VOL. 18 NO. 10

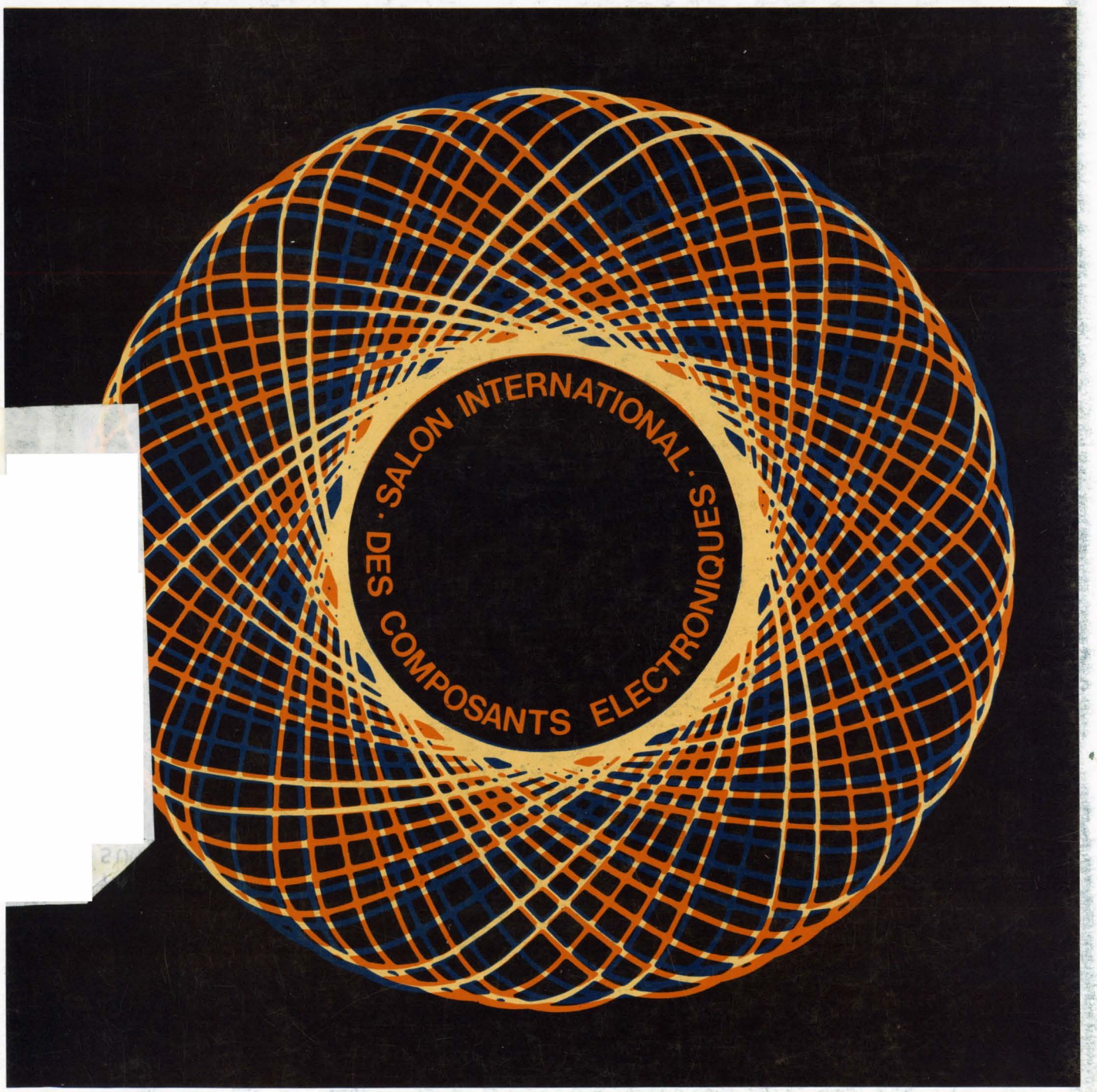
# Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 10, 1970



**The Paris Components Show** – where East meets West. This year's huge international trade exposition drew about 80,000 visitors and 784 companies from 20 countries, including the U.S. Products on exhibition? From microwave tubes to memories to LSI devices. For the story on Europe's big show, see p. 25



# If price and performance are important— here's a 7 MHz value

This is a lab-quality, all-solid-state scope—at a price you'd ordinarily expect to pay for older vacuum-tube models.

**Value** – DC to 7 MHz bandwidth. This frequency range covers audio, video and most control circuit applications.

**Value**—5 mV to 20 V per division deflection factor. Here is sufficient capability to pick up most electronic or electro-mechanical system outputs without distortion or need for additional amplifiers.

**Value**—Rock solid triggering with capabilities ordinarily found only in more expensive lab type oscilloscopes . . . triggered or recurrent sweep, single-sweep, and automatic triggering.

**Value**—Low drift, long-term stability. Field effect transistors virtually eliminate drift from temperature changes, shock or vibration. Long-term stability means less frequent calibration.

**Value**—Easy to use. Logical arrangements of controls, beam finder, auto-triggering make operation easy. Interlocking controls on sweep time and magnifier prevent readout errors.

**Value**—Easy-to-see display. Internal graticule, 8 x 10 cm CRT for measurement accuracy. Bright, small spot-size trace increases visibility and resolution.

**Value**—Available in single channel cabinet or rack versions (1215A or 1215B), or in dual-channel cabinet or rack versions (1217A or 1217B). Electrical characteristics are identical. Rack version is only 5¼" high. Panel on the cabinet version is about the size of this page.

**Value** – Price, 1215A/B, $950; 1217A/B, $1175. Add up the features, then divide by price and you'll find this is the greatest performance/dollar value ever offered. 080/8

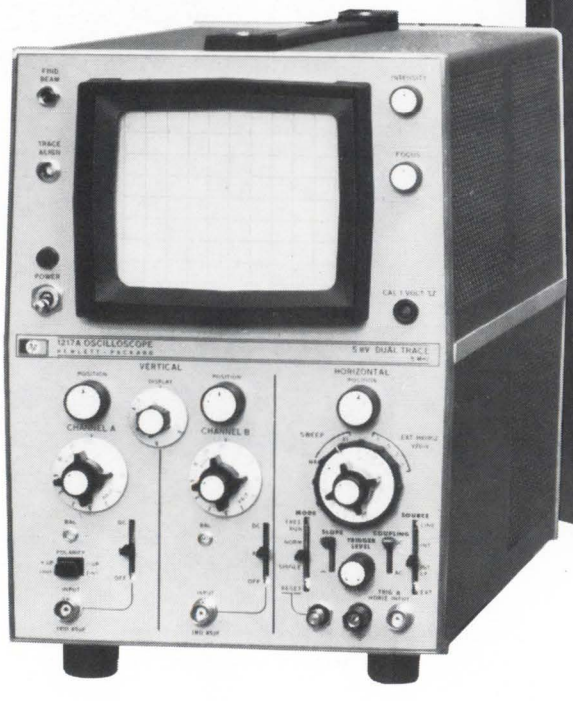
These 7 MHz oscilloscopes are new members of HP's growing family of low- and mid-frequency oscilloscopes. In addition to these new mid-range scopes you have 500 kHz scopes in 14 models with your choice of: Single or dual trace, 100 $\mu$V/cm or 5 mV/cm deflection factors, conventional display or variable persistence and storage, all in cabinet or rack versions.

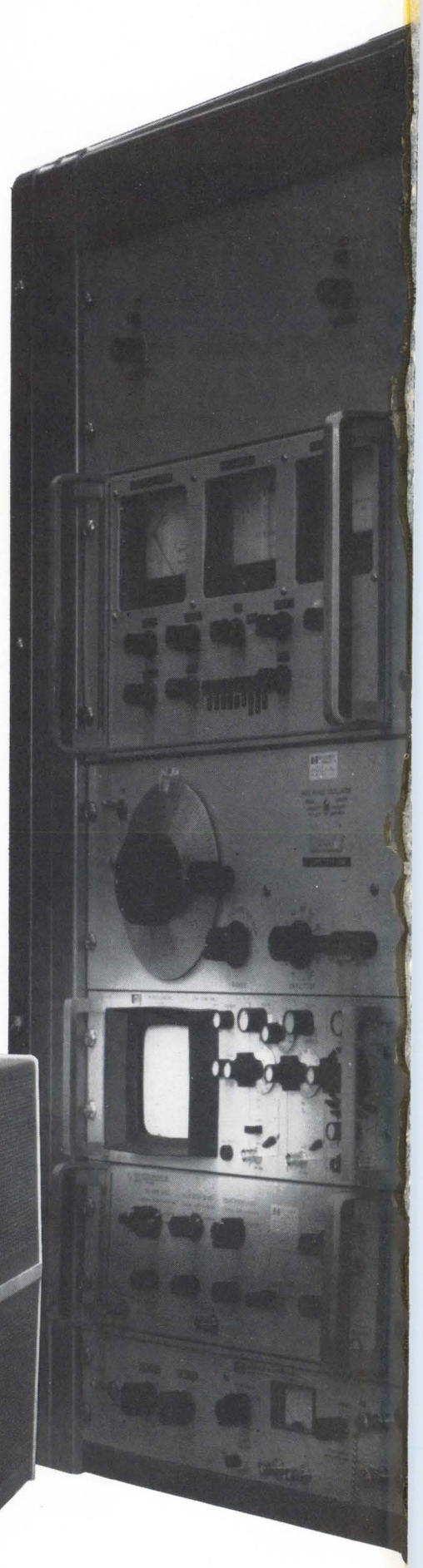
If you're looking for accurate mid-frequency measurements, ease of use, reliability—all at a low cost—here's a real 7 MHz value!

Call your local HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS



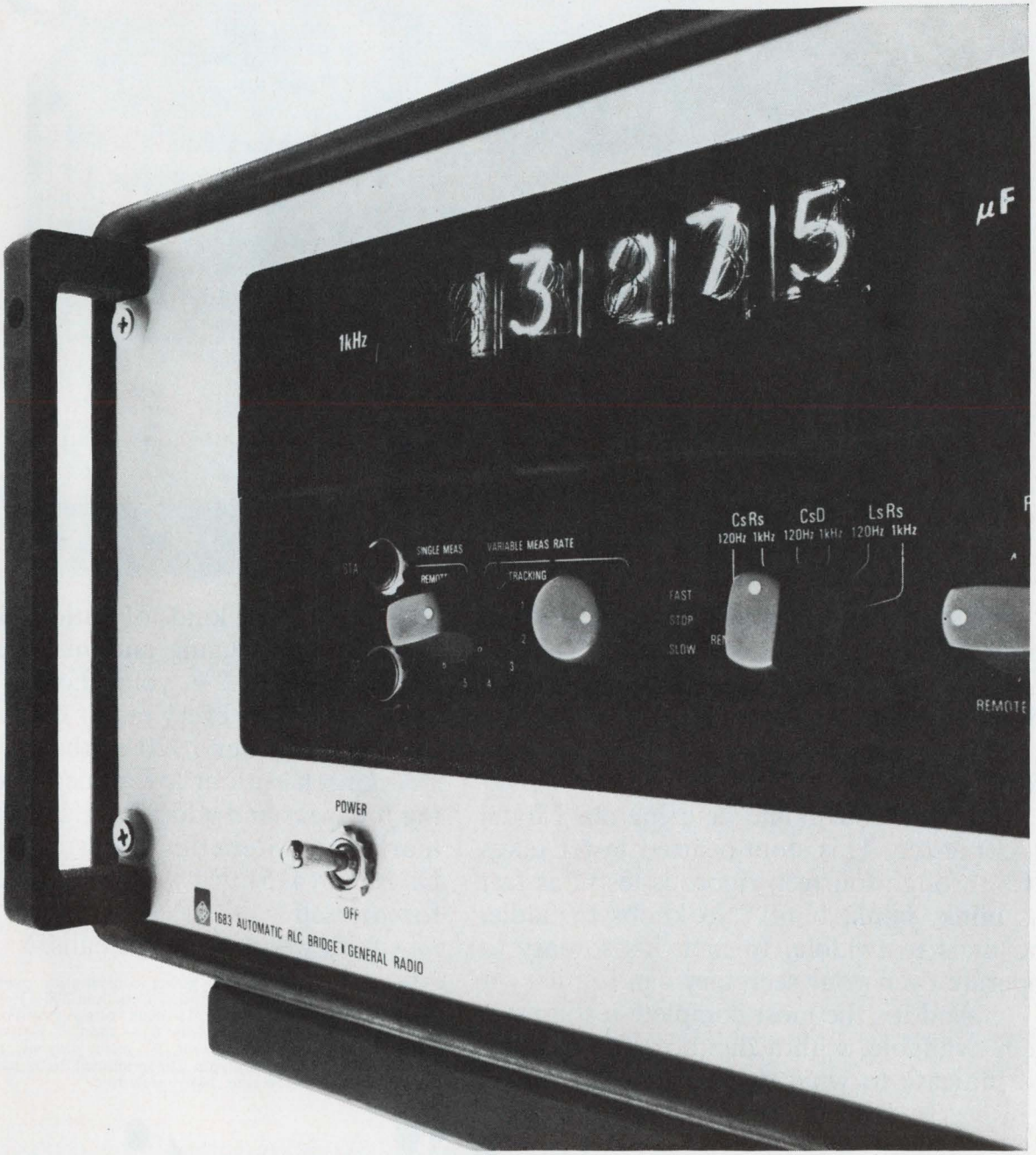
INFORMATION RETRIEVAL NUMBER 212

# Suppose you wanted an Automatic RLC Bridge

that could measure up to 2 MΩ resistance, 2000 H inductance, and 0.2 F capacitance, plus equivalent series resistance and leakage current. A bridge with 5-digit resolution for reactance and resistive readouts, automatic decimal point and units of measurement; a 20-measurements-per-second capability; 120-Hz and 1-kHz test frequencies; 5-terminal connections to preserve a basic 0.1% accuracy; a built-in 0 to 3-V bias or external bias to 600 V; optional remote programmability and data output.

And prices that start at $4,215. (in U.S.A.)

# Where could you possibly find such a bridge?




1683 Automatic RLC Bridge by GENERAL RADIO

West Concord, Mass. 01781 Tel: (617) 369-4400 Europe: Postfach 124, CH 8034 Zurich, Switzerland

INFORMATION RETRIEVAL NUMBER 2

# Is your IC tester physically fit?


Does your tester test comparators and op amps?

Does your tester test with single card programming?

Is your tester simple to operate and fast?

If not, you should be using our Model 1420 tester. This stout-hearted tester takes ICs through fourteen rigorous tests* as fast as blink, blink, blink. No knobs to fiddle, no dials to twiddle. In fact, it's so easy to operate even your secretary can use it.

And it's the most complete testing system available, with a digital readout meter to indicate to what degree each IC passes or fails. Plus, all kinds of options like classification, data logging and an accuracy rating from 1% to 5%, your choice.

That's why every major op amp manufacturer owns our 1420 or the 1410.

Check out our low priced line by writing for specs and addendum. Better yet, call marketing, Signetics Measurement Data Division, (415) 961-9384. And see the line for yourself.

Yes, we make house calls.

*The fearsome fourteen...1) power consumption overrange (greater than 200%), 2) power consumption (less than 200%), 3) offset voltage (source resistance zero ohms), 4) offset voltage (source resistance programmed), 5) + supply sensitivity, 6) − supply sensitivity, 7) common mode rejection, 8) bias current, 9) offset current, 10) gain (programmed full load), 11) gain (programmed light load), 12) noise, oscillation, 13) + slew rate, 14) − slew rate.

**Signetics** MEASUREMENT/DATA

Signetics, Measurement/Data, 341 Moffett Blvd., Mountain View, Calif. 94040/A subsidiary of Corning Glass Works

INFORMATION RETRIEVAL NUMBER 3

VOL. 18 NO.

# Electronic Design 10

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 10, 1970

## NEWS

21 **News Scope**

25 **Big show with an eye for the tiny**
Paris components exhibition lures manufacturers from 20 countries, and they stress miniaturization.

30 **Pilots ask FAA for proximity warner—now**
A cheaper device is sought instead of expensive time-frequency system under slow development.

32 **Navy to computerize its message processing**
Device under test screens radio transmissions to ships and accepts only those that are 'relevant.'

34 **Laser or millimeter space communications?**
Both can do the job, 3 specialists conclude, but millimeter system can be put into operation first.

39 **Washington Report**

## TECHNOLOGY

76 **Predict intermodulation distortion** from cross-modulation measurements. Third-order intermod and cross-mod have the same origin—and specs.

82 **Clock and control with TTL.** Standard logic components display time and generate command signals for as little as $180.

92 **Use ECAP to design transistor models**—and refine approximate circuits to compute more accurate parameters.

98 **Synchro-to-digital converters:** Part 5 (conclusion) describes a mathematically exact encoder and discusses multispeed design.

106 **Get to know your local SBA agent.** If you qualify, he can help you obtain loans, management assistance, and government contracts.

112 **Ideas for Design**

121 **Product Source Directory:** Oscillators

## PRODUCTS

129 **ICs & Semiconductors:** Schottky-clamped TTL ICs feature 3-ns delays.

136 **Modules & Subassemblies:** Chopperless op amp holds drift to 0.25 $\mu$V/°C.

140 **Data Processing:** Terminal with photochromic-glass CRT makes hard copy.

145 Instrumentation
149 Components
151 Microwaves & Lasers
155 Packaging & Materials
156 Tools & Engineering Aids
176 Product Index

### Departments

75 **Editorial:** Don't take technology out of ecology

13 Designer's Calendar
46 Sidelights
158 Evaluation Samples
160 Design Aids
162 Annual Reports
164 Application Notes
166 New Literature
174 Advertisers' Index

Information Retrieval Service Card inside back cover

**Cover:** Designed by Art Director Clifford M. Gardiner.

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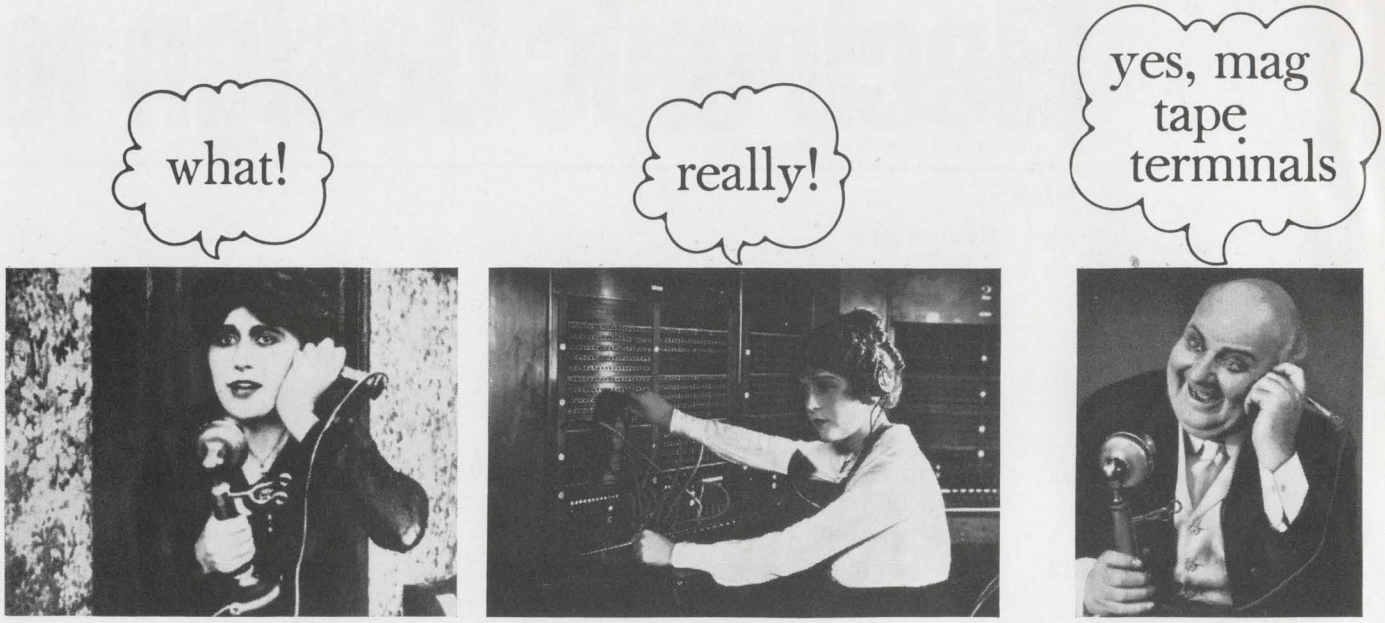
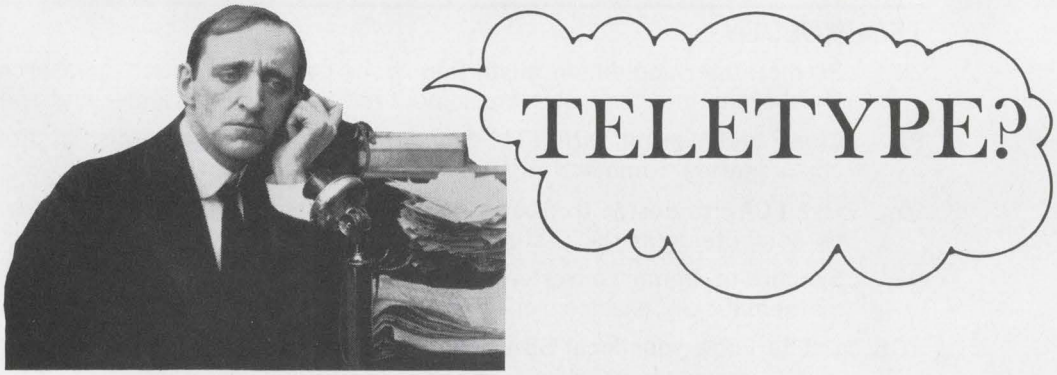


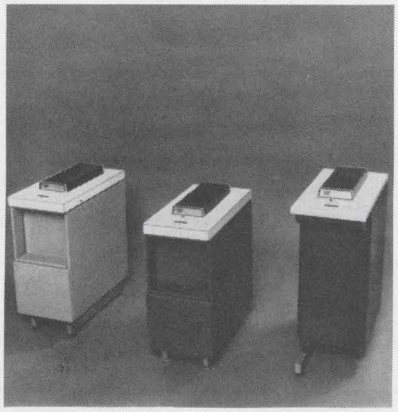




It's true.

After helping a jillion feet of paper tape wind and unwind its way through communications systems everywhere, Teletype announces the addition of magnetic tape data terminals.

There are some basic advantages in both mediums. But as you are well aware, the medium that's right for a system depends a lot on the application criteria.

The new magnetic tape data terminals have many operational features that make life less complicated for the operator.



*New, modular line of Teletype® 4210 magnetic tape data terminals.*

For example, take a look at the tape cartridge, which was specifically designed for reliability required for data transmission.

Its vital statistics are: 3″ x 3″ x 1″.

It contains 100 feet of ½″ precision magnetic tape.

It will hold 150,000 characters of data, recorded at a density of 125 characters per inch. The equivalent of a 1000 foot roll of paper tape.

This means that your data is easier to store, easier to handle, easier to work with than ever before. And it's reusable.

Teletype is a trademark registered in the U.S. Pat. Office.

The units have a "fast access" switch which will move tape forward or reverse at a speed of 33 inches per second. A digit counter provides a reference point to help locate various areas of the tape.

Four ASCII control code characters can be recorded in the data format to aid character search operations. When the terminal's "search" button is pressed, tape moves at the rate of 400 characters per second until the control code selected is detected. Then the terminal stops the tape automatically.

A "single step" switch is also provided which enables you to move the tape forward or backward one character at a time. In editing or correcting tape, you can send a single character using this feature.

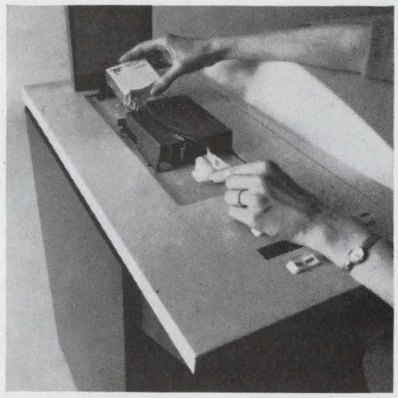
Also magnetic tape adds high speed on-line capability to low speed data terminals.

You can zip data along the line at up to 2400 words per minute. For example: Take a standard speed Teletype keyboard send-receive set, and a typical typist. Add a new magnetic tape unit to this combination and the on-line time savings can pay for the magnetic tape terminal in short order.

You can take better advantage of voice grade line speed capabilities.

An operator can prepare data for magnetic tape transmission using the keyboard terminal in local mode. Then send it on-line via the magnetic tape terminal up to 2400 words per minute.

These new modular magnetic tape data terminals offered by Teletype are perfectly compatible with model 33, model 35, model 37 and Inktronic® keyboard send-receive equipment.



*Straight-through threading makes tape loading and unloading exceptionally easy.*

They can send or receive at high or low speed. Or can be used independently as stand-alone terminals on-line.

If you would like to know more about this new line of Teletype magnetic tape data terminals, please write Teletype Corporation, Dept. 89-15, 5555 Touhy Avenue, Skokie, Illinois 60076.

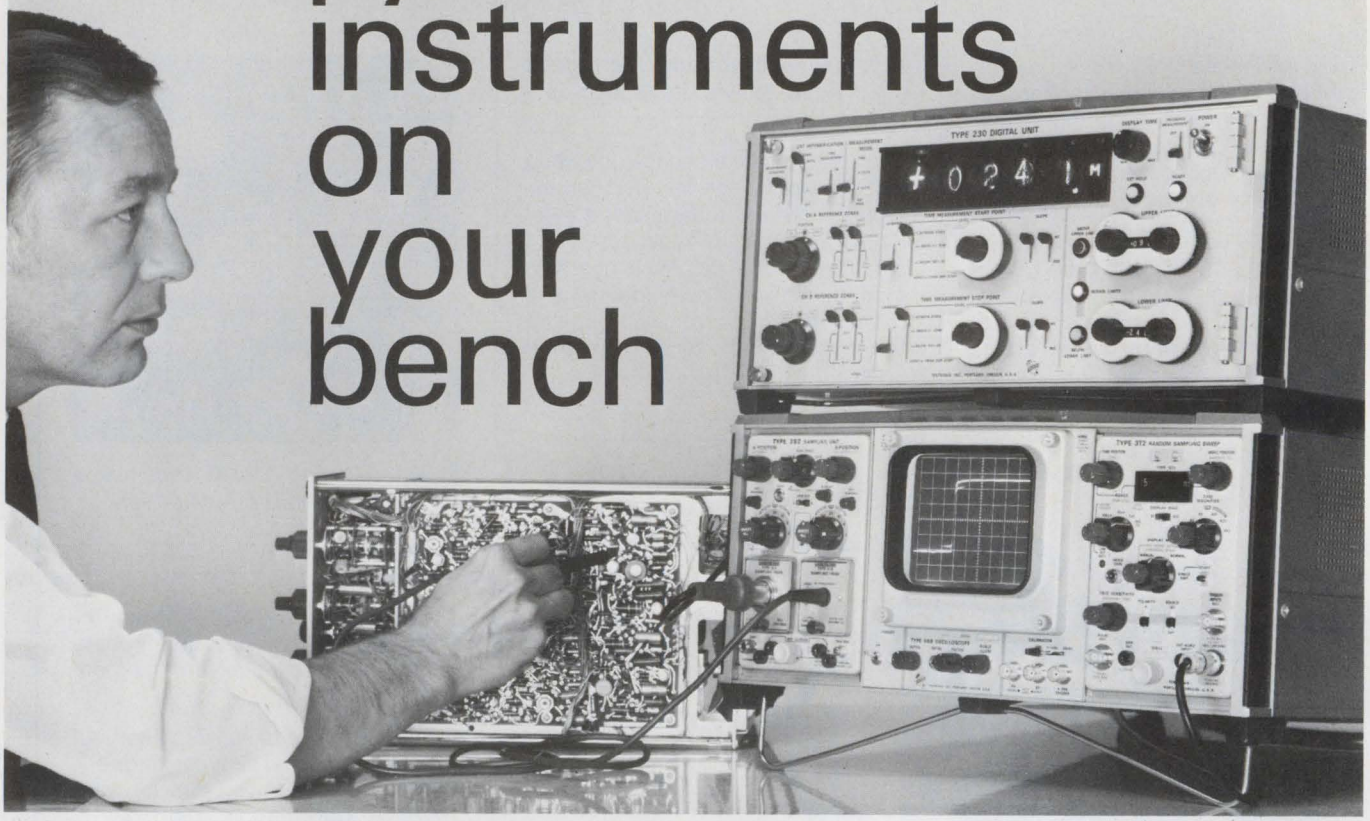
*Teletype 4210 magnetic tape data terminal with 37 keyboard send-receive set.*

TELETYPE

***machines that make data move***

INFORMATION RETRIEVAL NUMBER 4

# digital system instruments on your bench




## *Digitize Analog Information*

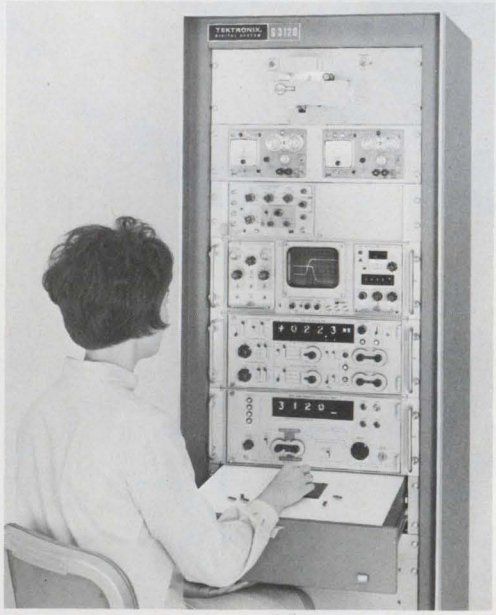
The Type 568/230 Digital Oscilloscope system provides digital readout of measurements from waveforms that are displayed in analog form on the CRT. The basic measurement characteristics are determined by the combination of the sampling sweep unit, the sampling vertical unit and the individual sampling heads used.

The Type 568/230 enables the engineer, technician or production worker to make dynamic switching time-measurements with greater speed, convenience and repeatability than is possible by making measurements directly from the cathode-ray oscilloscope display. Typical measurements include pulse amplitudes, risetime, delay time, storage time, pulse width and other related measurements.

The Type 568 Oscilloscope and the Type 230 Digital Unit are basic components in all Tektronix Digital Measurement Systems. Starting on your bench in development, progressing to a semi-automated system in pilot production and continuing in a fully-automated system in regular production, they provide the ability to correlate data on your product through all its testing phases.

| | |
|---|---|
| Type 568 Oscilloscope without Plug-In Units | $1025 |
| Type 230 Digital Unit | $3520 |
| Instrument Combination Pictured Above | $7330 |

U.S. Sales Prices FOB Beaverton, Oregon



For complete information on digital and sampling instruments, please contact your local Field Engineer or refer to your Tektronix catalog.

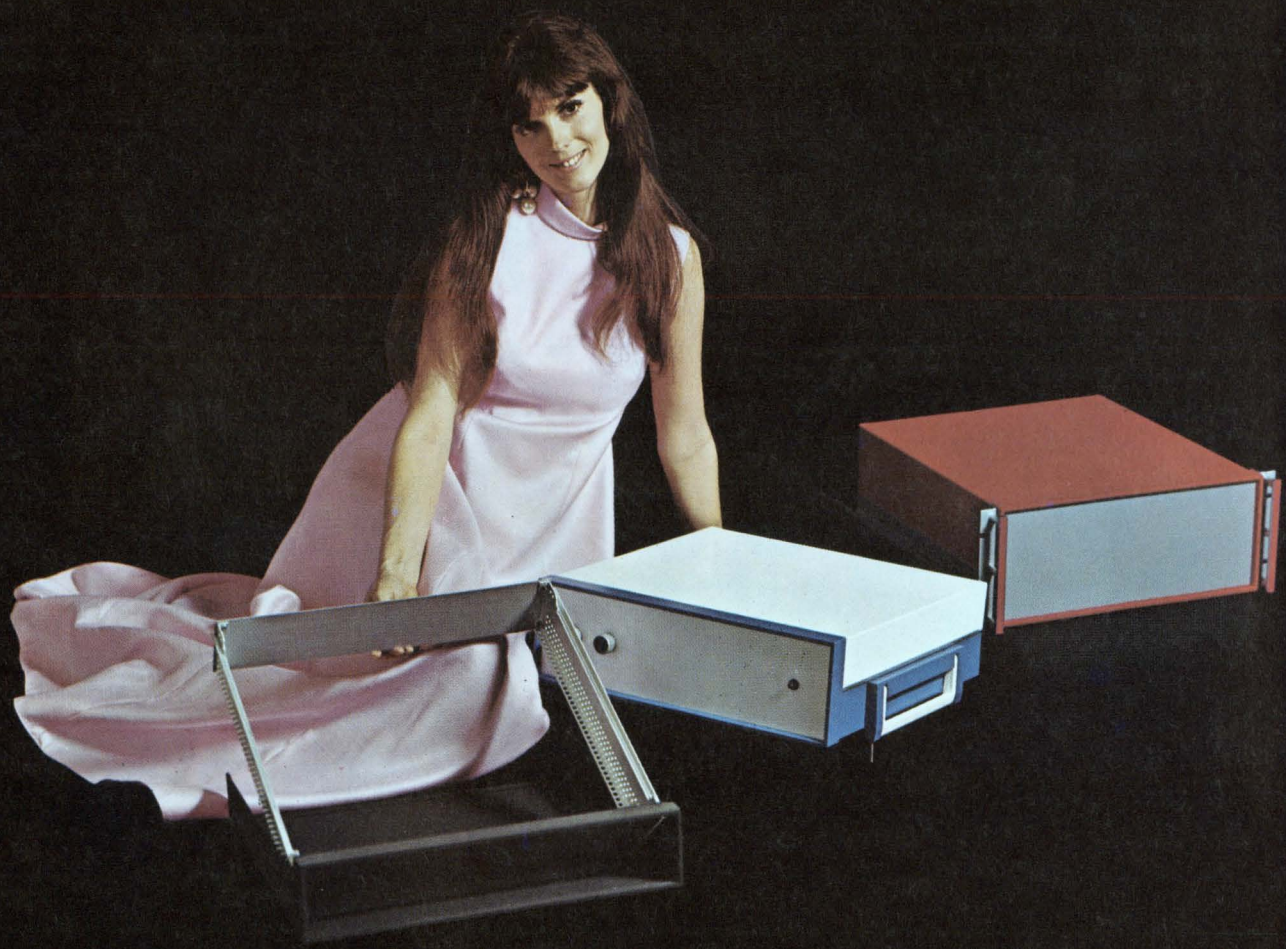
**Tektronix, Inc.**

***committed to progress in waveform measurement***

INFORMATION RETRIEVAL NUMBER 5



INFORMATION RETRIEVAL NUMBER 6 ►



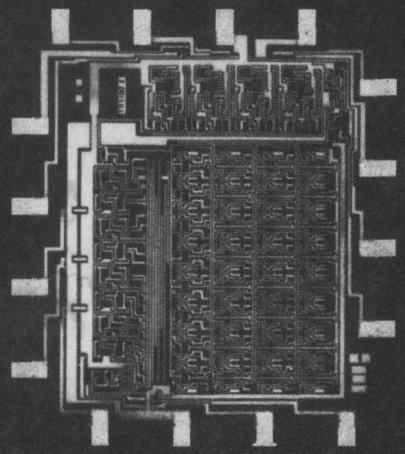
# Optima 17

an elegant combination of chassis and case. Rackable.

Optima enclosures, a division of Scientific-Atlanta, Inc. P.O. Box 13654, Atlanta, Georgia 30324. Telephone 404-939-6340

# Who says you can't get beam lead?

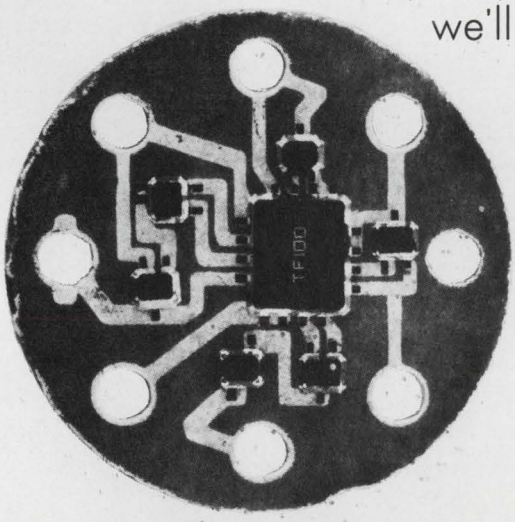
Raytheon beam lead devices
available now in chip form,
in standard or custom packages,
or in hybrid assemblies.



Help! We're up to our ears in beam lead semiconductor devices. All kinds. And more coming every day.

**Hybrids, cans, dips or chips**

Buy the chips. Take them in TO-18 cans or DIPs. Get them in custom packages. Or take advantage of our capability to design, assemble and completely test them in custom hybrid assemblies. Any way you need them, we'll sell them. Now. So don't just stand there. Send orders. To the company that gets the ideas and delivers the goods. Raytheon Semiconductor, 350 Ellis St. Mountain View, California 94040. Phone (415) 968-9211.



Raytheon custom beam lead hybrid assembly

## Come and get them

### Beam lead T²L RAY I & II series

| | |
|---|---|
| RG130, 1, 2, 3: Dual 4 input line driver | Now |
| RG200, 1, 2, 3: Expandable single 8 NAND gate | Now |
| RG220, 1, 2, 3: Quad 2 input NAND gate | Now |
| RG230, 1, 2, 3: Quad 2 input AOI expander | Now |
| RG240, 1, 2, 3: Dual 4 input NAND gate | Now |
| RG250, 1, 2, 3: Expandable quad 2 AOI gate | Now |
| RG310, 1, 2, 3: Exp. dual output, dual 2 input AOI gate | Now |
| RG320, 1, 2, 3: Triple 3 input NAND gate | Now |
| RG380, 1, 2, 3: Hex inverter | Now |
| RF100, 1, 2, 3: Dual J-K flip-flop (separate clocks) | Now |
| RF110, 1, 2, 3: Dual J-K flip-flop (common clock) | Now |
| RF200, 1, 2, 3: J-K flip-flop (AND inputs) | Now |
| RF210, 1, 2, 3: J-K flip-flop (OR inputs) | Now |
| RF9601/8601: Retriggerable monostable multivibrator | Now |
| RL10, 1, 2, 3: Fast full adder | Now |
| RL20, 1, 2, 3: Dependent carry fast adder | Now |
| RL30, 1, 2, 3: Independent carry fast adder | Now |
| RL40, 1, 2, 3: Carry decoder | Now |
| RL60, 1, 2, 3: Four bit storage register | Now |
| RL70, 1, 2, 3: Four bit storage register | Now |

### Beam lead T²L RAY III series

| | |
|---|---|
| RG3380, 2: Hex inverter | Now |
| RG3390, 2: Dual 4 input AND gate (split outputs) | Now |
| RG3410, 2: Quad 2 input NOR gate | Now |
| RF3200, 2: J-K flip-flop (AND inputs) | Now |

### Beam lead linear circuits

| | |
|---|---|
| RM709: Operational amplifier | Now |
| RM741: Operational amplifier | Now |

### Beam lead transistors

| | |
|---|---|
| BL1000: 2N930 equivalent. TO-18 cans 6/15. Chips | Now |
| BL1001: 2N2484 equivalent. TO-18 cans 6/15. Chips | Now |
| BL1002: 2N918 equivalent. TO-18 cans 6/15. Chips | Now |
| BL1003: 2N2221 equivalent. TO-18 cans 6/15. Chips | Now |
| BL1004: 2N2221A equivalent. TO-18 cans 6/15. Chips | Now |
| BL1005: 2N2222 equivalent. TO-18 cans 6/15. Chips | Now |
| BL1005QD: Quad DIP 2N2222 | Now |
| BL1006: 2N2222A equivalent. TO-18 cans 6/15. Chips | Now |
| BL1007: 2N2906 equivalent. TO-18 cans 6/15. Chips | Now |
| BL1008: 2N2906A equivalent. TO-18 cans 6/15. Chips | Now |
| BL1009: 2N2907 equivalent. TO-18 cans 6/15. Chips | Now |
| BL1010: 2N2907A equivalent. TO-18 cans 6/15. Chips | Now |
| 2N929: Available in chips only | Now |
| 2N2369: Available in chips only | Now |
| 2N2483: Available in chips only | Now |
| 2N2604: Available in chips only | Now |
| 2N2605: Available in chips only | Now |
| 2N2894: Available in chips only | Now |
| 2N2945: Available in chips only | Now |

### Beam lead diodes

| | |
|---|---|
| IN914: Available in chips only | Now |
| IN3600: Available in chips only | Now |

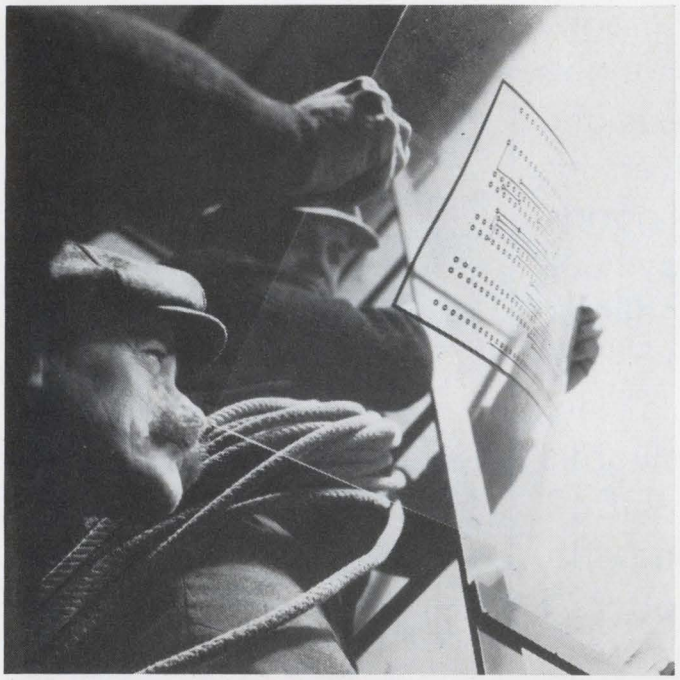
### Beam lead memories

| | |
|---|---|
| RR6100: 64 bit bipolar RAM (0° to 75°C) | 6/15 |
| RR5100: 64 bit bipolar RAM (−55° to 125°C) | 6/15 |
| RR6110: 256 bit bipolar RAM multi-chip array | 6/15 |

RAYTHEON

INFORMATION RETRIEVAL NUMBER 7

# Our plot to overthrow the electronics industry.



People are going to hate us.

Less than a year in the business, and already we're starting a revolution.

It's a revolution that revolves around our plot. A photoplot.

The idea is to produce a precision photoplotter system to generate all kinds of printed circuit and IC mask artwork.

The idea is to produce a cheap plot that is still the most accurate plot anywhere. It's shutterless to make it sharper and faster: accurate to 1 mil (or ½ mil, optionally). There's also a proprietary attachment allowing the use of Polaroid Land Film to produce test plots at 5 times the normal speed.

The idea is to produce a photoplotter that needs no darkroom for loading or plotting.

The idea is our Compucircuit 100. $49,700, including a free IBM-compatible mag-tape system.

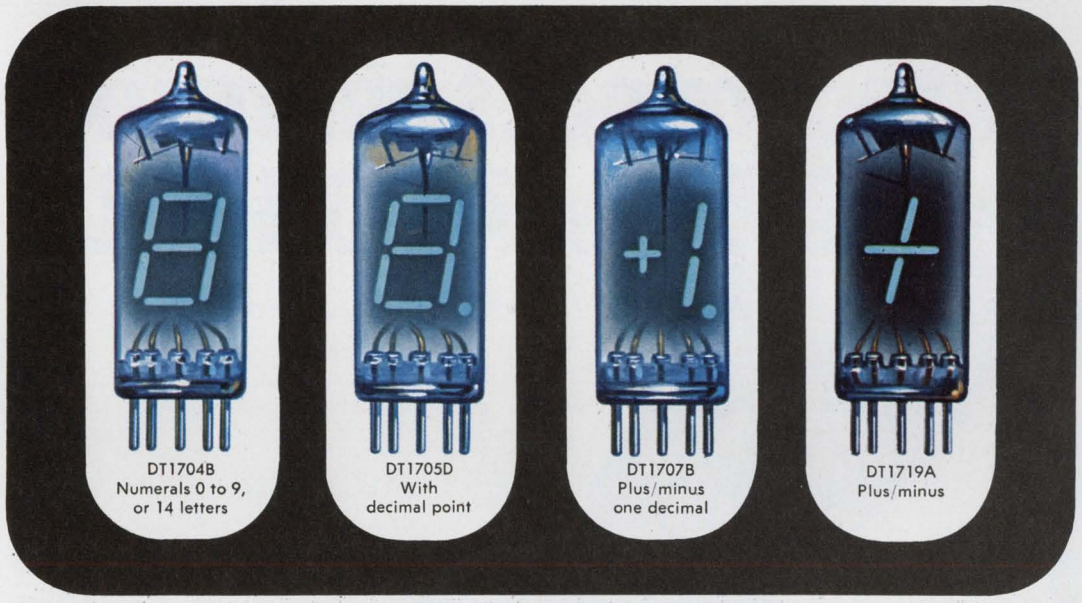
Instant revolution: take one home today and plug it in. Computervision, Northwest Industrial Park, South Avenue, Burlington, MA 01803, (617) 272-7240. See us at Booth 4932 Nepcon-East.

**Computervision Corporation**

Boy, have we got the vision.

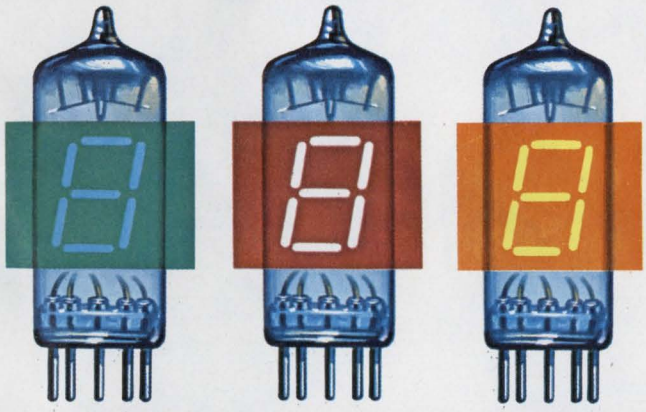
INFORMATION RETRIEVAL NUMBER 8

# The Tung-Sol® development that created a whole new set of digital display standards




STANDARD CONFIGURATIONS

Low-voltage, low-power drain (25 V and 1.6 V) permits battery-operated applications. Standard miniature tube base. Inexpensive logic/driver requirements. Meets MIL specs. Space-age-type segmented character. Single plane display. Standard alphanumeric, or special symbols. Optimum visibility under ambient light conditions. Common filters provide unlimited color selection for identification, or to heighten contrast. Circuit-board mounting, with solderable-lead option. Write, or phone for detailed technical information and pricing.



Standard filters provide color variation

DIGIVAC S/G™

VACUUM FLUORESCENT DISPLAY

**TUNG-SOL DIVISION**
**WAGNER ELECTRIC CORPORATION**
630 W. Mt. Pleasant Avenue
Livingston, N.J. 07039
TWX: 710-994-4865
Phone: (201) 992-1100; (212) 732-5426

Trademark TUNG-SOL Reg. U.S. Pat. Off. and Marcas Registradas

INFORMATION RETRIEVAL NUMBER 9

# Sylvania announces ninth-sourcing capability in 7400N TTL.

With eight other major sources of 7400N TTL already in the field, we'd be pretty silly to enter as a ninth source unless we had something very special to offer.

We do.

For a start, we guarantee* the hermeticity of every package to 1 x $10^{-7}$ cc/sec, 2% AQL. Try and find that spec on anybody else's data sheet.

We've also eliminated the only reason for ever considering plastic packages: price. Our Cerdip packages are priced directly competitive with any plastic package.

You can't get far in the 7400N business unless you have immediate availability, and we've got it. Your local Sylvania distributor has our complete line in stock right now.

For a starter, we have selected the 14 most useful types as shown in the table. There are 13 more to come and we will be telling you about them in the near future.

*Sylvania Electronic Components, Semiconductor Division, Woburn, Mass. 01801.*

| SYLVANIA CERDIP PACK | | |
|---|---|---|
| FUNCTION | TYPE | 100-999 |
| Quad 2 NAND Gate | SG7400N | .85 |
| Quad 2 NOR Gate | SG7402N | .97 |
| Triple 3 NAND Gate | SG7410N | .85 |
| Dual 4 NAND Gate | SG7420N | .85 |
| Single 8 NAND Gate | SG7430N | .85 |
| Dual 4 Buffer Gate | SG7440N | .97 |
| Dual 2 x 2 AND-OR-Invert Gate with Expander Inputs | SG7450N | .85 |
| Dual AND-OR-Inverter | SG7451N | .85 |
| 4 x 2 AND-OR-Invert Gate with Expander | SG7453N | .85 |
| Single AND-OR-Inverter | SG7454N | .85 |
| Dual 4-input Expander | SG7460N | .77 |
| Master/Slave J-K Flip-Flop | SF7472N | 1.31 |
| Dual Master/Slave J-K Flip-Flop | SF7473N | 2.15 |
| Dual "D" Flip-Flop | SF7474N | 1.88 |

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

*These integrated circuits are guaranteed to substantially conform to Sylvania's applicable specifications and be delivered free of defects in materials and workmanship. If they are defective in such respects, at Sylvania's election, Sylvania will either repair, replace or grant a credit at invoice prices if defective integrated circuits are returned to the factory pre-paid within one year after shipment. THESE GUARANTEES ARE IN LIEU OF ALL OTHER GUARANTEES EXPRESSED OR IMPLIED. Sylvania shall not be liable for special or consequential damages of any nature.

# Designer's Calendar

**MAY 1970**

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | | | | | | |

For further information on meetings, use Information Retrieval Card.

**May 19-21**
**Power Sources Symposium** (Atlantic City). Sponsors: U. S. Army Electronics Command, et al. Power Sources Division, U. S. Army Electronics Command, Fort Monmouth, N. J. 07703.

CIRCLE NO. 410

**May 26-28**
**Society for Information Display Symposium** (New York City). Sponsor: Society for Information Display. Bernard J. Lechner, RCA Laboratories, Princeton, N. J. 08540.

CIRCLE NO. 411

**May 26-28**
**IEEE Sixth Region Conference,** "West Into the 70's" (Seattle, Wash.) Sponsor: IEEE. P. R. Metz, Univ. of Washington, EE Dept., Seattle, Wash. 98105.

CIRCLE NO. 412

**JUNE 1970**

| S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
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| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 | 30 | | | | |

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◄ INFORMATION RETRIEVAL NUMBER 10

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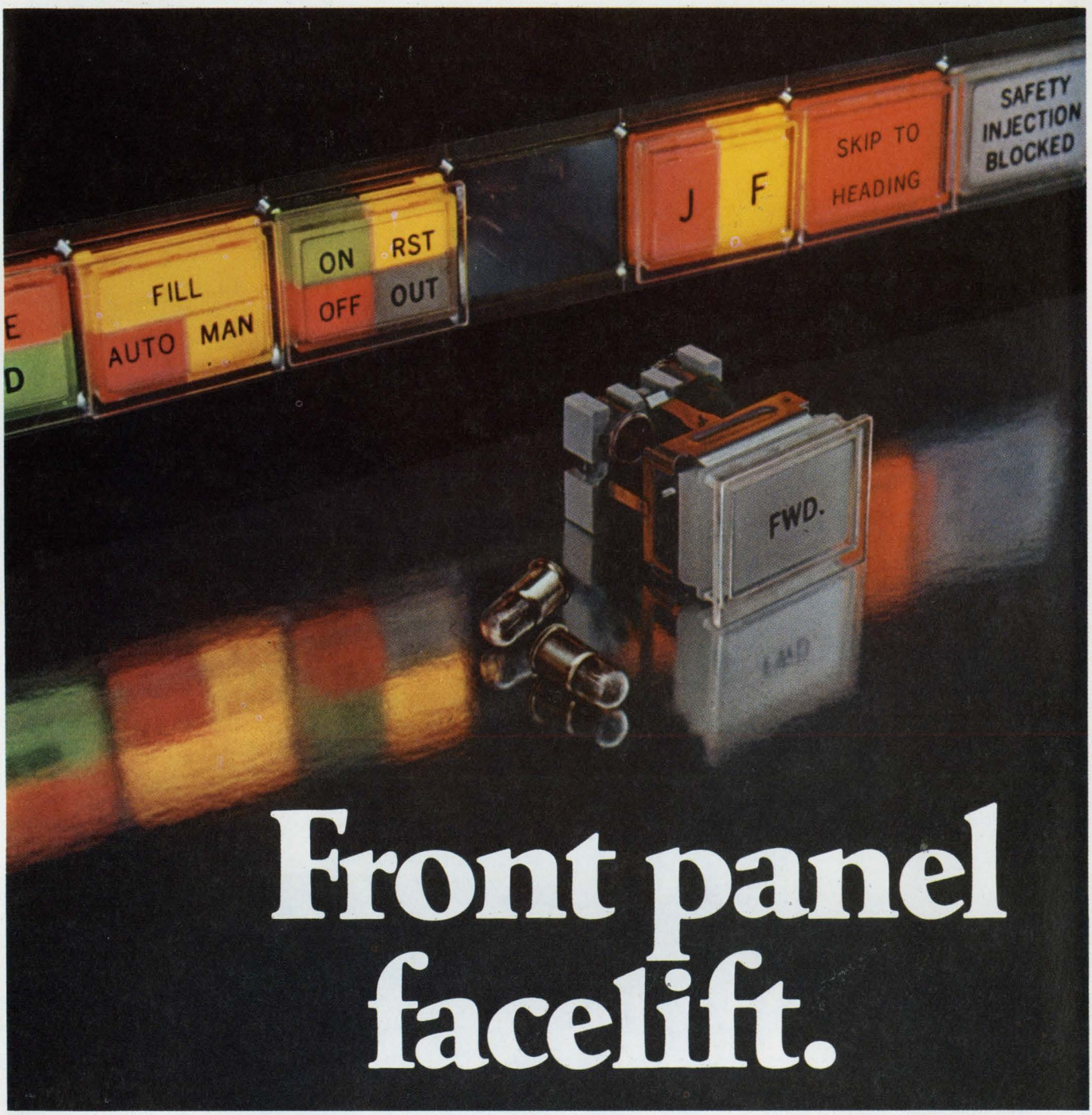


# Front panel facelift.

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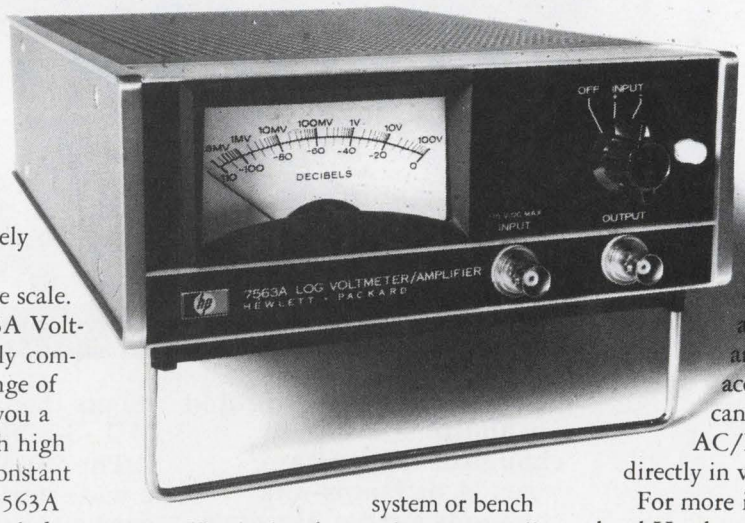
INFORMATION RETRIEVAL NUMBER 13

# Even if your data goes from  to  you can see it all on one display.




Some of your data will barely twitch an indicator.

Some of it goes right off the scale.

No problem. The HP 7563A Voltmeter/Amplifier logarithmically compresses data with a dynamic range of 110 dB—110 dB!—and gives you a single output that includes both high and low amplitude data with constant resolution and accuracy. The 7563A accepts positive or negative signals from vibration tests, geophysical measurements, pulse height analyzers, computers and similar sources, compresses the amplitudes logarithmically and feeds the results directly to a recorder or oscilloscope. The front-panel meter gives an instant visual display in dB. And when it's not performing that job, the 7563A will double as a voltmeter (calibrated from 0.3 mV to 100 V) for system or bench use. How's that for a voltmeter/amplifier with the modest price of $695 and one of the widest dynamic ranges you can buy?

To add AC log conversion and voltmeter applications to DC, use the 7562A with its 80 dB dynamic range. It's the only converter on the market that can measure the true rms value of an AC voltage. Turn it loose on vibration studies, biochemical data, seismographic studies, audio research or similar data with large asymmetrical wave forms and it will give you the most accurate log conversion you can get in AC. Or use it as an AC/DC voltmeter, calibrated directly in volts. Price is $995.

For more information, call your local Hewlett-Packard field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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4SC-9153R2

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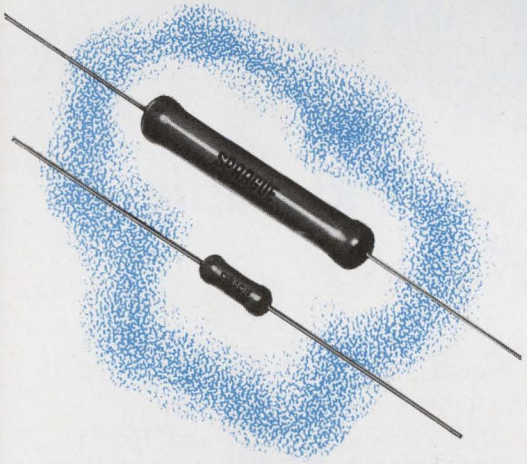

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• All-welded end-cap construction eliminates moisture along leads, also anchors leads securely to resistor body • Expansion coefficients of vitreous coating, ceramic core, and end caps are closely matched • Standard wattage ratings include 1, 2, 2.5, 3, 5, 7, 10, and 11 watts • Also available with radial tab terminals in ratings from 8 to 230 watts • **Request Engineering Bulletin 7410D**

4SR-9145R2

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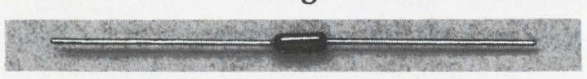

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The world could use more things like it. Low-noise in character. Highly stable (.01 to .0005%/C°) over long term. Thoroughly tested and proved true-blue. Immediately available. Delivered on time. And lifetime guaranteed. There's no broader line of glass-encapsulated temperature compensated zeners around.

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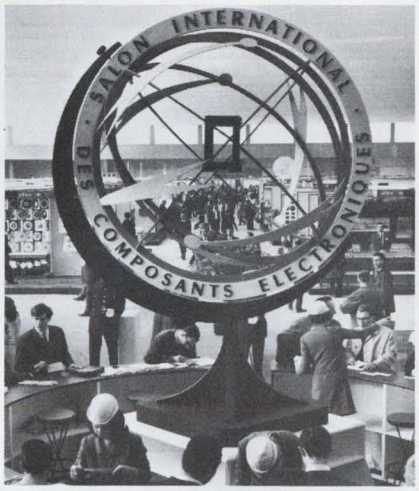
INFORMATION RETRIEVAL NUMBER 15

# Highlighting
## THE ISSUE

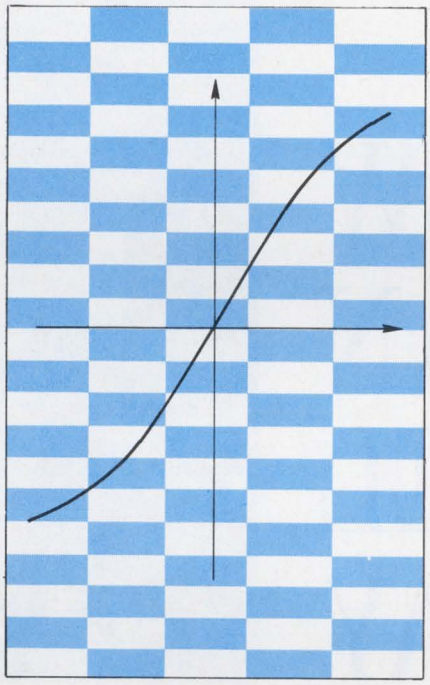



Every year they come from around the world—Americans, Germans, Italians, Japanese, Russians, Britons, Frenchmen and others—headed for the biggest electronic components show in the world: Salon International des Composants Electroniques in Paris.

The show lasted this year from April 3 to 8, and when it drew to a close, the management reported 80,000 visitors, 784 exhibiting companies and 20 nations represented.

Two broad trends emerged: miniaturization and mergers enabling European companies to compete with foreigners for growing commercial electronics orders.

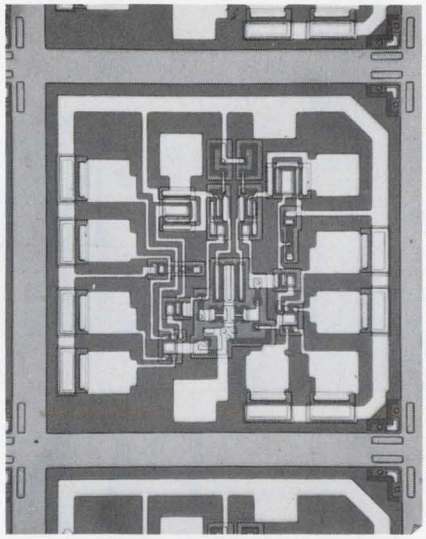
**PAGE 25**



It's a basic fact, but not apparently widely known, that the third-order intermodulation distortion level and the cross-modulation performance of a given device cannot be specified independent of each other.

Both phenomena are caused by a third-order or higher nonlinearity in the transfer characteristic of the device. So specifying either one of them defines the nonlinearity and, hence, specifies the other. Converting from one type of description to the other can be done analytically or by means of a graph, and much time can be saved by measuring only one of them and calculating the other.

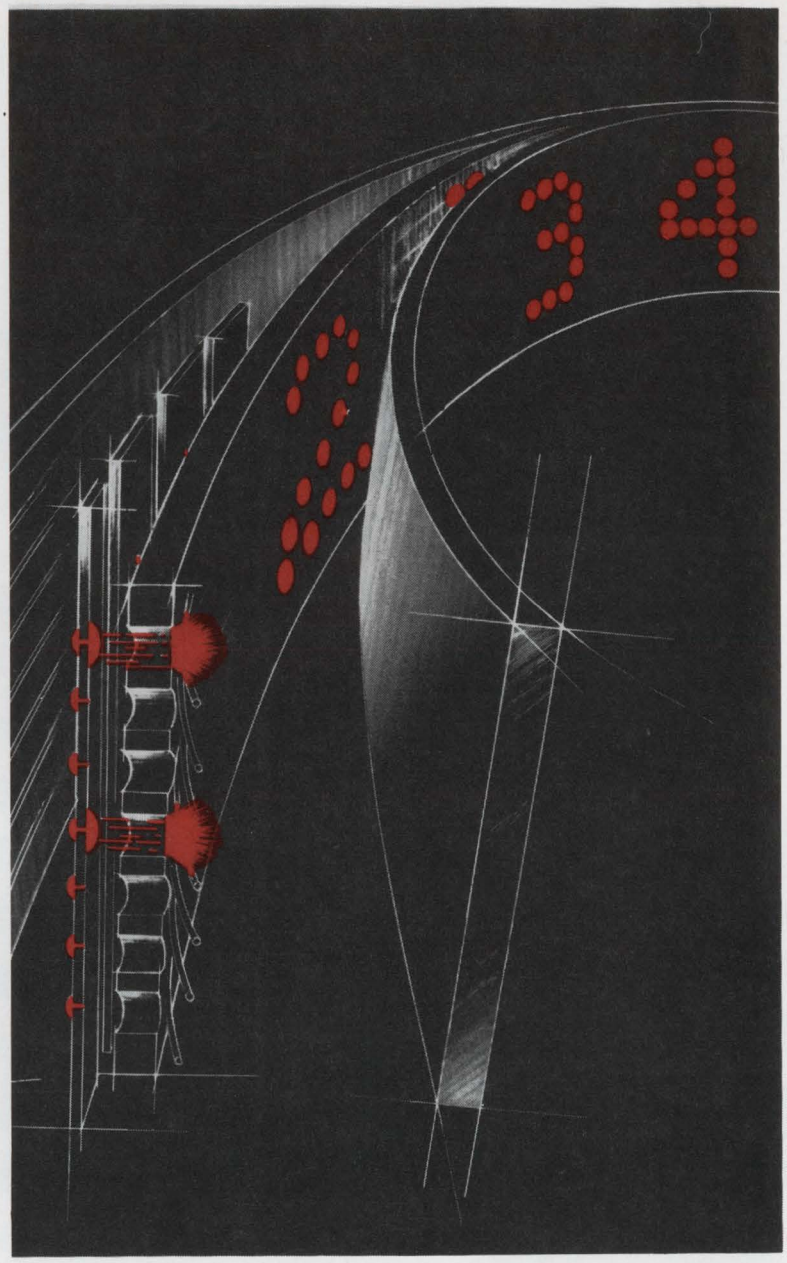
**PAGE 76**



Providing extremely fast switching speeds at low power levels, a new family of Schottky-clamped TTL integrated circuits features typical propagation delays of 3 ns while holding power dissipation to only 20 mW per gate. Designated as series 54S/74S, the new logic circuits use Schottky diodes to clamp active transistors, thus preventing conventional saturation.

Initiating this high-speed TTL line are two NAND gates and a 100-MHz flip-flop.

**PAGE 129**



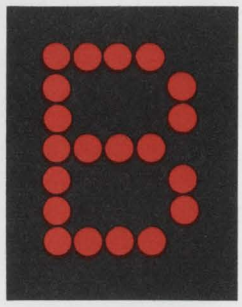
# NEW SELF-SCAN™ PANEL DISPLAY

## eliminates up to 90% of drive electronics

SELF-SCAN panel displays represent a Burroughs invention of panel design and circuitry that permits time sharing of the cathode electrode drivers in a flat panel display using gas discharge light emitters. Consequently a savings of up to 90% of the electronics required to drive the dot matrix display is realized.

For informational purposes the SELF-SCAN panel display can be thought of as a dot matrix panel with common cathode strips capable of glowing on both front and back sides. The glow on each side of the cathodes is independently controlled by a set of anodes located on the front and back of the panel. The rear portion of the display consists of 7 glow-priming anodes which work in conjunction with 111 vertical cathode strips (common to both sets of anodes). These cathodes are interconnected in three groups of 37 cathodes each and connected to a three phase clock which sequentially brings each cathode to ground potential. As each cathode is grounded in sequence, the glow is transferred to the adjacent cathode. This transferred glow at the rear of the panel is not discernible from the front. (The illustration shows the first cathode grounded and glow at the 7 rear anode intersections.)

When it is desired to display a dot on the viewing surface, the front glow transfer anodes are utilized. (The glow transfer anodes and common cathodes make up the front matrix.) The appropriate transfer-anode is selected in synchronism with the cathode and the glow transfers forward to the panel front for viewing. (The illustration shows the top and center dots on the first cathode transferred for viewing.)



The whole display panel is refreshed and updated to produce a bright flicker-free display.

As a normal dot matrix panel requires a cathode driver for each cathode (80 high-voltage drivers required for a 16 digit display) and the SELF-SCAN panel display requires *only* 3 clock controlled cathode drivers regardless of the number of digits, the significance of this development is immediately apparent.

The SELF-SCAN panel display has unlimited applications, as alphanumeric and graphic messages can be presented with simplicity.

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# News Scope

## Congress generous with NASA, DOD funds -- so far

The House of Representatives has beaten back an attempt to point NASA away from manned space flight toward cheaper unmanned flights. In approving an authorization of $3.6-billion for fiscal 1971, the House added $268-million to the amount the President requested.

The authorization provides a total of $1.087-billion for the Apollo program and the addition of one more flight—No. 20 in the series. NASA had asked for $956.5-million. The House called for $654.7-million in space-flight operations, including the Apollo Applications Program, and the development of a space shuttle and station—$155-million more than NASA requested.

The attempt to slash the manned space budget was led by Rep. Joseph E. Karth (D-Minn.). Karth wanted $240-million cut from the recommended appropriation, arguing that a shuttle was "the first step toward a Mars flight," and that such a mission had not been approved by Congress.

According to NASA, a shuttle would be used in a manned flight to Mars, but NASA has never asked for money for such a mission. The shuttle is needed for the manned orbiting laboratory, a project on which study contracts have been funded. The shuttle would be used to transport men and supplies to and from the laboratory.

Karth's amendment was defeated by a tie vote, 53 to 53.

While the House was taking the first step in the long funding process for NASA, the House Armed Services Committee approved an authorization bill for the Defense Dept. One big item was $3.014-billion for new ships. The bill stated, however, that no money would be committed until the National Security Council makes its ruling on the fate of CVAN-70, the third proposed nuclear carrier of the Nimitz class.

The committee also approved more than $6-billion to buy aircraft—$294.5-million for the Army, $2.452-billion for the Navy and Marine Corps and $3.314-billion for the Air Force.

For missile procurement, the Army got approval for $1.086-billion, the Navy for $946.6-million, the Marine Corps for $27.6-million and the Air Force for $1.505 billion.

## U. S. Commerce Dept. sponsors show in Japan

Japan, a major competitor with the U. S. for electronic markets, is also a major consumer of electronic equipment. To help penetrate this expanding market, the U. S. Dept. of Commerce is sponsoring a trade show in Tokyo, Oct. 12-17. The show will feature advanced computers and peripheral equipment.

In 1969, the Dept. of Commerce says U. S. companies supplied more than $91 million worth of computers and peripherals to Japan. This year, the figure is expected to exceed $105 million, making Japan one of the largest markets in the world for these U. S. products (see 'Made in Japan,' ED 6, Mar. 15, 1970, pp. U162-U176).

Commerce reports that installed computer systems will increase from 5,600 in 1969 to 10,000 units by 1972. A large portion of these future needs will be supplied by Japanese industry, but, the Department says, imports of peripherals and software will be required to fill "acknowledged technical gaps in key categories."

More than half of Japan's large-scale digital computers are now supplied by U. S. companies. The magnetic ink and optically sensed character imprinter market is totally supplied by imports. The demand for optical character readers continues, says the Dept. of Commerce, with imports accounting for 70 to 80% of needs.

The demand for software is expected to reach $23-million by 1972, an estimated increase of 233% over 1969. Another big future market is CRT light sensing pen systems and electronic handwriting systems.

## TI predicts worldwide boom in semiconductors

The worldwide market for semiconductor products will go from $2.5-billion in 1970 to $4-billion annually by 1980, Mark Shepherd, Jr., Texas Instrument's president, told last month's shareholders' meeting. In 1970, the U. S. market will grow 5% he said, to $1.39-billion, with solid growth in the computer and industrial segments. The increases in Europe and Japan should exceed 20%.

Th major feature in the semiconductor market growth is the integrated-circuit market, according to Shepherd. ELECTRONIC DESIGN was told by Charles Phipps, TI's maanger of logic and memory functions that the worldwide demand for MOS IC's should top $100-million this year. This is more than three times the $35-million spent in 1969. And with production capability in the $70-to-$80-million range, it is unlikely that the full demand will be met in 1970 by industry.

The two factors most responsible for the increased demand, Phipps says, are 1) the many products now ready to start in volume production and 2) the increased complexity of products being produced. Manufacturing capability will be the principal factor in any company's penetration of the MOS market, whereas in the past, engineering was the key.

Within the discrete market, power, optoelectronics, and microwave segments are growing strongly says Shepherd.

