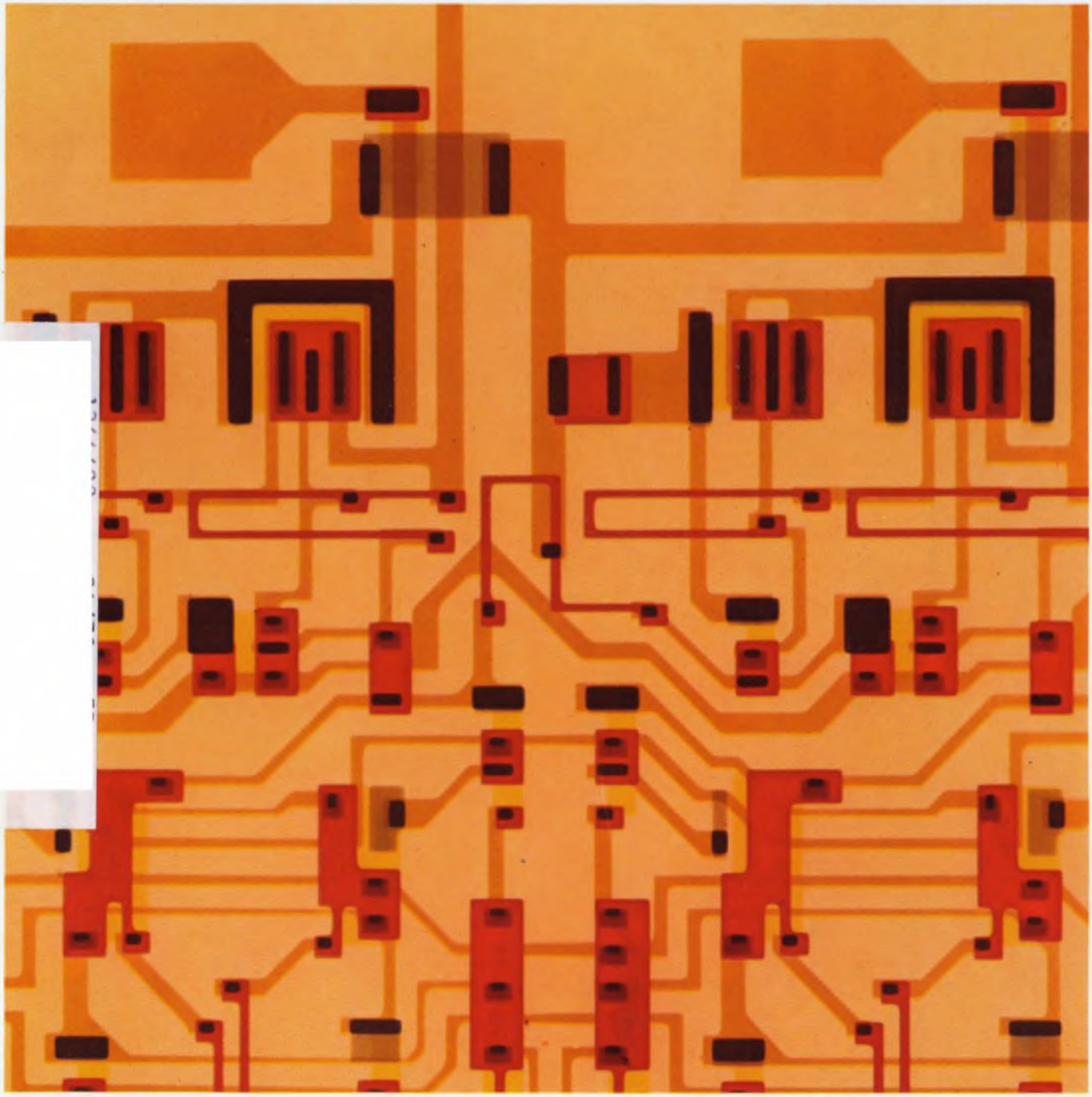
Electronic Design

VOL. 18 NO. 7

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 1, 1970

Now TTL can be wire-OR'd. A third, high-impedance output state isolates flip-flops from their output busses in a new quad-D circuit. The flip-flops, addressed using output enable lines, offer simpler computer organizations through hard-wired logic and full compatibility with 54/74 TTL. For the full story, see page 101.



New Roll Coated Choke

Now Dale can deliver standard epoxy roll-coated chokes that give you molded quality at lacquer-coated prices. This new Dale line includes 10 standard models designed to meet MIL-C-15305D (Grade 1, Class B). Inductance: .10μh to 1.00μh; Self-Resonant Frequency: 680-240 Mhz. All are designed for use on automatic insertion equipment and are available *now* in quantity. Standard or special — there's plenty of time and money to be saved in Coil Country.

CALL TODAY:
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DALE ELECTRONICS, INC.
Box 180, Yankton, South Dakota 57078
A subsidiary of The Lionel Corporation

INFORMATION RETRIEVAL NUMBER 246

The best gets better.

The HP 5248 General-Purpose Counter can now measure to 3 GHz with a single plug-in—without any gaps. This is made possible by our new 150 MHz to 3 GHz Heterodyne Converter, Model 5254C, and by extending the direct counting range of the 5248 counter mainframe to 150 MHz.

There's another benefit unique to these instruments that's not immediately apparent. Converter and counter ranges actually overlap so you derive the final answer by merely adding the converter dial reading and counter reading. There's no need to remember to subtract readings over any part of the frequency range.

Even before the latest improvements, no other counter could match the usefulness and flexibility of the 5245 Series. We now offer fourteen different plug-ins to help you make all the measurements you need. These include six frequency converters; transfer oscillator to 18 GHz; two time interval units; two prescalers; video amplifier; DVM; and preset unit.

And you can't beat the 5245 line for reliability either. Its remarkable dependability has made it extremely popular, particularly with rental firms—some of our best customers. When their clients rent an HP counter, rental firms know they won't lose rental fees because of downtime.

The price of the new 5254C Heterodyne Converter is $825. The 5248L counter is $2900. You won't find a more economical single-package solution to your dc to 3 GHz counter needs. Your local HP field office has all the details. Give them a call. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

02918

INFORMATION RETRIEVAL NUMBER 2

There's a new reason why this continues to be the world's most popular counter line.

You're looking at 35 new digital printers!

$995.

You only see one? That's because you don't see all the plug-in options and features packed into S-D's new printer . . . **including** features found only in $3,000 printers!

The basic Model 5103 is a 5-column, asynchronous, 3-line/sec. printer, so quiet-running you can hardly hear it. It expands to a 21 column printer with 16 characters/column simply by adding economical 5-column plug-in boards. Just slide them in yourself at any time.

Interface problems just don't exist. For example, Model 5103 handles any 4-line BCD code with a simple IC socket change. No disassembly or rewiring ever. For only $995, you get a printer that offers **dual source operation,** handles positive or negative logic, and features input channels that can be programmed to print in any column on the print drum. You get a printer with zero suppression, measurement units printout and two-color printing so you can use it directly with limit comparators.

Unique options for every situation. You have your choice of such useful options as plug-in boards for ±200 V levels, 1 msec transfer time, digital clock, buffer storage, floating decimal point and more.

For complete details, write Data Products Division, 888 Galindo Street, Concord, California 94520. Phone: (415) 682-6161.

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Another S-D instrument first! Electronic counters / Digital voltmeters / Pulse generators / Data generators / Time code generators / Sweep generators / Spectrum analyzers / Digital panel meters / Digital clocks / Signal generators / Oscillators Laboratory magnets / Precision Power Supplies / Analog & analog—hybrid computers / Data acquisition systems.

INFORMATION RETRIEVAL NUMBER 3

Electronic Design

VOL. 18 NO. 7

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 1, 1970

NEWS

TECHNOLOGY

PRODUCTS

Departments

Cover: Tri-state TTL flip-flops from National Semiconductor Corp., Santa Clara, Calif. Photo by Richard Steinheimer.

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N.Y. 10022. James S. Mulholland, Jr., President. Printed at Brown Printing Co., Inc., Waseca, Minn. Controlled circulation postage paid at Waseca, Minn., and New York, N.Y. 81,801 copies this issue.


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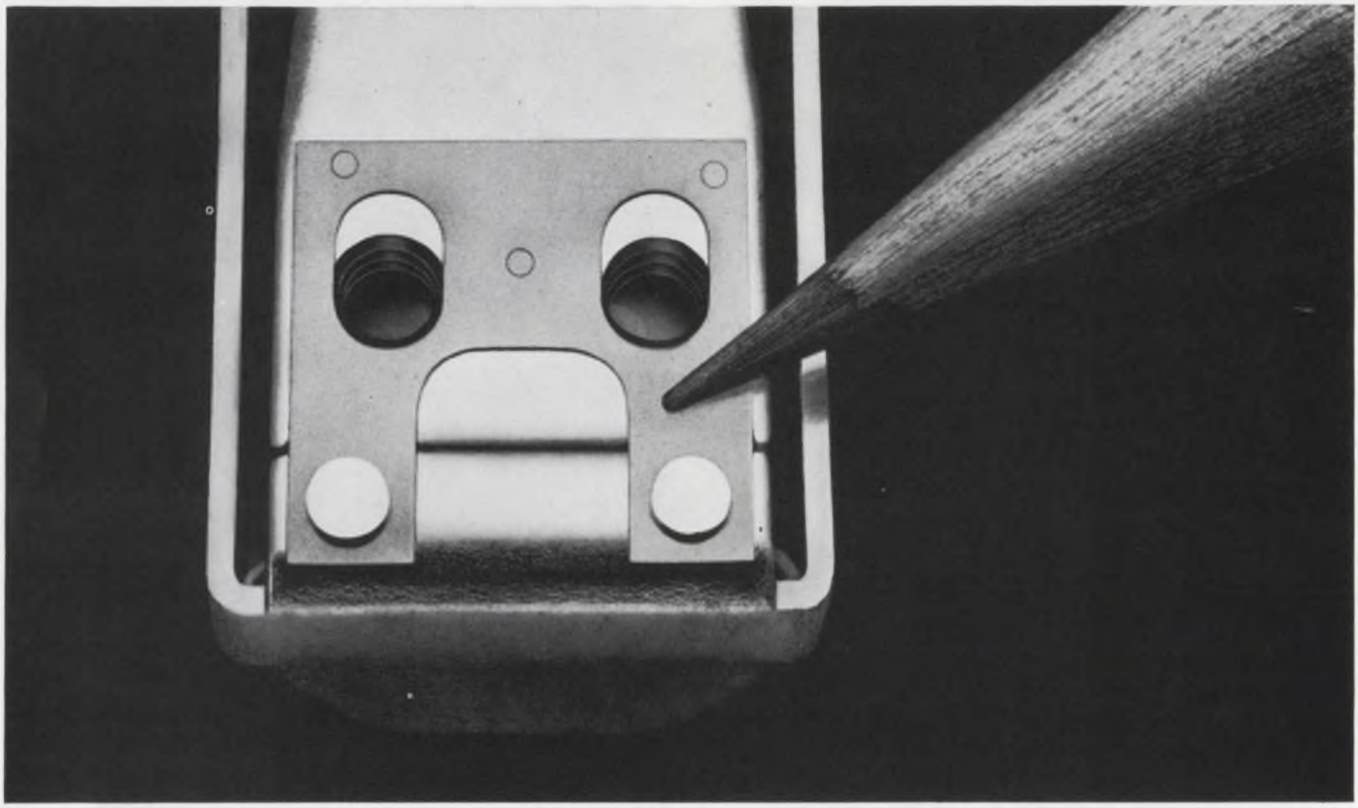

A new type relay hinge eliminates mechanical wear entirely.

It's called a reed hinge and we've substituted it for the conventional rocker type assembly in our imported JMR Miniature 5 Amp. Cradle Relay. The blade (reed) reduces 4 parts to 1. Simple, lastingly dependable and entirely free of mechanical wear. It's a Line Electric exclusive.

Other significant improvements are in the housing: Pure polycarbonate plastic which has 48% higher heat and 31% greater fracture resistance than nylon, styrene or butyrate. And gold-diffused silver contacts to ensure even greater reliability at low power levels while retaining full load switching capabilities. Also outgassing of all phenolic parts to prevent contact contamination.

Available in 2PDT, 4PDT, 6-12-24-48 or 110 VDC. Priced as low as $1.40 (5000 or more per year). You can't buy better. Write or call us at 201-887-2200.

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INFORMATION RETRIEVAL NUMBER 5

INFORMATION RETRIEVAL NUMBER 6 ▶

with sense amps.

The LM354A/SN7524 completes the logic and interface package for designers of mini-computers. Proprietary MSI circuits and a full line of the most popular second source DTL and series 54/74 TTL; everything into and out of the memory. Logically from National.

The LM354A and LM354. Pin-for-pin replacements for the SN7524 and SN7525 monolithic dual sense amps. Independent channel strobing built to fit the specs of the most demanding mini-computer designer.

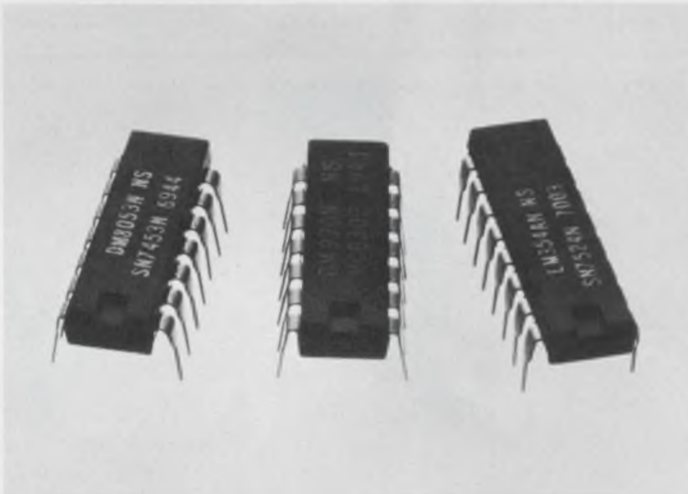
Our LM354A features plus or minus 4mV maximum threshold voltage tolerance. Parts to even tighter tolerances are available on special order. All circuits are 16-pin dual-in-line silicone.

LM354A/SN7524—$6.25 @ 100 up.

