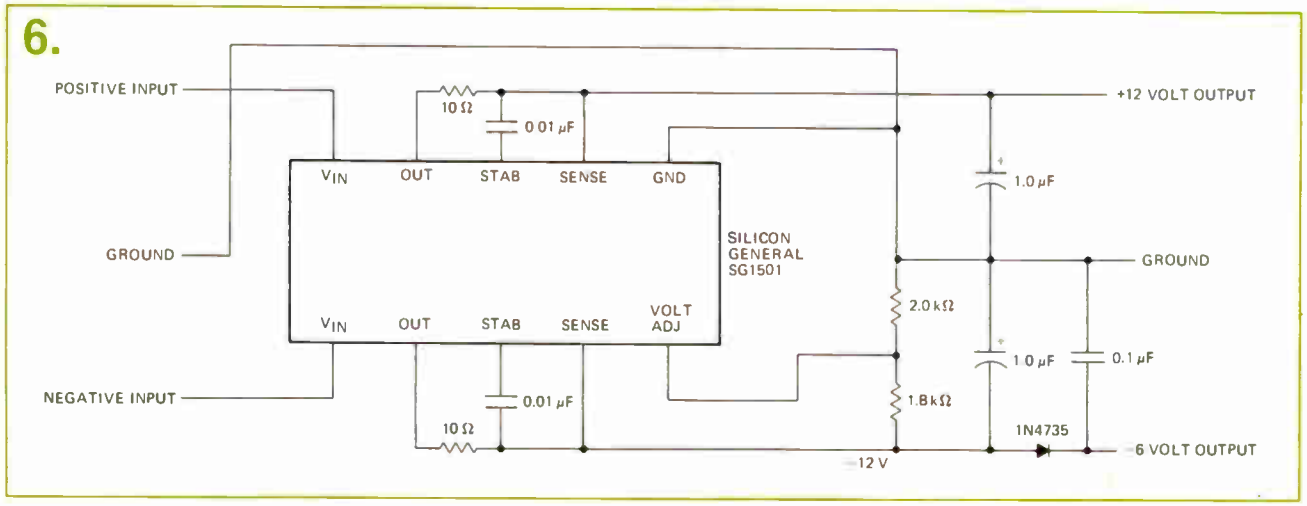
$$\text{Negative } V_o = 6.2(R_3 + R_4)/R_3$$
$$\text{Positive } V_o = R_5\,(\text{Negative } V_o)/R_6$$

The 6.2 in the first equation is the voltage of the zener reference, which means that, to retain good tracking, the minimum output is limited to about 8 V.

## 6. Voltage offset

The 710 and 711 IC voltage comparators are widely used in analog circuits. They require +12 V and −6 V for operation. Although 6 V is below the minimum output range of the SG1501, a more reasonable approach is to reduce the −15 V to −12 V, using the 1,800- and 2,000-ohm divider network. Because of the tracking feature, the +15 V drops to +12 V, as required. Then the −12-V output is reduced to the required −6 V by inserting a 6-V 1N4736 zener diode in the negative-output line.

Since the diode is outside the feedback loop, minor variations in the −6-V output may occur because of changes in temperature and dynamic impedance. However, since the negative voltage is used merely to bias high-impedance current sources in the voltage comparator, these variations will have a negligible effect on comparator operation. □



# ROMs cut cost, response time of m-out-of-N detectors

For computer and data-communications applications, the new technique using read-only memories operates faster than present shift register-counter designs and uses fewer ICs than conventional decoding-gate approaches

by A.W. Kobylar, R.L. Lindsay, and S.G. Pitroda, *GTE Automatic Electric Labs., Northlake, Ill.*

☐ It is often necessary to examine groups of independent signal leads in large digital systems to determine if a prescribed number of them carry true binary levels. Such a test circuit, which is useful for a variety of functions in computer and data-communications systems, is called an m-out-of-N (m/N) detector. It indicates if m-out-of-N leads carry the true output.

In previous approaches to building m/N detectors, a tradeoff was necessary between high component count and speed. But with the ready availability of monolithic read-only memories, this important function tester can be fabricated with a relatively small number of components and a response time on the order of 150 ns.

A design often used to implement m/N detecting circuitry utilizes decoding gates like those shown in the example of Fig. 1a. With decoding gates, however, a total of $\binom{N}{m}$* gates are required. Thus, when N exceeds about 15 or 20, the amount of needed hardware becomes unmanageable.

Another common approach that requires less hardware uses a shift register (Fig. 1b). Here, information on each of N parallel lines is stored in an N-bit register. The contents of the register are then counted bit-by-bit as the N-bit word in the register is serially clocked out. The counter is then checked to determine if only m 1s are contained in the N-bit word. This scheme requires considerably less hardware but, for large values of N, results in a very slow response time because of the serial counting operation.

A simplified special version of the m/N ROM detector—the 1/N decoder—serves to introduce the technique. The 1/N detector has broad application in testing for one and only one valid signal from a group of parallel lines at any given instant.

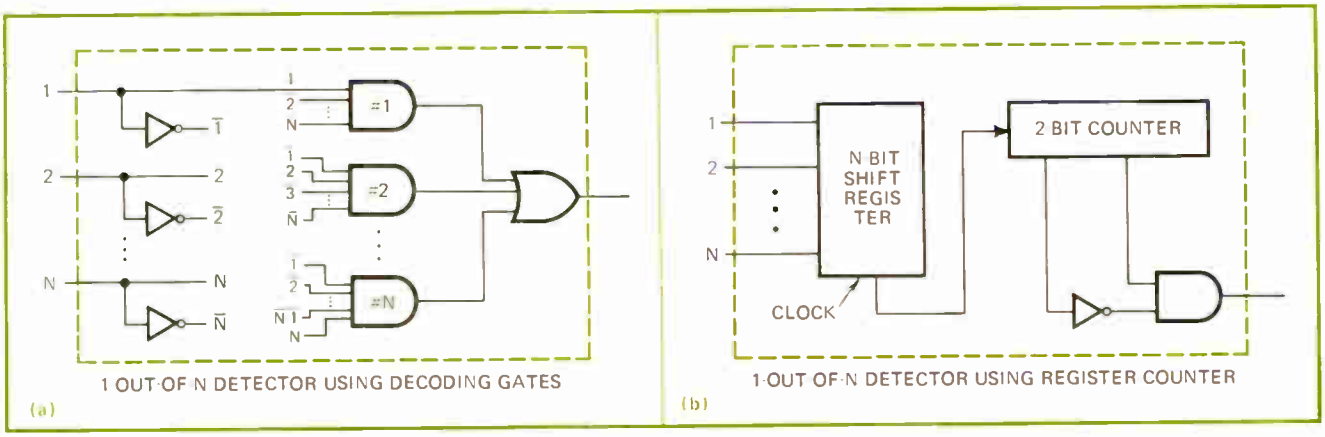
In general, a 1/N decoder requires $2^N$ bits of binary storage in a ROM. The memory is addressed by the N leads to be checked. The permanently stored information in the ROM contains one "true" state corresponding to all the addresses with a single 1 in the N-bit input word. For the remaining addresses—those containing all 0s, two 1s, and more than two 1s—a "false" is stored.

However, for a large number of inputs, N, the storage capacity for such a single-unit ROM is impractical. For a more versatile system, which uses more easily produced ROMs, a modular design approach has been taken (Fig. 2). For modularity, a large number of input leads, N, are subdivided into smaller groups of n leads. Therefore, a 1/n detector can be built from commercially available ROMs. The outputs of each smaller ROM are then cascaded to achieve the desired composite output.

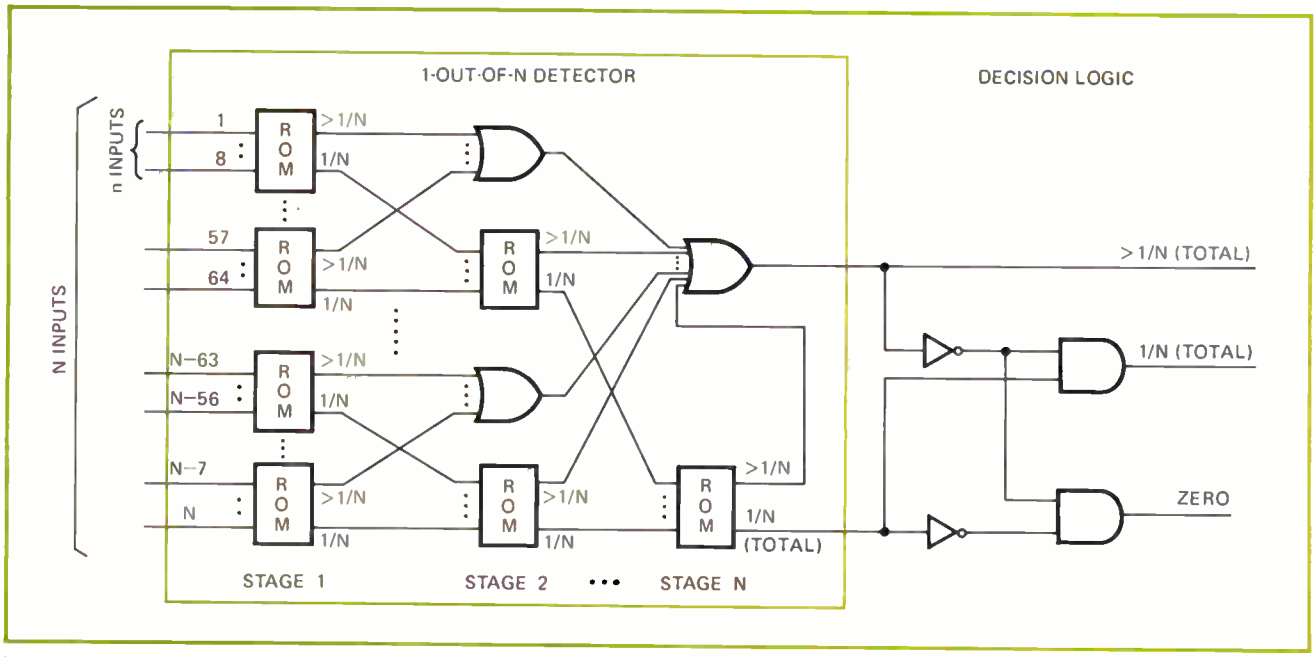
In such a decoder design, where N is divided into a smaller group of n inputs, three states can be distinguished at the output of each ROM module. These states are all 0s, a single 1, and two or more 1s.

Since the all-0s state can be decoded from knowledge of the other two states, only two output lines for each

*This is notation for N!/[m!(N−m)!], or the number of possible combinations of N dissimilar elements taken in groups of m at a time.




**1. Speed-size tradeoff.** For a large value of N, the decoding gate scheme (a) promises rapid response time, but it requires considerable hardware. The technique using shift registers and counters (b) requires less hardware, but it produces a slow response time.




**2. Best of both worlds.** A modular design using read-only memories offers a minimum response time with fewer ICs than competing approaches. Here, all 8-input modules are identical. By simply adding modules, 1-out-of-N detection is achieved for any desired value of N.

ROM are needed—one indicating a 1/N condition, one indicating that greater than 1/N input lines are true.

An input word size of 8 bits has been chosen to illustrate the modular design approach shown in Fig. 2. Thus, a 512-bit ROM ($2^8$ bits for an 8-line input) × 2 (for the 2-line output) is needed as the basic building block. Multiple stages can then be cascaded to derive a 1-out-of-N detector for any value of N.

The first stage is a set of 8-input ROMs, from which $\lfloor N/8 \rfloor$ sets of outputs are generated. (Note that throughout this article the symbol $\lfloor \ldots \rfloor$ indicates the next largest integer value.) The $\lfloor N/8 \rfloor$ outputs, representing greater-than-1/N inputs for each ROM, are ORed together in groups of eight. Then $\lfloor N/8 \rfloor$ outputs representing inputs from stage 1 become the input for the second stage, and so on.

In the second stage, the greater-than-1/N output lines are ORed together and the 1/N outputs form the inputs for the third stage so that $\lfloor N/512 \rfloor$ ROMs are required for this stage. Thus, a detector to decode one input out of as many as 512 can be made with only one ROM in the third stage.

The greater-than-1/N output generated in stage N is ORed with the greater-than-1/N ORed outputs from preceding stages to form a greater-than-1/N (total) output. Likewise, the 1/N line out of the final stage is applied to decision logic to form a 1/N (total) output.

In general, the number of n-bit ROMs required for a 1/N detector can be calculated from

$$\sum_{\alpha=1}^{\lfloor \mathrm{Log_n}\, N \rfloor} \lfloor N/n^{\alpha} \rfloor$$

A comparison of the number of integrated circuits and the response times required for detectors using individual decoding gates, shift registers, and the ROM decoder are compared in the table for varying values of N. The advantages of ROM techniques are evident.

The modular concept can be extended to the more general case where any number, m, lines out of a set, N, can be checked for true conditions. As in the 1/N detector, N is divided into smaller groups of n lines for each module. For such an m-out-of-N detector, the basic module is configured so that its output consists of m leads where (1) if zero out of n inputs is true, then all outputs are 0, (2) if 1-out-of-n inputs is true, then a single output is true, and so on until (3) if m-out-of-n inputs are true, then all m outputs leads are true. An additional output lead for each module indicates that the m-out-of-N condition has already been surpassed (greater than m/N) in that module.

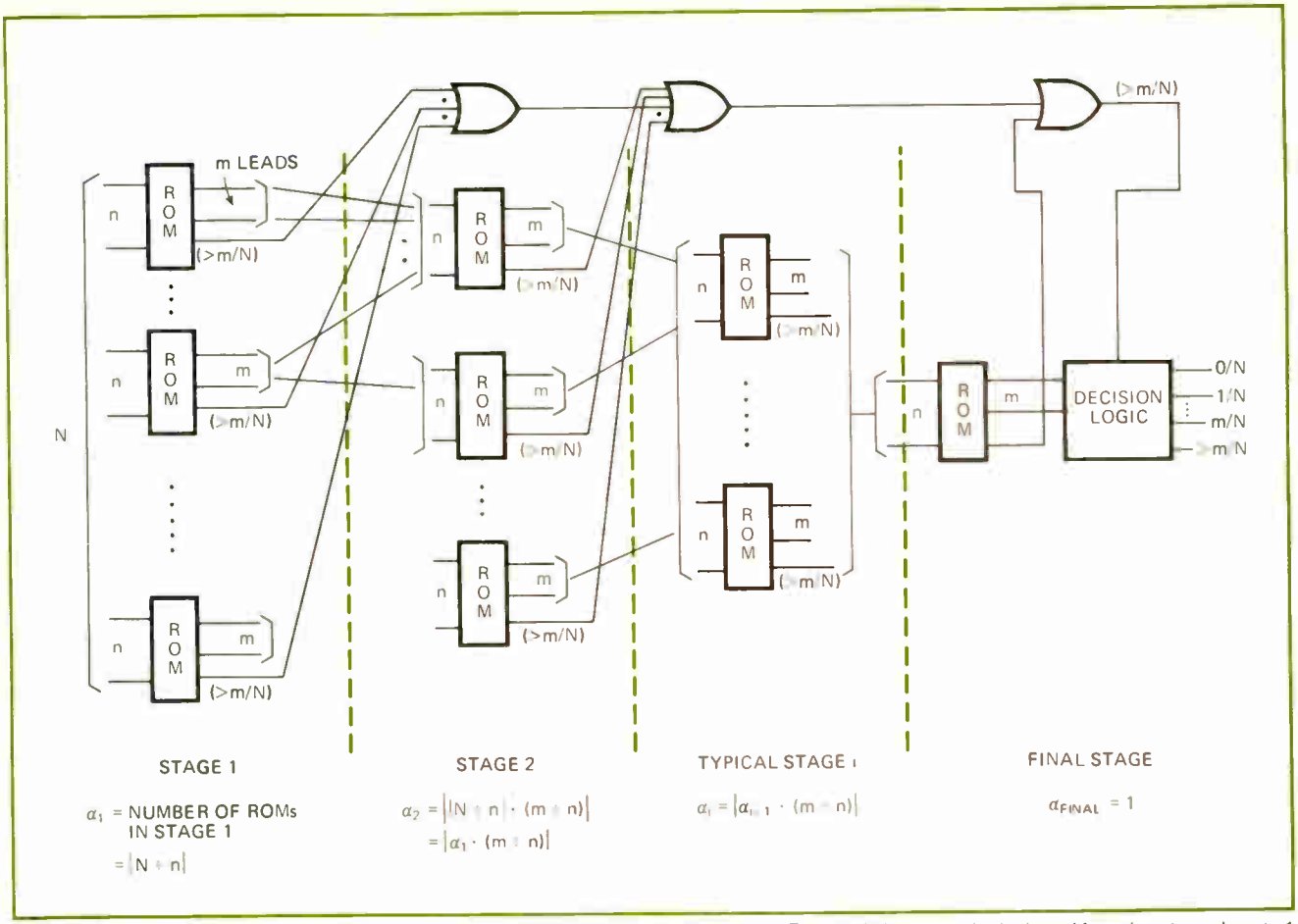
In arranging the ROM truth table in this way, each output lead carries independent information and can be used as an input to any of the memories in the following stage. Notice that, for this modular scheme, m must always be less than n.

The size of the ROM depends on the values of m and n. The total storage required is $2^n(m+1)$ bits, broken down as follows:

**IC REQUIREMENTS AND RESPONSE TIMES FOR 1/N DETECTOR**

| N | Decoding gates $T_r$ (ns)* | Decoding gates IC Packs** | Shift-register counter $T_r$ (ns)* | Shift-register counter IC Packs** | Read-only memory $T_r$ (ns)* | Read-only memory IC Packs** |
|---|---|---|---|---|---|---|
| 10 | 0.10 | 11 | 0.5 | 2 | 0.1 | 4 |
| 50 | 0.10 | 255 | 2.5 | 6 | 0.1 | 10 |
| 80 | 0.10 | 648 | 4.0 | 9 | 0.15 | 16 |
| 800 | 0.10 | 64,080 | 40 | 81 | 0.2 | 130 |
| 5,000 | 0.10 | 2,500,500 | 250 | 501 | 0.3 | 808 |

* A response time of 50 ns per level of logic or shift pulse is assumed.
** Assumes a 10-input AND gate, 10-input OR gate, 10-bit shift register, or a single counter for each IC package.




**3. Flexible.** The general m-out-of-N detector is built with ROMs that are all identical. Each building block is designed for n inputs and m + 1 output leads. Simple decoding logic, which derives the desired outputs, follows the final read-only-memory stag

## Applications

The concept of checking for m conditions on N parallel lines is useful for a number of applications. One specific installation at Automatic Electric Co. is in a data multiplexing system where 90 terminals are time-division multiplexed onto a single transmission line.

A fault in the control circuitry that multiplexes the data terminals would result in invalid transmissions because more than one terminal is connected at any time. Thus, a 1-out-of-90 detector was designed with ROMs, and with a minimum of hardware, it provides a real-time fault indication.