Today's $50-million optoelectronics market is expected to inrcease

# News Scope CONTINUED

by 15 to 20 times by 1980, according to Ed Youch, TI's Optoelectronics marketing manager. He said that significant breakthroughs in technology and processes have been bringing prices down while increasing performance.

## Minicomputer to do skyscraper chores

Computers will be taking on a new role in the monitoring and control of building services. Honeywell's Delta 2000 series of automation systems can be used to control the entire environment of a large building or a series of smaller ones.

Air conditioning, heating, lighting, and elevator sequencing can be programmed for the regular work week or for holiday periods where building services are not so much in demand.

The Delta system, being built at Honeywell's headquarters in Minneapolis, Minn., is offered in three models: the 2000, which includes simple monitoring and alarm capabilities; the 2100 with rudimentary hard-wired programming; and the 2500, which incorporates Honeywell's model 316 computer and has full computer-control functions.

The key to the system is a single two-conductor coaxial cable connected to data concentrators on each floor of the building. Data rates can be as high as 50 kbits/s. External communication between buildings con be carried on a single standard voice-grade leased telephone line at 1200 bits/s.

The system can be time-shared to the computer to control several smaller buildings.

## Microwaves may reduce sewage-treatment cost

By exploiting a phenomen long regarded as an obtacle to communications—the atmospheric attenuation of millimeter waves—a radar engineer in Torrance, Calif., proposes a way to reduce the cost of processing sewage and polluted water.

Edward J. Watt believes that his proposed approach can increase the efficiency of ozone-generating systerms to a spectacular degree over existing electrical-discharge methods. And ozone, Watt points out, is "by far the most effective agent for the reduction of odors and tastes, and for the reduction of bacterial and coliform (intestinal) organisms found in polluted water and sewage."

Usually, Watt explains, ozone is produced by passing air through an electrical discharge or corona that, of course, covers a broad frequency range. Unfortunately, the natural molecular-resonance frequency of the oxygen molecule—and hence the only frequency that converts oxygen ($O_2$) to ozone ($O_3$)—is 60 GHz. All the other frequencies in the discharge go to waste.

With a microwave oscillator that generates energy at 60 GHz only, Watt claims, the efficiency of the conventional broadband discharge approach—10 kilowatt-hours per pound of ozone—theoretically can be upgraded one millionfold.

## Automated heart care shown in N.J. hospital

Wireless monitoring of as many as 48 heart patients is a feature of the new convalescent wing of St. Barnabas Medical Center, Livingston, N.J. The installation is said to be the largest of its kind in the world.

The equipment, manufactured by Gulton Industries, Inc., consists of a sensor-transmitter worn by the patient and a receiver-monitor located at the nurse's station. The transmitter, no larger than a cigarette pack, permits a patient to be ambulatory and thus eases his convalescence. The receiving station, two banks of 24 receivers, has a display meter for each channel (patient) which includes high and low-limit alarms, a CRT display and a strip chart recorder.

If a danger condition is detected, alarm lights signal this fact to the nurse on duty, the CRT displays the cardiogram of the patient, and the strip chart recorder makes a hard copy record. Because the patients are under continuous surveillance, doctors can examine their patients, awake or asleep, without disturbing them and thus avoid any emotional reactions.

## NASA's job picture—a continuing decline

Illustrative of the changing set of national priorities that has cut civilian space jobs—including NASA employees and employes of NASA contractors—are the following figures supplied by the space agency:

The number of people working on U. S. space agency programs grew from 46,786 in 1960 to 409,900 in 1965, but is expected to drop to 143,900 by June, 1971. Here's how it has gone, year to year:

1960— 46,786
1961— 74,577
1962—137,656
1963—246,304
1964—379,084
1965—409,900
1966—393,924
1967—306,926
1968—267,871
1969—218,345
1970—166,900 (est.)
1971—143,900 (est.)

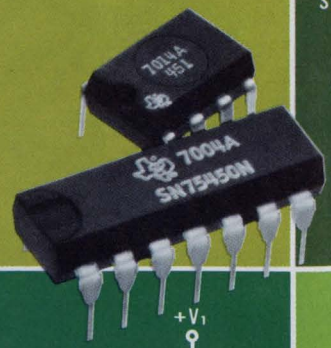
## New computer firm pushes modular concept

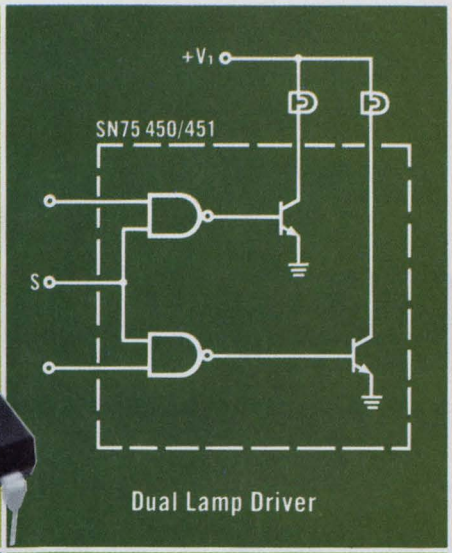
Another entry in the growing, highly competitive real-time computer market is Modular Computer Systems, Inc. of Fort Lauderdale, Fla., now four months old.

The new company, according to co-founder Kenneth G. Harple, will manufacture a family of "fourth generation general-purpose computers employing LSI circuitry and featuring a novel design approach."

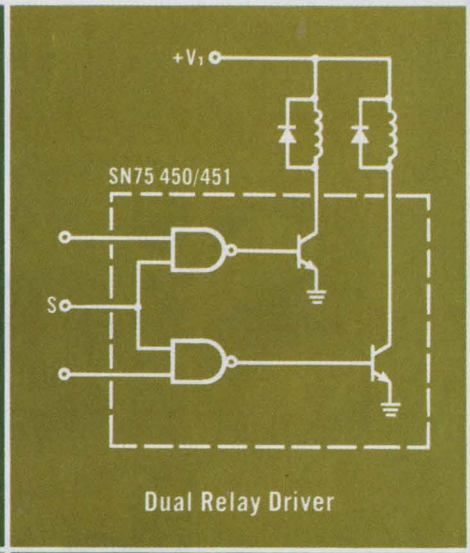
According to Harple, all computers will be assembled from four standard asynchronous modular blocks, which will include an 8-bit memory module, a control module with read-only memory, a register module and an input/output module. The modules will be designed with a byte format that will permit complete conversion of LSI as this technology develops. Powerful processor configurations can be built by adding modules.

# TI's quiet revolution in Linear ICs

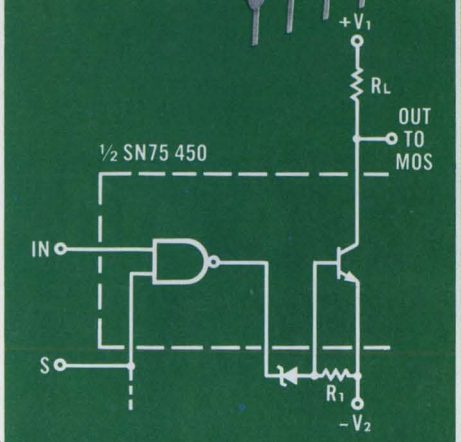


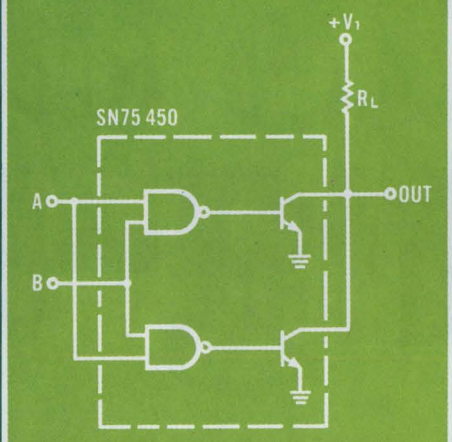

Dual Lamp Driver



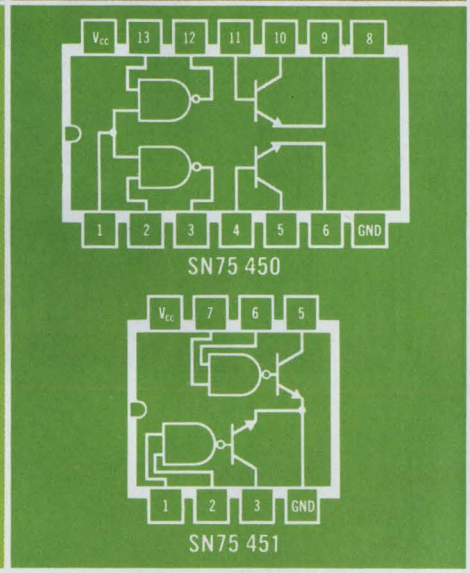

Dual Relay Driver




MOS Driver




500 mA Sink Driver




# As low as 97¢: TI's new "jack-of-all-trades" peripheral drivers.

TI's new SN75 450 dual peripheral driver is simply two TTL NAND gates and two transistors on a single chip. But because the transistors are not tied down, applications are virtually unlimited.

TI's new SN75 451 is identical except the transistors are tied down. In 8-pin plastic DIP, it's only 97¢ (100 pieces).

In addition to the applications above, use the SN75 450 as a gated comparator. Floating switch. Dual linear amplifier. Dual photo switch. NAND-gate Schmitt. High $Z_{in}$ low-speed Schmitt. Dual high-speed gate. SCR gate driver. Super TTL gate. Dual-channel single-ended line driver. Memory system current source. Film memory digit driver. Core memory driver. Phase detector. D-C to A-C converter. Tachometer. MOS memory/write driver. And you'll find dozens more.

Use the new 8-pin SN75 451 as a high-speed logic buffer and in most of your driver applications.


**For more facts** on the "jack-of-all-trades" SN75 450/451 and on all TI linear circuits, get our new Brochure CB-115. Just circle 225 on the Reader Service Card or write Texas Instruments Incorporated, P. O. Box 5012, M.S. 308, Dallas, Texas 75222. Or ask your nearest authorized TI Distributor.

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# Signetics has a hang-up.

**Tear here. And help us get rid of it.**
P. S. If someone beats you to it, circle readership card.


# Big show with an eye for the tiny

## Paris components exhibition lures manufacturers from 20 countries, and they stress miniaturization

**John N. Kessler**
News Editor

PARIS

Every year they come from around the world—Americans, Germans, Italians, Japanese, Russians, Britons, Frenchmen and others—drawn the way merchants of old were to the great bazaars of Damascus. They're headed for the biggest electronic components show in the world. Salon International des Composants Electroniques.

For six days, last April 3 to 8, they streamed into the Hall Monumental of the Parc des Expositions, and when the show finally drew to a close, the management released these statistics: visitors, 80,000; companies exhibiting, 784; nations represented, 20.

Amid the buzz, bustle and babble in the aisles, the give and take at technical sessions, two broad conclusions emerged:

- The major theme of technology at the salon exhibits was miniaturization.
- In the marketplace, mergers are enabling European companies to compete with foreigners for growing commercial electronics orders.

The components at the show that visitors ogled the most were the smaller devices, both active and passive. Manufacturers reported that these new components could perform with more sensitivity over a broader bandwidth at higher speed and lower cost.

### Advanced DVMs displayed

Schlumberger, claiming European leadership in digital instrumentation, introduced a new line of digital voltmeters, one of which it called "the most advanced in the world." The instrument, the company said, "reaches the present-day limit of technology in every basic parameter."

The new Schlumberger unit automatically calibrates itself. At preset time intervals, it disconnects itself from the voltage being measured and reconnects to an independent source. If the expected value is not observed, the instrument recalibrates itself, so there is no residual error. The company says this eliminates the effects of time and temperature and provides a long-term accuracy "not significantly different from short-term accuracy." The operation can be unattended or carried out by unskilled users.

The Schlumberger DVM has a scale length of 250,000 and can measure dc voltages from 0.1 to 1200 V. Control can be manual, automatic, variable or remote, at speeds from 4 seconds per measurement up to 500 readings per second. This instrument, as well as other DVMs in the new line, are being marketed through the Solartron Electronic Group Ltd., Farnborough, Hampshire, England—a Schlumberger company.

### Italian semiconductors on view

Ates Componenti Elettronici of Milan exhibited a full range of semiconductor devices for entertainment, industrial and profes-

sional applications. Ates is affiliated with Siemens and has a technical assistance agreement with RCA. The company now has the largest laminar-flow facility in Europe turning out new lines of linear and digital ICs. Its present production is concentrated on i-f amplifiers and automatic, fine-tuning devices for TV, transistor arrays and audio amplifiers up to 5 W. This is to be followed by a range of digital devices.

This year, according to Ernesto Bartolozzi, Ates commercial manager, the company will produce circuits for fully transistorized monochrome and color television. The exhibit at the Salon des Componsants included high-voltage (800 V, 4 A; 400 V, 4 A; 320 V, 10 A) and high-power (164 V, 10 A; 100 V, 15 A; 160 V, 15 A) transistors.

Ates is another company with an international marketing organization—in Britain, Austria, Denmark, Finland, France, Germany, Greece, Norway, Spain and South Africa.

## Russians lead East Europe

Soviet, Hungarian and East German exhibits drew the usual interested stares from Westerners. The Russians demonstrated their technology was the most advanced. They displayed 40 types of ICs, some with 1340 MOS devices on a single chip. And they had DTL and RTL devices, FETs, linear ICs, hybrid LSIs, gallium arsenide light-emitting diodes and a splash of high-quality passive components.

The Russians seemed particularly advanced in processing large ingots of silicon and germanium. They also had a range of cathode-ray tubes that were as small as one-inch across; they said they were for commercial TV.

Mullard House of London exhibited components for TV, radio, industrial process control, infrared detection and radar. The company's monochrome TV receiver uses variable-capacitance diodes (varactors) to do the tuning. No mechanical link is required between the tuning control and the module; tuning is effected by means of pushbuttons that apply dc potentials to varactors in the tuner rf stages and local oscillator.

Furthermore there is no high-frequency voltage on the lines between the tuner and the preset potentiometers that supply the control voltages. Therefore line length does not affect performance, and the designer can place the tuning module wherever he pleases in the set.

Because a solid-state television receiver can't use the same feedback techniques used in tube circuits to stabilize the line deflection current, it is necessary to stabilize the supply voltage instead. Mullard says that thyristor circuits that it has developed are "simpler and more reliable than similar transistor circuits."

Mullard's "supersquare" color-screen television picture—"the most advanced color tube in production"—was on view. It has, the company said, a "more rectangular and flatter faceplate than any color picture tube now available."

Mullard components for radio receivers included an integrated circuit for AM receivers that contained the mixer, oscillator, i-f amplifier and audio preamplifier stages. This avoids much of the manual work involved in building the conventional receiver.

New Mullard industrial components on display included three "trigger blocks" for control systems. The new units are easily connected to form a variety of circuits with a wide range of control functions.

## Microswitches operate car

The "car of the year 2000" was used by Honeywell S. A., France, to demonstrate its line of microswitches. These pushbutton devices maneuvered the car forward, backward, sideways, around and up and down at various speeds.

A number of Hall-effect devices were also exhibited by Honeywell. These could operate with DTL, TTL, RTL and MOS/LSI logic systems. They perform their switching operation by means of a magnetic field that ranges from 300 to 750 gauss. Applications for this type are primarily in command and control systems. It can perform a million switches a minute.

Other pushbutton switches from Honeywell were capable of lighting up in any of four colors—particularly useful in aircraft navigation systems.

Siemens exhibited three new types of semiconductor components: a new line of solar cells,


**Schlumberger digital voltmeter** measures dc voltages from 0.1 to 1200 V and can calibrate itself automatically. The scale length is 250,000.

**A random-access memory** shown by the Plessey Components Group.

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EC69-80

integrated solid-state circuits, and integrated operational amplifiers. The solar cells are of the n-p type and have boron-doped silicon as the base material. The junction can be located directly beneath the surface of the cells. This, says Siemens, makes the cells extremely sensitive to blue light.

Siemens' solid-state ICs are designed for AM/FM and i-f amplifiers in radio receivers. For AM operation (450 kHz), a control can be added to permit a voltage gain of 60 dB; without the control voltage, gain is 90 dB. In FM operation (10.7 MHz), the voltage gain is 86 dB at operating voltage of 9 V.

Op amps shown by Siemens, with stages that can be directly coupled, are for dc or ac amplifiers, servo amplifiers, active filters, ultra-linear rectifiers and many other applications.

Siemens' new core-memory stacks are—at their best—one-fifth the size of conventional designs, according to the company. In memories designed for high-speed computers, Siemens has eliminated one out of two matrix frames, and the units are said to be highly resistant to heat damage and vibration.

### Fluidics there, too

Britain's Plessey Components Group showed not only examples of random-access memories but also its new Logi-Pak fluidic system. It consists of miniaturized fluidic elements designed for industrial control systems.

There are nine basic elements, and most of these incorporate two or three gates each. A systematic method of port positioning is used throughout, to simplify mounting and connecting layouts.

Logi-Pak mounting provides a modular system for accommodating any number of elements, although for convenience, standard units that take from four to 48 elements are offered. Construction is simple, the elements mounting flat onto base units that incorporate the port nozzles.

### A drop in exhibitors

The number of exhibitors at this year's Salon des Composants was down a bit from last year. Manufacturers said the reason lay in the growing importance of instrumentation in Europe, not in a diminishing market for components. There was a sharp drop in instrumentation displays in the Hall Monumental. These manufacturers are saving their powder for other, upcoming shows: Mesacura in Paris later this month, and the Electronica Show in Munich in November. But even allowing for this, visitors to the components extravaganza felt the industry looked vigorous and profitable.

Corporate cooperation, to a large extent, is responsible for this vigor. Lacking the financial backing of defense budgets, European companies have joined together to meet U. S. competition and at the same time to assimilate U. S. technology by means of patent-licensing, cross-licensing and keen research efforts on their own. The two Continental electronic giants still remain Siemens and Philips, with plants spread throughout the world. Next come highly dynamic companies like Thomson-CSF in France, which also has factories scattered in many countries.

### The future wave: mergers

Mergers are spurring European electronics growth. For example, Thomson-CSF, the biggest electronics manufacturer in France, not only has a large central research laboratory but also an electronic tube group, an underwater division, Sescosem (for semiconductors and microelectronics) and 10 or more sub-groups that represent a combination of what were once individual firms.

In Germany, AEG has merged with Telefunken. In Italy, SGS (Societa Generale Semiconduttori), headquartered in Milan, is under the control of Olivetti and has facilities in Germany, France, Britain, Singapore and Sweden. In England, Marconi-Elliott Microelectronics Ltd., Witham, Essex, is a member of GEC Semiconductors. In Spain, there is a somewhat different arrangement with Secartys (Servicio de Exportacion de Componentes y Aparatos de Radio, TV y Sondio), being set up as a free association of Spanish electronics companies to promote sales.

The Societe Precis, now one of the largest manufacturers of capacitors in France, was founded in 1958. By 1968, it had merged with Societes Bonohm, Variohm, Sorelem, and Same, and had opened a factory in Turin, Italy. Today its five factories churn out monthly nearly a million plastic-film and mica capacitors plus 200,000 tantalum and aluminum capacitors and a range of potentiometers, some of which were shown at the Salon des Composants.

In France, according to information released by the National Chamber of Commerce, the French electronics components industry will double by 1975. ■■

**"Car of the year 2000,"** which Honeywell of France used to demonstrate its line of microswitches. Pushbutton-devices maneuver the vehicle.

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INFORMATION RETRIEVAL NUMBER 20

# Navy to computerize its message processing

## Device under test screens radio transmissions to ships and accepts only those that are 'relevant'

**John F. Mason**
Military-Aerospace Editor

The Navy is testing the prototype of an automatic message handling unit for destroyers and smaller ships that will solve a number of shipboard communications problems. And when funding loosens up, it should create a big market.

"I think there'll be one of these systems on almost every ship in the fleet," says D. W. Liddell, head of traffic management and system control at the Naval Electronics Laboratory Center in San Diego, where the system was developed.

Called GARD, for General Address Reading Device, the equipment screens incoming radio messages, allowing printout on standard teletype machines of only those with addresses that match a stored list. GARD is a stored-program computer with a memory capability of 99 addresses of 36 characters each. The system gets messages to addressees faster, by transmitting them to remote terminals equipped with high-speed printers. Now, they are printed and hand-carried.

GARD will achieve one of the Navy's major goals: It will reduce the personnel required to process messages. "Supporting a serviceman for 20 years costs $1-million," a cost-conscious Navy officer in Washington says.

"Screening messages automatically is a big step forward," Liddell says. "Now, small ships are inundated with messages that are of no interest to them. Probably only about 10% of the messages that come in are relevant."

### Excess printing is expensive

Printing unwanted messages requires additional personnel to screen them; it creates a pile of unwanted classified messages that must be safeguarded or destroyed; it wastes supplies and wears out equipment; and it creates unnecessary noise. Noise is such a problem on ships that the Navy would like a quiet—or better yet, a silent —teleprinter.

A GARD development model was tested for 12 months on the destroyer Joseph Strauss, and during this time it suffered only one failure: A microelectronic circuit went out. The mean time between failures was in excess of 5000 hours. Currently the GARD service test model is undergoing operational evaluation aboard the destroyer Richmond Turner prior to procurement by the Naval Electronic Systems Command in Washington, D.C.

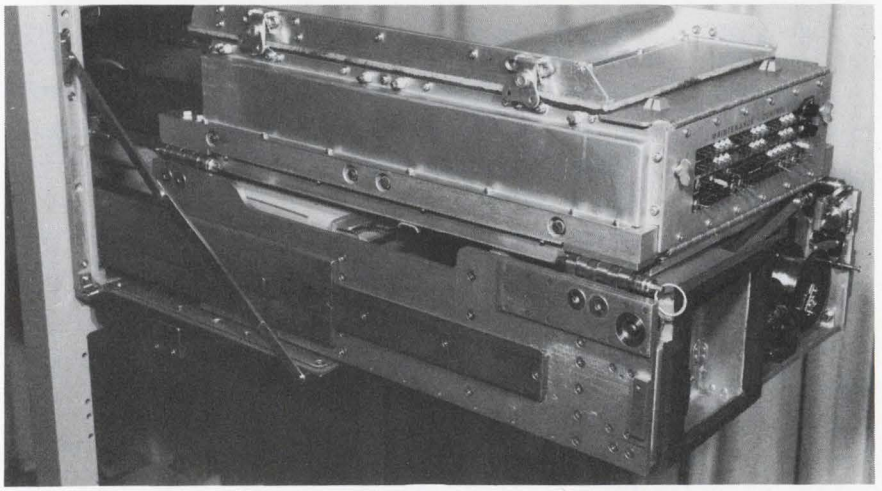
"The biggest problem" says the system's project manager, R. S. Rios, "is having to use the ship's power. If the voltage drops, GARD is bypassed automatically and all messages are printed."

There are several design features that Liddell feels are significant:

- Maintenance can be done without tools, except for a card puller. Everything can be repaired by hand. And all parts in the system are captive. "They are attached in some way so a sailor won't take a lid off, for example, and lay it down on the other side of the room," Liddell says.
- The machine opens up and slides out of its case, but it's not on ballbearings. "We don't want something that slides easily, which in heavy seas might come out and hit a sailor in the chest."
- Air filters are built on the front, where they won't be forgotten. They can be taken out and cleaned without tools and easily replaced.
- Flat cables are used instead of those that roll up. "The rollup kind causes trouble," Liddell says. "Ours lie flat, hooking into the chassis at the bottom. When you roll the chassis in, the cable just folds back on itself."
- Logic is partitioned between cards according to function. If a particular processor command can't be executed, the maintenance man knows that that function is associated with a particular card and can pull it out.

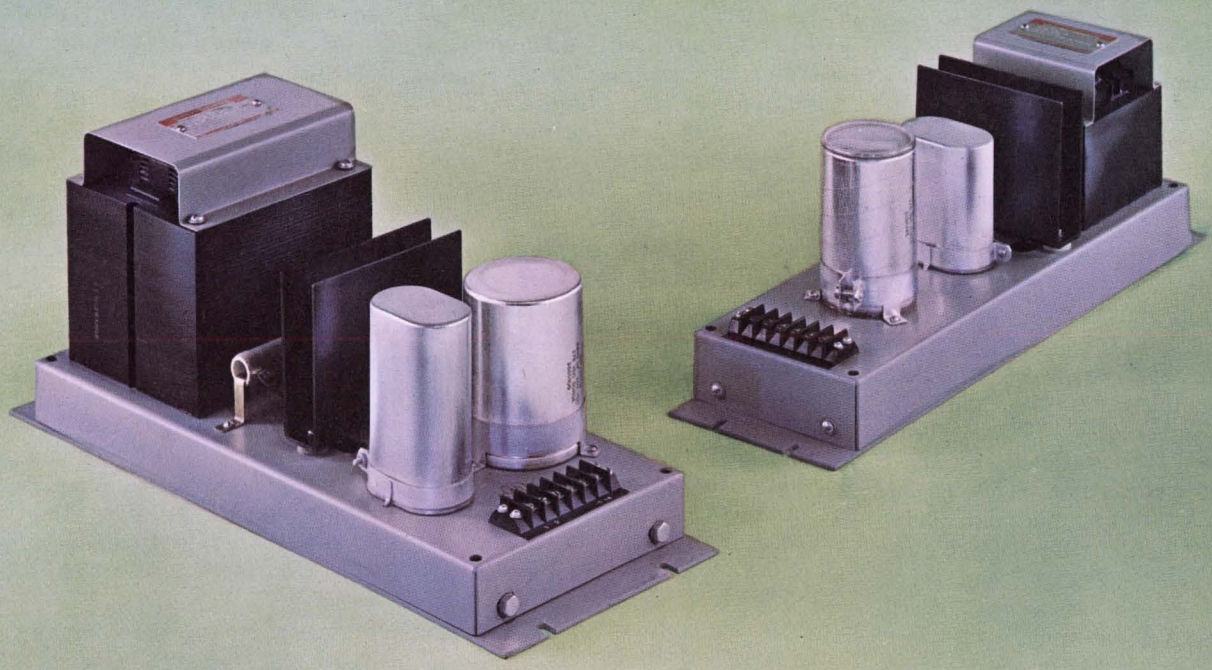
In designing the unit, Rios says, "we let one of our engineers who is accident-prone try it out.

"If anything can be broken, he'll break it, and if anything will hurt an operator, he'll get hurt. The system passed the test," Rios notes. ■■



**Compact design** of the General Address Reading Device speeds installation and maintenance on Navy ships, where space is at a premium.

# did you know?



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# Pilots ask FAA for proximity warner—now

## A cheaper device sought instead of expensive time-frequency system under slow development

**John F. Mason**
Military-Aerospace Editor

Tired of waiting for a panacea to prevent mid-air collisions, airline pilots and spokesmen for the general-aviation community have again urged the Federal Aviation Administration to initiate a high-priority project to develop a simple, inexpensive airborne proximity instrument that could alert a pilot to converging planes. Later, the device could serve as a building block for a more complicated system that would not only alert the pilot to an intruder but also evaluate the hazard and tell the pilot what maneuver to make and when to do it.

The plea for "action now" was made by spokesmen for the Air Line Pilots Association, the Aircraft Owners and Pilots Association and the National Business Aircraft Association. The occasion was FAA's second National Aviation System Planning Review Conference held at Gemma Conference Center in Washington, D. C., April 14-17. FAA organized the meeting. It wanted everyone in the aviation community to speak up, and many did.

### Complaints are heard

The general aviation spokesman had several complaints about the collision-avoidance system that now seems most likely to be officially accepted by FAA. A time-frequency system that consists of ground and airborne units, it won't be ready before 1972; it is a cooperative system, which means that any aircraft not equipped for it will not be detected; the airborne unit will cost far more than the small plane pilot can pay; and there are doubts in some quarters that the system will work efficiently. McDonnell Douglas, however, one of companies that has been working on the system for the past 10 years, says it will.

The Air Transport Association, which represents the air lines, agrees and adds that the cost of "a simple minimum-performance time-frequency airborne unit can eventually be brought down to within reach of the general aviation flier."

Three proximity-warning instruments designed for general aviation—or any other aircraft—were described to the meeting by three industry representatives.

Loral Electric System of New York City described its cooperative infrared system that began flight tests more than a year ago. Equipped with an infrared sensor, the plane can detect other planes equipped with strobe lights as far out as 2.5 miles during the day and 5 miles at night.

Cygned Inc., of Salem, N.H., announced an airborne, non-cooperative, coded radar that uses high repetition rates, short pulses and low radiated power. It has a range of 5000 feet. Bearing information, within 45 degrees, and range are displayed on an illuminated panel when an intruder approaches. At the same time an audio alarm goes off. The system is completely solid state, weighs about 12 pounds and when produced in quantity will sell for about $2000. The radar is called Aware.

Since 90% of all collisions happen in situations where one aircraft overtakes another from behind, the radar is designed to accommodate closing speeds of about 300 mph, providing the pilot with a 10-second warning (4500 feet) plus bearing information for making the right maneuvers. These minimum requirements were set forth by the Air Line Pilots Association.

Radiated peak power is 2.0 watts, and average power is 0.8-watt at 5.1 MHz, using a 400-ns pulse width and a 1-MHz repetition rate. A unique and proprietary antenna configuration rotates at 150 rpm with a radome to provide 360-degree bearing.

### A system with extras

The sleeper at the conference was a development announced by Escoa Corp. of Phoenix that the company reports is able to detect and warn the pilots of other aircraft, clear-air turbulence and mountains.

The system senses the natural E-field (electric) of any given molecular structure, solid, gaseous or fluid; electromagnetic signals emitted by explosion or burning; and signals emitted by ionization caused by the collision of molecules.

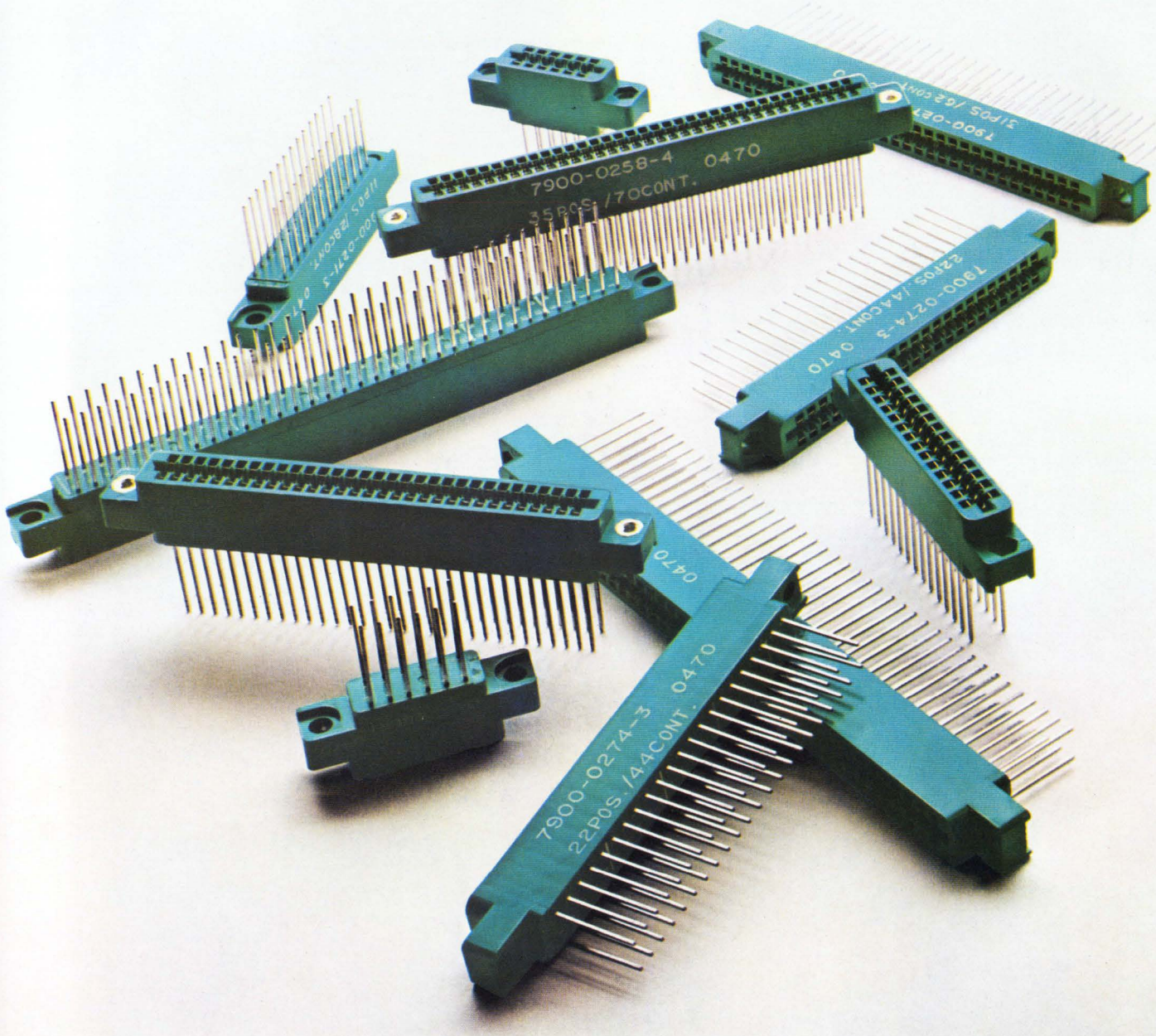
For a proximity-warning instrument, the E-field sensor will reportedly be "passive and non-cooperative, weigh 10 pounds or less, cost about $1000, display both azimuth and vertical displacement angle, operate in all weather, have a range of 3 to 10 miles, and require no more power than a VOR receiver."

According to the company's director of research, George Christofv, a successful test was made by airline captain Carl Smith, chairman of the Air Line Pilots Association's Collision Avoidance System Committee. Capt. Smith tested the equipment on Western Airlines flight 92, during descent over the Rock Mountains from 37,000 feet. The sensor picked up aircraft, Smith said, "anywhere from 2 miles to 10 miles away, 2000 to 4000 feet below us." Also, he said, he was able to "detect the anticipation of turbulence, and in about 15 seconds we'd hit the bump."

RCA's Secant system, among others, was not represented at the conference. The Air Transport Association, which is committed to the time-frequency system, says it can't comment on Secant because RCA has never let them in on how it works. ■■

# Sylvania ushers in the Golden Age of connectors.

# With two new off-the-shelf




Now we can give you quick delivery even on connectors that used to be considered custom jobs.

Our first new line of PC-card edge connectors runs from 12 to 100 contacts with .125″ contact spacing.

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For any connector in these lines, you can choose either gold-plated bellows contacts or gold-dot contacts which we've been making reliably for years.

No other manufacturer gives you this freedom of choice of contacts throughout a complete line in the same moldings.

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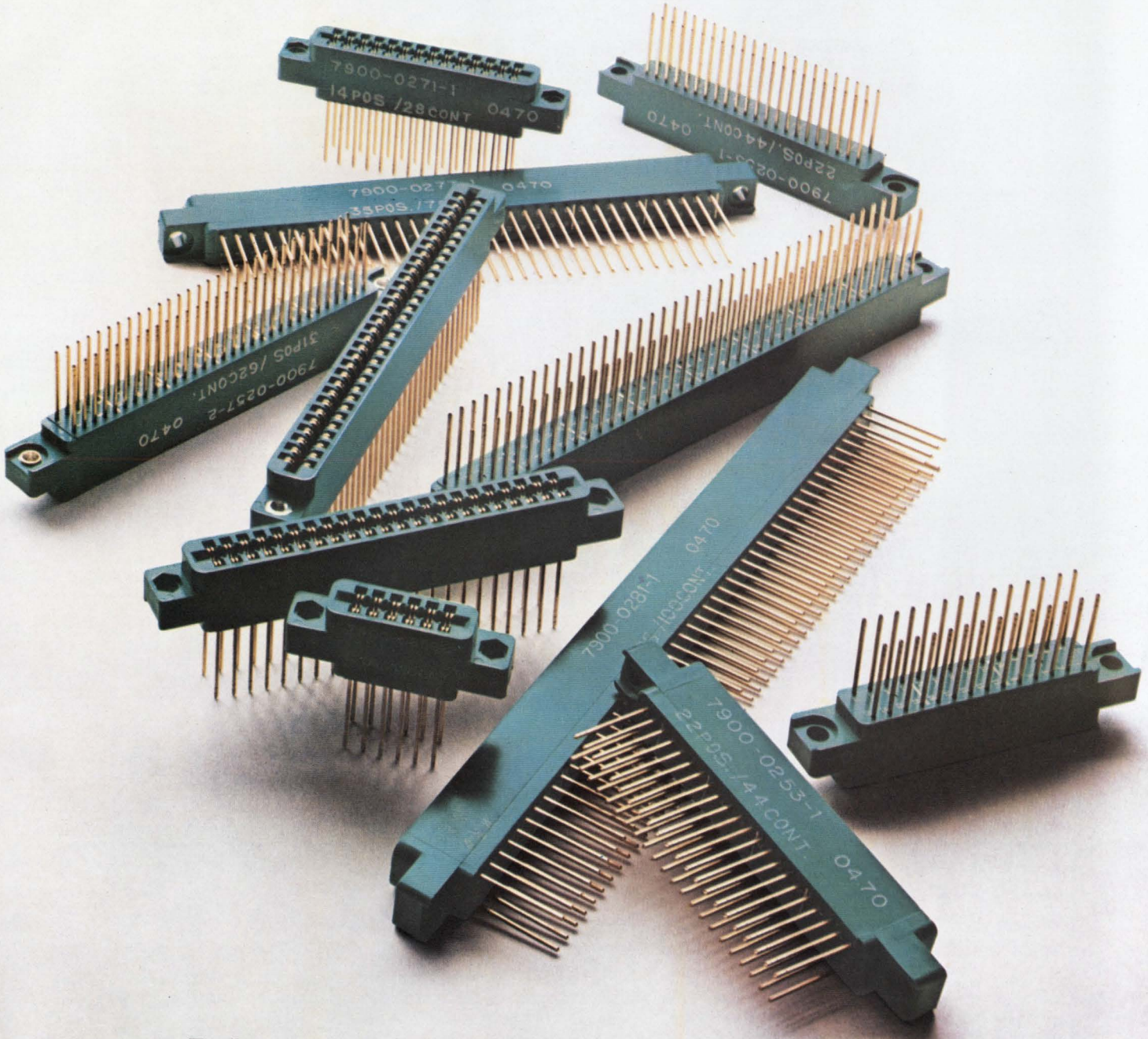
# custom lines.



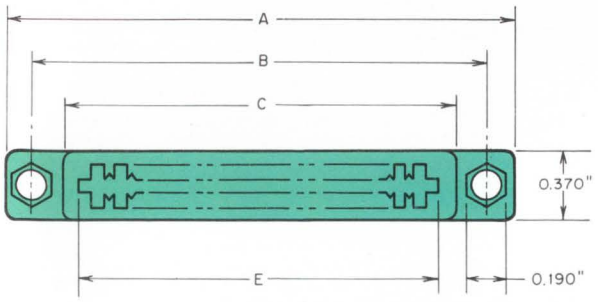

you money. Tooling costs are on the house. And if you choose gold-dot contacts, they'll cost you less.

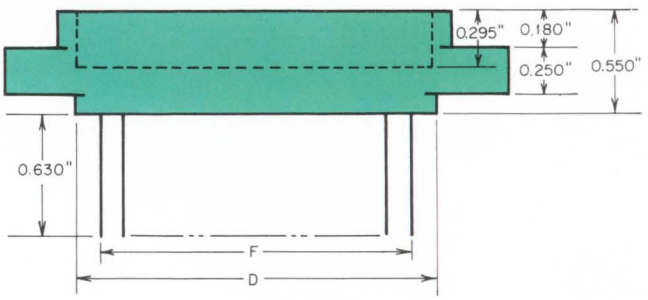
Our new connectors—including the gold-dot types—are designed to meet Mil Spec C21097B. Which means they're designed to give you 500 or more trouble-free insertions. We're able to hold the locus point on contact tails within .010″ radius of true position, so you won't have any trouble with your programmed wiring machines.

The main thing is—we've speeded up the process of getting you good connectors.

And that's as good as gold.

# Even the oddballs are conventional.




### .125" Contact Centers
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| Number of pairs/ contacts | Dimensions A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| **6/12** | 1.555 | 1.295 | 1.035 | .875 | .875 | .625 |
| **10/20** | 2.055 | 1.795 | 1.535 | 1.375 | 1.375 | 1.125 |
| **14/28** | 2.555 | 2.295 | 2.035 | 1.875 | 1.875 | 1.625 |
| **15/30** | 2.680 | 2.420 | 2.160 | 2.000 | 2.000 | 1.750 |
| **18/36** | 3.055 | 2.795 | 2.535 | 2.375 | 2.375 | 2.125 |
| **22/44** | 3.555 | 3.295 | 3.035 | 2.875 | 2.875 | 2.625 |
| **28/56** | 4.305 | 4.045 | 3.785 | 3.625 | 3.625 | 3.375 |
| **31/62** | 4.680 | 4.420 | 4.160 | 4.000 | 4.000 | 3.750 |
| **35/70** | 5.180 | 4.920 | 4.660 | 4.500 | 4.500 | 4.250 |
| **40/80** | 5.805 | 5.545 | 5.285 | 5.125 | 5.125 | 4.875 |
| **44/88** | 6.305 | 6.045 | 5.785 | 5.625 | 5.625 | 5.375 |
| **49/98** | 6.930 | 6.670 | 6.410 | 6.250 | 6.250 | 6.000 |
| **50/100** | 7.055 | 6.795 | 6.535 | 6.375 | 6.375 | 6.125 |

### .100" Contact Centers
(Rated for 600 volts DC)

| Number of pairs/ contacts | Dimensions A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| **18/36** | 2.635 | 2.375 | 2.060 | 1.950 | 1.900 | 1.700 |
| **20/40** | 2.835 | 2.575 | 2.260 | 2.150 | 2.100 | 1.900 |
| **22/44** | 3.035 | 2.775 | 2.460 | 2.350 | 2.300 | 2.100 |
| **25/50** | 3.335 | 3.075 | 2.760 | 2.650 | 2.600 | 2.400 |
| **28/56** | 3.635 | 3.375 | 3.060 | 2.950 | 2.900 | 2.700 |
| **30/60** | 3.835 | 3.575 | 3.260 | 3.150 | 3.100 | 2.900 |
| **31/62** | 3.935 | 3.675 | 3.360 | 3.250 | 3.200 | 3.000 |
| **35/70** | 4.335 | 4.075 | 3.760 | 3.650 | 3.600 | 3.400 |
| **36/72** | 4.435 | 4.175 | 3.860 | 3.750 | 3.700 | 3.500 |
| **40/80** | 4.835 | 4.575 | 4.260 | 4.150 | 4.100 | 3.900 |
| **43/86** | 5.135 | 4.875 | 4.560 | 4.450 | 4.400 | 4.200 |
| **44/88** | 5.235 | 4.975 | 4.660 | 4.550 | 4.500 | 4.300 |
| **49/98** | 5.735 | 5.475 | 5.160 | 5.050 | 5.000 | 4.800 |
| **50/100** | 5.835 | 5.575 | 5.260 | 5.150 | 5.100 | 4.900 |

**Some technical details**

Read between the lines for oddball connectors, such as 19/38 or 46/92. We supply these, too.

Connectors are designed for use with .062"-thick printed circuit cards. They are rated at 3 amps, voltage drop not to exceed 30 mV at rated current. Temperature range: —65 to +125°C.

Connector bodies of diallyl phthalate. Choice of bifurcated gold-plated bellows or gold-dot contacts. Choice of mounting holes: with or without bushing. Choice of plastic or metal polarizing keys.

For more information, write to: Sylvania Precision Materials, Parts Division, Warren, Pa. 16365.

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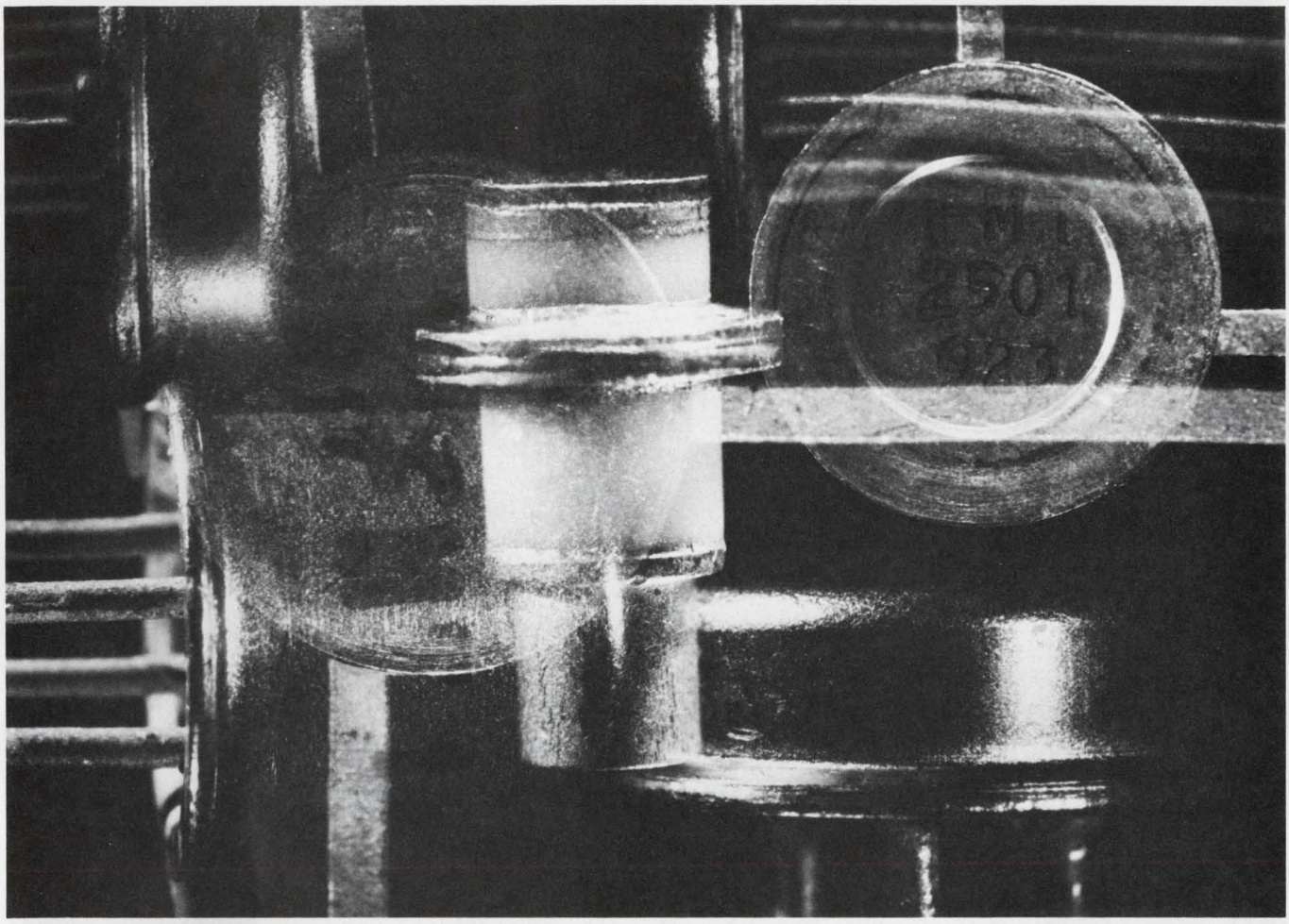
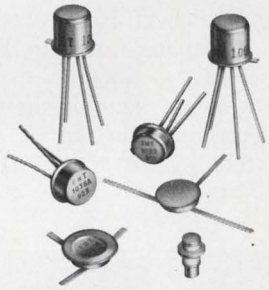


# The MOD line... HF transistors



MOD stands for the Microwave and Optoelectronics Division of Fairchild. If you are designing high frequency circuits you will find MOD transistors give you a wide choice of design parameters. As amplifiers you can use them in radio and television circuits, active filters, TWT replacements, CATV applications, etc., etc. As oscillators you can apply them in sweepers, signal generators and other instruments that can benefit from solid state reliability.

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|---|---|---|---|---|---|---|
| .5 | MT1060 MT1061 | MT2116 MT1038 | | | | |
| 1.0 | | | MT1060 MT1061 | MT1038 | | |
| 2.0 | | | | MT1070 MT2500 | MT1060 MT1062 MT1050 | MT1038 |
| 3.0 | | | | MT1116 | MT1070 | MT1050 MT1062 |
| 4.0 | | | | | MT1116 | MT1115 |
| 5.0 | | | | | | MT1116 MT2500 |

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# Laser or millimeter space communications?

## Both can do the job, 3 specialists conclude, but millimeter system can be put into operation first

**David N. Kaye**
West Coast Editor

The first requirement for a flexible world-wide communications network is an efficient means of communicating large amounts of data from one communications satellite to another.

Two technologies are being considered as a means to this end: one is a millimeter-wave system, and the other is a laser link. They were compared recently in a paper given at the International Symposium on Submillimeter Waves at Polytechnic Institute of Brooklyn.

The paper concluded that both technologies could do the job. The millimeter-wave system would be the easiest to put into early use, the authors said, but the laser system would, in the long run, be better.

The authors were LaRue A. Hoffman, Dr. Thomas S. Hartwick, and Herbert J. Wintroub, all of the Aerospace Corp. in El Segundo, Calif.

Dr. Hartwick, head of the Quantum Electronics section of Aerospace, told ELECTRONIC DESIGN that for deep-space communications, from space vehicle to space vehicle, laser systems are the only way to go.

An operable laser system, he said, could be ready in about five years. On the other hand, a three-satellite global system could be designed now and deployed in three to four years with millimeter-wave technology, according to Hoffman, associate director of the Electronics Research Laboratory at Aerospace. This system could relay information either from the ground or from another satellite, such as an earth resources satellite, to any point in the world.

### Delays in laser systems

"The biggest problem," said Hartwick, "in a laser communication system is to get systems built and working in the field. It's not a big extrapolation to go from microwaves to millimeter waves with the tremendous history of communications behind you."

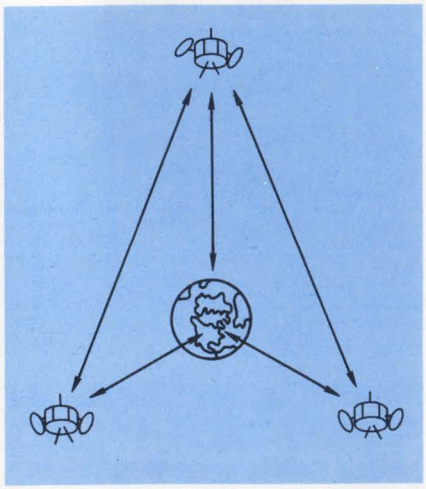
But if a laser satellite-to-satellite link were to be designed today, what form would it take?

Hartwick first divided lasers according to detection scheme. He pointed out that sources in the visible region—approximately 0.35 to 0.75 micron—can be detected with high quantum efficiency and long life, using direct or incoherent detectors. Sources in the infrared, however, are detected most efficiently by a coherent heterodyne system, using a laser local oscillator and a photoconductive or photovoltaic mixer.

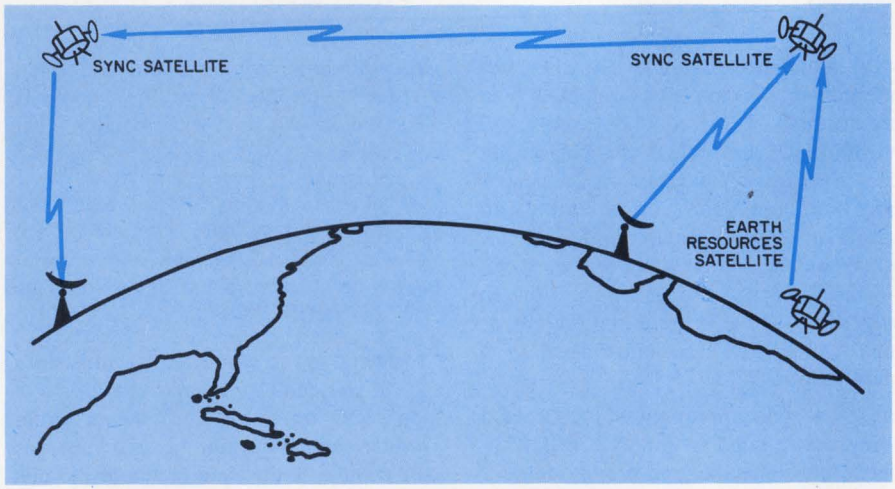
An infrared, 10.6-micron, $CO_2$ system is currently being built (see ED 4, Feb. 15, 1970, p. 30).

Although the $CO_2$ laser project is currently in progress, Hartwick noted that it is not practical for high data rate systems. "There are specific objections to this type of system," he pointed out:

- Cooled (approximately 100°K) mixers are required.
- Doppler shifts prevent communication to low orbiting satellites.
- Local oscillator and signal wave-fronts must coincide at the detector.
- The requirement for two lasers in a transceiver is complex.
- Modulation rates and detector response times both limit the information rate to approximately 10 Mbits/sec."



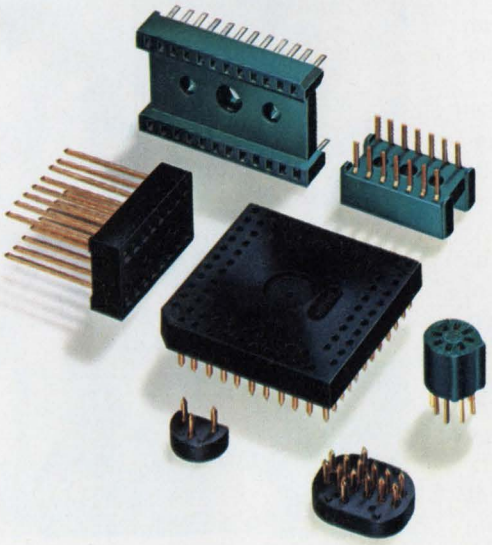
**Three synchronous satellites** would provide global coverage if spaced 120° apart.




**Information transmitted** either from the ground or from another satellite could be relayed anywhere in the world by such a global communications system. The system could be deployed in four years with mm-wave technology.


# CINCH PRECISION MINIATURE SOCKETS

## INSURE EQUIPMENT DEPENDABILITY



Equipment design frequently involves problems of field maintenance or circuit updating. Cinch component sockets provide inexpensive and effective solutions without compromising reliability.

DIP low-profile sockets for 14, 16 and 24 lead DIP's are typical of Cinch's specialized miniature sockets, available in three lead types for solder dip and wire wrap applications. Insulators are in GP black phenolic, dially phthalate or glass nylon. They are resistant to shock, vibration, humidity and corrosive atmospheres. Contacts are gold or tin plate for lower resistance and better solderability.

*MSI or LSI low-profile sockets,* utilizing Cinch's exclusive subminiature contact, can be custom-designed with up to 200 contacts per socket, for quantity production.

*IC sockets* for 6, 8 and 10 pin TO-5 cased devices, miniature NIXIE tube sockets and subminiature relay sockets are just a few of the other component sockets Cinch manufactures.

For information on these and other Cinch interconnection devices, write to Cinch Manufacturing Company, a division of TRW, Inc., 1501 Morse Avenue, Elk Grove Village, Illinois 60007. C-7030

CINCH

*CINCH DIVISIONS OF TRW INC., CINCH MANUFACTURING, CINCH-GRAPHIK, CINCH-MONADNOCK AND CINCH-NULINE*

(**Communications,** *continued*)

Therefore, Hartwick concluded that the visible spectrum should be utilized in order to use a direct detection scheme.

In the visible spectrum three types of lasers can be considered as sources. According to Hartwick: "The source must efficiently deliver a single mode diffraction limited beam with 0.1-1.0 watts of power, long lifetime, and a compact size. The GaAs diode laser is immediately ruled out because of poor lifetime, cryogenic cooling, and poor mode characteristics. Of the noble gas lasers, the He-Ne laser at 6328 Å is the best developed but suffers from a poor efficiency. The best choice, principally because of the high efficiency is the Nd:YAG laser."

Nd:YAG must be doubled in order to get into the visible spectrum. Doubling with nearly 100% efficiency has been demonstrated using $BaNaNbO_3$ crystals to yield an output at 0.53 micron.

At 0.53 micron, the best choice for a detector is a photomultiplier. A 30% quantum efficiency can be achieved at 0.53 micron with a photomultiplier.

Best of the currently available modulators is the potassium dideuterated phosphate electro-optic type. Using 60-mw/MHz drive power, a bandwidth of 525 MHz has been demonstrated. Hartwick believes that "low drive power modulators operating throughout the visible into the near infrared region should be space qualified without difficulty up to 1 GHz of bandwidth."

### Millimeters can be used now

According to Hoffman, "The specific advantage of millimeter waves is the extremely large data bandwidth that is theoretically feasible, while utilizing modest-size antennas to achieve both high radiation efficiency and protection from the detection and jamming threat by means of the narrow beamwidths obtainable."

If a millimeter system were designed today, Hoffman noted, "best judgment indicates the 70-GHz region of the spectrum as the highest frequency range providing a promising choice based on the present state of the technology."

As a source for the system, Hoffman told ELECTRONIC DESIGN that at present an impatt oscillator followed by a traveling-wave-tube amplifier to produce about 25 W at 70 GHz seems the best way to go. LSA is not far enough along yet to be considered for real systems. Impatt oscillators have been demonstrated at over 100-mW output with efficiencies of 2 to 4%.

Choice of an antenna is the old reliable Cassegrain. "Cassegrain is the most efficient millimeter antenna," Hoffman said. "Tolerances on the order of 0.007 inches for the surface of the dish are necessary at 70 GHz. Due to these tolerances and the state of the art in attitude control and steering technology an 8-foot dish is the largest that could be carried into space. This size is also compatible with existing launch vehicles."

Millimeter reception will be best handled by a superheterodyne system comprised of an uncooled parametric amplifier followed by a Schottky barrier diode mixer. ■■

# Laser beam draws quick and clean patterns for ICs

A laser beam is being used to draw mask patterns for highly sophisticated integrated circuits in one-sixtieth the time the operation takes when done by conventional mechanical techniques.

Developed by Bell Laboratories, Murray Hill, N. J., the laser-equipped machine is called a Primary Pattern Generator. Bell Labs is using it to create circuit patterns in photolithographic masks, which in turn, are used by the Western Electric Co. to produce ICs for Bell System Equipment.

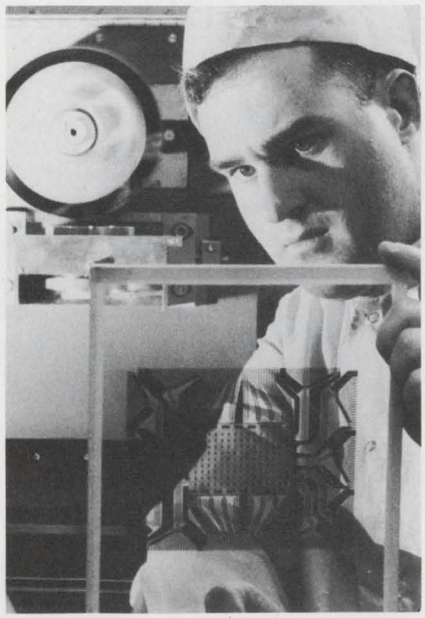
The machine consists of a moving table to hold an 8-by-10-inch photographic plate; an argon laser as the light source; modulators and lenses to control the laser beams; and a 10-sided mirror, rotating on air bearings, to reflect the laser beam and expose select portions of the photographic plate.

The laser beam is controlled with pin-point precision, Bell Labs engineers say, to traverse the photographic plate along 32,000 scan lines and with 26,000 positions per scan line.

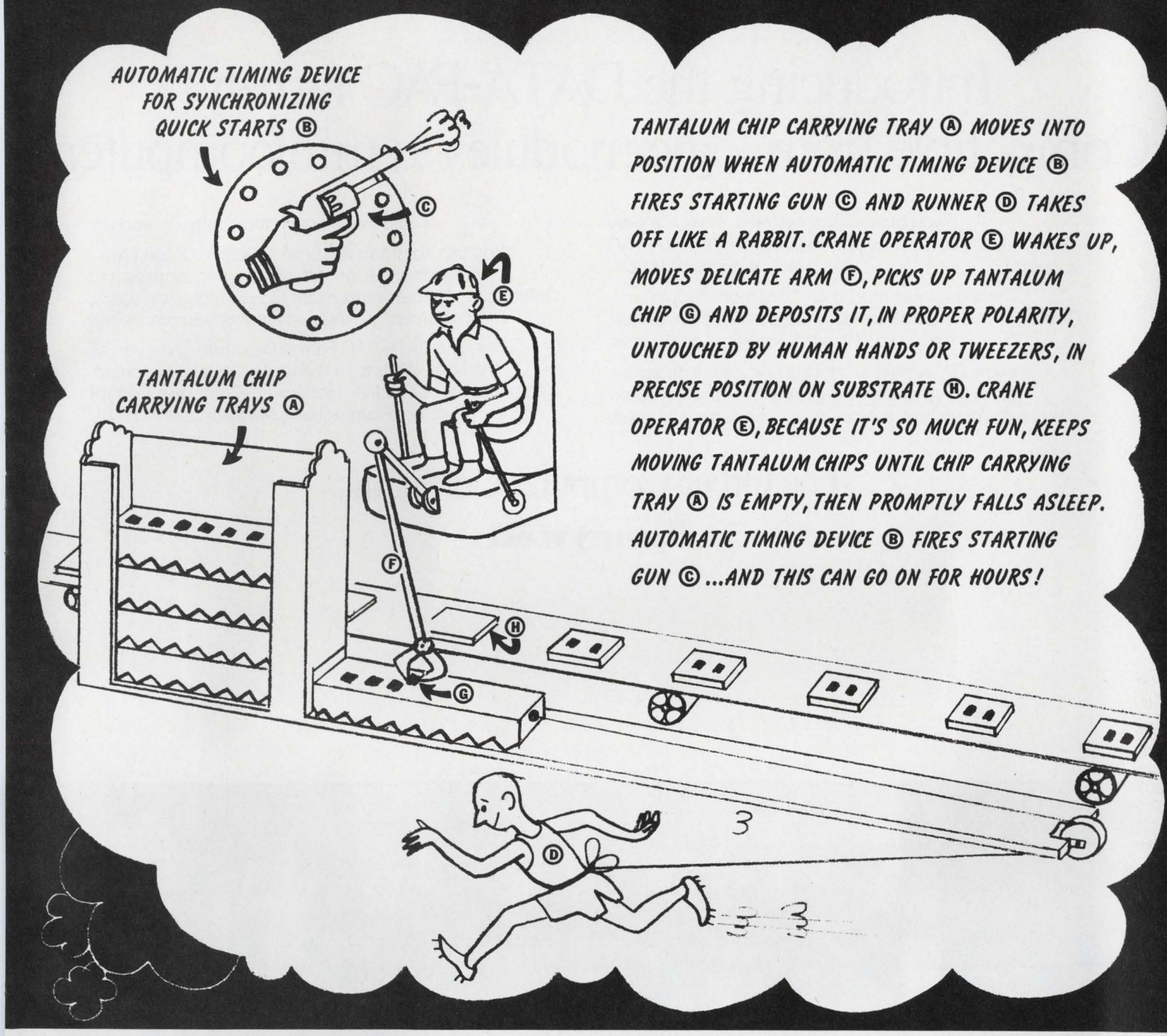
The beam can be directed with an accuracy of less than one arc-second, the equivalent of a mile-long straight line, with a deviation of less than 5/16 inch.

To obtain such precision, the generator is operated in a special controlled environment chamber, where the temperature is maintained within 1/4°F, and each cubic foot of air contains fewer than 100 dust particles larger than 1 micron.

The machine is so fast that it takes only 12 minutes to complete a highly sophisticated circuit mask that formerly required more than 12 hours of machine time. ■■



**Laser beam** and 10-sided rotating mirror cut time to one-sixtieth for drawing mask patterns for ICs.

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# Washington Report

DON BYRNE, WASHINGTON BUREAU

## ABM expectations soaring again in House

Hopes have been revived for expansion of the Safeguard antiballistic missile system—at least so far as approval by the House of Representatives is concerned. Rep. L. Mendel Rivers (D-S.C.), chairman of the House Armed Services Committee, has done another about face and is now supporting the $300-million expansion of the program.

Originally Rivers was for the program. But he became unhappy with the Pentagon and the White House when, in his opinion, they didn't ask for enough money for naval ship construction. About a month ago, Rivers let it "leak" that he might withdraw his powerful support from the Administration-backed plan to expand Safeguard. He supposedly felt that it would not get through Congress anyway, and he said publicly that he was "much more concerned about the Navy" than he was about ABM.

In short order, an invitation to the White House was received, and Rivers journeyed down to 1600 Pennsylvania Avenue, where he and the President had what is termed "an exchange of ideas." The upshot: Rivers will back ABM expansion, and the White House will not object to the Armed Services Committee adding $435-million to the Navy's request for new ships. The Navy will now have an authorization of $3,013,900,000 for new ships.

Rivers also wanted, and got, the inclusion of $152-million for design work on a new carrier, the third in the Nimitz class.

Meanwhile a joint Senate-House committee investigating the role of aircraft carriers has approved the funding of "long lead-time" construction items for the carrier without actually deciding the future of the big ships. That is now up to the National Security Council.

## NASA fund slash due to Apollo failure unlikely

The near disaster of Apollo 13 will probably not have any serious effect on NASA's funding this year, sources in the space agency believe. They see the failure of the mission and recovery of the crew as providing about equal ammunition for both the pro and anti space-flight camps in Congress, and there are more pros than there are antis. NASA sources also point out that a probe of the accident will not be completed until long after the appropriations process is finished.

There is talk within the agency, however, that Apollos 18 and 19, scheduled for 1973 and 1974, may be scrubbed and the money and vehicles used for a "Skylab" space station instead of for lunar exploration. No firm decision, however, has yet been made.

## FCC's proposed fee draws a loud no

The Federal Communications Commission is being inundated with literally hundreds of responses—all opposed—to its proposed rule to raise the fees for users of radiation-emitting equipment and to impose a new type of "acceptance" fee on manufacturers. The net intake would be about $24.5-million—$20 million more than the FCC takes in on its license-granting now.

Protests are coming in from the big communications common carriers, the National Association of Manufacturers and on down to individual ham radio operators.

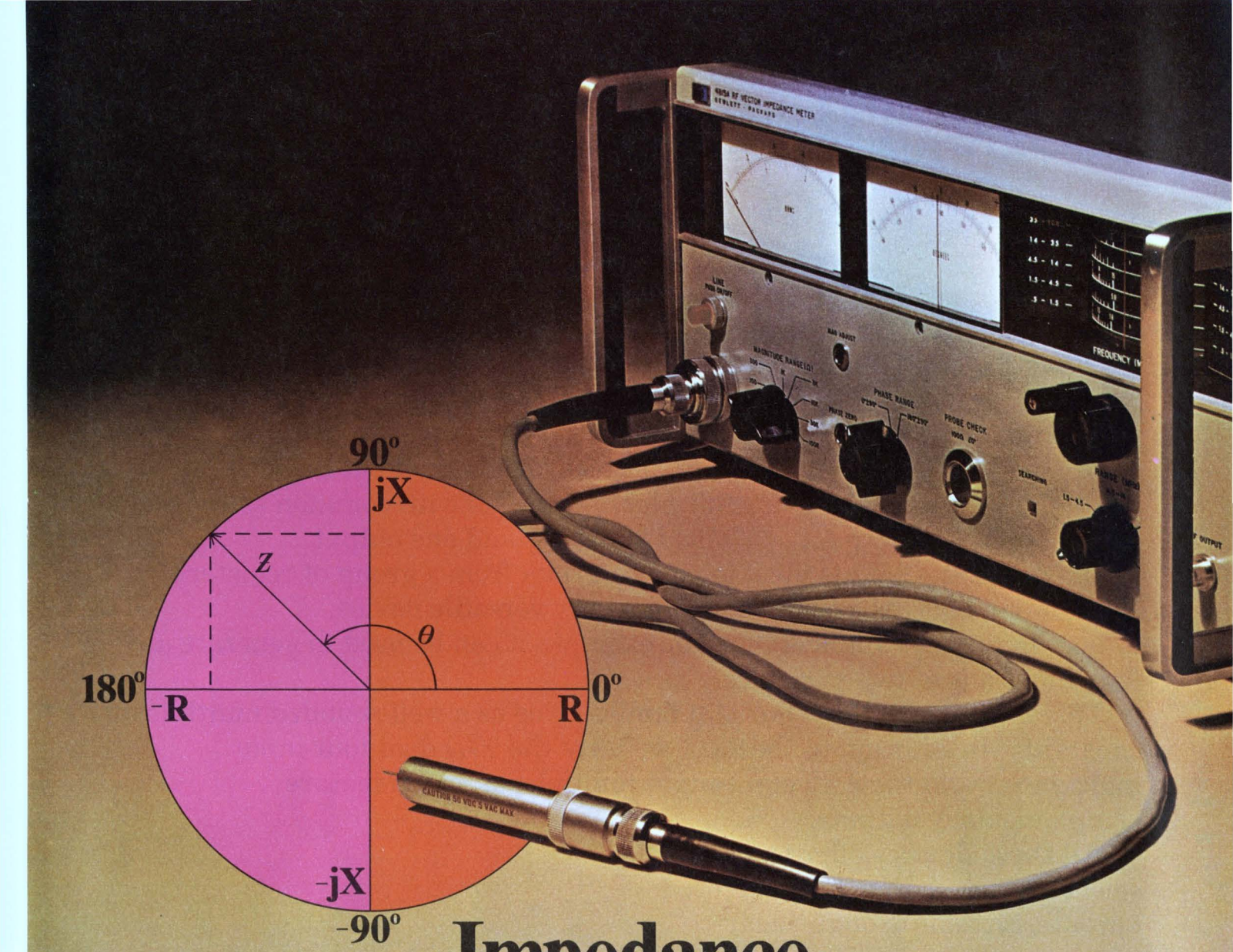
The Air Transport Association and its subsidiary, ARINC, suggested taking the matter to court. The NAM saw a dangerous precedent in a "tax, not a fee, without Congressional action." The deluge will end May 16, when all comments are to be in. The FCC will then begin its deliberation leading to a decision.

## Office proposed to educate Congress on technology

Congress is passing laws affecting modern technology, and modern technology is having a direct effect on Congress's laws. To help the men on the hill make the right decisions in the highly technical matters with which they must deal, an Office of Technology Assessment has been proposed to educate them as issues come up.

Proposed by Rep. Emilio O. Daddario (D-Conn), a key member of the House Science and Astronautics Committee and head of the subcommittee on Science, Research and Development, the office would not make actual assessments, it would operate no labs or test facilities, but it would rely on the National Science Foundation for referral to the right government agency, laboratory or company for help. Nor would the office's role be to recommend actions or positions; it would only provide Congress with information on which they could base conclusions. The bill (HR 17046) has been referred to the full Science and Astronautics Committee for action.

**Capital capsules:** The engineering development contract selection for the **B-1 advanced manned strategic aircraft has been pushed back** from the scheduled mid-May deadline. The selection board is now aiming for early June . . . . Federal Aviation Administration is seeking comments by June 15 on a proposed rule which **would ban flights by civil aircraft** over the U. S. at speeds that would cause a sonic boom to reach the ground . . . . **The joint study on civil aeronautical research and development** policy being made by NASA and the Dept. of Transportation is running a half year behind schedule and may not be completed until mid-1972. The purpose of the study is to identify benefits accruing to the public from specific levels of aeronautical R&D and to propose the levels necessary to achieve those benefits . . . . **Project Mallard,** the proposed tactical communications system to be used by the military forces of the U. S., Canada, Great Britain and Australia, will get the $14-million requested for it this year, but it faces an uncertain future. The House Armed Services Committee is beginning to have strong doubts as to its merits vs its cost. It also questions the practicality of four countries having cooperative equipment . . . . The Dept. of Transportation's plan for a 150-to-200 mph **tracked air-cushion transportation system** between a city center and its airport has run into local financing snags. Also, the site announcement is not expected now before the end of May. Kansas City and Denver were under consideration, but Kansas City is reportedly out as DOT seeks new entries.