LM354/SN7525—$4.80 @ 100 up.

We've taken a strong position in supplying production quantities of advanced ICs for the mini-computer manufacturer. Everything you need. Take it from National. Delivery, performance and competitive pricing always. Write for specs. National Semiconductor, 2900 Semiconductor Drive, Santa Clara, California 95051. (408) 732-5000. Telex: 346-353. Cables: NATSEMICON

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



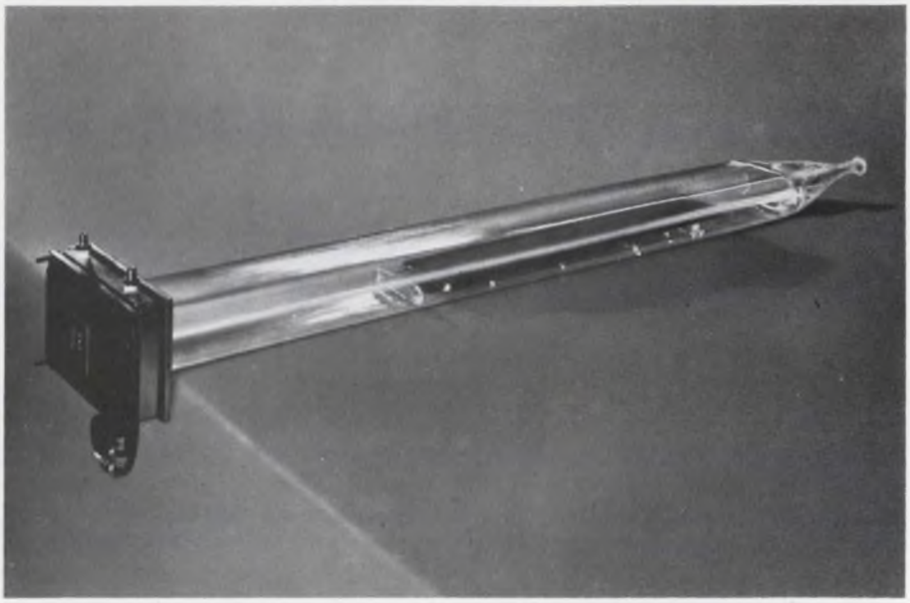
National/Linear

INFORMATION RETRIEVAL NUMBER 7

Discovering G L Q

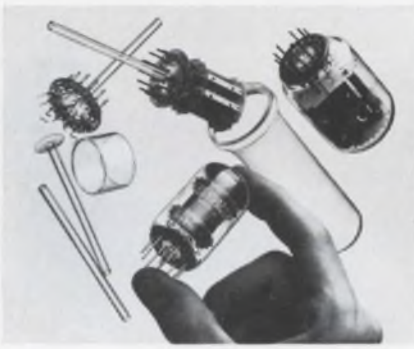
GLASS | LUCALOX® | QUARTZ

IN ELECTRONICS ... Electronic Glass, Lucalox® and Quartz Solve Challenging Problems

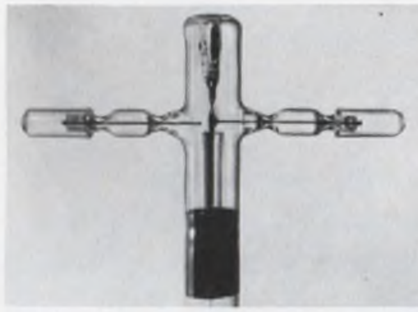


Epitaxial films grow to high resistivity and greater uniformity in this GE type 204 quartz horizontal reactor tube. Manufactured by Hugle Industries, Sunnyvale, California, the rectangular shape of the tube provides more uniform gas velocities around silicon wafers than can be achieved in round tubes. The reaction of silane or silicon tetrachloride at a temperature up to 1200°C creates epitaxial growth. Purity in the susceptor and quartz envelope is a must. And Hugle found that General Electric always meets their critical standards. A purely logical reason to grow with GE 204 quartz. **CIRCLE 811**

Lucalox® Ceramic plays the "Great Protector" role in this prototype pressure transducer developed for a nuclear space electric power system. The assembly, designed for NASA by Consolidated Controls Corporation, uses bellows and a thermionic sensor to measure pressures of circulating liquid potassium. Should the bellows fail, the Lucalox ceramic prevents leakage of 1000°C. liquid metal. Consolidated Controls experimented with many materials before discovering Lucalox, an extraordinary polycrystalline material that remains stable at 1600°C., and retains strength and form even at temperatures near its 2040°C. melting point. To save the time Consolidated Controls spent searching, why not begin today to learn more about Lucalox, a great protector. **CIRCLE 812**



Over 100,000,000 have been made, so there must be something special about the GE Compactron tube. There is. One Compactron, as produced by the GE Tube Dept., can do the work of up to three conventional vacuum tubes. But right here, we at the Lamp Glass Dept. think the Compactron can be used to illustrate our own capability in selecting specific glass types for specific applications. We provided three types for the Compactron: Type 008 lime glass, best for close tolerance forming of bulbs; Type 012 lead glass, best for preventing glass electrolysis in stems; Type 001 glass, best for close tolerance cutting of tubulations, in this case ±0.5 mm. If you want electronic glass to do something for you, call us. We have the types and we know when to use which one. **CIRCLE 813**



GE fused quartz tubing chimes in with the "sound source" for an amplified quartz bell carillon. Produced by G. Finkenbeiner, Inc., Waltham, Mass., the system weighs less than 40 pounds as opposed to bronze bells of 10 tons. General Electric's type 204 clear fused quartz was selected for its low coefficient of expansion, inherent strength, and absence of fatigue under vibration. To form the "bells" the quartz is drawn to desired length and diameter at 1800°C; then sealed inside a high vacuum, borosilicate glass tube. The quartz is fused to the borosilicate glass with GE graded sealing cane. Another example of how General Electric's glass technology can make sweet music for the electronic industry. **CIRCLE 814**

WORLDWIDE SERVICE. For sales and application assistance, contact your nearest regional office:

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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 8

The Competition And Us.

More than an open and closed case.

Three fine rotary switches. Two competitors'. And ours.

The open deck rotary switch on the right is probably the most versatile type switch available today. It is simple. Functional. And very inexpensive.

However, an open switch is highly susceptible to contamination, damage, even tampering. It must be handled carefully. Both in production and in end use.

At Stackpole, we've designed a *totally enclosed* rotary for only pennies more and without sacrificing flexibility. And tough as they come.

To the left is a closed type rotary often considered as top-of-the-line. Rugged. Well made. Expensive.

Unfortunately it is severely limited. No interconnection of adjacent terminals or decks is possible.

The slots through which riveted terminals protrude in this so-called closed rotary prevent total enclosure. Permit looseness. Stackpole molds contacts and terminals right into the switch body. Everything's rigid. Tight. We call it "Environment proof." And it costs a lot less.

That leaves the Stackpole Series 100 rotary switch. Front and center. A totally new concept in rotary construction. Decks interconnect internally. Adjacent terminals may be interconnected internally or externally. At no extra cost.

Another feature is compactness. Note the shorter build-up in length. Then there's the wear compensating dual-ball detent. Rotation is precise. Positive.

Compare. Send for a sample. Made to your specifications in 2 to 3 days. Production quantities in 2 to 3 weeks. For data, quotation or samples, contact: Stackpole Components Company, P.O. Box 14466, Raleigh, N.C. 27610.

Right in the middle is value. Stackpole rotary switches.

Now in two sizes

STACKPOLE®
COMPONENTS COMPANY

Also the leading producer of quality slide and rocker switches and linear potentiometers.

Designer's Calendar

APRIL 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		

For further information on meetings, use Information Retrieval Card.

Apr. 14-17
International Geoscience Electronics Symposium (Washington, D. C.) Sponsor: IEEE. Ralph Bernstein, IBM Corp., 18100 Frederick Pike, Gaithersburg, Md. 20760.

CIRCLE NO. 455

Apr. 16-17
Conference on Semiconductor Packaging in the 70s (New York City) Sponsor: Polytechnic Institute of Brooklyn. George J. Fischer, Polytechnic Institute of Brooklyn, 333 Jay St., Brooklyn, N. Y. 11201.

CIRCLE NO. 456

Apr. 21-24
International Magnetics Conference (Washington, D. C.) Sponsor: IEEE, D. S. Shull, Bell Telephone Labs., 3300 Lexington Ave., Winston-Salem, N. C. 27102.

CIRCLE NO. 457

Apr. 22-24
Southwestern IEEE Conference & Exhibition (Dallas) Sponsor: IEEE. A. P. Sage, Inst. of Technology, SMU, Dallas, Tex. 75222.

CIRCLE NO. 458

Apr. 27-30
National Telemetering Conference (Los Angeles) Sponsor: IEEE. A. V. Balakrishnan, UCLA, Rm. 3531, 405 Hilgard Ave., Los Angeles, Calif. 90024.

CIRCLE NO 459

◀ INFORMATION RETRIEVAL NUMBER 11

OVER 6 MILLION analog connections a second;

The Computer Labs Model MUX-810 Multiplexer will connect eight analog inputs to a single output at a rate of 6.6 million connections every second. Channels can be connected sequentially, with any number in the sequence; random access; or manually, with a front panel push button.

Equivalent "ON" resistance is 0.2 ohm, making the Model MUX-810 an ideal choice for switching 100-ohm lines.

INPUT CHANNELS: 8
Can be switched sequentially (any number); random access; or manually, with push button

INPUT VOLTAGE RANGE: 2.2 V P-P max. (−1.1 V to +1.1 V)

DC ACCURACY: ±2 mV (Max. difference input to output)

LINEARITY: 0.05%

DC OUTPUT IMPEDANCE: 0.1 ohm

SETTLING TIME:
±10 mV of final value = 150 ns
± 5 mV of final value = 400 ns

LOGIC LEVELS:
"1" = +2.5 V to +4.5 V
"0" = 0.0 V to +0.5 V
All loads 50 ohms or greater

LOGIC INPUT IMPEDANCE: 100 ohms

CHANNEL INPUT IMPEDANCE: 1000 ohms in parallel with 20 pF

CHANNEL BANDWIDTH (−3 dB): 15 MHz min.

CHANNEL CROSSTALK (@ 5 MHz): −60 dB

POWER: 120 V ±5%; 300 mA

PRICE: $2,400

followed by... converters that go from Analog to Digital and back again.

The HS Series A/D Converters extend from 4 bits at 25 MHz **word rates** through 9 bits at 5 MHz **word rates.** Sample-and-hold, test circuits, and power supplies are all included. No external test equipment required.

COMPUTER LABS

for tomorrow's technology today

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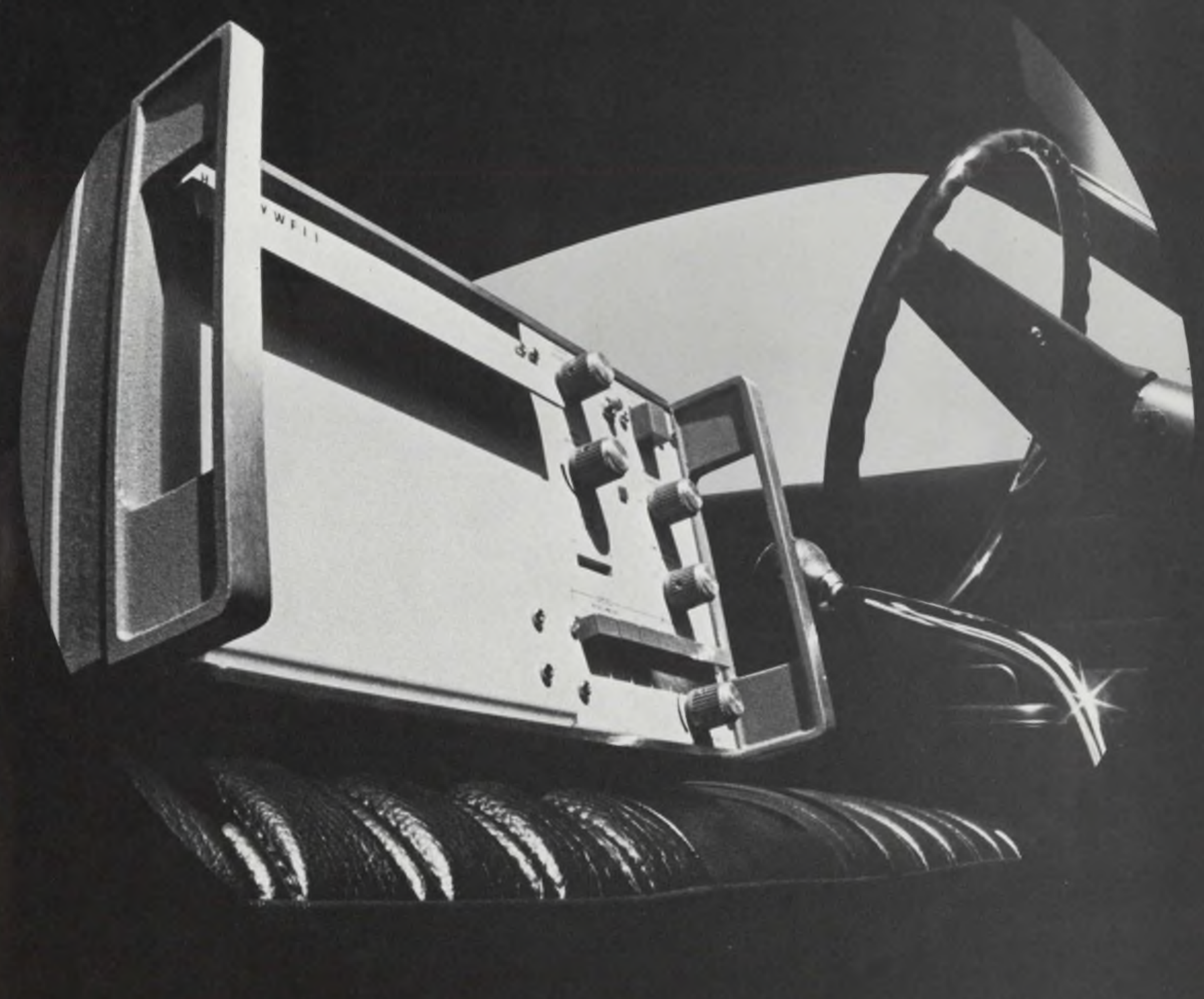
(919) 292-6427 / TWX 510 922-7954