The communications industry also requires m-out-of-N detectors routinely for other applications. To transmit each digit through standard tone-keyed format, for example, one tone from each of two sets of 4 tones is combined to address the central office; thus, two 1-out-of-4 detectors are required at the central office to locate faulty dialers.

Likewise, signaling between central switching offices is often effected by tone sets that can be checked for errors with a 2-out-of-6 detector.

For the general computing industry, the 2-out-of-5 decimal code (where five binary digits represent values of 0, 1, 2, 4 and 7) is commonly used when simple transmission-error checking is to be implemented. In these and many other applications in the expanding computer and communications fields, m-out-of-N detectors are sure to find greater usage.

- 1 address corresponds to all 0s at the input
- $\binom{n}{1}$ addresses correspond to a single 1 at the input
- $\binom{n}{2}$ addresses correspond to two 1s at the input
- ⋮
- $\binom{n}{m}$ addresses correspond to m 1s at the input
- $\sum_{i=1}^{n} \binom{n}{i}$ addresses correspond to greater-than-m 1s at the input.

The first stage of the m/N detector divides the N input leads into groups of n. The intermediate outputs up to m/n are necessary, since usually more than one stage is involved in the checking process, and it is essential to know exactly how many input 1s have been detected. The greater-than-m-out-of-n leads are simply ORed together, since any such output, no matter where it is generated, makes the input fail the m/N check.

Each successive stage uses the m outputs from the preceding stages as inputs and further concentrates the detecting process by a factor of m/n. The concentration process continues until the final stage when only one ROM is reached.

The outputs of the final stage then feed simple decoding gates to derive the desired information—usually m/N or 0/N. However, all intermediate values—from 1/N through (m–1)/N are available if the correct decoding logic is provided. □

# Two-level capacitor boosts MOS memory performance

Capacitor with two capacitance levels, above and below a MOS circuit's threshold voltage, is easy to build with silicon-gate technology; it can bootstrap logic swings and could help realize the single-transistor cell

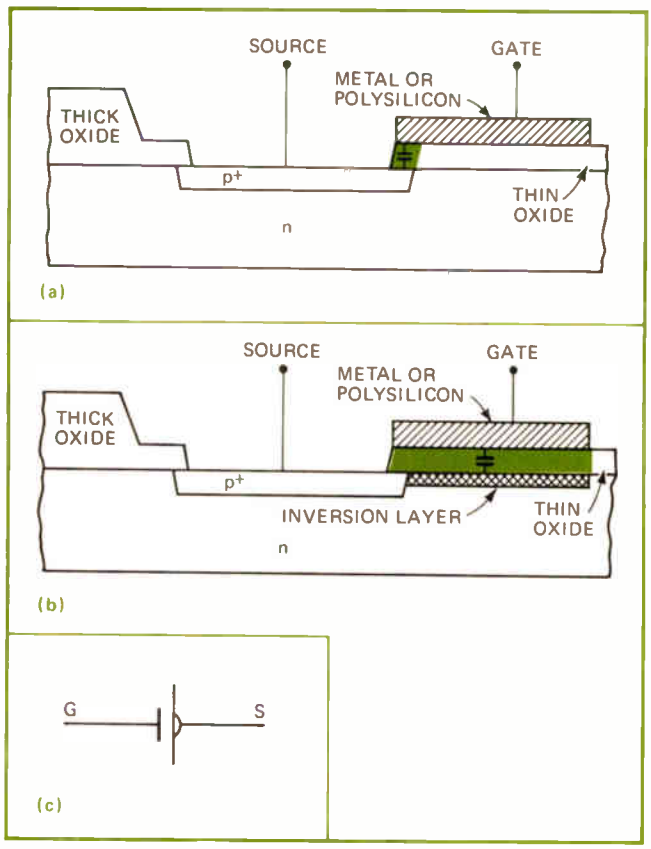
by Luciano Talamonti, *SGS-ATES, Milan, Italy*

☐ The best days of metal-oxide-semiconductor memories are yet to come, now that a new type of high-value capacitor has been developed for MOS ICs. The component, which is like a gated diode in configuration, is called a binary capacitor (Bicap) because it has two distinctly different values of capacitance above and below the operating threshold voltage of the circuit.

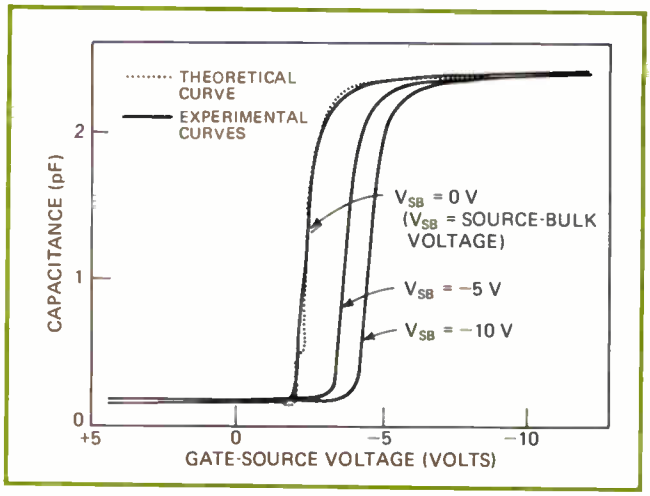
Storing charge in a memory with Bicaps in place of conventional MOS capacitors will greatly enhance the logic output voltages. As a result, it will be possible to use cheaper and less sensitive circuits to sense logic swings. Moreover, Bicap memories can be operated faster because the response time of a MOS memory cell is directly proportional to the voltage stored on the capacitor (RC time constant). Equally significant is the fact that binary capacitors can be built with either the standard metal-gate MOS process or a self-aligned process such as the silicon-gate technology. It is usually difficult and expensive to create a standard high-value gate capacitor between a polysilicon gate and the p+ region beneath it.

In existing memory designs, the immediate usefulness of the Bicap will lie in bootstrapping logic swings—enlarging them so that the circuits become faster. More important, however, is the prospect of a workable, single-transistor memory cell, pointing to memories with 4,000 to 8,000 bits on a chip.

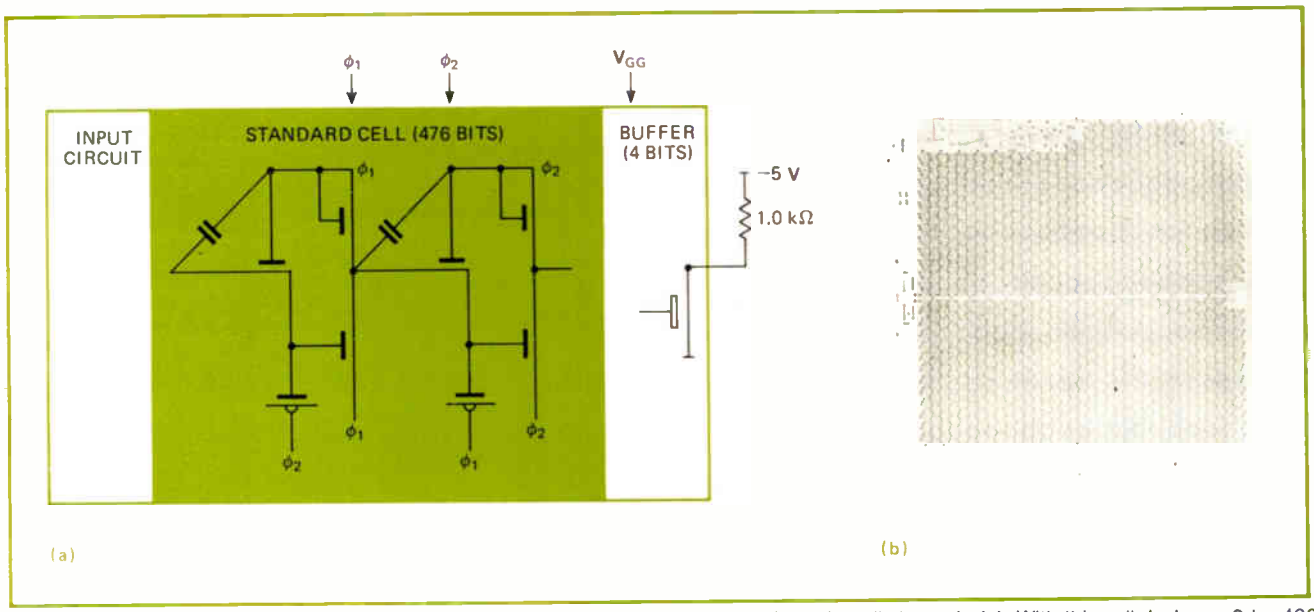
The key to the design of a good single-transistor cell, till now an interesting but elusive concept, is the ability to build a large-value integrated capacitance in a small area. In such a cell, all of the stored charge must be confined to one external capacitor, instead of spread out




**1. The Bicap.** Binary capacitor is made by partly overlapping the metal or polysilicon gate with the p+ diffusion. Below threshold (a), no inversion region exists under the gate, and the capacitance is small. Above threshold, a high-capacitance inversion layer is formed under the gate that communicates with the p+ region, forming a large-value capacitor between source and gate. Since only a gate and source electrode are used, the Bicap component is in effect an MOS transistor without a drain, symbolized in (c)




**2. It's nonlinear.** These theoretical and experimental curves of capacitance characteristics show the nonlinear nature of the Bicap device. Data for three values of substrate bias (source-to-bulk voltage) are given. Below threshold Bicap has a capacitance of less than 0.2 pF. Above threshold (say about 2 volts) Bicap shows a sharp increase in capacitance, about 2.5 pF. Threshold is determined by the source-to-bulk voltage. Note that Bicap is already saturated at−5-V levels and is therefore TTL-compatible.




**3. Logic boosts.** In a shift-register circuit, bootstrapping increases logic-one levels, as in cell shown in (a). With this cell design, a 2-by-480 dynamic shift register (b) has been built with an active area of only 133 by 133 mils. An operation frequency of 20 MHz can be predicted.

## The beginnings of Bicap

Though silicon-gate technology has from the beginning had certain obvious advantages over other standard processes, its usefulness has been limited by the impossibility of realizing capacitive coupling of the type that occurs between p+ material and thin silicon oxide. Circuits nearly always require capacitors, especially to achieve bootstrapping. But in such self-aligned processes as silicon-gate, a p+ region cannot in fact be placed under the gate electrode, since it is the gate electrode itself which fixes the boundaries of p+ regions.

Work on this problem was begun at the Agrate Laboratory in late 1970. Once the solution was found in the Bicap, moreover, the device's special characteristics proved applicable to quite other uses. For instance, the Bicap can be made with any process, self-aligned or not. Also, its high capacitance region allows it to replace ordinary capacitors wherever they are used. Finally, its transition region makes it suitable for such novel applications as large-scale integrated MOS logic chips.

among three or four transistors as in conventional cell designs; yet for measurable logic swings the single capacitor must be large because of losses on the bus lines. That requirement appears well satisfied by the high capacitance and small size of the Bicap component.

### What's in a Bicap?

In p-channel MOS technology, the Bicap starts with a $p^+$ region, the edge of which is overlapped by thin oxide topped by a metal gate. (For silicon-gate technology, a polysilicon gate is used.) When the gate voltage is lower than the threshold voltage (with body effect taken into account), the capacitance between the gate and the source is governed only by the small overlap of the metal on the $p^+$ region. This capacitance is very low. When the gate voltage is higher than the threshold voltage, an inversion layer is formed beneath the thin oxide (Fig. 1b). Highly capacitive with respect to the gate, this layer in effect extends the $p^+$ region. Now a highly capacitive path exists between source and gate. This is the high-capacitance mode of the Bicap.

Only gate and source electrodes are utilized. The Bicap therefore amounts to an MOS transistor without drain; its symbol is shown in Fig. 1c.

It should be noted that the Bicap's capacitance is highly nonlinear. At the threshold voltage it switches from a very low value of about 0.2 picofarads, involving only the small metal-$p^+$ overlap, to a high value of 2 to 3 pF, involving the entire gate area. This nonlinearity is crucial to the behavior of Bicap in circuit applications. Since it presents two values completely independent of each other, the Bicap allows an increase of the logic 1 level without disturbing the logic 0 level.

The nonlinear nature of the Bicap capacitor is illustrated in Fig. 2. Here the theoretical and measured values of capacitance as a function of gate-source voltage are shown for a silicon-gate Bicap with a 4-by-4-mil area. Below threshold the capacitance is about 0.2 pF, above threshold about 2.5 pF. Capacitance values are shown for two operating voltages: $V_{SB} = -5$ volts and $V_{SB} = -10$ v. Significantly, because saturation occurs at just over −5 volts, very little is gained by going to higher drive voltages. Thus the Bicap's efficiency is as good at TTL's 5-v level as at the 10-v MOS levels. Of course, the theory applies equally to n-channel technology.

### Bootstrapping

One immediate application of the Bicap structure is to bootstrapping—producing an extra voltage for a gate, boosting it to levels which may be higher than the supply voltage itself. Usually this is done by inserting a capacitor between gate and source, and so establishing positive feedback between the two points. When the nonlinear Bicap replaces the conventional capacitor, it is possible to operate the circuit at a higher speed. And as far as output buffers or internal clock generators are

**4. Good forms.** Typical output waveforms of a memory cell containing a Bicap show its high speed. In (a), the output waveform of the 2-by-480-bit register at 6 MHz closely resembles the input. In (b), an experimental 8-bit register is being driven to above 11 MHz. Blowing up this trace (c) shows a pulse width of less than 20 ns, indicating a theoretical phase repetition frequency above 20 MHz.

concerned, bootstrapping with the Bicap makes it possible to raise voltage levels up to the supply voltage.

To prove the viability of this technique, an experimental p-channel shift register with a Bicap bootstrap cell has been built and operated at high frequencies. The cell, diagramed in Fig. 3a, consists of six transistors, two capacitors, and two Bicaps. Two-by-480 of these cells make up the dynamic shift register, a photomicrograph of which appears in Fig. 3b. The low-voltage Planox process was used to build the circuit.

Since the introduction of the Bicap in the memory requires no extra contact, the extra area required is very small. The cell measures 133 by 131 mils, well within the cell size of conventional 1,024-bit registers. The speed characteristics of the circuit are excellent as well. Figure 4a shows the typical output waveform at a frequency of about 6.0 megahertz (most MOS shift registers of this capacity operate at less than 5 MHz).

### How fast can it get?

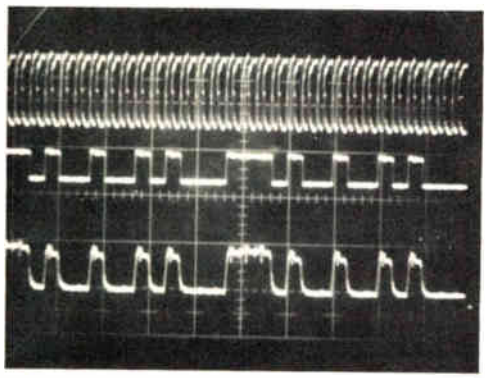
Six megahertz is not the upper limit of cell frequency, although it is rather difficult to drive this shift register correctly at higher frequencies because of the high value of the phase capacitance. To evaluate the maximum repetition frequency of the cell, therefore, a small eight-bit shift register was constructed. At about 12 MHz the output buffer began to fail—but not the memory cell. Figure 4b gives the output waveform at a repetition frequency of approximately 11.0 MHz.

When the waveforms are studied in detail (Fig. 4c), the minimum pulse width is seen to be less than 20 nanoseconds. With proper high-speed buffers, this implies a theoretical phase repetition frequency higher than 20 MHz. It should be remembered that this high frequency is from a p-channel device. When Bicap is applied to n-channel devices, still faster operation will surely result.

Following these results, a new two-phase cell is being developed. It has two capacitors, two Bicaps, and only four transistors. As a result, its area is very small, and the maximum repetition frequency is not very different from that of the cell in Fig. 3a. The main characteristic of this cell, apart from smaller area, is the lower value of phase capacitances. This makes it far easier to drive, especially when internally generated clocks must be used.

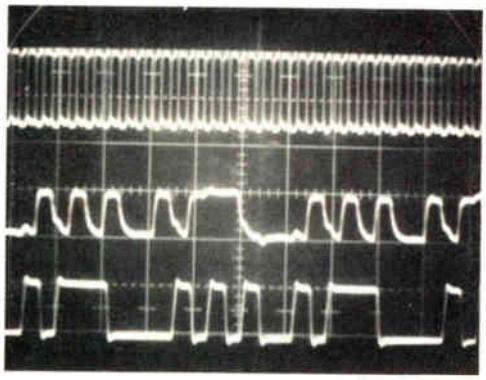
Other applications that will exploit the Bicap's unique nonlinear characteristics include the single-transistor cell for random-access memories and a self-refreshing dynamic RAM that requires no external refresh cycle. Work here is attempting to improve speed, increase output levels, and decrease power dissipation.

Also promising are Bicap logic applications, in which the transition region of the capacitance/gate-source-voltage curve of Fig. 2 is used to implement a high-speed logic function. This will be the first real attempt to build useful MOS logic circuits. □



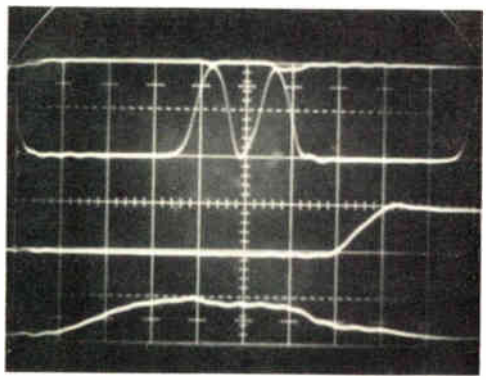
| | |
|---|---|
| CLOCK TRACES (top) : | 10 V/DIV. |
| INPUT TRACE (middle) : | 5 V/DIV. |
| OUTPUT TRACE (bottom) : | 5 V/DIV. |
| TIME SCALE : | 500 ns/DIV. |

(a)



| | |
|---|---|
| CLOCK TRACES (top) : | 10 V/DIV. |
| OUTPUT TRACE (middle) : | 5 V/DIV. |
| INPUT TRACE (bottom) : | 10 V/DIV. |
| TIME SCALE : | 250 ns/DIV. |

(b)



| | |
|---|---|
| CLOCK TRACES (top) : | 10 V/DIV. |
| INPUT TRACE (middle) : | 10 V/DIV. |
| OUTPUT TRACE (bottom) : | 5 V/DIV. |
| TIME SCALE : | 20 ns/DIV. |

(c)

## Measuring small currents with an ordinary voltmeter

by Robert J. Battes
*Quantic Industries, San Carlos, Calif.*

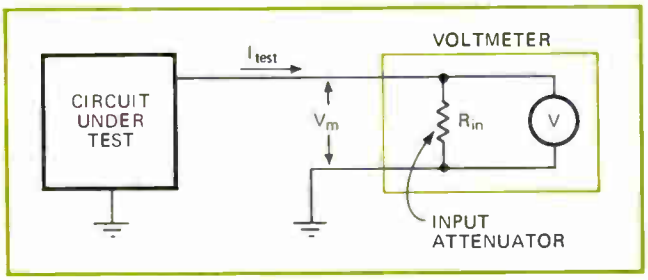
If it is necessary to measure extremely small currents only occasionally, the expense of a specialized instrument like an electrometer probably can't be justified economically. However, even semiconductor leakage currents and the input bias currents of FET-input operational amplifiers—on the order of nanoamperes and picoamperes—can be measured by a standard voltmeter, to within better than 5%. The meter should have a moderately high input impedance (approximately 10 megohms) and a reasonably good sensitivity rating (around 100 to 200 millivolts full scale).