# Impedance Measurement goes full circle

The HP 4815A RF Vector Impedance Meter will conveniently measure complex impedance over the entire impedance domain. You get instant, direct readout of impedance magnitude from 1 ohm to 100K ohms and phase angle from 0 to 360°, over a frequency range of 500 kHz to 108 MHz. Now you can easily measure impedances with negative real parts, often present in feedback amplifiers with small phase margin. To measure impedance at multiple frequencies, simply set the frequency, probe, and read. No nulling and balancing, as with conventional bridge measurements.

A convenient probe lets you measure directly in **active** circuits to determine driving point impedance under actual operating conditions, with minimum residual effects. For example, amplifier input or output impedance can be continuously monitored while bias, feedback, load, and frequency are varied. In-circuit measurements for determining loop gain and phase margin can also be made.

The 4815A is also ideal for evaluating **passive** devices, such as components and networks. Use it to characterize transformers, resonant circuits, transmission lines, filters, and crystals. You can measure at actual operating frequencies and make network adjustments while impedance parameters are monitored. For example, antenna/transmission line matching networks can be quickly adjusted. Price: $2650.

To learn more about how easy it is to use impedance for evaluating circuits and components, request Application Note 86 and a special impedance issue of the HP Journal. If you would like to discuss a particular application, call your local HP field engineer or write: **Hewlett-Packard, 100 Locust Ave., Berkeley Heights, N.J. 07922. In Europe: 1217 Meyrin-Geneva, Switzerland.**

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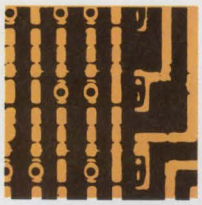
**IMPEDANCE INSTRUMENTS**

# One of the nicest things about our new MSI Multiplexer

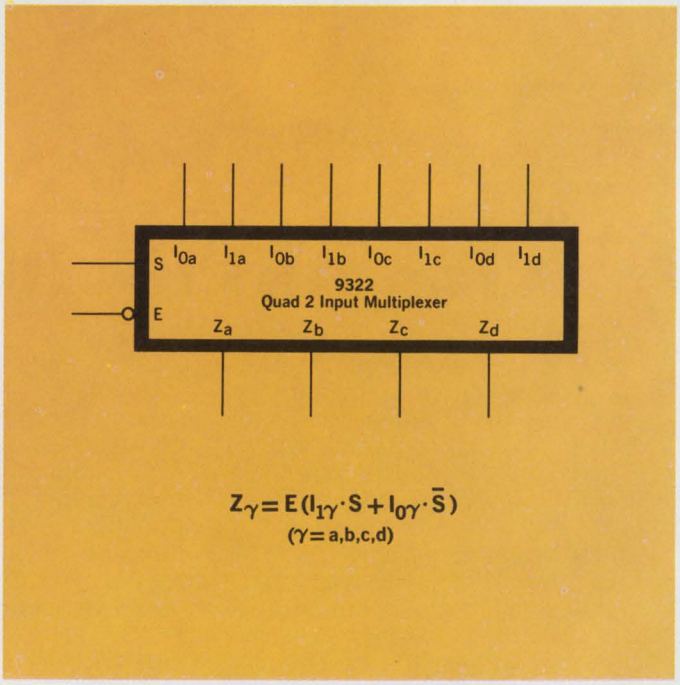


Even multiplexers can't escape the advantages of MSI family planning. (When we plan a family, we plan a *complete* family.) Here's proof: The 9322. Our third extremely versatile MSI multiplexer. A high-speed, quad two-input device that consists of four multiplexing circuits with common select and enable logic. Each circuit contains two inputs and one output.

Of course, the 9322 is ideal for moving data from a group of registers to a common output buss. But, being a very versatile device, it has many other applications. For example, it can be used to generate any four functions of two variables.

This latest addition to our MSI family gives us a well-rounded multiplexer capability. In addition to the 9322, we have the 9309 dual four-input multiplexer and the 9312 eight-input multiplexer which feature complementary outputs.

All three devices offer on-chip select logic decoding, fully buffered outputs, typical through delay of 9ns, and complete compatibility with Fairchild DT$\mu$L, LPDT$\mu$L, TT$\mu$L and MSI families.




*To order MSI Multiplexers, call your Fairchild Distributor and ask for:*

| PART NUMBER | PACKAGE | TEMPERATURE RANGE | PRICE (1-24) | (25-99) | (100-999) |
|---|---|---|---|---|---|
| U6B930951X | DIP | −55°C to +125°C | $15.80 | $12.70 | $10.60 |
| U6B930959X | DIP | 0°C to + 75°C | 7.90 | 6.35 | 5.30 |
| U4L930951X | Flat | −55°C to +125°C | 17.40 | 14.00 | 11.70 |
| U4L930959X | Flat | 0°C to + 75°C | 8.70 | 7.00 | 5.85 |
| U6B931251X | DIP | −55°C to +125°C | 15.80 | 12.70 | 10.60 |
| U6B931259X | DIP | 0°C to + 75°C | 7.90 | 6.35 | 5.30 |
| U4L931251X | Flat | −55°C to +125°C | 17.40 | 14.00 | 11.70 |
| U4L931259X | Flat | 0°C to + 75°C | 8.70 | 7.00 | 5.85 |
| U6B932251X | DIP | −55°C to +125°C | 15.80 | 12.70 | 10.60 |
| U6B932259X | DIP | 0°C to + 75°C | 7.90 | 6.35 | 5.30 |
| U4L932251X | Flat | −55°C to +125°C | 17.40 | 14.00 | 11.70 |
| U4L932259X | Flat | 0°C to + 75°C | 8.70 | 7.00 | 5.85 |

# is the family it comes from.

We put together a family plan by taking systems apart. All kinds of digital systems. Thousands of them.

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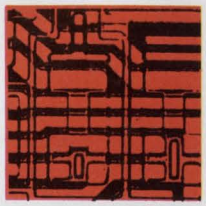
Inside each of the seven categories, we sifted by application. We wanted to design the minimum number of devices that could do the maximum number of things. That's why, for example, Fairchild MSI registers can be used in storage, in shifting, in counting and in conversion applications. And you'll find this sort of versatility throughout our entire MSI line.

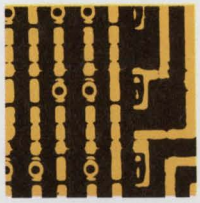


**OPERATORS**
9304 – Dual Full Adder/Parity Generator

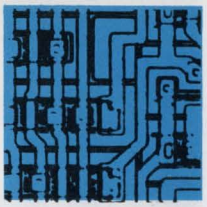
Finally, we studied ancillary logic requirements and packed, wherever possible, our MSI devices with input and output decoding, buffering and complementing functions. That's why Fairchild MSI reduces – in many cases eliminates – the need for additional logic packages.

**LATCHES**
9308 – Dual 4-Bit Latch
9314 – Quad Latch

**REGISTERS**
9300 – 4-Bit Shift Register
9328 – Dual 8-Bit Shift Register



**MULTIPLEXERS**
9309—Dual 4 Input Digital Multiplexer
9312—8-Input Digital Multiplexer
9322—Quad 2-Input Digital Multiplexer



**DECODERS AND DEMULTIPLEXERS**
9301 – One-Of-Ten Decoder
9315 – One-Of-Ten Decoder/Driver
9307 – Seven-Segment Decoder
9311 – One-Of-16 Decoder
9317 – Seven-Segment Decoder/Driver
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**COUNTERS**
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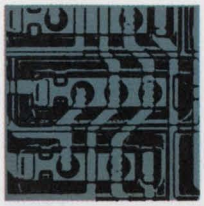
9316 – Hexidecimal Counter



**ENCODERS**
9318 – Priority 8-Input Encoder

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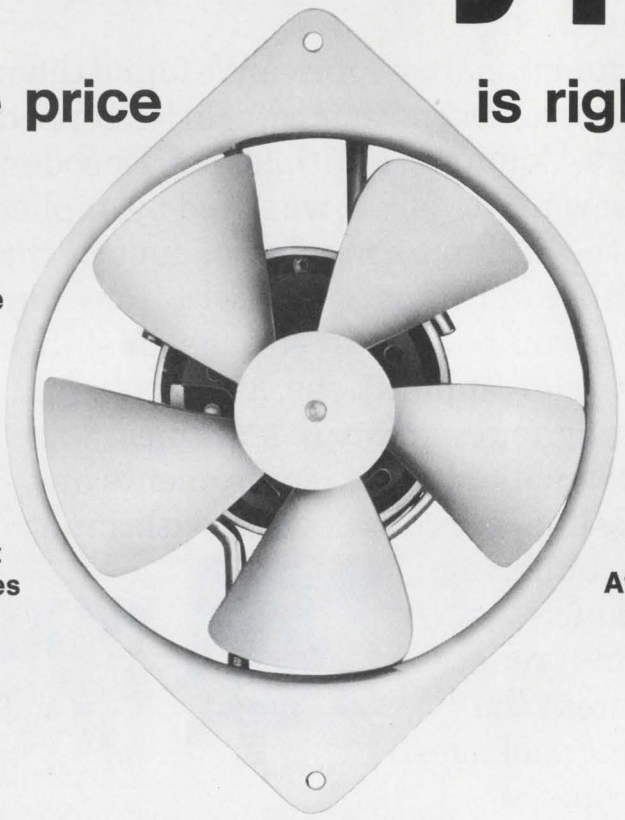
INFORMATION RETRIEVAL NUMBER 26

# Strong, silent type

## ...and the price is right*!



Low, low price — *less than $5.00 in 1000 lots.

Delivers a full 100 CFM at free delivery.

Quiet operation.

Lightweight — only 20 ounces

Five year operating life at continuous duty.

Simple installation — only two mounting screws required.

Three optional mounting arrangements available.

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# Sonotone—the industry's broadest line of nickel-cadmium sealed cells—now has our name on it.

The new name for Sonotone sealed cell nickel-cadmium batteries is Marathon. The name is the only thing that has changed. The batteries are still made in the same way. In the same plant. By the same people. And they are still available through the same sales representatives and distributors.

Marathon has been growing and expanding for 47 years. Now we have added the world's most versatile rechargeable to our diversified battery line.

Because you have relied on Sonotone for so many years, we want to be certain that you know the name — and only the name — is changed. So the next time you need Sonotones, ask for Marathon. Cold Spring, New York 10516.

**marathon battery company**

INFORMATION RETRIEVAL NUMBER 28

## Paris (and electronics fever) in the spring


Paris in the springtime: The bustling outdoor markets. The chestnut trees in bloom. Occasional showers. The sidewalk cafes. Love . . . And the Salon International des Composants Electroniques.

News Editor Jack Kessler was there mainly to cover the electronics show, the world's largest in the components field. But after a week in Paris, he kept moving—to Toulouse, London, Berlin, Munich, Eindhoven in the Netherlands and elsewhere on the Continent. The purpose of that two-week tour was to get an intimate look at what's reported to be exciting progress in Europe: industrial electronics. But that's a story for an early, upcoming issue. In the meantime, turn to page 25 and find out what happened at the electronic components exhibition, where the United States once again joined a field of 20 nations.

## Editors on the move

Steven A. Erenburg

Polytechnic Institute in Brooklyn, N. Y., has its eye on ELECTRONIC DESIGN. At its request, Managing Editor Raymond Speer was chairman of a technical panel session on IC chip interconnections. The session was part of a two-day professional seminar on "Semiconductor Packaging in the 70s," held in New York City in mid-April. Discussion periods were held each day.

Our new microelectronics editor, Steven A. Erenburg, is back from a nationwide get-acquainted trip on which he met manufacturers and users. Steve's experience has been mainly with automatic control and navigation systems in the aerospace and other industries. A BEE from Pratt Institute in Brooklyn, he will receive in June a master's degree in systems science from Polytechnic Institute.

# Two best sellers with the same silly problem

When your 1969 model looks the same as your 1968 model—getting across the engineering advances and improvements that are on the *inside* is a problem.

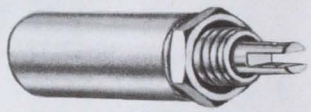
For instance, in 1966 we started using fully-annealed Armco steel for all Guardian Solenoid plungers . . . an "inside" improvement. Then, to compound the problem, we covered up this improvement with copper/nickel plating.

In 1968 we did it again. We took those long-life plungers and started running them in a cavity lined with low-friction phenolic. This alone increases operating life by maybe half a million operations.

And there's more: The new acetate-yarn-sealed coil cover that's standard this year means better protection, complies with U/L construction at no extra cost.

Our "bug" changes. Inside. Where an engineering advance makes for a better solenoid. Write for Bulletin G2, TS.

**NEW! TUBULAR SOLENOIDS**



Eleven new Guardian Tubular Solenoids to fit every application. Practically install themselves. Just insert threaded bushing through installation hole and tighten furnished nut.

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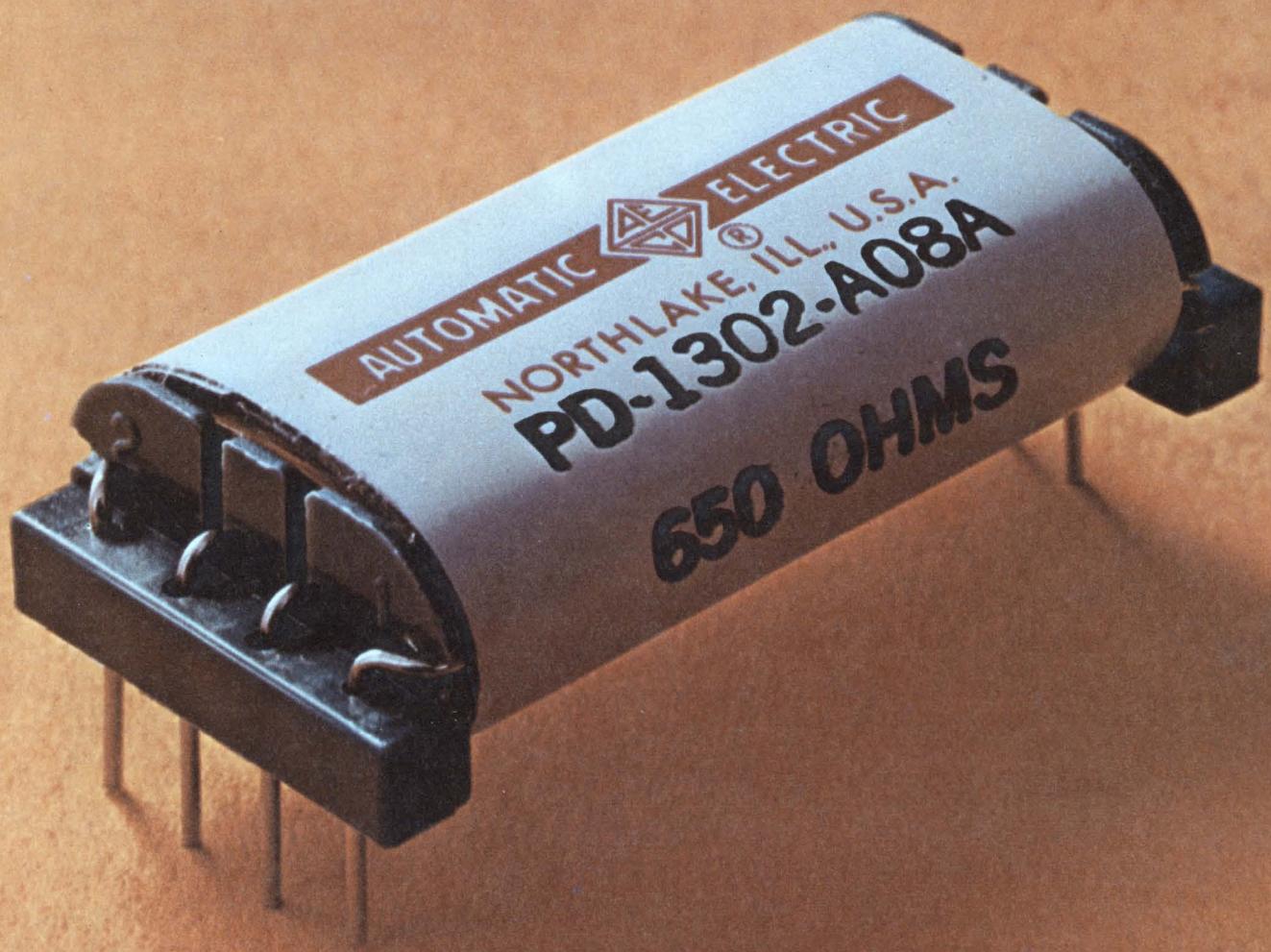
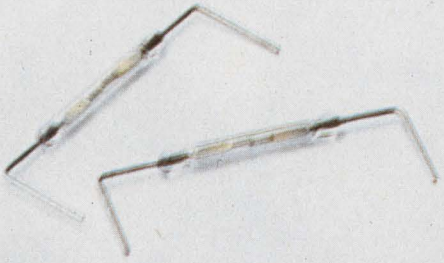
Check **18**

# Everyone talks correed reliability,



# here's the way it looks.



**Switches under glass.**

The heart of every AE correed is a reed switch consisting of two overlapping blades. For protection, we seal them inside a glass capsule. But only after we pull out all the dirty air and pump in a special, pure atmosphere. That way there's no chance of contact contamination or oxidation. Ever.

Notice our terminals are one piece. A special machine delicately forms them to precision tolerances. It's a lot of work, but one-piece terminals have distinct advantages over the two- and three-piece kind.

For one thing, there's no extra joint so you're always assured of a positive contact. Also, one piece terminals are more reliable when the correed is used to switch low-level analog signals. That's because thermal EMF is reduced to practically zero.

**A different kind of bobbin.**

Since we go through so much trouble with our correed capsules, we designed a special bobbin to protect them.

It's molded of glass-filled nylon. (You know how plastic chips and cracks.) Moisture and humidity have no effect on this stubborn material. No effect means no malfunctions for you to worry about. No current leakage, either.

Running the full length of the bobbin are a series of slots. They pamper the capsules and keep them from getting damaged or jarred.

And to help you remember which terminal is which, we mold the terminal numbers into the end of the bobbin. You can read them at a glance.

**Little things mean a lot.**

Reliability means that we pay attention to the little things. Like the tiny pressure rods we use in every miniature correed. They're placed at each end of the bobbin, across the one-piece terminals. What they do is prevent stresses from being transmitted from the terminals to the reed blades. This keeps the contact gap right on the button. All the time.

The contacts are normally open. To provide them normally closed, we employ another little device—a tiny magnet. It's permanently tucked into a slot next to the reedcapsule. The magnetic action keeps the contacts normally closed.

**Coiled by computer.**

Once all the parts are secure in the bobbin, we cover them with protective insulation. Around this, we wind the coil. You can be sure the coil winding is correct. It was all figured out for us by computer.

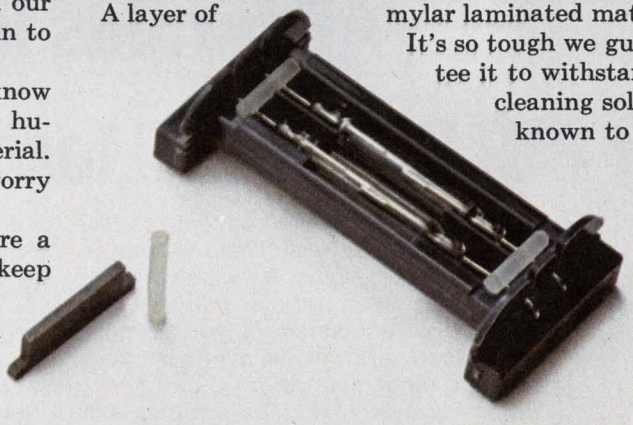
Our next step is to protect the coil. We do that with more protective insulation.

**A coat of iron.**

On top of the insulation goes a layer of annealed iron. It acts as a magnetic shield and minimizes interaction between coils. Also, it improves the sensitivity of the entire unit. A coat of iron is standard on all AE correeds.

**Finally comes super wrap.**

To wrap it all up, we use some very special stuff. A layer of mylar laminated material. It's so tough we guarantee it to withstand all cleaning solvents known to man.



It's attention to detail that helps us keep our miniature relays miniature. Now we're just waiting to show you how perfectly it measures up to your specifications. Automatic Electric Company, Northlake, Illinois 60164.

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SUBSIDIARY OF GENERAL TELEPHONE & ELECTRONICS

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# Our PULSE-RATED™ toroids really are alike.

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*Pulse-rated* toroids not only simplify your selection process, they practically eliminate scrap. So you get 100% yield in your pulse transformer production.

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Parylene-coated *pulse-rated* toroids in sizes and specifications to suit your design requirements are now available for off-the-shelf delivery. Want some? We welcome the opportunity to send you samples. And hot-off-the-press spec sheets. And to consult with you about your design problems. Write Indiana General, Electronic Products, Keasbey, N. J. 08832.

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272 pages of data list specs, illustrate logic diagrams, give test conditions for

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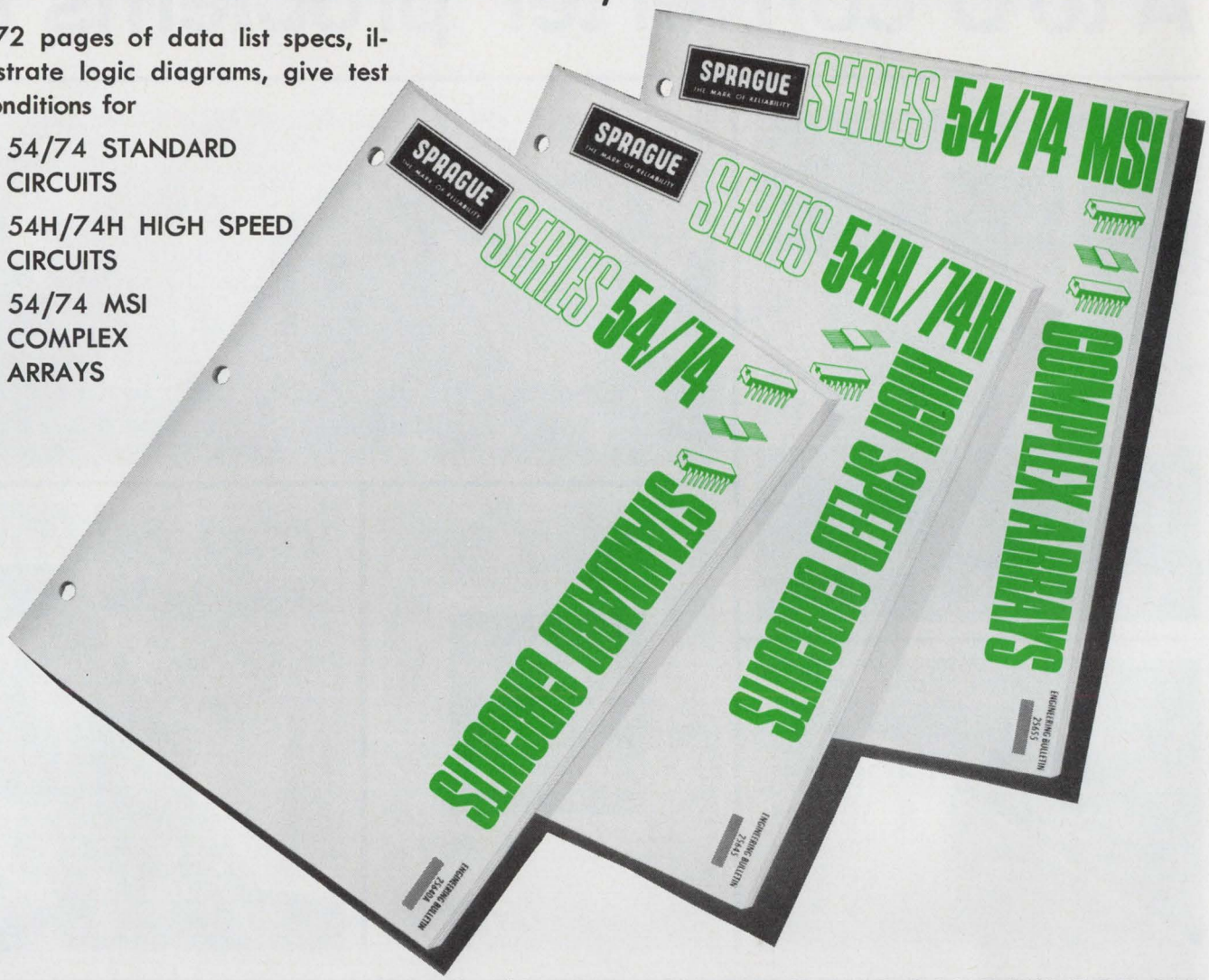
- 54/74 MSI COMPLEX ARRAYS

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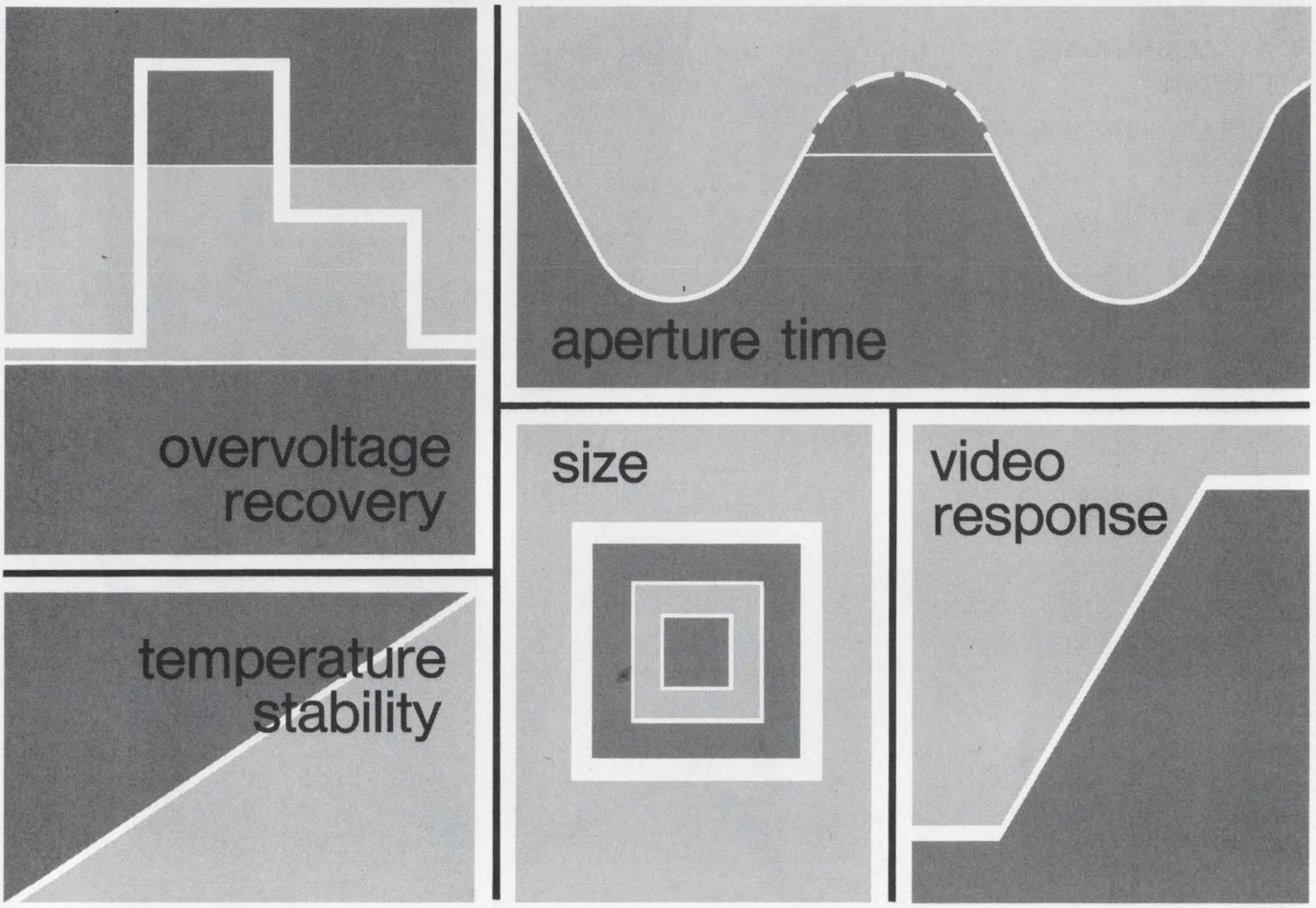


You may have tried to solve one or more of these problems. We have solved them for you. Satisfy your requirements with an extremely fast, accurate but stable and dependable Analog-to-Digital Converter. You can rely on them to consistently provide the conversion necessary for accurate and reliable system performance.

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Size: Standard Units
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Need a fast, accurate solution to an IC problem? E-H Research Laboratories, Inc. teams up with Iwatsu Electric Company, Ltd. to offer you the ideal test instrumentation.

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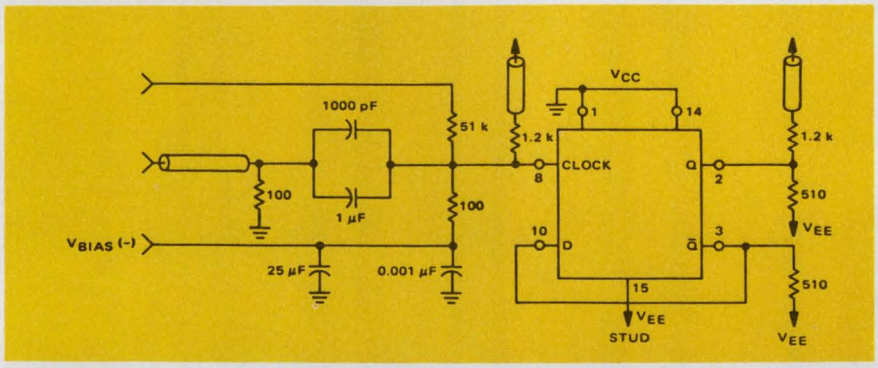
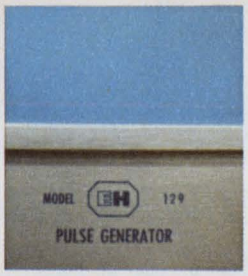
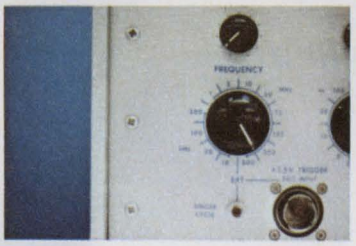
And the ideal mate for this instrument is the **Iwatsu 5009B sampling scope** which allows you to observe and control the waveforms you generate. The Iwatsu 5009B with 18GHz bandwidth lets you evaluate fast circuits with high accuracy—in fact, direct measurements on 100 ps edges with less than 2% display error. Features include less than 20 ps risetime, sensitivity from 10mV/cm, dual-trace performance with seven operating modes, separate miniature sampling heads, big CRT and triggering to full bandwidth for extra convenience.

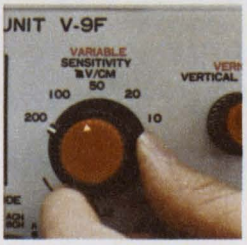
If these two instruments can't solve your problems, E-H can offer you E-H and Iwatsu instrumentation that can. Contact an E-H representative and get a fast solution. Today.

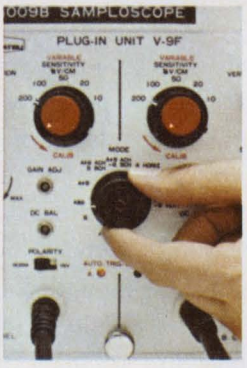


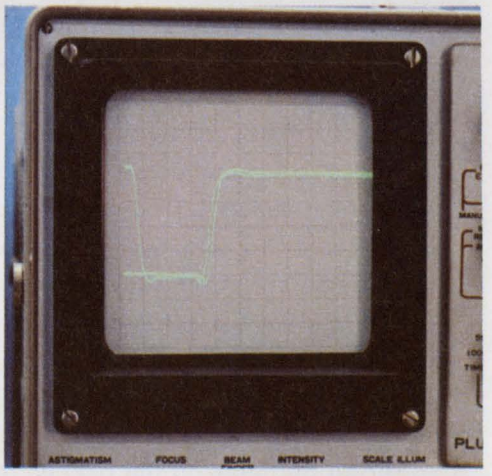





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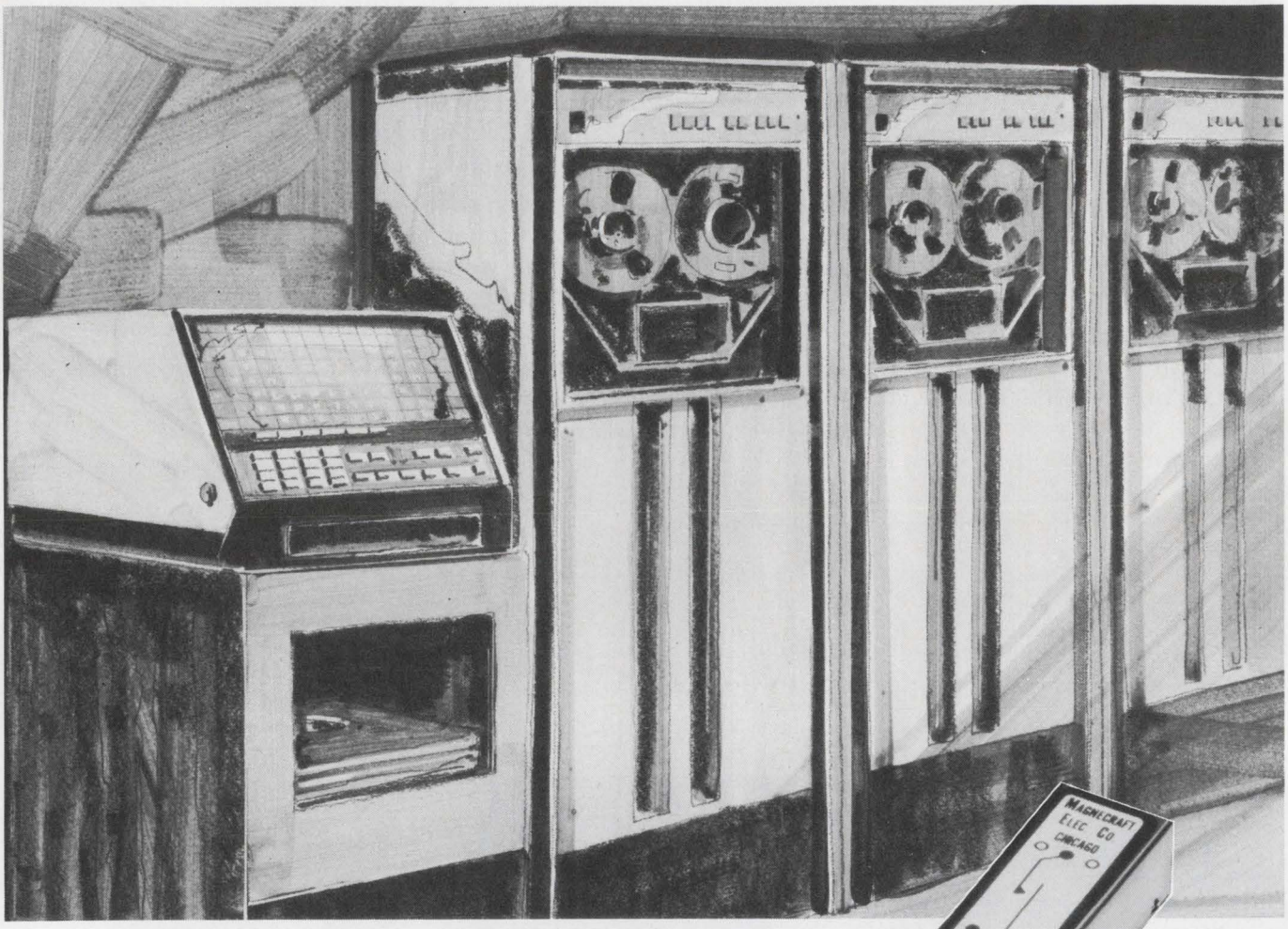

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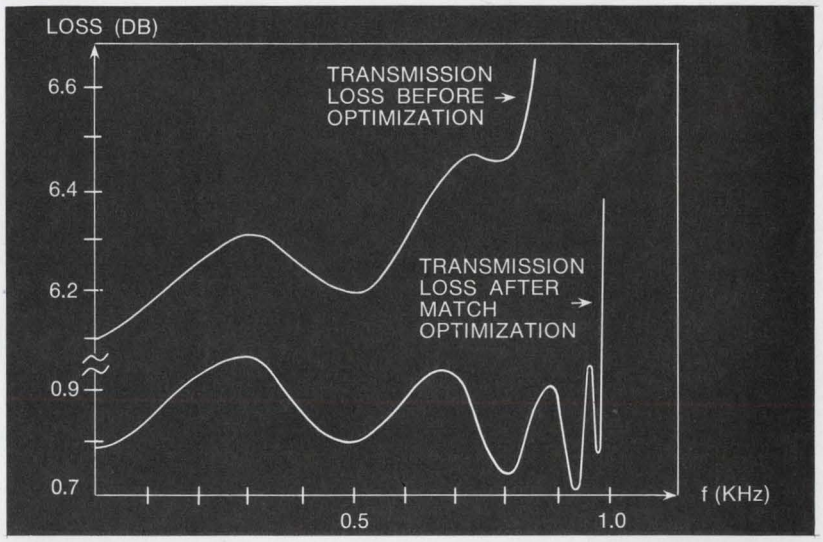


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Design Assistance for Design Engineers

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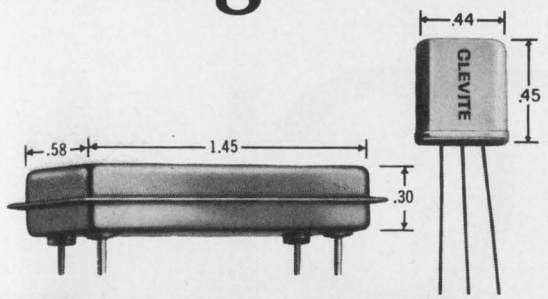
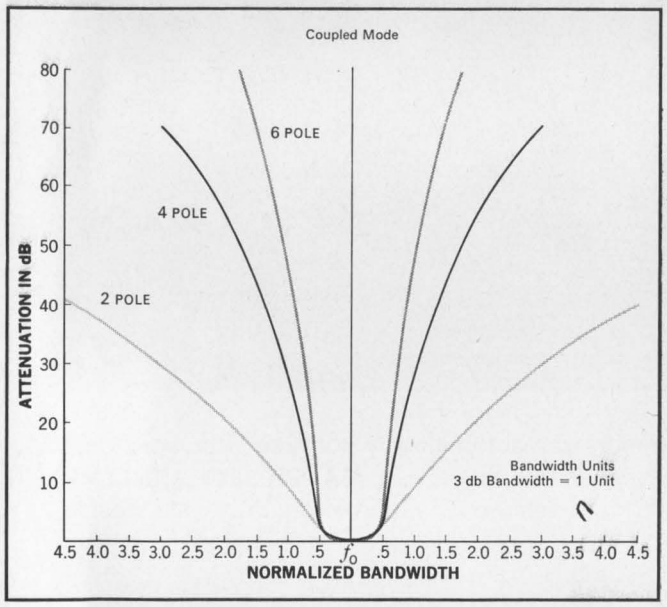
# Going to IC's? Or Higher IF's?




# Go with Clevite's off-the-shelf coupled-mode quartz filters.




Now you can get *immediate delivery* on Clevite Uni-Wafer® coupled-mode Quartz Filters. Eleven models are available right off-the-shelf—two, four, and six pole; center frequencies of 10.7, 20.5, and 30 MHz; AM or FM bandwidths of 9, 14, and 30 kHz. And they're available in coldweld-sealed flatpacks or solder-sealed HC 18 cans.

Clevite's exclusive Uni-Wafer design uses trapped energy techniques to maximize resonant energy over arrays of resonators on a single quartz wafer. As a result, you get higher performance in a smaller package.

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If you're going to IC's or higher IF's, Clevite Uni-Wafer coupled-mode Quartz Filters are the best way to go. For more information, including complete specifications, write Piezoelectric Division, Gould Inc., 232 Forbes Road, Bedford, Ohio 44146, or: Brush Clevite Company, Limited, Southampton, England.

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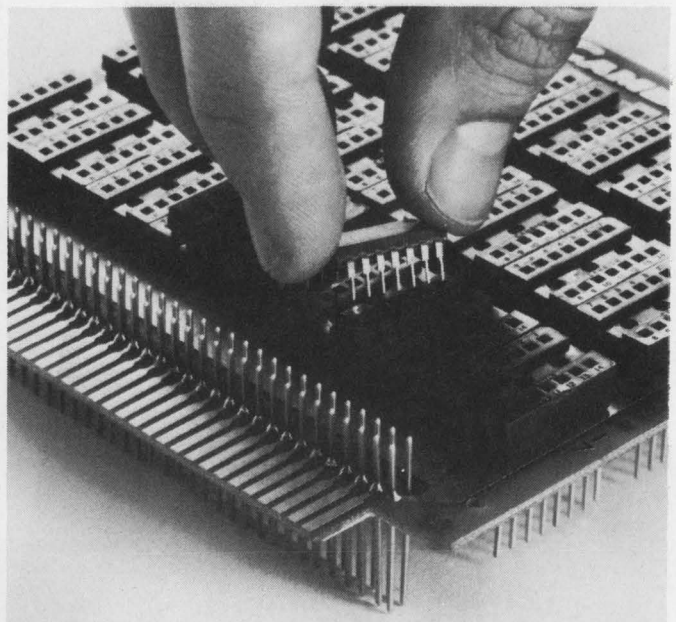

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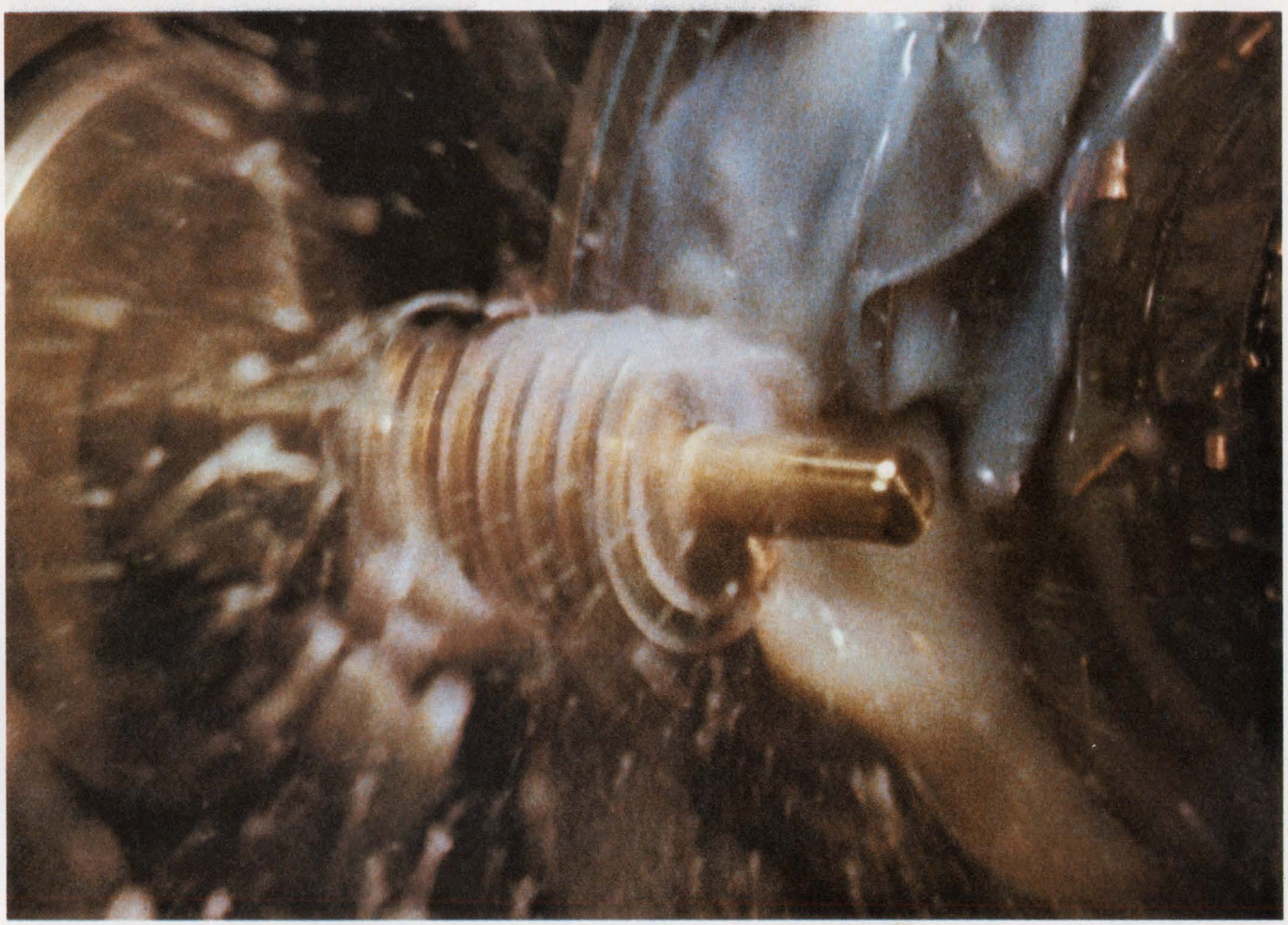

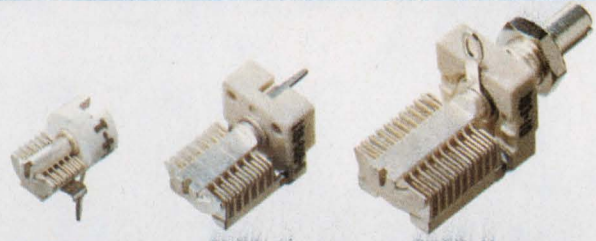

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pF: 1.3-5.4 to 1.9-15.7
TC: plus 30 ± 15 ppm/°C

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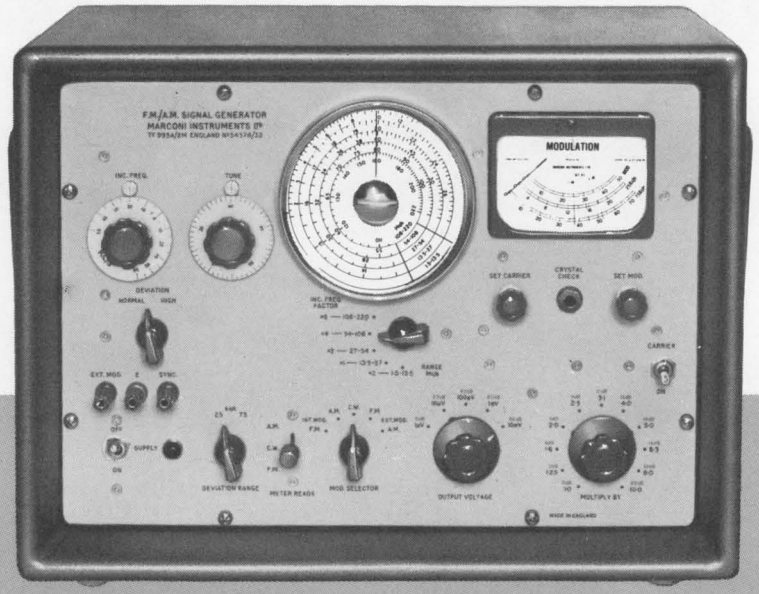


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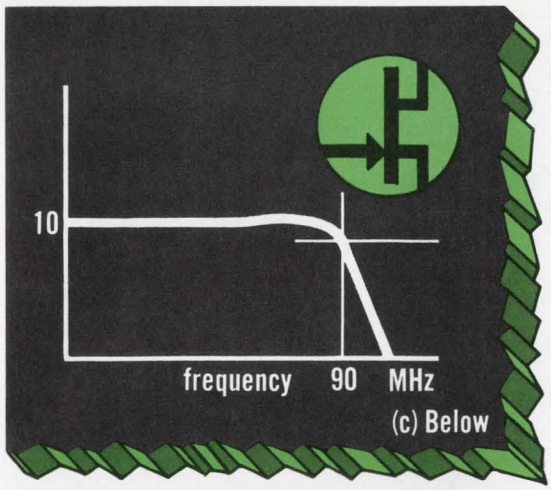


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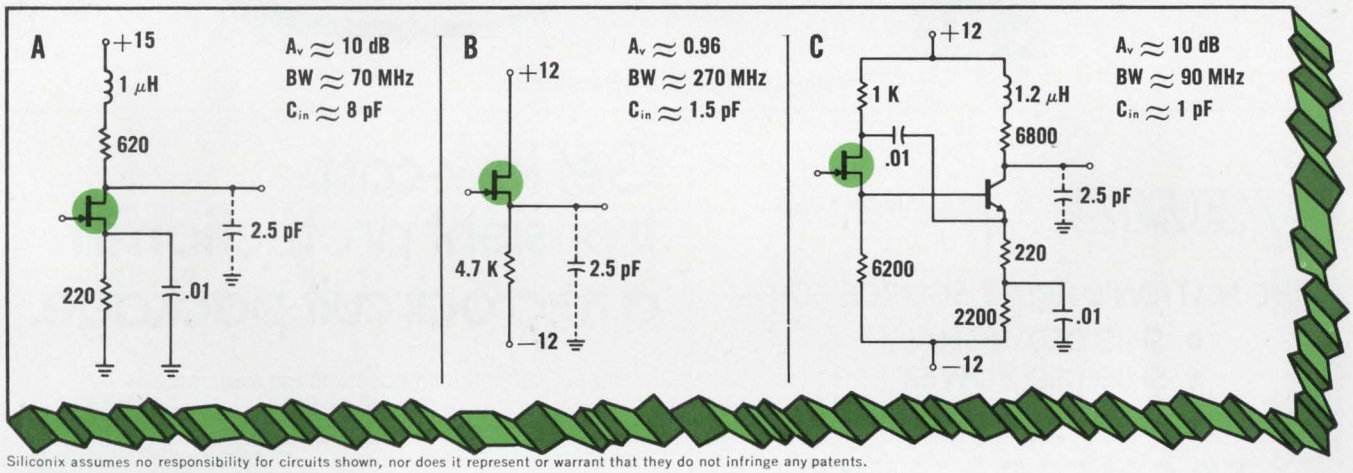
If you've a wide band application (approaching 100 MHz), need high $Z_{in}$ (10 MΩ @ 1 MHz) and want low $C_{in}$ (down to 1 pF), think FETs. Here are three circuit ideas for starters:






The Siliconix 2N5397 gives you the best $g_{fs}/C_{in}$. We do have FETs with even lower $C_{in}$. For details on these and other circuit approaches, write or call any of the numbers below.

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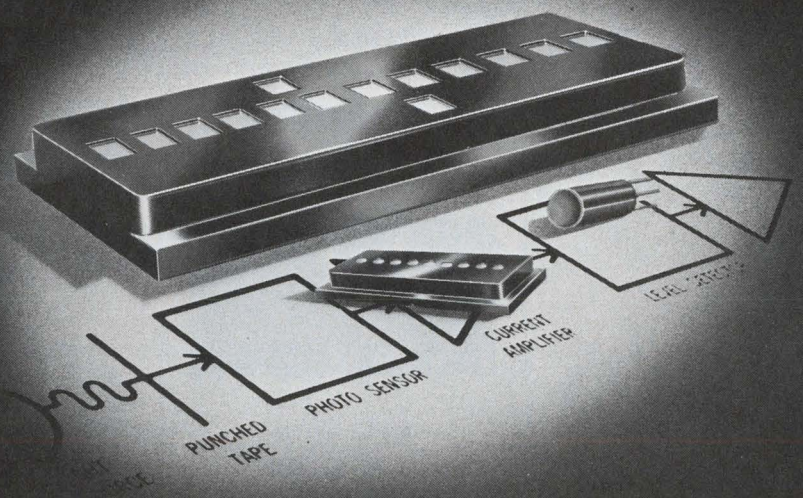


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## and also get accurate, precise control

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***EXTREME VERSATILITY*** Regardless of size or shape needed CDI is well prepared to meet your every switch requirement.

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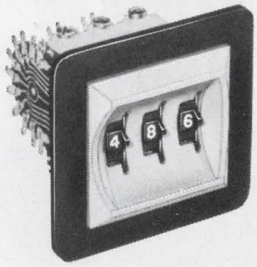

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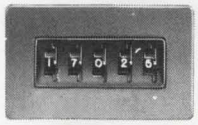
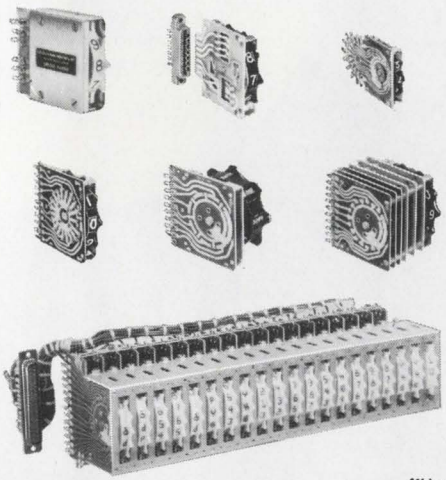
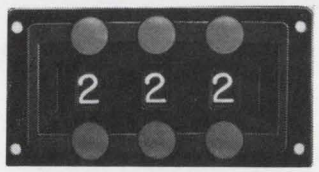




### PUSHBUTTON SWITCHES

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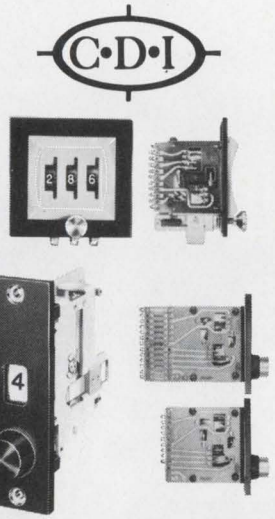
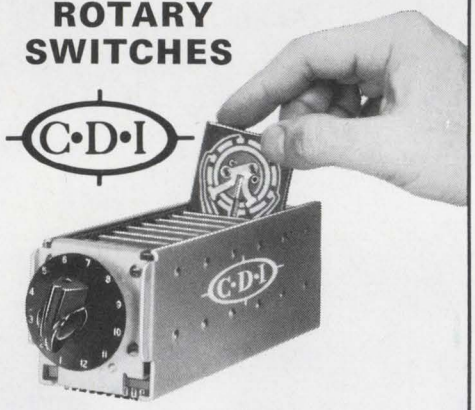
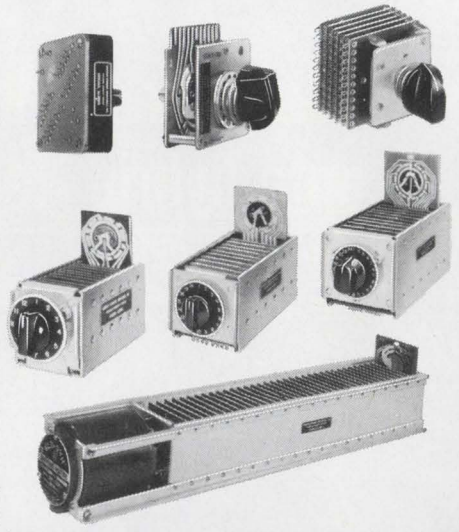


### ROTARY SWITCHES



For critical reliability applications. Meet MIL-S-22710. Removable wafers permit quick changing of programs, configurations, circuits. CDI patented switches with dust covers available in sizes 2" x 2", 3" x 3" and 4" x 4" with lengths to accommodate up to 36 wafers. Operation may be manual, motor or solenoid.



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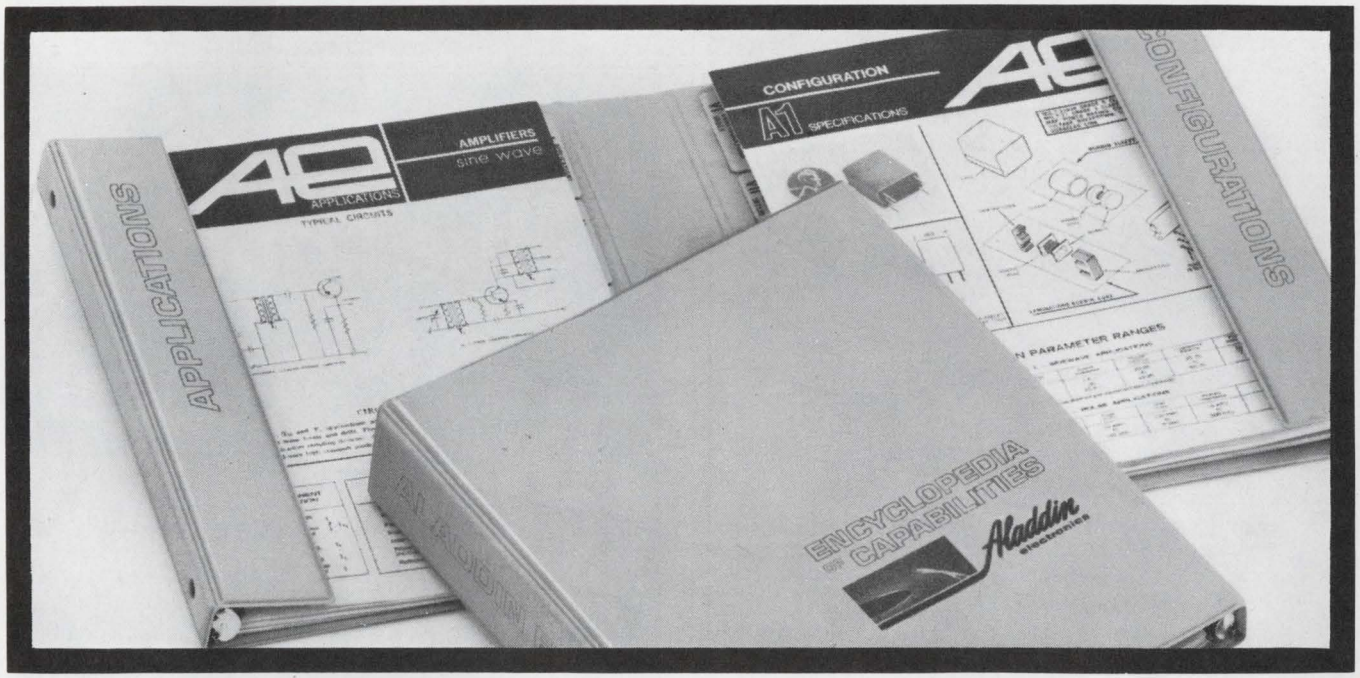


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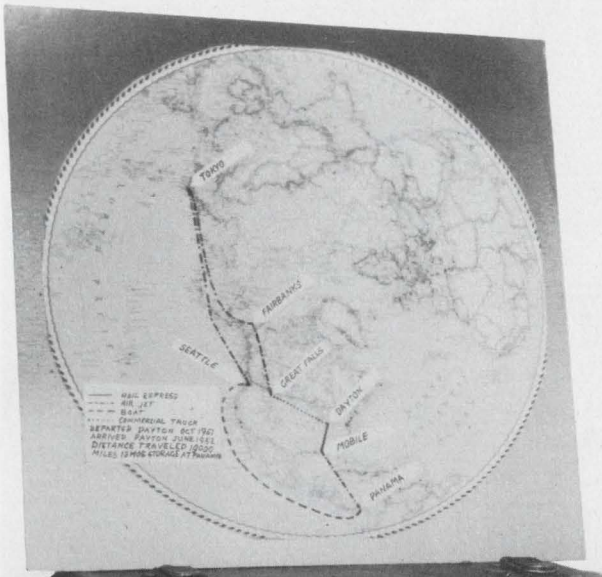


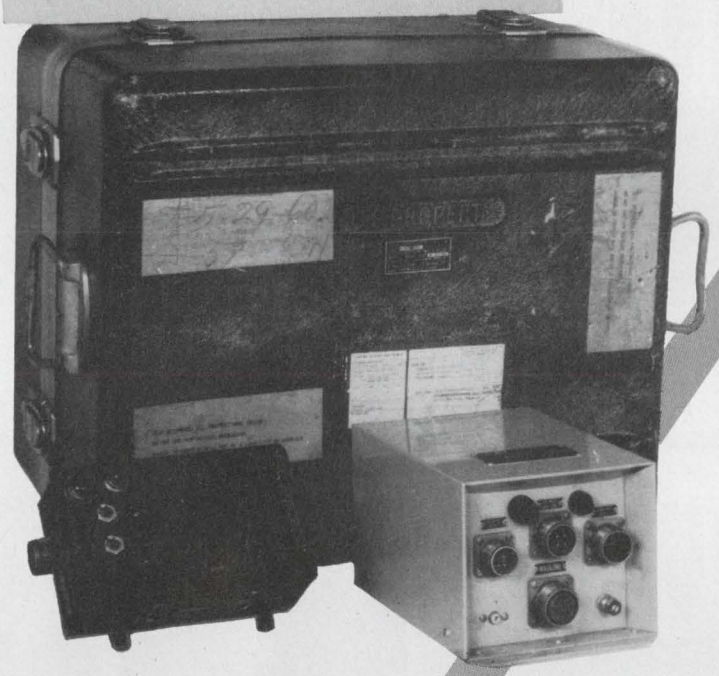

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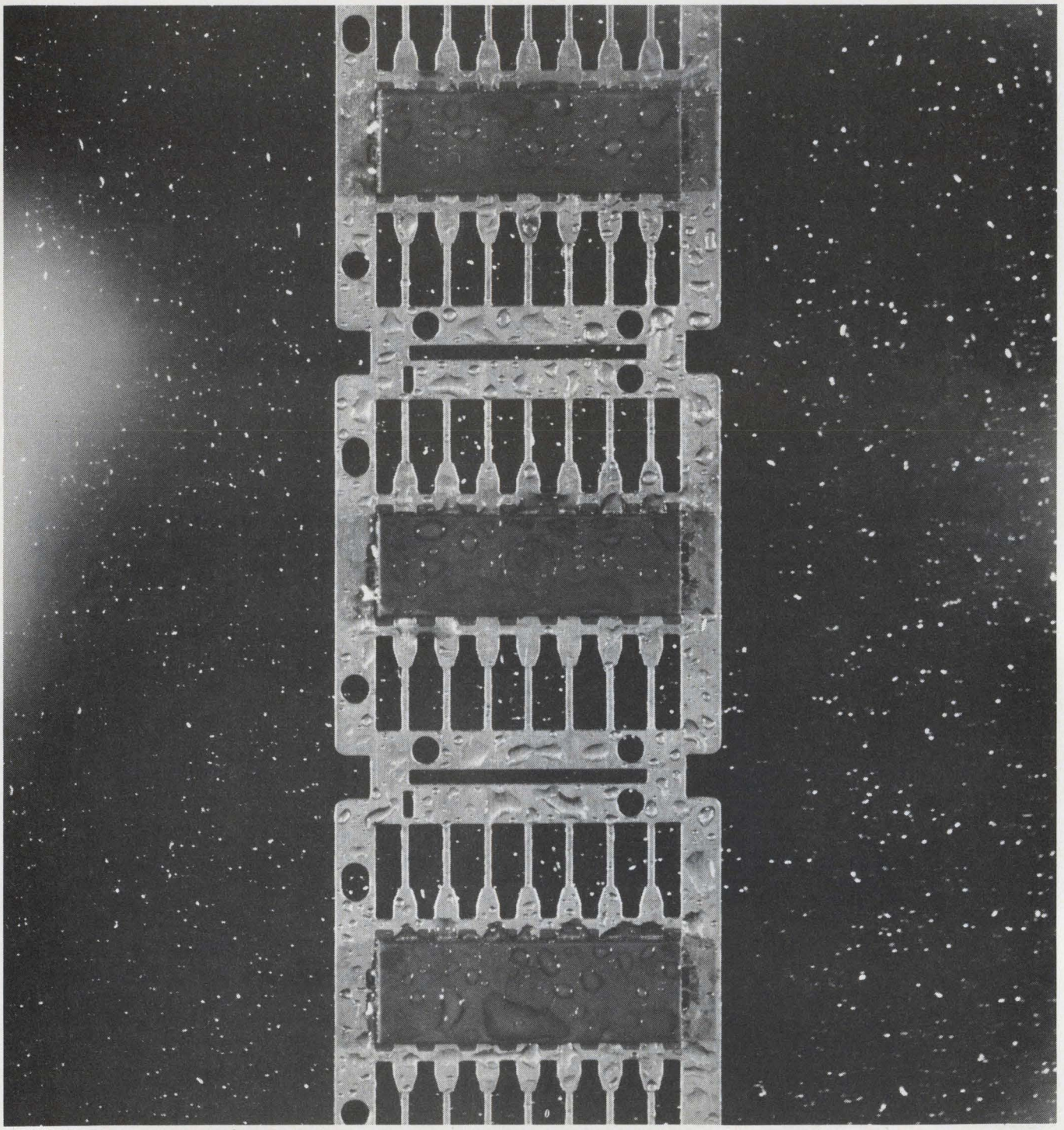

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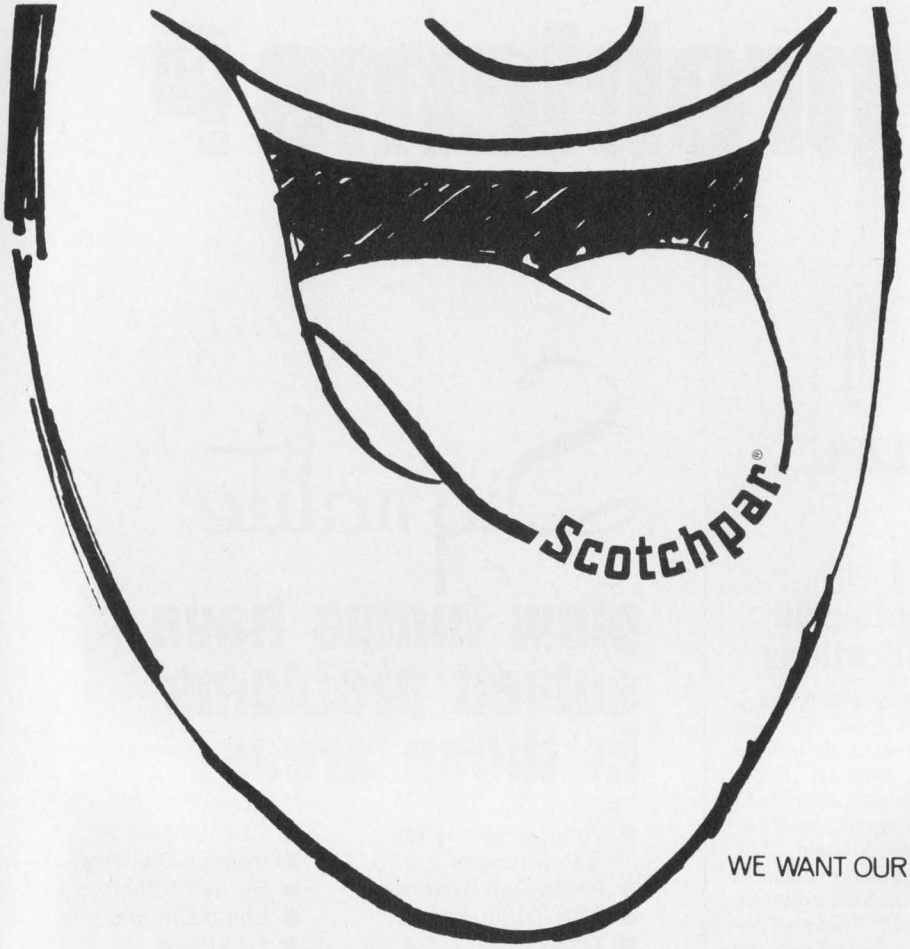


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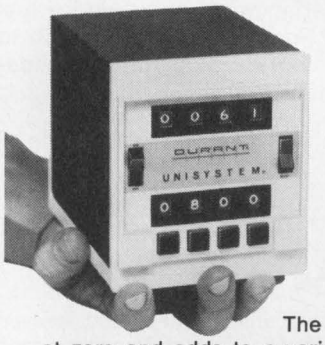


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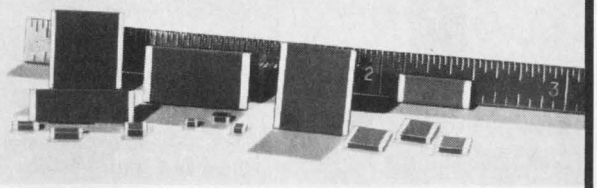

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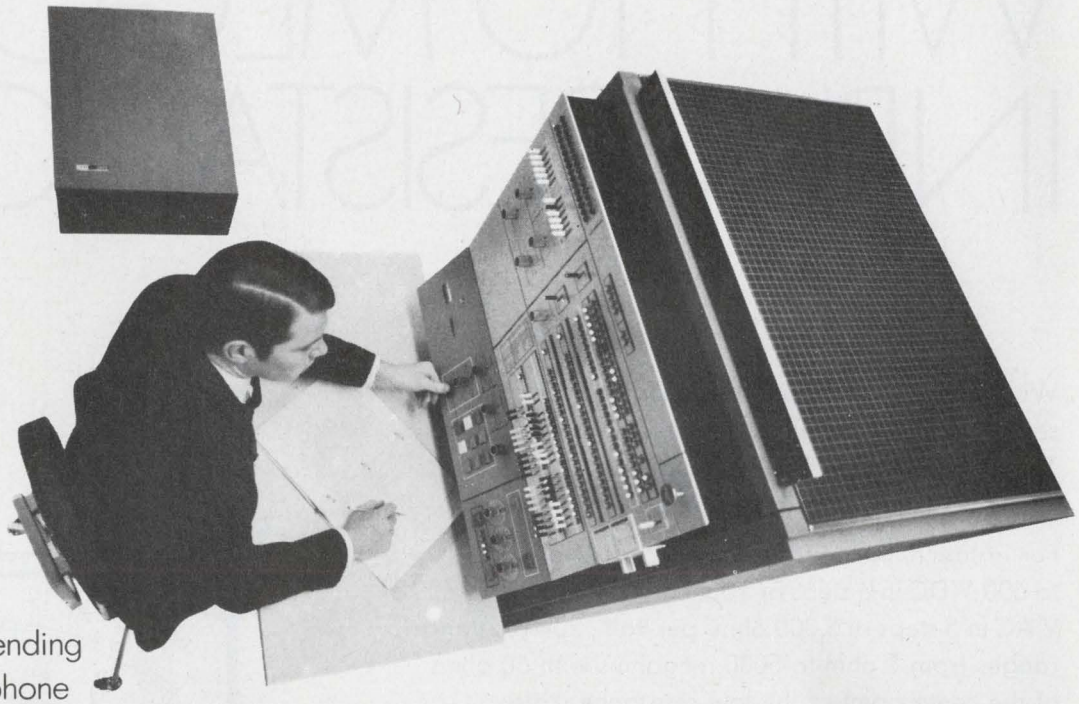

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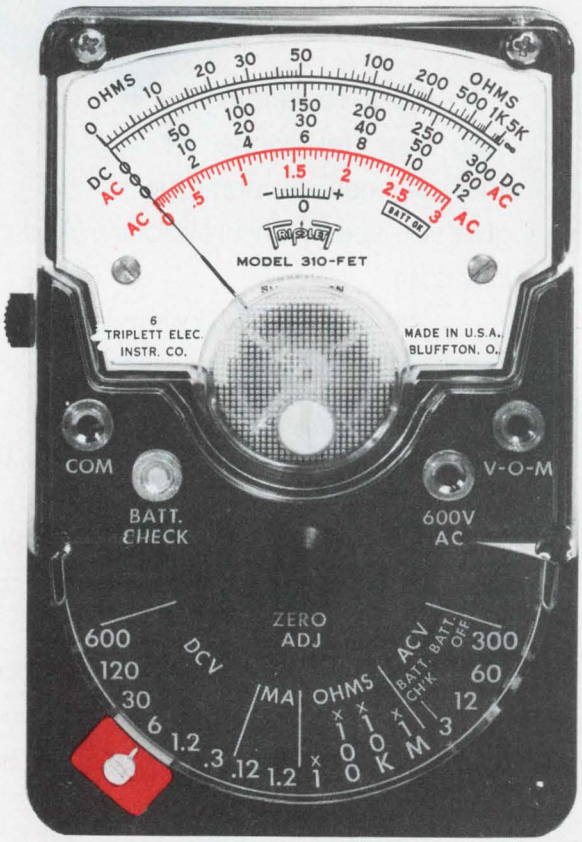


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EDITORIAL

# Don't take technology out of ecology

Of late, the hue and cry over pollution has reached gigantic proportions in some quarters. And, considering the stakes involved, it is a good thing that our society is finally waking up to the critical nature of the problem.