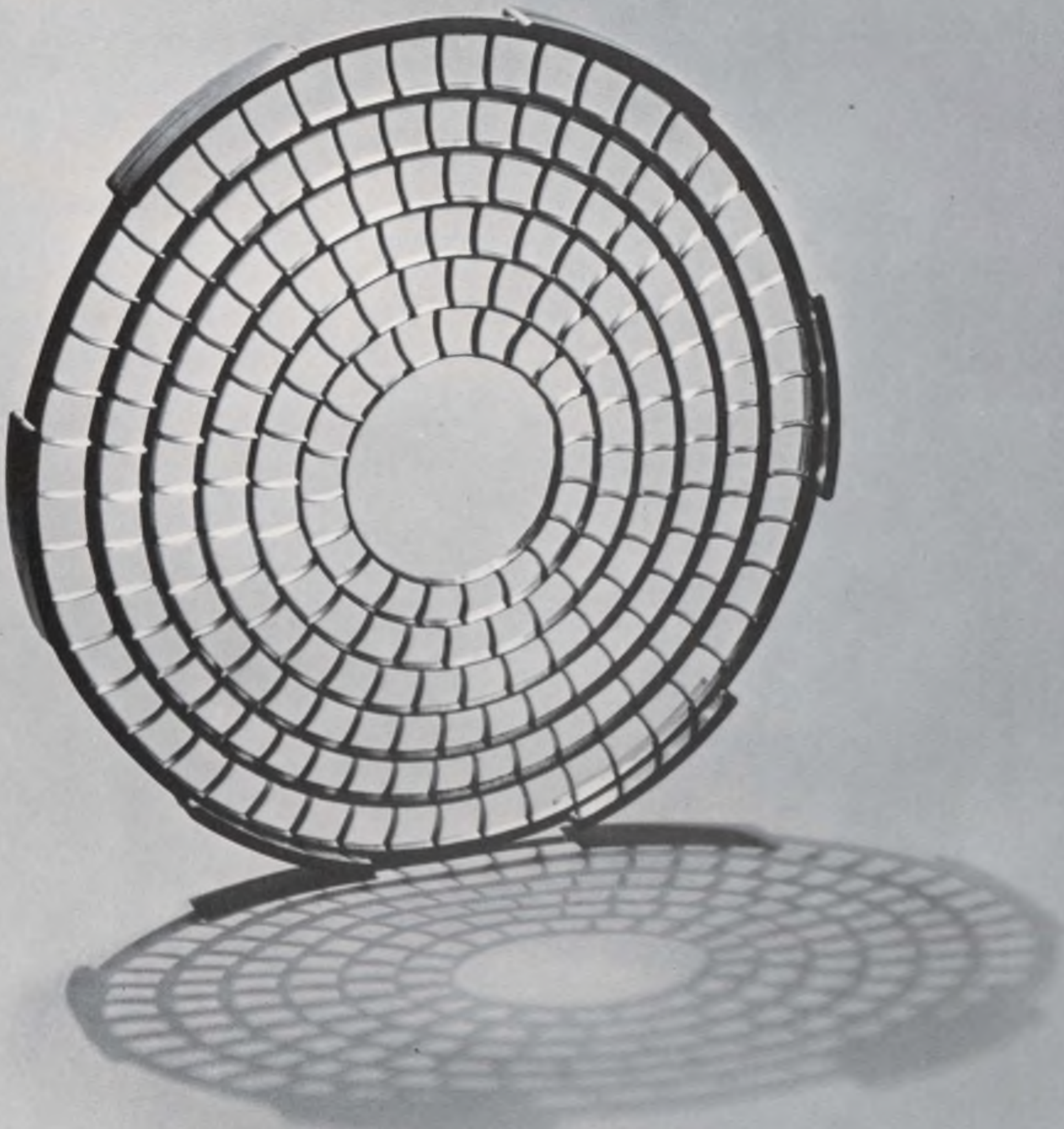
The HS-2000 Series D/A Converters match the Computer Labs A/D line in high-speed capabilities. In addition, they can be used as function generators, programmable attenuators, or modulators, because of the ability to vary external bias and reference signals at frequencies up to 25 MHz.

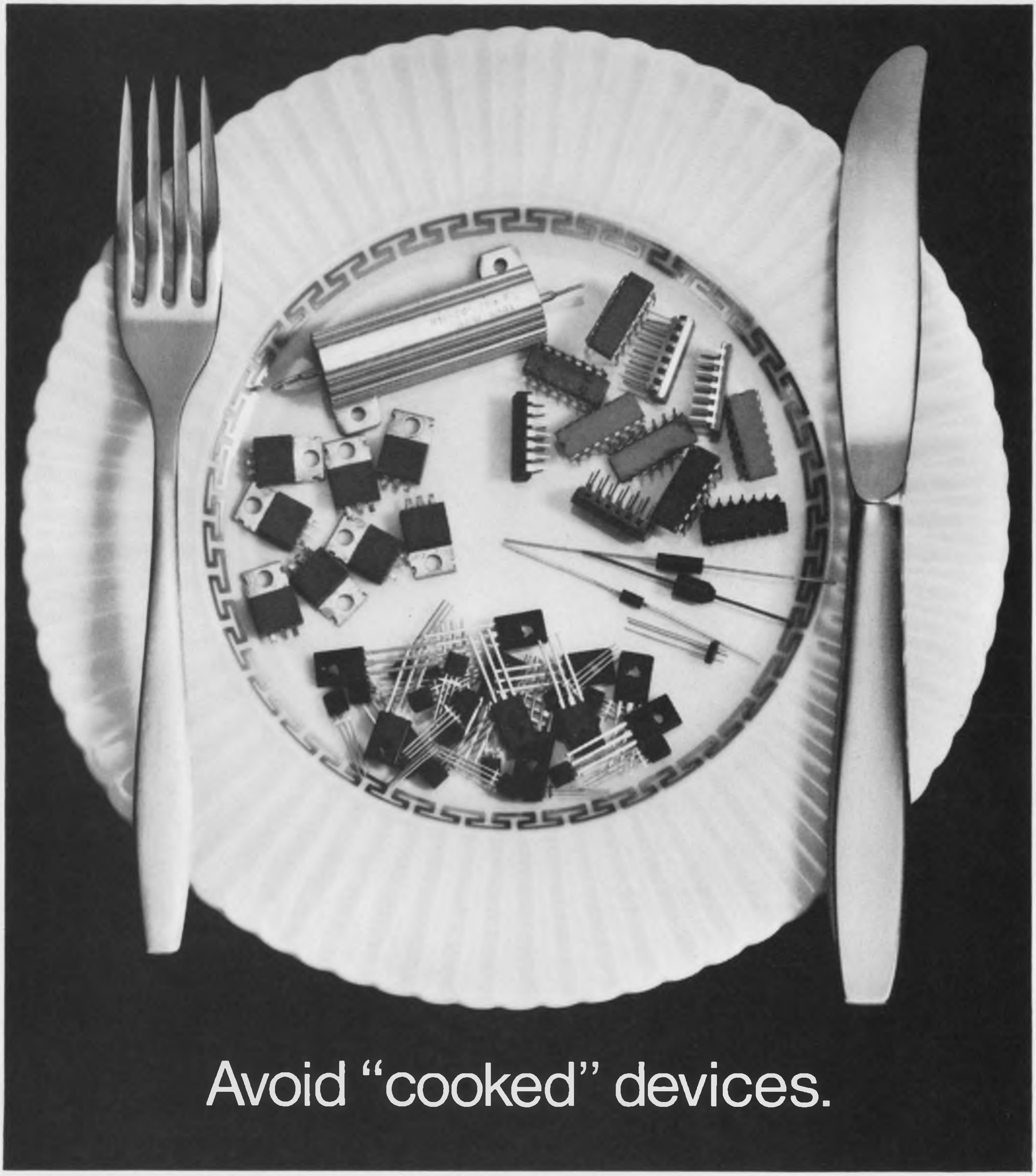
Analog Multiplexers / Analog-to-Digital Converters / Digital-to-Analog Converters / Operational Amplifiers

INFORMATION RETRIEVAL NUMBER 9



National comes full circuit





Heat, built up by high-frequency voltage variations, can melt molding compounds made of organic plastic. So the semiconductor devices they enclose can fail. But they won't fail if they're encapsulated in Dow Corning® silicone molding compounds.

Dow Corning silicone molding compounds are stable over a wide range of temperature and humidity conditions. Dielectric losses at high frequencies, junctions operating at high temperatures and soldering baths are not a problem with Dow Corning molding compounds. They are stable over a wide range of frequencies and temperatures, and are self-extinguishing, chemically compatible and easy to mold. They can make a significant contribution to your product's reliability.

For more information, write Dow Corning Corporation, Dept. C-9356, Midland, Michigan 48640.

Molding Compounds from

DOW CORNING

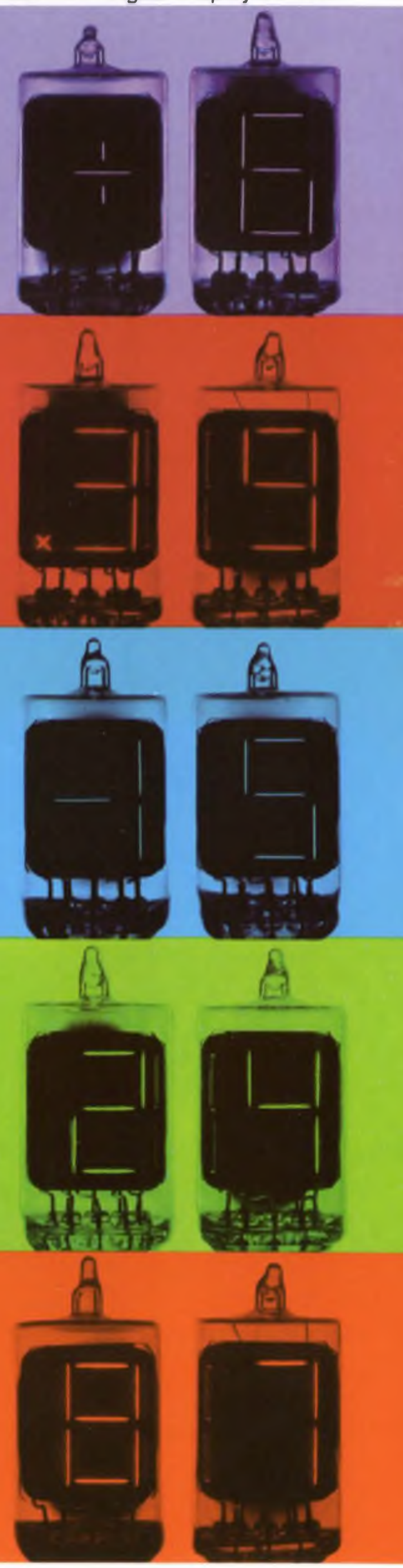
DOW CORNING

INFORMATION RETRIEVAL NUMBER 10

SEE BRIGHTER, MORE COLORFUL DIGITAL DISPLAYS WITH NUMITRON DEVICES

DR2100 NUMITRON Digital Display Devices

DR2000 NUMITRON Digital Display Devices



Your enthusiastic acceptance of RCA's DR2000 family of NUMITRON Digital Display Devices led to a decision to broaden the NUMITRON line with a new DR2100 family of smaller-size devices.

Both NUMITRON families give you the same unlimited filter-color selection for their sharp, bright and clean numerals. The DR2000 types are now available in production quantities. And, the new compact DR2100 types, which may be mounted on one-half inch centers, are only available in sample quantities.

Both families of NUMITRON Digital Display Devices feature:

- ☐ High contrast display ratio—bright segmented digits against a dark background
- ☐ Controllable high brightness
- ☐ Up-front planar numerals for wide viewing angle
- ☐ Rugged construction—high reliability

Here's another big benefit! Both NUMITRON families are designed for low voltage operation—4½ volts—and they are fully compatible with RCA's CD2500E and CD2501E 7-Segment Decoder Drivers.

Type numbers of RCA's NUMITRON Digital Display Devices:

☐ Numerals 0 through 9	DR2000,	DR2100
☐ Numerals 0 through 9, with decimal	DR2010,	DR2110
☐ Plus-Minus and numeral 1	DR2020,	DR2120
☐ Plus-Minus	DR2030,	DR2130

For further information on RCA's NUMITRON devices, see your RCA Representative or your local RCA Distributor. Also ask for information on RCA's 7-Segment Decoder Drivers especially designed for use with NUMITRON devices. For information on both of the two NUMITRON families and the Decoder Drivers, write to RCA Electronic Components, Commercial Engineering*, Harrison, N.J. 07029.