The trick is to use the voltmeter's input attenuator as a calibrated current shunt, as shown in the figure. Then, only a single calculation is necessary to read nanoamperes or picoamperes directly from the voltmeter scale, since:

$$I_{test} = V_m/R_{in}$$

where $I_{test}$ is the current being measured, $V_m$ is the displayed voltage measurement, and $R_{in}$ is the voltmeter's input resistance. The current is measured accurately, because voltmeter input attenuators are usually specified within ±5% of their nominal value.

As an example, assume the voltmeter being used is a standard economy-priced 3½-digit multimeter. The most sensitive multimeter current-measuring range usually found on such an instrument is 2.000 milliamperes full scale, providing a resolution of 0.001 mA, or $10^{-6}$ amperes. The voltmeter section of this type of multimeter usually has a sensitivity of 0.2000 volt full scale and an input impedance of 10 megohms. With the meter connected as shown, each 0.0001 V displayed on the meter will represent a current as small as 10 pA, or $10^{-11}$ A. When the meter is used this way, its current-measuring sensitivity is increased by five orders of magnitude. □




**Applying Ohm's law.** Nanoampere or picoampere currents can be measured accurately with a standard voltmeter by taking advantage of the tight tolerances of input attenuators of today's instruments.

## Three-step shortcut for finding square roots

by James R. Whitmore
*Whitmore Electronics Co., Miami, Fla.*

Although a very useful tool, the popular four-function calculator is intended primarily for home use, and therefore, it cannot directly perform such sophisticated mathematical functions as finding square roots. However, here is a three-step technique that uses only the three functions of addition, subtraction, and division, which are always available on the home calculator, to determine square roots accurately.

Each step involves four mathematical operations, and the number of steps can be increased if greater accuracy is desired. With this technique, an initial approximate answer must be estimated—the closer this first approximation, the fewer steps are needed to compute a square root with at least four significant digits.

An example, in this case finding the square root of 624, will illustrate how to use the method. The approximate answer could be 20, 25, or 30. While the estimate of 30 is not too close to the correct answer, it is still within the range of this three-step technique. Here are the steps for obtaining the square root of 624 when the first approximation is 30:

Step 1:
- 624/30 = 20.8 (divide by 30)
- 20.8 – 30 = –9.2 (subtract 30)
- –9.2/2 = –4.6 (divide by 2)
- –4.6 + 30 = 25.4 (add 30)

Step 2:
- 624/25.4 = 24.566929
- 24.566929 – 25.4 = –0.833071
- –0.833071/2 = –0.4165355
- –0.4165355 + 25.4 = 24.983465

Step 3:
- 624/24.98 = 24.979983
- 24.979983 – 24.98 = –0.000017
- –0.000017/2 = –0.0000085
- –0.0000085 + 24.98 = 24.979992 (answer)

(If the estimate of 25 had been chosen as the first approximation, then only two steps would have been required to reach an accurate final answer.)

For an eight-digit calculator, the last step should contain at least four most significant digits in the divisor (24.98 in the example). If the calculator has a constant register, the answer can be easily verified without losing the data. □

# Using pocket calculators to square numbers directly

by Paul B. Wesling
*Itel Corp. / ISS Division, Cupertino, Calif.*

The inexpensive four-function calculator with the constant register, which is now available for less than $100, can do addition, subtraction, multiplication, and division, as well as chain and mixed calculations. But, with a little know-how, it can be made to take reciprocals [*Electronics*, "Finding reciprocals easily with pocket calculators," Jan. 18, 1973, p. 186] and to square a number or raise a number to some integer power, without clearing or re-entering any of the data.

To square a number, especially a long one, the user usually writes it down, presses the multiply (×) key, re-enters the number, and then presses the add/equal (+/=) key. An easier way is to load the number to be squared into the constant (K) register, then multiply the constant and display registers to get the answer. The steps are:

- Enter the number to be squared
- Press and hold down the K key
- Press and release the × key
- Release the K key

**CALCULATOR OPERATIONS**

| Calculation | Entry Operation | Display Register | K Register | K Operation |
|---|---|---|---|---|
| $n^2$ | Enter number | n | Clear | – |
| | Hold K button [ X | n | n | Multiply |
| | +/= | $n^2$ | Clear | – |
| $n^3$ | Enter number | n | Clear | – |
| | Hold K button [ X | n | n | Multiply |
| | +/= | $n^2$ | n | Multiply |
| | +/= | $n^3$ | Clear | – |

- Press and release the +/=

The square of the original number is now in the display register and can be used for additional computations.

To cube a number, hold the constant key down through both the multiply and add/equal operations, then release the constant key and press the add/equal once more. Again, the answer is in the display register. Any integer power of any number can be calculated by simply extending this method.

The table summarizes the operations required for squaring and cubing. □

Engineer's notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.

# Adding numeric readout to logic probe displays

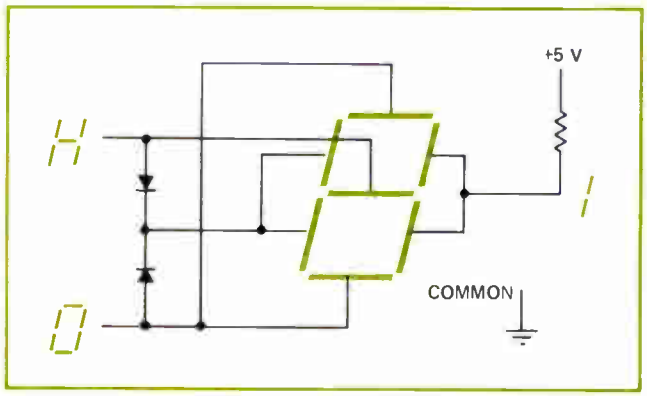
by Kai Lanz
*Stanford University, Stanford, Calif.*

Not too long ago, logic probes were little more than a light bulb, plus the necessary driver circuitry. Nowadays, however, they are more likely to consist of three light-emitting diodes, indicating the three possible logic states—logic 1, logic 0, and high impedance. And with three flashing displays crowded into the narrow probe body, it is not uncommon to have to pause and check which legend is actually illuminated. A simple way to build a compact probe readout that is unambiguous and easy to decipher is to substitute a solid-state numeric readout for the three discrete LEDs.

The figure shows a seven-segment readout connected to display 0, 1, and H (for high impedance). The two right-hand segments are on at all times since they are tied directly to the 5-volt supply. A pair of diodes serves as a simple decoding network to prevent undesired segments from lighting. Any good general-purpose silicon diodes should be adequate, but devices having a low forward voltage drop will help to equalize segment brightness.

The cost of building a logic probe this way is less than the cost of building one with three discrete LEDs. With the numeric readout connected as shown, the sense and drive circuitry for displaying a logic 1 can be eliminated because the 1 is always lit.

The readout's power requirement averages about 10 milliamperes per segment. Miniature readouts, such as Monsanto's MAN-3A, are slim enough to mount without difficulty in the end of the probe body, where they will be readily visible. □




**Deluxe display.** Solid-state numeric readout shows three possible logic states—1, 0, or H (high impedance)—for logic-probe display. Since the two right-hand segments are always illuminated, only two standard diodes are needed for decoding. The sense and drive circuitry for displaying a logic 1 can then be eliminated.

# Engineer's newsletter

**Take a signal's complement for a free logic 1**

Designers buying the new displays that have built-in decoders are delighted with the saving in board space that's the result of not needing a separate decoding package. **Still more space could be saved by making double use of the decoding logic that's needed to interface the display.** For example, using a simple inverter or gate to take the complement of the blanking signal **often produces a useful function—such as a logic 1**—and it comes practically for free. In a DPM display this logic 1 is then available to get a half digit, say, or the inverted signal could act as a control pulse to sync the display to other parts of the system.

**Test DACs the easy way**

Testing digital-to-analog converters has generally meant building your own special test setup each time. —But no more. Sitek Inc., 1078 W. Evelyn Ave., Sunnyvale, Calif. 94086, has an automatic bench-top DAC **tester that can evaluate the accuracy of any modular or monolithic converter.** The tester, which compares the accuracy of your DAC with a reference device, can accommodate converters of up to 12 bits in all standard packages. It's fast, too—**it tests a typical 10-bit device in four seconds flat.**

**Bit count of core mats quadruples**

Still want to use cores in your minis? Some minicomputer manufacturers are planning to build machines this year with **core mats of 8,000 and 16,000 bits.** Previously, core mats larger than 4,000 bits were considered impractical because the sense line mismatch became formidable with planes of this complexity.

**Get flexible with expandable C-MOS**

Logic designers can get more flexibility out of circuits by being smart about the new expandable-type C-MOS circuits. For example, Solid State Scientific's 4402A dual four-input expandable NOR **will give you direct TTL outputs as well as the NOR function.** Connect the n-channel output of the device to an external pull-up resistor. Since the n-channel transistor current capability is typically 3 milliamperes with a 10-volt gate drive, **a TTL fanout of two can be accommodated.** If the p-channel transistor output is used with the same pull-down resistor, the device acts as a positive-to-negative level shifter. In either case, the pull-resistor could be connected to a negative supply of up to -30 V.

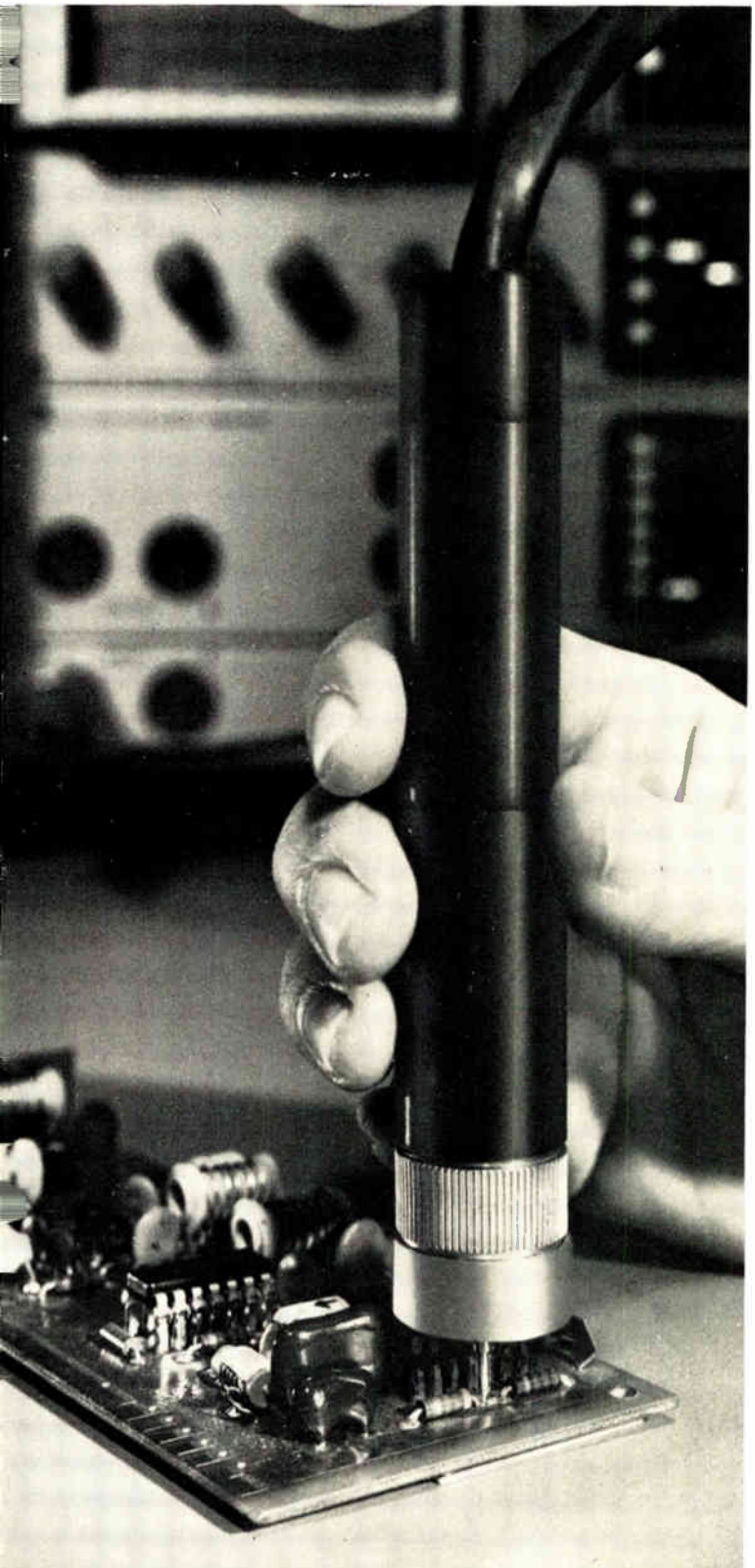
**Glossary explains new terms**

**Stumbling over some of the new jargon** that's piling up around the electronics industries? A handy glossary of electronic terms, costing $1.50 from Henry Lavin Associates, P.O. Box 921, Meriden, Conn. 06450, will straighten you out. It'll teach you, for example, **what a KISS means to a programer.** An acronym for keep it simple, stupid, KISS refers to a method for reducing the complexity of information that's to be fed into a computer.

**P-i-n point**

Many microwave designers are finding that **the best way to get a low-loss resistance (up to 50 kilohms) at high radio frequencies** is to use a p-i-n diode—it appears as an almost pure resistance in the rf range.

# Complete RF Network Analysis — IMPEDANCE



**NEED** to make high-frequency measurements of dielectric materials? To determine transistor $Y_{22}$ parameters? To match a network to nearly any impedance over a broad frequency range?

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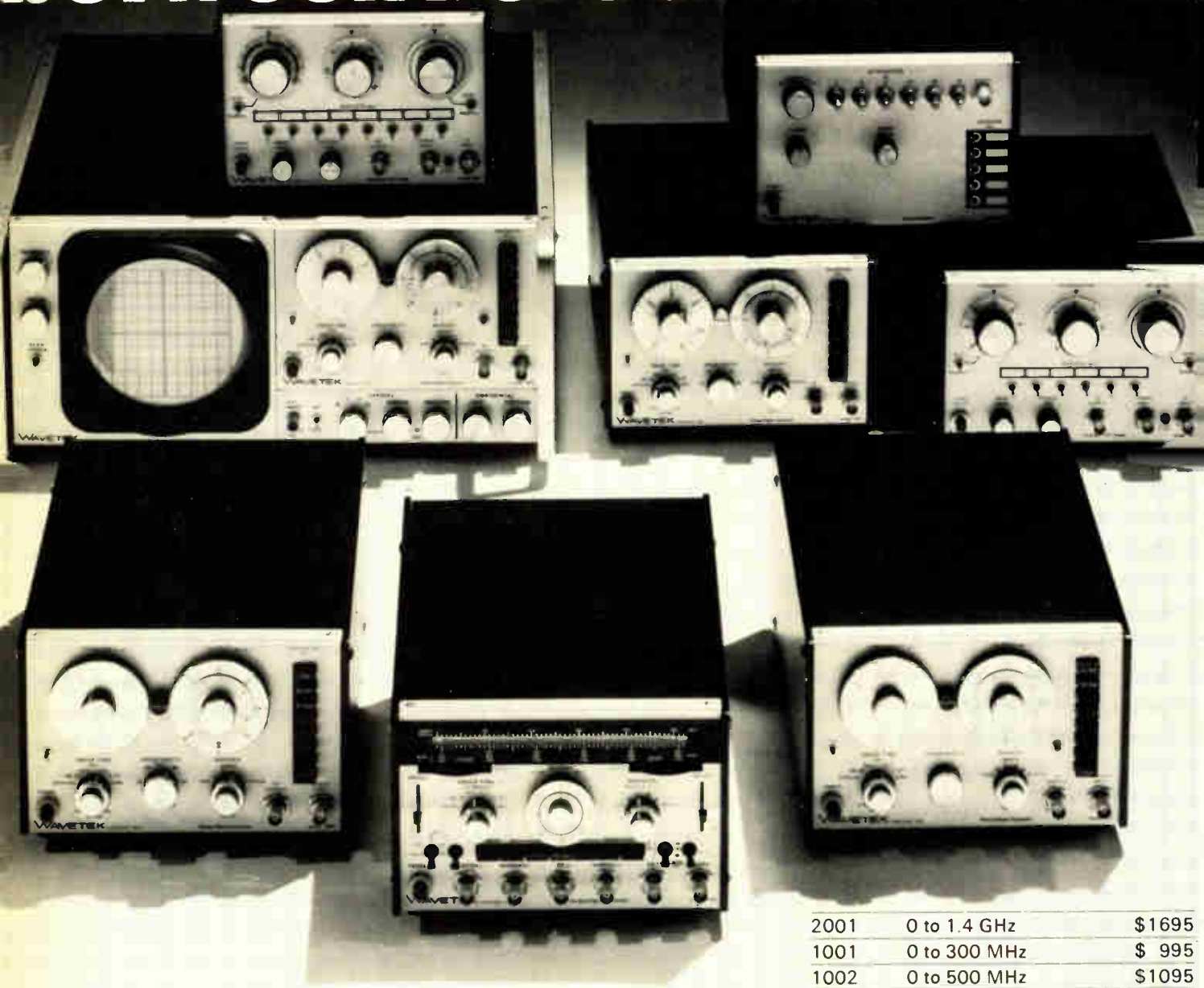

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# Inter-bus modules fashion mini arrays

## User of PDP-11 can build his own multiprocessors, networks, and computer hierarchies; unified bus architecture is the key

*by James Brinton, Boston bureau manager*

**Spokesmen** for the Digital Equipment Corp. say that DEC's introduction of three bus-interconnection modules for its PDP-11 computers could be that firm's most important move of 1973. For the first time, a major computer maker is offering its customers the capability to construct multiprocessor arrays, computer hierarchies, and networks—and all with minimal need for manufacturer support.

With this approach, a user can start out with a single processor system and add processing power as needed. Users with high-reliability applications now can easily construct redundant processor systems. Others with costly peripherals can profit from DEC's modules. With the lower cost of integrated circuitry, central processors have become one of the least costly parts of any computer system—computer power is inexpensive, compared to peripheral and interfacing equipment.

**Thrifty.** But as yet, "men specifying systems don't tend to think of multiprocessors as money-savers," says a DEC engineer. "We figure that a third or more of the tasks now reserved for medium-scale machines could be performed more economically with multiprocessor minicomputers, and now we are giving users the tools needed to put them together without the cost penalties associated with custom-multiprocessor installations."