In some instances, though, it appears that concern has given way to mania—and that logical consideration has been replaced by precipitous action. Some recent examples of this include the public wreckage of brand-new cars, mass mailings of "no-return" bottles to a major soft-drink company, and a "trash-in" in Seattle, where refuse was returned to the companies responsible for the original product. Granted that such public demonstrations call attention to the problem, but they do little to promote practical solutions.

Condemn, if you will, the internal-combustion engine but not the automobile; rail against the dumping of garbage in off-shore waters or the burning of trash—but don't send burned-out light bulbs back to the manufacturer or apple cores back to the farmer. Such antics gain newspaper space but little else.

Of course, our environment could be cleansed to a remarkable degree if we all consented to revert to the agrarian society of our ancestors. But man has never tolerated a backward step in his social and economic evolution, and we doubt that he ever will.

The true solution seems obvious: namely, to bring technology to bear on pollution—the same technology that many accuse of causing the problem.

To be sure, modern technology is not going to clean our air and waterways by itself. Government regulations and funding, as well as public awareness and concern, will play major roles. But an equally important role should be played by engineers and scientists.

These are the people who can develop a practical electric car, clean power systems, and foolproof monitoring and detection equipment. And they can do so whether mobilized in the form of a national commitment, such as was done for the Manhattan Project and Project Apollo, or whether they operate within the framework of their own company or organization.

They and their talents must be committed to the fight against pollution; then an analytic rather than a headline-grabbing approach to the problem will be possible.

FRANK EGAN

# Predict intermodulation distortion

## from cross-modulation measurements. Since third-order intermod and cross-mod have the same origin, specifying one specifies both.

It's a basic fact, but not apparently widely known, that the third-order intermodulation distortion level and the cross-modulation performance of a given device cannot be specified independent of each other. If the fact were widely known, one wouldn't see so many procurement specifications with inconsistent cross-mod and intermod figures.

Both phenomena are caused by a third-order (or higher) nonlinearity in the transfer characteristic of the device. (In this article, higher-order nonlinearities will not be considered as they are usually not significant.) Specifying either one of them defines the nonlinearity and, hence, specifies the other. Converting from one type of description to the other can be done analytically or, more conveniently, by means of a graph. Similarly, in measuring these quantities, much time can be saved by measuring only one of them and calculating the other.

Cross-mod is measured by applying two carriers to the input of the device under test—one modulated and the other unmodulated. The amount of modulation transferred to the initially unmodulated carrier is a measure of the cross-modulation performance of the device.

Intermod is measured by applying two unmodulated carriers to the device input and measuring the output signal at a third (intermod) frequency. Let's see how the two measurements are related.

### Examine the cross-mod

The transfer characteristic of a device can be expressed as the sequence of coefficients of the Maclaurin series relating the device's output to its input. The series will generally be of the form

$$E = A_0 + A_1V + A_2V^2 + A_3V^3 + \cdots \quad (1)$$

where E is the output voltage, V is the input voltage and $A_0$, $A_1$, $A_2$, etc. are constants.

A perfectly linear device, of course, would have all of its coefficients except $A_1$ equal to zero and thus would introduce no distortion at all. If two sinusoidal signals were applied to such a perfectly linear device, the same two signals would appear at its output. They might be changed in amplitude and/or phase, but their frequencies would be unchanged. And no new frequencies would be generated.

In the nonlinear real world, however, the picture is a bit different. Let the composite input signal consist of two sinusoids, one of which is amplitude-modulated by a third sinusoid. The input voltage is thus given by

$$V = V_1 \sin \omega_1 t + V_2(t) \sin \omega_2 t \quad (2)$$

where

$$V_2(t) = V_2(1 + m \sin \omega_m t). \quad (3)$$

The modulation index, m, must satisfy the inequality $0 \leq m \leq 1$.

Substituting Eq. 2 into Eq. 1 gives us an expression for the output voltage. The first term in the expression containing new frequencies is the second-order term, $A_2V^2$. It contains signals at twice the input frequencies and at the sum and difference frequencies, but none that affect the signals at $\omega_1$ or $\omega_2$.

The third-order term, $A_3V^3$, contains a signal at frequency $\omega_1$ whose amplitude is partially controlled by $V_2(t)$. The complete expression for the output signal at $\omega_1$ is

$$E_{\omega_1} = \{A_1V_1 + (3/4)A_3V_1^3 + (3/2)A_3V_1V_2^2 [1 + (m^2/2) + 2m \sin\omega_m t - (m^2/2) \cos 2\omega_m t]\} \sin\omega_1 t. \quad (4)$$

For small values of m, Eq. 4 reduces to

$$E_{\omega_1} = [A_1V_1 + (3/4)A_3V_1^3 + (3/2)A_3V_1V_2^2 + 3A_3V_1V_2^2 m \sin\omega_m t] \sin \omega_1 t \quad (5)$$

and the effective modulation index, m′, is given by

$$m' = 3A_3V_2^2 m/[A_1 + (3/4)A_3V_1^2 + (3/2)A_3V_2^2]. \quad (6)$$

By forming the ratio m/m′, we can relate the cross-modulation produced by a device to the input voltages, the coefficients of the transfer characteristic, and the original modulation index.

**Harold B. Goldberg,** Government Contracts Engineering Manager, Computone Systems, Inc., Liberty Corner, N.J.

The expression is.

$$m/m' = (A_1/3A_3V_2^2) + (V_1^2/4V_2^2) + 1/2. \quad (7)$$

### Now look at the intermod

Algebraic manipulations similar to those used in the cross-modulation analysis will also yield expressions for the output signals at $\omega_2 \pm 2\omega_1$ and $\omega_1 \pm 2\omega_2$. These third-order intermodulation outputs are

$$E_{\omega im} = (3/4)A_3V_1V_2^2(t)\sin(\omega_1 \pm 2\omega_2)t + (3/4)A_3V_1^2V_2(t)\sin(\omega_2 \pm 2\omega_1)t. \quad (8)$$

Since intermod measurements are usually made with unmodulated equal-amplitude signals, ($V_2(t) = V_2 = V_1$), the amplitude of each third-order intermod product is simply

$$E_{im} = (3/4)A_3V_1^3. \quad (9)$$

A standard way of specifying intermodulation distortion is to specify the third-order intercept point.[1] This point is defined as the output power level at which the third-order intermodulation power, at any one of the intermod frequencies, is equal to the first-order signal power at either of the input-signal frequencies. If the output impedance of the device is assumed to be the same at both the fundamental and the intermod frequencies, the output powers can be set equal to each other by simply setting the squares of the output voltages equal:

$$(A_1V_1)^2 = [(3/4)A_3V_1^3]^2. \quad (10)$$

Solving for $V_{ip}$, the intercept-point input voltage, Eq. 10, yields

$$V_{ip}^2 = 4A_1/3A_3. \quad (11)$$

It should be noted that Eq. 11 is valid only for relatively low signal levels—levels at which the distortion contributions of the higher-order terms in the series expansion of the output voltage contribute negligible amounts of power at the frequency of measurement.

By solving Eq. 11 for $A_3$ and then plugging the result into Eq. 9, an expression relating the output intermod voltage to the input voltage and the intercept-point voltage can be obtained:

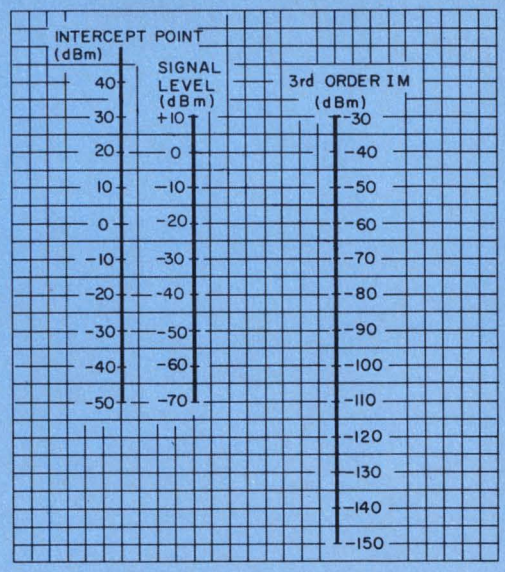
$$E_{im} = A_1V_1^3/V_{ip}^2. \quad (12)$$

Eq. 12 can be transformed into a relationship between output powers by making the following substitutions: Intermodulation power, $P_{im} = E_{im}^2/R$; intercept-point power, $P_{ip} = (A_1V_{ip})^2/R$; and signal power $P_1 = (A_1V_1)^2/R$, where R represents both the input and output resistances (assumed equal) of the device. The resulting equation is:

$$P_{im} = P_1^3/P_{ip}^2. \quad (13)$$

(Note that Eq. 13, which was developed in terms of output power levels, can also be applied at the input by dividing all voltages by the linear gain, $A_1$, of the device.)

Once the intercept point has been found, from a single intermod measurement, Eq. 13 makes it possible to predict the intermod performance at any signal level. The nomograph of Fig. 1 can greatly simply the job.




**1. The third-order intermodulation produced by any two equal input signals** is found by connecting a line between the intercept point and the signal level and reading the answer where this line intersects the third-order intermod line. The nomograph can be used with either input or output powers.

### Relate cross-mod to the intercept point

With cross-mod and intermod both described and defined, our task now is to relate them to each other. This is easily done by solving Eq. 11 for $A_3$ and plugging the result into Eq. 7, yielding:

$$m/m' = V_{ip}^2/4V_2^2 + (1/4)V_1^2/V_2^2 + 1/2. \quad (14)$$

In most practical cross-modulation measurements, $V_1$ is much smaller than $V_2$. Eq. 14 can thus be simplified to:

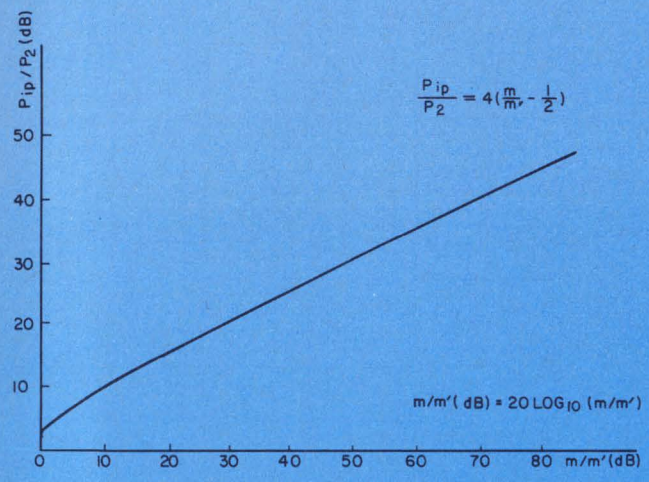
$$m/m' = V_{ip}^2/4V_2^2 + 1/2. \quad (15)$$

This equation gives the cross-modulation transferred from a large signal to a smaller one, in terms of the input level of the large signal and the intercept point for third-order intermodulation of the device. It should be noted that the cross-modulation is independent of the level of the smaller signal.

Since the ratio $V_{ip}^2/V_2^2$ is equivalent to the power ratio of the input intercept point and input signal (or, equivalently, the output intercept point and output signal), Eq. 15 can be modified to read

$$m/m' = P_{ip}/4P_2 + 1/2. \quad (16)$$

By solving Eq. 16 for $P_{ip}$, an expression is obtained that gives the intercept point for third-order intermodulation in terms of data gathered




2. **By relating the cross-modulation ratio m/m',** to the ratio of intercept point and signal power, $P_{ip}/P_2$, this curve demonstrates the equivalence of cross-modulation and intermodulation measurements.

from a cross-modulation measurement:

$$P_{ip} = 4P_2 [(m/m') - 1/2]. \quad (17)$$

To speed intercept-point calculations, a graphical version of Eq. 17 (Fig. 2) may be used.

## Method's accuracy is good

To experimentally verify the usefulness of this technique, the intercept point of a Computone SSMC-H antenna multicoupler was determined by a cross-modulation measurement and then compared with the same quantity as determined by a conventional intermodulation measurement. The SSMC-H is a broadband (2 to 30-MHz) coupler with a gain of 2 dB that can connect one antenna to 12 receivers. The 12 outputs are all isolated from each other by at least 50 dB.

To perform the cross-modulation measurement, a receiver tuned to 16 MHz was connected to one of the multicoupler's outputs. Then a 16-MHz carrier, modulated 50% by a 1-kHz tone, was applied to the input to establish a reference level in the receiver.

This large signal was then tuned out of the passband of the receiver, and a small (10-mV) unmodulated 16-MHz carrier was added to the multicoupler's input. (Sufficient attenuation was placed between the multicoupler ouput and the receiver to prevent the receiver from contributing any significant cross-modulation of its own).

The out-of-band large signal was then increased until a cross-modulation level 30 dB below the reference level was detected by the receiver. The 30-dB ratio corresponds to an m/m' ratio of 31.5 (because 20 $\log_{10}$ 31.5 = 30 dB).

The input power level, $P_2$, required to obtain the 30-dB cross-modulation ratio was +12.5 dBm. Thus, from Eq. 17 or Fig. 2, $P_{ip}$ is found to be +33.5 dBm (because $4P_2$ [31.5 − 0.5] = 6 dB + 12.5 dBm + 15 dB = 33.5 dBm).

For comparison, the intercept point was also measured by applying two 250-mV unmodulated signals to the multicoupler's input. One signal was at 18 MHz and the other at 20 MHz. Thus, third-order intermodulation could be expected at 16 MHz (since 2 × 18 − 20 = 16).

A 16-MHz output that was equivalent to an input level of 100 $\mu$V was measured. By applying Eq. 13 to these input voltages, and noting that the coupler's impedance is 50 ohms, a value of + 35 dBm is easily calculated for $P_{ip}$. This is in pretty good agreement with the +33.5-dBm value calculated from the cross-modulation measurement. ■■

**Reference:**

1. McVay, Franz C., "Don't Guess the Spurious Level," *Electronic Design*, ED 3, Feb. 1, 1967, pp. 70-73.

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Jeske, Harold O., "Rf Intermodulation Characteristics of Vhf Telemetry Preamplifiers and Receivers," *Telemetry Journal*, April/May, 1967.

McKeon, E. F., "Cross-Modulation Effects in Single-Gate and Dual-Gate MOS Field-Effect Transistors," *RCA Application Note AN-3435*, RCA Electronic Components and Devices, Harrison, N.J.

Reid, James R., "Spurious-Free Dynamic Range in Wideband High-Sensitivity Amplifiers," *Microwave Journal*, September, 1965.

### Test your retention

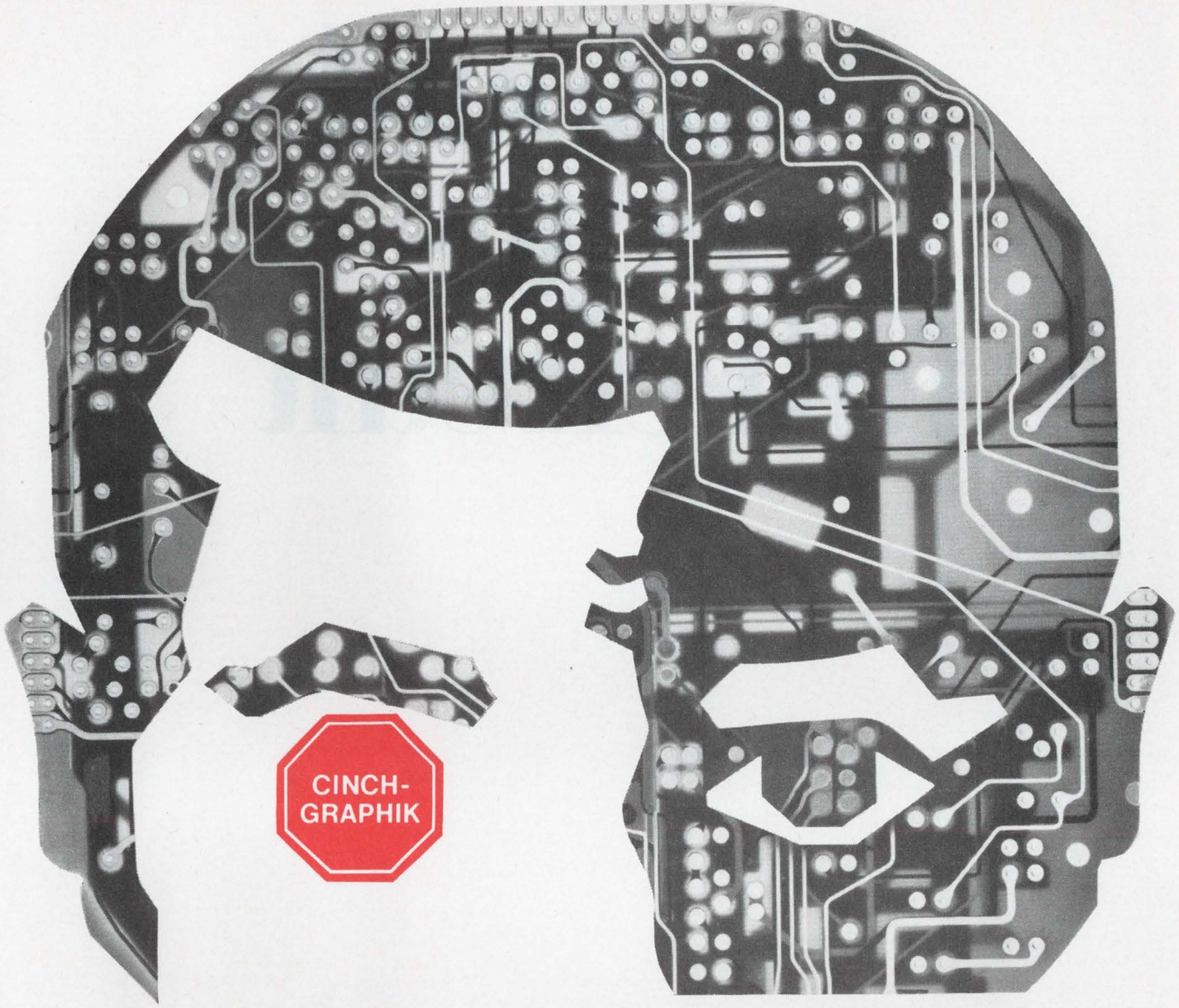
*Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.*

*1. What is the common origin of both third-order intermodulation distortion and cross-modulation?*

*2. How is the intercept point used to describe intermodulation? Can it also describe cross-modulation?*

*3. Why was the placement of an attenuator in front of the receiver (in the cross-mod measurement described in the text) able to reduce the cross-mod produced by the receiver to a negligible level?*

*4. What important restriction must be placed on the amplifier's signal levels if the analysis described in this article is to be valid? Why?*

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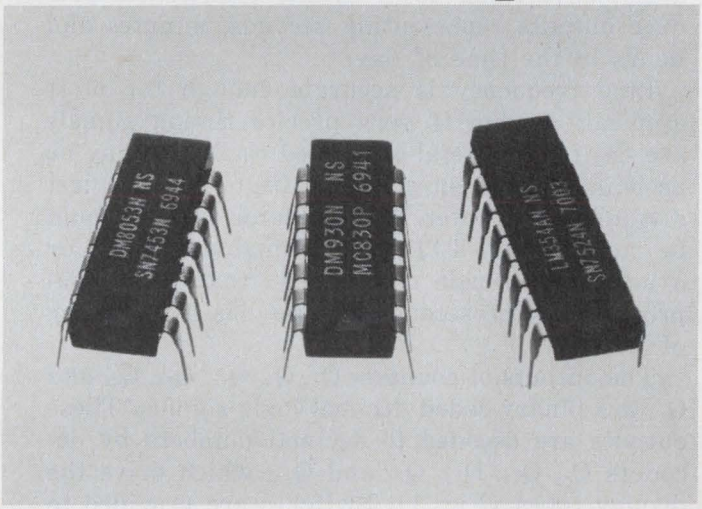
## TTL, DTL & linear ICs for the mini-computer.

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INFORMATION RETRIEVAL NUMBER 64

# Clock and control with TTL.

## Standard logic components display time and generate command signals for as little as $180.

A digital clock can be much more than a timepiece. In addition to displaying time on a readout, a simple TTL clock circuit can serve as the nucleus of a digital timing and control system—for consumer, industrial or scientific use.

The basic clock is formed by the counter chain, shown in the lower half of Fig. 1. The input time base in this case is 60-Hz line voltage, which is formed into a square wave by the Schmitt trigger and then divided down by the counters to produce outputs representing seconds, minutes and hours in the time of day.

Line frequency is accurate enough for most applications, but if very precise timing signals are desired a crystal-controlled oscillator may be used in the system as a substitute for the first divide-by-60 counter. The oscillator output should be run through TTL programmable dividers or a series of decade counters so that the signal provided to the seconds counter has a frequency of 1 Hz.

The outputs of counters $Q_7$, $Q_9$, $Q_{11}$, $Q_{13}$, $Q_{16}$ and $Q_{19}$ are binary-coded decimal logic signals. These outputs are decoded to decimal numbers by decoders $Q_8$, $Q_{10}$, $Q_{12}$, $Q_{14}$ and $Q_{18}$, which drive the display tubes (Fig. 1). Switches are provided to set the correct time on the display when the clock is first turned on.

The parts list for the basic 12-hour clock is given in Table 1. The voltages required by all components are provided by a single multiwinding transformer. The display tubes receive a supply of 250 V, and the other components receive a dc supply ($V_{CC}$) level of 5 V.

### Shape the clock waveform

The raw 60-Hz line frequency cannot be used as the timing reference for the TTL logic circuits, because the rise and fall slopes are too gradual. TTL circuits are designed to operate at frequencies of roughly 20 MHz. This means that pulses used for timing reference must have very fast rise and fall times, otherwise the TTL outputs tend to oscillate.

To avoid the rise-time problem the Schmitt trigger circuit (Fig. 1) is inserted between the 6.3-V transformer tap and the input of the first TTL logic stage ($Q_5$). This circuit converts the sine wave into a sharp square wave with a frequency of 60 Hz. The 0-V to 6.3-V wave is also clipped, to the standard TTL logic level of 4.5 V. (The logic reads a voltage below 0.8 V as a logic ZERO and a voltage above 2.0 V as a ONE.)

To generate the 1-Hz signal for the clocking logic the 60-Hz square wave is applied through a divide-by-60 network consisting of the first two counters, $Q_5$ and $Q_6$. $Q_5$ has a maximum count or divide capability of 12, but it divides an input pulse train by six when connected as shown in Fig. 1. The output, at pin 8, therefore has a frequency of 10 Hz, which is divided down to 1 Hz by decade counter $Q_6$.

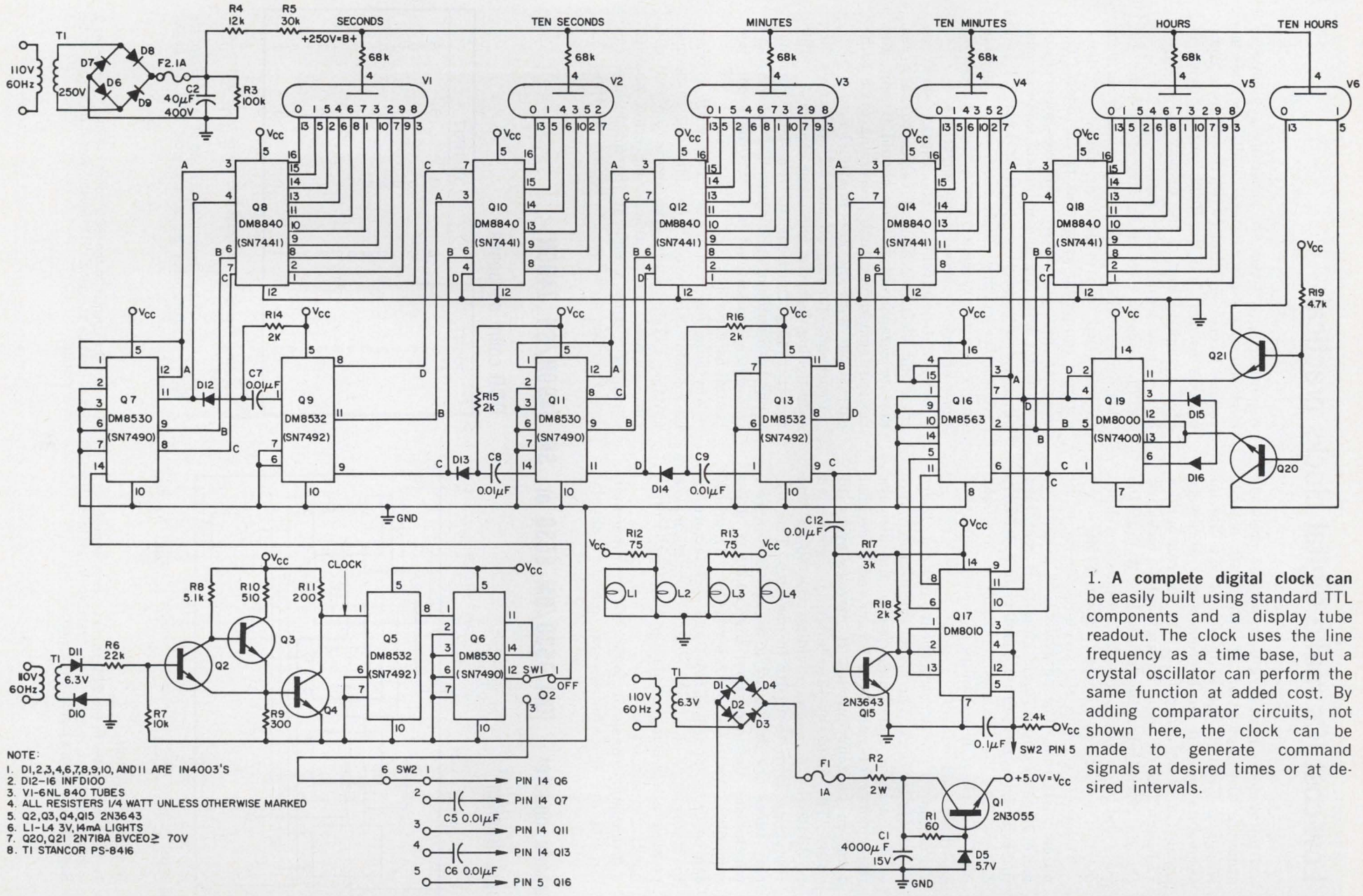
When the 1-Hz timing signal is applied through switch $SW_1$ to the seconds decade counter $Q_7$ (in position 1), the counter's BCD output steps from 0 through 9. This type of counter is designed so that external feedback from the A output to the BD input (pin 12 to pin 1) causes it to divide any input frequency by 10. It resets itself, in this case, a frequency of f/10, or 0.1 Hz, and delivers a pulse train at f/10 to the next counter on output pin 11. The next decade counter, $Q_9$, is connected to divide by six. It ticks off the tens-of-seconds digits at the f/10 frequency and transmits pulses at f/60 to the minutes counters.

The binary-coded decimal outputs of $Q_7$ are applied to the ABCD inputs of $V_1$'s decoder/driver $Q_8$. This device converts the 0 through 9 BCD inputs into decimal outputs, as shown in the upper part of the DM8840 logic table (see box). Unlike most TTL ICs, the DM8840 is designed for high-voltage output—up to 70 V—so it can fire the display tube segments directly. The seconds tube thus displays numerals 0 through 9 at exactly the same rate as the input square wave, one per second.

In the divide-by-six connection of the tens-of-

*(continued on page 86)*

**Wendell Dennison,** Design Engineer, National Semiconductor Corp., Santa Clara, Calif.




NOTE:
1. D1,2,3,4,6,7,8,9,10, AND 11 ARE IN4003'S
2. D12–16 INFD100
3. V1–6NL 840 TUBES
4. ALL RESISTERS 1/4 WATT UNLESS OTHERWISE MARKED
5. Q2,Q3,Q4,Q15 2N3643
6. L1–L4 3V, 14mA LIGHTS
7. Q20,Q21 2N718A BVCEO≥ 70V
8. T1 STANCOR PS-8416

1. **A complete digital clock can** be easily built using standard TTL components and a display tube readout. The clock uses the line frequency as a time base, but a crystal oscillator can perform the same function at added cost. By adding comparator circuits, not shown here, the clock can be made to generate command signals at desired times or at desired intervals.

# Low-cost ICs make digital clocks practical

Digital clocks have long been used to precisely sequence the separation of spacecraft booster stages and control the actuation of satellite instrumentation, but until recently they were very expensive. Now, using TTL ICs, you can build a 12-hour clock for approximately $180, including the six Nixie tubes in the display. And if the logic and tubes used to display seconds are eliminated, the parts cost drops to about $150.

The use of complex ICs accounts for the minimized parts cost. The equivalent of a score or more of conventional logic circuits is contained in each of the monolithic counters and decoder-drivers used in this design. Each is a single, plug-in package less than an inch long and about one-third inch wide.

Familiar TTL IC components are the heart of the digital clock. The monolithic decade counter (a) accepts and counts pulses and displays the number of pulses in binary-coded decimal form on its four outputs. It recycles every 10 pulses. The divide-by-12 counter (b), connected to divide by 6, allows dividing the 60-Hz line frequency down to 10 Hz in one step. The display tubes are driven by a decoder-driver (c), which has the necessary high voltage drive capability. And the up-down counter (d), which can be programmed to reset and cycle according to states applied at its control inputs, makes possible a less complex counter than would ordinarily be necessary.

Transistor-transistor logic (TTL) integrated circuits are best for several reasons: all the required circuit types are generally available at electronic parts distributors; TTL operates at voltage levels compatible with the discrete components needed; and the TTL output drive is high enough to control the display or small relays without using buffer amplifiers.

TTL circuits have a fanout of at least 10. This drive capability allows the counter outputs to be tapped to provide logic signals to drive external equipment as well as the decoders. The designer has an almost limitless number of choices for handling and using the counter outputs. A few possible applications are:

*Scientific*—making data-acquisition system sample and record experimental data at specific times of day for preset time durations.

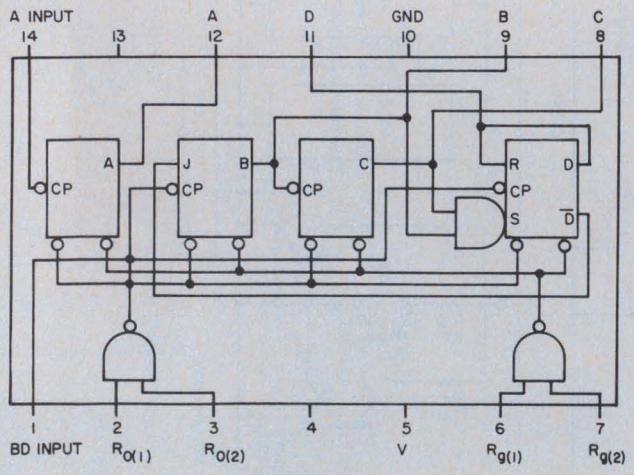
*Industrial*—controlling apparatus, such as operating electromechanical valves to vary gas flow to ceramic kilns. This should permit any desired temperature/time processing cycle to be carried out with the kiln unattended.

*Consumer*—turning on and off appliances, air conditioning, lighting, and other electrical equipment; timing functions in time-lapse photography with automatically controlled camera; and stop-watch applications in sports, or event-time recording control.

Anything that can be actuated with a relay or solenoid can be controlled by the clock and suitable TTL detectors. And any action that will make or break an electrical connection, such as a runner hitting a tape at the finish line, can stop the clock or be used to record the time.

## decade counter (DM 7530/DM 8530 or SN 5490N/SN 7490N)

### logic diagram




### BCD count sequence

| COUNT | OUTPUT | | | |
|---|---|---|---|---|
| | D | C | B | A |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 1 | 1 |
| 4 | 0 | 1 | 0 | 0 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 1 | 1 | 1 |
| 8 | 1 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 1 |

Notes:
1. Counting occurs on the negative-going edge of the input pulse.
2. At least one of the Reset 0 inputs and at least one of the Reset 9 inputs must be at a logical "0" for proper counting.

RESET OPERATION

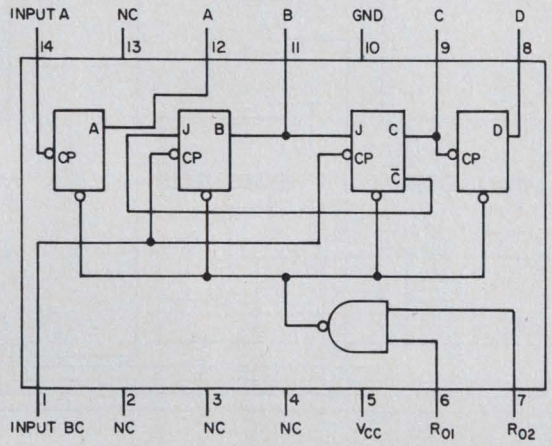
To reset the counter to the BCD count of zero, both Reset 0 inputs must be at logical "1" levels while at least one Reset 9 input is at a logical "0" level.

To reset the counter to the BCD count of nine, both Reset 9 inputs must be at logical "1" levels. Reset 0 inputs may be in any state.

(a)

## divide-by-twelve counter (DM 7532/DM 8532 or SN 5492N/SN 7492N)

### logic diagram




RESET OPERATION

To reset the counter to the count of zero, both Reset 0 inputs must be at logical "1" levels.

### count sequence

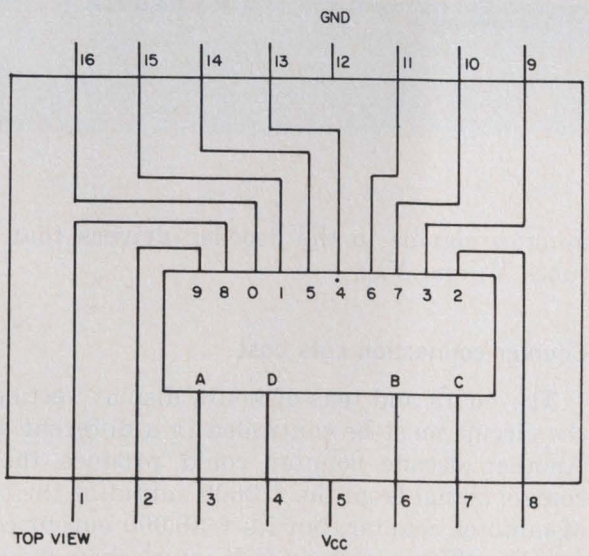
| COUNT | OUTPUT | | | |
|---|---|---|---|---|
| | D | C | B | A |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 1 | 1 |
| 4 | 0 | 1 | 0 | 0 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 1 | 0 | 0 | 0 |
| 7 | 1 | 0 | 0 | 1 |
| 8 | 1 | 0 | 1 | 0 |
| 9 | 1 | 0 | 1 | 1 |
| 10 | 1 | 1 | 0 | 0 |
| 11 | 1 | 1 | 0 | 1 |

Notes:
1. Counting occurs on the negative-going edge of the input pulse.
2. At least one of the Reset 0 inputs must be at a logical "0" for proper counting.
3. For ÷ 12 counting, connect the A output to the BC input.

ⓑ

## decimal decoder/nixie driver (DM 7840/DM 8840 or SN 5441A/SN 7441A)

### pin configuration




### logic table

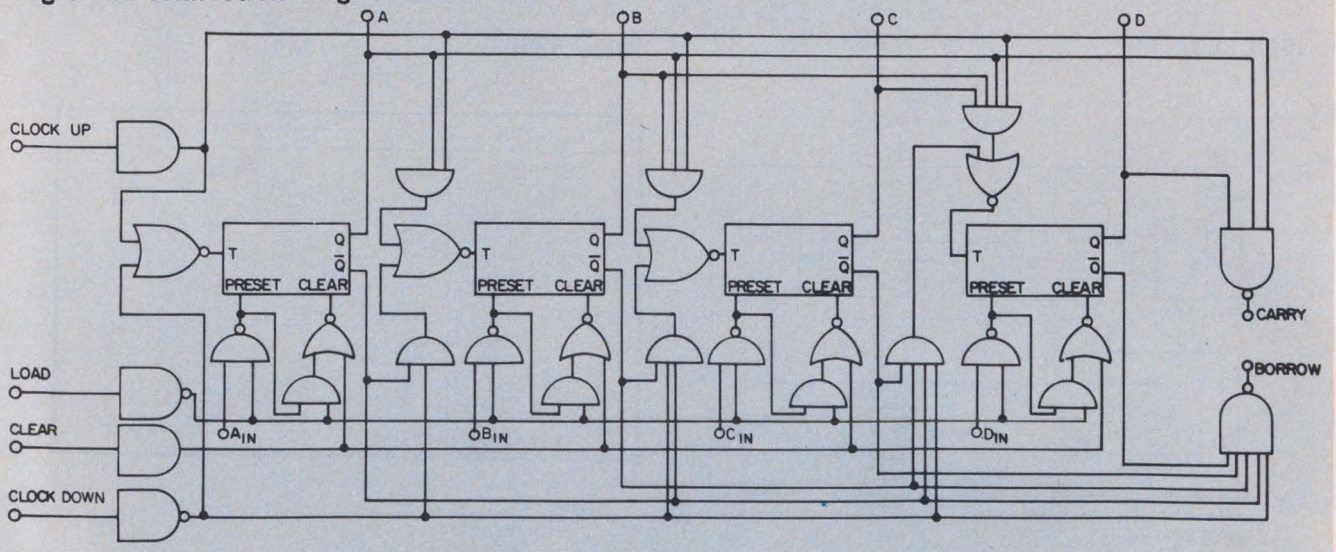
| INPUT D | C | B | A | LOW OUTPUT |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 1 | 1 | 3 |
| 0 | 1 | 0 | 0 | 4 |
| 0 | 1 | 0 | 1 | 5 |
| 0 | 1 | 1 | 0 | 6 |
| 0 | 1 | 1 | 1 | 7 |
| 1 | 0 | 0 | 0 | 8 |
| 1 | 0 | 0 | 1 | 9 |
| (OVER-RANGE) | | | | |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 2 |
| 1 | 1 | 0 | 1 | 3 |
| 1 | 1 | 1 | 0 | 4 |
| 1 | 1 | 1 | 1 | 5 |

ⓒ

*Box continued on next page*

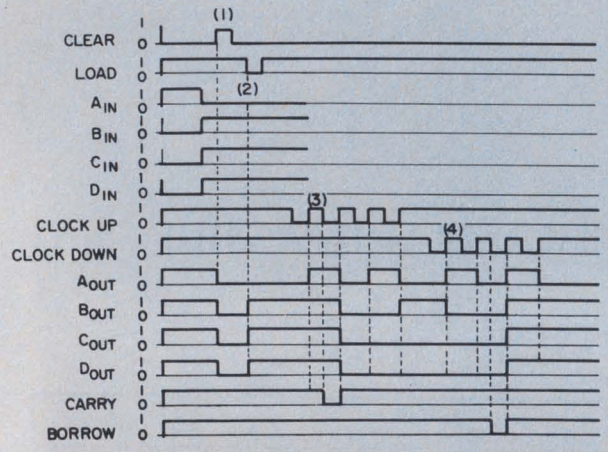
## up/down binary counter (DM 7563/DM 8563)

### logic and connection diagrams

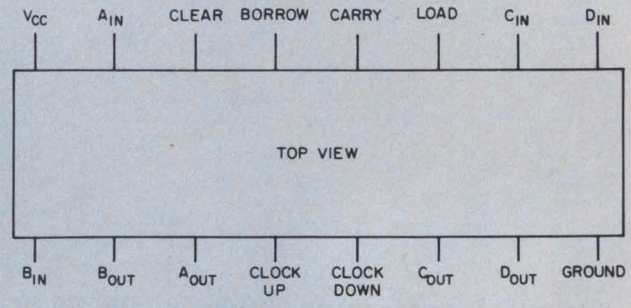



### logic waveforms

(EXAMPLE SHOWN FOR (1) CLEARING, (2) ASYNCHRONOUSLY SETTING TO FOURTEEN COUNT, (3) COUNTING "UP" TO TWO, AND (4) COUNTING "DOWN" TO FOURTEEN.)




### pin configuration




NOTES:
1. LOAD AND CLEAR INPUTS SHOULD NEVER BE ENABLED TOGETHER.
2. A, B, C, AND D INPUTS ARE FREE TO CHANGE AFTER LOAD INPUT IS DISABLED.
3. WHEN COUNTING "UP", THE "DOWN" CLOCK MUST BE IN THE LOGICAL 1 STATE, AND CONVERSELY.

(d)

*(continued from page 82)*

seconds counter $Q_9$, shown in Fig. 1, the counter steps from 0 through 5, but it does not provide a normal BCD output to decoder $Q_{10}$ (see box). This situation is corrected by using the special interconnection scheme shown in Table 2. Note also that the D input of decoder $Q_{10}$ must rise to logic ONE level (2.0 V or more) only when decimal outputs greater than 7 are to be produced. Since 5 is the largest number decoded by the counter, the $Q_{10}$ decoder input is simply connected to ground.

The f/60 output of the tens-of-seconds counter is divided down in the same way by the next two counters, supplying the minutes and tens-of-minutes signals to the decoder/drivers that fire tubes $V_3$ and $V_4$.

### Counter connection cuts cost

The hours and tens-of-hours display section of the circuit must be controlled in a different way. Another decade counter could produce the $V_5$ control signal from the f/3600 output of the tens-of-minutes counter, but its f/36,000 output could not drive $V_6$ in turn since $V_6$ must show 0 for 10 hours and then a 1 for three hours. Doing this with counters and decoders would be complex and costly.

## TABLE 1. Digital clock parts list

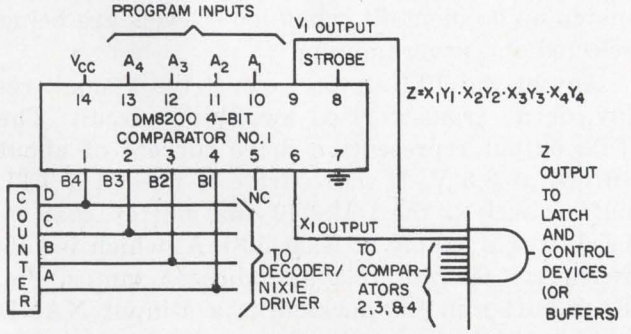
| Part | Function | Type number |
|---|---|---|
| Q1 | transistor | 2N3055 |
| Q2, 3, 4, 15 | transistors | 2N3643 |
| Q5, 9, 13 | TTL counter (÷ 12) | DM8532 (SN7492) |
| Q6, 7, 11 | TTL decade counter | DM8530 (SN7490) |
| Q8, 10, 12, 14, 18 | TTL BCD-to-decimal decoder/Nixie*driver | DM8840 (SN7441) |
| Q16 | TTL triple 3-input NAND gate | DM8010 (SN7410) |
| Q17 | TTL up/down counter | DM8560 (SN7419) |
| Q19 | TTL quadruple 2-input NAND gate | DM8000 (SN7400) |
| Q20, 21 | transistors | 2N718A |
| D1-4, D6-11 | diodes | 1N4003 |
| D5 | diode | 5.7 V zener |
| D12-16 | diodes | 1NFD100 |
| V1-6 | Nixie* tubes | NL840 |
| T1 | transformer | Stancor PS8416 |
| L1-4 | lamps | 3V, 14 mA |

*Nixie is a trademark of the Burroughs Corp. Equivalent display devices made by other manufacturers may be used.

## TABLE 2. DM8532/DM8840/Nixie Connections

| DM8532 Output | DM8840 Decoder/Driver Input | DM8840 Decoder/Driver Output | Number on Display |
|---|---|---|---|
| B | A | 0 | 0 |
| C | B | 1 | 1 |
| D | C | 2 | 2 |
| | | 4 | 3 |
| | | 5 | 4 |
| | | 6 | 5 |

Note: Package pin numbers are shown in wiring diagram.




2. **Control is achieved through comparators** that compare programmed input states with the coded decimal time signals generated by the counters. Combinations of gates, comparators and up-down counters can yield control functions whose intricacy is limited only by the designer's ingenuity.

The hours-counting arrangement shown in Fig. 1 saves a decoder and requires only one counter, two low-cost TTL gate circuits and three transistors. The output of the tens-of-minutes counter is applied to one of the three 3-input NAND gates in $Q_{17}$. Its output, on pin 12, is reinverted by the second gate in the package and used to clock up the up-down counter, $Q_{16}$. This counter is programmable—it resets and cycles according to the states of the logic signals applied to its control inputs.

As connected, the counter will produce BCD outputs 0 through 13, enough to take the total hours count from 0 through 1 o'clock. Here's where the DM8840's overrange capability (Fig. 2) comes in handy. This IC was originally developed to permit automatic overranging on digital voltmeters and similar instruments. Outputs over 9 do not affect the accuracy of the hours display on $V_5$, because the DM8840 decodes the least significant bit in larger numbers. It fires the 0 segment of $V_5$ on the count of 10, and so forth.

In the BCD code, 13 is represented by logic ONEs on the ACD outputs and a ZERO on the B line. The ACD outputs are connected to the inputs of the third NAND gate on $Q_{17}$, and the gate's output, on pin 8, therefore loads a logic ZERO on pin 11 of the counter. This input causes the counter to parallel-load a ONE on an output because only an input of the DM8563 is tied to a logical ONE. All of the other parallel inputs are connected to ground.

Three 2-input NAND gates in the DM8000 ($Q_{19}$) also decode the counter output. They are connected so that the 0 segment of $V_6$ is held ON and the 1 segment held OFF when the counter output represents 0 through 9. During outputs 10 through 13, the 1 segment is ON and the 0 segment turned OFF. The change occurs at the end of the ninth hour, turning the display from 09-59-59 to 10-00-00.

Allowing the counter to go to 13 is cheating a bit, but it keeps the logic simple. Actually, the number 13 is never visible on the display. It fires for only a few nanoseconds every 12 hours.

The display should change to 01-00-00 immediately after 12-59-59, but it is allowed to go to 13-00-00 for the time it takes the counter's ACD outputs to go around the resetting circuit through the DM8010. As soon as the counter display inputs receive the ONE the display changes to 01-00-00 and the normal operation resumes.

### Use high $BV_{CEO}$ drive transistors

One cautionary word about the two transistors, $Q_{20}$ and $Q_{21}$, used to drive $V_6$. These must have a breakdown voltage $BV_{CEO}$ of at least 70 V, since they have to hold display-tube segments OFF at

that level for long periods of time, and 2N718A or similar transistors are recommended.

If one or both of the transistors should short out, however, there will be no chain reaction through the logic circuitry. This is one of the virtues of connecting the emitters to the logic output stages. Another advantage is that the emitters are not continually biased, as in conventional display-tube drive circuits (biasing the emitters permits leakage currents to put an annoying glow on tube segments that are supposed to be OFF).

### Fast-cycle to set the clock

Switches $SW_1$ and $SW_2$ allow the clock to be set to the correct time of day after it is turned on. Moving the switch from position $SW_1$-1 to $SW_1$-2 stops the clock. Moving $SW_1$ to position 3 and $SW_2$ to the various positions shown on the wiring diagram will cause the 1-Hz square wave to directly cycle the selected counters. All but the seconds counter can be rapidly advanced. The seconds display cannot catch up to real time, but it can be preset and stopped until real time catches up with it.

To synchronize the clock to a tone signal broadcast by radio, for example, the clock can be set to 12-00-00 and then stopped by placing the toggle switch at $SW_1$-2. When the tine is heard, the switch is flipped to $SW_1$-1 to restart the clock.

The four-lamp inset diagram in Fig. 1 can be used to insert small punctuation lights between display sections. One possible arrangement is 00:00:00, with the dots continuously lit.

### Control system demonstrates use

Since many different external control systems can be built around the clock, only one example will be given here. This subsystem is suitable for actuating an external device—say, a relay—at a specific time of day.

The 4-bit comparators shown in Fig. 3 are connected to the counter outputs, the number of comparators used depending upon the time resolution desired. For a 10-second resolution four comparators will be needed, and these would be connected to all counters except the seconds counter.

The input side of each comparator can be programmed to represent the desired counter output. That is, the logic level applied to each input pin matches the counter output to be detected. To detect the BCD 3 output of a DM8530 decade counter, for instance, the comparator pins corresponding to the counter's DCBA outputs would be set at ZERO-ZERO-ONE-ONE. These levels are established by connecting the comparator pins to ground or to $V_{CC}$ as the case may be. The connections can be made through 2-position switches for manual selection of the time detected. (Remember to use the connections in Table 2 when a comparator is connected to the DM8532 counter outputs.)

External logic can be used to control a rapid timing sequence. The first comparator output, for example, might be used to start a counter driven by the 1-Hz square wave, as well as to close a relay. Then the counter output at the end of a desired number of seconds or minutes might be used to open the relay. A similar subassembly, or one built around a TTL divider, could be used to open or close the relay every N seconds starting with the time programmed on the comparators.

The comparator produces a ONE pulse on both its X and Y outputs only when the logic levels on the comparator inputs match those produced by the counter (or other logic). At all other times, one or both of the comparator outputs are at the ZERO level. The match condition on one comparator can be detected with a 2-input AND gate, which will transmit a ONE control pulse to the relay circuit. If four comparators are used, an 8-input AND gate will detect a match on all four.

As a precaution against false triggering because of noise or other accidental perturbations, it is best to run the gate outputs through a latch, such as a J-K master-slave flip-flop. The DM8501 (or SN7473) dual J-K is a good device to use because it contains a special clock-line clamp to reduce ringing and prevent false clocking. It will hold the control signal at the correct logic level between state changes in the AND gate output, no matter how long the interval. Each DM8501 contains two independent flip-flops.

Normally, the comparator strobe pins should be at logic ZERO. But it's a good idea to provide a switch for changing the level of logic ONE during the reset operations. This will prevent a false all ONEs output of the comparators if the comparator inputs and counter outputs should match up accidentally when logic levels are being selected for programming.

Any of the TTL devices can drive a small relay, or a transistorized switching circuit. The TTL output represents a drive current of about 16 mA at 3.5 V. If more drive is needed a TTL buffer, such as the DM8040 dual buffer, may be used. It will supply at least 50 mA, which is sufficient to operate relays, indicator lamps, etc. Each buffer in the package is a 4-input NAND gate, providing a couple of extra inputs for additional control functions, if desired. Higher drive capability can be obtained with transistor circuits or hybrid IC buffers. A buffer such as the NH0006 will supply up to 400 mA at 28 V, which is enough to operate small motors. ■■

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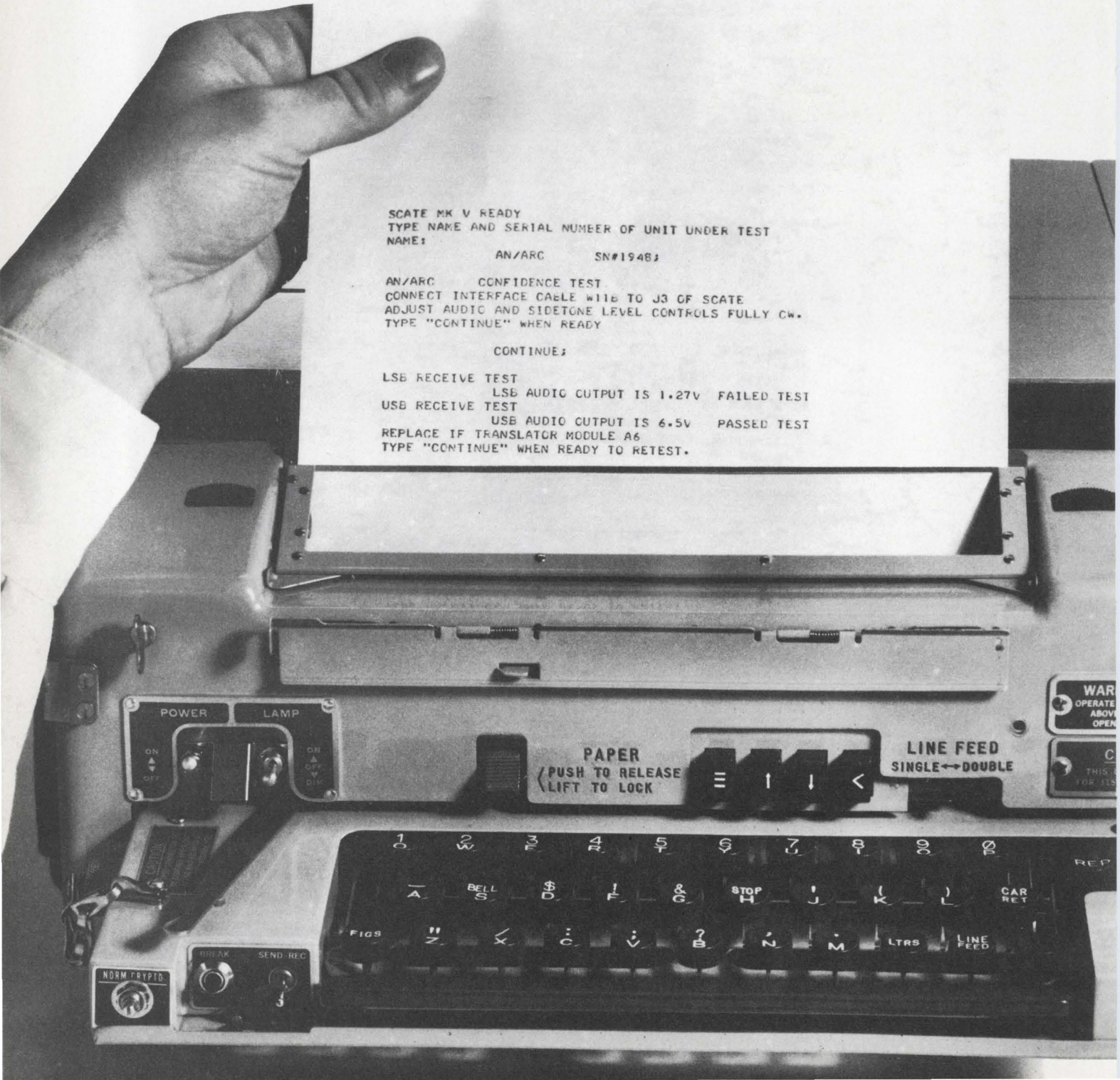

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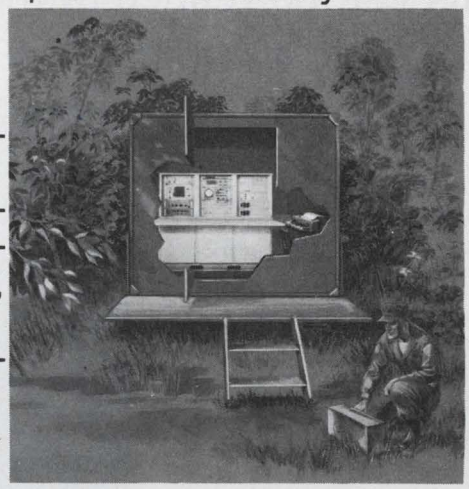

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INFORMATION RETRIEVAL NUMBER 66

# Use ECAP to design transistor models.

## Approximate circuits can be refined by means of the program to compute more accurate parameters.

Computer-aided design programs have become a great convenience in building circuits. Unfortunately, most of the easily available programs in this category have one serious limitation: inadequate capabilities for modeling semiconductor devices.

It is possible, however, to provide excellent results by using a computer subroutine in conjunction with the program. With this technique, ECAP, for example, can rival those programs known for their modeling of transistor nonlinearities.

### ECAP has many advantages

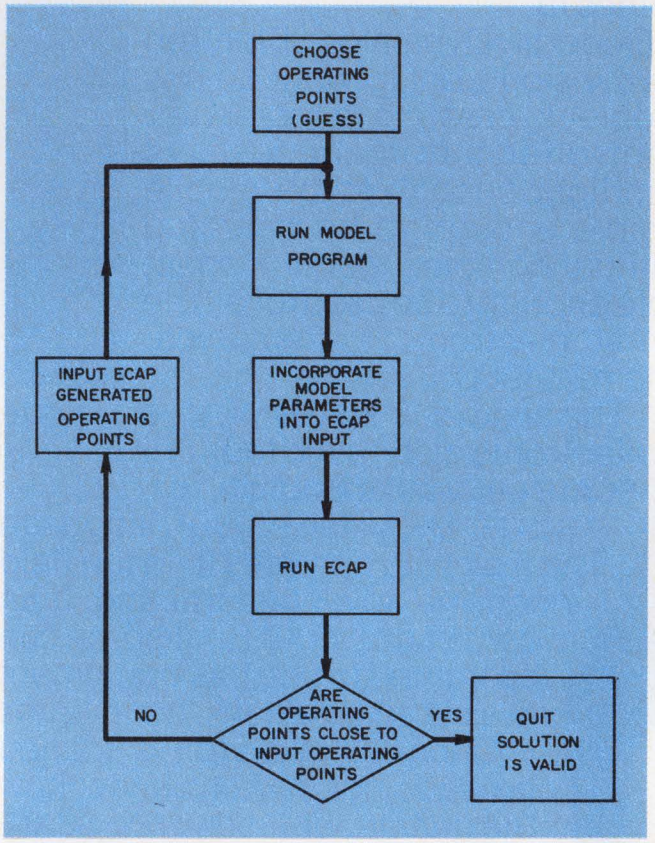
The Electronic Circuit Analysis Program (ECAP) is one of the most suitable programs for the circuit designer for many reasons: it is widely available on many time-sharing services; it is easy to learn, and can readily handle circuit blocks, especially in transient analysis; and it has been around for a long time so is very well documented.[1]

The method by which ECAP can be expanded to operate with transistor models is direct: You repeatedly feed the model into the ECAP program and use each computed result to refine the model for the next attempt. Thus, a man-machine iteration loop is obtained that closes out when the model is satisfactory (Fig. 1).

On a step-by-step basis, the procedure operates this way: Choose the device's operating points and obtain a set of model parameters; perform an ECAP analysis to get new operating points from which an improved set of model parameters can be derived; rerun the ECAP analysis; and repeat this process until the operating points are proper. Usually, two iterations suffice.

### Choose the proper model

The modeling program uses the hybrid pi[2] configuration for dc and linear ac analysis, and a simplified Ebers-Moll model for transient or switching, analysis (Fig. 2).




1. **Flow chart of the man-machine iteration process** closes the loop through the man. The machine runs the program; the man decides whether the resulting operating points are good enough.

The dc model takes three branches, but if $R_{bb}$ is ignored only two branches are needed. The ac model takes four or five branches, depending on the need for $R_{bb}$. The switching model takes eight branches, but many of them are unnecessary for most applications. $R_{bb}$ and $R_{sat}$ are often not required. The current generator $\alpha_I T_c$ and the collector diode $S_2$, $V_{BC}$ and $R_{CD}$ are not required if the transistor does not saturate. Thus, for many applications as few as four branches may be enough.

Once the appropriate model[3] has been chosen, there must be adequate input data to support it. Most manufacturers supply excellent data that can be had for the asking.[4,5,6,7] However, some-

**Bruce Gladstone,** Manager, Computer Systems, Gulton Industries, Inc., Hawthorne, Calif.

## Table 1. Data Inputs for Model

| Circuit element | Parameters | Input data | Precautions | Comment |
|---|---|---|---|---|
| Base—Emitter Diode | $V_{be}$, $R_{ed}$, $R_{bb}$ | $V_{be}$, $I_e$ (3 points) $I_c/I_b$ | Use 2 points at low currents to minimize effect of $R_{bb}$ | |
| Base—Collector Diode | $V_{bc}$, $R_{cd}$ | $V_{bc}$, $I_{cd}$ (2 points) | Data points should be 2-3 decades apart | Data is usually not supplied, measurement is required. This data is needed only for the saturation region of the transient model |
| $\beta$ | $\alpha$, $\beta$, $h_{oe}$, $h_{ie}$ | Nine values of $\beta$ for 3 values each of $V_{ce}$ & $I_c$ | Cover range of interest check for consistent values | |
| Bulk Resistances, Inverted Alpha | $R_{sat}$, $R_{bb}$, $\alpha_I$ | $V_{ce\,(sat)}$ at 2 values of $I_c$, $I_c/I_b$ | Take lower set of data near minimum $V_{sat}$ point. Accuracy of data is imperative. | Not needed for linear models |
| Transition Capacitance | $C_{te}$, $C_{tc}$ | Two values each of transition capacitance at two values of reverse bias. $\eta_e$, $\eta_c$ | Take data at extreme points | $C_{te}$ needed only for back biased transient model |
| Emitter Diffusion Capacitance | $C_{de}$ | Three values of $f_t$ at 3 collector currents | Cover frequency range of interest | |
| Collector Diffusion Capacitance | $C_{dc}$ | Value of storage time at $I_c$, $I_{b1}$, $I_{b2}$ | | Not needed for linear models |

times the information is inconsistent, particularly if data from two different manufacturers is compared. One explanation for this condition is that different manufacturers use different processes, so that a device with the same type number can actually have two or more sets of parameters to describe it. To avoid this, you can stick to the data supplied by one reliable manufacturer or make the measurements yourself.

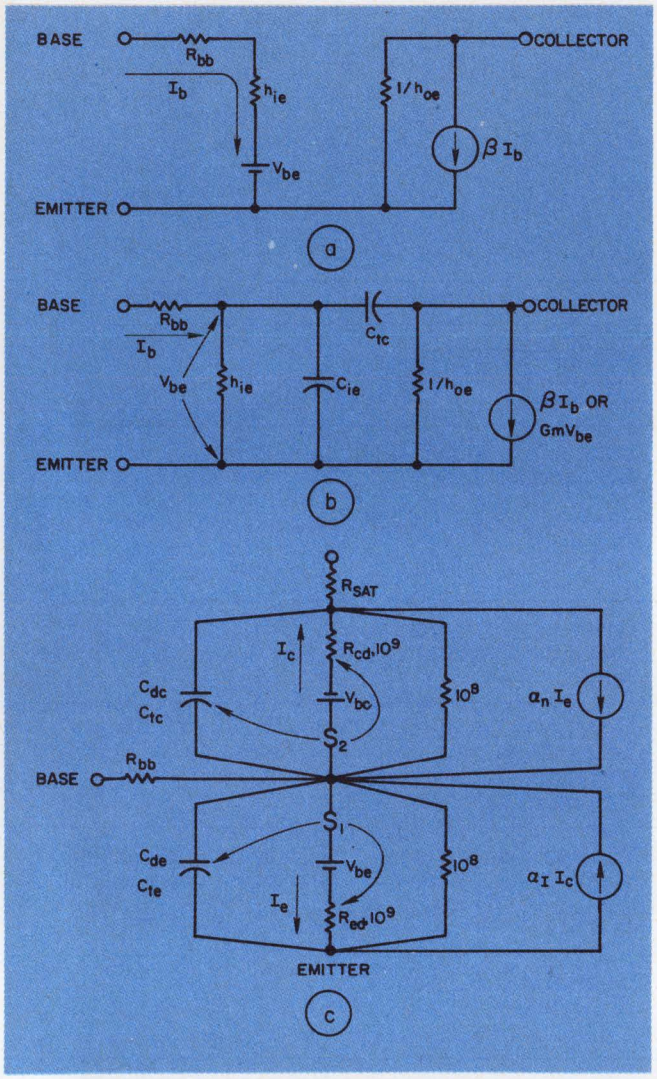
A listing of the pertinent parameters and their sources is given in Table 1, with precautions to ensure obtaining consistent results.

A few pieces of data are usually not available on a data sheet. The most important of these are the two grading constants, $\eta_e$ and $\eta_c$. These are a function of the manufacturing process (see Table 2).[6]

The grading constants are necessary to model the transition capacitances (junction capacitances under reverse bias conditions). Other parameters needed to help evaluate whether the

## Table 2. (Grading Constants)

| Transistor Process | $\eta_e$ | $\eta_c$ | $\alpha_I$ |
|---|---|---|---|
| Diffused-Base Epitaxial | 0.33 | 0.1 | 0.1-0.4 |
| Diffused-Base Mesa | 0.33 | 0.33 | 0.2-0.8 |
| Alloy | 0.5 | 0.5 | 0.8-0.95 |




2. **Three models are used for representing a transistor,** depending on its operation. The dc model in (a) is simplest; the ac model is shown in (b); and the switching model (c) is the most complex. The symbol S is a switch with lines to the controlled elements.

## Table 3. Model Constants

| Model elements | Model constants | Definition of constant |
|---|---|---|
| $R_{ed}$, $h_{ie}$, $V_{be}$, gm | $k_1$, $k_2$ | $k_1=I_{c1}/(e^{k_2 V_{be}}-1)$<br>$k_2=\ln((I_{c2}+1)/k_1)/V_{bc2})$ |
| $R_{ed}$, $V_{bc}$ | $k_3$, $k_4$ | $k_3=I_{c1}/(e^{k_4 V_{bc}}-1)$<br>$k_4=\ln((I_{c2}+1)/k_3)/V_{bc2})$ |
| $R_{bb}$ | $R_{bb}$ | $R_{bb}=(V_{be3}-\ln(1+I_{e3}/k_1)$<br>$(6I_{e3}+1)/V_{be3}$ |
| $\beta$, $h_{oe}$ | $[K]=\begin{bmatrix}k_{11}k_{12}k_{13}\\k_{21}k_{22}k_{23}\\k_{31}k_{32}k_{33}\end{bmatrix}$ | $[I]=\begin{bmatrix}1I_1\ 1/I_1\\1I_2\ 1/I_2\\1I_3\ 1/I_3\end{bmatrix}$;<br>$[A]=\begin{bmatrix}A_{11}\\A_{12}\\A_{13}\end{bmatrix}$<br>$[D]=\begin{bmatrix}1/(\beta_{11}+1)\\1/(\beta_{12}+1)\\1/(\beta_{13}+1)\end{bmatrix}$;<br>$[V]=\begin{bmatrix}1\ V_1^{1/n}\ V_1^{2/n}\\1\ V_2^{1/n}\ V_2^{2/n}\\1\ V_3^{1/n}\ V_3^{2/n}\end{bmatrix}$<br>$[I]\,[A]=[D]_{V=V_1}$;<br>$V=V_2$<br>$V=V_3$<br>$[V]\,[k]=[A]_{A=A_{1j},\ j=1,2,3}$<br>$A=A_{2j},\ j=1,2,3$<br>$A=A_{3j},\ j=1,2,3$ |
| $\alpha_I$ | $\alpha_I$ | $\alpha_I=\dfrac{(1+I_c/I_b)}{(1-I_c/\beta_{11})(e^{V_{sat1}/.0257}+I_c/I_b(1-I_c/\beta_{11}I_b)}$<br>($\beta_{11}$ is beta at minimum measured V and I) |
| $R_{sat}$ | $R_{sat}$ | $R_{sat}=(V_{sat2}-V_{sat1})/I_{c3}$ |
| $C_{tc}$ | $k_5$, $k_6$, $\eta_c$ | $k_5=(k_6/C_{ob1})^{1/\eta_c}-V_{bc1}$<br>$k_6=C_{ob2}(k_5+V_{bc2})^{\eta_c}$ |
| $C_{te}$ | $k_7$, $k_8$, $\eta_e$ | $k_7=(k_8/C_{ib1})^{1/\eta_e}-V_{be1}$<br>$k_8=C_{ib2}\,(k_7+V_{be2})^{\eta_e}$ |
| $C_{dc}$ | $t_s$ | $t_s=\tau_{stor}/\ln((I_{b1}+I_{b2})$<br>$/(I_{b2}+I_c/\beta))$ |
| $C_{de}$, $C_{ie}$ | $[F]=\begin{bmatrix}F_1\\F_2\\F_3\end{bmatrix}$ | $[1/F_t]=\begin{bmatrix}1/F_{t1}\\1/F_{t2}\\1/F_{t3}\end{bmatrix}$;<br>$[I]\,[F]=[1/F_t]$ |

model is reasonable, are the emitter and collector emission constants, M(E) and M(C). The emission constants at the emitter junction are usually 1.0 to 1.5 for low $V_{be}$ transistors, and 1.5 to 2.0 for high $V_{be}$ transistors. Generally they are nearly equal for the two junctions of a given transistor. This may also allow modeling of the collector diode without resorting to measurements.

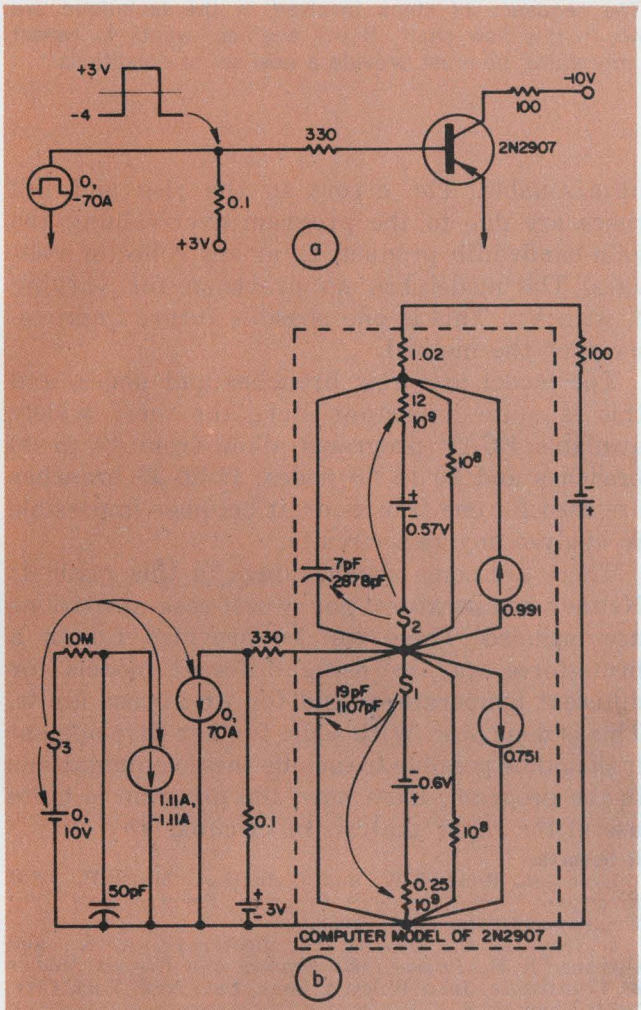
Expected values for $\alpha I^{7,8}$ are also given in Table 2.

The 26 modeling constants required to define a transistor are listed in Table 3. These constants are generated by the program from the input data. They are assumed to be invariant with operating points. This is not strictly true, but the results are still useful.

The modeling constants are then used to compute the model parameters (Table 4). Values are now known for all of the elements in the equivalent circuits of Fig. 2.