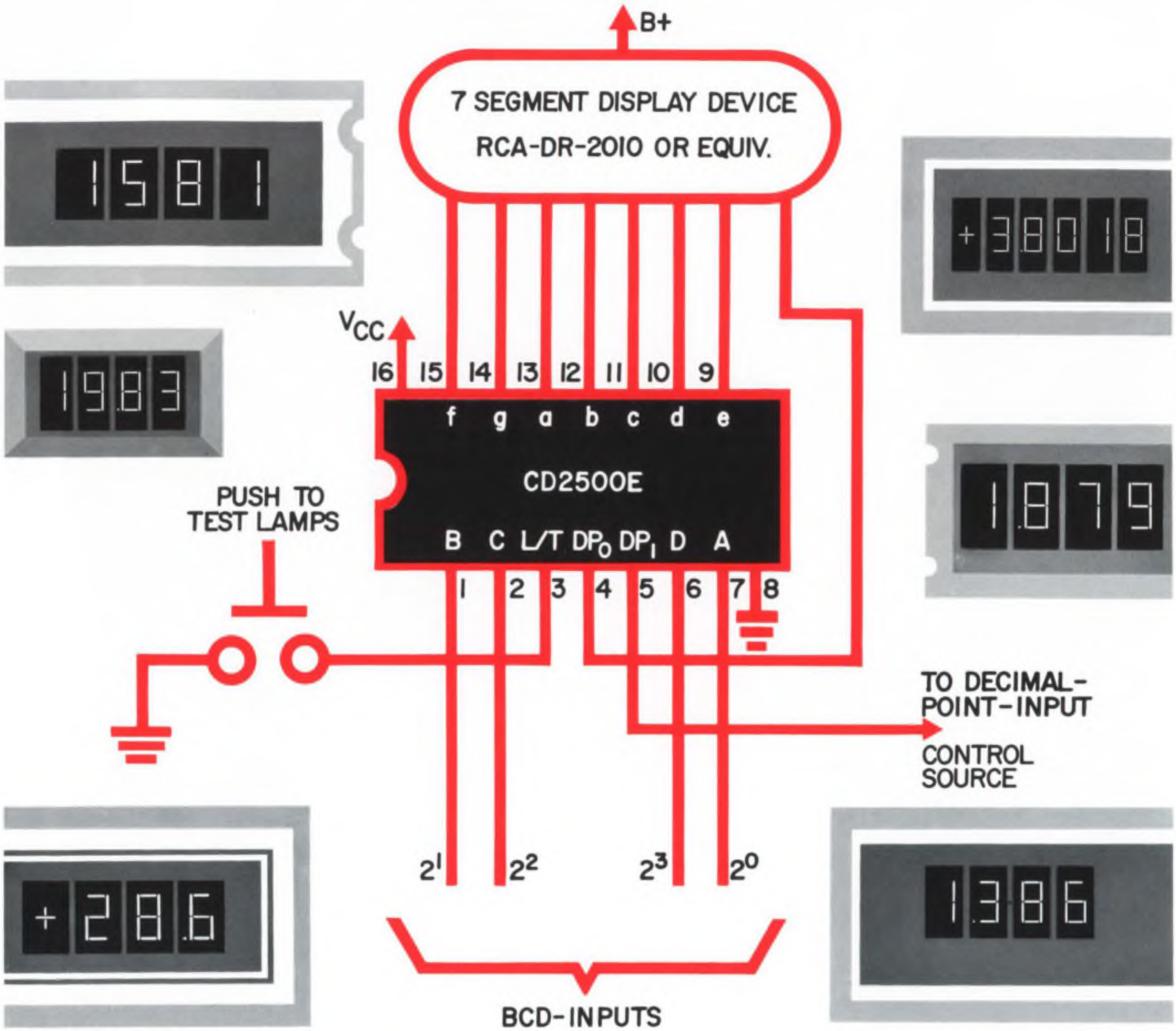
In Europe: RCA International Marketing, S.A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

RCA

*Section C18DE-25/CN2

Behind the new versatility and lower costs of digital displays...

RCA's New 7-Segment Decoder-Drivers



Whether you drive your digital displays with low current or high current, your drive circuits can now be more versatile—simpler—lower in cost. RCA's new CD2500E series of 16-lead DIP 7-segment Decoder Driver MSI integrated circuits includes both 30 mA devices for driving RCA's new NUMITRON 7-segment Digital Display Units and 80 mA devices to drive miniature low-voltage lamps or relays.

Look at the tabulation of the new CD2500E devices. Compare their prices and their advantages with present decoder-drivers and decoder and driver combinations. Then contact your local RCA Representative for details. For technical data, write to RCA Electronic Components, Commercial Engineering, Section ICG 25, Harrison, N. J. 07029.

RCA's 7-segment Decoder-Drivers

Operating Current per Segment	Type Number	Price (1,000 units)	
30 mA 80 mA	CD2500E CD2502E	$6.75 $8.00	with decimal point
30 mA 80 mA	CD2501E CD2503E	$6.75 $8.00	with ripple blanking

ADVANTAGES

- Power supply and input voltages compatible with DTL and TTL devices
- Lamp test provision
- High current sinking capability for direct display driving
- Clamp diodes on all inputs
- Intensity control capability
- Over-range detection
- 0° to 75°C temperature range
- Lamp supply voltage up to 8 V

RCA Integrated Circuits

What you hear about our new dry test bath is true.

The tape recorder is operating in a dry bath of Fluorinert® Brand Electronic Liquids. Just as your electronic and microelectronic units will.

Fluorinert Liquids give you an accurate method of temperature testing or testing for gross leaks. They keep their efficiency over a wide range of temperatures. They do not react with even the most sensitive of materials. They won't deteriorate with use.

And you can ship or use parts directly out of the test bath without cleaning because Fluorinert Liquids evaporate, leaving no residue.

If you've been listening, you know that Fluorinert Electronic Liquids are specified for Mil-Standard 883 and Mil-Standard 750A gross leak tests for microcircuits.

The coupon will bring you copies of both Mil-Standards and a lot of good solid information about test baths. Send it or call your local 3M man.

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Send me all the details about Fluorinert Brand Electronic Liquids.

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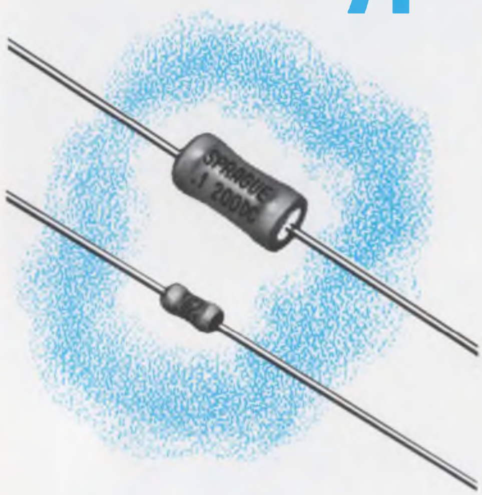
INFORMATION RETRIEVAL NUMBER 32

Now...new, lower capacitance values!

Type 192P PACER® FILMITE® 'E' CAPACITORS



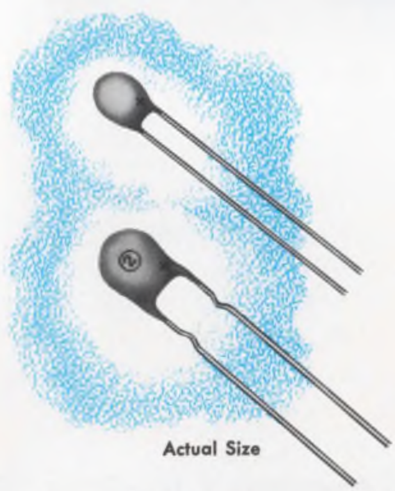
INFORMATION RETRIEVAL NO. 823

• **Low-cost** film capacitors with one-third the size of conventional tubulars • Eight new low-capacitance values (100 pF thru 390 pF @ 200V) added to broad range of standard ratings • Special construction—extended foil sections terminated in metal end caps, assuring positive contact with every turn of the electrodes • End caps are also effective moisture barriers • Entire assembly protected by special sleeve of high dielectric strength • **Request Engineering Bulletin 2066B**

4SC-0105R1

Newly broadened low-cost line!

Type 196D Dipped Solid-Electrolyte Tantalex® Capacitors



Actual Size

INFORMATION RETRIEVAL NO. 824

• Here's a capacitor design that admirably fills the need for low-cost yet dependable solid tantalum capacitors suitable for printed wiring boards • Straight leads as well as crimped leads are readily available to meet your manufacturing needs • Covering a broad range of capacitance values from .1 μF to 330 μF, with voltage ratings from 4 to 50 VDC, Type 196D Capacitors are protected by a tough insulating coating which is highly resistant to moisture and mechanical damage • **Request Engineering Bulletin 3545A.**

4SC-9124R1

For Engineering Bulletins as noted above, write to: Technical Literature Service, Sprague Electric Co., 347 Marshall Street, North Adams, Massachusetts 01247.

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Highlighting
THE ISSUE

For decades the vitality of the American economy has testified to its superiority in management methods. But the traditional experience-based management style is now becoming unfashionable according to Charles Anderson, president and chief executive officer of Stanford Research Institute. He explains that engineering is moving to knowledge-based management, not only because of the increasing complexity of technology but because the younger generation requires it.

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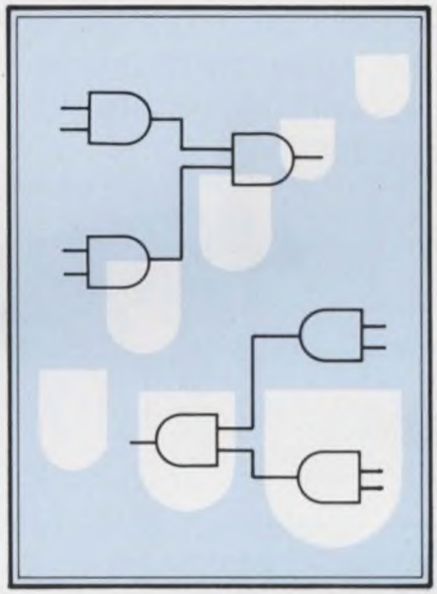
"By the year 2000, the concept of a wristwatch will give way to a more complete communications center that includes a means of keeping accurate time, has both transmitting and receiving capabilities, and perhaps has a miniature computer."

PAGE 25



Now designers can get an extra gate function at no extra cost with a three-logic-state digital circuit from National Semiconductor Corp. The new TTL flip-flop can assume one of three output conditions—low-impedance ON, low-impedance OFF, or a high-impedance state. This means that the DM8551 quad D flip-flop can be wire-OR'd (its four outputs can be joined together directly without using an OR gate).

In addition there is no sacrifice in gate speed or fanout. The device also has the advantage of TTL-type switching, and can drive active loads.

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News Scope

Defense chiefs say restraints on R&D 'cripple' leadership

A strong bid to Congress not to "cripple" the research programs vital to the nation's technological leadership was made last month by Defense Secretary Melvin R. Laird and by John S. Foster, Jr., Director of Defense Research and Engineering.

The restrictions on research stem from two legislative actions—one under consideration by the Senate and the other already enacted. The bill under study would prohibit reimbursement for independent research and development under negotiated contracts, except where the costs have been specifically provided for in the contract and are of direct or indirect benefit to the work performed.

The other bill, the recently enacted Section 203 of the fiscal year 1970 Military Procurement Authorization Act, prohibits the use of funds for projects unless they have a "direct and apparent relationship to a specific military function or operation.

At the Electronic Industries Association Conference in Washington, D.C., Laird said, "While I understand the concern of the Congress I believe such restrictions would unnecessarily stifle new and imaginative efforts."

He stated that the result of such restrictions would reduce the technological effectiveness of defense-related industries. "We are working with the Congress to clarify the potential impact of this legislation. I deeply appreciate the parallel efforts of the EIA in that regard. It is particularly difficult," Laird said, "to identify in advance the ultimate applications of basic research." Laird's fear, he says, is that this will "tend to discourage talented scientists from potentially productive research areas." (For Navy's complaint see p. 40.)

Foster, the Pentagon's research chief, made an even stronger plea later in the month at a dinner of the National Security Industrial Association in Washington, D.C. Unless the lag in research is reversed, Foster said, the United States will lose its world technological and economic leadership.

Foster said the U.S. is being challenged in military, space and atomic fields by the Soviet Union and in the consumer area by Japan and West Germany.

What role for the FCC in the future of CATV?

How the CATV industry is going to be regulated in the future is by no means clear. Speaking at the EIA Spring Conference, last month, Jack Mayer, deputy to the director of the FCC's Cable Television Bureau, pointed to five big issues that will soon be settled:

- Should CATV be allowed to develop as a separate competitive technology? (The FCC has been acting on the premise that CATV should be supplemental to broadcast TV, filling in only those service gaps that over-the-air television can't fill.)
- What is the future role of the telephone industry in the cable field?
- Will some form of licensing procedure be implemented instead of "present go-no-go authorizations for new systems?
- Will cross ownership or multiple-ownership between TV broadcast and cable operations within the same markets be banned?
- What will be the role of the federal and state authorities in such matters as service standards, rates, franchising, and so forth?

So far, the FCC has resolved only one issue: it has decided that as of January 1, 1971, CATV systems with 3500 or more subscribers will be required to originate a substantial amount of broadcasting. At the same time, said Mayer, they will be allowed to sell commercial advertising to lessen the cost of such programming.

It's too early, Mayer declared, to predict which of the technologically feasible systems will prove most marketable. "Much less regulation," he said, "seems needed for a cable system that simply carries broadcast signals than one that originates programs of its own."

Computer terminal prints four alphabets

A quardri-alphabetic keyboard and printer was shown to the public March 15, opening day of Expo '70 in Osaka, Japan.

The experimental system, designed by IBM in Yorktown Heights and in Endicott, N.Y., prints any of 10,000 Kanji characters (Chinese graphics), the written language of Japan at the rate of 300 16-character lines per minute on standard business forms.

The printer also prints Hiragana and Katakana (Japanese phonetic alphabets) and the latin alphabet. Characters—one quarter inch square—are formed by overlapping dots made by tiny print wires inked by a ribbon.

The keyboard consists of 3520 symbols from the four alphabets. It can be used either as an on-line input terminal for a computer-controlled graphic display or to control a key punch.

'Second-sourcing' starts in minicomputer market

Indicative of the feverish activity in the minicomputer market, a relative newcomer has announced a model that it says can replace the mini-machine in widest use today—the PDP-8 series, manufactured by Digital Equipment Corp., Maynard, Mass.

The new mini is the DCC-112, built by Digital Computer Controls, Inc., Fairfield, N.J. It is described as a second source for the PDP-8—"plug, program and mechanically interchangeable."

This is the first time that any computer has been "second-sourc-

News Scope CONTINUED

ed," industry observers say.

John N. Ackley, president of the one-year-old Jersey company, asserts:

"Although the price of the stripped down model is only slightly below the lowest-priced model in the PDP-8 line, the differential in favor of the DCC-112 rapidly increases as additional memory or other options are specified."

He adds that he expects the new mini to have higher reliability, because it uses only five circuit cards, compared with 110 in the PDP-8.

There are also fewer back panel connections, fewer individual semiconductor components and lower power dissipation—all of which tend to increase the mean time between failures.

Digital Computer-Controls doesn't plan to supply any software. It hopes that the original equipment manufacturers who buy the DCC-112 will make use of the extensive libraries of proprietary software that have been written for the PDP-8.