The new tools are made possible by the PDP-11's unified bus architecture. The so called Unibus scheme is democratic in the sense that every part of the computer can be addressed as if it were a location in memory. This approach can now make possible complex gross architectures as DEC's new interconnecting modules address other buses and devices on them as if they were at addresses on the host computer's buses.

**A trio.** DEC is offering three types of interconnection modules—the switch (DT-03), the link (DA-11-B), and the window (DA-11-F). The switch, the simplest of the three, is expected to sell into applications where computer reliability is at a premium. A typical installation might consist of a 100% redundant processor system expected to run an industrial process with a minimum of downtime. One processor would be in operation with the other on standby. Should the running computer fail, the switch would place the other computer on line either manually or automatically. Switching time is less than 1 microsecond, and during that time, the two computers' buses are synchronized.

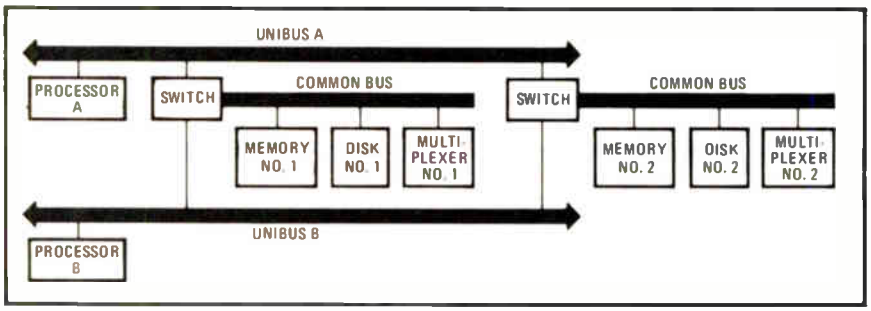
In shared peripheral applications, the switch's latency time becomes an important specification; in this case, bus cycles that pass through the switch are lengthened by 450 nanoseconds. The switch is all-solid-state, not only for speed, but also to maintain the impedance characteristics of the extended bus structure. In its various uses, the switch can be more than merely a single-throw, double-pole device; switches can be arranged to form matrixes that allow communication among several bus structures. The constraints are the imagination of the user and a 100-foot limit on the length of any combination of buses.

**On guard.** The switch includes a so-called watchdog timer, which allows a back-up computer to take peripheral control away from a failed processor—one that doesn't respond to a request signal within 10 milliseconds.

Power-isolation circuitry is also included in the switch to prevent its loading down a mainframe power supply and also to remove its dependence on mainframe power. Obviously, in a high-reliability application, the switch must not depend on power from a computer that might fail, nor can such an application allow failed peripheral equipment to drain off mainframe power. Failed peripherals also are disconnected automatically.

**Linking up.** Where a system demands greater interaction between connected computers, the link is the

**Reliability.** One PDP-11 interconnection module—the DT-03 switch—makes possible a dual redundant system complete with peripherals and memories as well as processors.



## New products

choice. This is a parallel transfer channel between computer buses 16 bits wide and capable of operation at memory speeds. Two or more computers can talk to one another via their memories and the half-duplex transmission capability provided by the link, which effectively offers shared access to memory.

The link can transmit blocks of data up to 32,000 words long at up to 8 megabits per second. Each computer processor programs its end of the link; to transmit, it sends to the link an interrupt signal, a status header, control word, and an answer request. Communications protocols are justified at the link, and system balancing is a matter of presetting the appropriate transfer rate. The CPUs don't need to waste computer power on this.

The link might find itself, for example in laboratory instrumentation dual-processor systems. The foreground and background tasks of data acquisition and data analysis would be divided between the two processors, each of which is dedicated. The foreground CPU would occupy itself with acquisition while the background machine would be processing the acquired information. Both phases would be closely coordinated, but with software interaction at a minimum.

**Networking.** DEC spokesmen expect the link to be used in combination with the company's communications equipment to construct networks of computers. "In the past, an EDP designer would look at the total amount of work to be done in an organization, then pick a machine large enough to take it all on," says an engineer. "Now, distributed nets of smaller computers often will cost less than single larger machines and would also simplify programing. Just as there would be nodes of computer power, there would be specific programs for each node and very little need to consider software interaction as it would occur in a single large mainframe."

But it is through the bus window that DEC expects to compete most directly with large computers. The window makes the bus of a connected computer appear like an extension of its own to a host processor, and because it operates synchronously with bus cycles, the window's actions appear instantaneous to the host processor.

Unlike the link, the window is full-duplex and allows simultaneous multiple-CPU operations with fewer interrupts than the link. At its input port, the window looks like a memory, and at its output it looks like a direct-memory-access channel. Memory may be dynamically shared or not, in real-time under programed control of the memory's host processor. A host CPU can be programed to allow no access, partial access, or read-only or read-write access to its memory. Once this is done, the window makes the proper connections between bus and memory locations, and future memory requests are handled on a completely transparent basis—hence the term "window." And since all peripherals have memory-like addresses, full peripheral sharing comes along as a matter of course.

**Mixable.** And there is no rule against mix and match. The switch, link, and window could appear in the same complex system. Also, because each member of the PDP-11 family is program- and hardware-compatible, users can mix slower machines with faster ones.

A large-scale data-acquisition and handling system might use four processors. At the first level, a processor would interact with a process or experiment through sensors and analog-to-digital converters. After some quick preprocessing, the data would be passed on—perhaps by a link system—to two other machines, which would split the analysis and reduction tasks. These two machines might be linked together themselves, or use a window, depending on the desired throughput. A final processor, probably on a link, would handle files and input-output control. And such a multiprocessor array might be only one node in a larger network.

The switch is priced at $8,400, the link at $3,500, and the window at $5,950.

Digital Equipment Corp., 146 Main St., Maynard, Mass. 01754 [338]

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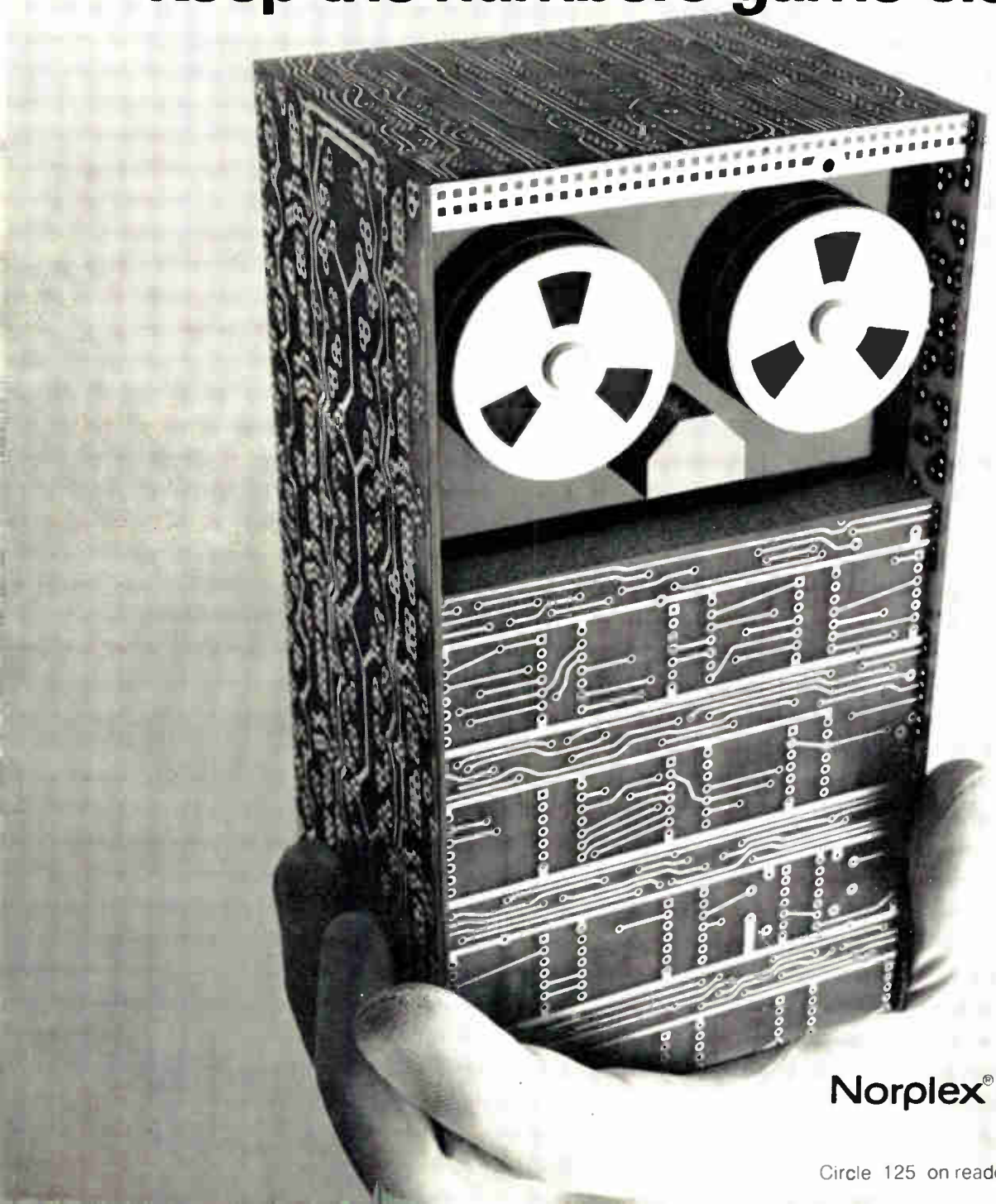

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# Amplifier built to cover all bases

Speedy sample-and-hold unit is designed for a variety of data handling tasks

In the new sample-and-hold amplifier from Teledyne-Philbrick, a promise of fast performance is to be expected. What's unexpected is the improved and more thorough specifications. Often, users buy seemingly good sample-and-hold devices, only to find them faulty in some key aspect. T-P spokesmen say this usually results from insufficient or misunderstood specifications, and with its new 4853 the company is trying to cover all the bases, whether the device is to be used in data acquisition, analog-to-digital or digital-to-analog conversion systems, pulse stretchers, process control, or "deglitching" circuits.

The 4853's usual specifications are respectable. Acquisition time is 1 microsecond to ±0.01% for a 10-volt input step signal. Its bandwidth can extend to 20 kilohertz within ±0.01%. Settling-time to 0.01% is 1.4 μs for a 20-V input, and 1 μs for a 10-V step. The network slews at 30 V/μs, and accuracy is nominally to within −0, +0.05%, with linearity to within 0.005%.

But other specifications often are missing, or misapplied. Examples are aperture-time uncertainty and feedthrough.

The 4853's aperture time can be 0 to 10 nanoseconds. Aperture time uncertainty—the time variation between a hold command and its actuation—is ±1 ns. When combined with an application's required accuracy, uncertainty time can give the useful bandwidth of a sample-and-hold amplifier and the ultimate magnitude of any output error—factors an engineer often needs, but sometimes may not have, for choosing the right device.

And according to T-P spokesmen, the importance of feedthrough, if not misunderstood, is often underestimated. T-P designed it as the effect of an input signal on the output signal when the amplifier is in the hold mode. Normally this varies with input level and frequency, but T-P uses a proprietary circuit to cut feedthrough to 1 millivolt at most, regardless of frequency and at inputs of up to 10 V. Not only does low feedthrough improve accuracy, but it also allows higher throughput. Multiplexing can continue during analog-to-digital conversion—there is no need to synchronize conversion to sampling time.

Small quantities of the 4853 are available within two weeks at $125 each. Lots of 100 or more are priced at $99.50 each.

Teledyne-Philbrick, Allied Dr. at Rte. 128, Dedham, Mass. 02026 [381]

## Oscillators tunable over three decades

Three new tunable quadrature-output sine-wave oscillators are finding ready application in testers, demodulation filters, synchros and servos, resolvers, and other equipment, in addition to the usual fixed or swept-output applications. The modules, which measure 2 by 3 inches, can be tuned over three decades. Made by Frequency Devices Inc. of Haverhill, Mass., the model 444 is tunable from 20 kilohertz to 20 Hz, the 442 from 500 Hz to 0.5 Hz, and the 440 from 50 Hz to 0.5 Hz.

The quadrature outputs from each of the modules are kept in phase to within 0.1° over its full frequency range, accounting in part for their acceptance in synchro/servo applications. Distortion is low, with 0.27% total harmonic distortion at the sine output and 0.087% at the cosine output. Spurious response is 85 decibels below 10 volts peak-to-peak output, and output, which is adjustable over a peak-to-peak range of 2 – 20 V, can be either controlled resistively or by voltage. Amplitude/temperature drift is only 0.0008 dB/°C.

With addition of associated electronics, the devices become part of systems to test harmonic or intermodulation distortion in audio equipment, modulator/demodulator pairs, transmitters and receivers, and even spectrum analyzers. Frequency synthesizers normally trade their frequency accuracy for distortion figures in the order of 1%. Few available commercial testers have distortion below 0.1%, and these usually include precision RC oscillators that are costlier than the frequency technology modules.

Prices for the 440 and 444 range from $113 each in single quantities to $66 each in lots larger than 100; the 442 costs $99 and $56.

Frequency Devices Inc., a subsidiary of Frequency Technology Inc., 25 Locust St., Haverhill, Mass. 01830 [382]

## Supply delivers 250 watts in 10-pound package

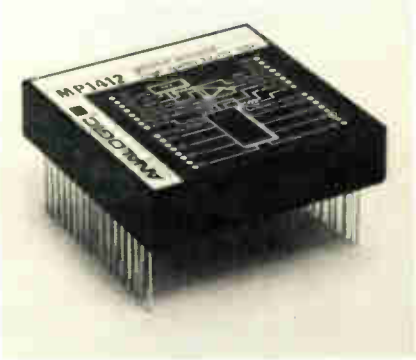
High power levels in space-restricted systems are provided by the 662 series of power supplies, which deliver 250 watts. Model 662A05 delivers 5 volts at 50 amperes over the range of −20°C to +40°C with no moving air required. Efficiency is reported to be 70%, and combined line and load regulation is ±0.2%. Model 662 accepts either 102–130 V ac or 198–256 V ac input with no circuitry changes required. Output noise and ripple are only 50 mV peak-to-peak measured differentially. The 662A05 weighs approximately 10 pounds.

Trio Laboratories Inc., 80 Dupont St., Plainview, L.I., N.Y. 11803 [384]

## Low-priced digital-analog converter resolves 12 bits

Designed for such large-quantity applications as data-distribution, process-control, and instrumentation systems, a 12-bit modular digital-to-analog converter provides typical settling times (to within ½ the least-significant bit) of 5 microseconds, linearity to within 0.012%, and a typical temperature coeffi-

cient of 15 ppm/°C. The units are priced at $39 each in quantities of 100. They make extensive use of medium-scale integration to keep the parts count down to 27 components, with a resulting mean-time-between-failure reported by the company as 500,000 hours. The MP1412 is self-contained, with an

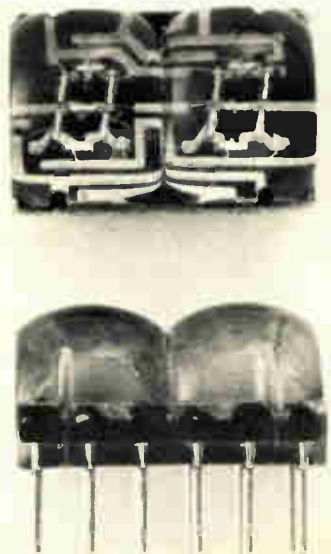



internal precision reference supply, ladder network and output amplifier. Full-scale analog outputs of −10 to +10 volts, 0 to +10 V, −5 to +5 V, and 0 to +5 V are pin-selectable to match nearly all DAC applications. The MP1412 accepts standard TTL-logic-level inputs and can be interfaced directly with computers.

Analogic, Audubon Rd., Wakefield, Mass. 01880 [383]

### Two-digit LED module built for multiplex jobs

A two-digit LED module with 0.19-inch characters is designed to add economy to multiplex-drive applications. The DL-44 is designed for use where displays have multiple



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|---|---|---|---|---|---|---|---|
| **Package size I: 3 5/16 x 3 7/8 x 6 1/2** | | | | | | | |
| PTM-12-1D | 11<br>11 | 13<br>13 | 1.0<br>1.0 | 0.9<br>0.9 | 0.7<br>0.7 | 0.4<br>0.4 | $130 |
| PTM-15-.8D | 14<br>14 | 16<br>16 | 0.8<br>0.8 | 0.72<br>0.72 | 0.56<br>0.56 | 0.32<br>0.32 | $125 |
| PTM-5/12D1 | 4.75<br>11 | 5.5<br>13 | 2.0<br>0.5 | 1.8<br>0.45 | 1.4<br>0.35 | 0.8<br>0.2 | $135 |
| **Package size II: 3 5/16 x 5 1/8 x 6 1/2** | | | | | | | |
| PTM-12-1.6D | 11<br>11 | 13<br>13 | 1.6<br>1.6 | 1.44<br>1.44 | 1.12<br>1.12 | 0.64<br>0.64 | $155 |
| PTM-15-1.5D | 14<br>14 | 16<br>16 | 1.5<br>1.5 | 1.35<br>1.35 | 1.05<br>1.05 | 0.6<br>0.6 | $150 |
| PTM-5/12DII | 4.75<br>11 | 5.5<br>13 | 3.5<br>1.0 | 3.15<br>0.9 | 2.45<br>0.7 | 1.4<br>0.4 | $160 |
| **Package size III: 3 5/16 x 5 1/8 x 9 1/2** | | | | | | | |
| PTM-12-3D | 11<br>11 | 13<br>13 | 3.0<br>3.0 | 2.7<br>2.7 | 2.1<br>2.1 | 1.2<br>1.2 | $180 |
| PTM-15-2.8D | 14<br>14 | 16<br>16 | 2.8<br>2.8 | 2.52<br>2.52 | 1.96<br>1.96 | 1.12<br>1.12 | $175 |
| PTM-5/12DIII | 4.75<br>11 | 5.5<br>13 | 6.0<br>1.5 | 5.4<br>1.35 | 4.2<br>1.05 | 2.4<br>0.6 | $185 |

*U.S.A. list.

## New products

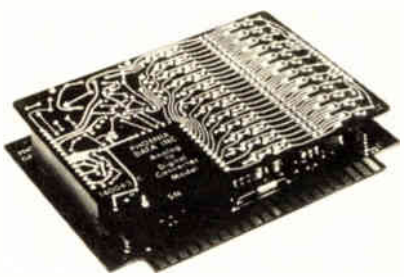
minimum of ±20 milliamperes at ±20 v. The unit also has a 25-nanoampere bias current, 1-megahertz bandwidth, 6-v/microsecond slew rate, and 86-db minimum common-mode rejection ratio. Housed in a low-profile module, the 1034 is


priced a $30 each in lots of 100. For critical applications, the model 103401, which offers ±5 μv/°C maximum offset voltage drift, is priced at $37 each in quantities of 100.