### Inverter is example

A simple inverter circuit using a 2N2907




```
ENTER THE TRANSISTOR DESIGNATION
? 2N2907:::
IS THE 2N2907::: A PNP OR NPN TRANSISTOR
? PNP
ENTER VALUES FOR USE CONDITIONS: I(C),
V(CE), I (CB), V(BB)
? .1,10,? .01,? 3
M(E)= 1.82
M(C)= 1.3572
R(EMITTER)= .14285714 OHMS
T(STORAGE)= 102 NANOSECONDS
F(T)= 2.1834061E+08 HERTZ
TRANSIENT MODEL
R(EMITTER DIODE)= .65788146 OHMS
R(BB)= 4.43 OHMS
V(BASE-EMITTER)= .61111911 VOLTS
R(COLLECTOR-DIODE)= 8.8221651 OHMS
V(COLLECTOR-DIODE)= .63389861 VOLTS
R(SAT)= 1.02 OHMS
ALPHA= .99266969
INVERTED ALPHA= .751
C(TC)= 7.4689056 PICOFARADS
C(DC)= 2878.8851 PICOFARADS
C(DE)= 1107.9954 PICOFARADS
C(TE)= 18.647661 PICOFARADS
```

c

3. **An example of the modeling technique** uses a transistor operating in the switching mode. The actual circuit is shown in (a) and its equivalent circuit in (b). The two values on the controlled elements are for the switch open and closed. The unusual current values are chosen for convenience in ECAP. The model computed by ECAP is given in (c).

## Table 4: Model Parameters

**DC model:**

$\gamma=(k_{11}+k_{12}V_{ce}^{1/n}+k_{13}V_{ce}^{2/n})+(k_{21}+k_{22}V_{ce}^{1/n}+k_{23}V_{ce}^{2/n})\,I_c+(k_{31}+k_{32}V_{ce}^{1/n}+k_{33}V_{ce}^{2/n})/I_c$

$\beta=(1-\gamma)/\gamma$. note: $\gamma=1/(\beta+1)$

$h_{ob}=I_c(-1+\beta_2/\beta)/.05V_{ce}$ ($\beta$ is evaluated at use voltage; $\beta_2$ is evaluated at 1.05 use voltage)

$h_{ie}=\beta/I_ck_2$

$V_{be}=\ln((1+I_c/k_1)/k_2)-I_ch_{ie}/\beta$

$gm=I_c/k_2$

$R_{bb}=R_{bb}$

**In addition, for AC model:**

$C_{tc}=k_5/(k_6+V_{ce})^{\eta_c}$

$C_{ie}=k_3I_c/2\pi f_t$ where $f_t=1/(F_1+F_2I_c+F_3/I_c)$

**In addition, for switching model:**

$\alpha_I=\alpha_I$

$\alpha=\beta/(1+\beta)$

$V_{be}=\ln((1+I_c/100k_1)/k_2)$

$V_{bc}=\ln((1+I_{bb}/100k_3)/k_4)$

$R_{em\ diode}=[\ln((1+I_c/k_1)/k_2)-V_{be}]/I_c$

$R_{col\ diode}=[\ln((1+I_{cb}/k_3)/k_4)-V_{bc}]/I_{cb}$

$R_{sat}=R_{sat}$

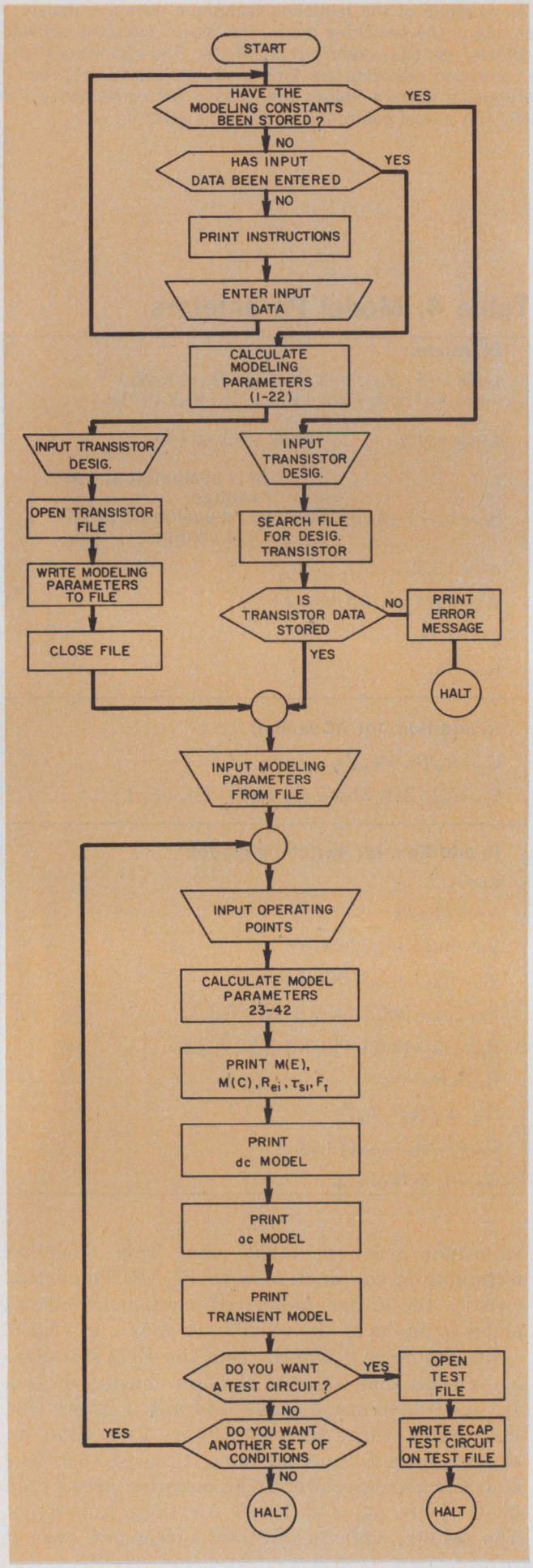
$C_{te}=k_7/(k_8+V_{be})^{\eta_e}$

$C_{dc}=\tau_s/R_{col\ diode}(\beta+1)$

$C_{de}=1/2\pi fR_{em\ diode}$

transistor was evaluated using this modeling technique in conjunction with ECAP. The actual circuit, the program-derived equivalent circuit and a printout of the results are shown in Fig. 3.

Results were obtained from the ECAP equivalent circuit that followed the flow chart of Fig. 4. $I_{B1}$ was −9.86 mA. $I_{B2}$ was −11 mA. $I_C$ was −101 mA. Delay time, $t_d$, was 8.8 ns. Rise time, $t_r$, storage time, $t_s$, and fall time, $t_f$, were 16.9, 68.8 and 12.8 ns respectively. The manufacturer's data gives 7, 18, 54, and 15 ns for these quantities. The results, while not in total agreement, are not




4. **The sequence of steps involved in the technique** are shown in this flow chart. If the engineer wants to repeat the procedure, he must provide a new set of conditions.

unreasonable. The errors in the rise and fall times are due to the program over-valuing the gain-bandwidth product, $f_t$, at low collector voltages. The model has no provision for varying $f_t$ with $V_{cc}$. This is one possible future improvement of the method.

The model uses few branches and nodes, and this is quite important since the most widely available ECAP programs allow from 40 to 90 branches and 20 to 30 nodes. If 20-30 branches are used for one transistor, it becomes impossible to analyze any real circuits.

There are some shortcomings in this method: Neither temperature nor worst-case provisions are included. These can be provided for in a brute-force way by using different models for different temperatures and for worst-case limits. This is done now. With some further development it should be possible to include these computations in the program. Even now, the program is quite useful for rapid analysis of circuits. ■■

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6. *Motorola Switching Transistor Handbook*, First Ed., Phoenix, Ariz: Motorola Semiconductor Products Div., Chap. 5.
7. *General Electric Transistor Manual* (Seventh Edition) General Electric Co. N.Y. 1964, Chapters 1-3, 6.
8. *Motorola Switching Transistor Handbook*, ibid., Chap. 4.


**Test your retention**

*Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.*

*1. What are the advantages of ECAP?*

*2. What is the most significant limitation of ECAP?*

*3. Which transistor model is most complex? Which is simplest?*

*4. Why must the number of branches and nodes used by a model be minimized?*

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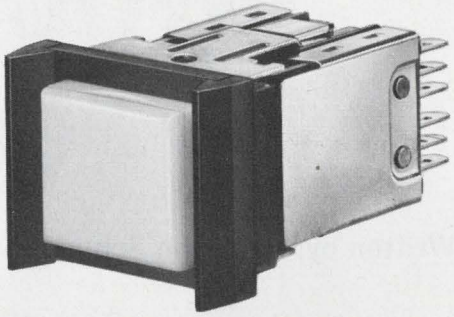

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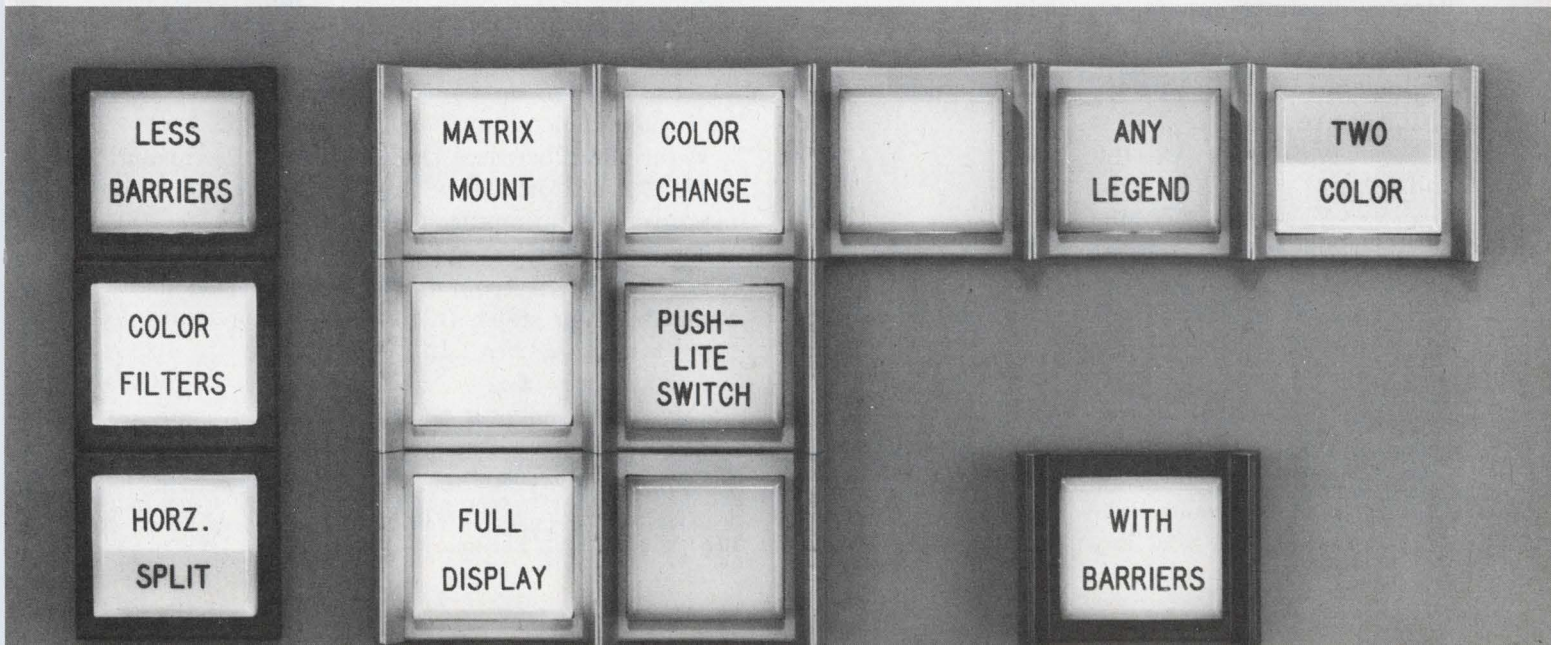


# An Electronic Design practical guide for

# synchro-to-digital converters

**Written by: Hermann Schmid, Senior Engineer, General Electric Co., Binghamton, N. Y.**

Edited by: Don Mennie, Circuits Editor

## Part 5: The Type VI and the multispeed converter.

### Type VI converter is mathematically exact

This technique of encoding resolver output signals is based on the operation of the digital resolver.[28] It differs from previous designs in three ways:

- The technique is mathematically exact.
- The solution is generated by a sequence of fixed-magnitude rotations.
- The output signal is produced by summing all the fixed-magnitude rotation angles.

There are several possible implementations for this technique. One will be described.

#### Vectors illustrate general principle

The general expressions relating vector coordinates ($V_X$, $V_Y$; $V_X'$, $V_Y'$) to the angle of rotation $\theta$ are

$$V_X' = V_X \cos\theta + V_Y \sin\theta \quad (82)$$

and

$$V_Y' = V_Y \cos\theta - V_X \sin\theta \ . \quad (83)$$

When the vector is rotated until Y′ is zero,

$$\theta = \tan^{-1} V_Y/V_X \ . \quad (84)$$

The circuit in Fig. 37 employs a unique charge transfer technique* and implements the general rotation equations

$$\sin(\theta \pm \alpha) = \sin\theta \cos\alpha \pm \cos\theta \sin\alpha \quad (85)$$

and

$$\cos(\theta \pm \alpha) = \cos\theta \cos\alpha \pm \sin\theta \sin\alpha \quad (86)$$

where $\alpha$ may have an arbitrary value. Implementing Eqs. 85 and 86 in general form would require complex circuitry.

If $\alpha$ is limited to a number of constant values (90°, 45°, 22.5°, etc.), $\sin\alpha$ and $\cos\alpha$ are constants. Dividing both equations by $\cos\alpha$, gives

$$(1/\cos\alpha) \sin(\theta \pm \alpha) = \sin\theta \pm \tan\alpha \cos\theta \quad (87)$$

and

$$(1/\cos\alpha) \cos(\theta \pm \alpha) = \cos\theta \pm \tan\alpha \sin\theta \ . \quad (88)$$

The equations above can be implemented with one addition and one scaling operation (multiplication by a constant). The constant multiplier $(1/\cos\alpha)$ is of no concern, because succeeding operations depend only on the sign of $V_Y$.

Figure 36 illustrates the rotation of $\overline{R_i}$ through angle $\theta_i$, performed with a sequence of fixed magnitude rotations through angle $\pm\alpha_i$.

The subscript i denotes that the desired angle $\theta$ is determined from a series of iterations or approximating steps. In three steps for example, $\theta_3 = \pm\alpha_1 \pm \alpha_2 \pm \alpha_3$. In general form

$$\theta = \pm\alpha_1 \pm\alpha_2 \pm\alpha_3 \ . \ . \ . \pm\alpha_n \quad (89)$$

Figure 38 shows a timing generator peak de-



* Extracted from "Multiple Input Electronic Synchro/Resolver Encoder," *Internal Publication of Towson Laboratories* by permission from P. A. Hoffman, Towson Laboratories, Inc., Baltimore, Md.

tector, summing amplifier and two identical analog circuits that implement Eqs. 87 and 88. Each analog circuit performs resolver output signal sampling, the scaling operation and addition of sine and cosine terms.

### Capacitive divider performs scaling

The scaling operation is performed with a capacitive divider. The charge initially on one capacitor ($C_A$, for example) is divided between capacitors $C_A$ and $C_B$. The values of $C_A$ and $C_B$ are related to the charges across them, $Q_A$ and $Q_B$, by

$$K = Q_B/(Q_A + Q_B) = C_B/(C_A + C_B) \quad (90)$$

Two types of switches are used in Fig. 37. Switches $S_9$, $S_{10}$, $S_{11}$, $S_{12}$ . . . may be operated by control signals and retained in the ON or OFF conditions as long as desired. Switches $S_1$ through $S_8$ close for short intervals only. Closure times of these switches are adjusted by a choice of circuit constants. Two operational amplifiers are provided in both the sine and cosine channels, one for summing and scaling, the other for polarity inversion.

To illustrate circuit performance, a sample operation will be followed for the first few binary digits. It will be assumed that the resolver shaft angle $\theta$ is at $+65°$. Therefore, voltage $V_{Y1}$ is positive and the comparator output is zero, indicating that the resolver shaft angle lies in the first or second quadrant. $V_{X1}$ is positive, indicating that $\theta$ is in the first or fourth quadrant. Positive $V_{Y1}$ and $V_{X1}$ polarities establish the resolver shaft angle in the first quadrant. The polarity of $V_Y$ and $V_X$ supplies the most-significant and the second-most-significant bits of $\theta$ and sets up logic circuits for the next switching sequence.

This sequence begins with the closure of $S_5$, $S_6$, $S_9$, $S_{10}$. Switches $S_5$ and $S_9$ charge $C_5$ to $-V_Y$ while $S_6$ and $S_{10}$ charge $C_6$ to $V_X$. Note that $S_5$ and $S_6$ close momentarily, whereas $S_9$ and $S_{10}$ are closed for one word period. Thereafter, $S_7$ and $S_8$ are momentarily closed, transferring the charge on $C_5$ to $C_4$ and the charge on $C_6$ to $C_3$. In both cases, the new charge adds algebraically to the charge already present. Voltages $V_Y$ and $V_X$ become

$$V_{Y1} = -V_{Y0} - (C_6/C_3)V_{X0} = -V_{Y0} - V_{X0} \quad (91)$$

and

$$V_{X1} = -V_{X0} + (C_5/C_4)V_{Y0} = -V_{X0} + V_{Y0} \quad (92)$$

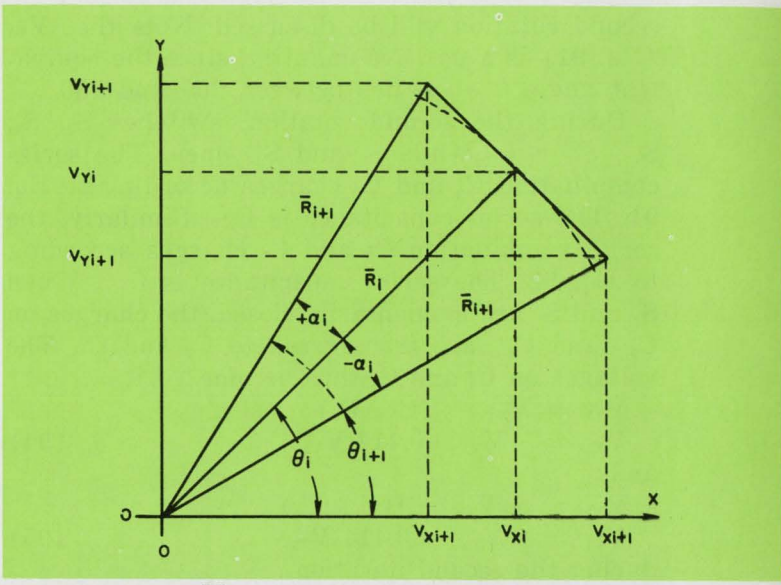
during the first iteration.

Since the ratio between these capacitors is

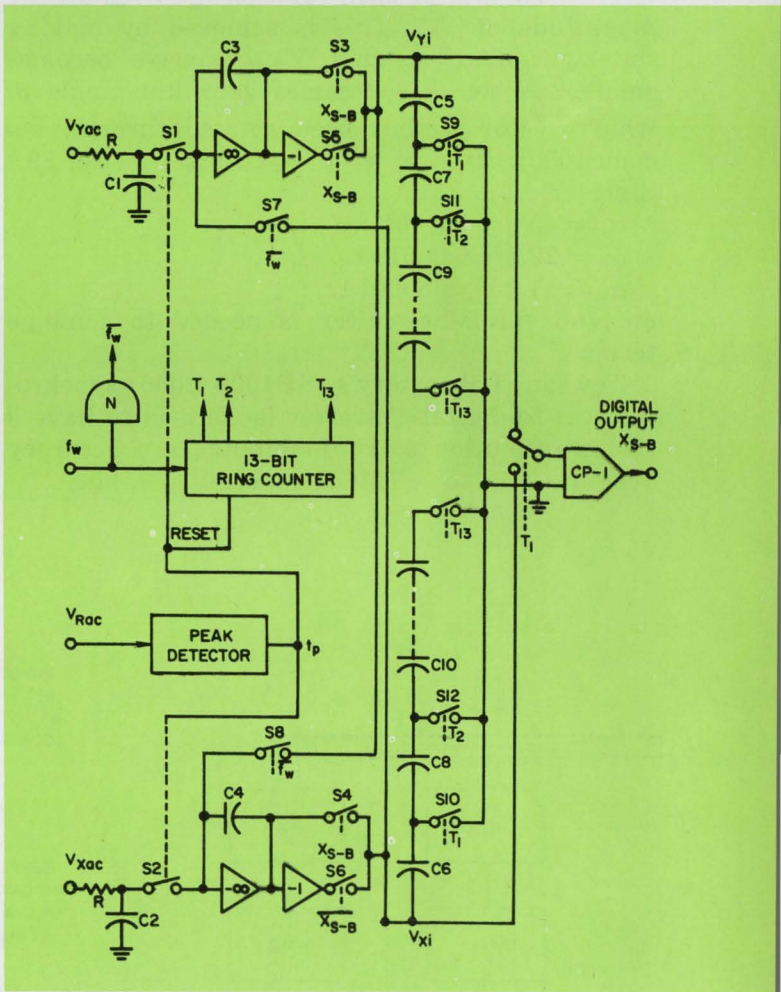
$$C_6/C_3 = C_5/C_4 = \tan\alpha_1 = 1$$

then $\alpha_1 = 45°$ (93)

To further illustrate the encoding process, the




36. **The vector $\bar{R}_i$ is tuned through angle $\theta_i$** in a series of n fixed-magnitude rotations through $\pm\alpha_i$. The Type VI converter output is produced by summing all such rotation angles.




37. **The Type VI converter features twin analog circuits** for sampling resolver outputs, a 13-bit ring counter timing generator and a capacitive divider network for scaling. A charge-transfer switching sequence reduces the $X_{Yi}$ magnitude to zero, thereby rotating $\bar{R}_i$ through $\theta_i$.

second rotation will be discussed. Note that $V_{Y1}$ (Eq. 91) is a positive quantity, since the equivalent angle $\theta + \alpha_1$ lies between 90° and 180°.

During the second rotation, switches $S_3$, $S_4$, $S_{11}$, $S_{12}$ close while $S_9$ and $S_{10}$ open. The series combination $C_5$ and $C_7$ charges according to Eq. 91. The series capacitance is $C_{5,7}$. Similarly, the series combination $C_6$ and $C_8$ charges according to Eq. 92. The series capacitance is $C_{6,8}$. When $S_7$ and $S_8$ are momentarily closed, the charges on $C_{5,7}$ and $C_{6,8}$ are transferred to $C_3$ and $C_4$. The voltages on $C_3$ and $C_4$ thus become

$$V_{Y2} = V_{Y1} + (C_{6,8}/C_3)$$
$$V_{X1} = -V_{Y1} + 0.414\ V_{X1} \quad (94)$$

and

$$V_{X2} = -V_{X1} - (C_{6,8}/C_3)$$
$$V_{Y1} = -V_{X1} - 0.414\ V_{Y2} \quad (95)$$

during the second iteration.

(Note: $C_{6,8}/C_3 = \tan\alpha_2 = \tan 22.5° = 0.414$)

The operation in succeeding rotations can be generalized by

$$V_{Yi+1} = V_{Y1} \pm V_{Xi} \tan \alpha_i \quad (96)$$

and

$$V_{Xi+1} = V_{Xi} \pm V_{Yi} \tan \alpha_i \quad (97)$$

The objective of each rotation is to reduce the magnitude of $V_{Yi}$. This is achieved by making the sign of $\alpha_i$ so that $V_{Yi+1}$ always becomes smaller. When $V_{Yi}$ becomes zero, the angle $\theta_i$ which vector $\bar{R}_i$ has been rotated through becomes $\theta = \pm \alpha_1 \pm \alpha_2 \pm \alpha_3 \ldots \pm \alpha_n$ (Eq. 89) Since

$\alpha_1 = 45° = 001000\ldots$,
$\alpha_2 = 22.5° = 000100\ldots$,
$\alpha_3 = 11.25° = 000010\ldots$,

etc., no special circuitry is needed to combine terms.

Towson Laboratory's SD1000/2000 synchro-resolver-to-digital converter is claimed to have a 13-bit resolution and ±6 minutes arc accuracy over a −54° to +71°C temperature range.

## Multispeed converters provide improved accuracy

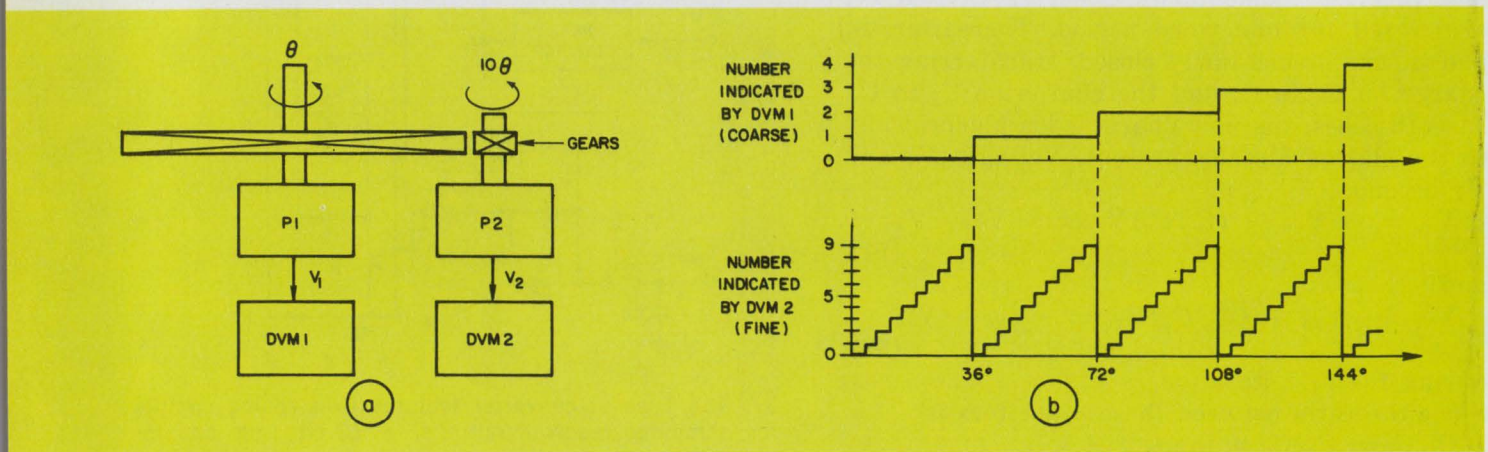
The accuracy with which the output signals of a conventional single-speed synchro or resolver represent the angular position of the shaft is limited, by electrical and mechanical tolerances, to about one part in 8000 (approximately 3 minutes of arc). To overcome this limitation, multispeed systems have been introduced.

### Two-speed operation explained

Most common is the two-speed system, consisting of coarse and fine circuits. The speed of the fine circuit is always n times higher than that of the coarse circuit. The number n is a multiple of the electromechanical transducer pole pair count; hence n = 8, 16, 32, etc.

Two-speed system operation is best understood by considering two single-turn (360°) potentiometers, $P_1$ and $P_2$, (Fig. 38a) the outputs of which, $V_1$ and $V_2$, are encoded with two digital voltmeters, $DVM_1$ and $DVM_2$. The potentiometers and voltmeters are assumed to be free of errors, but resolution is only one part in n for either voltmeter. The second potentiometer ($P_2$) is driven at n times the speed of $P_1$ through a 1:n gear-train ratio. One complete revolution of $P_2$ corresponds to 360°/n on the input shaft, or one unit increment on $DVM_1$. By contrast, one unit increment on $DVM_2$ represents $360°/n^2$. The input shaft angle $\theta$ can now (theoretically) be resolved to one part in $n^2$.

For example, if n = 10, then $DVM_1$ and $DVM_2$ are single-decade voltmeters, $P_2$ operates at 10 times the speed of $P_1$, and the resolution is 3.6°. Operation of the two-speed system is illustrated by curves (Fig. 38b) showing the numbers displayed by the two voltmeters plotted as a function of the input angle $\theta$.




38. **The two-speed converter system** (a) uses gear-driven potentiometers and digital voltmeters to provide coarse and fine outputs (b). Theoretical resolution for shaft angle $\theta$ is one part in $n^2$. In this case n=10.

In practice, all systems of this type have drawbacks due to the dial and gear tolerances. These problems occur when the numbers indicated change in both meters. If, in our example, the number in $DVM_1$ changes first, then the indicated value can jump from 09 to 19 before it becomes 10. Should $DVM_2$ change first, the indicated number could change from 09 to 00 before it reaches 10.

This ambiguity problem can be overcome if the resolution on $DVM_1$ is made 20 while the $P_1 : P_2$ gear ratio is kept at 1:10. One revolution of $P_2$ would still be 36°, but there are now two numbers on $DVM_1$ for every revolution of $P_1$.

### Multispeed design has advantages†

Conventional two-pole single-speed synchro and resolver development has progressed to the point where their accuracy often surpasses that of practical gear trains. Although the once common two-speed synchro system has apparently lost its usefulness, new multiple synchro components effectively provide electrical gearing. Their use with conventional syncros in a two-speed system provides 10 seconds of arc accuracy.

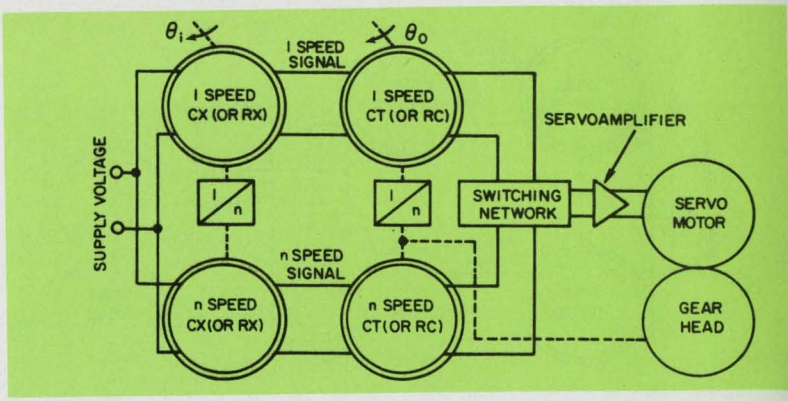
Mechanically geared two-speed synchro systems were used for years to achieve greater accuracy than that available from individual synchros (Fig. 39). The one-speed portion drives the system close to its equilibrium position. Then the synchronizing network switches a servo amplifier from the one-speed control transformer (CT) to the high-speed CT. Final servo output shaft position and system position accuracy are determined by the high-speed circuit portion. Errors in one-speed components seldom affect system accuracy.

### Mechanical gearing is error-limited

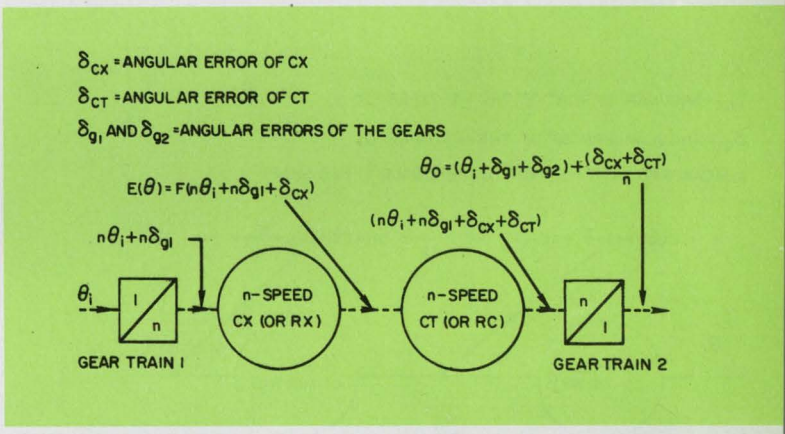
Because position accuracy in a two-speed system is not normally affected by errors in the one-speed loop, an error study can be confined to the n-speed portion. Signal flow and error accumulations through the n-speed loop are shown in Fig. 40. Two significant observations can be made: (1) n-speed control transmitter (CX) and n-speed CT electrical errors appearing at the output shaft, are reduced by the factor 1/n; (2) gear errors are unaltered as seen at the output shaft.

Assuming that the system's high-speed portion uses a CX having 10 minutes of arc inherent error, a CT with 10 minutes of error and 36:1 gear trains each with 2-minute errors, then

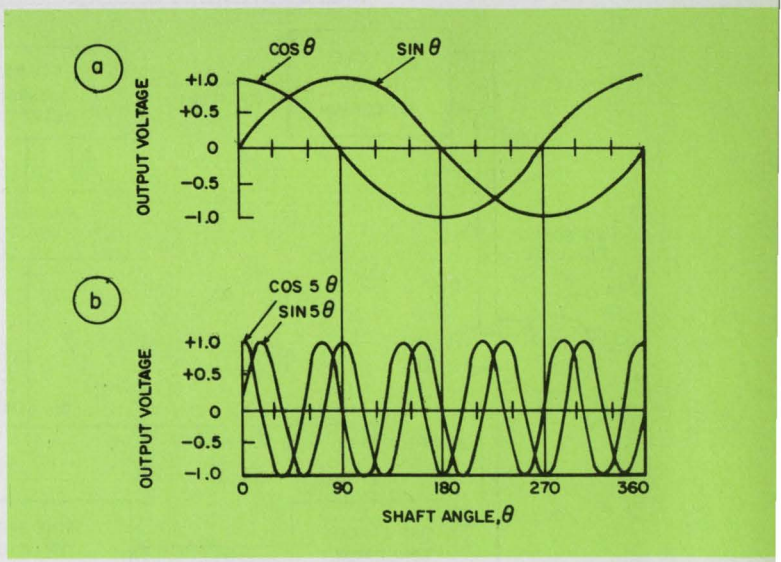
† Extracted from "Kearfott Technical Information for the Engineer, Number 1," by permission of General Precision System, Inc., Kearfott Products Division, Little Falls, N.J.



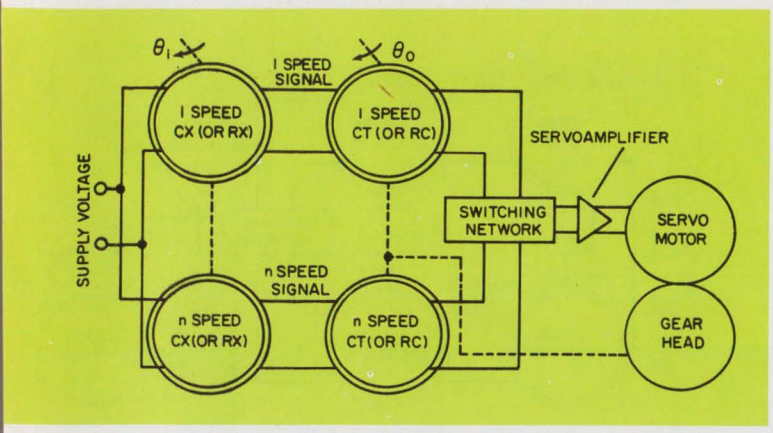

39. **A servo-controlled mechanical n-speed system** was long used to obtain greater accuracy than was available from one-speed units. The n-speed portion determines the final servo output shaft position, while the one-speed section seldom affects accuracy.



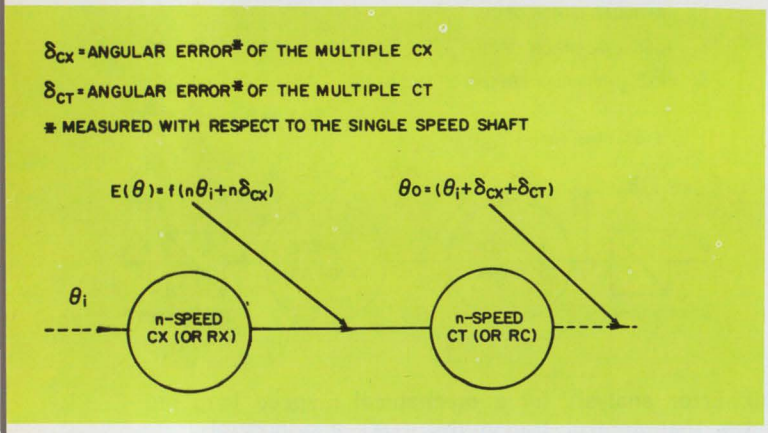

40. **Error analysis for a mechanical n-speed loop** indicates that control transmitter (CX) and control transformer (CT) errors appearing at the output shaft are reduced by 1/n. Gear inaccuracies are unaltered.



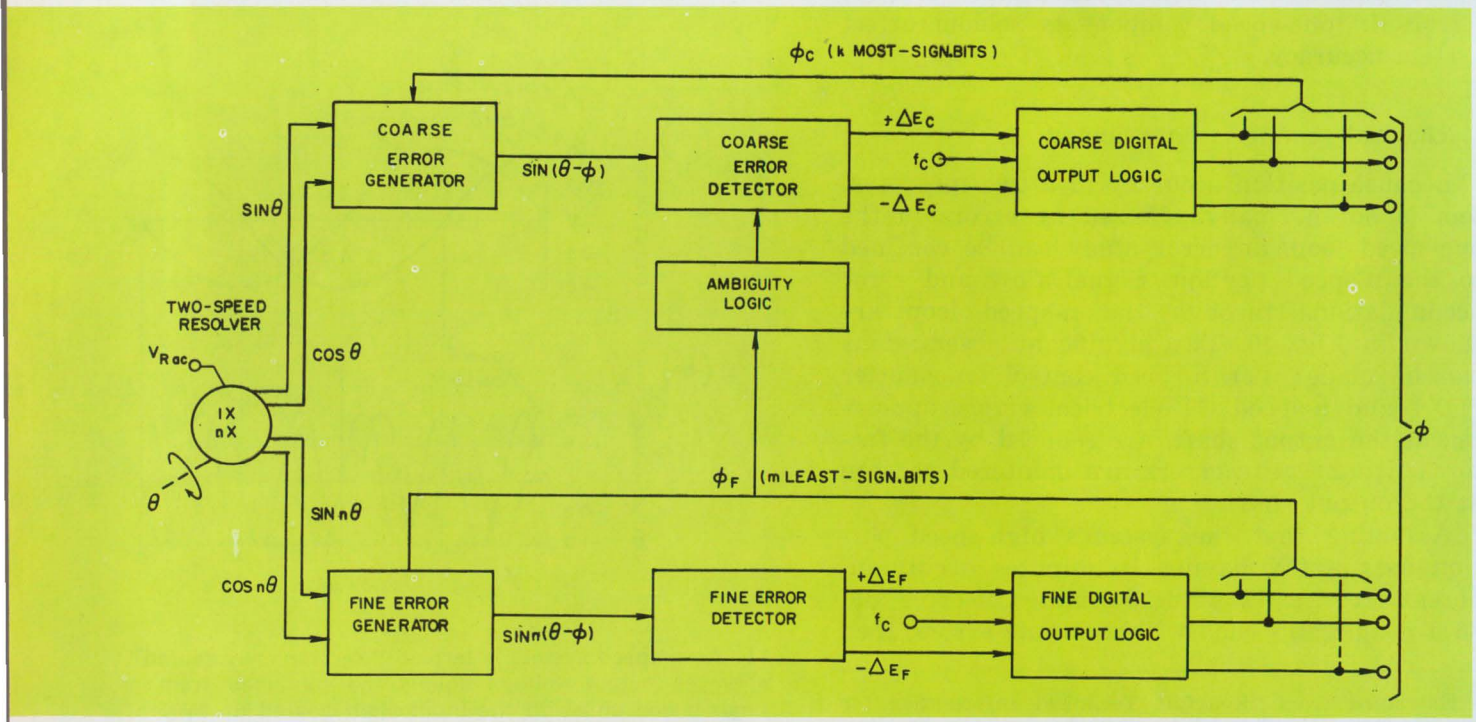

41. **An n-speed system is termed "electronically geared"** when its output voltage equals that obtained from a single-speed unit with the input shaft geared up by 1:n. This example compares the outputs of a single-speed and five-speed resolver.




42. **A servo-controlled electrical n-speed system** provides electrical gearing that overcomes the tolerance limitations of mechanical gears.




43. **Error analysis for an electrical n-speed loop** sums inaccuracies from the control transmitter (CX) and control transformer (CT). Although it affects system performance directly, this error is very low and therefore not a problem.




44. **The typical two-speed resolver-to-digital converter** is composed of coarse and fine digital logic. The fine (high-speed) output can present speed problems if the converter is time-shared between many input signals.

apparent CX or CT electrical error seen at the output shaft is 10/36 (≈0.3 minute each). Concurrently, gear error seen at this same shaft is 2 minutes per gear train. Thus gearing limits systems accuracy. Without improved gears, a two-speed system provides no advantage. CX and CT synchros having less than 2 minutes' error are readily available while 2-minute gears approach the best accuracy available at reasonable size and cost.

### Electronic gearing cuts inaccuracy

Multipole synchros and resolvers are components whose output voltage is a sine (or cosine) function of n times input shaft angle. Unit n = speed equals the number of pole pairs. Such units are called electrically geared because their output voltages are the same as outputs from a single-speed unit with its input shaft geared up by the ratio of 1:n. For example, Fig. 41 shows the two output voltages of a single-speed resolver (a) compared with the two outputs of a

five-speed multipole resolver (b).

Multipole synchros and resolvers in two-speed systems can eliminate the need for mechanical gearing. In such systems, gear inaccuracies are replaced by multipole component inaccuracies. Fig. 42 illustrates a two-speed synchro system in which the n-speed units are multipole synchros or resolvers and there is no mechanical gearing.

An electrically geared two-speed system's associated signal flow, and the error accumulations in the n-speed loop, are shown in Fig. 43. Inaccuracy introduced by this system is the error sum in the multipole CX and multipole CT. Note that synchro errors in this electrically geared system are not divided by speed.

If multipole synchros have a speed of 36 and a 10-minute error, the apparent electrical error per unit, as seen at the output shaft, is 10 minutes. The reason for no apparent component error division stems from error definition in multipole synchros. Normally, tolerances are given in shaft-position terms, relative to a complete input shaft revolution and therefore on a single-speed basis. Under this definition, error division caused by electrical gearing takes place inside the components themselves and therefore is already included in the manufacturer's specified synchro error. State error for multipole units is very low and is not a problem, even though it affects a system directly. Inaccuracies around 5 to 10 arc seconds are currently available, and since there is no gear error, 10 arc seconds' overall system accuracy is achieved.

### Multipole synchros gain acceptance

Though the multipole synchro concept is not new, the potential is just beginning to be realized. Many new multipole components are now being developed because of their accuracy advantage. Other considerations such as driving torque, size and shape also figure in their selection. They can be designed in a pancake shape, ideally suited for gimbal mounting on inertial platforms. Multipole synchros and resolvers are currently being exploited in analog-to-digital converters. Digital accuracies to $2^{16}$ have been attained with multispeed resolver systems having a 14-arc-second analog accuracy as input to the digital circuits.

### Two-speed unit has coarse/fine logic

The two-speed resolver-to-digital angle converter of Fig. 44 comprises a coarse and fine encoder, plus ambiguity logic circuitry that correlates the coarse and the fine data. Typical resolution values are 4 to 7 bits for the coarse channel and 8 to 12 bits for the fine channel.

Converter inputs to the dual-winding resolver in Fig. 44 are the outputs of a two-speed resolver. They also have been derived from a pair of single-winding resolvers using mechanical or electrical coupling. Either way, the coarse channel inputs represent $\sin\theta$ and $\cos\theta$, whereas the fine channel inputs represent $\sin n\theta$ and $\cos n\theta$, because the mechanical or electrical gear ratio is 1:n.

Each channel converts its analog inputs into digital output signals. The coarse channel outputs ($\phi_C$) represent the k most-significant bits, and the fine channel outputs ($\phi_F$), represent the m least-significant bits of digital output signal $\phi$. The most-significant bit of $\phi_F$ is allowed to overlap the least-significant bit of $\phi_C$. This arrangement eliminates spurious output signals found at critical points of the resolver shaft angle $\theta$.

The ambiguity logic shown (Fig. 44) provides control signals to the coarse error detector. The same task could be performed by using the ambiguity logic outputs to modify the coarse-channel digital output signal. In one example, the ambiguity logic compares the most-significant bit of $\phi_F$ with the least-significant bit of $\phi_C$ and subtracts a ONE from $\phi_C$ if the two bits are different.

One resolver-to-digital angle converter can be time-shared between the coarse and the fine channels, instead of using two separate encoders. Separate storage circuits must then be provided for the coarse and the fine values of the digital output signals.

Two-speed conversion systems impose speed problems. For example, if $\theta$ changes at 100 radians per second and n=36, the high-speed synchro or resolver output changes at 3600 radians per second. This requires the high-speed encoder to have a conversion rate of 3600 per second minimum, eliminating low-speed conversion techniques. If the converter is to be time-shared among a large number of input signals, the conversion rate becomes an important problem. ■■

**References:**
28. Volder, J. E., "The CORDIC Trigonometric Computing Technique," *"IRE Transactions on Electronic Computers,* EC-8, Sept. 1959.

## Correction

In Part 2 of this Practical Design Guide (ED 7 April 1, 1970), the term representing the n-3 significant bits of digital angle $\phi$ was defined as $\phi_F$. The subscript F was mistakenly discontinued beginning with the subhead: "Resolver bridge produces error voltage." Text and drawings should show all resolver bridge designs with $\phi_F$ as the input.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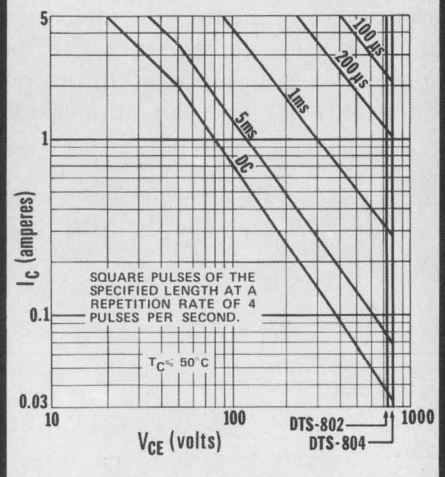
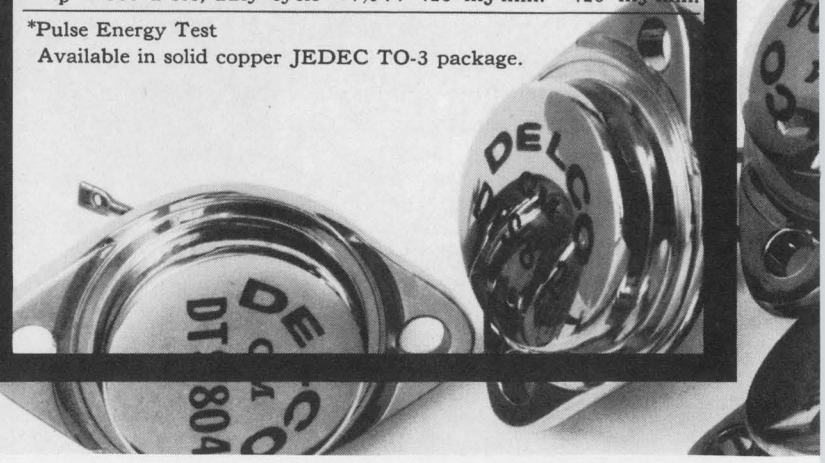



SAFE OPERATING CURVES

| PARAMETER | DTS-802 | DTS-804 |
|---|---|---|
| Collector to emitter voltage ($V_{CEX}$).. | 1200V max. | 1400V max. |
| Collector to emitter voltage ($V_{CEO}$).. | 1000V max. | 1000V max. |
| Sustaining voltage ($V_{CEO}$ sus)..... | 750V min. | 800V min. |
| Emitter to base voltage ($V_{EBO}$)..... | 5V max. | 5V max. |
| Collector current ($I_C$) continuous.... | 5A max. | 5A max. |
| $h_{FE}$, $I_C$ = 3.5A, $V_{CE}$ = 5V ..... | 2.2 min. | 2.2 min. |
| *P.E.T.; $I_C$ = 7A, $V_{CE}$ = 200V, $t_p$ = 300 u sec, duty cycle <4%.. | 420 mJ min. | 420 mJ min. |

*Pulse Energy Test

Available in solid copper JEDEC TO-3 package.



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INFORMATION RETRIEVAL NUMBER 68

# Get to know your local SBA agent.

## If you qualify, he can help you obtain loans, management assistance and government contracts.

**Richard L. Turmail,** Management Editor

In an industry that has a built-in capacity for rendering itself obsolete before its latest innovation can be comprehended, it's essential that electronics entrepreneurs and company managers learn of the government assistance that's available to them. Large numbers of companies have gone either public in search of funds or to a consultant in search of organization, when they might have gone to an independent government agency called the Small Business Administration.

### How large is small business?

There's nothing small about the Small Business Administration or the segment of the business community it serves. Created by an act of Congress in 1953 to encourage, assist, and protect small business, and particularly to aid in getting government contracts, SBA is a big business operation with 4,000 salaried employees and over 3,000 voluntary counselors. They serve 73 field offices in the principal cities of every state, as well as Guam, Puerto Rico, and the Virgin Islands. They assist small companies that make up more than 95% of the business population, account for more than 40% of the business activity and provide employment for 35-million people.

Although, according to an SBA spokesman, the main thrust of agency activity recently has been toward helping low-income, disadvantaged businessmen belonging to minority groups, the agency has also assisted major companies when they're considered to be the smallest company in their industry in competition for a particular market.

### Financial assistance varies in kind

The size standards of a small business vary widely from industry to industry, and from one type of assistance to another. Each standard is covered in the following descriptions of the four prime areas of assistance offered by SBA. They are: financial; lease guarantee plan; management; and procurement.

SBA loans are available to small companies that want to construct, expand or convert facilities; purchase buildings, equipment and materials; or obtain working capital. They are available for such disparate reasons as natural disasters and displacement caused by urban renewal or other government construction.

By law, the agency may not make a loan if a business can obtain funds from a bank or other private sources. And for purposes of making loans, SBA defines a small business as follows:

- Wholesale—annual sales of not more than $5-million.
- Retail or Service—annual sales or receipts of not more than $1-million.
- Manufacturing—not more than 250 employees.

The agency will consider either participating in, or guaranteeing up to, 90% of a bank loan. If the bank cannot provide the funds, SBA will consider lending the entire amount as a direct government loan. Two-thirds of SBA's loans are now made in participation with banks.

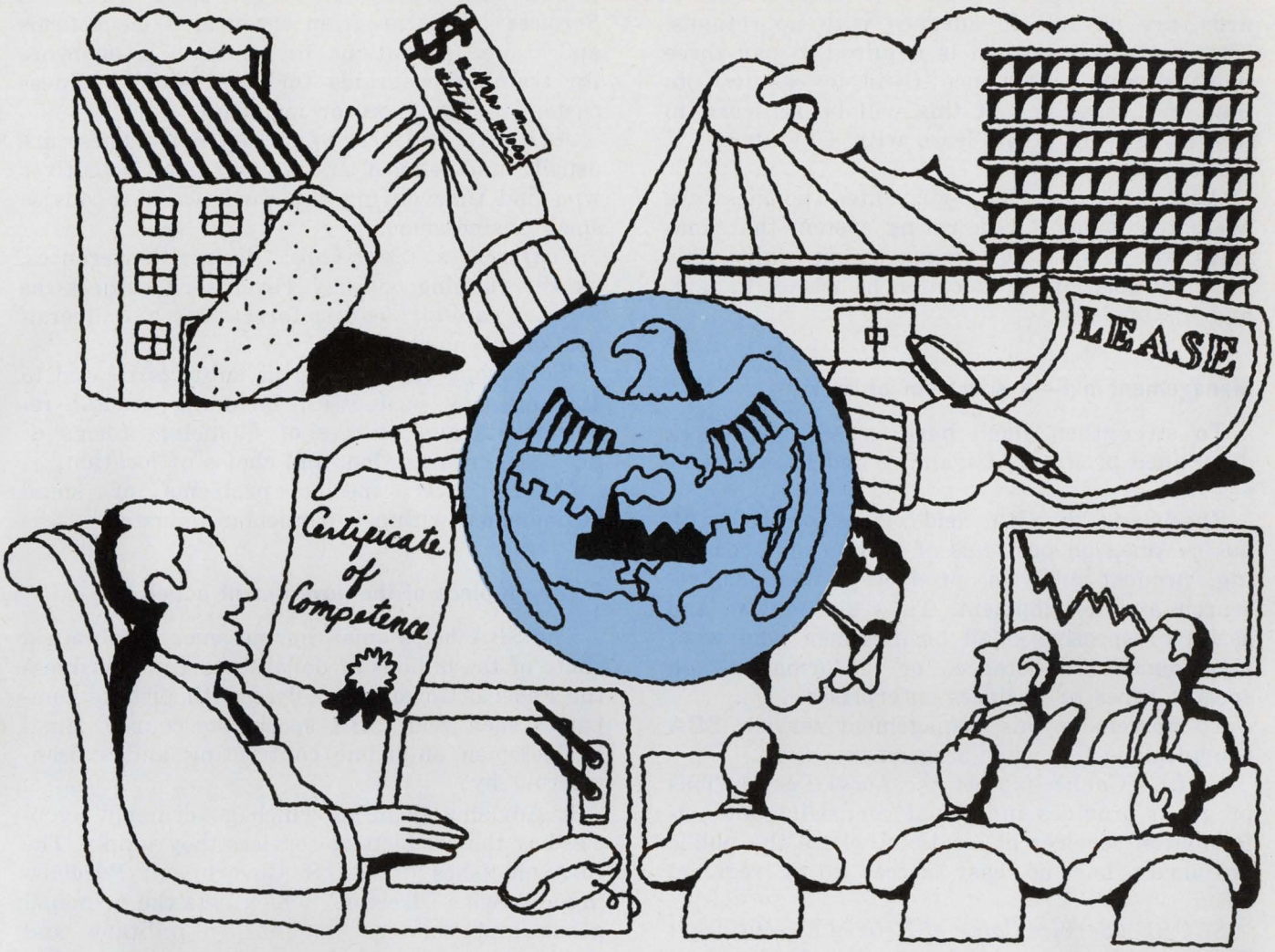
Limits for SBA loan participation are:

1. Guarantee of up to 90% or $350,000 of a bank loan, whichever is less, up to 10 years at 5-1/2% interest, and up to 15 years if the loan is for construction.
2. $150,000 as the SBA share of a participation loan with a bank.
3. $100,000 on a direct SBA loan.

SBA looks to past records and future prospects of a small businessman to decide whether he has the ability to repay a loan and any other debts out of company profits.

Three other loans made by SBA include:

- Pool Loans, whereby the agency lends money to corporations formed and capitalized by groups of small business companies for purchasing raw materials, equipment, inventory or supplies for the use of their individual businesses. Such loans may also be used to obtain the benefits of research and development or to establish facilities for these purposes;
- Economic Opportunity Loans, whereby the




agency assists low-income or disadvantaged persons, who own businesses or want to go into business but are generally unable to obtain financing;

- Economic Development Loans, whereby the agency helps small firms to acquire or build facilities, expand or modernize through loans to state and local development companies formed to finance small businesses.

Another service offered by SBA in the area of financial assistance is Small Business Investment Companies (SBICs).

Such companies are privately owned and privately operated, and have been licensed by the Small Business Administration to provide equity capital and long-term loans to small firms that often have difficulty obtaining long-term capital to finance their growth.

Many SBICs are owned by relatively small groups of local investors. However, the stock of over 40 SBICs is publicly traded; more than 80 SBICs are partially or wholly owned by commercial banks; and some SBICs are subsidiaries of other corporations.

The size standards for a firm eligible for SBIC financing are:

1. Assets do not exceed $5-million.
2. Net worth does not exceed $2.5-million.
3. Average net income after taxes for each of the preceding two years was not more than $250,000.

### SBA will often guarantee your rent

To help small businessmen obtain leases in choice business locations, such as new shopping centers or industrial parks, SBA will often back an insurance policy guaranteeing to the landlord that rent payments will be made. The guarantee extends for a minimum of five years up to a maximum of 20 years on a participating basis. Where private policies are not available, SBA will guarantee the leases directly for a period of 15 to 20 years.

For lease-guarantee purposes, SBA defines a small business as one that is independently owned and operated, is not dominant in its field, and meets employment or sales standards developed by the agency.

Premiums, based on insurance-industry stand-

ards, are payable in advance with no refunds. The small businessman is required to pay three months' rent in advance (held in escrow), to pay rent defaults, but this will be returned to him at the end of his lease with 4% interest if no defaults occur.

Applicants for lease-guarantee policies are evaluated under a risk rating system that analyzes the applicant's management skills, his financial position, the location he wishes to rent, and his business.

### Management aid—a spectrum of services

To strengthen small business, SBA offers a diversified program of training and management assistance.

Specialists in SBA field offices advise small businessmen on problems of marketing, accounting, product analysis, production methods, research and development. They also advise and assist prospective small businessmen who want management assistance or information on specific types of business enterprises.

To implement this management service, SBA provides the following programs:

*CALL (Counseling At the Local Level).* This program provides individual counseling and information services at locations where the public ordinarily has no easy access to a regional office.

*SCORE (Service Corps of Retired Executives)*: This corps is composed of more than 3000 retired business executives in more than 190 chapters throughout the nation. A SCORE volunteer will visit the small businessman in his operation, and through careful observation make a detailed analysis of the business and its problems.

A businessman doesn't need to be in trouble to get such aid. Perhaps he thinks that his business should be doing better or that the record-keeping system is a little out of date. Perhaps he's not even in business yet, but needs some expert advice to help him plan one soundly.

The SCORE service is free—except for direct expenses—to all businessmen who might otherwise not be able to hire experts to help them with their business difficulties.

*Management Courses.* Administrative management courses, co-sponsored by SBA, public and private educational institutions, and business associations are offered to help increase management skills. These are generally evening courses and are designed for owners and managers of small firms. They deal with planning, organizing, directing, co-ordinating, and controlling a business, as distinguished from day-to-day operating activities.

*AIMS (Association and Industry Management Services)*: This program encourages large firms and trade associations to serve as co-sponsors for training programs for their small-business customers, suppliers, or members.

*ACE (Active Corps of Executives)*: These are usually middle-aged mid to top-level executives who find time during the work week to advise small businessmen.

*Conferences, Workshops, Clinics*: Conferences, usually running one day, cover such subjects as working capital, business forecasting and diversification of markets.

Workshops generally cover subjects related to starting new businesses, including capital requirements and sources of financing, forms of business, organization, and choice of location.

Clinics cover specific problems of small businessmen within a particular industry.

### Getting a piece of the government action

The SBA helps small businessmen to obtain a share of the billions of dollars' worth of business the Federal Government does with private companies each year. SBA specialists counsel small businessmen on prime contracting and subcontracting by:

1. Advising them on which government agencies buy the products or services they supply. The SBA publishes "The U.S. Government Purchasing and Sales Director," which lists the principal goods and services bought by military and civilian agencies and the purchasing offices that buy them.
2. Guiding them to have their names placed on bidders' lists so they will be notified of opportunities to bid on purchases.
3. Helping them to obtain drawings and specifications for proposed purchases.
4. Providing information about scheduled meetings where government contracting agencies and prime contractors present their needs and requirements and discuss bidding opportunities.
5. Watching out for purchases on which few small firms have bid in the past.

### Two additional assists

The major government purchasing agencies voluntarily set aside contracts or portions of contracts for small business. To increase this unilateral action, SBA has its own representatives stationed in major military and civilian procurement installations. They recommend additional "set-asides," provide small-business sources to contract officers, assist small concerns with contracting problems, and recommended relaxation of unduly restrictive specifications.

As an additional assist to the small company, which is the low bidder on a federal contract

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Hartford, Conn.
Hato Rey, P.R.
Helena, Mont.
Honolulu, Hawaii
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Syracuse, N.Y.

Tampa, Fla.*
Toledo, Ohio
Tucson, Ariz.*

Washington, D.C.
Wichita, Kan.

* Post-of-duty Office

and whose ability to perform the contract is questioned by the contracting officer, SBA specialists make an on-site study of the company's facilities, management, performance record, and financial status. If it concludes that the company can perform the contract, it issues a Certificate of Competence to this effect.

### Assistance for electronics companies

The following are examples of electronics companies that asked for assistance at one SBA field office. They had the usual business problems: no capital; no work in the house; too small a staff.

One of the firms produced signal breakers, radio telephones and depth gauges for marine electronics. The company head requested SBA specialists to assist him in the management areas of setting up a procedure for marketing and for records and control. He also requested financial assistance for expansion and received it.

Another company hadn't been able to generate business in burglar alarms. The staff was small and limited the amount of business that could be handled. The firm got a contract and requested—and obtained—a small SBA loan so that a larger staff could be hired.

Another company is operated by a small businessman of a minority group. He worked for a large company before he gained enough confidence to start his own operation. SBA gave him a loan to finance equipment, facilities, and a payroll. He got a government contract, and then another to assemble and test megaphone and telephone sets. He requested an SBA loan for expansion. In eight months his company expanded its payroll from nine to 30 people. With SBA's assistance, this electronics entrepreneur was able to increase his contracts from $60,000 to $3-million in three years.

Congress has directed SBA to ensure free competition as the essence of the American economic system of private enterprise, and to strengthen the over-all economy of the nation. One enthusiastic advocate of the agency wrote ELECTRONIC DESIGN that the free classes, services and other programs, arranged through SBA by retired and salaried consultant personnel, "have saved many a small business from collapse." ■■

**Bibliography:**
"Lease Guarantee," *Small Business Administration,* October, 1968.
"SBA Business Loans," *Small Business Administration,* October, 1969.
"SBIC Financing for Small Business," *Small Business Administration,* March, 1968.
"Small Business Administration—What It Is, What It Does," *Small Business Administration,* March, 1968.
"SCORE," *Small Business Administration,* 1968.

# end your signal pollution problems

## Beldfoil® ISO-Shielded™ Cable

It's the cable with virtually perfect shielding. It's a Belden exclusive. Beldfoil ISO-Shield is like a continuous metal tube enclosing each pair of conductors in a cable. It locks out crosstalk or interference . . . whether from outside sources or between shielded elements in the cable.

Beldfoil is a layer of aluminum foil bonded to a tough polyester film (for insulation and added strength.) To form an ISO-Shield, we apply it in any one of several unique ways to meet the requirements of different applications. (See Figures 1 and 2, for example). Each gives more physical shield coverage than braided wire or spiral wrapped (served) shields. And greater shield effectiveness . . . even after repeated flexing.

Beldfoil ISO-Shielded Cables are small, lightweight. They terminate easily. They're modest in price. Your Belden Distributor stocks a wide variety of standard Beldfoil shielded cables as listed in the "Belden Electronic Wire and Cable Catalog" (ask him for the latest edition). And, should you have specifications no standard product can meet, ask him to quote on a specially engineered design. Or, if you choose, contact: Belden Corporation, P. O. Box 5070-A, Chicago, Ill. 60680. Phone (312) 378-1000.

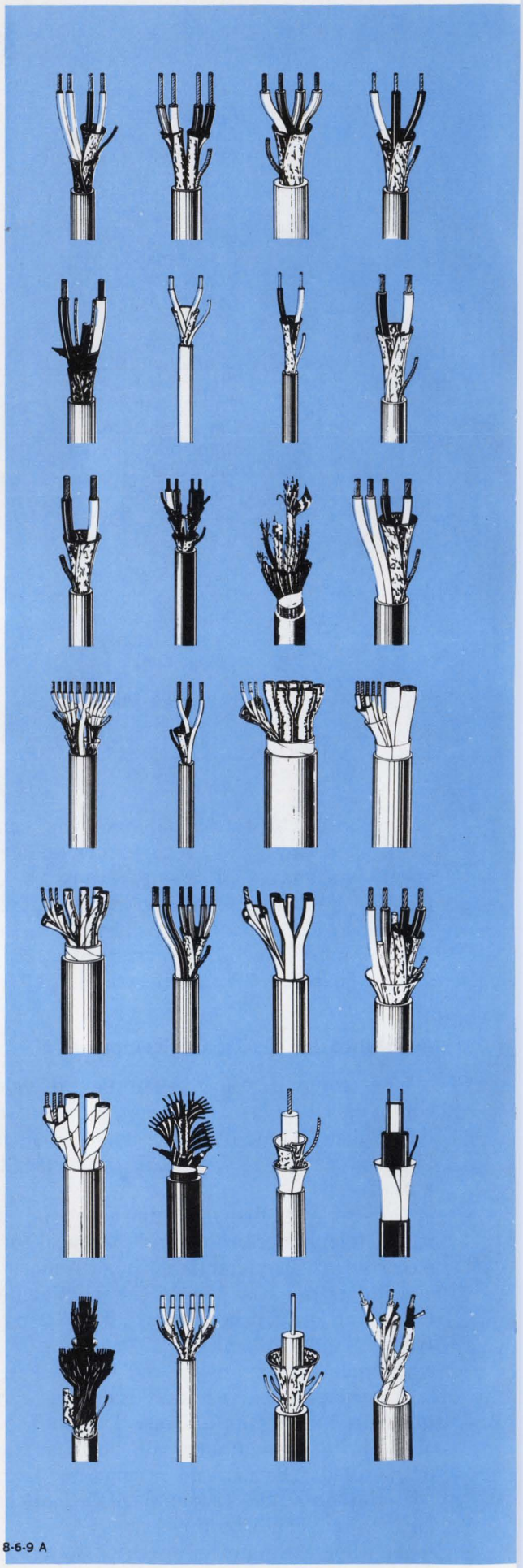

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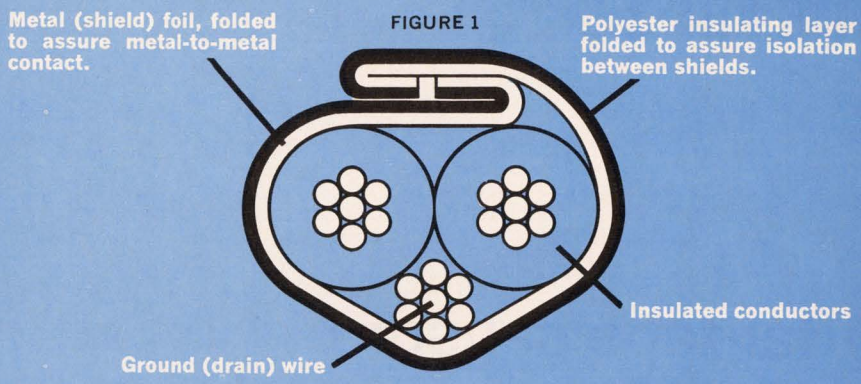
FIGURE 1




## Beldfoil Multiple Pair Individually Shielded Cable

The Figure 1 cross-section shows Belden's exclusive Z-folded Beldfoil ISO-Shield. Note the metal-to-metal contact between the two edges of the aluminum foil. In essence, you have a continuous aluminum tube. And the polyester layer on the outside of the fold assures the isolation between shields so necessary for best performance in the field.

### Technical Data

Nominal values for multiple pair individually shielded cables containing 3 to 27 pairs (inciuding 8769 and 8773 through 8778 Series cables)

Suggested working voltage: 300 volts rms max.

Working voltage between adjacent shields: 50 volts rms max.

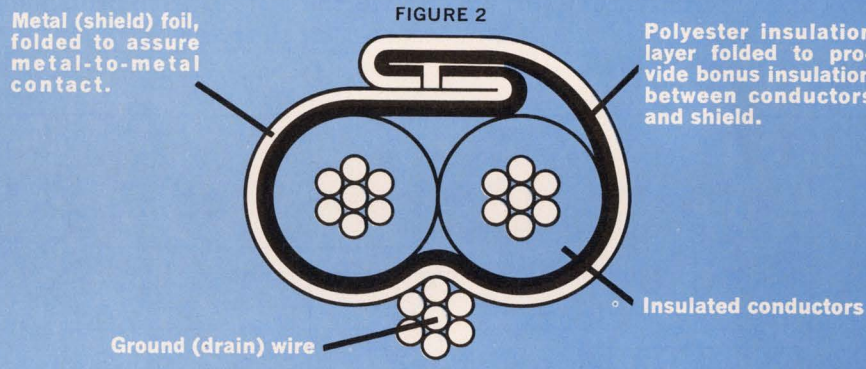
Capacitance between conductors in a pair: 30 pf per ft. nom.

Capacitance between one conductor and other conductor connected to shield: 55 pf per ft. nom.

Capacitance between shields on adjacent pairs: 115 pf per ft. nom.

Insulation resistance between shields on adjacent pairs: 100 megohms per 1000 ft. nom.

FIGURE 2




## Beldfoil Shielded Single Pair Cable

The Figure 2 cross-section shows the exclusive Belden Z-fold with the polyester insulating layer inward. This makes use of the high dielectric strength of the polyester film as bonus insulation between the conductors and the shield. (The cable jacket provides the primary insulation of the shield from outside objects or adjacent cables.)

### Technical Data

Nominal values for 8451 Shielded Pair Cable

Suggested working voltage: 200 volts rms max.

Capacitance between conductors: 34 pf per ft. nom.

Capacitance between one conductor and other conductor connected to shield: 67 pf per ft. nom.

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# Digital-tape sensor requires no adjustments

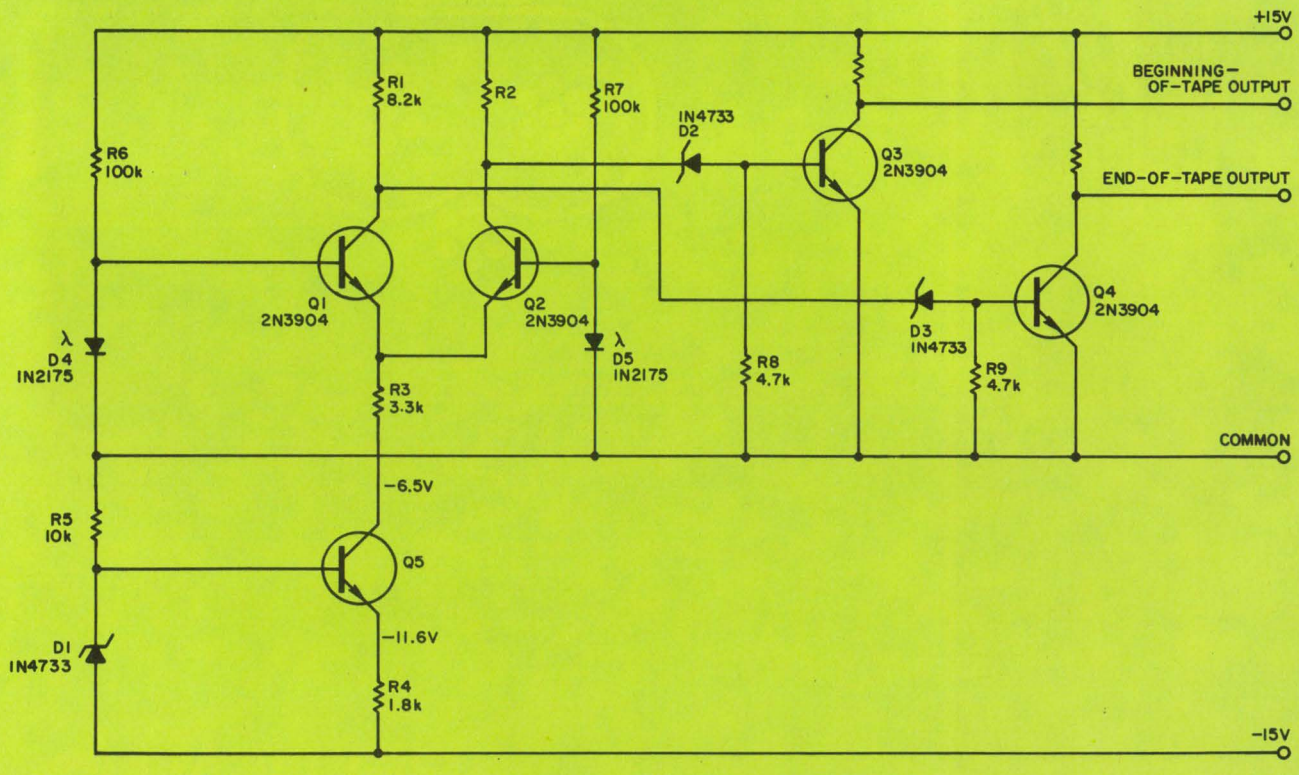
Reliable beginning-of-tape and end-of-tape detection is essential to the operation of all digital-tape memory systems. But many difficulties are involved.