Small microwave relays are ready for Air Force

The military is getting its first "ultra lightweight" (67 pounds) wideband microwave relay unit that, despite its small size, "does not compromise performance," according to a spokesman for the Air Force's Rome (N.Y.) Air Development Center.

The all solid-state unit, which can be set up by one man and operating in less than 10 minutes, provides 300 voice channels or the bandwidth for transmitting video or radar data.

It is designated AN/TRC-92 and built by Motorola Inc.'s Government Electronics Div. in Scottsdale, Ariz. Ten of the units will be installed in 10 Air Force Mark 113 troposcatter communications systems. The Mark 113 was built by REL Div. of Dynamics Corp. of America in Long Island City, N.Y., under contract to Page Communications.

The microwave units will relay transmissions from the tropo terminals to identical microwave units as much as 10 miles away set up in command posts in valleys or in places unsuitable for a tropo terminal. The microwave unit can also be used for transmitting high-density analog or digital data from one operational site on a base to another.

Raytheon, Co. in Norwood Mass., is building a similar microwave unit that will relay radar data from its AN/TPN-19 ground-based aircraft landing radar being readied for the Air Force air-transportable area defense system, the 407L. This relay unit won't be delivered to Rome for another year and a half.

The first microwave unit Rome tried out was built by ITT. Motorola won out, however, because of price.

Army favors beam scan for helicopter lander

Although the Army will look at other steep-angle landing systems for getting helicopters safely on the ground in rain or fog, it claims to be very pleased with the beam-scanning system now under test at FAA's research facility at Pleasantville, N.J.

Tactical instrument landing system for helicopters is tested by Army.

Developed and built by Cutler-Hammer's AIL Div., Deer Park, N.Y., and called A-Scan, the system uses a microwave scanning-beam technique that permits any descent angle from 2° to 29° above the local ground plane. The angle can be selected in the helicopter.

A-Scan provides a pulse-coded radio signal in an approach sector containing proportional signals 60° on either side of the chosen center line. By switches at the ground station, three approach lanes anywhere in the sector can be set to accommodate a helicopter in each lane, all landing at the same time.

The system was selected for testing over others, according to Lt. Col. E. D. Richards, the Army Avionics Laboratory's commanding officer and director, because its microwave scanning-beam technique offers sufficient versatility to bracket the wide range of guidance needs it will be required to satisfy. "Also, the scanning-beam guidance signals offer convenient selection of glide-slope angle, approach azimuth, and dimensions in space which correspond to the lateral and vertical boundaries of the intended descent path. And," he says, "the scanning-beam technique allows a precision to be designed into both ground and airborne equipment. The units are physically detachable and usable on an optional basis."

Data processor to cut communications costs

Motivated by the high and still-increasing growth rate of the computer communications market, the General Electric Co. has developed a new data-communications processing system, called Datanet-500. The device, the company says, will permit "more effective use of telephone lines and other common carrier facilities, and will greatly increase the reliability of data-communications functions."

The Datanet-500 contains memory, processor, communications, and input-output subsystems which can be interconnected to perform a variety of functions. Chief among its immediate applications are line-concentrating and store-and-forward message switching.

RCA-TA7487 is new.
It offers 2 W with 10 dB gain (min.)
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RCA-TA7487 is a ceramic-metal coaxial unit.
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*Section DI-18/UF7

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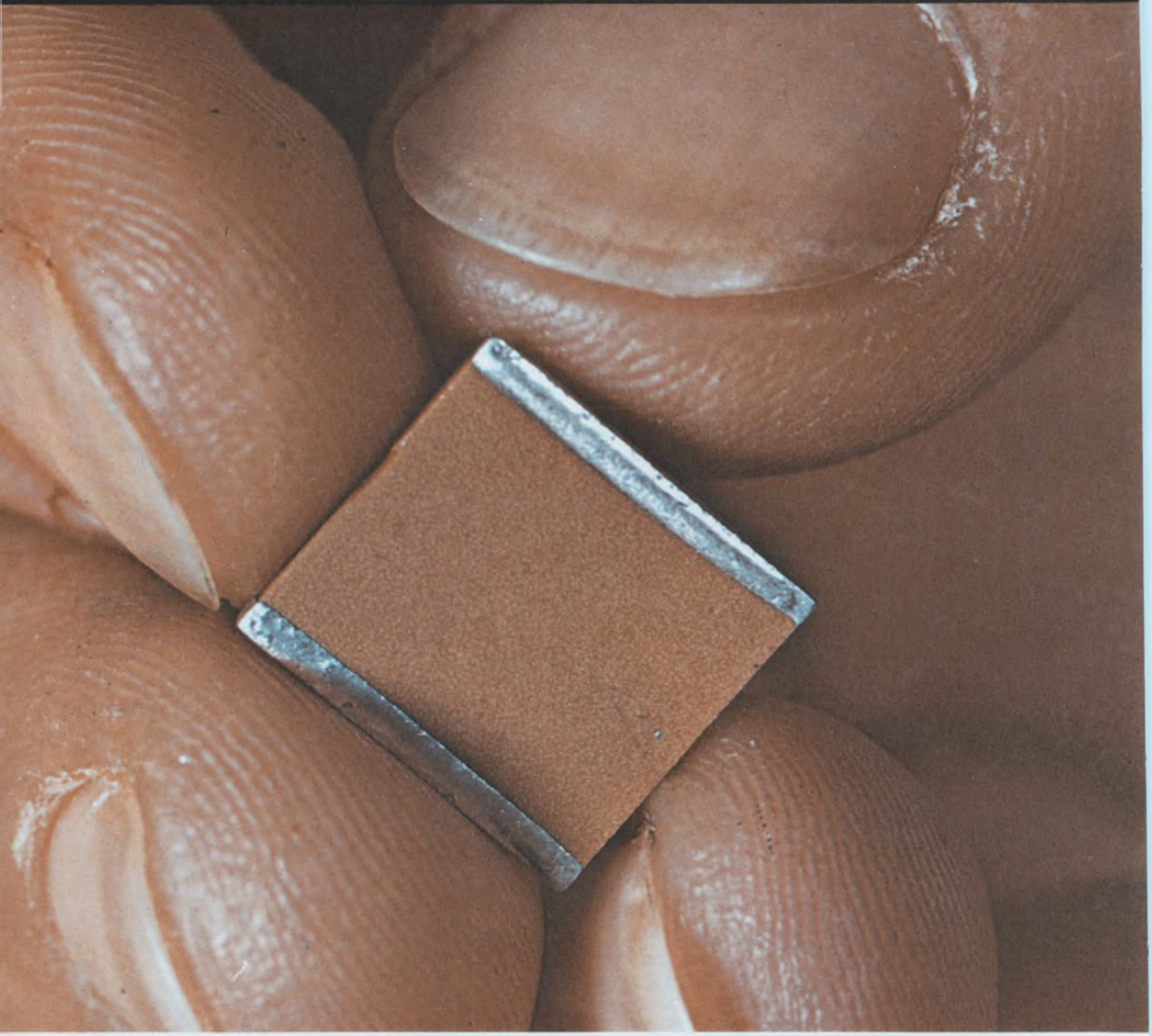

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Time marches on–but electronically now

More and more, mechanical wristwatches are giving way to timepieces with microcircuitry

Jim McDermott
East Coast Editor

"By the year 2000, the concept of a wristwatch will give way to a more complete communications center that includes a means of keeping accurate time, has both transmitting and receiving capabilities, and perhaps has a miniature computer."

John B. Bergey, director of watch research and development at the Hamilton Watch Co., Lancaster, Pa., is talking, and his prediction, made matter-of-factly to ELECTRONIC DESIGN, dramatizes what is happening in the watch industry today. For years, a timepiece—whether for the wrist, pocket or mantle—was strictly a simple mechanical device with fine springs and gears. But with inroads made by Bulova's Accutron and other electronic watches, the electronics industry is staking out a broad claim to the market. It is opening up new opportunities for designers to come up with accurate, ingenious, and yet relatively inexpensive, timepieces.

Bergey believes it's quite possible that there will be a number of central transmitters, either land-locked, or from orbiting satellites, transmitting accurate time and constantly updating the time of all watches within reception range.

In fact, the elements of such a system are already here. It could be a sophisticated combination of something like the transmitting system of the Seiko atomic-uhf time-distribution system now operating at the Japan World Exposition at Osaka (Fig. 1) plus the Bulova satellite clock in Mexico City (see photo). The latter clock receives signals from four timing satellites in polar orbits and displays them to one-tenth of a second. Located on the 39th floor of the Torre Latinoamericana, Mexico's tallest building, the clock is accurate to 86 one-millionths of a second per day.

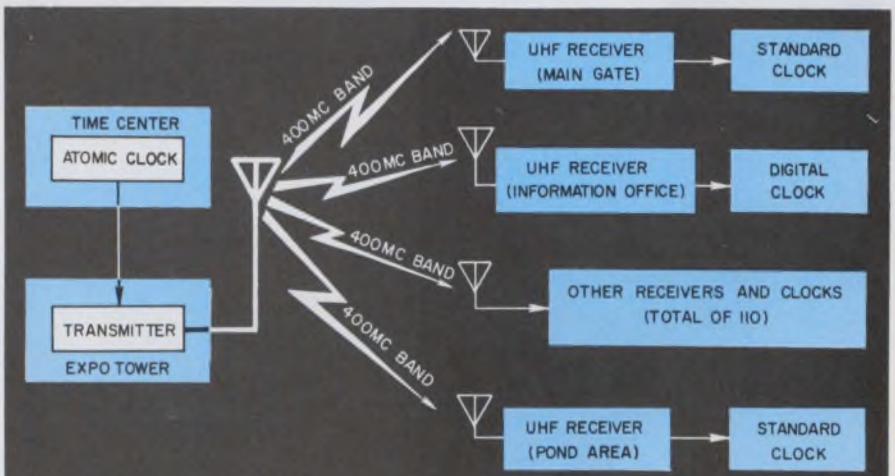
Batteries and displays lag

But Bergey cautions that the transition from the present crop of electrical and electronic wristwatches to an all solid-state wristwatch is beset by two widely recognized, and interrelated, problems that defy solution right now: solid-state displays and batteries.

Present solid-state displays need milliwatts of power—orders of magnitude greater than the 10 microwatts required to operate today's electronic watches. And the only batteries now small enough to run a wristwatch are already pushing their limit in delivering the 10 microwatts for a year or more. What is really needed to overcome the problem is a great increase in the energy density of batteries plus a tremendous decrease in the power now needed to operate the solid-state displays.

However, this doesn't mean the industry is limited for the next couple of decades to the performance of the electrically or electronically driven balance wheel (ac-

The Bulova satellite clock in Mexico City has a quartz-crystal time base and is updated from satellite signals.



1. **An atomic clock at the Japan World Exposition** feeds controlling signals to uhf receivers and clocks at over 100 locations in the fair, maintaining highly accurate time.

(**wristwatch,** *continued*)

curacy of 5 to 20 seconds a day) or even the tuning-fork Accutron (2 seconds a day). Major watch manufacturers questioned by ELECTRONIC DESIGN admit to much closely guarded research and development on the electronic wristwatch of the future, with principal emphasis on ultimately providing the wearer with timekeeping accuracies once obtained only by observatory clocks.

In fact, if you're a timekeeping buff who needs to be accurate to a fraction of a second a day—less than one minute a year—the quartz-crystal wristwatch is here in three versions. None has the conventional balance wheels or escapements, but the hands are still retained.

One version was announced for sale in Japan last Dec. 31 by Seiko Watch-K, Hattori & Co., Ltd.—Japan's leading watchmaker—in an effort to scoop two Swiss competitors: a 19-company combine called the Center of Electronic Horology (CEH) and Longines, which independently developed its own quartz-crystal watch.

The Seiko model sells for $1250 in an 18-carat gold case, but the prices will be substantially lower in subsequent models with less costly cases. The gold model will be sold in the United States "sometime in 1970," according to Shoji Hattori, president of Seiko. But CEH and Longines have also announced essentially the same availability and competitive pricing in the race for U. S. introduction.

All three quartz watches use the same type of hermetically sealed crystal oscillating at 8192 Hz, which is either divided down to a substantially lower frequency or otherwise applied to drive or control an electromechanical "motor" arrangement. The motor turns the hands through gearing.

In the Seiko watch (Fig. 2) the 8192 Hz is fed to a 13-divider chain ($2^{13}=8192$) the output of which is one pulse per second. Each pulse activates a geared, six-pole stepping motor, rotating in one-second increments of 60° per step.

In the CEH watch (Fig. 2) the 8192 Hz is divided down to 256 Hz, a reduction of 320 to 1. The 256 Hz is applied to a resonant-reed motor driving a ratchet arrangement and gearing to the hands. Like the Seiko watch, the electronic system is "open-loop," so that no means are provided for correcting timing errors that occur at the motor-driving frequency.

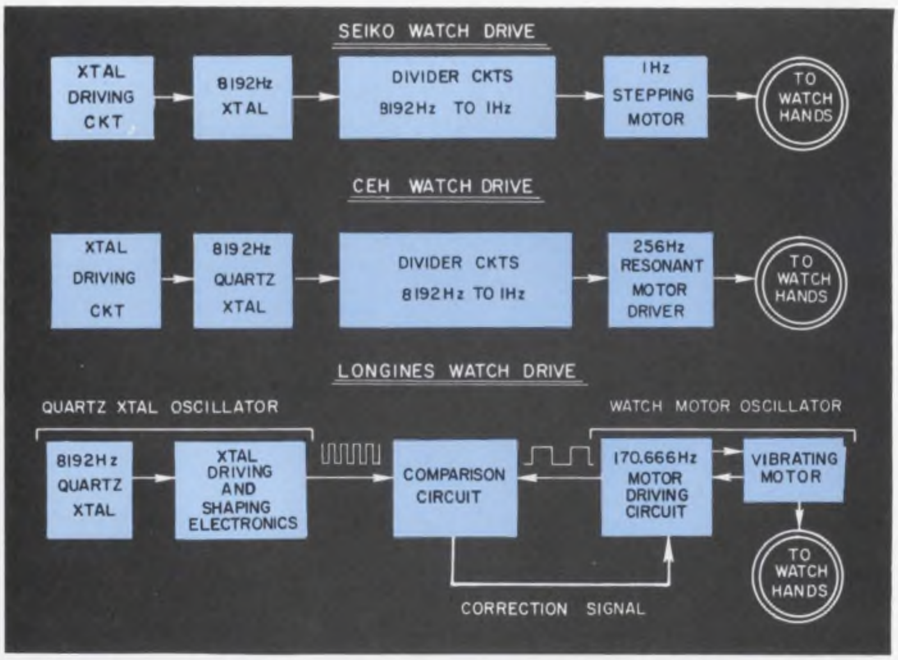
Longines designers have produced the most unique circuitry of the three: a closed-loop system in which the frequency of the motor-driving circuit is servo-controlled by the quartz-crystal oscillator (Fig. 2).