Teledyne Philbrick, Allied Drive at Route 128, Dedham, Mass. 02026 [387]

### A-d converters offer conversion time to 2 μs

A series of high-speed analog-to-digital converters providing binary resolution from 8 through 14 bits offer total conversion time as short as 2 microseconds. All units in the 800 series are complete, fully assembled, tested, and calibrated, system-ready, plug-in modules incorporating all of the functions except power supplies, necessary to perform conversions. No external reference-voltage



source, amplifiers, or trimming potentiometers are required.

Conversion times for specific units are as follows: 10 μs for 14 bits, 4 μs for 12 bits, 3 μs for 10 bits, and 2 μs for 8 bits.

Single-unit prices are: 8 bits, $295; 10 bits, $380; 12 bits, $515; 14 bits, $695.

Phoenix Data Inc., 3384 West Osborn Rd., Phoenix, Ariz. 85017 [384]

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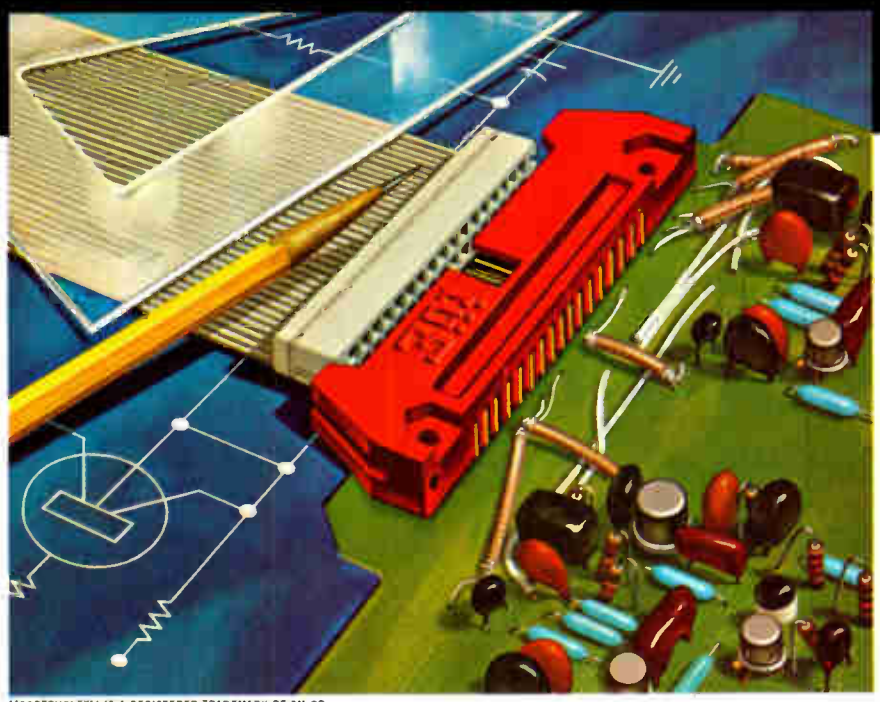

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Off-the-shelf stock offers you flat cable in a choice of lengths and number of conductors from 14 to 50. Connector models interface with standard DIP sockets, wrap posts on .100 x .100 in. grid, or printed circuit boards. Headers are available to provide a de-pluggable inter-connection between cable jumpers and printed circuit boards (as shown). Custom assemblies are also available on request.

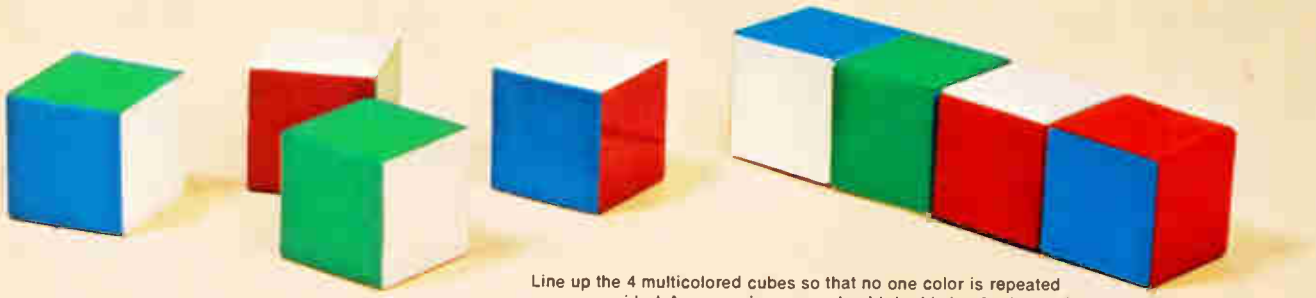
For full information on the "Scotchflex" systems approach to circuitry, write to Dept. EAH-1, 3M Center, St. Paul, Minn. 55101.

3M COMPANY



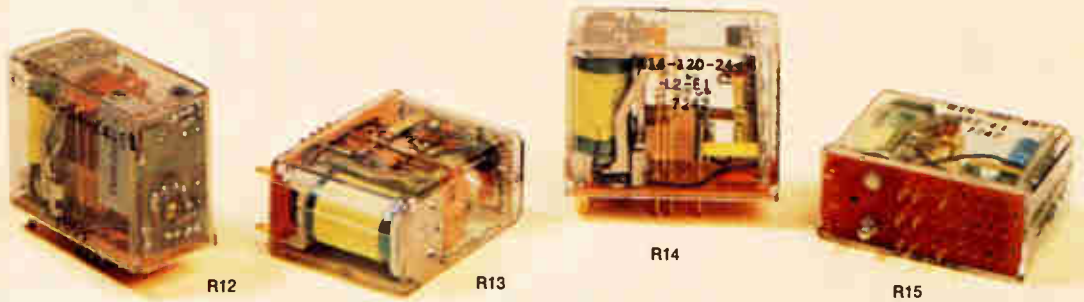
Circle 133 on reader service card

# This problem should take you about 42 minutes to solve.



Line up the 4 multicolored cubes so that no one color is repeated on any side.† As an engineer you should do this in 42 minutes.*

# With P&B's four new time delay relays you solve cost, accuracy and size problems. Immediately.




These new solid state time delays—each designed to solve different design problems—are built around our compact, widely accepted R10 relay. Each is available in 2 or 4 Form C contact arrangements and may be mounted directly to a chassis, printed circuit board, special mounting strip or in sockets having solder or printed circuit terminals.

**R12 Series.** A high resolution, 15-turn potentiometer provides delay on operate timing variations within ranges of 0.1 to 2.0, 1.0 to 30 and 5.0 to 120 seconds. Coils are for 12, 24 or 48V DC. Six contact styles cover a load range from dry circuit to 10 amperes.

**R13 Series.** These fixed, delay on operate time delays are available in 10 timing ranges from 1 to 300 seconds. They require less than 240 milliwatts of DC to operate. Operating voltages are 12, 24 and 48V DC. Contact ratings: dry circuit to 5 amperes.

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**R15 Series.** AC operated from 12, 24, 48 and 115V power sources, these compact time delays may be ordered fixed or externally adjustable in seven timing ranges from .025 to 300 seconds. Delay on operate (R15) or interval timer (R15A) modes are available.

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Circle 134 on reader service card

Instruments

# DMM specs rise, price stays low

## 4½-digit unit has five ac and dc voltage ranges, offers 3-year warranty, $595 price

The purchaser of a 4½-digit multimeter today is in an enviable position—at least eight major manufacturers are competing for his business. And they are offering him more value for his money than ever before. At least one company is trying to beat the industry leader by offering equivalent performance at a much lower price, while several others are offering substantially improved performance at a slightly higher price. Hickok, however, is pursuing a different route: its new model 3400 offers substantially improved performance at exactly the same price as the older model—$595.

The 3400 has five ac and dc voltage ranges, instead of the usual four; six resistance ranges instead of five; and a three-year warranty, instead of the usual one year, or, for a few instruments, 90-day guarantee. Furthermore, the 3400 has 100% overranging as a standard feature (some units have only 20%), and it has a $100 option that provides 300% overranging on the dc scales. The extra ac and dc voltage ranges provided by the 3400 are 100 millivolts full scale; the instrument, therefore, has a resolution of 10 microvolts. Both ac and dc current can also be measured in five ranges from 100 microamperes full scale to 1 A full scale. The current-measuring resolution is therefore 100 nanoamperes. And the six resistance ranges span 100 ohms full scale to 10 megohms full scale, giving the meter a resolution of 0.01 ohm on its lowest range.

Behind the 3400's long warranty period is the manufacturer's belief that its low parts count will make it one of the most reliable meters in the field. Although it uses more ICs than its principal competitor (11 vs five), it uses fewer capacitors, diodes, transistors, and resistors—for a total parts count of 245 vs 502 for the other unit.

The meter has a segmented fluorescent display with automatic polarity indication, and an automatically positioned decimal point. Overrange is indicated by blinking of the display.

A rechargeable nickel-cadmium battery pack, which is available as an option for $200, provides eight hours of continuous operation and has a maximum recharge time of 16 hours. Its lifetime is at least 1,000 recharge cycles.

The Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio 44108 [351]

## Laboratory tape recorder provides 28 channels

Advances in microcircuit logic during the past several years contributed significantly to development of a high-performance, laboratory-type magnetic tape recording system introduced this month by Honeywell Instruments Division. The ICs were used, not so much to reduce the size of the instrument as to pack more capability into the same space.

The analog recorder/reproducer, designated the model Ninety-Six, provides 28 channels, expandable to 42; nine selectable speeds from 15/16 to 240 inches per second, up to 16-inch reel capacity, solid ferrite heads with a 3,000-hour warranty, and all-solid-state modular construction.

In addition to features of earlier Honeywell models, the new system offers all-band data electronics, electronic shuttle programing, intermediate and wideband direct-phase equalization, digital ratio comparator end-of-tape sensing, and an LED electronic footage counter.

Of special interest to those interested in very-narrow-band analysis, Honeywell points out, the Ninety-Six achieves a high degree of spectral purity.

The system offers both inter-

# Guess the price. Win the box.

## Hint: Your first guess will probably be five or six hundred dollars high.

What we have here is our new 4700A. A full multimeter with 5 DC ranges (10 microvolt resolution), 4 AC ranges, and 6 ohm ranges.

What would you think that would cost?


Well, add to that *.01% DC accuracy for 90 days.*

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Next, you have full autoranging or manual selection of range in every function. And *100% overranging* in all functions.

Finally, the standard digital output and remote programming in every one of these units is fully isolated. This is a true systems box, with 100,000-to-1 reduction of errors caused by ground loops and power line hum.

Surely by now we've convinced you we have here a very expensive multimeter.

Well, that's the whole idea. Because the first person to guess the price of this new unit exactly, (F.O.B. Irvine, California), is going to win one.

Write your guess down and mail it to Cliff Hamilton at Dana Laboratories, Inc., 2401 Campus Drive, Irvine, California 92664. The correct guess with the earliest postmark wins. The contest closes March 15, 1973.

One more hint. The closest comparable box isn't even close.

DANA®

**Others measure by us.**

mediate band (0.6 MHz at 120 ips) and wideband (2.0 MHz at 120 ips) capabilities. An average system costs $25,000–$40,000

Test Instruments Division, Honeywell Inc., 4800 East Dry Creek Rd., P.O. Box 5227, Denver, Colo. 80217 [352]

## Sweep/function generator goes to 20 megahertz

The model 421 function/sweep generator provides a 20-MHz maximum frequency, an internal sweep generator with calibrated sweep limits, and 80-dB attenuation of a 20-volt peak-to-peak output. It provides 10-V dc offset, trigger and gate modes, and a distortion indicator when the combination of offset and output exceed ±10 V. Applications are in communications systems, amplifiers, phase-lock loops, and frequency discriminators. The unit handles sine, square, and triangle waveforms. Price is $895.

Systron-Donner Corp., Datapulse Division, 10150 W. Jefferson Blvd., Culver City, Calif. 90230 [353]

## LCR meter makes up to 10 readings per second

A meter that measures resistance, capacitance, and inductance checks low-value components, semiconductors, delay lines, and pulse transformers. The 1-megahertz unit uses

a four-pair measurement technique—four wires with individual shields—to reduce errors caused by stray capacitance, residual inductance, and noise. The instrument can make as many as 10 measurements per second. Error is a maximum of 0.1%. The model 4271A includes a four-digit light-emitting-diode display with 90% overrange,

and the price is below $4,000.
Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [354]

### Impulse generator gives flat output to 35 megahertz

An impulse generator with output that is flat to within ±1 dB from 500 hertz to 35 megahertz is designated the model 93453-1. The output is useful from dc to 400 MHz. The output level is adjustable in 0.25-dB steps from 0 dB above 1 μV/MHz to 121 dB above 1 μV/MHz. Pulse repetition rate is variable from 2 to 100 pulses per second. A single pulse can also be obtained from a manual switch. Pulse width is 10 nanoseconds. The generator is intended for making receiver bandwidth measurements, rapid checking of tuner gain, testing noise-suppression receivers, and receiver alignment.

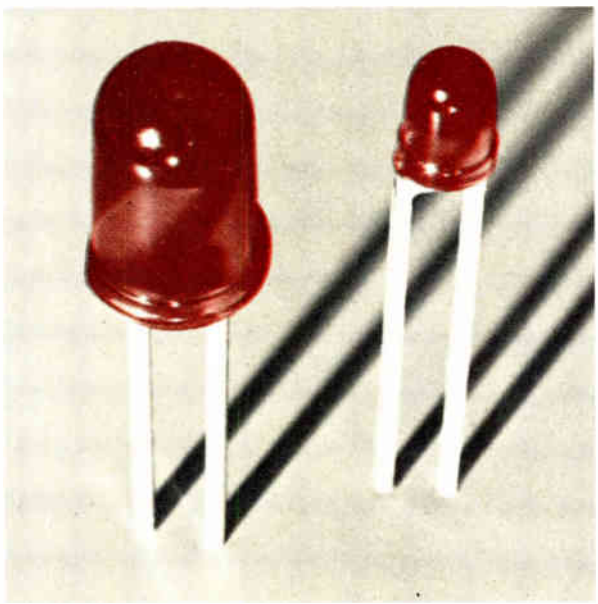

Singer Instrumentation, Los Angeles Operation, 3211 So. LaCienega Blvd., Los Angeles, Calif. 90016 [355]

### Active FET probe for scopes has 220-MHz bandwidth

Designed for wideband oscilloscopes, an active field-effect-transistor probe, designated the PM9353, measures low-amplitude, high-frequency signals without appreciable circuit loading. The probe's bandwidth is 220 megahertz, making it suitable for scopes with intrinsic bandwidths to 150 MHz with no adverse effect on the scope rise time.

Input impedance of the PM9353 is 3.5 picofarads in parallel with 1 megohm; its unity-gain FET amplifier eliminates the 10:1 attenuation

# HP's new LEDs



# Only 17¢

The low cost LED is here today! Only 17¢ in 100K quantities; even less in higher volumes. Advanced design and high volume production make these new low prices possible. So now you can use an LED for any application requiring an indicator light.

Two sizes of lamps are available: a T-1 and a T-1¾ size package. These long-life LEDs are ideal for housewares, appliances, automobiles — anywhere you need a brilliant long-life solid-state lamp.

To get a free sample, call your nearest HP distributor.

For application information, call or write Hewlett-Packard, 620 Page Mill Road, Palo Alto, Calif.
In Europe: P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland;
In Japan: Yokogawa—Hewlett-Packard, 1-59-1, Yoyogi, Shubuya-ku, Tokyo, 151.

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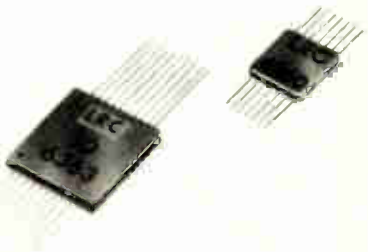
6 Frankfurt 1, Myliusstrasse 54, Germany
Tel.: (0611) 72 04 16/8

## New products

on conventional probes. Dynamic range of input signals for the PM9353 is ±1 volt, approximately triple the range of some earlier FET probes. This dynamic range is independent of the ±1 volt dc offset range of the probe. Priced at $325,



the probe is supplied in a carrying case that also contains a set of 26 accessories.

Test and Measuring Instruments Inc., a North American Philips Co., 224 Duffy Ave., Hicksville, N.Y. 11802 [356]

### Miniature decade counters plug in side-by-side

Operating from a single 5-volt power supply, a line of miniature high-speed modular decade counters offers a side-by-side plug-in feature that allows fast assembly of any number of digits with no unit-to-unit wiring for main-sequence operations. The DEC-100 series of Decaplugs uses miniature seven-segment incandescent readouts that are

available in several styles. Full use of the company's 7447 decoder can be obtained from both the DEC-100 up-down and DEC-101 up counter. Single-unit prices for these modules, including readouts, are $29.50 for the DEC-100 and $26.90 for the DEC-101.

Compton Electronics, P.O. Box 5326, Compton, Calif. 90224 [357]

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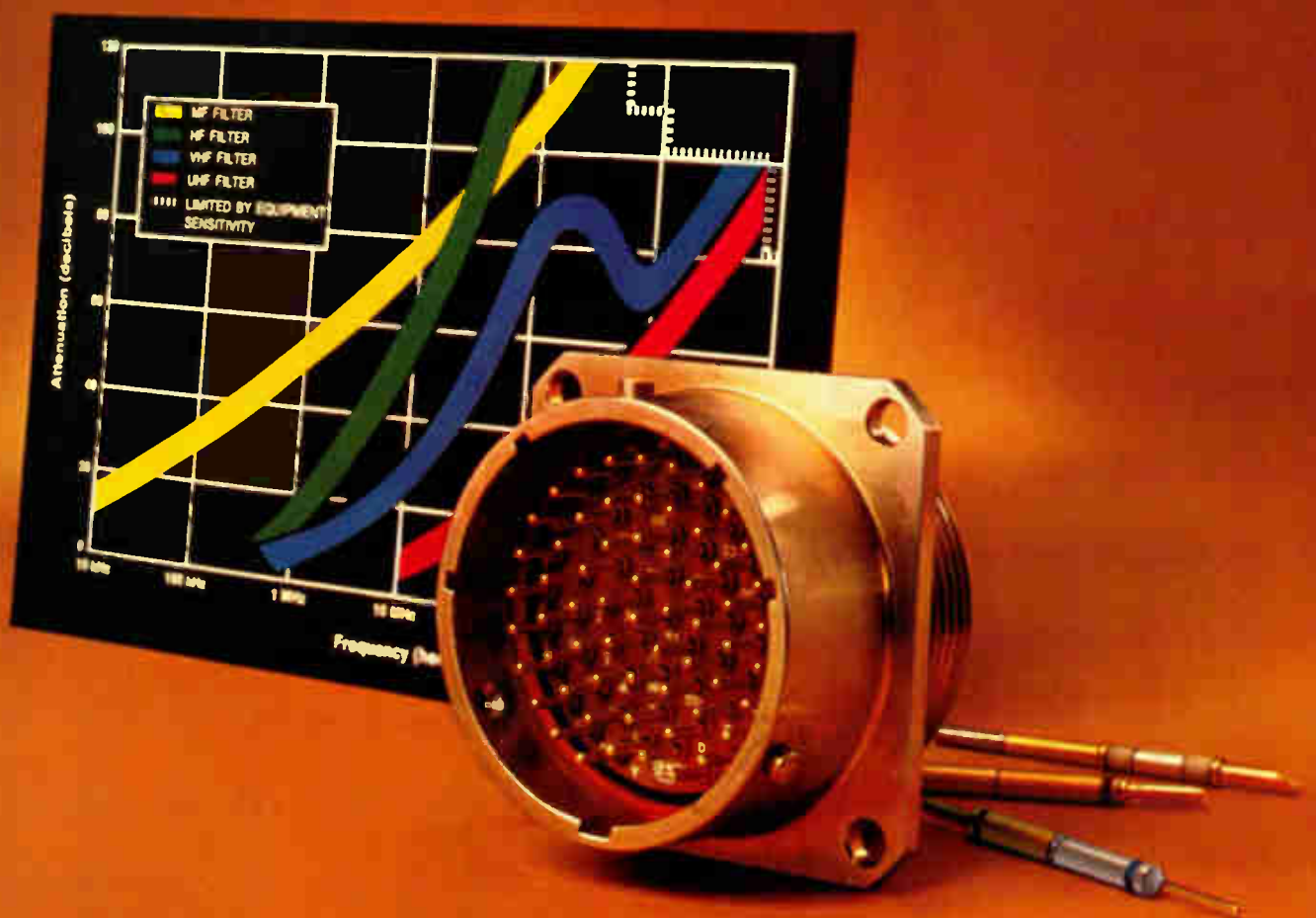
# Are you getting static?