The design shown operates, without adjustment, over wide ranges of the following variables:

- Illumination.
- Detector sensitivity.
- Wrinkled tape.
- Dull reflective tabs.
- Power-supply output.
- Temperature.

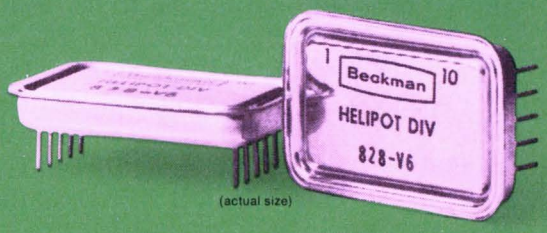
The key to the success of the design is that it monitors the differential output between the end-of-tape and the beginning-of-tape sensors. When a significant change is detected between the two sensors, the appropriate output signal is given —either beginning-of-tape or end-of-tape.

The circiut operates in the following manner. Photo-diodes $D_4$ and $D_5$, coupled with transistors $Q_1$ and $Q_2$, form the two sensors. The output of these transistors results in a beginning-of-tape or end-of-tape signal at $Q_3$ and $Q_4$, respectively. Transistor $Q_5$ acts as a constant-current source to supply $Q_1$ and $Q_2$. This current source is achieved by maintaining a constant potential between the negative 15-V supply and the base of $Q_5$ via zener diode $D_1$. The potential drop across $D_1$ is approximately 4 V with the current used. In




**Stable sensor circuit** uses differential sensing to provide beginning-of-tape and end-of-tape detection.

# SUDDENLY ALL OTHER VOLTAGE REGULATORS ARE SECOND BEST.



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this range $D_1$ has nearly a zero temperature coefficient, thus assuring setting consistency.

With no sensor output, the collector current of $Q_5$ is divided equally between $Q_1$ and $Q_2$. Transistors $Q_3$ and $Q_4$ are on. Assuming that a beginning-of-tape tab is detected, the potential is decreased at the base of $Q_1$ by at least 50 mV. This decreases the collector current of $Q_1$, which results in a higher $Q_2$ collector current. This $Q_2$ collector current cuts off $Q_3$. As $Q_3$ goes off, its collector potential increases, providing the beginning-of-tape output.

In a similar fashion, the end-of-tape output is provided by $Q_4$. Detection of an end-of-tape tab causes the $Q_2$ collector to decrease. Next, the $Q_1$ base potential increases, turning off $Q_4$, which gives end-of-tape output.

Selection of $R_4$ current determines the initial drive current available to $Q_3$ and $Q_4$, thus defining the detection threshold. This initial setting will depend upon the detector sensitivities, their output level and the light level.

The circuit has high common-mode noise rejection capability, in excess of 1000:1. If a considerable noise is present on both detectors simultaneously, no output variation occurs. This feature is very desirable under low input signal level and noisy environment conditions.

*Charles E. Wallace, Engineering Consultant, Palos Verdes Estates, Calif.*

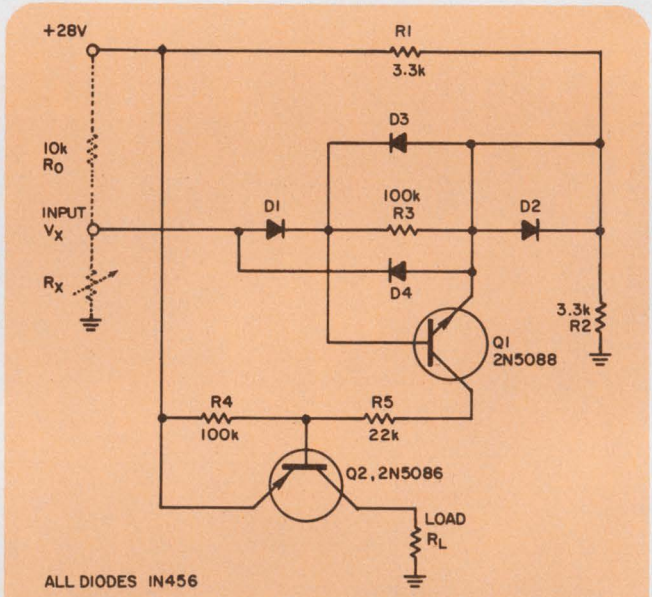
VOTE FOR 311

## Voltage window detector provides logical output

When a varying voltage enters a window within the voltage's range of values, the circuit shown changes state from logical ONE to logical ZERO.

The input voltage, $V_X$, is compared with the voltage at the junction of $R_1$ and $R_2$. If the absolute value of the difference between these two voltages exceeds approximately 2 V (that is, three pn junction drops), the network composed of $D_1$, $D_2$, $D_3$ and $D_4$, gates current through $R_3$, turning on $Q_1$ and $Q_2$. During this condition, a logical ONE exists at the collector of $Q_2$ and may be used to activate load $R_L$ (relay coil).

The circuit window is approximately 4 V wide and is level-centered by the $R_1$, $R_2$ voltage divider. It is not possible to turn on the two gating diodes—$D_1$ and $D_2$, if $V_X$ is high or $D_3$ and $D_4$ if $V_X$ is low—*and* the emitter-base junction $Q_1$, once $V_X$ is in this region. Consequently, while $V_X$ is in the voltage window, $Q_1$ and $Q_2$ are turned off, producing a logical ZERO at the collector of $Q_2$.




**Voltage divider** composed of $R_0$ and a resistance sensor, $R_X$, generates $V_X$. The window width is $8k < R_X < 12k$.

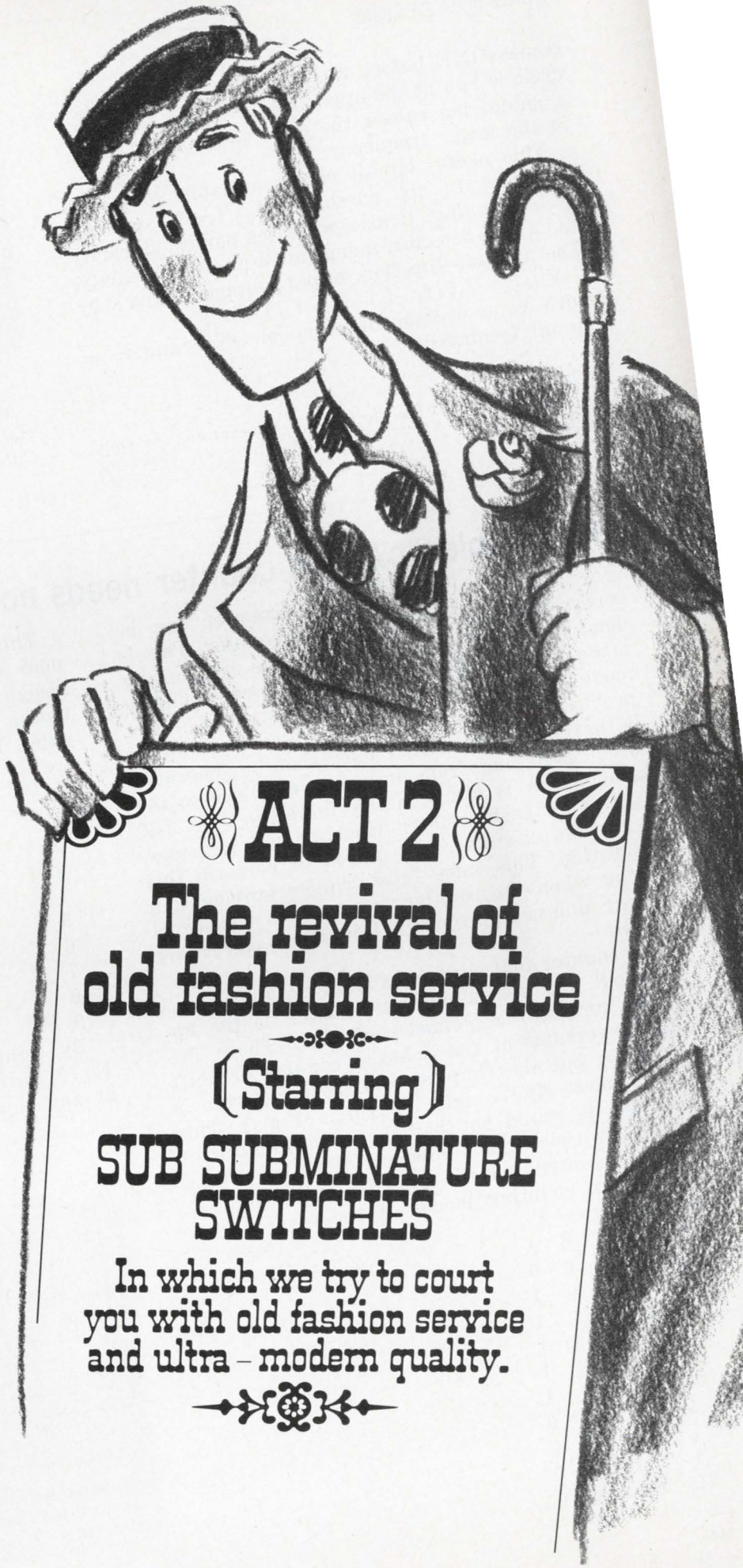
*Tom McDonald, Electronics Systems Division, Babcock Electronics Corp., Costa Mesa, Calif.*

VOTE FOR 312

## Phase-locked loop utilizes current-controlled oscillator

Phase-locked oscillators are frequently used for regenerating and predicting signals for synchronous detection and for fm discrimination. A simple phase-locked loop using a current-controlled oscillator (CCO)[1] is shown in the figure.

The CCO is operated at two frequencies, $f_0$ and $f_1$, which correspond to the ZERO and ONE states of the flip-flop. This flip-flop is clocked at the end of each oscillator cycle. If the signal phase leads the oscillator phase, the D input be-



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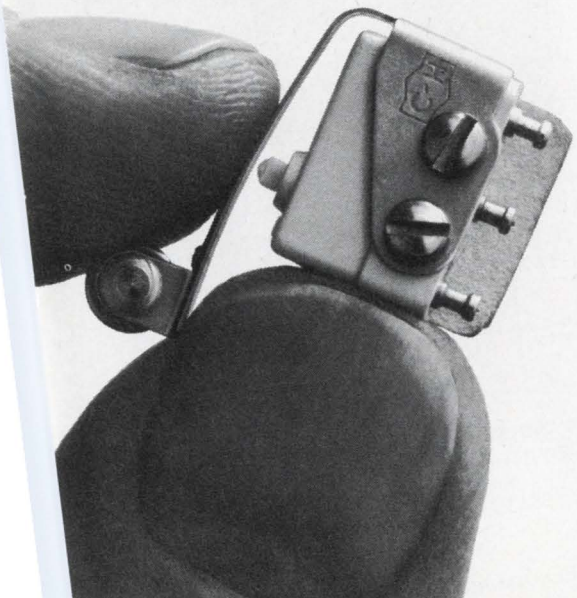


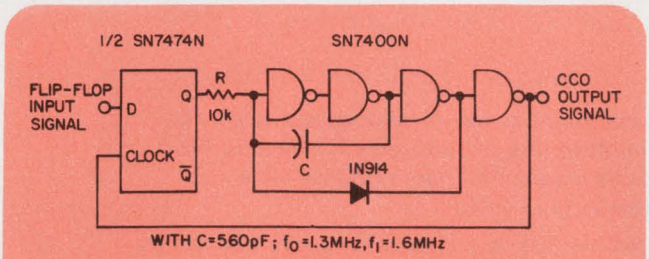
comes ONE before the clock does, and the next cycle is run at the upper frequency, $f_1$. Similarly, a signal lag causes the subsequent cycle to run at the lower frequency, $f_0$.

This useful circuit can immedately lock onto a signal in its passband, $f_0 \leq f_S \leq f_1$, without cycle skipping. It also possesses perfect linearity as an FM detector, independent of CCO linearity. The average flip-flop output voltage is given by

$$V_{ave} = V_1[(f_S - f_0)/(f_1 - f_0)]$$

with $V_1$ = voltage of a logical ONE, and $f_S$ = signal frequency.

**Reference:**
1. Osborn, C., "TTL Clock Pulse Generator Uses Only One Capacitor," *Electronic Design*, June 21, 1969, pp. 84-85.




**Binary phase-locked loop** acquires in-band signals without cycle skipping. C sets the center frequency, and R determines the deviation.

*Michael Lampton, Assistant Research Physicist, Space Sciences Laboratory, University of California, Berkeley, Calif.*

VOTE FOR 313

# Presettable up/down counter needs no inhibits or one-shots

A binary or BCD up-down counter can be constructed easily from a ripple counter. This is done by gating the Q output for the up counting mode and the $\overline{Q}$ output for the down counting mode to the counter's clock input stage. The one problem with this method of up-down counters is that erroneous trigger pulses can be generated when switching from one counting mode to the other. This is corrected by inhibiting the J-K inputs on each counter when changing modes, but extra circuits are required to perform this operation. This same false trigger problem can occur when the counter is preset to a selected count unless appropriate inhibit measures are taken.

A counter that eliminates all of these problems without any special inhibit function is the up-down presettable Johnson counter. There are many versions of the Johnson counter or shift counter, but the simplest and most versatile is the reverse ring counter shown in Fig. 1. This counter is wired so that the total number of counts is twice the number of flip-flops. For a decade counter, five flip-flops are required.

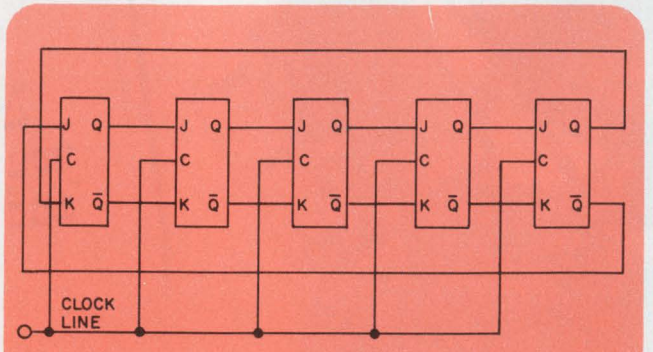
The ten counting modes of the reverse ring counter are:

| E | D | C | B | A |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 |

This counter is attractive because it is synchronous as opposed to the binary ripple counter design. Another feature is that all ten counting modes can be decoded by using only two-input gates. The Boolean expressions for the ten counts are:

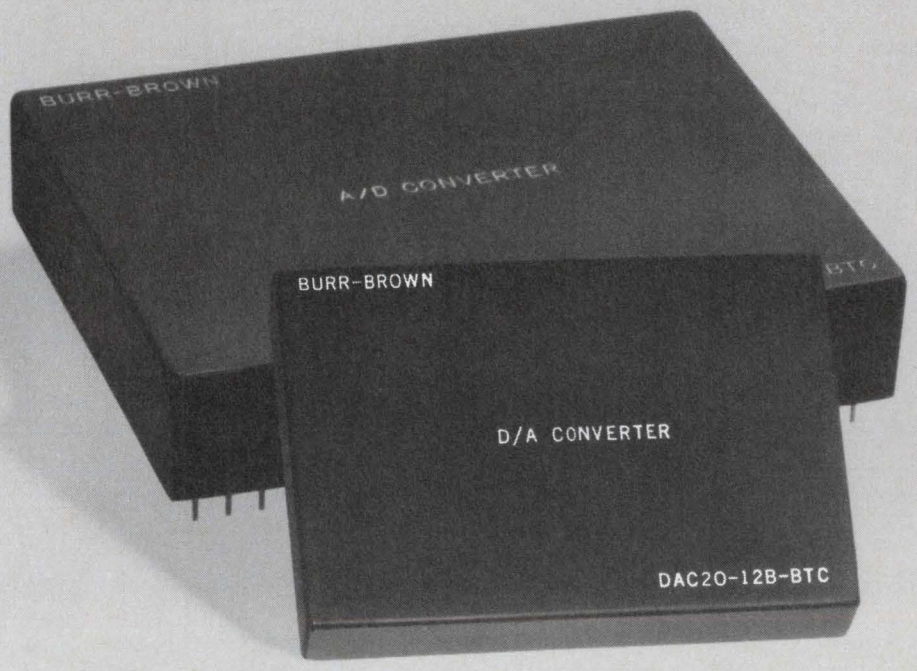
| | |
|---|---|
| 0 | $\overline{A}\ \overline{E}$ |
| 1 | $A\ \overline{B}$ |
| 2 | $B\ \overline{C}$ |
| 3 | $C\ \overline{D}$ |
| 4 | $D\ \overline{E}$ |
| 5 | $A\ E$ |
| 6 | $\overline{A}\ B$ |
| 7 | $\overline{B}\ C$ |
| 8 | $\overline{C}\ D$ |
| 9 | $\overline{D}\ E$ |

By using the gating arrangement shown in Fig. 3, the up-down counting mode can be changed at any time without effecting the count being




1. **Basic Johnson counter** has twice as many counts as flip-flops. Design can be both reversible and presettable.

# New, high-speed A/D-D/A converters from Burr-Brown

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ACCURATE: $\pm\frac{1}{2}$ LSB relative accuracy for all models.
MANY OPTIONS: Operational input buffer amplifier. Four popular digital codes.

| LOW COST (1-9 units): | | |
|---|---|---|
| | 8-bit | $195.00 |
| | 10-bit | $225.00 |
| | 12-bit | $295.00 |

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LOW DRIFT: 20 ppm/°C for 10-bit converter.
ACCURATE: $\pm\frac{1}{2}$ LSB relative accuracy for all models.
MANY OPTIONS: Optional input buffer register. Four popular input codes.

| LOW COST: (1-9 units) | | |
|---|---|---|
| | 8-bit | $ 95.00 |
| | 10-bit | $125.00 |
| | 12-bit | $155.00 |

**FOR COMPLETE TECHNICAL INFORMATION contact Burr-Brown, your Burr-Brown Engineering Representative, or use this publication's reader service card.**

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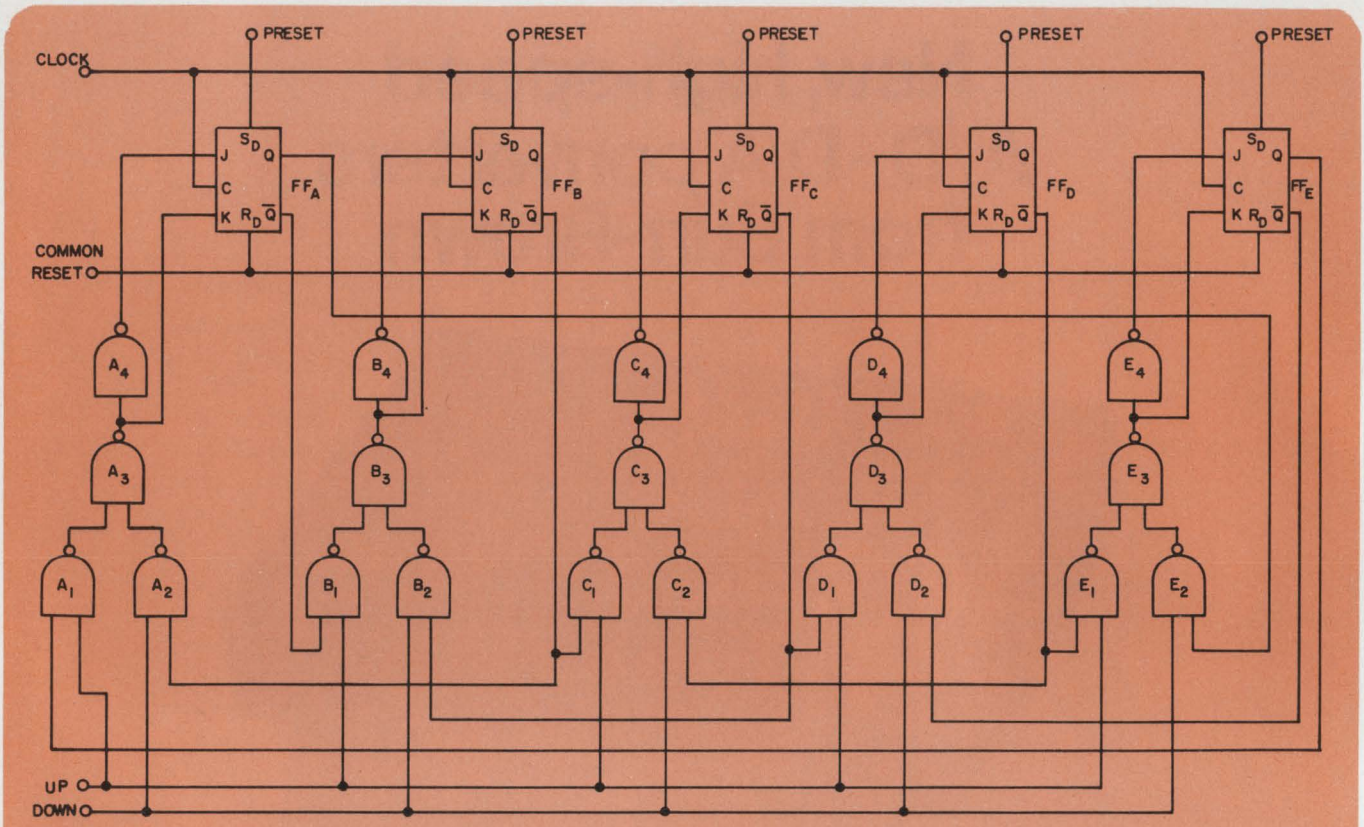
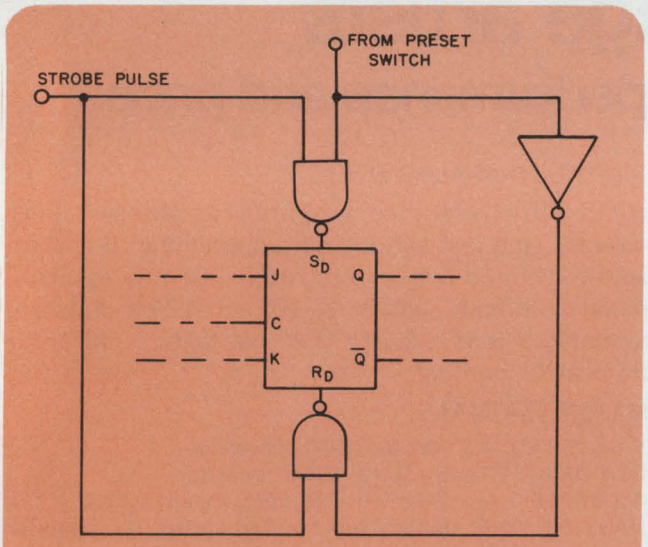



3. **Gating system** permits a count change at any time without affecting the existing count.




2. **Typical stage** of a reset method which eliminates the need for resetting prior to presetting.

held. Five sets of gates are used for the counter's updown steering networks, each gate set composed of a five-gate IC. The counter could also be built using gates in a wired-OR configuration. This approach uses only four IC's.

There are two methods used to preset the counter. The first method is to reset the counter with a common reset line and then preset it with a separate pulse routed to each flip-flop as shown in Fig. 3.

If desired, a separate line to each direct preset and reset input of each flip-flop can be used to eliminate the two-step presetting operation. This is shown for one stage in Fig. 2.

This counter can be preset with either of these two methods without any need for inhibit functions to suppress extra trigger pulses.

*John T. Hannon, Jr., Design Engineer, Brown Engineering, Huntsville, Ala.*

VOTE FOR 314

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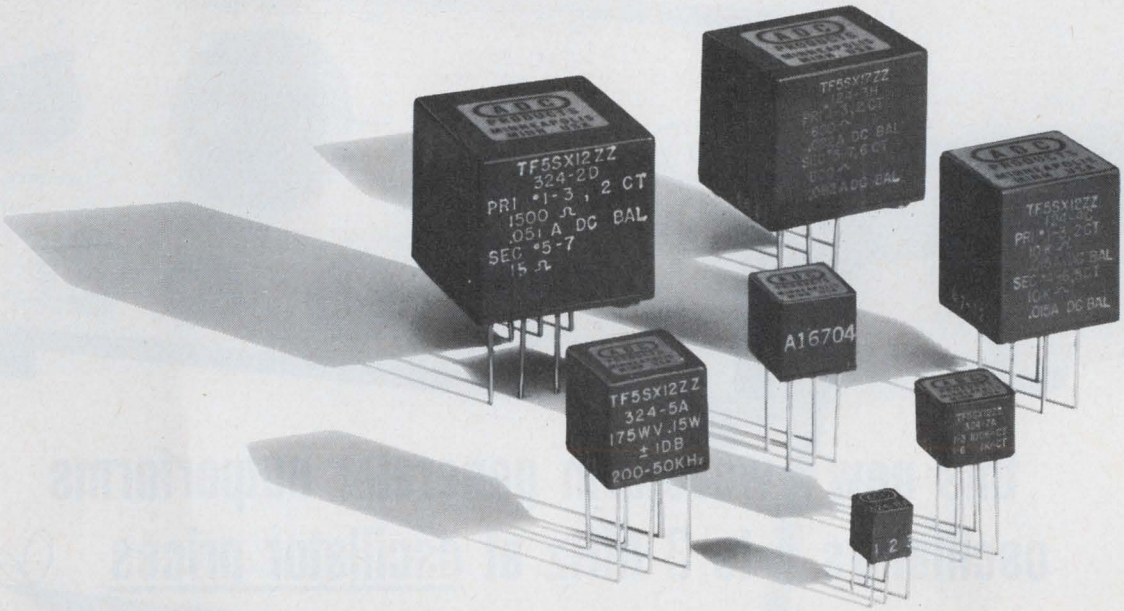
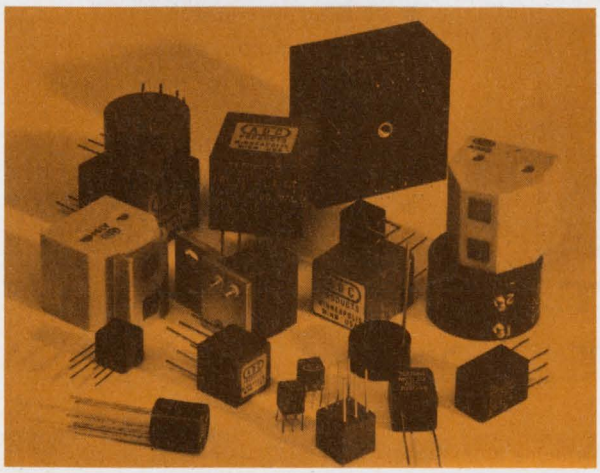



## But do you know... ADC Products makes 19,897 different transformers, 3,512 different filters, 2,863 different jacks, plugs, jack panels and allied components, plus power supplies, solid state relays, pre-wired jack fields and complete communications sub-systems?



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INFORMATION RETRIEVAL NUMBER 74

# Product Source Directory

# Oscillators

This Product Source Directory covers Oscillators. It contains products frequently purchased by design engineers. For each table, the instruments are listed in ascending order of one major parameter. The column containing this parameter is color-coded white.

Unless otherwise noted in the tables, all oscillators have input requirements of 95-135 Vac, single phase. The following abbreviations apply to all instruments listed:

ina—information not available
reg—request
n/a—not applicable

An index of models by manufacturer is included at the end of each table. Manufacturers are identified by abbreviation. The complete name of each manufacturer can be found in the Master Cross Index below.

| Abbrev. | Company | Reader Service No. |
|---|---|---|
| AIL | Airborne Instruments Labs<br>Microwave Inst. Div.<br>Farmingdale, N.Y. 11735<br>(516) 595-3500 | 453 |
| B&K | B&K Instruments<br>5111 W. 164th St.<br>Cleveland, Ohio 44124<br>(216) 267-4800 | 454 |
| B&W | Barker & Williamson<br>Beaver Dam & Canal Rds.<br>Bristol, Pa. 19007<br>(215) 788-5581 | 455 |
| EICO | Electronic Instrument Co., Inc.<br>283 Malta St.<br>Brooklyn, N.Y. 11207<br>(212) 949-1100 | 456 |
| Exact | Exact Electronics<br>P.O. Box 160<br>Hillsboro, Ore. 97123<br>(503) 648-6661 | 457 |
| FEL | Frequency Engineering Lab.<br>P.O. Box 527<br>Farmingdale, N.J. 07727<br>(201) 938-9221 | 458 |
| GR | General Radio Co.<br>22 Baker Ave.<br>W. Concord, Mass. 01781<br>(617) 369-4400 | 459 |
| Heath | Heath Co.<br>Benton Harbor, Mich. 49022<br>(616) 983-3961 | 460 |
| H-P | Hewlett-Packard Co.<br>1501 Page Mill Rd.<br>Palo Alto, Calif. 94302<br>(415) 326-7000 | Contact local slaes office |
| Inst Labs | Instrument Labs. Corp.<br>315 W. Walton Pl.<br>Chicago, Ill. 60610<br>(312) 642-0123 | 461 |
| Krohn-Hite | Krohn-Hite Corp.<br>580 Massachusetts Ave.<br>Cambridge, Mass.<br>(617) 491-3211 | 462 |
| Kruse | Kruse Electronics<br>790 Hemmeter Lane<br>Mountain View, Calif. 94040<br>(415) 967-2299 | 463 |

| Abbrev. | Company | Reader Service No. |
|---|---|---|
| Leader | Leader Instruments Corp.<br>37-27 27 St.<br>Long Island City, N.Y. 11101<br>(212) 729-7410 | 464 |
| Marconi | Marconi Instruments<br>111 Cedar Lane<br>Englewood, N.J. 07631<br>(201) 567-0607 | 465 |
| Microdot | Microdot Inc.<br>220 Pasadena Ave.<br>S. Pasadena, Calif. 91030<br>(213) SY 9-9171 | 466 |
| Optimation | Optimation Inc.<br>9421 Telfair Ave.<br>Sun Valley, Calif. 91352<br>(213) 768-0830 | 467 |
| PRD | PRD Electronics Inc.<br>6801 Jericho Tpke.<br>Syossett, N.Y. 11791<br>(516) 364-0400 | 468 |
| Polarad | Polarad/Nelson Ross<br>5 Delaware Dr.<br>Lake Success, N.Y. 11040<br>(516) 328-1100 | 469 |
| Radiometer | Radiometer<br>The London Co.<br>811 Sharon Dr.<br>Westlake, Ohio 44145<br>(216) 871-8900 | 470 |
| R&S | Rohde & Schwarz<br>111 Lexington Ave.<br>Passaic, N.J. 07055<br>(201) 773-8010 | 471 |
| Sage | Sage Labs.<br>3 Huron Dr.<br>Natick, Mass. 01760<br>(617) 653-0844 | 472 |
| TMC | Technical Material Corp.<br>700 Fenimore Rd.<br>Mamaroneck, N.Y. 10543<br>(914) 698-4800 | 473 |
| Wavetek | Wavetek<br>9045 Balboa Ave.<br>San Diego, Calif. 92123<br>(714) 279-2200 | 474 |

# Oscillators



| | | | FREQUENCY | | | | OUTPUT | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Manufacturer | Model | Min. MHz | Max. MHz | Acc. % | Stability % | Power mW | Power W | Power Acc.% | Conn. or W/G Flange | Misc Features | Price $ |
| OS1 | B & K | 1017A | 2 Hz | 0.002 | 1 | ina | n/a | 2 | ina | conn | | 1460 |
| | Optimation | RCD-11 | 0.1 Hz | 0.01 | 1 | 0.01 | 50 | n/a | ina | GR | 4 phase | 1490 |
| | GR | 1311 | 50 Hz | 0.01 | 1 | 0.02 | n/a | 1 | ina | GR938 | h | 295 |
| | R & S | SRN | 2 Hz | 0.02 | ±2 | 0.01 | n/a | 30V | 5 | BNC | | 775 |
| | B & K | 1024A | 20 Hz | 0.02 | 1 | ina | n/a | 2.5 | ina | conn | | 1795 |
| | B & K | 1022A | 20 Hz | 0.02 | 1 | ina | n/a | 2.5 | ina | conn | | 1195 |
| | Marconi | 2000 | 20 Hz | 0.02 | ±3 | 0.02 | n/a | 10 dBm | 1 dB | bp | | 875 |
| | Marconi | 2005 | 20 Hz | 0.02 | ±3 | 0.02 | n/a | 10 dBm | 1 dB | bp | o | 1295 |
| | H-P | 201C | 20 Hz | 0.02 | ±1 | ±2 | n/a | 3 | ± 1 dB | bp | | 295 |
| | GR | 1308-A | 20 Hz | 0.02 | 3 | 0.03 | n/a | 200VA | ina | GR938 | g | 1575 |
| OS2 | H-P | 200AB | 20 Hz | 0.04 | ±2 | t | n/a | 1 | 12 | bp | t | 235 |
| | GR | 1304-B | 20 Hz | 0.04 | 1 | 7 Hz | ina | 1 | 0.25 dB | GR938 | cef | 1275 |
| | GR | 1313-A | 10 Hz | 0.05 | 4 | ina | 10 mV | n/a | 2 | GR938 | de | 350 |
| | Krohn-Hite | 4024 | 0.001 Hz | 0.1 | 0.5 | ina | 125 | n/a | 1 | BNC | bd | 1200 |
| | Krohn-Hite | 4025 | 0.001 Hz | 0.1 | 0.1 | ina | 125 | n/a | 1 | BNC | bd | 1950 |
| | Optimation | RCD-2 | 0.01 Hz | 0.1 | 0.1 | 0.01 | 50 | 5 | 0.01 | GR | | 835 |
| | Krohn-Hite | 4001 | 0.1 Hz | 0.1 | 0.1 | ina | 125 | n/a | 1 | BNC | b | 1450 |
| | Krohn-Hite | 4000 | 0.1 Hz | 0.1 | 0.5 | ina | 125 | n/a | 1 | BNC | b | 850 |
| | Krohn-Hite | 4031R | 0.1 Hz | 0.1 | 0.1 | ina | 125 | n/a | 1 | BNC | bl | 2145 |
| | Krohn-Hite | 4030R | 0.1 Hz | 0.1 | 0.5 | ina | 125 | n/a | 1 | BNC | bl | 1495 |
| OS3 | Optimation | RCD-10 | 0.1 Hz | 0.1 | 0.1 | 0.01 | n/a | 1 | ina | GR | | 695 |
| | Optimation | RCD-4 | 0.1 Hz | 0.1 | 1 | 0.01 | 50 | 5 | 0.01 | GR | | 795 |
| | Optimation | RCD-1 | 0.1 Hz | 0.1 | 1 | 0.02 | 50 | 5 | 0.01 | GR | | 595 |
| | H-P | 202C | 1 Hz | 0.1 | ±2 | t | 160 | n/a | t | | t | 325 |
| | B & W | 210 | 10 Hz | 0.1 | ±2 | ina | ina | 10V | 0.2 | ina | | reg |
| | H-P | 205AG | 10 Hz | 0.1 | ±2 | y | n/a | 5 | ±1 dB | bp | y | 700 |
| | GR | 1309-A | 10 Hz | 0.1 | 2 | 0.01 | 10 | n/a | 2 | GR938 | de | 375 |
| | EICO | 378 | 1 Hz | 0.11 | ±5 | ina | 0 | 3V | ina | bp | | 90 |
| | Leader | LAG-53 | 20 Hz | 0.2 | 3 | 2 Hz | n/a | 7V | 0.5 dB | | bd | 49 |
| | EICO | 377 | 20 Hz | 0.2 | ±3 | ina | 100 | n/a | ina | bp | d | 60 |
| OS4 | Marconi | 1101 | 20 Hz | 0.2 | 1.5 | 0.15 | n/a | 20V | ±1 dB | BNC | | 600 |
| | Leader | LAG-54 | 20 Hz | 0.2 | 3 | 2 Hz | n/a | 3V | 0.5 dB | ina | bd | 85 |
| | B & K | 1013A | 200 Hz | 0.2 | 1 | ina | n/a | 2 | ina | conn | | 1460 |
| | R & S | SRM | 30 Hz | 0.3 | ±2 | 0.01 | 500 | n/a | ina | BNC | | 560 |
| | GR | 1210-C | 20 Hz | 0.5 | 3 | ina | 0 | 45V | ina | GR938 | cd | 255 |
| | H-P | 208A | 5 Hz | 0.56 | ±3 | ina | 10 | n/a | ±3/skp | bp | n | 565 |
| | H-P | 236A | 50 Hz | 0.56 | ±3 | ina | 10 | n/a | r | bp | r | 600 |
| | H-P | 200CD | 5 Hz | 0.6 | ±2 | t | 160 | n/a | t | bp | t | 275 |
| | Inst Labs | TR | 6 Hz | 0.6 | 2 | 1 | 40 | n/a | ina | bp | | 255 |
| | Krohn-Hite | 4100 | 0.01 Hz | 1 | 0.5 | ina | 500 | n/a | 1 | BNC | b | 550 |
| OS5 | Optimation | RCD-3 | 0.1 Hz | 1 | 1 | 0.01 | 50 | 5 | 0.01 | GR | | 795 |
| | Marconi | 2103 | 10 Hz | 1 | 3 | ina | n/a | 2.5V | ±1 dB | bp | dn | 135 |
| | Optimation | RCD-9 | 10 Hz | 1 | 0.1 | 0.01 | n/a | 1W | ina | GR | | 895 |
| | GR | 1312 | 10 Hz | 1 | 1 | 0.005 | 160 | n/a | 2 | BNC | di | 495 |
| | H-P | 4204A | 10 Hz | 1 | ±0.2 | ±0.01 | 160 | n/a | ±2 | bp | z | 695 |
| | H-P | 241A | 10 Hz | 1 | ±1 | ±0.04 | 10 | n/a | ±2 | bp | s | 490 |
| | R & S | SRB | 10 Hz | 1 | ±1 | 0.03 | n/a | 1.5 | ina | BNC | | 880 |
| | Radiometer | RCO11 | 10 Hz | 1 | 1 | 0.1 | ina | ina | ina | UHF | b | 633 |
| | H-P | 204D | 5 Hz | 1.2 | ±3 | ina | 10 | n/a | p | bp | p | 325 |
| | H-P | 204-C | 5 Hz | 1.2 | ±3 | ina | 10 | n/a | 0.5-1 | bp | q | 250 |
| OS6 | Wavetek | 130 | 0.2 Hz | 2 | 2 | 0.05 | 0.025 | 0.25 | n/a | BNC | | 295 |
| | GR | 1310-B | 2 Hz | 2 | 3 | 0.03 | 160 | n/a | 2 | GR938 | d | 295 |
| | H-P | 209A | 4 Hz | 2 | ±3 | ina | 40 | n/a | ina | ina | dm | 345 |
| | EICO | 379 | 20 Hz | 2 | 3 | ina | 0 | 7.5V | ina | bp | d | 95 |
| | Exact | 123 | 0.1 Hz | 3 | 2 | 0.05 | ina | ina | ina | ina | a | 345 |
| | Exact | 120 | 0.1 Hz | 3 | 2 | 0.05 | ina | ina | ina | ina | | 295 |
| | Wavetek | 142 | 0.0001 Hz | 10 | 1 | 0.05 | $.562X10^{-3}$ | 0.562 | 1 | BNC | | 595 |
| | Marconi | 1370A | 10 Hz | 10 | 2 | $1/10^{-3}$ | n/a | 30V | ±1 dB | BNC | d | 935 |
| | H-P | 652A | 10 Hz | 10 | 2-3 | ina | 200 | n/a | w | BNC | w | 725 |
| | H-P | 654A | 10 Hz | 10 | 2-4 | ina | 12.6 | n/a | u | BNC | u | 875 |
| OS7 | H-P | 651B | 10 Hz | 10 | 2-3 | ina | 200 | n/a | x | BNC | x | 590 |
| | H-P | 653A | 10 Hz | 10 | 2-4 | ina | 21 | n/a | v | v | v | 990 |
| | Krohn-Hite | 4200 | 10 Hz | 10 | 2 | ina | 500 | n/a | 1 | BNC | b | 350 |
| | Microdot | 445/M183 | 2 | 10 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | TMC | VOX-7 | 1 | 30 | 100 | 0.0001 | ina | 1 | ina | conn | | 6900 |
| | GR | 1211-C | 0.5 Hz | 50 | 2 | 0.4 | n/a | 1 | ina | GR874 | c | 495 |
| | Microdot | 445/M184 | 10 | 50 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | Microdot | 404A | 10 | 50 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | Heath | IG-102 | 0.1 Hz | 110 | 2 | ina | 100 mV | n/a | ina | ina | | 32 |
| | Heath | IGW-19 | 0.1 Hz | 110 | 2 | ina | 100 mV | n/a | ina | ina | | 30 |
| OS8 | Kruse | 2038A | 8 | 112 | ±0.5 MHz | ±0.025/°C | 20 | n/a | ina | OSM | | 1990 |
| | Microdot | 445/M185 | 50 | 200 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | Microdot | 406A | 50 | 200 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | GR | 1215-C | 50 | 250 | 1 | 0.2 | ina | 0.3 | ina | GR874 | c | 325 |
| | Kruse | 2039A | 45 | 255 | ±1 MHz | 0.025/°C | 20 | n/a | n/a | OSM | | 1990 |

# FROM THE WAVE MAKERS: A NEW SERIES OF SOLID STATE PROGRAMMABLE OSCILLATORS


Krohn-Hite's Series 4100 Rack-Mounted Solid State Programmable Oscillators are *the* new generation of medium-priced, precision general purpose oscillators. They combine the convenience of automatic programmed frequency and amplitude selection with the outstanding performance characteristics of the popular Model 4100 Push-Button Oscillator. Covering the frequency range of 0.1 Hz to 1 MHz, Series 4100 Programmable Oscillators boast a frequency calibration accuracy as low as 0.1%.

Available in four models, Series 4100 Oscillators are designed for either standard manual operation or automatic programmed frequency or amplitude selection by any one of several commonly available means, such as computer output, punched cards, punched tape or computer mag tape. Programming format is the standard 1-2-4-8 binary coded decimal system. A unique feature of the Series 4100 Programmable Oscillators is the capability to produce both sine and square wave outputs with ½ watt of power into 50 ohms with remote or local frequency control. Best of all, Series 4100 provides a degree of frequency stability, low distortion, and amplitude stability that can't be matched by competitive units.

The following chart provides a brief rundown of the important operating parameters of the new generation Series 4100 Solid State Programmable Oscillators. And don't forget the model 4100A non-programmable oscillator is still available at $550. They're all products of the recognized leader in variable filters who's out to make waves in oscillators, too. For complete technical information on any of these new Krohn-Hite Oscillators, write THE WAVEMAKERS: Krohn-Hite Corporation, 580 Massachusetts Avenue, Cambridge, Massachusetts 02139 U.S.A.

Tel: (617) 491-3211 TWX: 710-320-6583

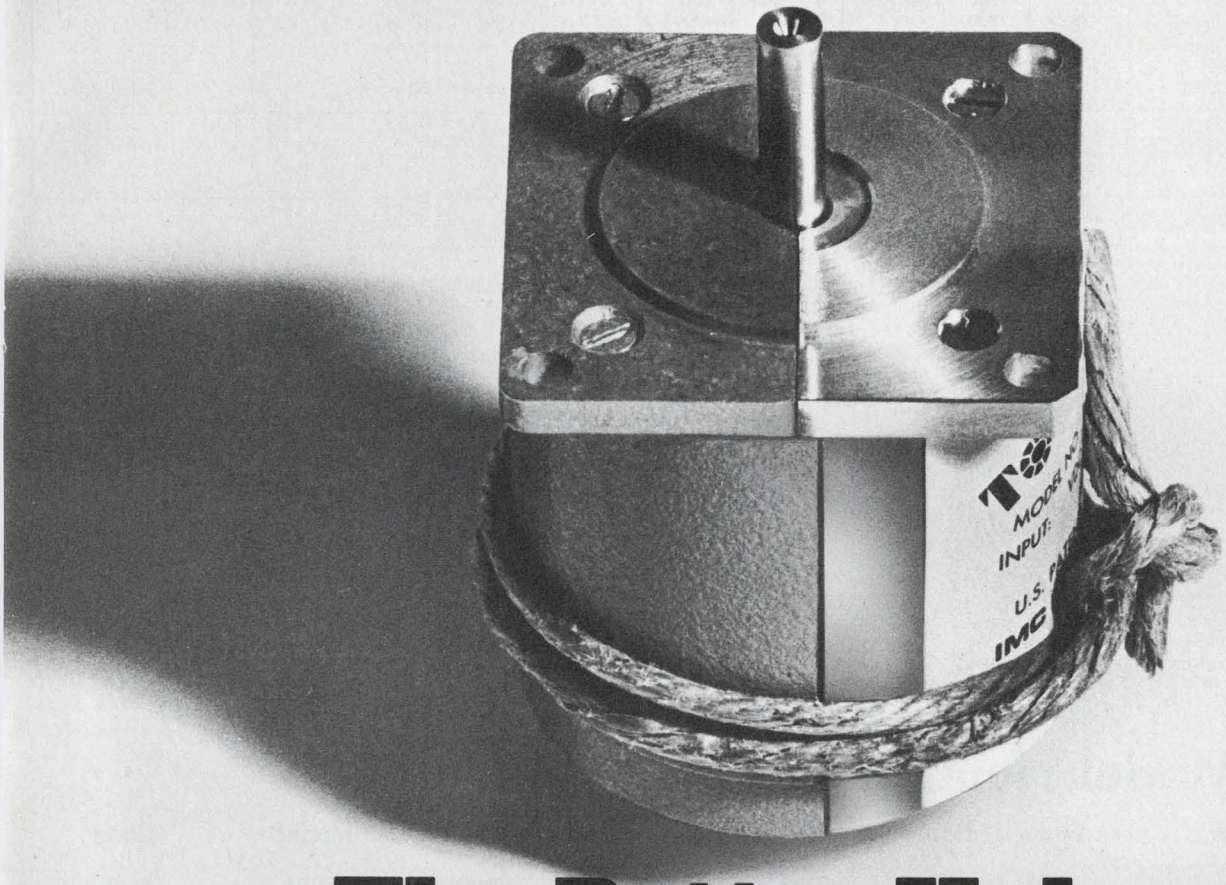
SERIES 4100 SOLID STATE PROGRAMMABLE OSCILLATORS

| Frequency Range | Osc. Model | Freq. Acc. % | Max. Volts | Output Impedance | Dist. | Square Wave | Prog. Amplitude | Approx. Ship. Wt. lbs/kgs | Price |
|---|---|---|---|---|---|---|---|---|---|
| 0.1 Hz to 1 MHz | 4131R | 0.1 | 10 RMS | 50 | 0.02% | yes | no | 30/15 | $1375 |
| 0.1 Hz to 1 MHz | 4141R | 0.1 | 10 RMS | 50 | 0.02% | yes | yes | 30/15 | $1585 |
| 1 Hz to 1 MHz | 4130R | 0.5 | 10 RMS | 50 | 0.02% | yes | no | 27/13 | $1075 |
| 1 Hz to 1 MHz | 4140R | 0.5 | 10 RMS | 50 | 0.02% | yes | yes | 27/13 | $1285 |

KROHN-HITE CORPORATION

OSCILLATORS / FILTERS / AC POWER SUPPLIES / AMPLIFIERS

| | | | FREQUENCY | | | | OUTPUT | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Manufacturer | Model | Min. MHz | Max. MHz | Acc. % | Stability % | Power mW | Power W | Power Acc.% | Conn. or W/G Flange | Misc Features | Price $ |
| OS 9 | GR | 1330-A | 40 Hz | 500 | 5 | ina | 500 | n/a | ina | GR874 | j | 1150 |
| | H-P | 3200B | 10 | 500 | ±2 | ±0.002 | 200 | n/a | ina | BNC | | 525 |
| | GR | 1363 | 56 | 500 | 2 | 0.8 | 500 | n/a | ina | GR874 | c | 495 |
| | Microdot | 445/M186 | 200 | 500 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | Microdot | 408B | 200 | 500 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | Kruse | 2039A-1 | 90 | 510 | ±2 MHz | ±0.03/°C | 20 | n/a | ina | OSM | | 2190 |
| | GR | 1362 | 220 | 920 | 1 | 0.2 | 400 | n/a | ina | GR874 | c | 495 |
| | Microdot | 410B | 500 | 1000 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | Microdot | 445/M187 | 500 | 1000 | 1 | ±0.002 | 50 | 50 | ±0.2 dB | ina | | reg |
| | Fel | SSH24VO | 500 | 1000 | ina | ina | 200 | 0.35 | ina | OSM | | 325 |
| OS 10 | Kruse | 2041A | 470 | 1030 | ±2.5 MHz | ±0.05/°C | 20 | n/a | ina | OSM | | 1990 |
| | GR | 1361-A | 450 | 1050 | 1 | 0.2 | 400 | n/a | ina | GR874 | c | 445 |
| | Microdot | 445/M188 | 1000 | 1800 | 1 | ±0.002 | 50 | 25 | ±0.2 dB | ina | | reg |
| | Microdot | 411A | 900 | 1800 | 1 | ±0.002 | 50 | 25 | ±0.2 dB | ina | | reg |
| | GR | 1218-BV | 900 | 2000 | 1 | 0.1 | ina | 0.3 | ina | GR874 | c | 995 |
| | PRD | L712-B | 950 | 2000 | 1 | ina | 10 | n/a | ina | N | | 1440 |
| | Sage | 831-L-1 | 1000 | 2000 | ±0.1 | 1 ppm | 80 | 0.15 | ina | ina | | 6400 |
| | Sage | 851-L-1 | 1000 | 2000 | ±1 | ina | n/a | 0.1 | ina | ina | | 2995 |
| | Sage | 841C-L-1 | 1000 | 2000 | ±0.1 | 1 ppm | 80 | 0.15 | ina | ina | | 9195 |
| | Kruse | 2042A | 940 | 2060 | ±5 MHz | ±0.05/°C | 20 | n/a | ina | OSM | | 1990 |
| OS 11 | Marconi | 6055 | 850 | 2150 | 1 | ina | 60 | n/a | ina | N | | 945 |
| | Polarad | 1205 | 950 | 2400 | ±0.5 | 0.0008 | 50 | n/a | ±2 dB | N | | 1590 |
| | Polarad | 1605 | 950 | 2400 | ±0.5 | 0.0008 | 1 | n/a | ±2 dB | N | | 2330 |
| | Polarad | 1105 | 950 | 2400 | ±0.5 | 0.0008 | 1 | n/a | ±2 dB | N | | 2090 |
| | Kruse | 2043A | 1340 | 2460 | ±5 MHz | ±0.05/°C | 20 | n/a | ina | OSM | | 2190 |
| | Sage | 851-S-51 | 2000 | 2500 | ±1 | ina | n/a | 0.1 | ina | ina | | 2995 |
| | Sage | 814A-L-9 | 2000 | 2500 | ±0.1 | 0.05 ppm | n/a | 0.1 | ina | ina | | 5950 |
| | Microdot | 445/M189 | 2000 | 2500 | 1 | ±0.002 | 50 | 15 | ±0.2 dB | ina | | reg |
| | Microdot | 413 | 1800 | 2600 | 1 | ±0.002 | 50 | 10 | ±0.2 dB | ina | | reg |
| | AIL | 125 | 200 | 3000 | 1 | 0.05 | n/a | 50 | n/a | N | | 4250 |
| OS 12 | Sage | 814A-S-1 | 2500 | 3050 | ±0.1 | 0.05 ppm | n/a | 0.075 | ina | ina | | 4250 |
| | Sage | 851-S-52 | 2500 | 3600 | ±1 | ina | n/a | 0.1 | ina | ina | | 2995 |
| | Sage | 814A-S-2 | 2950 | 3600 | ±0.01 | 0.05 ppm | n/a | 0.08 | ina | ina | | 4250 |
| | PRD | S112-B | 1900 | 4000 | 1 | ina | 10 | n/a | ina | N | | 1440 |
| | Sage | 831-S-1 | 2000 | 4000 | ±0.1 | 1 ppm | 40 | 0.2 | ina | ina | | 6400 |
| | Sage | 841C-S-1 | 2000 | 4000 | ±0.1 | 1 ppm | 40 | 0.2 | ina | ina | | 9195 |
| | Sage | 841B-S-1 | 2000 | 4000 | ±0.1 | 0.2 ppm | 40 | 0.2 | ina | ina | | 7950 |
| | GR | 1360-B | 1700 | 4100 | 1 | 0.15 | 200 | n/a | ina | GR874 | | 1750 |
| | Kruse | 2044A | 1900 | 4100 | ±10 MHz | ±0.05/°C | 10 | n/a | ina | OSM | | 2290 |
| | Polarad | 1206 | 1950 | 4200 | ±0.5 | 0.0008 | 50 | n/a | ±2 dB | N | | 1590 |
| OS 13 | Sage | 814A-S-31 | 3700 | 4300 | ±0.01 | 0.05 ppm | n/a | 1 | ina | ina | | 8350 |
| | Polarad | 1606 | 1950 | 4600 | ±0.5 | 0.0008 | 5 | n/a | ±2 dB | N | | 2330 |
| | Polarad | 1106 | 1950 | 4600 | ±0.5 | 0.0008 | 15 | n/a | ±2 dB | N | | 2090 |
| | Sage | 851-C-51 | 5100 | 5900 | ±1 | ina | n/a | 0.1 | ina | ina | | 2995 |
| | Sage | 814A-C-1A | 5100 | 5900 | ±0.1 | 0.05 ppm | n/a | 0.06 | ina | ina | | 4250 |
| | Sage | 814A-C-10 | 5400 | 5900 | ±0.1 | 0.05 ppm | n/a | 0.2 | ina | ina | | 4500 |
| | Sage | 851-C-52 | 5925 | 6525 | ±1 | ina | n/a | 0.2 | ina | ina | | 2995 |
| | Sage | 814A-C-31 | 5925 | 6525 | ±0.1 | 0.05 ppm | n/a | 1 | ina | ina | | reg |
| | Sage | 851-C-53 | 6575 | 7125 | ±1 | ina | n/a | 0.2 | ina | ina | | 2995 |
| | AIL | 126 | 2000 | 8000 | 2 | 0.05 | n/a | 6 | 2 | N | | 4950 |
| OS 14 | Sage | 841B-C-1 | 4000 | 8000 | ±0.1 | 0.2 ppm | 20 | 0.1 | ina | ina | | 7950 |
| | Sage | 831-C-1 | 4000 | 8000 | ±0.1 | 1 ppm | 20 | 0.1 | ina | ina | | 6400 |
| | Sage | 841C-C-1 | 4000 | 8000 | ±0.1 | 1 ppm | 20 | 0.1 | ina | ina | | 9195 |
| | Polarad | 1607 | 3800 | 8200 | ±0.5 | 0.0008 | 5 | n/a | ±2 dB | N | | 2330 |
| | Polarad | 1107 | 3800 | 8200 | ±0.5 | 0.0008 | 5 | n/a | ±2 dB | N | | 2090 |
| | Polarad | 1207 | 3800 | 8200 | ±0.5 | 0.0008 | 25 | n/a | ±2 dB | N | | 1840 |
| | Sage | 854-X-55 | 7500 | 8500 | ±1 | 0.2 ppm | n/a | 0.2 | ina | ina | | 5995 |
| | Sage | 851-X-55 | 7500 | 8500 | ±1 | ina | n/a | 0.2 | ina | ina | | 2995 |
| | Sage | 814A-X-5 | 7500 | 8500 | ±0.1 | 0.05 ppm | n/a | 0.2 | ina | ina | | 4700 |
| | Sage | 851-X-53 | 8500 | 10000 | ±1 | ina | n/a | 0.1 | ina | ina | | 2995 |
| OS 15 | Sage | 851-X-51 | 8500 | 10000 | ±1 | ina | n/a | 0.5 | ina | ina | | 2995 |
| | Sage | 814A-X-21 | 8500 | 10000 | ±0.1 | 0.05 ppm | ina | 0.5 | ina | ina | | 4150 |
| | Sage | 814A-X-2 | 9000 | 10000 | ±0.1 | 0.05 ppm | n/a | 0.08 | ina | ina | | 4250 |
| | Sage | 814A-X-21S | 9600 | 10200 | ±0.1 | 0.05 ppm | n/a | 0.5 | ina | ina | | 4300 |
| | Sage | 814A-X-12 | 9800 | 10300 | ±0.1 | 0.05 ppm | n/a | 0.2 | ina | ina | | 4450 |
| | Polarad | 1108 | 6950 | 11000 | ±0.5 | 0.0008 | 5 | n/a | ±2 dB | N | | 2090 |
| | Polarad | 1608 | 6950 | 11000 | ±0.5 | 0.0008 | 5 | n/a | ±2 dB | N | | 2330 |
| | Polarad | 1208 | 6950 | 11000 | ±0.5 | 0.0008 | 25 | n/a | ±2 dB | N | | 1840 |
| | Sage | 851-X-52 | 9800 | 11200 | ±1 | ina | n/a | 0.2 | ina | ina | | 2995 |
| | Sage | 814A-X-3 | 9800 | 11200 | ±0.1 | 0.05 ppm | n/a | 0.5 | ina | ina | | 4750 |
| OS 16 | Sage | 814A-X-3M | 10600 | 11800 | ±0.1 | 0.05 ppm | n/a | 0.1 | ina | ina | | 4750 |
| | Sage | 841B-X-1 | 8000 | 12400 | ±0.1 | 0.2 ppm | 50 | 0.35 | ina | ina | | 7950 |
| | Sage | 831-X-1 | 8000 | 12400 | ±0.1 | 1 ppm | 50 | 0.35 | ina | ina | | 6400 |
| | Sage | 841C-X-1 | 8000 | 12400 | ±0.1 | 1 ppm | 50 | 0.35 | ina | ina | | 9195 |
| | PRD | X712-A | 8200 | 12400 | 1 | ina | 10 | n/a | ina | UG-39/U | | 1475 |

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INFORMATION RETRIEVAL NUMBER 76

| | Manufacturer | Model | FREQUENCY Min. MHz | Max. MHz | Acc. % | Stability % | Power mW | OUTPUT Power W | Power Acc.% | Conn. or W/G Flange | Misc Features | Price $ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OS17 | Marconi | 6058 | 7000 | 12500 | 1 | ina | 10 | n/a | ina | N | | 1395 |
| | Sage | 851-K-51 | 12400 | 14500 | ±1 | ina | n/a | 0.1 | ina | ina | | 2995 |
| | Sage | 814A-K-21 | 12800 | 14500 | ±0.1 | 0.5 | n/a | 0.1 | ina | ina | | 4150 |
| | Polarad | 1809 | 10000 | 15500 | ±1 | 0.0008 | 1 | n/a | ±2 dB | WR75 | | 3765 |
| | Polarad | 1709 | 10000 | 15500 | ±1 | 0.0008 | 1 | n/a | ±2 dB | WR75 | | 3525 |
| | Sage | 814A-K-22 | 15000 | 17300 | ±0.1 | 0.05 ppm | n/a | 0.2 | ina | ina | | 5150 |
| | Sage | 831-K-1 | 12400 | 18000 | ±0.1 | 1 ppm | 40 | 0.2 | ina | ina | | 6400 |
| | Sage | 841B-K-1 | 12400 | 18000 | ±0.1 | 0.2 ppm | 40 | 0.2 | ina | ina | | 7950 |
| | Polarad | 1810 | 15000 | 21000 | ±1 | 0.0008 | 1 | n/a | ±2 dB | WR51 | | 3765 |
| | Polarad | 1710 | 15000 | 21000 | ±1 | 0.0008 | 1 | n/a | ±2 dB | WR51 | | 3525 |
| OS18 | Sage | 814A-K-24 | 23000 | 25000 | ±0.1 | 0.05 ppm | n/a | 0.1 | ina | ina | | 6950 |
| | Sage | 817A-K-35 | 34000 | 36000 | ±0.1 | 0.5 ppm | n/a | 0.05 | ina | ina | | 8200 |

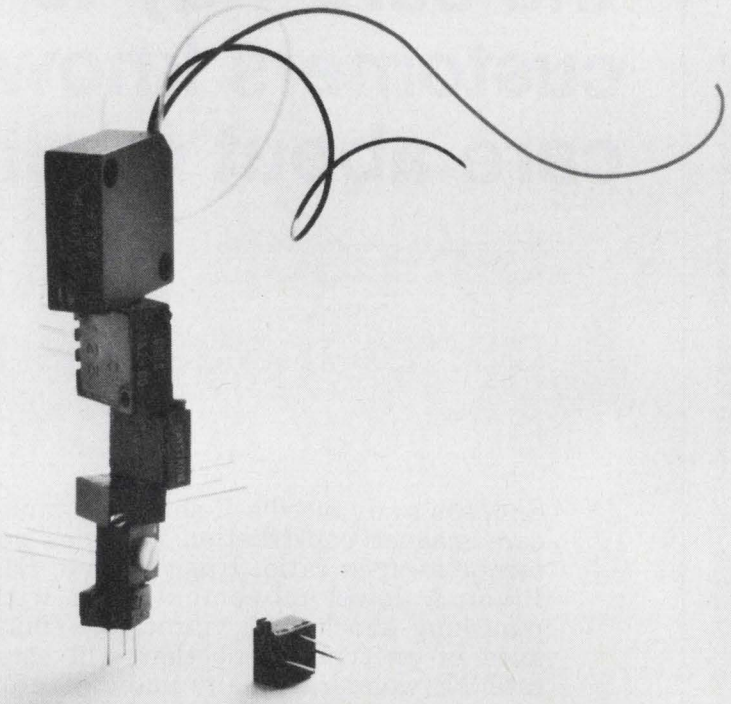
a. Dc offset, dB step attenuator included.
b. Solid state.
c. Unit power supply required, check with factory.
d. Also squarewave generator.
e. Power output into 600Ω.
f. Power accuracy to 20 kHz, 0.5 dB, 20-30 kHz, 1 dB, 30-40 kHz.
g. Includes power amplifier.
h. Transformer output.
i. Decade oscillator.
j. Accuracy, 400-1000 Hz, 3% to 150 kHz, 2% above 150 kHz.
l. Programmable.
m. Balanced output, 40 dB. Programmable sync. Distortion 0.1%, 200 Hz-200 kHz.
n. Battery operated.
o. Two tone test oscillator.
p. Flatness 0.3-0.5 dB. Programmable sync. Distortion 0.1%, 30 Hz-100 kHz. Output attenuator 80 dB, accuracy ±0.3-0.5 dB, balanced output 40 dB.
q. Programmable sync. Distortion 0.1%, 30 Hz-100 kHz. Output attenuator 40 dB. Balanced output 40 dB.
r. Level accuracy, -31 to +10 dBm, ±0.2 dBm. Connector type WE241, 309, 310.
s. Frequency selected by pushbutton, 4500 increments. Output -30 to +10 dBm.
t. Stability included in accuracy spec at normal temperature. Voltage accuracy ±1 dB. Balanced output, 600Ω.
u. Voltage accuracy, 0.15 dB or 1%/90 days. Output Z, 50, 75Ω unbalanced; 135, 150, 600Ω balanced.
v. Voltage accuracy, reference ±2%, level ±0.1 dB/90 days. Output Z 75Ω unbalanced, 124Ω balanced. Connector type WE358A, WE408.
w. Voltage accuracy, expanded scale adjustable to set-level 0.25-1.75%. Attenuation 90 dB, output Z 50Ω and 600Ω.
x. Voltage accuracy 2-4%, no adjustment. Attenuation 90 dB, output Z 50 and 600Ω.
y. Stability included in accuracy spec at normal temperature. Four output impedances floating and balanced.
z. Digital frequency selection by rotary switch.

# Index by Model Number


| Name | Model | Code |
|---|---|---|
| **AIL** | 125 | OS11 |
| Airborne Inst. | 126 | OS13 |
| **B&K** | 1013A | OS4 |
| B&K | 1017A | OS1 |
| Instruments | 1022A | OS1 |
| | 1024A | OS1 |
| **B&W** | 210 | OS3 |
| Barker & Williamson | | |
| **EICO** | 377 | OS3 |
| Electronic | 378 | OS3 |
| Instrument | 379 | OS6 |
| **Exact** | 120 | OS6 |
| Exact | 123 | OS6 |
| Electronics | | |
| **FEL** | SSH24VO | OS9 |
| Freq. Eng. | | |
| **GR** | 1210-C | OS4 |
| General | 1211-C | OS7 |
| Radio | 1215-C | OS8 |
| Co. | 1218-BV | OS10 |
| | 1304-B | OS2 |
| | 1308-A | OS1 |
| | 1309-A | OS3 |
| | 1310-B | OS6 |
| | 1311 | OS1 |
| | 1312 | OS5 |
| | 1313-A | OS2 |
| | 1330-A | OS9 |
| | 1360-B | OS12 |
| | 1361-A | OS10 |
| | 1362 | OS9 |
| | 1363 | OS9 |
| **Heath** | IG-102 | OS8 |
| Heath Co. | IGW-19 | OS8 |
| **H-P** | 200AB | OS2 |
| Hewlett- | 200CD | OS4 |
| Packard Co. | 201C | OS1 |
| | 202C | OS3 |
| | 204C | OS5 |
| | 204D | OS5 |
| | 205AG | OS3 |
| | 208A | OS4 |
| | 209A | OS6 |
| | 236A | OS4 |
| | 241A | OS5 |
| | 651B | OS7 |
| | 652A | OS6 |
| | 653A | OS7 |
| | 654A | OS6 |
| | 3200B | OS9 |
| | 4204A | OS5 |
| **Inst Labs** | TR | OS4 |
| Instrument | | |
| Labs. Corp. | | |
| **Krohn-Hite** | 4000 | OS2 |
| Krohn-Hite | 4001 | OS2 |
| Corp. | 4024 | OS2 |
| | 4025 | OS2 |
| | 4030R | OS2 |
| | 4031R | OS2 |
| | 4100 | OS4 |
| | 4200 | OS7 |
| **Kruse** | 2038A | OS8 |
| Kruse | 2039A | OS8 |
| Electronics | 2039A-1 | OS9 |
| | 2041A | OS10 |
| | 2042A | OS10 |
| | 2043A | OS11 |
| | 2044A | OS12 |
| **Leader** | LAG-53 | OS3 |
| Leader | LAG-54 | OS4 |
| Instruments | | |
| **Marconi** | 1101 | OS4 |
| Marconi | 1370A | OS6 |
| Instruments | 2000 | OS1 |
| | 2005 | OS1 |
| | 2103 | OS5 |
| | 6055 | OS11 |
| | 6058 | OS17 |
| **Microdot** | 404A | OS7 |
| Microdot | 406A | OS8 |
| Inc. | 408B | OS9 |
| | 410B | OS9 |
| | 411A | OS10 |
| | 413 | OS11 |
| | 445/M183 | OS7 |
| | 445/M184 | OS7 |
| | 445/M185 | OS8 |
| | 445/M186 | OS9 |
| | 445/M187 | OS9 |
| | 445/M188 | OS10 |
| | 445/M189 | OS11 |
| **Optimation** | RCD-1 | OS3 |

| Name | Model | Code |
|---|---|---|
| Optimation | RCD-2 | OS2 |
| | RCD-3 | OS5 |
| | RCD-4 | OS3 |
| | RCD-9 | OS5 |
| | RCD-10 | OS3 |
| | RCD-11 | OS1 |
| **PRD** | S112-B | OS12 |
| PRD | L712-B | OS10 |
| Electronics | X712-A | OS16 |
| **Polarad** | 1105 | OS11 |
| Polarad/ | 1106 | OS13 |
| Nelson | 1107 | OS14 |
| Ross | 1108 | OS15 |
| | 1205 | OS11 |
| | 1206 | OS12 |
| | 1207 | OS14 |
| | 1208 | OS15 |
| | 1605 | OS11 |
| | 1606 | OS13 |
| | 1607 | OS14 |
| | 1608 | OS15 |
| | 1709 | OS17 |
| | 1710 | OS17 |
| | 1809 | OS17 |
| | 1810 | OS17 |
| **R&S** | SRB | OS5 |
| Rohde & | SRM | OS4 |
| Schwarz | SRN | OS1 |
| **Radiometer** | RC011 | OS5 |
| Radiometer, London Co. | | |
| **Sage** | 814A-C-1A | OS13 |
| Sage Labs | 814A-C-10 | OS13 |
| | 814A-C-31 | OS13 |
| | 814A-K-21 | OS17 |
| | 814A-K-22 | OS17 |
| | 814A-K-24 | OS18 |
| | 814A-L-9 | OS11 |
| | 814A-S-1 | OS12 |
| | 814A-S-2 | OS12 |
| | 814A-S-31 | OS13 |
| | 814A-X-2 | OS15 |
| | 814A-X-3 | OS15 |
| | 814A-X-3M | OS16 |
| | 814A-X-5 | OS14 |
| | 814A-X-12 | OS15 |
| | 814A-X-21 | OS15 |
| | 814A-X-21S | OS15 |
| | 817A-K-35 | OS18 |
| | 831-C-1 | OS14 |
| | 831-K-1 | OS17 |
| | 831-L-1 | OS10 |
| | 831-S-1 | OS12 |
| | 831-X-1 | OS16 |
| | 841B-C-1 | OS14 |
| | 841B-K-1 | OS17 |
| | 841B-S-1 | OS12 |
| | 841B-X-1 | OS16 |
| | 841-C-1 | OS14 |
| | 841C-L-1 | OS10 |
| | 841C-S-1 | OS12 |
| | 841C-X-1 | OS16 |
| | 851-C-51 | OS13 |
| | 851-C-52 | OS13 |
| | 851-C-53 | OS13 |
| | 851-K-51 | OC17 |
| | 851-L-1 | OS10 |
| | 851-S-51 | OS11 |
| | 851-S-52 | OS12 |
| | 851-X-51 | OS15 |
| | 851-X-52 | OS15 |
| | 851-X-53 | OS14 |
| | 851-X-55 | OS14 |
| | 854-X-55 | OS14 |
| **TMC** | VOX-7 | OS7 |
| Tech. Material | | |
| **Wavetek** | 130 | OS6 |
| | 142 | OS6 |

# How can such a little guy uphold the family reputation?



Our new 561/562 series are true Squaretrim® potentiometers down to the last quarter inch. As the smallest members of this distinguished family, they have to live up to a bigger reputation than other pots their size.

They do. We made sure.

We gave them the same high quality element that makes our military pots so reliable . . . the same tight ±5% tolerance . . . the same wide 10 ohms to 20K standard resistance range and −55°C to +150°C temperature range. We even designed them to meet all environmental requirements of MIL-R-27208, like their larger military brothers.

Models 561 and 562 ¼" Squaretrims are available in three configurations, top or side adjustable, and they give you a generous 13:1 adjustment ratio. You wouldn't expect a general-purpose pot to have all these features and still be reasonably priced. But it's just another example of how our Squaretrim family supports its reputation as the biggest name in value for the smallest thing in pots.

They're in stock now at Weston Potentiometer distributors. Or ask us about special resistance values, data sheets, evaluation samples.

The little guys.

WESTON COMPONENTS DIVISION, Archbald, Pennsylvania 18403, Weston Instruments, Inc. a Schlumberger company

**WESTON®**

# New Products

## Low-power Schottky-clamped TTL circuits boast propagation delays of just 3 ns

*Texas Instruments Inc., Components Group, P.O. Box 5012, Dallas, Tex. Phone: (214) 238-2011. P&A: $3.90 or $10.51 for 1 to 24, $2.65 or $7.15 for 100 to 999; stock to 3 wks.*

Providing extremely fast switching speeds at low power levels, a new family of Schottky-clamped TTL integrated circuits features typical propagation delays of 3 ns while holding power dissipation to only 20 mW per gate. Designated as series 54S/74S, the new logic circuits use Schottky diodes to clamp active transistors, thus preventing conventional saturation.