Unlike its two competitors, Longines does not count down the output of its 8192-Hz crystal oscillator. Instead, the quartz output is used as a frequency standard, against which the frequency of the 170-Hz torsion-balanced vibrator motor, which drives the hands, is compared and accurately controlled.

This is accomplished by making the resonant motor and its driving electronics an independent, 170-Hz, electromechanical oscillator that can free-run by itself. The outputs of the quartz oscillator and the motor-driving circuit are then applied to a comparison circuit. If the drive motor frequency is exactly 170.666 Hz, the error signal is zero and the motor is exactly in step with the crystal. But if the motor-driving frequency is higher or lower, the comparison circuit produces a correcting signal that is applied to the driving circuit to keep the vibrating motor armature in exact step.

Interestingly enough, the same basic, readily available type of 8192-Hz quartz crystal was chosen for the watches of all three competitors.

As far as the driving and counting electronics are concerned, the Seiko watch uses hybrid circuitry, the Swiss CEH has integrated circuits, and the Longines watch has discrete components that consist of 14 transistors, 19 resistors and 7 capacitors.



2. **Quartz-crystal wristwatch hands are driven** by three methods at present. The first two (by Seiko and CEH) use counter chains, while the third (Longines) has a servo system.

Quartz designs still use hands

While the new quartz wristwatches have increased the accuracy over current electronic watches by better than an order of magnitude, the quartz designs still rely on electromechanical drives and gearing to turn the hands and other indicators, such as the date. But the designer who would eliminate all mechanical elements and come up with an all-electronic wristwatch, including displays, faces the formidable joint problem of useful solid-state displays and batteries.

"For a timepiece the size of a small clock, no such problems

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N8241A	Quad Exclusive OR	1.62
N8242A	4-Bit Comparator	1.62
N8243N	8-Bit Position Scaler	12.60
N8250A	Binary-to-Octal Decoder	3.88
N8251B	BCD-to-Decimal Decoder	3.88
N8260N	Arithmetic Logic Element	18.90
N8261A	Fast Carry Extender	1.26
N8262A	9-Bit Parity Generator and Checker	3.62
N8263N	3-Input, 4-Bit Digital Multiplexer	9.15
N8264N	3-Input, 4-Bit Digital Multiplexer	9.15
N8266B	4-Bit Multiplexer	2.72
N8267B	4-Bit Multiplexer	2.72
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INFORMATION RETRIEVAL NUMBER 15

NEWS

(**wristwatch,** *continued*)

exist," Bergey points out. "But when you attempt to reduce this to wristwatch size, you run into power problems, particularly in solid-state designs using present and relatively high-priced technologies."

Power consumption an obstacle

Since it requires only about 10 microwatts to run both balance-wheel and quartz-crystal electronic watches, a small mercury or silver cell can last over a year, Bergey points out. But in going to an all solid-state, active readout, the power consumption jumps orders of magnitude because of required decoding circuits as well as the light-emitting devices themselves.

However, the technology is here to overcome the problem, and a step in applying it has already been taken by Longines in a hand-held, quartz-controlled electronic sports timer, which displays down to 1/100th of a second (see photo). Working on a rechargeable battery, it uses integrated circuits and light-emitting diodes (LEDs) supplied by Hewlett-Packard Associates, Palo Alto, Calif.

With all six solid-state numerals glowing, each comprised of a 5 × 7 dot matrix, the display consumes about 1/2 W, according to Richard Kniss, Hewlett-Packard product planning engineer. The IC decoder/drivers, operating at 5 V, are integral with each numeral and require only a four-line binary-coded decimal input. The LEDs themselves need only 4.2 V.

Passive displays investigated

But other types of displays are also of interest to the watchmakers, including passive displays operating from ambient light, such as liquid crystals. Considerable work has been done in this area by RCA Laboratories in Princeton, N. J., where the company demonstrated an all-electronic clock with a liquid crystal readout in May, 1968.

But Dr. George Heilmeier, director of device concepts research at RCA Laboratories, holds little hope for application of the crystals to wristwatch displays.

Their big limitation for wristwatch applications, he told ELECTRONIC DESIGN, is in the fact that they require voltages ranging from 6 to 50 V—far higher than that of currently available cells. Although the power consumption of 0.1 mW per cm² of display area is promising, particularly when it is only intermittently required for changes in display, Dr. Heilmeier says that the threshold at which the phenomenon occurs is voltage-dependent and cannot, with present materials, be lowered.

What is needed is a research break-through, and Dr. Heilmeier is frank to admit he's not very enthusiastic about the prospects.

Battery progress pushed

Even with the optimum solid-state displays of the future, wristwatch power requirements will certainly be increased. And as for traditional batteries, Bergey of Hamilton doesn't look for dramatic improvements.

"Traditional batteries, be they silver oxide or mercuric oxide, have distinct limitations," he says. "Their energy densities are fairly low, based on electrochemical relations. And the watch industry alone can't support the vast research necessary for a quantum improvement in battery performance."

But the problem may not be so bad as he thinks. One battery expert who refused to be quoted, told ELECTRONIC DESIGN that industry efforts have uncovered a new cell with a non-aqueous electrolyte. Its voltage ranges from 3 to 3.5 V, and it's considered to have good potential as a watch cell. Energy density is substantially improved—about twice that of mercuric oxide. And if made rechargeable, it can't be overcharged. But it's still in the laboratory stage and not expected to reach the market for three to five years.

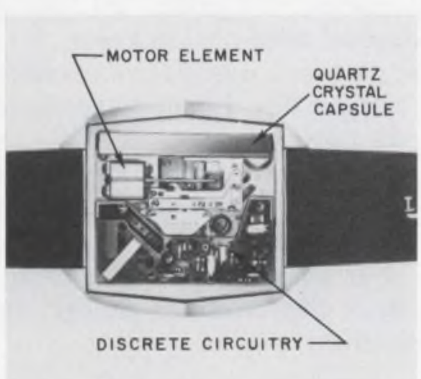
The quartz-crystal time base for wristwatches is still new. But already R&D is going on to replace that element with a more accurate, rugged standard. For example, John Carpenter, vice president of the Electronics Div. of the Bulova Watch Co., New York, says that his advanced research department has been working on nuclear systems that use about a milligram of an Alpha particle-emitting radioactive isotope as a time base.

The Alpha emanations are picked up by a solid-state detector to provide a long-term count, which, on the average, is very stable. The pulse-count output of the detector is amplified and applied to a series of binary dividers.

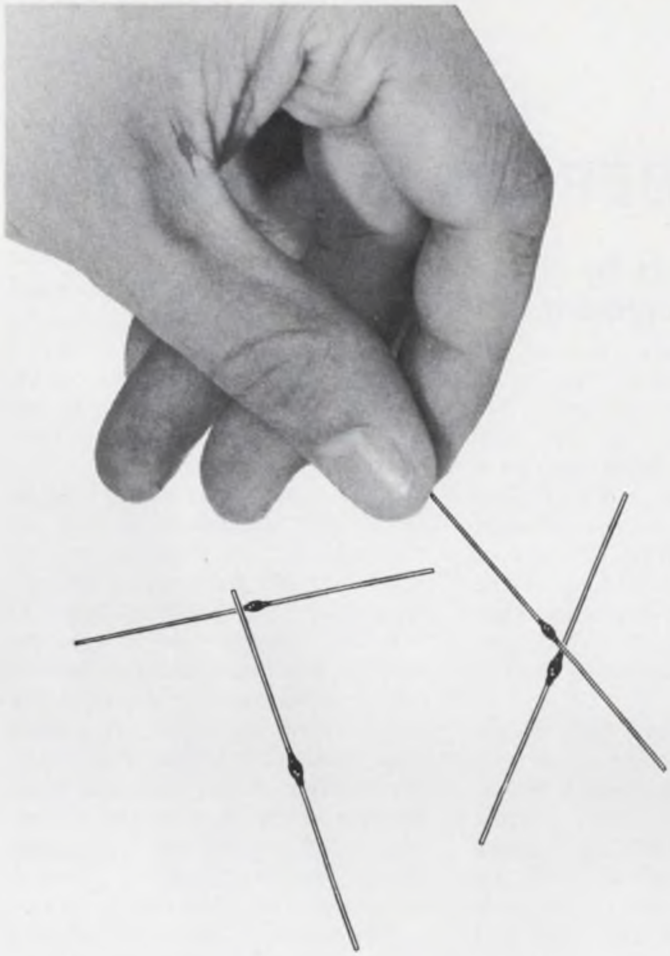
The radioactive time base needs no external power to activate it. And since it is not affected by temperature, no frequency variations would be produced by putting it in a wristwatch. Such a system, Carpenter says, has a potential accuracy of better than one minute a year.

But complex unsolved problems are involved in microminiaturizing the count down and detection circuitry. And no present prediction can be made as to when it could be reduced to wristwatch size. ■■

The basic technology for the wristwatch of the future is incorporated in this quartz-crystal stopwatch for sports, using solid-state displays.



The electronics and motor element of the Longines Ultra-Quartz crystal-controlled wristwatch are shown.



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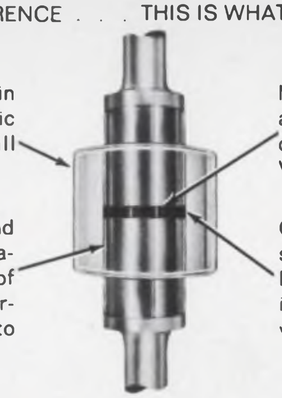

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INFORMATION RETRIEVAL NUMBER 16

Curing engine failures BEFORE they occur

Ampex R&D system uncovers worn parts by displaying the audio frequencies of equipment

Elizabeth de Atley
West Coast Editor

You drive up to the computer terminal at your local auto diagnostic center and leave the motor running.

"Another '72 Mustang," says the attendant with a glance at your car. Out of the file, he pulls a black card, riddled with holes, and inserts it into a slot. Lifting the hood of your car, he connects a wire from the terminal to a plug in the motor. This plug contains connections from sonic tranducers placed throughout the engine. Almost immediately a typewriter terminal begins to type:

"Replace main bearing within 500 miles . . . replace intake hydraulic lifter on cylinder 7 immediately. . . ."

A dream? Right now it is—but closer to reality than you might imagine, says Gordon R. Knight, a staff member of the Research and Advanced Technology Div. at Ampex Corp., Redwood City, Calif. Already the equipment necessary to isolate and display a broadband of audio frequencies exists in the laboratory at Ampex. This equipment can quickly distinguish between two sounds that are very close together in frequency—such as, for example, the rotating noise produced by two slightly different types of ball bearings. What does not yet exist, says Knight, is the mechanical data to determine what frequencies are emitted by specific moving parts in automobile engines as they wear out.

However, he points out, considerable data on jet engines has been supplied by the Airesearch Manufacturing Div. of the Garrett Corp., Torrance, Calif., and other companies in connection with the Mechanical Failures Prevention Program of the Office of Naval Research. This information has been used with considerable success in interpreting outputs from the Ampex equipment.

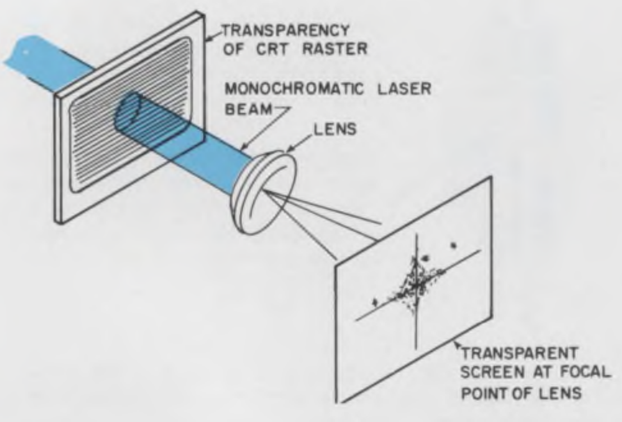
Optical technique used

One day such data should be available for automobiles, Knight believes.

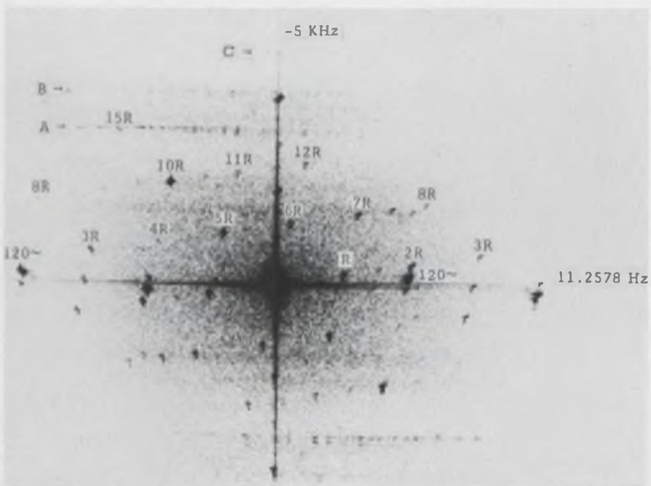
For the work with jet engines, the Ampex equipment includes a cathode-ray tube with a raster format of 512 lines and an optical spectrum analyzer, which consists of a transform lens and a laser source.

The engine vibrations are translated into electrical signals by microphones or accelerometers. These signals are used to intensity-modulate the electron beam of the CRT. On the tube screen, the original variations in amplitude of sound appear as variations in the intensity of the trace. The click-click sound of a broken gear tooth, for example, would appear as a recurring bright spot on the screen. The CRT scanning equipment tracks the jet engine speed to compensate for changes in speed.