Our filter connectors are designed to eliminate interference from your circuits. See those attenuation curves? They are just a part of our selection. We can mix and match filters to solve your low pass filtering requirements. Small wonder Bendix filter connectors are first choice in the fight against electronic noise pollution.

Bendix filters come packaged in connectors intermateable with MIL-C-26482, MIL-C-83723, MIL-C-38999 and MIL-C-5015 connectors. In addition, filter contacts can be packaged to mate with other popular connector types including rectangular in military, industrial and commercial applications. There's sure to be one to meet your attenuation and frequency requirements.

You'll like the price, too.

Delivery? We won't give you any static there, either. Write for our brochure. The Bendix Corporation, Electrical Components Division, Sidney, New York 13838.

Bendix

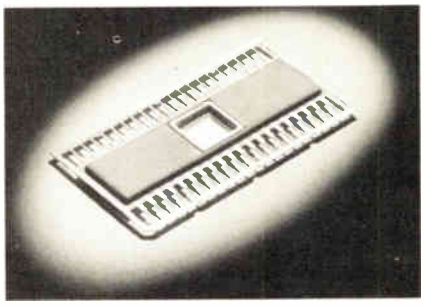
Circle 142 on reader service card

Packaging & production

# Hermetic pack is low-priced

Ceramic cavity is sealed, but bulk of 40-pin package is low-cost plastic

A plastic-ceramic package developed by Space Ordnance Systems may satisfy requirements for lower-cost MOS LSI packaging without the need to change packaging techniques. The company's Glass Seal division, which has been supplying hermetic flatpacks, has a new package called Ultrapak that uses a sealed ceramic cavity, and the bulk of the 40-pin package consists of low-cost plastic supporting the leads. C.A. Registro, general manager, says that a semiconductor manufacturer can bond and seal the package just as he has been doing with conventional ceramic packages. However, the part sells for only 55 to 60 cents each in 100,000 quantities, compared to 85 to 90 cents for an equivalent 40-pin package plated with gold 40 microinches thick.



In addition to cost savings, the company claims that the package offers more impact resistance than ceramic, and it has several advantages over the even less-expensive all-plastic packages. Registro says that a big advantage over user-molded packages is improved yield because the delicate wire bonds aren't subjected to the stresses of molding, then curing, which he says typically cause a large yield loss in expensive LSI dice. Also, no conformal coating or special—and very expensive—encapsulating equipment is required.

The ceramic insert cavity also permits conventional die attachment, instead of specialized approaches required for premolded-cavity plastic packages. The loaded glass (25% alumina) has better thermal characteristics than plastic.

Registro says that the cavity can be sealed with the usual gold-tin eutectic, or with Malon Meg-165, a thermosetting plastic that is becoming increasingly popular for sealing. The Meg-165 is supplied as a preform attached to the lid; for eutectic sealing, either metal or ceramic lids can be used.

The package meets MIL STD 883, Registro says, and he has heated the package to 450°C (100°C over the usual die-attach termperature) for a number of minutes with no problems. He says there is no apparent movement between the ceramic and plastic, and the Kovar lead frame is chosen to match the thermal movement of the ceramic.

Space Ordnance will have 40-pin packages with 250-mil cavities available in late April. And smaller 24- and 28-in pin versions may become available later. But Registro says the main call is for 40 pins. "They contain the most expensive dice and provide the most problems in encapsulation."

Space Ordnance Systems, Glass Seal Division, 25977 Sand Canyon Rd., Saugus, Calif. 91350 [391]

## System tests diodes, zeners, rectifiers simultaneously

The model Z337 computer-operated test system for diodes, rectifiers, and zeners tests all three types of components simultaneously. At $49,000, it costs less than some systems which can test only one type, and for manufacturers who must classify these three components, the Z337 costs less than three separate classification systems.

The Z337's wide range of analog

capability allows it to supply forward current to 10 amperes and voltage up to 1,200 volts for testing diodes and rectifiers. For zeners, it can handle a 1-kilohertz impedance measurement and up to 200 v zener voltage.

A voltage-sensing capability controlled by software allows the Z337 to measure the squareness of the voltage change at zener breakdown voltage or on a controlled avalanche rectifier. The system offers a test time up to three times faster than in previous generations of test equipment, a faster computer testing sequence than the industry standard, and an automatic recording of test values.

As many as 50 tests may be stored in the computer, and the number performed can be limited to only those necessary for the device being tested. The Z337 can accept up to 10 test stations, although the average is five stations, or the unit can multiplex two handlers that are processing 10,000 components an hour each, and it still has time for one manual station.

Applications also include data recording directly on magnetic tape, burn-in, and data processing, as well as classification. Richard J. Lucey, manager of discrete-component test systems at Teradyne, points out that software packages allow data to be processed in two ways: the end-of-life application compares present with previous readings, and the automatic distribution curve takes all standard statistical points, such as median, mean, and sigma, from the data. This is essential for process control feedback, the test systems manager points out.

Teradyne, Inc., 183 Essex St., Boston, Mass. 02111 [392]

## Abrasive resistor trimmer provides to 1,000 trims/hour

The model RT-10SA abrasive resistor trimmer is designed to meet accuracy requirements in thick- and thin-film printed circuits, and the unit is capable of trimming up to 0.1% of the desired value. Produc-

# Caught in the old cassette vs. ½"-drive, price vs. performance crunch?

With a choice like that you pay the price no matter what you do.

So we've come up with the first real alternative you've ever had.

The "Scotch" Brand Data Cartridge.

It's a unique approach to digital tape storage that's priced like a cassette but performs like a ½" -compatible drive.

It operates at speeds up to 90 ips, starts/stops with accelerations up to 2000 in/sec² and offers transfer rates up to 48,000 bps.

It uses ¼" tape and records at up to 3200 frpi, so it stores up to 5.5 million bits of data per track on 1 to 4 tracks.

It needs only a single point drive and no external tape guidance, so tape can never cinch, spill, stretch or break and each cartridge has a life expectancy in excess of 5000 passes.

Because the "Scotch" Data Cartridge functions as its own transport, tape handling is fast, accurate and precise at all times. It's ideal for: Word processors and terminals. Point-of-sale data capture and computer data entry. Minicomputer I/O and paper tape replacement.

And if you need more information, you've got a choice there, too.

Just contact any of the major peripheral manufacturers or Data Products, 3M Company, 300 South Lewis Road, Camarillo, Calif. 93010. Telephone: (805) 482-1911. TWX: 910-336-1676.

**We've been there. And brought the answers back.**

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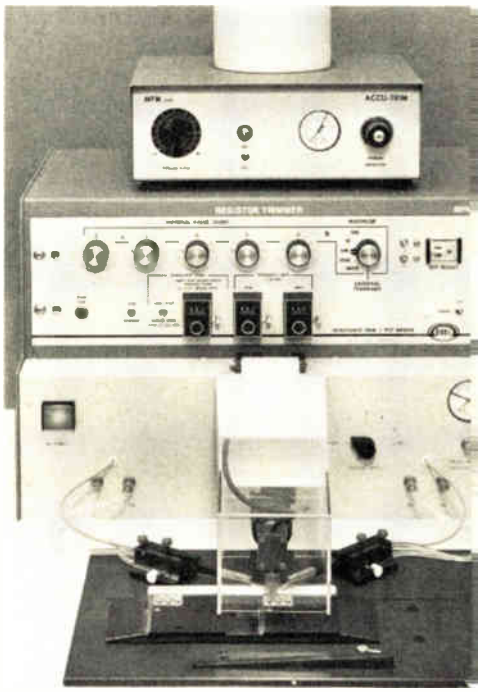
tion rates are up to 800 to 1,000 trims per hour at a range from 0.1 ohm to 11 megohms with a maximum power dissipation of 12 milliwatts. The unit has a shuttle mechanism that allows loading and unloading of a substrate during a



trim cycle, which is said to double the trim capability on a single-station abrasive trimmer. Price is $6,500.

M.P.M. Corp., 2225 Massachusetts Ave., Cambridge, Mass. 02140 [393]

### Contact printer offers precision to within ±0.5 μm

A manual loading and unloading contact printer called the CP-551, an automatic cycling device, dupli-

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Whether it's a police officer in a patrol car requesting information on a suspect, an architect specifying coordinates for plumbing fixtures in a new building, or a type setter verifying type for a mail-order catalog, SELF-SCAN panel displays guarantee the most accurate transfer of data between the operator and the computer. If you need a computer display and demand error-free communications, follow the lead of Kustom Electronics (1) in Chanute, Kansas; Science Accessories Corporation (2) in Southport, Connecticut; Automix Keyboards (3) in Bellevue, Washington, and the many other SELF-SCAN panel display users. Have a Burroughs salesman demonstrate his "terminal in a briefcase." You'll see why the SELF-SCAN panel display is the most effective man/machine interface device available today.

Burroughs Corporation, Electronic Components Division, Plainfield, New Jersey 07061. (201) 757-3400.

Burroughs

Circle 147 on reader service card

## New products

cates photomasks. It is designed to handle any combination of master and copy plates from 2 by 2 by 0.06 inch to 5 by 5 by 0.25 inch. Illumination of ±5% is provided over a 5.6-inch diameter, permitting printing of a 4-inch-square format. Precision is to within ±0.5 micrometer from the master over a 3.5-inch diameter for most applications. Price begins at $13,900 for a basic unit without options. Delivery time is 60 to 90 days.

The Jade Corp., 3063 Philmont Ave., Huntingdon Valley, Pa. 19006 [394]

### Screen printing system is fully automated

Magazine feed and magazine reload are features of an on-contact/off-contact screen printer designed for hybrid-circuit production. The unit maintains an accuracy to within ±0.001 inch in printing at rates up to 1,000 pieces per hour. The model SPS-1 is equipped with an electric-motor-driven print head, a walking-

beam part-transfer system, a collocator, and infrared dryer. Magazines can be changed while the printer is running and each magazine holds up to 800 0.025-inch-thick substrates measuring 3 by 3 inches in size. Price is $24,200.

Wells Electronics Inc., 1701 S. Main St., South Bend, Ind. 46623 [395]

### Pluggable sockets built for disconnect system

The series 741 individual pluggable sockets on plastic carrier strips can be used with the company's printed-circuit-board jumpers to provide a

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## (p.s. they're a bargain!)

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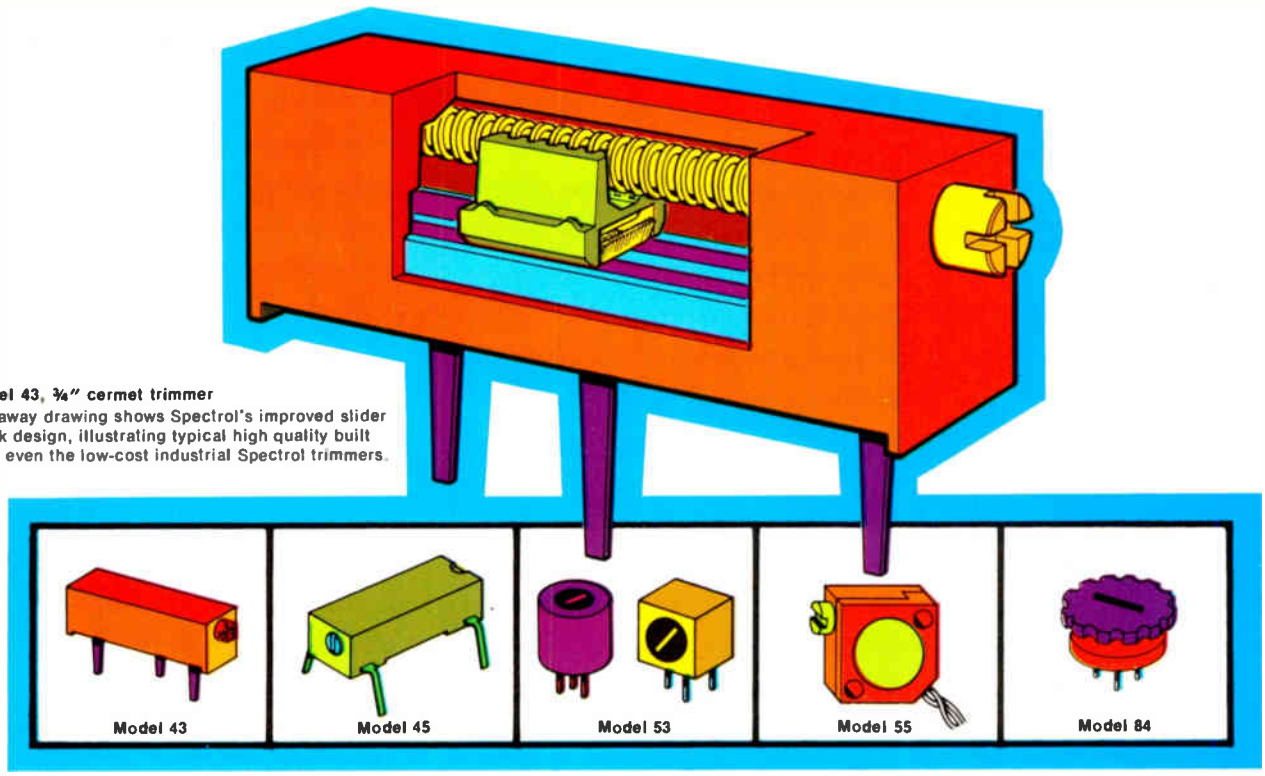


**Model 43, ¾" cermet trimmer**
Cut-away drawing shows Spectrol's improved slider block design, illustrating typical high quality built in to even the low-cost industrial Spectrol trimmers.

Spectrol

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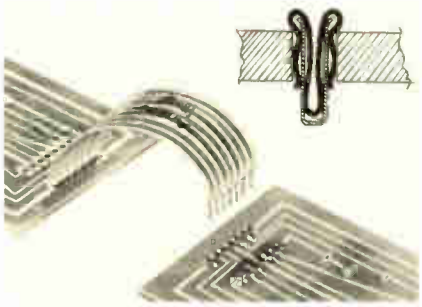
## New products

connect/disconnect system. The sockets fit a range of board hole sizes from 0.050 to 0.058 inch in diameter and provide positive retention in the board prior to soldering. Installation may be made by hand or semiautomatic tooling. The use



of the sockets allows the jumper to be used as a direct connect/disconnect interconnection between two printed-circuit boards, eliminating the use of conventional connectors. Price is 5 cents per socket, depending on quantity.

Ansley Electronics Corp., Old Easton Rd., Doylestown, Pa. 18901 [396]

### Test jacks, points facilitate circuit test readings

A line of test jacks and test points are designed for use in high-density electronic assemblies where test readings are desirable or necessary at certain circuitry points. This not only facilitates circuit test readings, but the miniature points can also be used as receptacles for jack-in connections between components or chassis. Other test points can be used with molded insulators or as feed-through test points in thick housings. The printed-circuit test jacks are designed to receive 0.080-inch-diameter probes.

Sealectro Corp., Circuits Hardware Division, Mamaroneck, N.Y. 10543 [397]

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Ruggedly constructed, precise card/connector fit, holds up to 14 socket cards in standard EIA racks. Standard sizes for all socket cards—customs also available. Standard I/O systems include connectors, optional mother board and I/O panel.

**Socket Cards**
40 and 60 position cards that mount 14 and 16 pin devices universal cards that mount any device 6 to 40 pins, Kit Cards for those special customs. Cards have 72 or 122 I/O connections. All have decoupling capacitor provisions. Prices about $1.00/position.

**Socket Panels**
14 and 16 pin models provide 30 to 180 sockets in zones of 30; Universal model for 6 to 40 pin devices with 9 to 54 pin rows in 9 row zones. All have decoupling capacitor provisions and female or feed-thru pin I/O systems.
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**Socket Panel Drawers**
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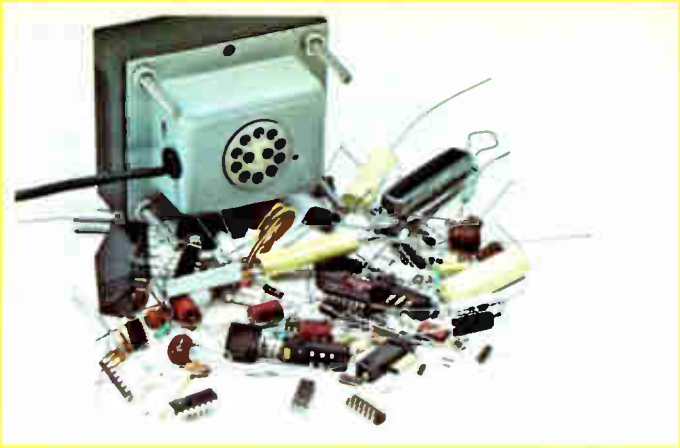
Circle 151 on reader service card



# all DVM's start like this

# ...but only CIMRON puts it all together like this...

# and like this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Do you need a 5½ digit systems DMM with optical coupled programming, parallel and serial BCD outputs? Do you need high noise rejection coupled with high speed and accuracy? The DMM 50 does it all.
Then, there's the DMM 40.
Do you need 5 ranges of AC and DC, 6 ranges of ohms plus internal AC and DC current shunts and complete autoranging . . . all with 140% overrange? How about battery operation and isolated data outputs?
The DMM 40 does it all at an extremely attractive price.
For more information about these and other Cimron multimeters or to arrange for a demonstration of these state-of-the-art instruments, write or call Lear Siegler, Inc., Cimron Instruments, 714 North Brookhurst Street, Anaheim, California 92803, (714) 774-1010, or circle the number below.