Initiating this high-speed TTL line are: the SN74S00 quadruple two-input positive NAND gate; the SN74S20 dual four-input positive NAND gate; and the SN74S-112, a 100-MHz dual negative edge-triggered J-K flip-flop with preset and clear.

Additional circuits will be added to the family at the rate of about one per month for the balance of this year. These will include MSI functions, other NAND and AND gates, hex inverters, AND-OR inverters, and dual J-K and D flip-flops.

Because the effective storage time of individual circuit transistors is zero, the 54S/74S Schottky-clamped devices can operate at high speeds and yet retain the low power consumption of saturated-logic lines. The clamped npn transistor is formed by placing an integrated Schottky-barrier diode in parallel with the base-collector junction. A metal electrode is then connected to the base and to the n region of the collector, where it forms a rectifying contact.

Since the Schottky diode has a lower forward voltage than the collector-base junction, it clamps the transistor by diverting excess base current and stops the transistor from saturating. This means there is practically no stored charge in either the diode or the transistor.

The result is a large reduction in storage time and an improvement in switching time. As a matter of fact, the performance of the new Schottky-clamped TTL IC family is comparable to that of unsaturated-logic families, but with the added advantage of low power dissipation, which is typical of popular saturated-logic families.

Able to interface directly with all standard TTL and DTL circuits, the new ICs can also use the same single 5-V power supply. In addition, their packaging and pin configurations are identical to those for conventional 54/74 TTL devices.

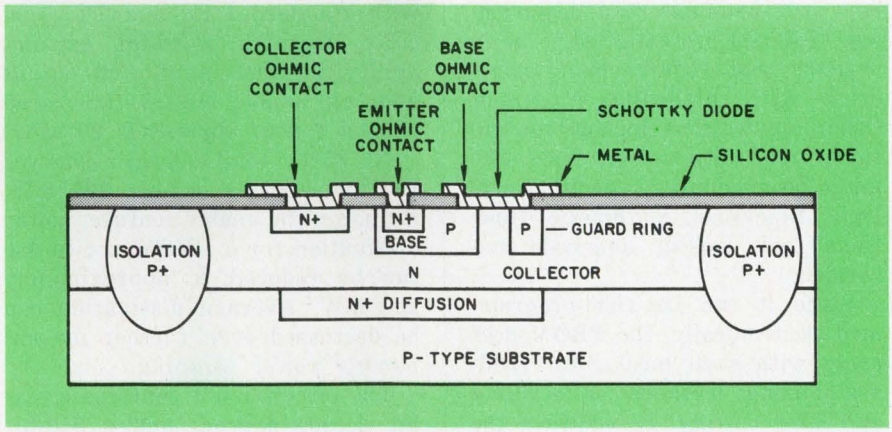
Series 54S/74S units have a low output impedance for high ac noise immunity. This also permits the circuits to drive highly capacitive loads with only small line reflections. Tight chip geometry and shallow diffusions also reduce capacitance to further enhance circuit performance and costs.

For many applications, series 54S/74S systems can be designed on conventional printed circuit boards with unterminated lines. This reduces a number of the costs normally associated with very high-speed digital systems.

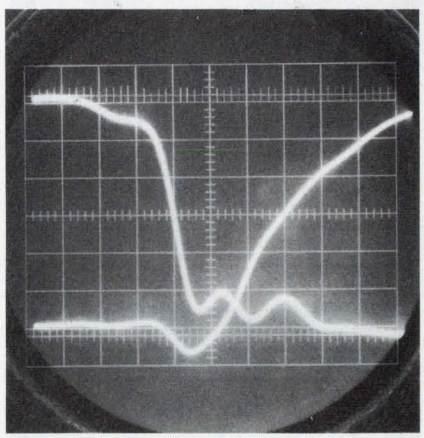
Immediate applications include: computer central processor units and peripheral equipment, digital test and measuring equipment, and digital communication systems.

The three current 54S/74S devices are supplied in plastic dual-in-line packages. Future units will be available in ceramic dual-in-line packages and flatpacks, in both military and commercial versions.

CIRCLE NO. 250

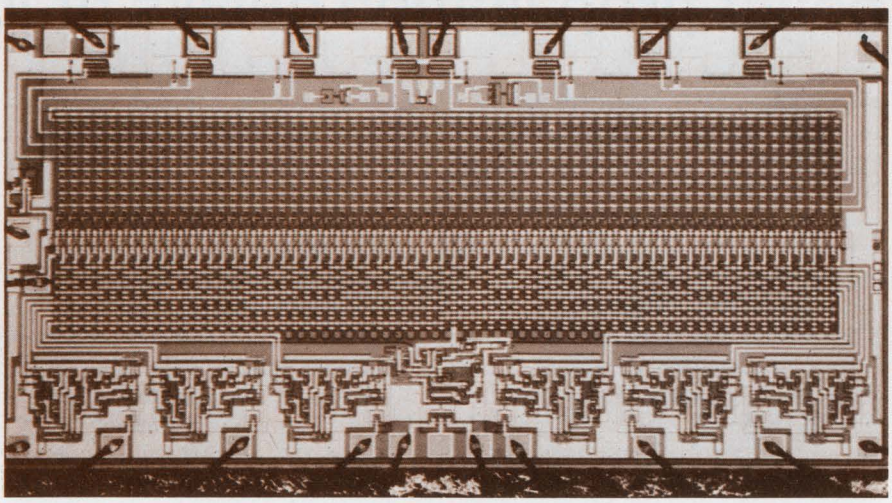



**Schottky-clamped TTL ICs** achieve delay times of 3 ns while keeping power levels to 20 mW per gate. Fast switching times are result of eliminating stored transistor charge with diode shunt across base-collector junction.



**High-speed performance** is verified by scope display that shows typical rise and fall times of 3 ns.

# Read-only 512-bit memory programs electronically



*Radiation Inc., Microelectronics Div., sub. of Harris-Intertype Corp., P.O. Box 37, Melbourne, Fla. P&A: $47 or $61.50; stock.*

Able to store up to 512 bits, a new monolithic bipolar read-only memory can be field-programmed by the user after it has been hermetically sealed. Because of this, there is no need for final pattern masking, which is always performed by the manufacturer, and memory costs can be reduced considerably. A military (−55 to +125°C) version sells for $61.50 in quantities of 100 to 999, while a commercial version (0 to 75°C) is priced at $47 for 100 to 999 units.

Primary applications for the new programmable read-only memory (PROM) are expected to be in systems that require many memories with differing programs. Other applications include conventional read-only-memory uses like micro-programming, combinational logic functions, arithmetic functions, table look-up and code conversion.

Since it can be field-programmed electronically, the PROM does away with such mechanical field-customizing methods as scribing and laser cutting. In addition, the user can stock a single type of read-only memory for any and all applications through both breadboard and production phases of his design.

All bits of the memory matrix are set at logical 0. A logical 1 is patterned by simply programming the desired bit with a 30-mA current. Since, in any given word, each bit is in series with the base of one of the output buffers, a bit programmed as logical 1 is an open circuit and prohibits the flow of base current.

This causes a high or logical 1 voltage to appear at the output of the buffer. Conversely, bits that are programmed as logical 0 permit base current to flow, thus causing a low or logical 0 voltage at the buffer output.

The PROM, which is compatible with standard DTL and TTL circuits, features word-bit expandability, parallel input, and output and chip enable. Access time is 65 ns and fanout current is 20 mA.

At 25°C, total operating power for the memory is only 400 mW. By using the enable feature, power dissipation for a PROM not in use can be reduced to approximately 250 mW. Average dissipation can be decreased even further by employing power strobing.

The circuit itself contains a six-bit decode address and a 512-bit memory matrix organized as 64 eight-bit words.

CIRCLE NO. 251

# Time interval measurements like you've never seen before.

Plug the HP 5379A Time Interval Unit into the HP 5360A Computing Counter and things happen faster than they could ever happen before.

This unique combination resolves time intervals to 100 picoseconds. With absolute accuracy of 1 nanosecond. And you can measure zero, positive and negative intervals, which makes it ideal for checking coincidence.

By adding the HP 5375A Keyboard, you can enter programs to produce instantaneous answers about phenomena that you could never previously measure with a counter. Things like peak-to-peak jitter; rms jitter; phase measurements; duty cycle; and radar ranging in feet, inches, meters or any other units you want.

Thanks to the 5379A, dozens of jobs can be handled easily and accurately. These include calibration of radar, lasers, and laboratory instruments; testing semiconductors and computers; cable fault location; delay line adjustment; ballistic and nuclear measurements.

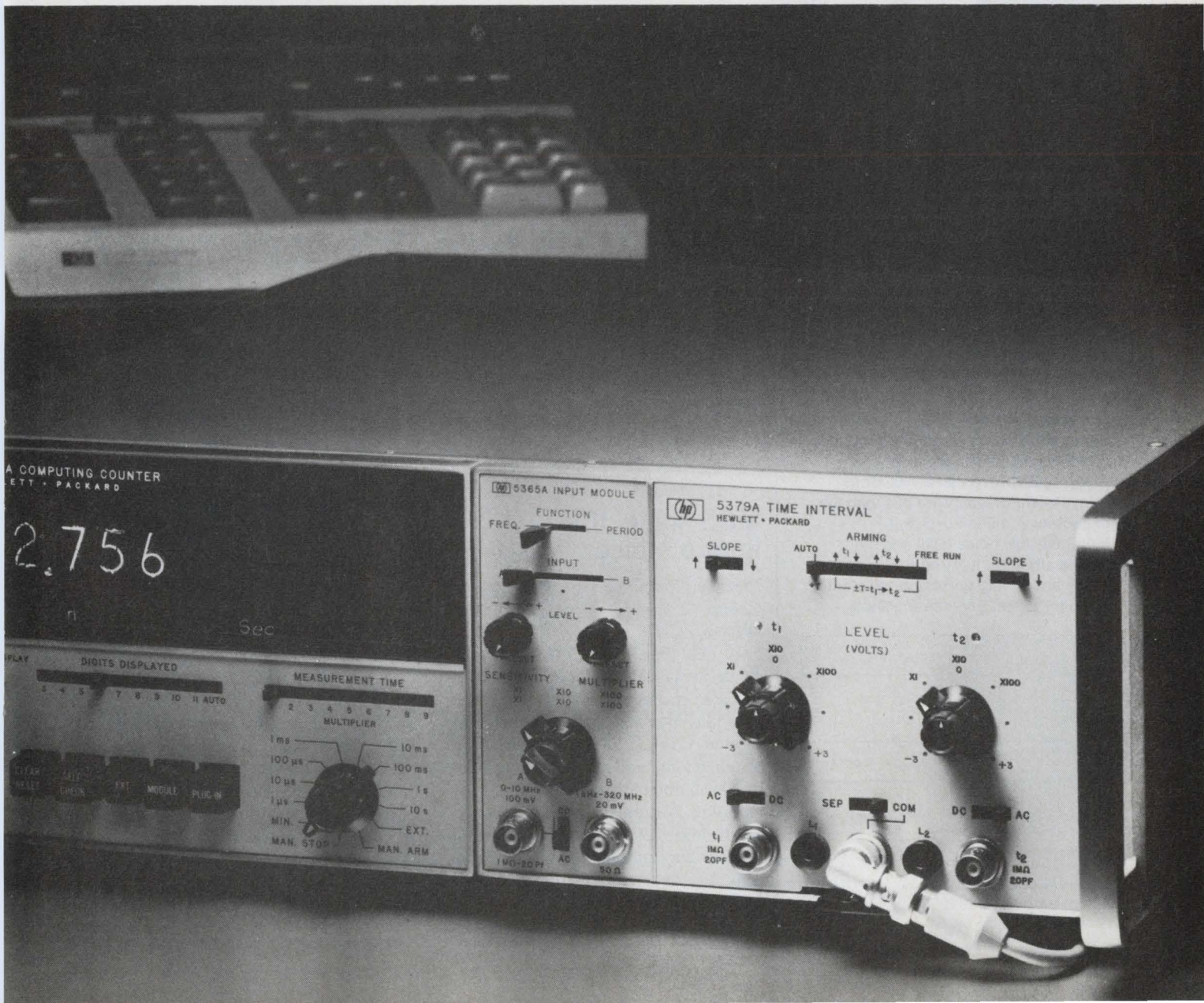
It does all this while saving you the cost of a computer, because the computer's built in. And you're not buying a counter that only measures time interval. You're getting the most advanced frequency measuring system available today, ideal for measuring pulses, pulse trains or any time-based events.

The cost is $750 for the plug-in and $6500 for the mainframe. Your local HP field engineer will be glad to arrange a demonstration. Give him a call. Or write for complete information to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

02920



## AM/FM demodulators use phase-locked loop

*Signetics International Corp., Hamill Toms Public Relations S.A., 115, Rue Defacqz-1050 Brussels, Belgium. Price: $18 or $22.*

Two new linear integrated circuits, which employ a phase-locked loop, can precisely duplicate the frequency of a signal and can demodulate FM and AM signals without tuned circuits. Models NE 560b and NE 561b operate over the frequency range of 1 Hz to 30 MHz. Their lock range is adjustable from ±1 to ±15%; input voltages can be 100 μV to 1 V.

CIRCLE NO. 252

## Multiplier chip sells for just $18

*Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-3563. Price: $18.*

Able to perform multiplication, squaring and division functions, the μA795C four-quadrant analog multiplier costs only $18 in single-unit quantities and only $12 in 100 to 999-unit lots. This monolithic circuit offers an input voltage range of ±10 V, and operates a bandwidth of dc to 3 MHz with a typical error of less than 1% full scale.

CIRCLE NO. 253

## MOS logic ICs ignore noise

*Plessey Company Ltd. Components Group, Cheney Manor, Swindon, Wittshire, England.*

A new family of MOS logic circuits, series MP100, are said to offer a high degree of noise immunity. The devices are primarly intended for general industrial applications and as peripherals to, or breadboarding elements for, complex systems and subsystems. Each logic input has a protection device incorporated on the chip, making special handling precautions unnecessary.

CIRCLE NO. 254

## Monolithic regulators dissipate up to 5 W

*General Electric Co., Corporations Park, Scotia, N.Y. P&A: $4 or $4.50; 30 days.*

Two new monolithic integrated circuit voltage regulators are capable of 5-W power dissipation over a wide range of input voltages and current levels. The PA264 has a maximum voltage rating of 25 V, while the PA265 is rated at 37 V maximum. Both units are housed in a plastic package with eight staggered leads and two heat-sink tabs. Output voltages can be as low as 3 V.

CIRCLE NO. 255

## Trimmed amplifier slews at 1.4 V/μs

*Sprague Electric Co., Marshall St., North Adams, Mass. Phone: (413) 664-4411.*

A new high-speed operational amplifier contains a built-in trimming resistor to ensure a slew rate of 1.4 V/μs in voltage-follower configurations. Two versions are available: the ULS-2139D for operation from −55 to +125°C and the ULN-2139D for operation from 0 to 75°C. Offset current is 60 nA, and minimum large-power bandwidth is 20 V pk-pk at 20 kHz.

CIRCLE NO. 256

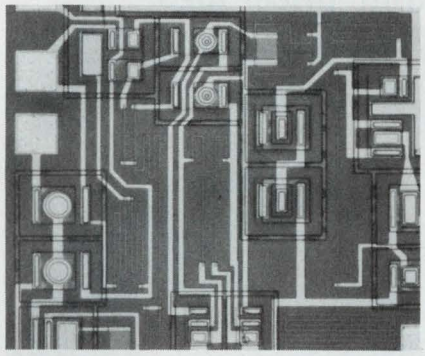
## Monolithic circuit is full sound system

*RCA/Electronic Components, 415 S. Fifth St., Harrison, N.J. Phone: (201) 485-3900.*

Developed primarily for use as a television sound system, a new integrated circiut contains: a multi-stage i-f amplifier/limiter, FM differential peak detector, electronic attenuator, zener-diode-regulated power supply, and an audio amplifier/driver that can directly drive an npn transistor or a high-transconductance electron tube. Volume control for the CA3065 is implemented by varying the attenuator bias levels.

CIRCLE NO. 257

## Low-cost 100-μW op amp holds bias to 3 nA



*Qualidyne Corp., 3699 Tahoe Way, Santa Clara, Calif. Phone: (408) 738-0120. Price: $15, $12, $9.60 per 100.*

Featuring a high input impedance of greater than 10 MΩ and low input bias current of only 3 nA is the new model QC1735 low-cost micropower operational amplifier.

Key features of this new unit are a low quiescent power consumption of less than 100 μW with the use of a ±3-V supply, a wide range of operations up to ±18 V, and an input bias current of 3 nA with a 1-nA offset.

These features were made possible through the use of two state-of-the-art processes.

One process is the use of high-gain low-noise transistors that operate with collector currents that are below 1 μA.

The other process is the use of a proprietary thin film on a silicon resistor network. This allows the processing of many wafers at once and thereby reduces the cost per wafer.

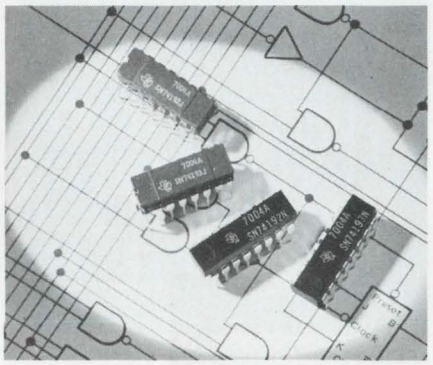
The new amplifier exhibits a stable performance over a wide range of temperatures and has good common-mode and power supply rejection.

Three versions are available: one (QC1735) operates in the military temperature range of −55 to +125°C; another (QC1735B) is an airborne version that operates from −20 to +85°C; and a third (QC1735C) is a regular version operating from 0 to 70°C.

Prices for the military, airborne and regular versions are, respectively, $15, $12 and $9.60 per 100.

CIRCLE NO. 258

## Up/down counters trim price tags

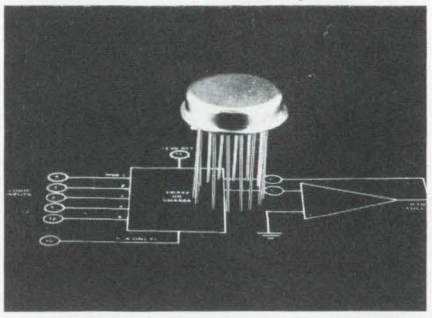


*Texas Instruments, Inc., Components Group, P.O. Box 5012, Dallas, Tex. Phone: (214) 238-2011. P&A: $7.70 to $26.31; 3 wks.*

Ranging in price from $7.70 to $26.31, two new TTL MSI synchronous up/down counters offer a complexity of 55 equivalent gates. Model SN54/74192 is a 4-bit binary counter, while model SN54/74193 is a binary-coded decimal (BCD) counter. Both units can be cascaded without the need for external circuitry. Power dissipation is 325 mW.

CIRCLE NO. 259

## Hybrid d/a converter works 6 bits for $75



*Crystalonics, a Teledyne Co., 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. P&A: $75; stock.*

Costing only $75, a new six-bit hybrid d/a converter is a complete circuit with a ladder network and switching system. The model CDAS2/A converter operates directly from logic, and features a typical 1-$\mu$s settling time over the full military temperature range of −55 to +125°C. The unit's maximum error is 1% of full scale.

CIRCLE NO. 260

## Fast number converter uses read-only memory

*Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Ariz. Phone: (602) 273-6900. P&A: $5.60; stock.*

Employing a 128-bit read-only memory, a new binary-to-BCD/BCD-to-binary number converter allows the building of very-short-conversion-time systems—for example, 12 bits of binary data can be converted to BCD information in only 400 ns. Conversion of any-length binary or BCD words can be accomplished by interconnecting these type MC4001 packages.

CIRCLE NO. 261

## Triple amplifier draws only 5.4 mW

*Kinetic Technology Inc., 3393 De La Cruz Boulevard, Santa Clara, Calif. Price: $6.*

Containing three fully compensated operational amplifiers on a single chip, a new integrated circuit needs only 5.4 mW of power at ±15 V from dc to 10 kHz. Model KA-10 triple amplifier has a maximum voltage gain of 86 dB at ±15 V, a slew rate of 0.3 V/μs, and an input voltage range of ±2 to ±12 V. It is a general-purpose device that is housed in a 12-lead TO-101 package.

CIRCLE NO. 262

## Monolithic amplifier holds offset to 0.5 nA

*Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. Phone: (408) 257-5450. P&A: $9.60; stock.*

Model ICB8008C monolithic operational amplifier features a typical input bias current of 3 nA and an input offset current of 0.5 nA. The device has total short-circuit protection, internal compensation, high common-mode voltage range and the advantages of no latch-up. Applications include integrators, voltage followers, and sample-and-hold circuits.

CIRCLE NO. 263

## IC memory chip accesses in 40 ns

*Computer Microtechnology Inc., 610 Pastoria, Sunnyvale, Calif. Phone: (408) 736-0300. P&A: $74; 1 wk.*

The CM 2100 64-bit random-access integrated-circuit memory has a typical read access time of 40 ns and a typical power dissipation of 360 mW. The unit's outputs offer both DTL and TTL compatibility and can drive ten unit loads. Input clamp diodes provide minimum line ringing, and operating temperature range is 0 to 75°C. The memory comes in a 16-lead DIP.

CIRCLE NO. 264

## Sense amplifier has dual inputs

*Qualidyne Corp., 3699 Tahoe Way, Santa Clara, Calif. Phone: (408) 738-0120. P&A: $5.75; stock.*

Intended for use between core memories and TTL circuits, the 1541-1441 interface sense amplifier is a dual-channel gated device with dual differential input amplifiers and a single gate output that is compatible with DTL and TTL levels. The unit's input threshold, which is normally 17 mV, can be adjusted from 10 to 25 mV. Typical input offset voltage is 1 mV and propagation delay is less than 20 ns from input to gate output.

CIRCLE NO. 265

## Read-only memory stores 256 bits

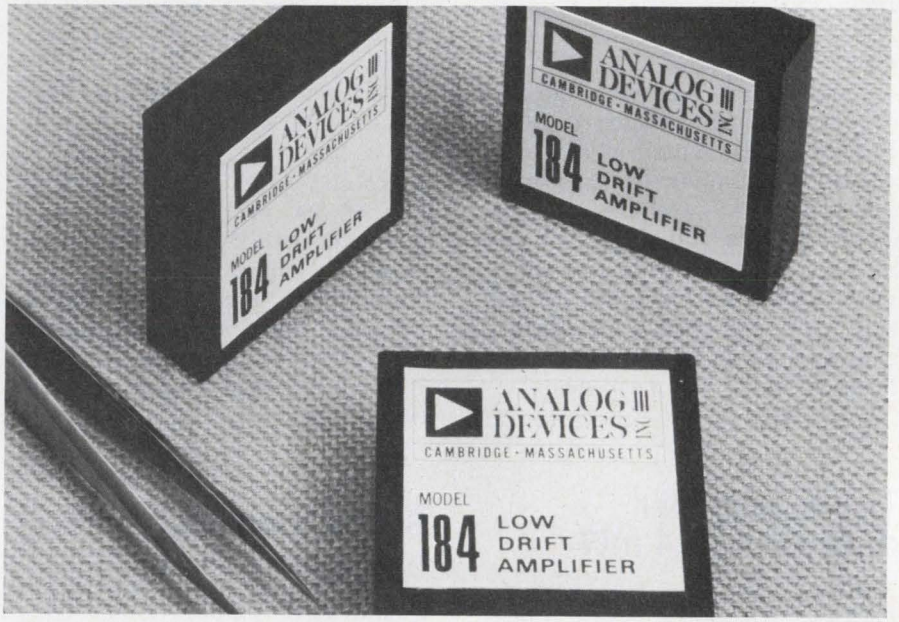
*Sylvania Electric Products Inc., Semiconductor Div., 1100 Main St., Buffalo, N.Y.*

A new monolithic TTL-compatible 256-bit read-only memory is capable of storing up to 32 eight-bit words. Model SM320 achieves on-chip full-address decoding with a five-input address code that allows random selection of any of the 32 words stored. A chip-enable line allows individual package selection when the outputs are OR-wired.

CIRCLE NO. 266

INFORMATION RETRIEVAL NUMBER 84 ►

# Trimmed chopperless op amp minimizes drift to 0.25 μV/°C




*Analog Devices, Inc., 221 5th St., Cambridge, Mass. Phone: (617) 492-6000. P&A: $45, $60, $75; stock.*

A maximum voltage drift of only 0.25 μV/°C and maximum initial offset voltage of 100 μV in a low-cost operational amplifier without chopper stabilization? Yes, it's true, with the new model 184L ultrastable amplifier.

It uses a newly developed dual monolithic transistor pair for the input stage to achieve ultra-stable performance features.

With a long-term drift of only 5 μV/month, the unit features all the attributes of a chopper-stabilized amplifier without its limitations.

The low offset voltage of 100 μV, which until now was only possible with a chopper-stabilized amplifier, means that the user need not perform any input voltage trimming.

Another important virtue of the model 184L is its low noise of 1 μV/°C for the frequency range of 0.01 to 1 Hz. This is principally due to the absence of a chopper which causes intermodulation problems.

The unit can be used in differential non-inverting as well as inverting circuit configurations. With chopper-stabilized amplifiers, only inverting modes could be used since one of the input terminals must be grounded.

Other important characteristics are a maximum bias current of 25 nA and a maximum bias-current drift of 0.25 nA/°C. Offset current is 2 nA maximum and offset-current drift is 0.02 nA/°C maximum.

Dc gain is 300,000 and bandwidth is 500 kHz. Common-mode rejection is 100,000 and output rating is ±10 V at 5 mA.

Three amplifier versions are available: the models 184J, 184K and 184L with unit prices of $45, $60 and $75, respectively.

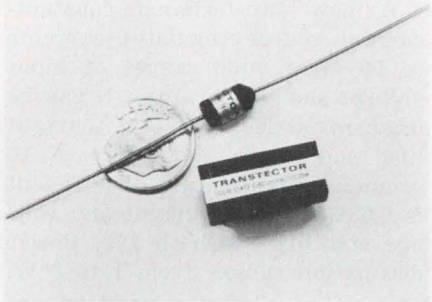
The model 184J has an offset voltage of 250 μV and a voltage drift of 1.5 μV/°C. The model 184K has a voltage drift of 0.5 μV/°C. Otherwise, the performances of the three versions are identical.

All units measure 1.5-in. square by 0.4-in. high and are epoxy encapsulated.

Typical applications include use in null detectors for bridge measurements, strain gauges and thermistors.

CIRCLE NO. 267

## Tiny SCR crowbars pass up to 10 A

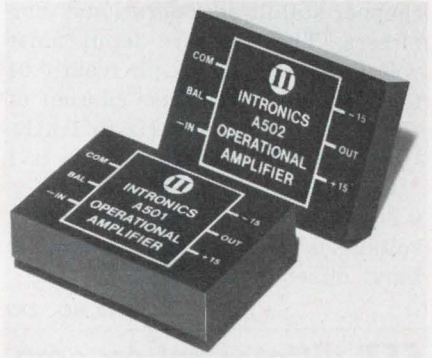



*Transtector Systems, div. of M & T Chemicals Inc., sub. of American Can Co., 1161 Monterey Pass Rd., Monterey Park, Calif. Phone: (213) 264-0800. Availability: stock.*

Housed in dual-in-line or DO-27 diode packages, a line of subminiature hybrid SCR crowbar circuits feature operating current levels as high as 10 A. They are capable of deflecting several million overvoltage transients. Standard overvoltage trip points range from 5 to 200 V dc.

CIRCLE NO. 268

## High-speed op amp reaches 0.1% in 60 ns

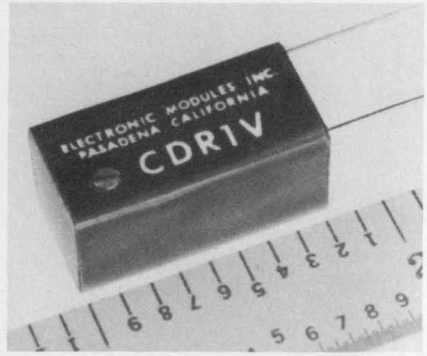



*Intronics, 57 Chapel St., Newton, Mass. Phone: (617) 332-7350. P&A: $125; stock.*

Exhibiting extremely high-speed performance for high-frequency inverting applications, a new operational amplifier offers a slew rate of 100 V/$\mu$s, a 100-MHz gain-bandwidth product, and a settling time of 0.1% of 60 ns. Model A502 can drive loads as large as ±50 mA at ±10 V. It operates over a temperature range of −25 to +85°C.

CIRCLE NO. 269

## Constant-current source regulates up to 1%

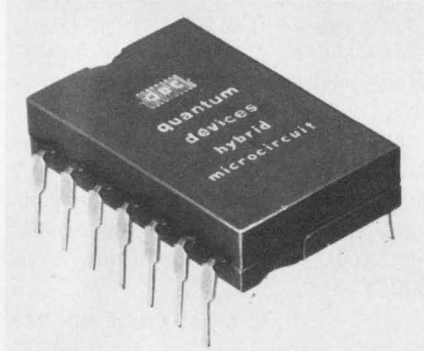



*Electronic Modules, Inc., 2560 E. Foothill Blvd., Pasadena, Calif. Phone: (213) 795-4231. P&A: $30 to $45; 2 to 3 wks.*

A new two-terminal constant-current source regulates currents to 1% over wide ranges of input voltage and temperature. It can be used in series with the current line and needs no reference to ground. Temperature coefficient is 0.03%/°C and current and voltage stability are both 1%. Power dissipation ranges from 1 to 3 W.

**CIRCLE NO. 270**

## DIP hybrid voltage unit regulates load to 0.5%

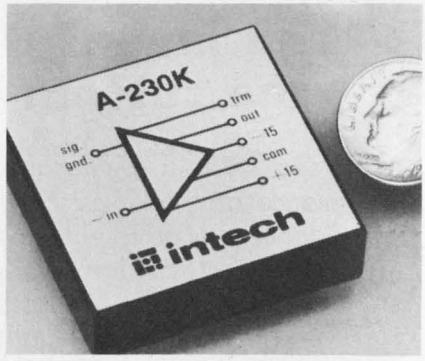



*Quantum Devices Corp., 15 W. Main St., Bergenfield, N.J.*

Featuring an output-voltage temperature stability of 0.01%/°C, the model VR401 hybrid voltage regulator provides load regulation of 0.5% at ±15 V from 0 to 100 mA. Input voltage is 18 V dc. Standby current drain is held to 3 mA and output noise is 60 μV rms. Ripple rejection is 60 dB and output impedance is 0.1 Ω. The unit is available in a 0.7x5x 0.7-in. dual-in-line case.

**CIRCLE NO. 271**

## Wideband amplifiers lower noise to 0.8 μV

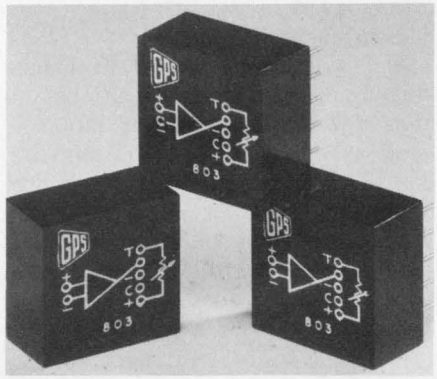



*Intech Inc., 1229 Coleman Ave., Santa Clara, Calif. Phone: (408) 244-0500. Price: $85 to $125.*

The series A-230 are low-noise chopper-stabilized operational amplifiers. They feature input noise voltage of 0.8 μV pk-pk from 0.01 to 1 Hz and input noise current of 35 pA pk-pk from 10 Hz to 1 kHz. Unity-gain frequency response is 1 MHz and supply rejection ratio is 0.1 μV/V. Maximum input offset voltage is ±15 μV, and maximum input offset drift is 0.25 μV/°C.

**CIRCLE NO. 272**

## FET differential op amp gives 15-pA bias current

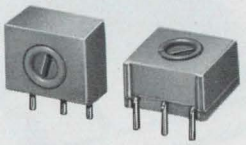



*GPS Corp., 14 Burr St., Framingham, Mass. Phone: (617) 875-0607. Price: $60.*

Model 803 is a high-performance low-cost FET differential operational amplifier with a bias current of less than 15 pA and an input impedance of $10^{11}$ Ω. It exhibits exceptionally high stability and features an offset temperature coefficient of 10 μV/°C, a slewing rate of 10 V/μs and a 20-mA output. The unit can drive high-capacitance loads without instability.

**CIRCLE NO. 273**

# CTS TRIMS CERMET INDUSTRIAL TRIMMER PRICES TO 50¢



- **50¢ each in 50,000 quantity**
- **65¢ each in 1,000 quantity**
- **$1.14 each in 100 quantity**

for ±20% Tolerance (Add 4¢ for 10% tolerance)

## Series 360 single-turn cermet industrial trimmers provide...

- **Setability ±.03%**
- **Environmental performance requirements of characteristic C of MIL-R-22097D**

**...plus!**

- 1.5% average equivalent noise resistance
- 0.5% average contact resistance variation
- Compact, single-turn design
- Top or side adjust
- ½ watt @70° C
- Tolerance to ±5%
- TC ±150 ppm/°C available at no extra cost over most of the resistance range.

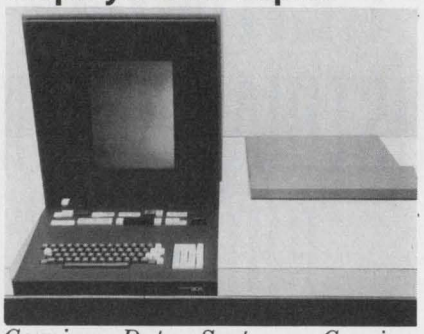
Your CTS Distributor will have both styles in stock for fast, prototype delivery. Production quantities to you in 4 weeks.

See your distributor... call your CTS sales engineer... or write for complete data. We'll respond quickly. CTS of Berne, Inc., Berne, Indiana 46711. Phone: (219) 589-3111.

**CTS CORPORATION**
*Elkhart, Indiana*

INFORMATION RETRIEVAL NUMBER 88

## Interactive terminal displays and copies

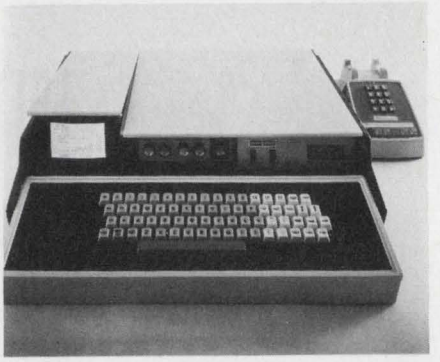


*Corning Data Systems, Corning Glass Works, 3900 Electronics Dr., Raleigh, N.C. Price: $19,650 or $670/month.*

Offering both graphic and alphanumeric display, a new time-sharing computer terminal features a built-in system for making electrostatic hard copy, and a system for superimposing slide data over computer-generated information. The heart of the 904 is a storage photochromic-glass CRT, which darkens when exposed to ultraviolet light and erases (regains transparency) when exposed to red light.

CIRCLE NO. 274

## Portable CRT terminal shows 1024 characters



*Applied Digital Data Systems, Inc., 89 Marcus Blvd., Hauppauge, N.Y. Phone: (516) 273-7799. P&A: $3200 or $3700; 90 days.*

Featuring complete editing and formatting capabilities, a new portable CRT terminal can display up to 1024 alphanumeric characters. Operating the Envoy is simple. The user plugs it into an ordinary outlet, folds out the keyboard, pops up the screen, inserts a standard telephone into the built-in acoustic coupler and dials his computing center.

CIRCLE NO. 276

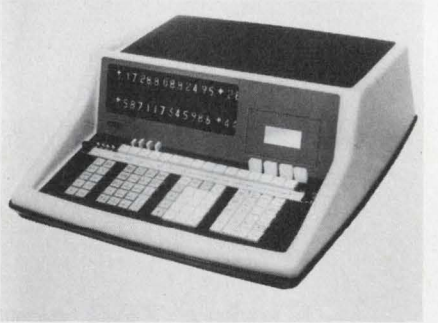
## Computer terminal is portable system

*Logitron, Inc., 197 Albany St., Cambridge, Mass. P&A: $3000; 60 days.*

Weighing approximately 25 pounds and packaged in a convenient case with a retractable CRT display, the Logiport/1 remote stand-alone computer terminal includes a complete standard alphanumeric keyboard and an integral acoustic coupler. It can be easily carried about and plugged into the ac line. The unit can transmit 10 or 30 characters per second.

CIRCLE NO. 275

## Desktop calculators program 1984 steps

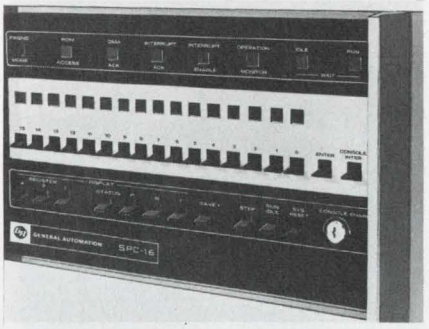


*Wang Laboratories, Inc., 836 North St., Tewksbury, Mass. Phone: (617) 851-7311. P&A: $6700 or $6800; 6 months.*

The 720A and 720B are programmable desktop calculators that have a capacity of 1984 program steps or 248 data storage registers. Each machine can accommodate five levels or five nested subroutines. The units can remember up to five addresses when a subroutine within a subroutine occurs. Actual core memory storage is 16,384 bits.

CIRCLE NO. 277

## Digital 16-bit computer has two memory types



*General Automation, Inc., 706 W. Katella Ave., Orange, Calif. Phone: (714) 633-1090. Price: from $10,000.*

Capable of either on-line or off-line operation, the SPC-16 16-bit computer provides up to 64 hardware priority interrupts, and incorporates completely interchangeable read-only and read/write memories, as well as 16 general-purpose registers. A set of base-relative/program-relative instructions allows full advantage to be taken of both memory types.

CIRCLE NO. 278

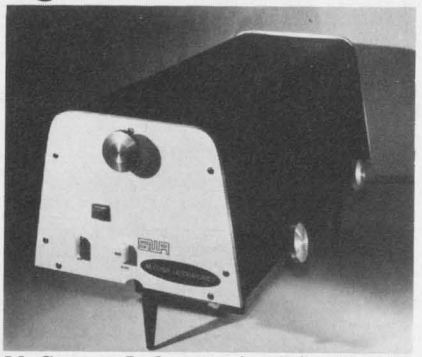
## MSI minicomputer cycles in 750 ns

*Varian Data Machines, a Varian subsidiary, 2722 Michelson Drive, Irvine, Calif. Phone: (714) 833-2400.*

Incorporating state-of-the-art planar memories, MSI circuitry, and high-speed I/O transfers, the 620/f minicomputer boasts a cycle time of only 750 ns. Besides speed, this new computer also provides an extended set of instructions. Another feature is a priority memory access mode that permits asynchronous data transfers at rates to 1.3 MHz.

CIRCLE NO. 279

## Laser page scanner digitizes in 30 s

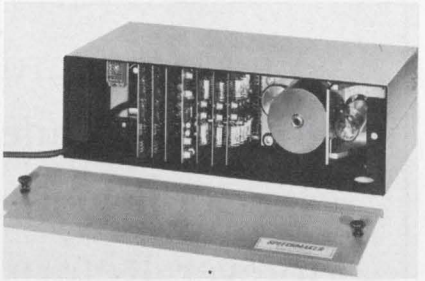


*McCowan Laboratories Div., Southwestern Research Corp., 1155 W. 23rd St., Tempe, Ariz. Phone: (602) 967-8765. Price: $15,000.*

In less than 30 seconds, the 8511-1 laser scanner can digitize an 8-1/2 by 11-in. page containing typewritten, handwritten or graphic information. Part of a complete laser document translator system, the laser scanner supplies a video signal to a translator, which converts the signal to 16-bit digital data. A graphic generator then provides the necessary readout medium.

CIRCLE NO. 280

## Audio response system is compatible with ICs



*Cognitronics Corp., Speechmaker Div., 333 N. Bedford Rd., Mount Kisco, N.Y. Phone: (914) 666-2941.*

Able to accept IC logic levels directly, Speechmaker 636 is a real-time audio response system that can interface with any commercial computer to give spoken answers in words, phrases or numbers to a request for information. It provides a direct and flexible means of machine-to-man speech communication. Vocabularies of up to 31 words can be stored in the unit.

CIRCLE NO. 281

## Hard-copy peripherals print electrostatically

*Versatec, Inc., 10100 Bubb Rd., Cupertino, Calif. Phone: (408) 257-9900. P&A: $5500 to $7900; June, 1970.*

Six new hard-copy-output peripherals, the Matrix series, employ non-impact silent electrostatic printing. The Matrix 300 and Matrix 600 can put out 300 (400 characters per second) and 600 (800 characters per second) lines per minute, respectively. Matrix 100 and Matrix 200 are graphic output devices, Matrix 100A is a combination printer/plotter, and Matrix 200A is a combination of the 600 and 200 models.

CIRCLE NO. 282

## Reel tape system packs 800 bits/in.

*Wang Computer Products, Inc., 2000 Stoner Ave., Los Angeles, Calif. Phone: (213) 478-7727. P&A: $3475; 30 days.*

Emphasizing ease of use, the Mod 10 tape system can write or read IBM-compatible tapes at densities of 200, 556, or 800 bits per inch with phase-encoded 1600-bit-per-second operation optional. The unit incorporates automatic buffer arm retraction to reduce tape threading time to less than 10 seconds. It uses 0.5-in. tape on 10-1/2-in. or smaller reels.

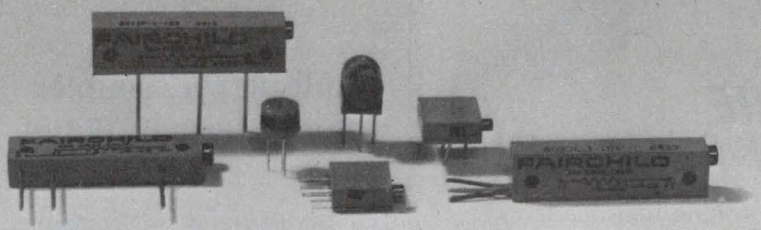
CIRCLE NO. 283

# Now you're down to no reasons not to buy Fairchild trimming pots

☑ **QUALITY.** Better than MIL requirements

☑ **PRICE.** Cost less

☑ **DELIVERY.** Immediate



Fairchild trimming potentiometers meet — and in the most important ways exceed — MIL-R-22097C and 27208B requirements and they cost less to boot. And now these great wirewound and film trimmers are available *off-the-shelf*. That leaves no reasons not to call or wire Fairchild today for complete specs and prices.

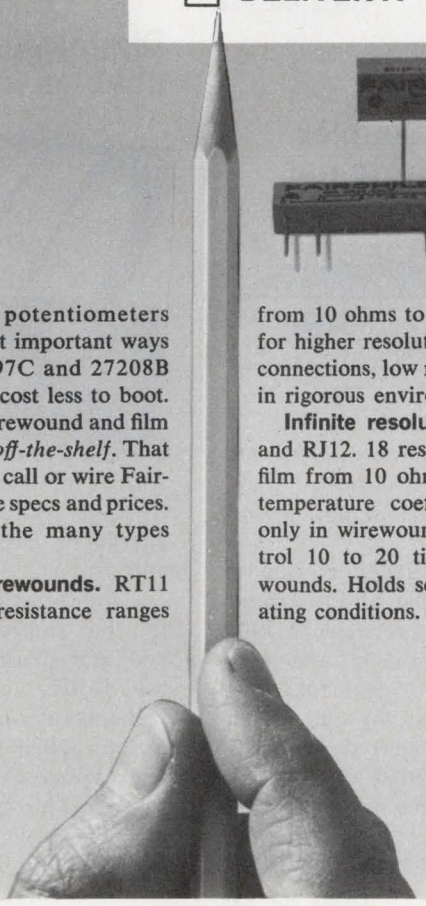
Here are some of the many types available:

**High resolution wirewounds.** RT11 and RT12. Eighteen resistance ranges from 10 ohms to 175K. Longer element for higher resolution, fewer parts, fewer connections, low noise, keeps performing in rigorous environmental conditions.

**Infinite resolution Filmpots®.** RJ11 and RJ12. 18 resistance ranges in metal film from 10 ohms to 1 megohm. Low temperature coefficient you could get only in wirewounds before, circuit control 10 to 20 times better than wirewounds. Holds setting in extreme operating conditions. Low contact resistance variation (noise in wire types). Low inductance lets you use Filmpots in high frequency applications.

Commercial-industrial grade Filmpots also available in 1¼" narrow rectangular, ¾" rectangular, and ¼" round. Also MIL grade ⅜" square RJ24C type.

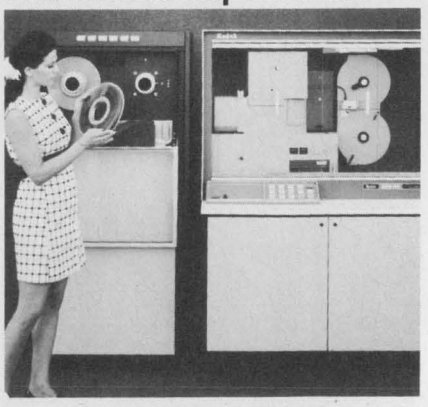
See your Fairchild Controls representative or contact us at 5625 Kearny Villa Road, San Diego, California 92123. (714) 279-5600. Unless you like waiting. Or paying more.



FAIRCHILD
CONTROLS
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

INFORMATION RETRIEVAL NUMBER 92

## Microfilm station translates taped data

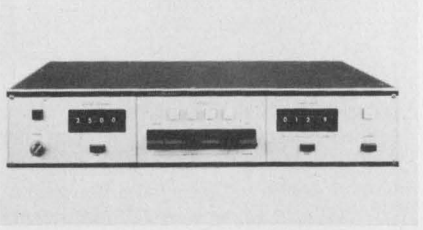


*Eastman Kodak Co., Business Systems Markets Div., 343 State St., Rochester, N.Y. Phone: (716) 325-2000.*

Converting taped information from computers into readily readable film images, KOM90 microfilmer processes up to 90,000 computer characters per second on to as many as 300 pages of man-readable information per minute. After decoding from tape, the microfilmer displays data on CRT. The displayed material is then photographed on 16-mm microfilm.

CIRCLE NO. 284

## Multiplexer/coupler is interface terminal

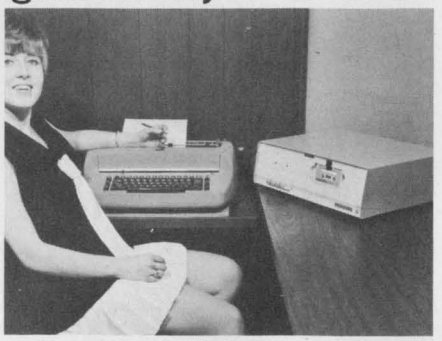


*Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. Phone: (415) 686-4200. Price: $1350.*

Designed for either on-line or off-line use, a new all-integrated-circuit multiplexer/coupler links digital instrumentation and computers, making it ideal for unattended data collection and reduction via a time-shared computer service. Model 5010 features a modular expandable configuration, selectable header control, word length and file length.

CIRCLE NO. 285

## Data transfer systems go from key to cassette

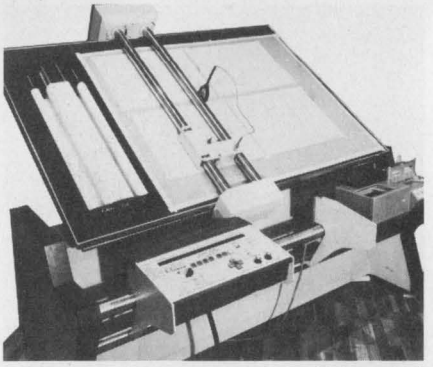


*International Computer Products, Inc., P.O. Box 34484, Dallas, Tex. Phone: (214) 239-5381.*

Three new key-to-cassette data transfer systems include: the Key-Cette 1000, a duplex I/O system with tape-to-key and key-to-tape capability for read/write applications; the Key-Cette 1100, a data entry system for applications requiring write-only key-to-tape transfer; and the Key-Cette 1200 data logging system for read-only tape-to-key data transfer.

CIRCLE NO. 286

## Digital plotter doubles surfaces

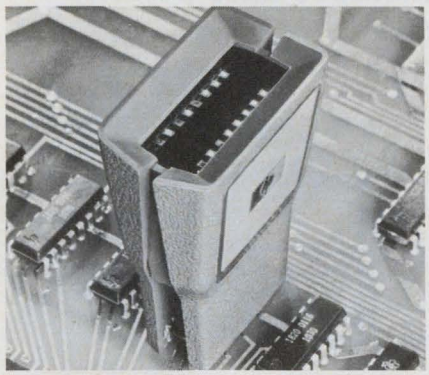


*Auto-Trol Corp., 6621 W. 56th Ave., Arvada, Colo. Phone: (303) 421-5670. Price: $35,000 to $50,000.*

Combining two plotting surfaces in the same machine—both flat bed and drum style—a new digital plotter can do straight-line drawing at any angle with a resolution of 0.0005 in. Model 6030 has a drawing speed of 10 inches per second. The sprocket on the drum is adjustable for varying paper widths from 11 to 36-in. wide.

CIRCLE NO. 287

## Clip for DIP ICs shows logic with LEDs



*Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $95; stock.*

Model 10528A logic clip is a troubleshooting device that clips onto DTL or TTL DIP ICs and displays the logic states of all 14 or 16 pins at the same time. The unit has 16 light-emitting diodes, each of which follows voltage-level changes of one pin; a lighted diode indicates a high logic state (5 V). The clip draws its power from the test circuit.

CIRCLE NO. 288

## Auto-ranging counter displays with LEDs

*Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N.J. Phone: (201) 228-3800. Price: $1775.*

Emphasizing solid-state reliability, the model 120A 150-MHz universal counter/timer uses MSI circuits for 60% of its components and light-emitting-diode numerics for its eight-digit display. All frequency and period measurements are automatically displayed with maximum resolution. The instrument can also operate in a pulse-burst mode.

CIRCLE NO. 289

## VOM with 68 ranges gauges capacitance


*Simpson Electric Co., div. of American Gage & Machine Co., 5200 W. Kinzie St., Chicago, Ill. Phone: (312) 379-1121. Price: $230.*

Powered by its self-contained battery supply, the 2795 solid-state FET-input multimeter offers 68 switch-selectable ranges: 13 ac and dc voltage ranges (as low as 1 mV full scale), 14 ac and dc current ranges (down to 1 $\mu$A full scale), six resistance ranges (from 1 $\Omega$ to 100 k$\Omega$), six capacitance ranges (from 1 nF to 100 $\mu$F), two temperature ranges, and 12 output (dB) ranges.

CIRCLE NO. 290

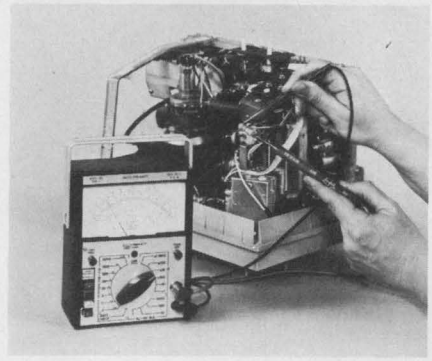
## DIP IC tester isolates malfunctions

*Innovation Development Co., P.O. Box 7, Azusa, Calif. Price: $89.*

Developed for remote testing of dual-in-line integrated circuits, the ICS-100 DIP tester allows the user to connect or isolate each IC pin in order to locate circuit malfunctions. The to-be-tested IC is removed from its in-circuit socket and plugged directly into the testing instrument. This provides for component isolation and also permits the monitoring of individual parameters.

CIRCLE NO. 291

## Battery-powered VOM includes auto-polarity

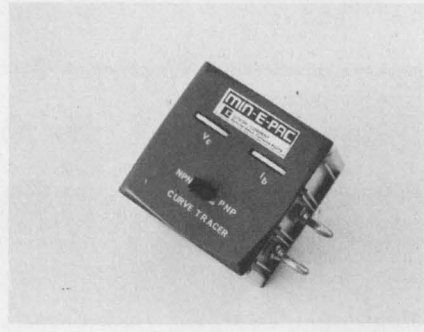


*Triplett Corp., 286 Harmon Rd., Bluffton, Ohio. Phone: (419) 358-5015. P&A: $100; stock.*

A battery-operated solid-state volt-ohm-milliammeter, model 602, features an auto-polarity circuit, which is actuated by functional pushbutton switches and which eliminates the need for switching test leads. The new instrument has a full-scale sensitivity of 0.3 V for both ac and dc at a constant input impedance of 11 M$\Omega$ on dc and 10 M$\Omega$ on ac.

CIRCLE NO. 292

## Curve tracer plug-in converts most scopes




*Eltron Co., 2501 Artesia Blvd., Redondo Beach, Calif. Phone: (213) 370-5749. Price: $49.95.*

The MOT-1 curve tracer plug-in module is a compact all-solid-state device that transforms most oscilloscopes to test instruments with the capability of displaying the voltage-current characteristics of a wide variety of solid-state devices. Thumbwheel controls allow collector or anode voltages to range from 1 to 12 V and base currents to be adjusted from 0 to 25 $\mu$A.

CIRCLE NO. 293

## Digital panel counters can log up to 500 kHz


*Starmark Electronics, 3710 Main St., Kansas City, Mo. Phone: (816) 931-7367. Price: from $200.*

General-purpose panel-mounted digital counters are now available with up to six digits of display and for operation at frequencies in excess of 500 kHz. Series 300 units will count contact closures or voltage signal inputs. All models have provisions for remote control, front-panel control, and BCD output for data acquisition or external monitoring.

CIRCLE NO. 294

## Twin chart recorder monitors 16 events


*Rustrak Instrument Div., Gulton Industries, Inc., Municipal Airport, Manchester, N.H. Phone: (603) 623-3591.*

Measuring only 5-5/8x6-5/8x6-1/2 in., a new twin strip-chart recorder monitors 16 events at one time. Model 392-16 gives time analysis and cost study data in a continuous rectangular trace, making an accurate time-correlated record of events and ON/OFF operations. It consists of two basic recorders sharing a single time base and chart.

CIRCLE NO. 295

## PC-board exerciser simulates in-circuit test


*Testex, Inc., 162 San Lazaro Ave., Sunnyvale, Calif. Phone: (408) 732-0461. P&A: $945; 30 days.*

A circuit board exerciser, the model number 420, enables the in-circuit testing of integrated circuits on a board as if the board were plugged into a system. The device generates a grey-code square wave to exercise the circuit board. The testing unit is available with 12, 16, 20 or 24 stages (outputs).

CIRCLE NO. 296

## Digital panel meters are loaded with extras

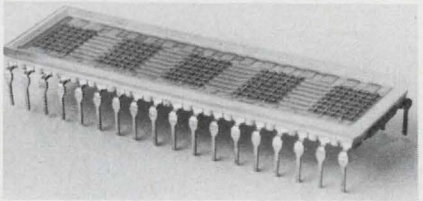

*Newport Laboratories, Inc., 630 E. Young St., Santa Ana, Calif. Phone: (714) 540-4914. P&A: $300; 3 to 4 wks.*

Series 2000 digital panel meters are 4-1/2-digit instruments offering 30 readings per second, ±19,999 counts full scale, automatic polarity, an accuracy of ±0.01% of reading, ±0.01% of full scale, and isolated BCD outputs. Besides determining ratios, the DPMs measure ac or dc voltages from 10 μV to 200 V, and ac or dc currents from 1 nA to 200 mA.

CIRCLE NO. 297

COMPONENTS

## LED display modules show alphanumerics

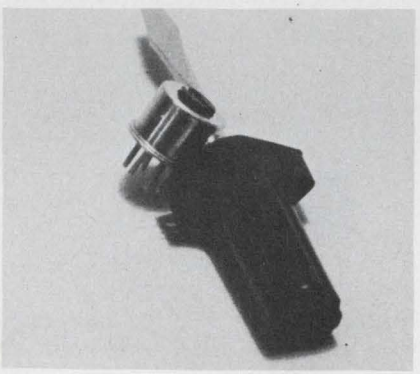


*Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $30/character; 2 wks.*

Consisting of light-emitting gallium-arsenide-phosphide light-emitting diodes mounted in a 5 by 7 matrix, the type 5082-7100, 01 and 02 alphanumeric displays come in a standard dual-in-line package as clusters of three, four and five characters. The modules are IC compatible and have 1/4-in.-high characters on 1/3-in. spacings. Display packages are end stackable so that spacing between characters within a package and between two packages is the same.

CIRCLE NO. 298

## Rotary sp7t TO-5 switch adjusts by screwdriver

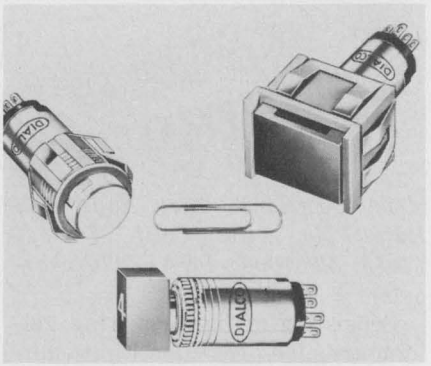


*Chicago Switch, Inc., 2035 Wabansia Ave., Chicago, Ill. Phone: (312) 489-5500. P&A: $5.55; 4 to 6 wks.*

Featuring an sp7t rotary switch with an eighth OFF position at the case tab, the model 30-000-001 TO-5 PC board switch includes a top-of-the-case screwdriver adjustment. It is rated at 100 mA and 5 V dc and its initial contact resistance is 50 mΩ. Switch adjustment is in a clockwise direction with bidirectional versions to be made available later.

CIRCLE NO. 299

## Illuminated pushbuttons enhance switching mode



*Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. Phone: (212) 497-7600.*

Featuring spdt or two-circuit contact arrangements are new illuminated pushbutton switches with alternate and snap action styles. They include contact ratings of 5 A and accommodate T-1-3/4 incandescent bulbs with midget flanged bases up to 28 V. Two varieties are available: snap-in mounting types for low-profile panels and standard-panel-mounting types.

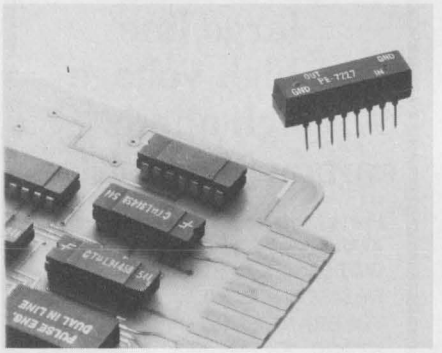
CIRCLE NO. 335

## DIP delay line series ranges over 5 to 45 ns

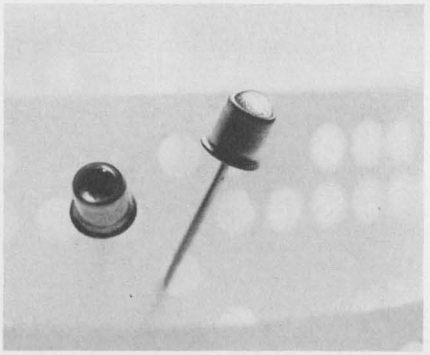
*Pulse Engineering Inc., Box 12235, San Diego, Calif. Phone: (714) 755-9723. P&A: $9.50; stock.*

Eight new distributed-constant delay lines cover the time delay range of 5 to 45 ns with impedances of 100 and 390 Ω. Series 7200 units feature rise times of 2.2 to 12 ns. Other specifications include a peak pulse voltage of 100 V and maximum distortion of 15%. Maximum attenuation is 5% and temperature coefficient is 200 ppm/°C. All units are in 16-lead DIP cases.

CIRCLE NO. 336



## IR LED lamp puts out 1 mW

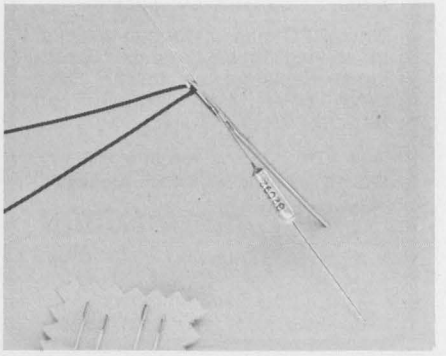


*General Electric Co., Miniature Lamp Dept., Nela Park, Cleveland, Ohio. Phone: (216) 266-2258. Price: $7.79.*

A new gallium-arsenide solid-state lamp produces a 1-mW infrared output at 9400 Å peak when input current is 20 mA. Model SSL-315 is ideally suited for use with integrated circuits in such applications as paper-tape and card readers, and end-of-tape and start-of-tape sensing. The device is mounted in a coaxial package.

CIRCLE NO. 337

## Small timing cell can delay for 1 h



*Gibbs Manufacturing & Research Corp., sub. of Hammond Corp., Janesville, Wis. Phone: (608) 756-1261. Price: $10.*

Called the model 1010 Coul-Cell, a new subminiature timing coulometer can handle time delays from a few seconds to about one hour. The device is actually an electrolytic cell that can be compared to a tiny plating tank. It has a capacity range from 1 to 100 μA-h, and a current range of 3 to 90 μA for accuracies to ±5%.

CIRCLE NO. 338

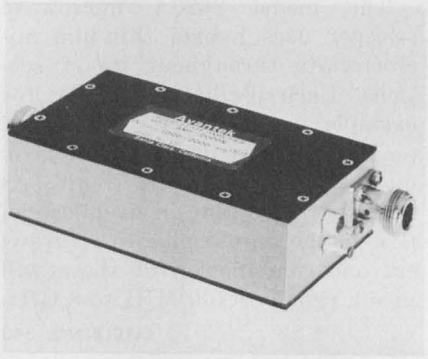
## Coaxial transistor pushes 5 W at 2 GHz


*RCA/Electronic Components, 415 South Fifth St., Harrison, N.J. Phone: (201) 485-3900.*

Intended to bring higher efficiency to uhf/microwave power amplifiers, a new silicon npn overlay transistor delivers a 5-W output with a minimum gain of 7 dB at 2 GHz and a 10-W output with 11-dB gain (typical) at 1.2 GHz. For coaxial, stripline, and lumped-constant circuit applications, the 2N5921 is housed in a ceramic-metal hermetic package with low parasitic capacitance.

CIRCLE NO. 339

## S-band amplifier puts out 20 dBm

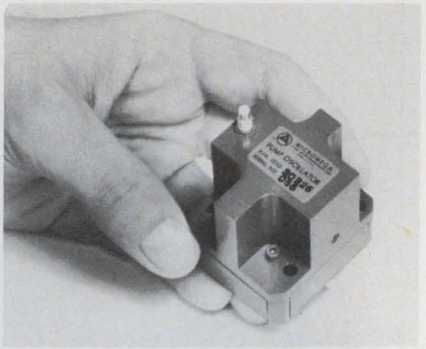



*Avantek, Inc., 2981 Copper Rd., Santa Clara, Calif. Phone: (408) 739-6170. P&A: $2000; 30 days.*

Holding noise figure to 7 dB maximum, the AMP-2000N transistor amplifier supplies 20-dBm power output at the 1-dB gain compression point over the frequency range of 1 to 2 GHz. The unit has a minimum gain of 30 dB with a gain flatness of +1 dB. Its input VSWR is 2, while its output VSWR is 1.5. Required dc input power is only 15 V at 165 mA.

CIRCLE NO. 340

## Tunable Gunn oscillator covers 8 to 12.4 GHz

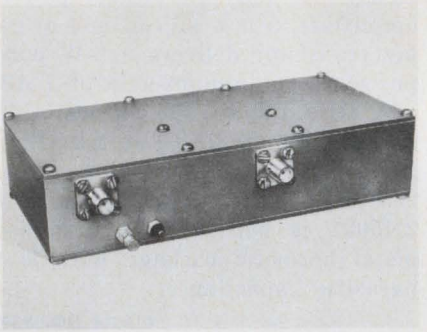


*Micromega 12575 Beatrice St., Los Angeles, Calif.*

Mechanically tunable over 1 GHz, a new solid-state Gunn oscillator for pumping low-noise parametric amplifiers spans the frequency range of 8 to 12.4 GHz. Its FM and AM noise (in a 1-kHz band at 10 kHz from the carrier) are under 50 Hz rms and 120 dB below the carrier level respectively. Outputs ranging from 25 to 100 mW are available and operating temperature range is −54 to +71°C.

CIRCLE NO. 341

## Multi-channel converter switches electronically



*Acrodyne Industries, Inc., 666 Davisville Rd., Willow Grove, Pa. Phone: (215) 657-1800.*

Performing low-noise frequency translation and up or down conversion, a new rf converter provides three or more electronically switchable crystal-controlled channels. The rf input range of model 205/3 is 20 to 1000 MHz, while the i-f output range is dc to 500 MHz. The converter unit uses p-i-n diode switching to change the local-oscillator channels.

CIRCLE NO. 342

## Microwave sweeper uses thin-film hybrids

*Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. Price: from $1450.*

The model 8620A microwave sweeper uses hybrid thin-film microcircuits throughout its rf sections. Each oscillator module, for example, contains a YIG-tuned oscillator microcircuit and a p-i-n diode modulator microcircuit. As many as three plug-in modules can nest in the unit's plug-in rf drawer; one combination of these will give a range of 100 MHz to 8 GHz.

CIRCLE NO. 343

## L-band amplifiers deliver 10 W cw


*Microwave Power Devices Inc., 556 Peninsula Blvd., Hempstead, N.Y. Availability: 4 to 8 wks.*

Transistorized modular amplifiers covering the instantaneous bandwidths of 1175 to 1424 MHz supply a cw power output of 10 W. These L-band units can be combined to provide an overall gain of 40 dB and power outputs as high as 35 W. They can operate indefinitely into load VSWRs of 2:1, any phase. The amplifier operates over the temperature range of −20°C to +80°C.

CIRCLE NO. 344

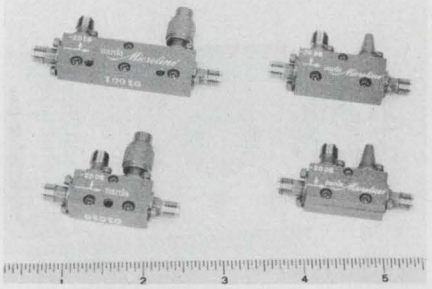
## Versatile generator sweeps 5 to 2350 MHz

*Texscan Corp., 2446 N. Shadeland Ave., Indianapolis, Ind. Phone: (317) 357-8781. P&A: $2495; 8 wks.*

Providing a full 10 mW of output power in both the cw and sweep modes, a new sweep-signal generator covers the frequency range from 5 to 2350 MHz in three overlapping bands. Model VS-90 has provisions for both single-frequency and harmonic-type frequency markers with crystal accuracies of 0.005%. It can also accept cw frequencies from external sources.

CIRCLE NO. 345

## Miniature hybrids weigh but 0.5 oz

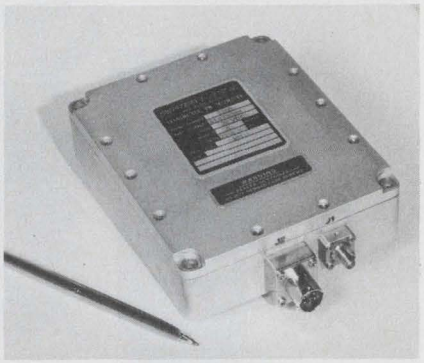


*Narda Microwave Corp., Plainview, New York. Phone: (516) 433-9000. P&A: $125 or $135; stock.*

Labeled Mini-Hybrids, series 4000C lightweight (0.5 oz) miniature hybrids are said to take up to 50% less space and weight than previously available units. They are ideal for systems use as power splitters, signal splitters, and mixers. Four models are available, covering the octave ranges of L, S, C and X bands. The units are equipped with stainless steel precision connectors.

CIRCLE NO. 346

## Telemetry transmitter delivers 10-W rf power

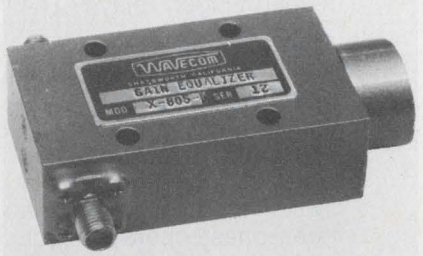


*Bertea Corp., 18001 Von Karman Ave., Irvine, Calif. Phone: (714) 833-1424. Availability: stock to 90 days.*

Employing solid-state circuitry, a new uhf telemetry transmitter suppiles 5 to 10 W of rf power from a package measuring only 6 × 5 × 1-1/2 in. Model 1100 weighs but three pounds and features modular construction. Its rfi/emi characteristics comply with standards IRIG 106-69, MIL-STD-461 and MIL-STD-826A.

CIRCLE NO. 347

## Adjustable equalizer smooths TWT outputs




*Wavecom, Inc., 9181 Gazette Ave., Chatsworth, Calif. Phone: (213) 882-3010.*

Model X-805 user-adjustable gain equalizer is designed to flatten the output curve of broadband amplifiers operating in the frequency range of 7 to 11 GHz. Three continuously variable adjustments are available to the user so that practically any TWT response can be leveled. Midband attenuation can be varied from 4 to 8 dB; power capability is 10 W cw.

CIRCLE NO. 348

## S-band circulator slims down size


*Trak Microwave Corp., 4726 Eisenhower Blvd., Tampa, Fla. Phone: (813) 884-1411.*

Spanning the frequency range from 2.6 to 3.2 GHz, an S-band ferrite circulator with 20-dB isolation measures only 1.25x1.25x0.5 in. Model 1420-1300 has 100% shielding and an insertion loss of 0.4 dB maximum. VSWR for both input and output is less than 1.2. The completely self-contained device has a maximum phase deviation of ±2 degrees.

CIRCLE NO. 349

## Sweep signal generator runs over 0.5 to 1 GHz

*Texscan Corp., 2446 N. Shadeland Ave., Indianapolis, Ind. Phone: (317) 357-8781. P&A: $1350, 6 wks.*

Utilizing a voltage-swept oscillator, a new sweep generator ranges over 500 to 1000 MHz. Sweep control of the VS-71 is such that any center frequency from 500 to 1000 MHz or any sweep width from 0.2 to 500 MHz can be selected. Built-in automatic leveling keeps the output within ±0.25 dB.

CIRCLE NO. 350

## Mounting system snaps into place

*Electraid, Inc., P.O. Box 53, Cambridge, Mass. Availability: 2 wks.*

A solderless component mounting system employs boards called Hook-n-Push that easily snap into pegboard holes, allowing vertical mounting of all components including transformers. The boards, which are terminated with Flexi-Grip solderless connectors, are held firmly in place by a spring clip. The connectors can accept up to eight solid leads of various diameters.

CIRCLE NO. 351

## Miniature coax has 19-mil OD

*Berk-Tek, Inc., P.O. Box 60, Reading, Pa. Phone: (215) 376-8071.*

Dubbed ultraminiature, a new line of 50-Ω coaxial cable features an outside diameter of 13 by 19 mils nominal. The center conductor is AWG#42 wire; the dielectric is a modified Teflon whose dielectric constant is below that of Teflon; the drain wire (for terminating) is AWG#36; the shield is aluminized Mylar; and the jacket is Vylex, a Mylar laminate. Applications include cryogenic environments.

CIRCLE NO. 352

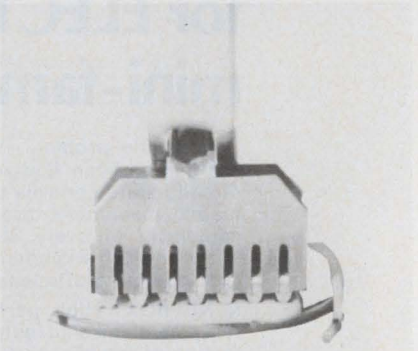
## Fiber-optic bundles come as flat ribbons

*Edmund Scientific Co., 380 Edscorp Bldg., Barrington, N.J. Phone: (609) 547-3488. Price: $9 or $81.*

Resembling a paper-thin sandwich, new 1-in.-wide fiber-optic ribbons, which contain 330 glass fibers, can be cut, split, bent, bundled or stacked to transmit illuminated images through any zig-zag path. Besides the type 41,225 ribbons, type 60,795 9-by-12-in. sheets are also available. Both types can be shaped to form a polished point for spectrographic applications.