The screen is photographed and a transparency is made. This transparency is placed between the lens and the source of the laser, causing a complex diffraction pattern to appear at the focal point of the lens. This diffraction pattern looks like a cluster of dots of varying intensity. Because of the nature of the lens, the diffraction pattern is



To obtain the frequency spectrum of sounds from a jet engine displayed on a CRT screen in raster format, Ampex engineers photograph the CRT display, pass a monochromatic laser beam through a transparency of the display and then through a transform lens. The frequency spectrum of the original sounds is immediately projected onto a screen at the focal point of the lens.



The sounds from a jet engine look like this in an optical diffraction pattern. Frequency is a function of position on the X and Y axes. R is a rotor frequency in the jet engine. Harmonics of this frequency are shown as 2R, etc. One day such data could be used to predict component failures in automobiles. A method for reproducing the CRT screen in real time is needed.

actually the Fourier transform of the original CRT display, or the frequency spectrum of the engine vibrations that occurred during the time of the trace. Each frequency is represented by a dot in a particular location on the diffraction pattern. The intensity of the dot is proportional to the amplitude of the frequency.

How can one relate a spot on the diffraction pattern to a particular frequency, and from there to a particular component in the engine?

"We know the dimensions of the optical system," says Knight. "We also know how we laid the data on the film in the first place. So we know that a particular spot on the diffraction pattern represents a particular frequency. The mechanical engineers have given us a handbook of mathematically calculated frequencies for particular components. For example, certain frequencies, due to the passage of air through the compressor blades, are conspicuous in every display. We list all of these frequencies in our computer program, and it tells us that if we lay a piece of grid paper over the diffraction pattern, a particular frequency appearing so many units over and up from the center means a defective ball bearing—or whatever."

How far off is the computerized diagnostic center that does real-time trouble-shooting?

"As far as the equipment is concerned," says Knight, "the only thing missing for real-time, trouble-shooting of any mechanism is a technique for providing a visual reproduction of the CRT screen in real time.

"For every kind of engine," Knight explains, "we would need a piece of black paper with holes or slits in it at particular frequencies that we know mean particular kinds of trouble for that engine. We would insert this mask into the optical analyzer at the focal point of the lens and put photodiodes, or a vidicon, and threshold devices at the output. When the light through a particular hole got above a certain intensity, that would mean the vibrations at that frequency had increased to the danger point, and we would know that that component was going to fail. ■■

INFORMATION RETRIEVAL NUMBER 17

Antenna design aid rises in the desert

Patterns for airborne and vehicular radio antennas can now be measured with precision on the ground

Story and photographs by **John F. Mason,** Military-Aerospace Editor

Rising 104 feet above the flat Arizona desert, a skeletal pyramid supports a slender white arc 140 feet long (shown, right). Along the arc, from about 30 feet above the ground to its nearly horizontal end, five radio receivers are fixed. Underneath, a rotatable platform, resembling a scaffold, holds a gutted Army Mohawk surveillance aircraft, strapped upside down. The purpose of the setup is to test aircraft antennas.

Signal generators on the plane, transmitting up to the five receivers on the arc, simulate the Mohawk's radio transmitters, as if they were transmitting to planes below them or to the ground. Ground returns are avoided because the platform holding the plane is 28 feet high.

When completed, this unique test facility will make life simpler and cheaper for Army engineers who write specifications for airborne antennas, for those who test prototypes, and for manufacturers who design and build radios and antennas.

Operator straps an electronic jammer on to wing of Army's Mohawk to measure its effectiveness.

"Designers, we hope, will eventually be able to come here and run a quick-and-dirty test early in the game instead of going through a whole design cycle and then having to backtrack," says the facility's designer, Nicholas Glauber. He is an electronics technician in the Avionics, Meteorology and Electronic Warfare Div. of the Army Electronics Proving Grounds at Fort Huachuca, Ariz.

Glauber adds, "The results from ground tests are far more precise than those from the air.

"In flight there's an aircraft attitude problem," he explains. "Wind causes a plane to pitch and roll, and unless we've got instrumentation that can correlate that pitch and roll with variations of signal strength on the ground, the data is not accurate."

Glauber is pleased with the system's accuracy. "With five receivers we get five cuts of a transmitter at the same time. The signals are fed to a van equipped with amplifiers and recorders. Here we make rectilinear plots of all five signals simultaneously. The time correlation is perfect."

The reason for five antennas and for taking measurements each time the platform is turned five degrees is to measure the antenna pattern in relation to the antenna's position on the aircraft to every elevation and direction.

"We might have to change the location of an antenna or redesign it, or at least let the pilot know where his blind spots are," Glauber says.

"Up to now, industry has been guessing what antennas would do. Now, for the first time, we can run a performance test and check it against the technical characteristics of the system, including the antenna pattern. As more tests are made, we are going to find most of our answers right in our antenna patterns."

When this turntable is completed, vehicular radio antennas will transmit to five receivers in the 100-foot tower 500 feet away. Buried steel-wire mesh will provide a swamplike or saltwater environment to the transmission.

The receivers used now vary in frequency. Some are 30 MHz to 400 MHz and use a half-wave dipole; others, between 400 and 1000 MHz, use a dipole with corner reflector; and some, above 1000 MHz, use a directive antenna with side-lobe attenuation at least 16 dB down from the main lobe.

For polarization measurements, two orthogonally polarized but otherwise identical sensor antennas such as crossed linear, are used.

Each of the arc's five receivers reveals:

- Relative antenna gain (dB) vs azimuth and elevation angle in degrees
- Phase, or phase difference, in degrees vs azimuth and elevation angle in degrees.
- Polarization data vs azimuth and elevation angle.

By July, a new, and very important, dimension will be added to the facility. Besides antennas for aircraft, antennas for vehicular and other ground-based radios will be tested in both desert and swampland environments.

Five hundred feet to the east of the airborne testing platform, a tower, 100 feet high, is being equipped with five receivers. And 500 feet east of it, an automatic turntable is being built. To simulate the marshland or saltwater environment, a steel-wire mesh is being laid a few inches below the surface of the new turntable all the way to the central tower. For convenience of trucks and personnel, the mesh will be covered by asphalt. ■■

Electronics tunes in on muscle fatigue

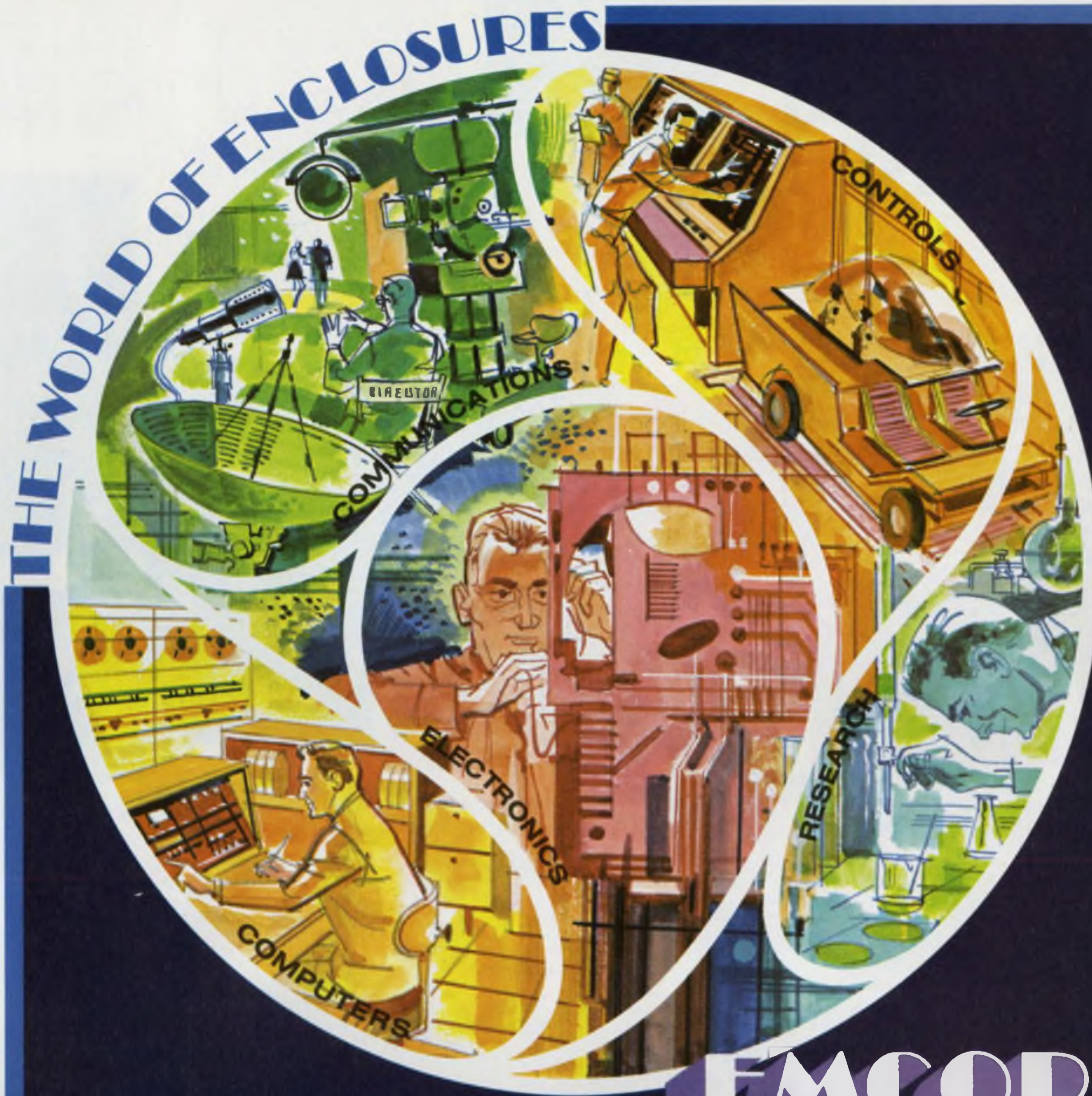
Electronics is being used to study muscle fatigue of production-line workers at Western Electric's Kansas City Works. Electrodes pick up impulses less than 1/1000 V that are emitted as muscle fibers contract in the course of normal job activity. These impulses are then transmitted from a tiny radio on a worker's shoulder and sent to electromyographic (EMG) recording equipment.

The purpose of the EMG study is to improve the environment of employees engaged in making products for the Bell System.

The new EMC approach is being made with the participation of the University of Michigan department of industrial engineering under a research grant from Western Electric.

Results from the Ann Arbor campus have shown that there is definite relationship between muscle power and frequency. University of Michigan researchers found that there is a continual shifting of signal power from higher to lower frequencies. The greater the fatigue, the greater the shift. ■■

Nothing shocking about her signals. Only 1/1000th V is generated by muscles at the elbow, but this is enough for study of causes of muscle fatigue. The girl is testing small components at Western Electric's Kansas City Works.



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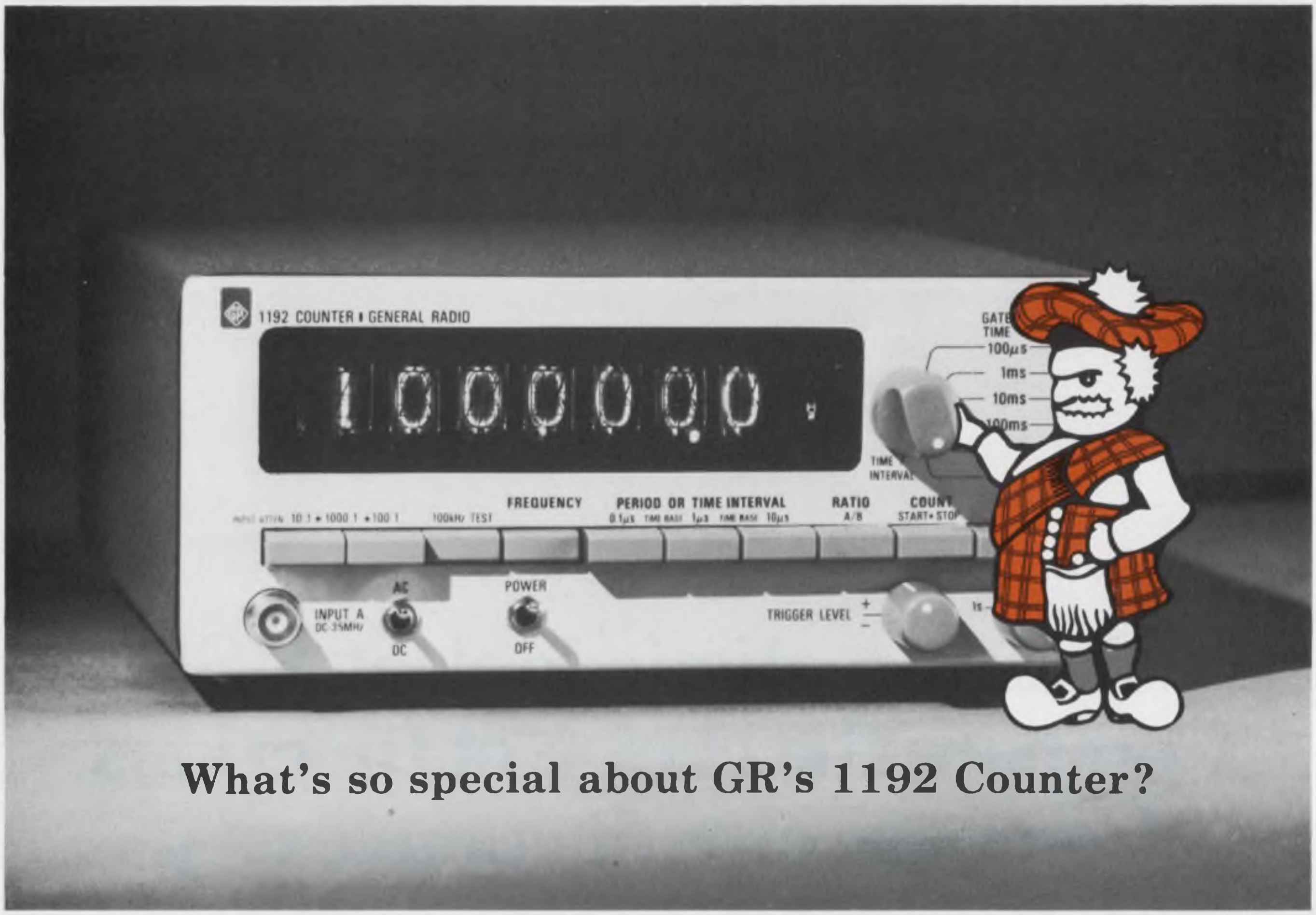
INFORMATION RETRIEVAL NUMBER 19

TI's quiet revolution in TTL/MSI



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GENERAL RADIO

INFORMATION RETRIEVAL NUMBER 20

Washington Report

CHARLES D. LA FOND, WASHINGTON BUREAU

Underseas missile program faces budget test

The 1971 federal budget includes a request of $44-million to proceed with engineering development of the Navy's Undersea Long-range Missile System. Many in industry here and on Capitol Hill believe this to be a pivotal point: If the full request is approved, it will be difficult in the future to curtail the program. Congress will certainly look closely at a request for funds that quadruple 1970 appropriations.