LSi

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Circle 152 on reader service card

Semiconductors

# C-MOS ROM has 1,024 bits

Power, noise benefits of complementary units are extended to ROMs

Read-only memories have become vital to the modern digital logic system, but until now, designers of complementary MOS systems have had to be content with p-MOS or even bipolar ROMs because no C-MOS versions were available. That inconvenience has now been corrected by Motorola's introduction of a 1,024-bit C-MOS ROM, which extends the low power and high noise advantages of C-MOS to ROMs. The Motorola part, the latest in the company's line, will be almost doubled in size to 90 functions by the end of the year, says Ron Komatz, manager of Motorola's C-MOS product planning.

The new part, the MCM14524, is arranged 256 by 4 bits. Like other C-MOS parts, it can operate from 3 to 15 volts, and quiescient power is only 11 nanowatts. Actual operating power depends on operating frequency, as well as supply voltage; it's about 100 microwatts at 5 V and 10 kilohertz.

The ROM's clock-access time varies significantly with supply voltage. At 5 V, compatible with TTL circuits, the value is 1,800 ns; at 10 V, 825 ns; and at 15 V, 530 ns. These times indicate an operating frequency of approximately 1.5 MHz at 10 V.

Komatz expects that the major use of the part will be in industry, where the low power consumption, simple power supplies and high noise-immunity of C-MOS make it especially attractive for controls, communications, and microprograming storage.

The new ROM is triggered on the negative edge of the clock, and internal latches store output data. The inputs to the device are protected by diodes. A chip-enable permits simple expansion for applications that require more than 1,024 bits. The part is mask-programed. Turnaround time is about 10 weeks. Programs can be supplied in either truth-table form or on IBM cards.

The 16-pin package is ceramic, with the military (MCM14524AL) version priced at $24.70, and commercial (MCM14524CL), at $13.75. Both prices are for more than 500 pieces. Mask charge for 100 to 500 parts is $700.

Motorola Semiconductor Products Inc., Technical Information Center, Box 20924, Phoenix, Ariz. 85036 [411]

## Darlington transistor delivers 20 A at 400 V

Building on its recently introduced line of monolithic Darlington power transistors TRW Semiconductor has added a device capable of switching 20 amperes at 400 volts. Richard Seinfeld, product-line manager, points out that power transistors generally have been limited to about 5 A at 300 V. The devices offer fast switching as well as high voltage-current capability.

TRW is already providing the 20-A Darlington in quantity for a variety of control applications, including 5- to 10-horsepower motor drives. Other applications for the new high-current, high-voltage units in the series include off-line switching of power supplies and such consumer equipment as TV sweep circuits. Seinfeld says the 20-A version is particularly well suited for application where SCRs or a multitude of transistors were formerly used in parallel. The company also has 5- and 10-A versions; all are of triple-diffused mesa construction.

The Darlington is, in effect, two transistors, one driving the other, and they have common collectors. The device provides higher gain than a single transistor, in this case a forced beta of over 10 at a collector current of 20 A compared to 1 or 2, or a fractional value, for conventional transistors of this rating.

The device can be used in power-

supply design instead of conventional power transistors to permit elimination of the 60-hertz power transformer. The switching techniques permit significant reductions in size and power dissipation when used in power supplies and similar applications. The units are housed in standard TO-3 packages. The fast switching time of 300 nanoseconds allows operation of the devices to 40 or 50 kHz.

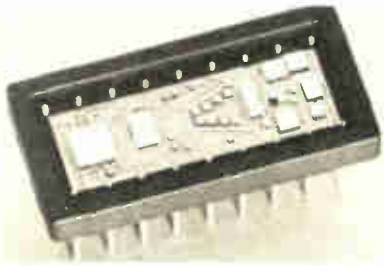
The TRW 20-A Darlingtons have sustaining breakdown voltage ratings (collector-to-emitter) of 300 v (type SVT 6060), 350 v (SVT 6061), and 400 v (SVT 6062). An unusual feature of the Darlington construction is self-compensating collector-emitter saturation voltage. It typically changes from only 1.15 v at –40°C to 1.09 v at +150°C, rather than the usual large increase with temperature change. This effect is caused by the base-emitter voltage of one transistor cancelling the collector-emitter voltage of another. Maximum saturation voltage is 2 v at 20 A.

Price for the SVT 6060 Darlington transistor in 100-unit quantities is $15.54 each.

TRW Semiconductor Operations, 14520 Aviation Blvd., Lawndale, Calif., 90260 [412]

## Analog-to-digital converter operates in 1 microsecond

Packaged in an 18-pin dual in-line case, the model MN500 analog-to-digital converter is an eight-bit successive-approximation device. It is



# MONSANTO LAUNCHES NEW 50MHz COUNTER ATTACK


**New Model 100C**
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## New products

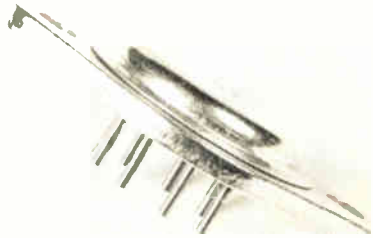
both is by two control lines that determine the operational mode of the counter. Lines S1 and S2 control one of four operations: preset, increment, decrement, or hold. A third terminal allows cascading of multiple units. Price is $14.23 to $17.79 depending on quantity.
Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Ariz. [416]

### Receiver-transmitter is programed for 1.5 stop bits

An MOS LSI asynchronous receiver-transmitter is capable of half-duplex or full-duplex operation. The device is TTL- and DTL-compatible and can be programed to transmit 1.5 stop bits. The internal control, programmable from the device terminals, is a static control register. The programmable transmitter portion of the TR1602A links variable-length parallel-input data to a serial channel and converts parallel characters into a serial data stream with a format compatible with all standard, asynchronous data-communications media. Price is $8.80 in quantities.
Western Digital Corp., 19242 Red Hill Ave., Newport Beach, Calif. 92663 [417]

### Hybrid voltage regulators supply 5 amperes

A line of high-power, 5-ampere dc voltage regulator has three circuits in each series for both positive and negative applications. The positive circuits are identified as CJCA001.



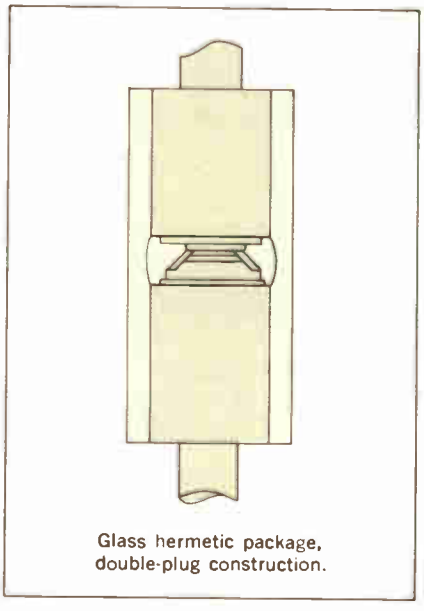
CJCA003, and CJCA005. The negative circuits are the CJCA002, CJCA004, and CJCA006. The series is available with a FET internal current source and a current limiter.


# Hard-boiled hermetics...
## TI's rugged 1-amp glass rectifiers.

TI's 1-amp glass rectifiers are tough, high-performance units you can depend on.

They're proven through extensive high-reliability testing—like 168 hours in a pressure cooker at 15psi, 120°C (no failures). This high reliability is achieved by combining the best processing, construction and packaging technologies.

The silicon mesa oxide-passivated structure has additional nitride and glass passivation over the junction. Double-plug construction provides highest mechanical integrity. Matched coefficients of expansion of the glass case and dumet leads provide hermeticity under widely varying temperatures (−65° to 175°C max operating range).



Glass hermetic package, double-plug construction.

Designated 1N4001 through 1N4006, the 1-amp devices offer a reverse voltage range of 50 to 800V. Repetitive peak forward current (10 cycles, 75°C or below) is 10 amps. Peak surge current is 30 amps. Static reverse current is 10 microamps at 25°C and 50 microamps at 100°C.

**For more information**

For price and delivery, call your local TI sales office or authorized TI distributor. For complete data sheet covering the 1N4001-1N4006 1-amp glass series, circle 243 on the reader service card. Or write Texas Instruments Incorporated, P.O. Box 5012, MS 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
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## New products/materials

lectronic circuits. The material is formulated to be screened on, and is fired to develop interdiffusion bonding, which results from the formation of the eutectic phases during the firing process. Price is $45 per pound.
Transene Co. Inc., Rte. 1, Rowley, Mass [478]

**A high-temperature alumina ceramic coating** for thermocouple protection tubes is called Pyro-Clad, and provides heat resistance to 3,000° F. The process matches the thermal rate of the alumina ceramic coating to the base metal in the thermocouple protection tube, and the responsiveness of the tube is not impaired because the coating acts as a thermal conductor. Price is from $10 per unit depending on quantity and size of tubes to be coated.
Aremco Products Inc., Box 145, Briarcliff Manor, N.Y. [479]

**A series of alloys** consists of alloy 194, a copper alloy for contacts and lead frames; alloy 195, a high performance material for terminals, lead frames and springs; alloy 688, a cobalt aluminum modified brass material for contacts, terminals and connectors; and alloy 638, a cobalt-modified aluminum silicon bronze material used as a replacement for phosphor bronzes and nickel silvers in spring applications, and as a glass-to-metal seal in semiconductor packages.
Olin Corp., 460 Park Ave., New York, N.Y. 10022 [480]

**Stycast HiHiK** is a material that has an isotropic dielectric constant and is offered in rod, bar and sheet stock. The dielectric constant range is 3.5 to 30, and the dielectric constant increments are one with inter-

 

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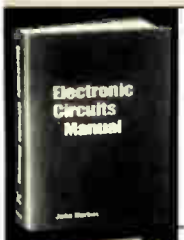


404/445
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by Texas Instruments Inc.
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by Deboo & Burrous
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**SOURCEBOOK OF ELECTRONIC CIRCUITS**
by J. Markus
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Club price, $14.75


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**HANDBOOK OF SEMI-CONDUCTOR ELECTRONICS, 3/e**
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Club price, $21.50

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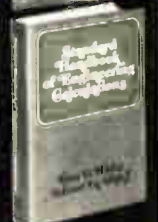
**COMMUNICATION SYSTEM ENGINEERING HANDBOOK**
by D. H. Hamsher
Pub. price, $29.50
Club price, $22.50



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## New products/materials

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Emerson & Cuming Inc., Canton, Mass. 02021 [403]

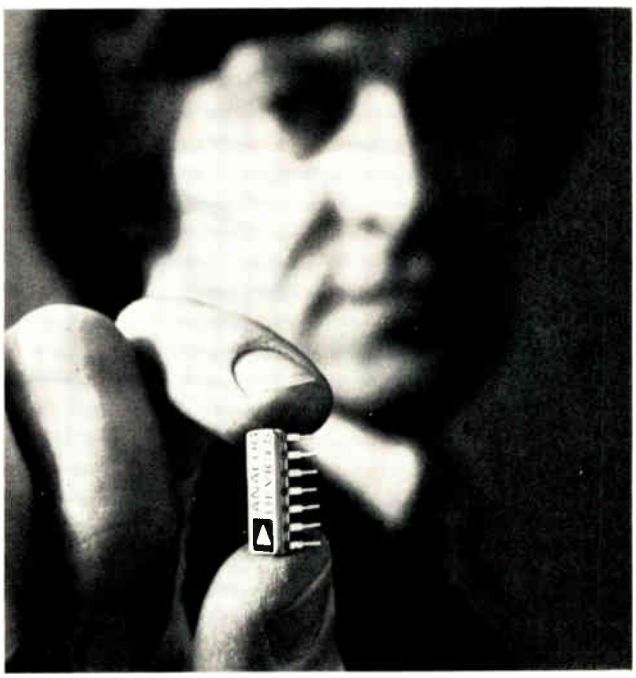
**A polyester film** with flame retardant properties is for applications in transformers, flat cables, and other uses of polyester film. Use of the material eliminates the need to encapsulate television flyback transformers in silicone rubber, and the material is self-extinguishing. The Scotchpar film has a minimum oxygen index of 28.
3M Co., Box 33600, Dept. Fi3-1, St. Paul, Minn. [401]

**The custom packaging** of most multicomponent resins into one packet allows the packaged materials to be compatible with most epoxies, urethanes, and RTV silicones used as adhesives, sealants, potting compounds, and electronic filler materials. The Acu-Paks are filled with materials to customer specifications, and the package is a transparent

pouch separated into compartments.
Allied Resin Corp., Weymouth Industrial Park, East Weymouth, Mass. 02189 [404]

**A release agent** called Exxit-II offers release quality for any type of polyurethane, compression-molded epoxy-resin, and other types of materials. It does not permit buildup of molds on steel, aluminum, epoxy or polyester resins, ceramics, and glass. The material applies with a fine mist spray and will provide instant release of clean pieces with good surface finish and without sticking or tearing thin sections.
Contour Chemical Co. Inc., 4 Draper St., Woburn, Mass. [405]

# If you thought our first I.C. multiplier solved a lot of your problems, take a look at this one.



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Plus a differential $V_X$ input with 75dB of common mode rejection. All this makes a lot of complex applications very simple. Like automatic gain control.

True RMS-to-DC conversion. Absolute value.

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You can use the instrumentation amplifier input to reject common mode noise. Or to subtract two input signals prior to further processing.

Or you can use the AD531 just to multiply, divide, square, or square root.

The AD531 will help you do all of this and more with an error guaranteed to be less than 0.5%.

The package is the TO-116 14-pin ceramic DIL for high reliability and handling ease. You can choose from three accuracy versions (J,K,L) for operation over the 0°C to +70°C temperature range, and one for −55°C to +125°C operation(S).

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Analog Devices, Inc., Norwood, Massachusetts 02062.

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## New literature

**Capacitors.** ITT Jennings, 970 McLaughlin Ave., San Jose, Calif. 95116, has published a catalog on its line of fixed and variable vacuum capacitors. The 52-page bulletin can assist the designer of high-power radio-frequency equipment to select a specific unit for a particular application. Circle 421 on reader service card.

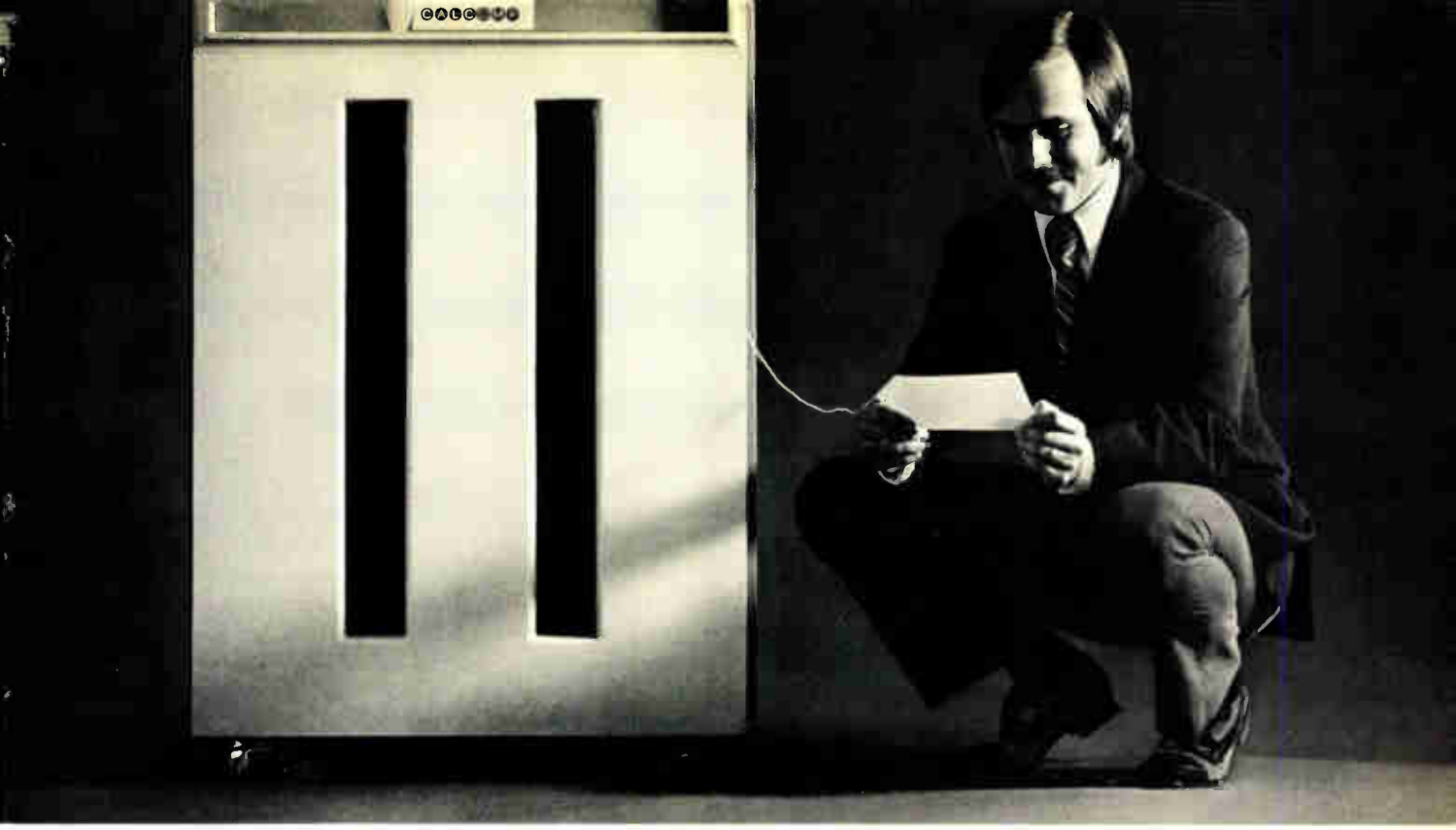
**Automatic testers.** A 12-page brochure from Datatron Inc., 1562 Reynolds Ave., Santa Ana, Calif., describes a line of automatic testers. The brochure provides technical details and applications data. [422]

**Conversion devices.** Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. A three-ring binder catalog contains detailed electrical and mechanical information on a line of data-conversion modules, systems, and subsystems. The prod-


ucts described include a-d converters, d-a converters, sample-and-hold modules, digital panel meters, dc power supplies, and data acquisition systems. [423]

**Display modules.** A six-page catalog from Optical Electronics Inc., P.O. Box 11140, Tucson, Ariz., describes a line of analog three-dimensional display-generation modules. [424]

**Power supplies.** A two-page data sheet from Spellman High Voltage



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Call your local CalComp office, or contact California Computer Products, Inc., EM-M2-73, 2411 West La Palma Avenue, Anaheim, California 92801. (714) 821-2011.