CIRCLE NO. 353

## Spring-loaded heat sink protects DIP devices

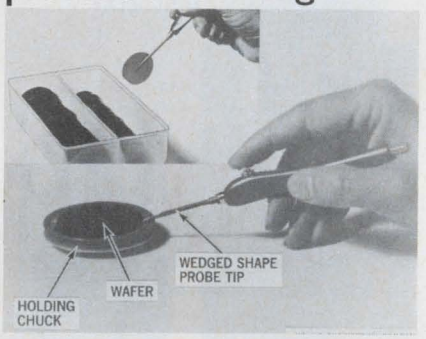


*Techni-Tool Inc., 1216 Arch St., Philadelphia, Pa. Phone: (215) 568-4457.*

Ensuring the thermal protection of dual-in-line packages during wave soldering, a new heat sink effectively wicks heat away from components without any danger to the machine transfer mechanism or the DIP itself. Model 4917 uses spring-loaded aluminum construction for easy installation and removal. It can accommodate either 14 or 16-pin dual-in-line packages.

CIRCLE NO. 354

## Wafer vacuum tips prevent scratching

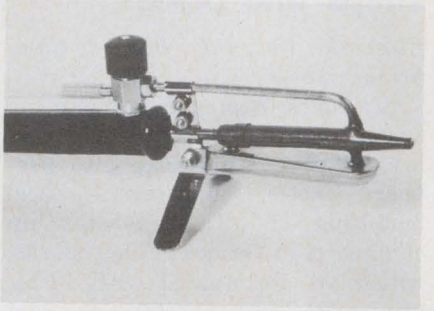



*Air-Vac Engineering Co., Inc., 100 Gulf St., Milford, Conn.*

Teflon-coated vacuum tips allow silicon wafers to be handled so gently that scratching or marring is virtually eliminated. Two tips are available: one is slender with a wedge-shaped point that can be slipped under the wafer while it is on the holding chuck, permitting the wafer to be picked off and transferred without touching the top surface; the second is a round disc that forms a tapered vacuum cup to facilitate removing and positioning of the wafer into the holding boat.

CIRCLE NO. 355

## Desoldering tool cleans itself



*Hunter Associates, 182 Clairmont Terrace, Orange, N.J. Phone: (201) 672-0423. P&A: $21.95; stock.*

Working from compressed air, the model GSS desoldering tool, which is designed for use on miniature and microminiature circuit boards and subassemblies, continuously cleans itself by means of the high-pressure air flow. The unit has a stainless-steel solder catcher that is fitted with a hinged cover to prevent solder fragments from falling onto the circuit board or subassembly.

CIRCLE NO. 356

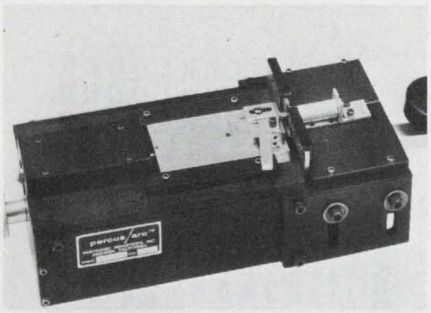
## Thermal wire stripper uses centrifugal force

*Republic Corp., Roto-Therm Div., 950 N. Sepulveda Blvd., El Segundo, Calif.*

Able to strip most insulations including Teflon and Kapton, a new thermal wire stripper features a centrifugal-force insulation-severing technique that ends conductor damage. Model RT-1 uses a spinning gimbal-mounted thermal element that is applied to the wire by its own centrifugal force. Since the centrifugal force approaches zero as the element approaches the vertical position, application of the element is delicate yet positive.

CIRCLE NO. 357

## Capacitor fixture butt-welds leads

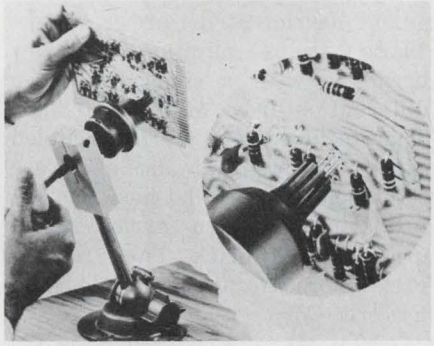


*Protronic Industries, Inc., 2415 S. Manchester Ave., Anaheim, Calif. Phone: (714) 635-9310. P&A: $895; 2 wks.*

Utilizing the percussive arc welding method, a new welding fixture can butt-weld headed leads to aluminum foil-wound tubular capacitors. Tinned copper or nickel leads are metallurgicaly joined to the aluminum foil of the capacitor, creating a good electrical connection and a strong mechanical joint. Model ABW-310 handles capacitors with 3/8 to 2 in. dia and 3/4 to 2 in. long.

CIRCLE NO. 358

## Component loader handles TO devices

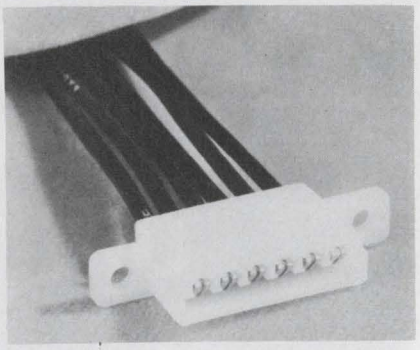


*Solatron Enterprises, 421 E. Beach Ave., Inglewood, Calif. Phone: (213) 678-4981.*

Available in several models, the model 79-3370 component loader allows quick and convenient handling of multiple-lead op amps and relays in TO-style packages. The unit will accommodate from 3 to 12 leads in any length on various pitch circles in round or square packages. As many as 12 units per minute can be loaded and their leads combed for quick insertion into insulators, printed circuit boards, carriers or sockets.

CIRCLE NO. 359

# Evaluation Samples



## Six-circuit connector

A free sample is available of a new six-circuit straight-on printed circuit edge connector. This connector, like others in the Edge-Con series, has reliable crimp-type terminals supplied in chain-link form. It can be easily handled with automated crimping machines. Terminals snap-lock into nylon housings, but can be easily removed with a simple tool. Also included in the series are 9, 15, 21 and 22-circuit right-angle and straight-on models. Molex Products Co.

CIRCLE NO. 360

## Temperature monitors

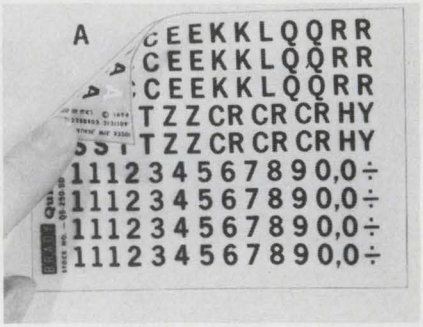
Free samples of self-adhesive temperature monitors are available. These monitors are transparent heat-resistant labels that turn black once the rated temperature on the label is reached. Because the color change is irreversible, a permanent temperature record of any device under test is available. Ratings are available from 100 to 500°F. Tempil Div. of Big Three Industrial Gas & Equipment Co.

CIRCLE NO. 361

## Microwave substrates

Rf sputtered chrome-gold substrates for microwave integrated circuits are available as free evaluation samples. The latest in deposition technology, they offer the ultimate in film adhesion and quality. Electrotec, Inc.

CIRCLE NO. 362




## Dry transfer lettering

A sheet of Quikset, a new dry transfer PC lettering that offers extra convenience in handling and inventory because of its compact design is available as an evaluation sample. Each sheet contains several complete sets of either numbers, alphabets or sequential designations. Two sizes are available: 1/4-in. high lettering for 4:1 layouts and 1/8-in. high lettering for 2:1 layouts. W. H. Brady Co.

CIRCLE NO. 363

## Barrier strips

Samples of new low-cost resilient barrier strips are available. These strips eliminate barrier breakage with a choice of three different sturdy strip materials. They include factory pre-assembled captive screws that also eliminate screw shake-outs. Flat-base or self-insulating feed-thru carrier configurations and black, blue, red or gray colors are available. Magnum Electric Corp.

CIRCLE NO. 364

## Electronic lubricant

Electrolube is a new highly effective cleaning agent for lubricating contacts in electronic circuits. This lubricant combines the desired properties of conventional contact lubricants with a unique property that decreases contact resistance. It is available in aerosol spray cans, tubes, pen and bottle dispensers or bulk packages. Free samples are available. Trans Atlantic Electronics Inc.

CIRCLE NO. 365

# Tin-novation

**Solder preforms . . . a new way to use tin solder**

Automation and miniaturization have made it necessary to change the physical structure and dimensions of many components and products. Solder is no exception.

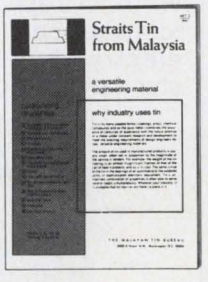
Solder preforms are available from most of the large solder manufacturers — in either flux cored or solid forms — in an almost limitless variety of shapes, sizes, designs, and configurations: washers, discs, rectangles, ovals, pellets, rings, coils, stampings, wire, sleeves, tubes, spheres, etc.

Just the right amount of flux and solder of a predetermined tin alloy is placed exactly where it is required. Waste is eliminated, production increased, joints uniform, and rejects reduced. Many soldering operations can be made part of an automatic operation, eliminating the need for skilled soldering help. Solder preforms are especially adaptable for soldering inaccessible points — and where previous bonds should not be disturbed. Further operating cost reductions are realized with mass production heating techniques.

Solder is the second largest user of tin in the world, tinplate being first. About 20% of the world's consumption of tin goes into solder. Tin's unusually advantageous combination of properties makes it an ideal metal for use in solder alloys. Tin has a low melting temperature, malleability, corrosion resistance, and an attractive lustrous appearance.

## Think Tin

Just as tin works so well in solder and solder preforms, it may also hold the answer to one of your current or future metal problems — as an additive, an alloy, or coating. Straits Tin from Malaysia, the sterling of tin . . . world standard for uniformity.

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Contains thorough descriptions of major applications and useful technical data on general, thermal, electrical, and mechanical properties. Send for your free copy today.

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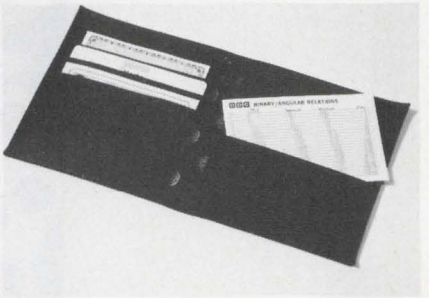
Dept. S19-E, 2000 K St., N.W., Washington, D.C. 20006

INFORMATION RETRIEVAL NUMBER 111

# Design Aids



## Binary/angular card

Binary and angular relationships are shown on a new laminated wallet-sized card that is useful to the engineer working with the conversion of data, such as synchro-to-digital applications. In chart form, it shows equivalent angular values in degrees and minutes per bit, and the least significant bit in percent of full scale. DDC, a Div. of Solid State Scientific Devices Corp.

CIRCLE NO. 366

## Paste-on logic symbols

Various geometric symbols such as circles, squares, triangles and rectangles that can be pasted on PC boards for use as logic symbols are available. These symbols could be used to indicate operational amplifiers, gates, mixers, and summing junctions. They were designed to be used with the Wrap-X system of PC boards. Datascan Inc.

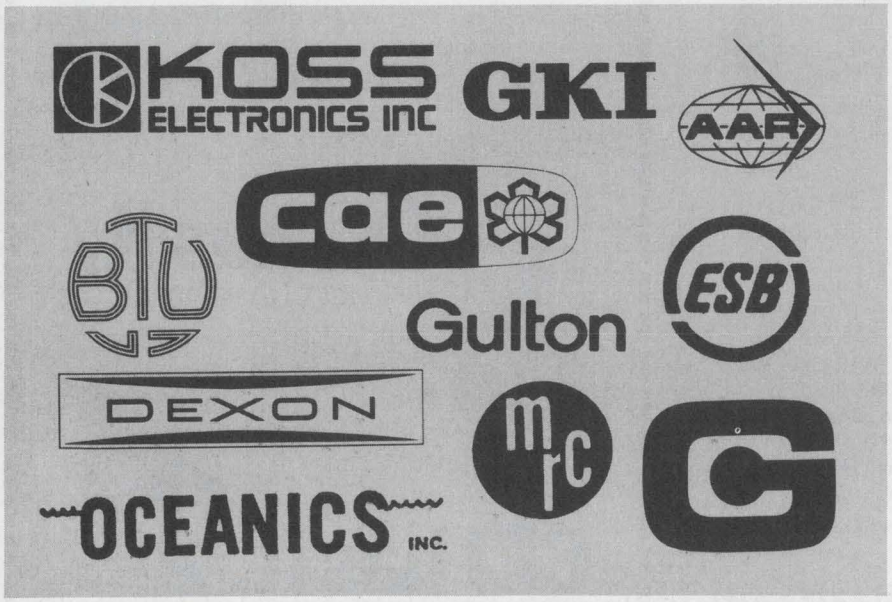
CIRCLE NO. 367

## Zener surge guide

Especially useful when designing for surge applications is a zener surge selection guide which lists zener types from 1 to 10 W with specific voltage and surge ratings for each individual type. This handy reference guide includes a graph showing reverse surge power for pulse durations from 100 ns to 10 ms for each family. It also includes each zener package's outline drawing. Unitrode Corp.

CIRCLE NO. 368

# Annual Reports




**Allen Aircraft Radio, Inc.,** 2050 Touhy Ave., Elk Grove, Ill.

Aircraft instrumentation, manufacturing, overhaul and certification, aviation services.

1969: Net sales, $9,956,274; net income, $354,210.

1968: Net sales, $5,722,861; net income, $64,880.

CIRCLE NO. 369

**BTU Engineering Corp.,** 179 Bear Hill Rd., Waltham, Mass.

Furnaces for flatpack lidding and soldering and for high-temperature hydrogen sintering.

1969: Net sales, $3,433,118; net income, $215,196.

1968: Net sales, $2,745,940; net income, $153,281.

CIRCLE NO. 370

**CAE Industries Ltd.,** P.O. Box 6166, Montreal, Quebec, Canada.

Airlines, flight simulators, data processing, pulp, paper, textiles, sheet metal fabrication.

1969: revenue, $39,244,350; earnings, $1,008,453.

1968: revenue, $42,820,898; earnings, $1,153,367.

CIRCLE NO. 371

**Dexon, Inc.,** 3440 Belt Line Blvd., Minneapolis, Minn.

Ultra-clean process equipment for the microelectronic, biological and hydraulic industries.

1969: sales, $1,468,108; net earnings, $1,564.

1968: sales, $1,212,437; net earnings, $154,645.

CIRCLE NO. 372

**ESB Inc.,** 2 Penn Center Plaza, Philadelphia, Pa.

Batteries, lighting devices, minerals, chemicals, plastics, power and communications systems.

1968: net sales, $232,833,988; net income, $7,020,705.

1967: net sales, $227,077,002; net income, $9,386,166.

CIRCLE NO. 373

**Genisco Technology Corp.,** 18435 Susana Rd., Compton, Calif.

Control systems, tape recorders, filters, panel lamps, PC boards, accelerometers, transducers.

1969: net sales, $11,786,509; net income (loss), ($1,085,654).

1968: net sales, $13,295,377; net income, $349,973.

CIRCLE NO. 374

**General Kinetics Inc.,** Isaac Newton Square, Reston, Va.

Tape equipment, metal enclosures, instruments for analysis.

1969: sales, $3,447,856; net income (loss), ($374,948).

1968: net sales, $4,262,680; net income, $470,321.

CIRCLE NO. 375

**Gulton Industries, Inc.,** Gulton St., Metuchen, N.J.

Aircraft systems, components, power and medical systems.

1969: net sales, $92,201,813; net earnings, $2,950,036.

1968: net sales, $92,487,576; net earnings, $4,794,289.

CIRCLE NO. 376

**Koss Electronics Inc.,** 2227 N. 31st St., Milwaukee, Wis.

Electrostatic stereo-fidelity headphones and home entertainment products.

1969: net sales, $2,902,932; net income, $251,569.

1968: net sales, $1,846,556; net income, $115,619.

CIRCLE NO. 377

**Materials Research Corp.,** Orangeburg, N.Y.

Sputtering systems and targets, metal purification and fabrication, ceramic substrates.

1969: net sales, $4,174,951; net income, $302,259.

1968: net sales, $2,692,317; net income, $145,978.

CIRCLE NO. 378

**Oceanics, Inc.,** Technical Industrial Park, Plainview, N.Y.

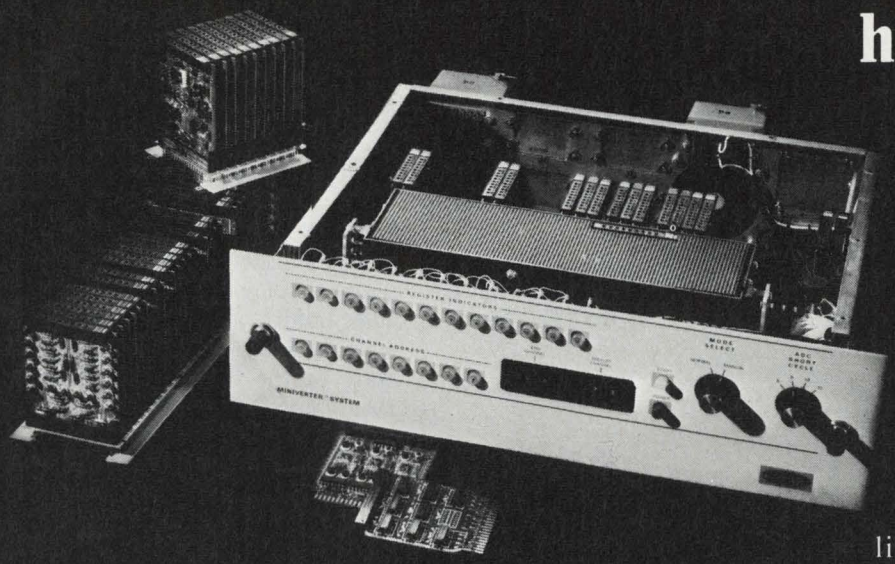
Ship propulsion systems and computerized routing, computers and computer services.

1969: total income, $526,203.52; net income, $27,945.24.

1968: total income, $426,812.06; net income, $28,705.67.

CIRCLE NO. 379

# Making speed/cost trade-offs in conversion equipment? With Raytheon Computer, you can have it both ways.



Analog/digital interfaces and conversion can end up costing you more than any other portion of your system.

So we've come up with a system of our own. Instant conversion in a range of prices and performance levels. All with the best price/performance ratio in the industry.

For analog-to-digital conversion, $1,220 buys you our 10-bit A-to-D converter and a 50kHz word rate. $1,790 buys our 12-bit high-speed 100kHz Miniverter™. $4,095 gets our 100kHz, 15-bit Multiverter® III. Each of these analog-to-digital converters has 8 multiplexed channels (expandable to 128) and a short-cycle control for even higher through-puts with shorter words.

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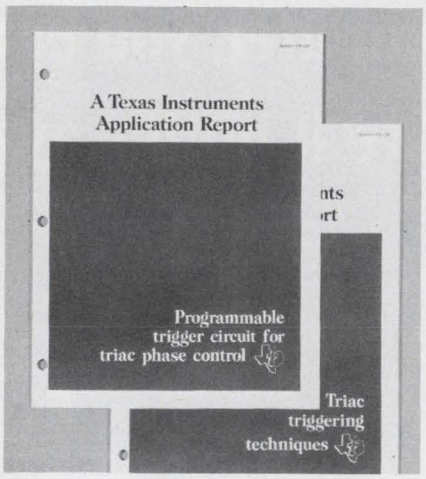
# Application Notes




## Triacs

Two new application reports cover triac phase-control and triac triggering techniques. Bulletin CA-137, "Programmable Trigger Circuit for Triac Phase Control," explains how a trigger circuit combined with a suitable triac can regulate ac power by phase control in response to voltage inputs to an operational amplifier. Bulletin CA-138, "Triac Triggering Techniques," describes how to accomplish the triac triggering function and illustrates different methods for controlling ac power with triacs. This 20-page bulletin reviews triac characteristics and principles and then discusses triac construction and electrical parameters. Texas Instruments, Inc.

CIRCLE NO. 380

## Electromagnets

The laboratory electromagnet and its applications are discussed in a new 37-page booklet. Through simple qualitative discussions, the booklet acquaints the reader with the basic features of the laboratory electromagnet, its principle applications, and the terms which describe its performance. References are furnished throughout for readers who wish to study an application in depth. Varian Analytical Instrument Div.

CIRCLE NO. 381

## Materials publication

A new publication titled the SAMPE Quarterly (Science of Advanced Materials and Progess Engineering) published by the Society of Aerospace Materials and Process Engineering is now available. It includes thorough articles on materials, disciplines, current advanced materials technology and the latest developments in materials research, written by experts in the field. Society of Aerospace Materials and Process Engineering.

CIRCLE NO. 382

## Fast-recovery diodes

Circuit applications of fast-recovery power diodes are discussed in a 24-page report. It discusses the measurement of reverse waveforms and recovered charge. Also included are circuit applications for high-frequency power rectification, free-wheeling diodes and inverters and dc choppers. Schematic representations and characteristic curves are also given. International Rectifier, Semiconductor Div.

CIRCLE NO. 383

## Filter simulation

A technical abstract giving analog techniques for filter simulation is available. It provides various simulation techniques for low-pass and high-pass filters. These techniques are based on the filter transfer function. Frequency scaling is discussed for converting cutoff frequencies from the normalized one radian per second to the desired cutoff frequencies. The abstract is illustrated with circuit configurations and contains many useful equations. Electronic Associates, Inc.

CIRCLE NO. 384

## Neon-lamp applications

The application of neon glow lamps to a test system and to diagnose computers is discussed in two feature articles of a recent issue of Signalite Application News, volume 7, number 3. It explains how a relatively inexpensive testing system was designed to check the circuits on a multilayer board. Also in this issue an article discusses the diagnosis of a computer employing neon glow lamps. The lamps are used to indicate malfunctions, and the amount and state of the data stored. Signalite Inc.

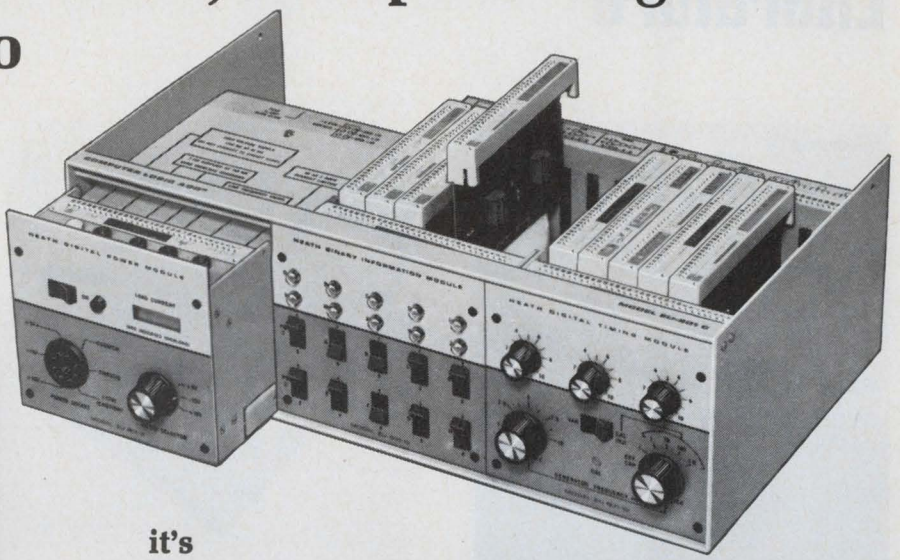
CIRCLE NO. 385

## Thermocouple response

A 20-page brochure contains the basic theory of millisecond-response thermocouples. It includes a mathematical anlysis of the basic theory of thermocouple response, accuracy and the relationship of heat transfer to thermocouple junctions. It concludes that ultra-miniature thermocouples, having the smallest exposed junction available, offer faster temperature measurements than other thermocouple junctions having identical materials of larger size. It notes that small size has the advantage of offering a minimum disturbance to the temperature and flow fields of the environment in which they are used. Also included is information regarding the effect of the time constant on thermocouple response to discontinuous and linear temperature variations and the effect of thermocouple time constant on frequency response. Radiation error versus thermocouple wire diameter, thermocouple time constant versus wire diameter, and the effect of gas velocity on thermocouple time constant are also shown. High Temperature Instruments Corp.

CIRCLE NO. 386

# Now There's A Better, More Effective Way To Teach (And Learn) Computer Logic... Costs Less Too

## the NEW Heath 801C Computer Logic Teaching System...

## $365* Complete

**it's**

**Complete**— Includes the Computer Logic (ADD™); a Workbook and a Text "Digital Electronics For Scientists".

**Versatile**— Circuit Cards can be plugged in and arranged in any order; Chassis Modules are removable and rack-mountable.

**Expandable**— Other Digital, Analog and Analog-Digital functions can be studied by substituting appropriate plug-in circuits cards.

**Sophisticated**— Modern, state-of-the-art TTL IC's are used throughout the system; complete complex function circuit cards are also available to ensure up-to-date capability.

**Inexpensive**— Complete 801C System, including the Computer Logic ADD, workbook and text is only $365.00* ... 20% less than any other logic system.

**The New Heath 801C Computer Logic Teaching System** is a radical departure from ordinary computer logic systems. Designed by professional educators (Drs. Malmstadt and Enke) with the problems of teaching this complex subject in mind, it will do a thorough, effective job. Here's why...

**It's Complete.** The new 801C System includes the EU-801C Computer Logic Analog-Digital Designer (ADD™), a pioneering new text by Drs. Malmstadt & Enke "Digital Electronics For Scientists" and a detailed, comprehensive workbook containing 50 experiments. The EU-801C ADD is a complete computer logic training device, including Power, Binary Information and Timing Modules and 18 NAND Gates, 4 And-Or-Invert Gates and 8 J-K Flip-Flops on plug-in circuit cards. The Workbook "Computer Logic", by Drs. Malmstadt & Enke, includes 50 experiments written to be performed on the 801C ADD and keyed to the text. The 500 page "Digital Electronics For Scientists" is an up-to-date text for the study of modern digital logic. Although only the non-electronic portions of the text are used with the 801C ADD, the complete text is an invaluable study and reference source for modern digital techniques.

**It's Versatile**... far more so than any other logic training device available. Each plug-in circuit card contains a discrete function such as a gate or flip-flop, and the cards can be arranged in any order. All cards are labeled with standard logic symbols. Cards are simply patched together with ordinary hook-up wire without soldering to form complete logic sub-systems or systems. The three Chassis Modules can be removed from the cabinet, interchanged, even rack mounted.

**It's Expandable.** The 801C is the only logic teaching system available that can be expanded to other uses... quickly, efficiently and inexpensively. Heath now offers over 20 plug-in circuit cards and more are being introduced regularly. Combinations of these low-cost cards can be used to provide teaching and design capability for computer interfacing, digital instruments and analog-digital measurement and control systems... merely by plugging in the appropriate cards. No other system at any price has this vast flexibility.

**It's Sophisticated.** TTL Integrated Circuit Logic—as used in modern computers—is used throughout the 801C to provide reliable operation, high speed and noise immunity and compatibility with today's computers. And because new circuit cards are continually being introduced, the 801C will never be obsolete.

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**Write For The New Free Heath Scientific Instrumentation Catalog** and investigate this unique system now.

**EU-801C,** complete Computer Logic System ..... **$365.00***

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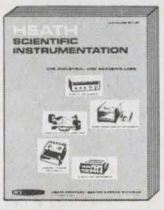


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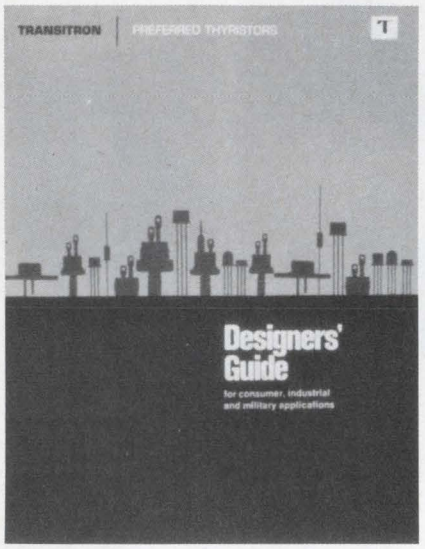
INFORMATION RETRIEVAL NUMBER 119

# New Literature




## Thyristors

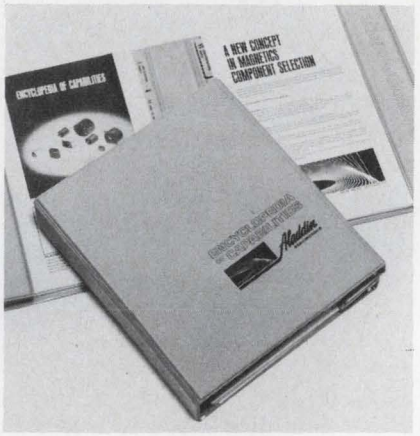
A new 20-page designer's guide to industry-preferred thyristors is available. It covers triacs, SCRs, gate-turn-off and photosensitive devices and chips. Included are thyristor symbology and definitions, applications suggestions and packaging considerations. Products covered are used in computers, opto-electronic circuits, displays, power conversion, ac power control and microwave systems. Transitron Electronic Corp.

CIRCLE NO. 387

## Active filters

Salient features of a previously unexploited transistor mechanism which has been found to yield a stable high-Q inductance are outlined in a new paper on active filters for uhf and microwave applications. It shows how a transistor can be substituted for an inductor in conventional filter designs. Described are such characteristics as stability, frequency range, temperature effects, noise figure, and dynamic range. Several applications are discussed including active bandpass and bandstop filters, and active frequency multiplexing or contiguous channelizing filters. Wavecom, Inc.

CIRCLE NO. 388




## Magnetics encyclopedia

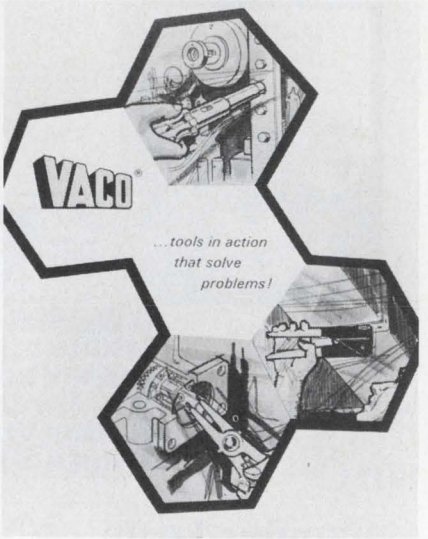
The "Encyclopedia of Capabilities" is a comprehensive publication which provides direct access to magnetic-component design capabilities, including more than 15,000 designs without listing a single part number. It is contained in a double-ring binder, which separates the book into an applications section and a configurations section. The reader can open to any applications page and configurations page simultaneously. The applications section allows the reader to specify pertinent parameters while the configurations section contains line drawings showing actual internal construction as well as external dimensions and mounting. Aladdin Electronics

CIRCLE NO. 389

## Infrared spectroscopy

Applications and techniques useful to infrared spectroscopists are included in a new 40-page authoritative handbook. Performance characteristics, spectra, prices and ordering information are given on a complete line of IR spectrophotometer cells, crystals and accessories. Hundreds of items illustrated show advanced designs in micro-sampling accessories including a new precision microcell, specular reflectance units, a new pyrolyzer and liquid and gas cells. Barnes Engineering Co.

CIRCLE NO. 390




## Tools

Catalog SD-170 is a 36-page book that contains hand tools of nearly every variety. These tools include screwdrivers, nutdrivers, pliers, wrenches, fasteners, riveters, wire strippers and ratchet sets. Also included are special tools such as clutch-head drivers, hex-key wrenches, offset drivers and screw launchers. Included in the catalog are complete descriptions, dimensions and handy tool accessories. Vaco Products Co.

CIRCLE NO. 391

## Time-share program

A seven-page application abstract explains how a remote time-sharing terminal and a computer program allows circuit designers to quickly and efficiently determine where to place components and how to route conductors on IC boards. Called PWR, the program is one of several that can be used for electrical-engineering applications. Described are the program's input and output. A simple problem illustrates its over-all capability. Execution times for several jobs that were performed by the program in analyzing various circuits are tabulated. Remote Computing Corp.

CIRCLE NO. 392

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INFORMATION RETRIEVAL NUMBER 120

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PEC in 1967 was the first to recognize the need for compact inexpensive IBM compatible magnet tape units to serve the rapidly expanding market for small computers, data terminals and digital systems.

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An exceptional opportunity to join PEC in opening new accounts and maintaining contact with prospective and existing digital tape unit customers based out of San Francisco. Successful candidates should possess a BSEE, ME, Math or Physics plus 4 years directly applicable experience.

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INFORMATION RETRIEVAL NUMBER 904

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# radar simulators

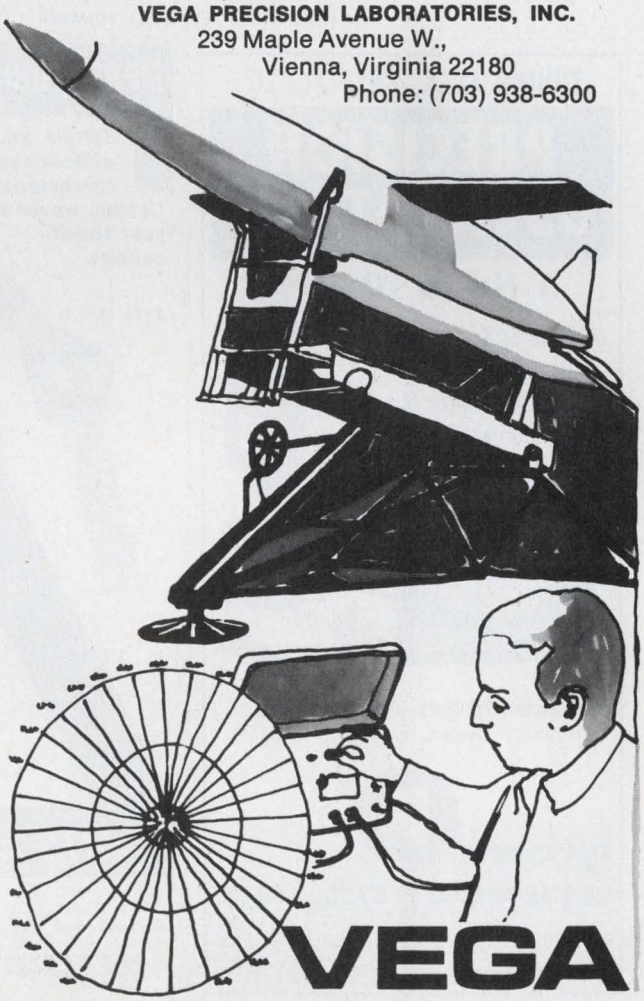
Vega Radar Simulators are flight line test sets which are used to interrogate and measure the parameters of a radar transponder or beacon for purposes of final checkout on the launch pad or flight line. It is particularly useful when tracking radars are located at great distances from the launching site.

The Vega Radar Simulator incorporates a transmitter and receiver calibrated and controllable from the front panel in tuned frequency, output power, code spacing and sensitivity, with which the parameters of a remote transponder can be monitored and measured. In addition, it also contains a built-in Oscilloscope, which is used for viewing transmitted and received pulses. The entire unit operates on either external 117 VAC, 12 VDC or internal battery.

Vega C, S and X-Band Radar Simulators will check these transponder parameters while under test: Receiver Frequency • Receiver Sensitivity • Transmitter Frequency • Transmitter Power Output • Code Spacing • Pulse Parameters (Pulse width, rise time, fall time, etc.)

Units with telescoping legs are also available. Picture how a Vega Radar Simulator would fit into your launch operation, particularly for final checkouts. Contact:

**VEGA PRECISION LABORATORIES, INC.**
239 Maple Avenue W.,
Vienna, Virginia 22180
Phone: (703) 938-6300




INFORMATION RETRIEVAL NUMBER 121

## ICs and semiconductors

A condensed 16-page catalog describes several lines of integrated circuits and discrete semiconductors. Integrated circuits include TTL, linear and DTL lines. Discrete components include epoxy and glass rectifiers, germanium, silicon and thyristor diodes and silicon transistors. Also included are MOS arrays, military and high-reliability semiconductors, semiconductor chips and wafers, modules and special products. ITT Semiconductor Div.

CIRCLE NO. 393

## Terminals

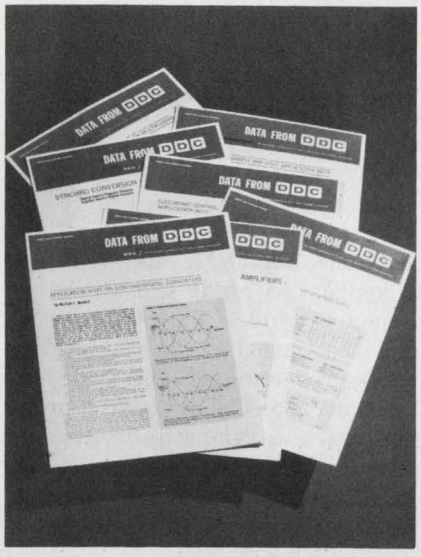
An entire line of solderless electrical terminals is contained in a new 20-page catalog. It includes complete descriptions, electrical and mechanical specifications, and dimensional data for nearly 300 items. Products described include straight and flag-type terminals, splices and quick disconnects. The terminals described can be crimped either individually or with semi-automatic machinery at various production rates. AMP Incorporated.

CIRCLE NO. 394

## Graphic recording

The "Flying Spot" component recorders for pattern, plot or picture forms are described in a 16-page catalog. Featured applications include frequency spectrum analysis. Recordings of low radio-frequency emanations from lighting and other electromagnetic phenomena of interest in communications studies are clearly illustrated. Also included are recordings of ionospheric back scatter made during long-range communications studies by radar in real time. Alden Electronic & Impulse Recording Equipment Co., Inc.

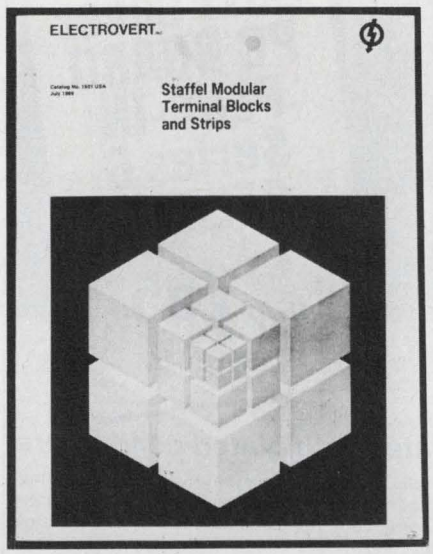
CIRCLE NO. 395




## Design notes sets

Many fields of interest to design engineers are covered by several sets of application notes. They cover topics such as applications of wideband amplifiers, digital-to-analog converters and analog-to-digital converters. Also covered are sample-and-hold circuits, multiplexers and synchro converters. Recipients of these application notes will have the opportunity to receive future notes as they are produced. DDC, a div. of Solid State Scientific Devices Corp.

CIRCLE NO. 396




## Terminal blocks

Complete information and specifications on a modular terminal-block and terminal-strip line are shown in a 32-page catalog. The line provides a wide range of precision engineered melamine terminal blocks which snap individually into or out of one of two standard assembly rails. All units are shrouded by the insulating body for safety and feature captive screws to prevent loss during shipping or installation. Electrovert, Inc.

CIRCLE NO. 398

## Hewlett-Packard Journal

The March 1970 issue of the Hewlett-Packard Journal is now available. It includes three articles. One article deals with a computing counter and a keyboard combination that form a programmable measurement and computing system. A second article deals with factors to be considered in protecting hospital patients from dangerous electrical hazards. A third article discusses a processing system formed of a desktop calculator and a multichannel analyzer system for data processing. Hewlett-Packard.

CIRCLE NO. 397

## Test accessories

Electronic test accessories covering 56 pages are contained in a new catalog. Featured are 420 items such as molded test accessories and patch cords, cable assemblies, test and connecting leads, socket adapters, black boxes and other items. Complete engineering information on each item is provided, including photographs, dimensioned drawings, schematics, specifications, features and operating ranges. All items are designed to meet rigid industrial and military specifications. Pomona Electronics.

CIRCLE NO. 399

NEW LITERATURE

## Silicones

A wide variety of General Electric silicone greases and compounds are described in a 12-page technical data book. Contained within the data book are sections detailing silicone greases for lubrication and silicone compounds for insulation and general-purpose applications. The book also features an application guide and a product summary guide. The latter outlines the typical physical and electrical properties of the full line of products. Silicone grease properties such as compatibility, resistance to temperature variations, stability, oxidation resistance and chemical content are discussed. General Electric Co.

CIRCLE NO. 400

## Vhf and uhf filters

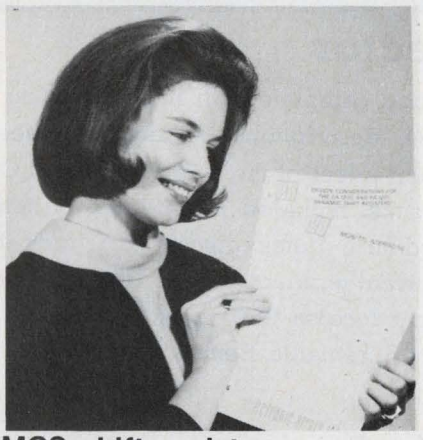
A line of standard low-pass filters for incorporation in vhf and uhf transmitters and receivers are described in a new catalog. They operate in the frequency regions of 110 to 150 MHz and 225 to 400 MHz and feature power capabilities up to 75 W. Filters described include connector options of N, BNC, TNC, HN, and subminiature types. The catalog includes typical operating characteristics and case outline drawings. Microwave Filter Co., Inc.

CIRCLE NO. 401

## Instrument cases

Standard fiberglass cases designed for hand-held portable field instruments and equipment are the subject of a 12-page catalog. Specifications and general information are included for an extensive line of cases that are available from stock. Also described and illustrated are cases manufactured to military specifications, custom case interiors, special hardware, cases with sandwich-construction features, and plastic and custom models. Skydyne, Inc.

CIRCLE NO. 402



## MOS shift registers

An eleven-page paper generated to aid the user in the selection, testing and proper electrical implementation of dynamic MOS shift registers is available. It covers general design considerations and includes sections concerning clock options, power dissipation considerations, interfacing factors, a shift register circuit and application examples. Electronic Arrays, Inc.

CIRCLE NO. 403

## Minicomputer report

The entire special 1970 Spring Joint Computer Conference section of the April 26 issue of ELECTRONIC DESIGN, which includes the directory on minicomputers, is now available. The section also includes a special 10-page report on minicomputers, plus the conference's complete product highlights and features. Hayden Publishing Co., Inc.

CIRCLE NO. 404

## Tools

Catalog 171 is a new publication that contains a listing of hand tools, tool kits, and tool assortments. It includes such tools as screwdrivers, nutdrivers, scratch awls and four-in-one tools. In addition, 44 new items are included. Prices, a list of sales representatives and important conversion tables that are applicable to the hand-tool industry are provided. Upson Tools, Inc.

CIRCLE NO. 405

## Ethyl silicates

The scope of information on ethyl silicates has been increased with a new 11-page bulletin. Several applications are described in an expanded applications section. In many instances the U. S. patent number is listed so that the reader can follow through in obtaining information. An expanded formulations table outlines the formulations to use in preparing solutions for hydrolysis. It is supplemented by a complete description of both the solvent and the nonsolvent methods for achieving this hydrolysis. Union Carbide Corp.

CIRCLE NO. 406

## Metal powder directory

The latest edition of a directory of domestic and foreign sources of metal powders is available. The directory, which was released by the Metal Powder Producers Association lists more than 50 ferrous and nonferrous metal powders. These are indexed alphabetically according to the types of powders supplied by each of 52 companies. Complete addresses of all the firms, who are members of the Metal Powder Producers Association, are also given. Metal Powder Producers Association.

CIRCLE NO. 407

## Aluminum capacitors

New performance data on aluminum capacitors is available in an engineering bulletin that describes a tubular non-aqueous electrolyte capacitor series for operation over an extended-temperature range. Within their temperature range of $-55$ to $+85°C$, these capacitors show performance characteristics which equal those of the more costly tantalum foil units. Included in the bulletin is a list of standard ratings in capacitance values from 13,000 $\mu$F at 5 V dc to 290 $\mu$F at 200 V dc. Complete performance characteristics are also given. Sprague Electric Co.

CIRCLE NO. 408





INFORMATION RETRIEVAL NUMBER 129 ►

# Electronic Design

ELECTRONIC DESIGN'S function is:

- To aid progress in the electronics manufacturing industry by promoting good design.
- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
- To promote two-way communication between manufacturer and engineer.

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# Design Data from

## Terminal Block Selector


A new 24-page, completely illustrated catalog contains photos, descriptions, ratings, engineering drawings, and prices of the complete line of Curtis terminal blocks. Included are printed circuit, insulated feed-thru, quick disconnect, track type, and high current terminal blocks. Handy selection chart quickly locates the perfect block for your particular requirements. Send today for your free copy.

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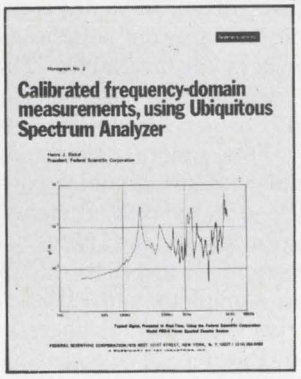
171

## Calibrated Frequency-Domain Measurements




A theoretical discussion of the methods of performing calibrated frequency-domain measurements using narrow-band and wide-band signals are detailed. Methods of calibrating real-time spectrum analyzers, such as with the Ubiquitous® Spectrum Analyzer, are discussed using pure sine waves and broadband noise to obtain power spectral density plots. The calibration method described provides accurate, quantitative measurement of noise, vibration, and underwater acoustic signals which have been processed by a power spectral density system using the well-known Ubiquitous® Spectrum Analyzer. Send for free Technical Monograph #2.

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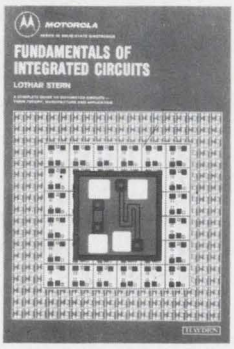
172

## FUNDAMENTALS OF INTEGRATED CIRCUITS




A practical guide to integrated circuits, their theory, manufacture, and applications. This new guide by Lothar Stern offers compete, highly readable coverage of the various techniques of circuit fabrication, and their effect on circuit design and performance. As to marketing considerations, it compares the characteristics of the numerous IC structures devised to date in terms of economics and logistics. A volume in the **Motorola Series in Solid-State Electronics.** 198 pages, 7 x 10, illustrated. $8.95, clothbound. Circle the reader-service number below for 15-day examination copies.

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173

# Manufacturers

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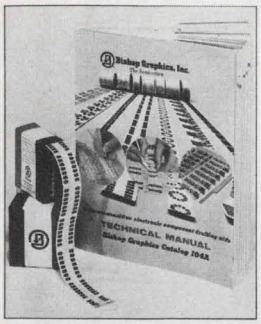
## 1970 Electronic Components Drafting Aids Catalog

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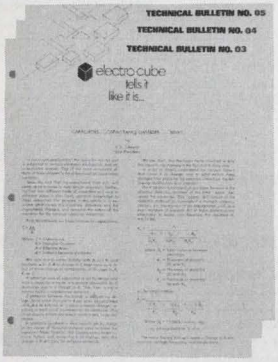


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# Advertisers' Index


| Advertiser | Page |
|---|---|
| ADC Products, A Division of Magnetic Controls Co. | 119 |
| Aladdin Electronics | 63 |
| Alco Electronic Products, Inc. | 130, 169, 171 |
| Allco | 64D |
| Allen-Bradley Co. | 27 |
| American Astronics, Inc. | 52 |
| Analogic Company | 154 |
| Applicon Incorporated | 55 |
| Associated Testing Laboratories, Inc. | 64 |
| Automatic Electric Company | 48, 49 |
| Beckman Instruments, Inc., Helipot Division | 113 |
| Belden Corporation | 110, 111 |
| Bishop Graphics, Inc. | 173 |
| Burr-Brown Research Corporation | 117 |
| Burroughs Corporation | 20 |
| CTS Corporation | 141 |
| Calvert Electronics, Inc. | 161 |
| Cambridge Thermionic Corporation | 56 |
| Centralab Semiconductor Division, Globe Union, Inc. | 61 |
| Chicago Dynamics Industries, Inc. | 62 |
| Cinch-Graphik | 79 |
| Cinch Manufacturing Company | 35 |
| Clare & Co., C. P. | 153 |
| Cohn Corp., Sigmund | 132 |
| Computervision Corporation | 10 |
| Coto Coil Company, Inc. | 170 |
| Curtis Development & Mfg. Co. | 172 |
| Cutler-Hammer | 115 |
| Dale Electronics, Inc. | Cover III |
| Datascan, Inc. | 145 |
| Delco Radio, Division of General Motors | 104, 105 |
| Diversified Electronics, Inc. | 156 |
| Dow Corning Corporation | 66 |
| Durant Digital Instruments, A Cutler-Hammer Company | 68 |
| E-H Research Laboratories, Inc. | 53 |
| EICO Electronic Instr. Co., Inc. | 173 |
| ENM Company | 161 |
| ERA Transpac Corporation | 150 |
| Eastman Chemical Products, Inc. | 168 |
| Edmund Scientific Company | 161 |
| Electro Cube | 149, 173 |
| Electro Products Laboratories, Inc. | 155 |
| Exact Electronics, Inc. | 120 |
| Executone, Inc. | 170 |
| Fairchild Controls, A Division of Fairchild Camera and Instrument Corporation | 143 |
| Fairchild Microwaves and Optoelectronics | 33 |
| Fairchild Semiconductor, A Division of Fairchild Camera and Instrument Corporation | 42, 43 |
| Federal Scientific Corp. | 172 |
| Fork Standards, Inc. | 168 |
| Gencom Division, Varian/EMI | 158, 167 |
| General Dynamics | 90, 91 |
| General Electric Company | 31 |
| General Radio Company | 1 |
| Gould Inc., Piezoelectric Division | 56 |
| Guardian Electric Manufacturing Company | 47 |
| Hansen Manufacturing Co., Inc. | 138 |
| Hayden Book Company, Inc. | 64H, 70, 172, 175 |
| Heath Company | 165 |
| Hewlett-Packard | Cover II, 16, 41, 131 |
| Honeywell, Computer Control Division | 38 |
| Hudson Lamp Company | 64 |
| Hysol Division of Dexter Corporation | 157 |
| IBM Marketing Information | 73 |
| IMC Magnetics Corp. | 125 |
| Indiana General, A Division of Electronic Memories & Magnetics Corporation | 50 |
| Industrial Timer Corporation | 72 |
| International Rectifier, Semiconductor Division | 17 |
| JFD Electronics Corp/Components Division | 151 |
| James Electronics, Inc. | 60 |
| Johanson Manufacturing Corp. | 135 |
| Johnson Company, E. F. | 57 |
| Joslyn Electronic Systems | 147 |
| Koch & Sons, H. | 65 |
| Krohn-Hite Corporation | 123 |
| Kurz-Kasch, Inc. | 72 |
| L.A.B. Corporation | 152 |
| 3M Company, Scotchpar | 60, 68 |
| M & T Chemicals, Inc. | 60 |
| Magnecraft Electric Company | 54 |
| Malayan Tin Bureau, The | 159 |
| Marathon Battery Company | 45 |
| Marconi Instruments Division of English Electric Corporation | 58 |
| Mellonics Systems Development Division, Litton Industries | 14 |
| MicroSwitch, A Division of Honeywell | 15 |
| Monolithic Dielectrics, Inc. | 68 |
| National Semiconductor Corporation | 80, 81 |
| New Product Engineering Inc. | 133 |
| Oak Manufacturing Co. | 72 |
| Philips Electronic Components and Materials Division | 64F, 64G |
| Plastic Capacitors, Inc. | 146 |
| Premier Metal Products Co. | 174 |
| RCA Electronic Components and Devices | Cover IV |
| Radio Switch Corporation | 160 |
| Raytheon Computer | 163 |
| Raytheon/Semiconductor | 8, 9 |
| Redcor Corporation | 141 |
| Rental Electronics, Inc. | 142 |
| Resistance Products Company | 149 |
| Rohde & Schwarz | 64B |
| Rotron, Incorporated | 44 |
| San Fernando Electric Manufacturing Company | 148 |
| Schauer Manufacturing Company | 144 |
| Scientific Atlanta, Inc. | 7 |
| Schlumberger | 64A, 64C, 64E |
| Servo-Tek Product Company | 136 |
| Signalite, Incorporated | 67 |
| Signetics Corporation | 24, 24A-Y |
| Signetics Corporation, Measurement/Data | 2 |
| Siliconix, Incorporated | 46, 59 |
| Simpson Electric Company | 13, 127 |
| Sprague Electric Company | 18, 51 |
| Stackpole Carbon Company | 69 |
| Stalwart Rubber Company | 137 |
| Switchcraft, Inc. | 97 |
| Sylvania Components, Semiconductor Division | 12 |
| Sylvania Precision Materials, Parts Division | 32 A-B-C-D |
| TEC Incorporated | 64 |
| Tektronix, Inc. | 6 |
| Teletype Corporation | 4, 5 |
| Texas Instruments Incorporated, Components Group | 23 |
| Thermal American Fused Quartz Co., Inc. | 140 |
| Triplett Corporation | 74 |
| Tung Sol Division, Wagner Electric Corporation | 11 |
| Union Carbide, Components Department | 37 |
| Unitrode Corporation | 29 |
| Universal Relay Corp. | 170 |
| Vega Precision Laboratories, Inc. | 167 |
| Victoreen Instrument Division | 134 |
| Wall Manufacturing Co. | 160 |
| Weston Instruments, Inc., Newark Division | 89 |
| Weston Instruments, Inc., Archbald Division | 128 |
| Zenith Radio Company | 160 |
| Zippertubing Corp., The | 168 |

*Career Advertising:*

| | |
|---|---|
| Fairchild Camera and Instrument Corporation | 71 |
| Peripheral Equipment Corp. | 167 |

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# Product Index

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| Category | Page | IRN |
|---|---|---|
| **Components** | | |
| capacitors (NL) | 171 | 408 |
| delay lines, DIP | 150 | 336 |
| displays, LED | 148 | 298 |
| electromagnets (AN) | 164 | 381 |
| filter simulation (AN) | 164 | 384 |
| filters (NL) | 170 | 401 |
| filters, active (NL) | 166 | 388 |
| IC catalog (NL) | 168 | 393 |
| lamp, solid-state | 150 | 337 |
| lamps (AN) | 164 | 385 |
| magnetics (NL) | 166 | 389 |
| switch, rotary TO-5 | 149 | 299 |
| switches, pushbutton | 150 | 335 |
| thermocouples (AN) | 164 | 386 |
| thyristors (NL) | 166 | 387 |
| timing cell | 150 | 338 |
| triacs (AN) | 164 | 380 |
| zener guide (DA) | 160 | 368 |
| **Data Processing** | | |
| audio response system | 142 | 281 |
| calculators | 140 | 277 |
| computer, 16-bit | 141 | 278 |
| computer terminal | 140 | 274 |
| data transfer system | 144 | 286 |
| graphic recording (NL) | 168 | 395 |
| microfilmer | 144 | 284 |
| minicomputer | 141 | 279 |
| minicomputers (NL) | 171 | 404 |
| multiplexer/coupler | 144 | 285 |
| plotter, digital | 144 | 287 |
| printers, electrostatic | 142 | 282 |
| scanner, laser | 142 | 280 |
| tape system | 142 | 283 |
| terminal, portable | 140 | 275 |
| terminal, portable | 140 | 276 |
| time sharing (NL) | 166 | 392 |
| **ICs & Semiconductors** | | |
| amplifier, sense | 135 | 265 |
| amplifier, triple | 135 | 262 |
| converter, d/a | 134 | 260 |
| converter, number | 135 | 261 |
| couters, up/down | 134 | 259 |
| demodulators, IC | 132 | 252 |
| diodes (AN) | 164 | 383 |
| IC catalog (NL) | 168 | 393 |
| ICs, MOS logic | 132 | 254 |
| ICs, TTL | 129 | 250 |
| memory, 64-bit | 135 | 264 |
| memory, read-only | 130 | 251 |
| memory, read-only | 135 | 266 |
| multiplier, analog | 132 | 253 |
| op amp | 135 | 263 |
| op amp, high-speed | 132 | 256 |
| op amp, micropower | 133 | 258 |
| regulators, voltage | 132 | 255 |
| shift registers (NL) | 171 | 403 |
| sound system, TV | 132 | 257 |
| thyristors (NL) | 166 | 387 |
| triacs (AN) | 164 | 380 |
| zener guide (DA) | 160 | 368 |
| **Instrumentation** | | |
| clip, logic | 145 | 288 |
| counter/timer | 145 | 289 |
| counters, digital | 147 | 294 |
| curve tracer plug-in | 146 | 293 |
| DIP tester | 146 | 291 |
| DPMs, 4-1/2-digit | 148 | 297 |
| instrument journal (NL) | 169 | 397 |
| multimeter | 146 | 290 |
| PC-board exerciser | 148 | 296 |
| recorder, chart | 147 | 295 |
| spectroscopy, IR (NL) | 166 | 390 |
| test accessories (NL) | 169 | 399 |
| VOM, portable | 146 | 292 |
| **Microwaves & Lasers** | | |
| amplifier, S-band | 151 | 340 |
| amplifiers, L-band | 152 | 344 |
| circulator, S-band | 154 | 349 |
| converter, rf | 152 | 342 |
| equalizer, gain | 154 | 348 |
| generator, sweep | 153 | 345 |
| generator, sweep | 154 | 350 |
| hybrids, compact | 153 | 346 |
| oscillator, Gunn | 152 | 341 |
| substrates (ES) | 158 | 362 |
| sweeper | 152 | 343 |
| transistor, coaxial | 151 | 339 |
| transmitter, telemetry | 154 | 347 |
| **Modules & Subassemblies** | | |
| amplifier notes (NL) | 169 | 396 |
| circuit protectors | 137 | 268 |
| filter simulation (AN) | 164 | 384 |
| filters (NL) | 170 | 401 |
| op amp, fast | 137 | 269 |
| op amp, FET | 138 | 273 |
| op amps | 137 | 272 |
| operational amplifiers | 136 | 267 |
| regulator, current | 138 | 270 |
| regulator, voltage | 138 | 271 |
| **Packaging & Materials** | | |
| barrier strips (ES) | 158 | 364 |
| cases, instrument (NL) | 170 | 402 |
| coax, miniature | 155 | 352 |
| connector (ES) | 158 | 360 |
| lubricant (ES) | 158 | 365 |
| materials (AN) | 164 | 381 |
| monitors, temp (ES) | 158 | 361 |
| mounting system | 155 | 351 |
| powders, metal (NL) | 171 | 407 |
| ribbons, fiber-optic | 155 | 353 |
| silicates, ethyl (NL) | 171 | 406 |
| silicones (NL) | 170 | 400 |
| terminal blocks (NL) | 169 | 398 |
| terminals (NL) | 168 | 394 |
| **Tools & Engineering Aids** | | |
| binary card (DA) | 160 | 366 |
| desoldering tool | 156 | 356 |
| heat sink, DIP | 156 | 354 |
| lettering (ES) | 158 | 363 |
| loader, component | 157 | 359 |
| logic symbols (DA) | 160 | 367 |
| tips, vacuum | 156 | 355 |
| tools (NL) | 166 | 391 |
| tools (NL) | 171 | 405 |
| welding fixture | 157 | 358 |
| wire stripper | 156 | 357 |


## New Literature


| | | |
|---|---|---|
| amplifier notes | 169 | 396 |
| capacitors | 171 | 408 |
| cases, instrument | 170 | 402 |
| filters | 170 | 401 |
| filters, active | 166 | 388 |
| graphic recording | 168 | 395 |
| IC catalog | 168 | 393 |
| instrument journal | 169 | 397 |
| magnetics | 166 | 389 |
| minicomputer report | 171 | 404 |
| powders, metal | 171 | 407 |
| shift registers | 171 | 403 |
| silicates, ethyl | 171 | 406 |
| silicones | 170 | 400 |
| spectroscopy, IR | 166 | 390 |
| terminal blocks | 169 | 398 |
| terminals | 168 | 394 |
| test accessories | 169 | 399 |
| thyristors | 166 | 387 |
| time sharing | 166 | 392 |
| tools | 166 | 391 |
| tools | 171 | 405 |


## Application Notes


| | | |
|---|---|---|
| diodes, fast-recovery | 164 | 383 |
| electromagnets | 164 | 381 |
| filter simulation | 164 | 384 |
| lamps | 164 | 385 |
| materials | 164 | 382 |
| thermocouples | 164 | 386 |
| triacs | 164 | 380 |


## Design Aids


| | | |
|---|---|---|
| binary card | 160 | 366 |
| logic symbols | 160 | 367 |
| zener guide | 160 | 368 |


## Evaluation Samples


| | | |
|---|---|---|
| barrier strips | 158 | 364 |
| connector | 158 | 360 |
| lettering | 158 | 363 |
| lubricant, electronic | 158 | 365 |
| monitors, temperature | 158 | 361 |
| substrates, microwave | 158 | 362 |

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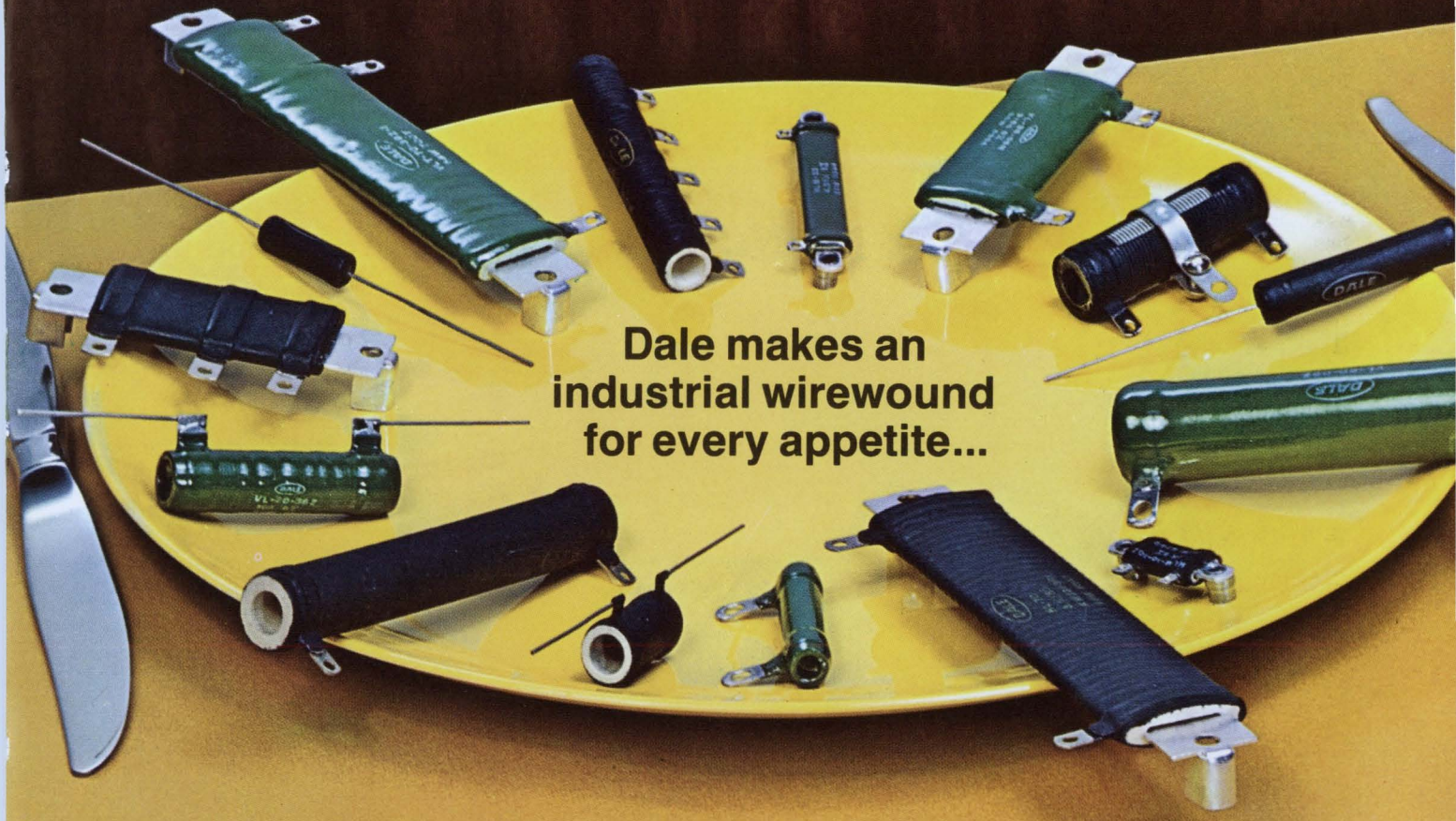

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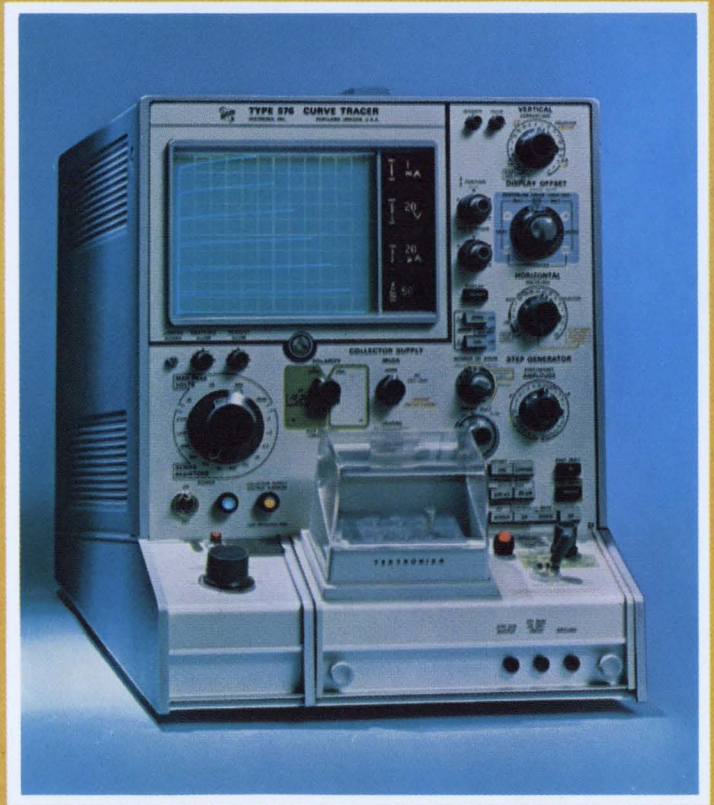


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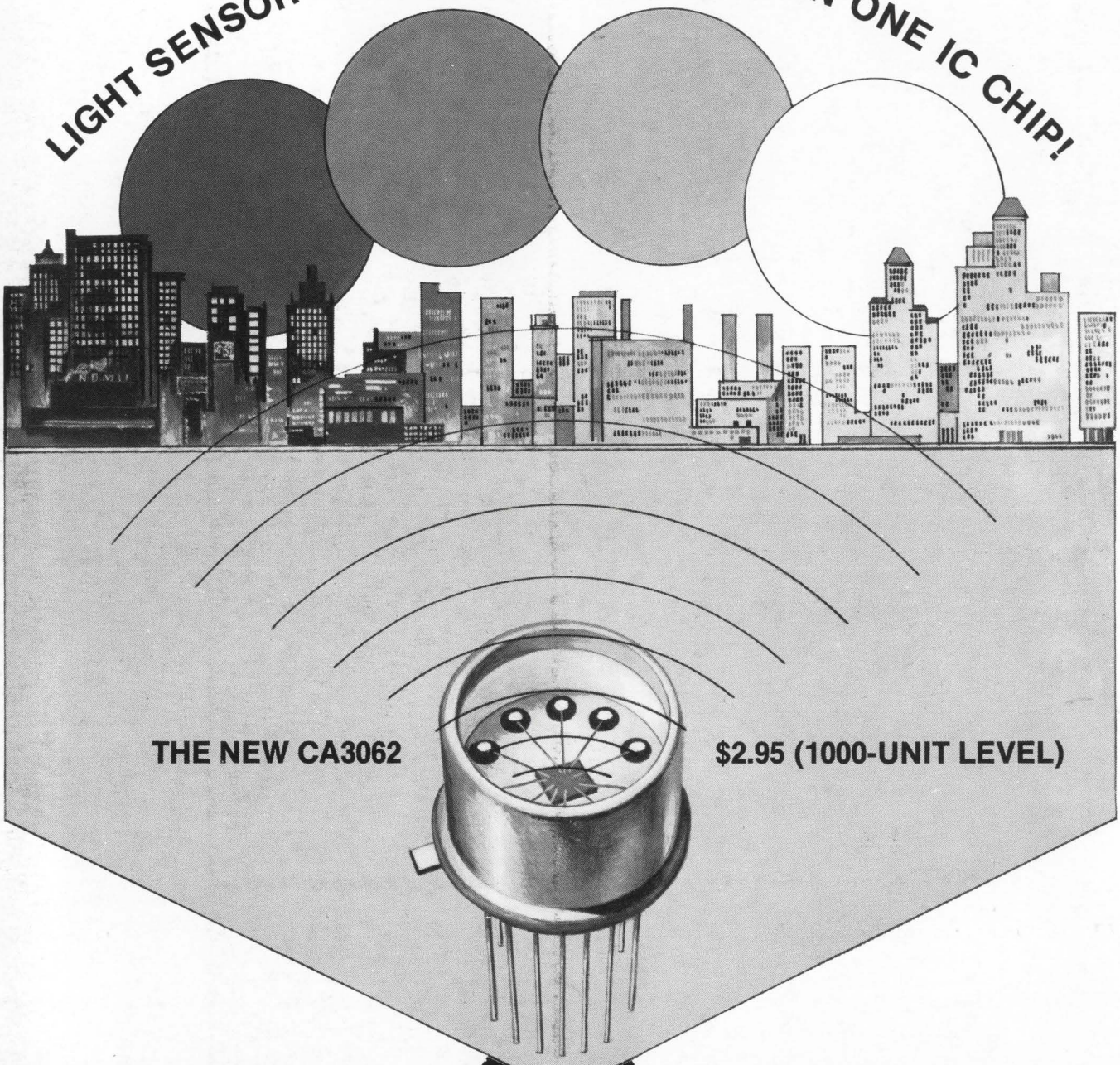

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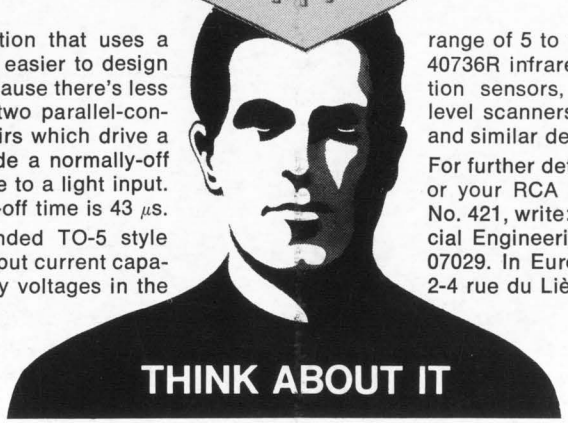


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