CALCOMP

## New literature

Electronics Corp., 1930 Adee Ave., Bronx, N.Y., details the Mini-Module RMX series of regulated high-voltage dc power supplies. [425]

**Process controller.** Leslie Co., Parsippany, N.J. The model 2610 process controller for temperature, pressure, power, and other applications is discussed in a two-page data sheet. [426]

**Thin-film measuring.** Bulletin 203-72 from Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill., describes equipment and accessories for thin-film measuring. [427]

**Capacitors.** A four-page variable capacitor-selection guide is available from Codi Semiconductor, Pollitt Dr., Fairlawn, N.J. 07410. [428]

**Oscillograph.** The series 870 portable test oscillograph is the subject of a brochure from Hathaway Instruments Inc., 5250 E. Evans Ave., Denver, Colo. 80222 [429]

**Instruments.** A 52-page catalog from Heath/Schlumberger Scientific Instruments, Benton Harbor, Mich. 49022, provides descriptions and specifications for a line of design and laboratory instruments, including a series of vhf counters that can provide capability to 600 MHz. [430]

**Switches.** An eight-page brochure being offered by Micro Switch, a division of Honeywell Inc., 11 W. Spring St., Freeport, Ill., describes the company's mercury-switch development, engineering and manufacturing capabilities. [431]

**Test sockets.** K-Tech Inc., 885 Waverly St., Framingham, Mass., has published a six-page brochure describing electrical and burn-in test sockets and carrier contact systems for semiconductor devices. [435]

**Memories.** A brochure available from Data Disc Inc., 686 W. Maude Ave., Sunnyvale, Calif., describes plug-in disk memories for most minicomputers, including those made by DEC, Honeywell, Interdata,

# Two decisive differences!

# The aperture-time uncertainty. The feed-thru.


*Aperture-Time Uncertainty—the tolerance of the delay between a hold command and the actual opening of the hold switch, i.e., the repeatability of the aperture time.*

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## Philbrick Circuit Modules.
The best makes the difference.

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## New literature

Hewlett-Packard, Varian, and Data General. [432]

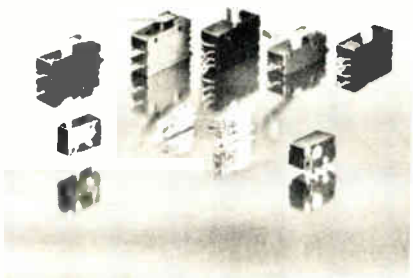
**Panel meters.** LFE Corp., Process Control division, 1601 Trapelo Rd., Waltham, Mass. 02154. A six-page bulletin describes the company's line of analog panel meters. [433]

**Data conversion.** An eight-page selection and evaluation guide on data conversion from Data Device Corp., 100 Tec St., Hicksville, N.Y., covers a-d, d-a, and multiplying converters, plus sample-and-hold modules. Included are applications notes and approaches available to the systems engineer. [434]

**Switches.** Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, Ill., has published a 30-page guide to 12 series of snap-action switches. [437]

CHERRY

PRECISION SNAP-ACTION SWITCHES..



**Lasers.** International Laser Systems Inc., 3404 North Orange Blosson Trail, Orlando, Fla. A four-page brochure provides information on high-energy, high-repetition-rate, neodymium YAG laser systems. [436]

**Panel meters.** A 28-page catalog, available from Triplett Corp., Bluffton, Ohio 45817, covers panel meters and accessories plus a customized panel meter service for use in industrial process control, electronic instrumentation, communications equipment, and computer and data processing systems. [438]

# Major breakthrough in advanced power tube technology

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We call it the **Pyrobloc* Grid** and it surpasses all earlier grid designs.
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For more information on our Pyrobloc Grid Tubes, please circle the appropriate number
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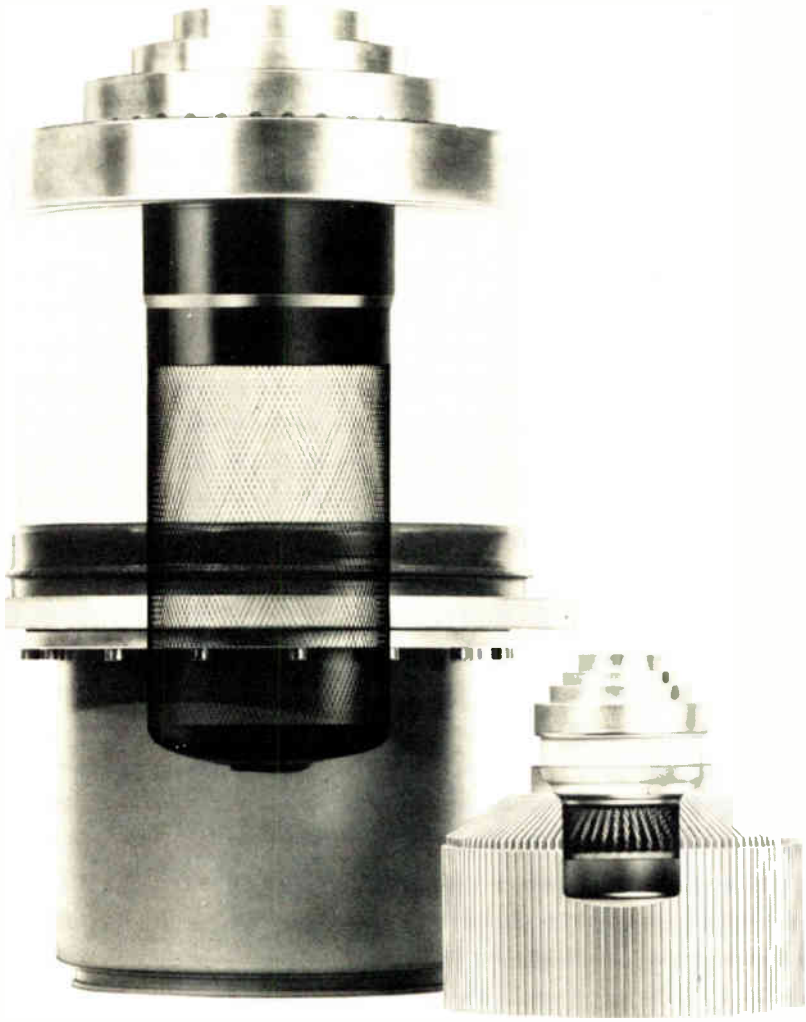

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Sweden - THOMSON-CSF Elektronror AB / Box 27080 / S 10251 STOCKHOLM 27 / Tel. 08/22 58 15
United Kingdom - THOMSON-CSF Electronic Tubes Ltd / Bilton House, Uxbridge Road, Ealing / LONDON W5 2TT / Tel. 01-579 1857 / Telex: 25 659

1659

# New books

**Handbook of Wiring, Cabling, and Interconnecting for Electronics,** Charles A. Harper, editor-in-chief, McGraw-Hill Book Co., 1,142 pp., 1,034 illustrations, $29.50.

Although many design engineers probably have one or more sources of basic data on wire and cable, be they handbooks or wire and cable catalogs, this book provides an exhaustive source of data that is probably not available elsewhere in a single volume. Most of the material was prepared two years ago, but the book is nonetheless quite up-to-date. Moreover, a dividend of owning this volume is the large bibliography included.

Charles Harper has assembled a volume with a great wealth of materials in diverse interconnection fields. The book discusses such traditional technologies as magnet wire and coaxial cable, as well as newer techniques such as printed circuits, flat cable, and microelectronic interconnections.

One strength of this book is its coverage of competing techniques, and much of this data is tabulated so that the reader may, for example, compare the reliability of soldered, welded, and wrapped connections with respect to their abilities to endure such environmental hardships as vibration, shock, and humidity.

**Organization.** Preparing such a handbook is an extremely ambitious undertaking, and this volume incorporates detailed inputs by knowledgeable people in the industry. It is hoped, however, that this volume will be revised from time to time—not only to update it as technology progresses, but also to reorganize material. The volume is organized in a chapter format, and it appears that the chapters have been printed as they were submitted by the various authors. This results in a good deal of redundancy. For example, the information on printed circuits appears in at least two chapters and flat wiring in three.

Frank Keister, in his chapter on soldered, welded, and mechanical terminating systems, begins with a comparison of termination techniques from the standpoint of reliability, design, ease of manufacture,

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and maintainability. His section on wire-wrap is brief, but it contains important data on the reliability of this technique, including the effects of various environmental factors—important because of the relatively recent arrival of wire-wrapping on the electronic production scene.

The chapter on connector systems provides the designer with significant information for connector selection. A table compares the characteristics of 21 plastics used as insert materials. Another valuable section provides working formulas that enable the reader to calculate failure rates based on the following: insert material, current load through the contact, size of contact, insert-temperature rise, ambient temperature, maximum operating temperature, number of active contacts, and mating and unmating cycles.

Elmer Goodwin's chapter on hookup wire, multiconductor cable, and terminating devices describes alloys used in conductors, and it contains data on insulating and jacket materials. There is a section on thermocouples and thermocouple leads.

**Coax.** As for coaxial cable and connectors, the material by Jack Spergel on this topic alone is worth the price of the book. Spergel goes beyond the usual domain of a handbook. Beginning with Maxwell's field equations, he develops the formulas governing electric and magnetic-field propagation down transmission lines. The additional topics are too voluminous to list, other than to note that they include power handling, voltage-standing-wave ratio and attenuation, and their variations with just about any line or load condition.

There are chapters on telephone cable, together with high-voltage-, magnet-, and flat-wire.

There has been little written on telephone cable technology (outside of telephone publications), and the chapter on telephone cable will probably be useful to engineers on the outside who wish to know something of telephone cabling techniques. It covers cable used for inside and outside plant, and splicing techniques, and discusses wideband

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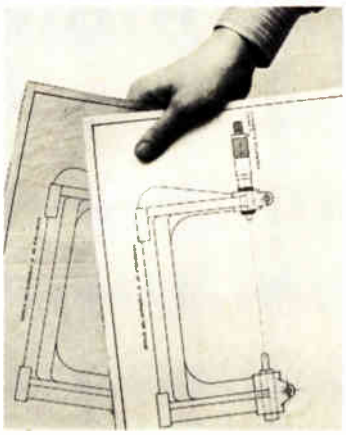

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signal distribution, such as that used in CATV applications.

The chapter on printed-circuit boards considers their fabrication and electrical and thermal characteristics, besides throwing in some historical titbits, such as the fact that pc boards date back to a British invention of 1903. Pc connector design is also dealt with, and the section on reliability, though brief, is important in view of the low confidence many engineers have in the one-piece pc connector.

In a well-written chapter on formed high-frequency circuits, Joseph Marshall discusses the electrical properties of strip line and microstrip. He explains how some semi-lumped circuit components can be formed on a pc board to behave as inductive and capacitive reactances, the equivalent of inductors and capacitors. He also describes the basis of strip-line resonant-circuit design.

**Performance.** Burton Gerpheide has written a concise but satisfactory evaluation of flexible, flat-printed wiring. He discusses the electrical and mechanical characteristics of flat wire along with its performance at radio frequencies.

John McCormick of the Air Force's Rome Air Development Center was chosen to prepare a chapter on microelectronics. The RADC has been deeply involved in the reliability of technology processes, and excellent samples of its investigations are presented in this chapter. McCormick presents concise discussions of many of the technologies employed in microelectronics such as thin- and thick-film fabrication processes. Some scanning-electron-microscope photographs, along with some good text discussion, provide excellent insight into these metalization techniques. The chapter goes into chip bonding and wire bonding, along with some detailed reliability data.

The glossary lists many of the terms used in the book, and an index is well-structured. Unfortunately, not all terms contained in the glossary appear in the index.

—Stephen E. Grossman,
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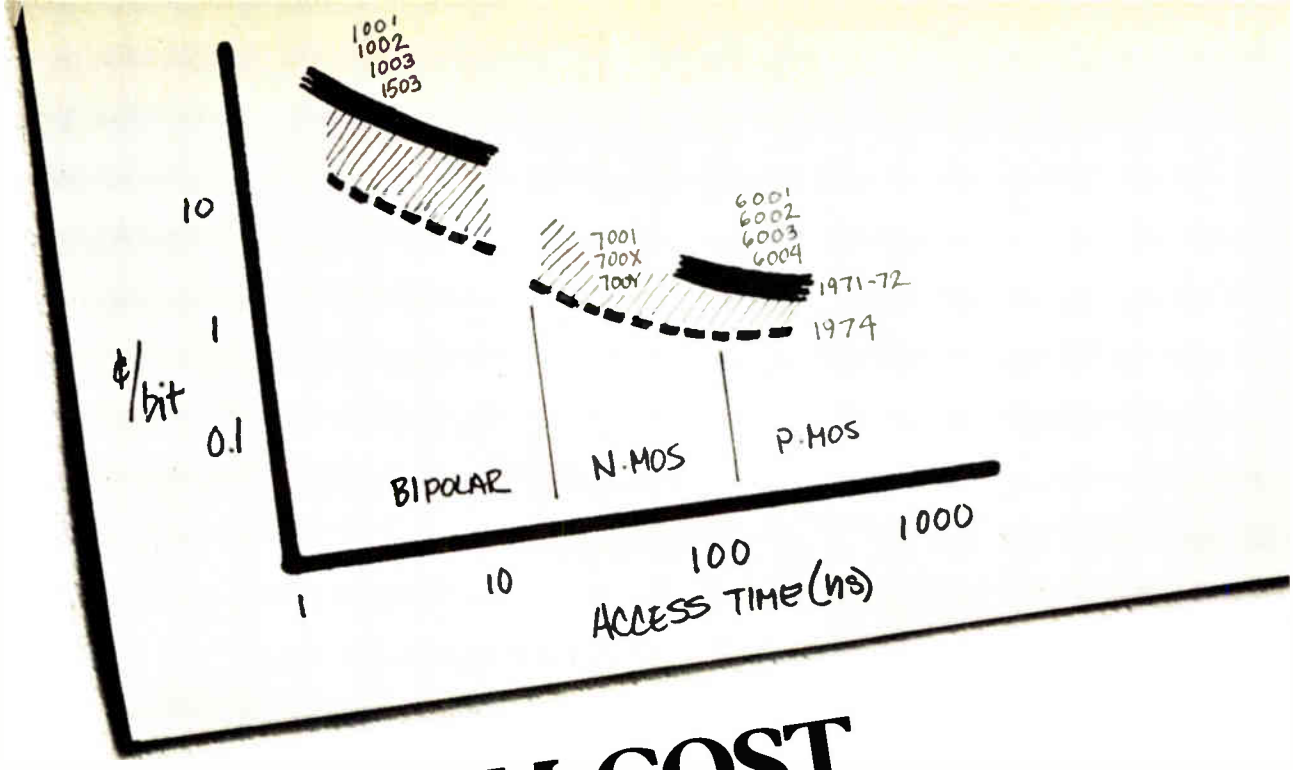


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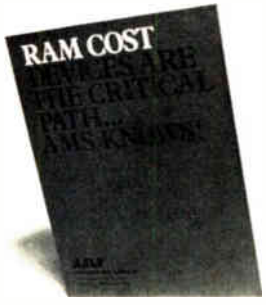


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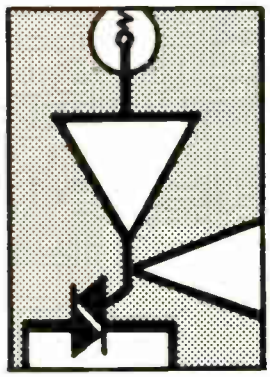

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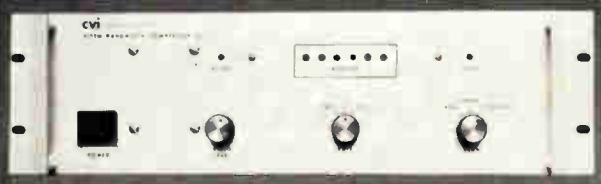

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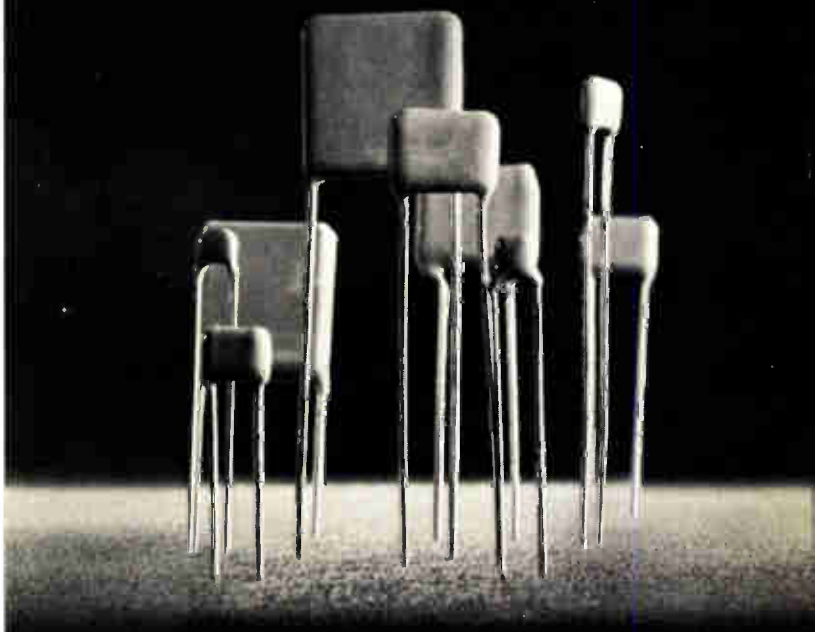

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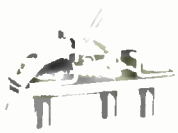

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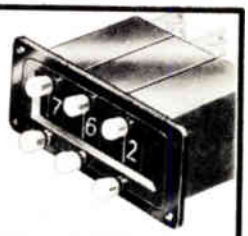

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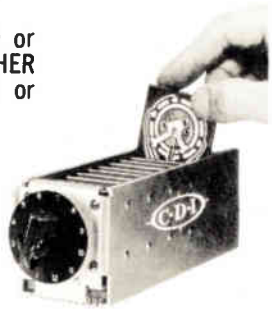

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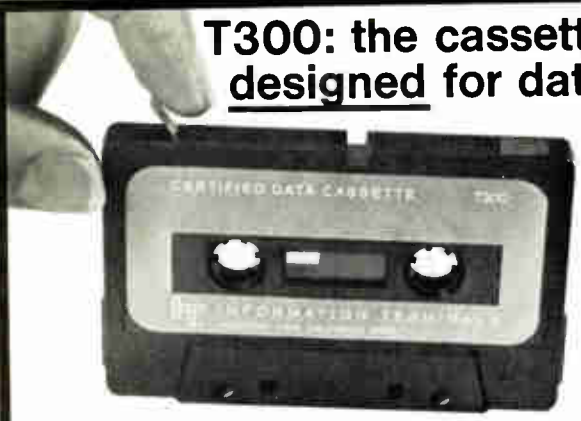

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