The new submarine and weapon vehicle, compared with existing Polaris/Poseidon submarines, will be larger, quieter and dive deeper. It may carry over 20 extra-long missiles in a horizontal position, externally. The missile system will have a range capability of over 5000 miles and will carry a MIRV-type cluster of warheads. And the missile electronics may very much resemble those used in Minuteman III, according to Washington industry informants.

No official estimates have been released, but cost for the total program, if it replaces the existing ballistic-missile submarines, could total $25-billion, according to the House Democratic Study Group.

Deep-submergence vehicle could take a dive

Also under close inspection is the Navy's Deep Submergence Rescue Vehicle program. The General Accounting Office has made a detailed study of it and reports an enormous growth curve in six years—from a planned $36.5-million for 12 craft to $463-million for six vehicles. Furthermore, the GAO study notes that, in 1964, the Navy said it could build the 12 vehicles in four years; now it claims it will require 10 years to build six.

Needless to say, members of Congress are concerned over conduct of the program, the costs of which have escalated by over 2000%. Sen. John J. Williams (R-Del.) declares his support for the development of the craft but says: "There can be no justification for such a wide error in the estimate presented to Congress."

Congressman lowers the boom on NASA

"NASA must consider the members of Congress a bunch of stupid idiots—worse yet, they may believe their own estimates." This blast, aimed at the space agency's penchant for underestimates of program costs, was delivered recently by Rep. Joseph Karth (D-Minn.) before the Earth Resources Observations and Information Systems Meeting in Annapolis, Md. He warned that the present low NASA budget could even go lower—and he emphasized that this downward trend might be reversed by Congress "if we make appropriate decisions to redirect the program along lines more acceptable to the man in the street."

Karth, who is chairman of the House Subcommittee on Space Sciences and Applications, has been for years an outspoken critic of what he considers the great imbalance in the U.S. space program between too large a manned effort and too small an applications and scientific effort.

Are foreign imports hurting U.S. electronics?

Watch for some effort by Congress this year to partially wedge the door on foreign electronics imports. This will be a response to data, recently released by the Electronic Industries Association, which shows sharply rising electronics imports both in dollars and in market percentage. The 1969 figures show imports totaling $1.8-billion, an increase of nearly 35 per cent over 1968.

"It is totally unrealistic to expect that our domestic electronics industries can compete effectively with products imported from abroad produced by competent 25-cent-an-hour labor," says Rep. Clark MacGregor (R-Minn.). The time has come, he suggests, when either the governments involved—principally Japan—will have to reach some agreement to limit exports to this country or the U.S. will have to provide some more direct assistance, probably in the form of restrictive tariffs.

Restrictions threaten oceanography research

"The majority of 'first-string' oceanographic research being done in the country today is either done directly by Navy in-house laboratories or is sponsored by Navy requirements and funding in industry and in the universities," declares a top Navy official.

This program is now endangered by the Mansfield Amendment, enacted in the 1970 Military Procurement Authorization Act, says George B. Anderson, director of the Ocean Sciences Dept., Naval Undersea R&D Center, San Diego. Speaking here recently before the American Oceanic Organization, he notes that Section 203 of the procurement act, introduced by Sen. Mike Mansfield (D-Mont.), denies use of the authorized funds for "any research project or study unless such project or study has a direct and apparent relationship to a specific military function."

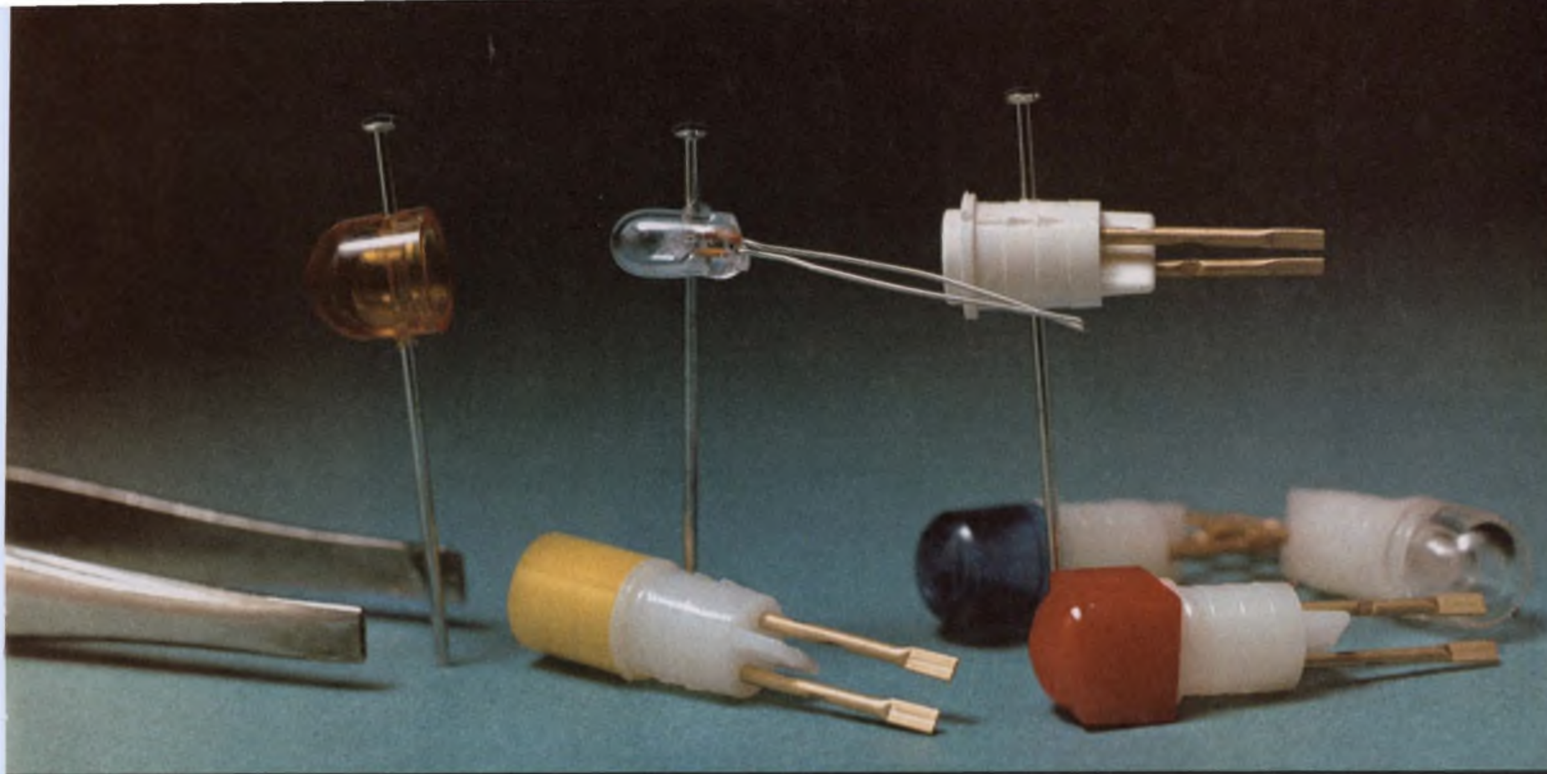
Anderson argues that the line between basic and applied research is unclear. Typical of past research gains now being applied by the Navy, he points out, was the discovery and definition of the deep scattering layer now known to be responsible for acoustic scattering of sonar transmissions. "Let us therefore," he says, "be very concerned about jeopardizing some of these efforts for the sake of fiscal tidiness."

Do data banks invade personal privacy?

Are computerized data systems so different from previous record systems that new policies will be needed to protect individual liberties?

That is the question, according to Dr. Alan F. Westin, professor of public law and government at Columbia University, and director of a 2 1/2-year study sponsored by the National Academy of Sciences. At present, he asserts, there are no laws or court decisions in the country supporting the individual's right to see, contest, change or eliminate any of the information about him in a data bank. The study, supported by $150,000 from the Russell Sage Foundation, will for the first time attempt to learn the impact of such computerized information on the privacy of individuals and the legal aspects of using such data banks.

INFORMATION RETRIEVAL NUMBER 21 ▶



Relamping is simple with Chicago Miniature's CM-25 "Brite-Lites." No tools are required. You merely unsnap the cap and remove the unbased T-1 lamp with your fingers. Our engineers devised an ingenious way to simplify lamp insertion, too. The new lamp easily inserts into internal wire lead guides. The lead guides are indented (patent pending) to assure positive contact with the lamp leads. There's no need for lead soldering. Relamping is all done from the front of the panel, so base removal is unnecessary.

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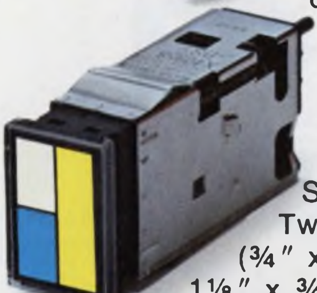

Big dividends from small pushbuttons.

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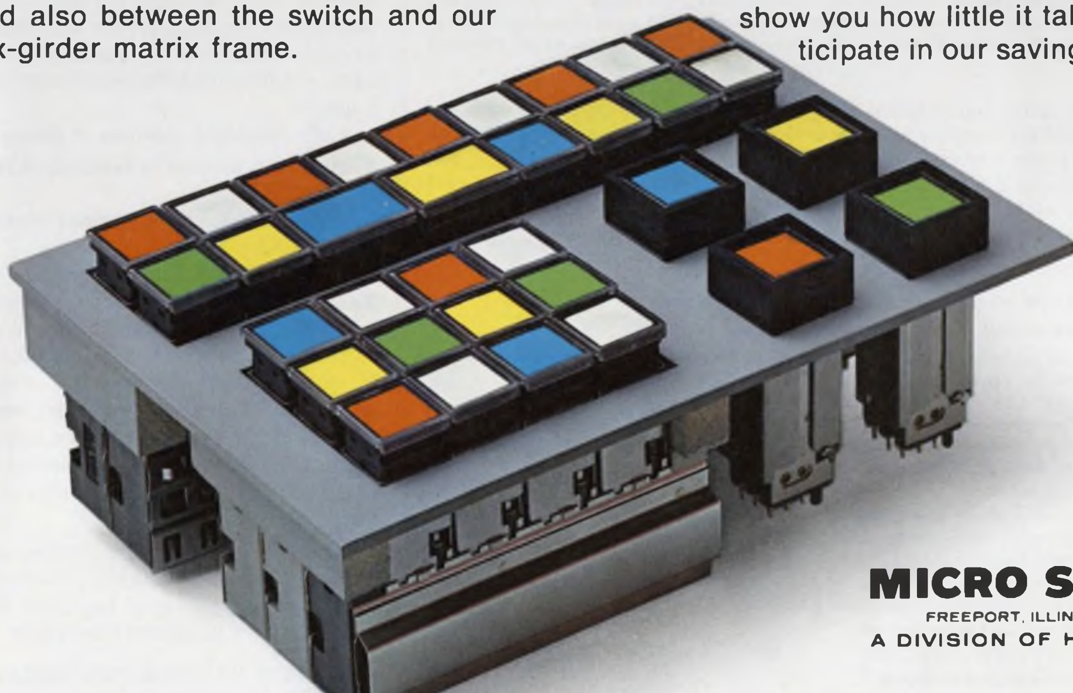

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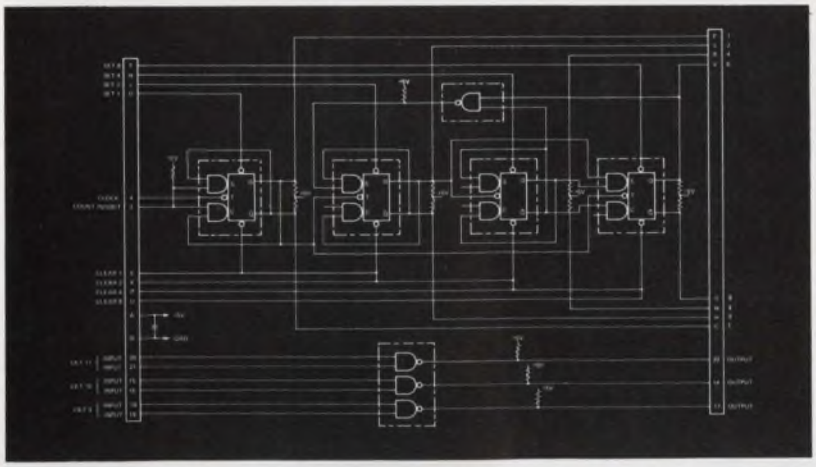

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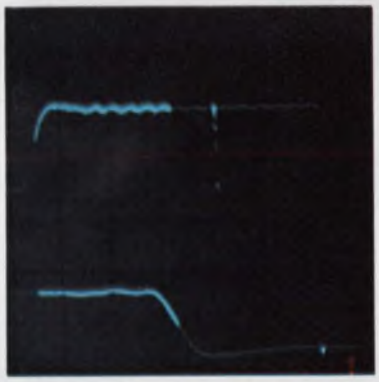

Whether you need a complete dynamic test system or the ideal components to integrate with your present system, look no further. E-H Research Laboratories, Inc. and its subsidiary, Automated Measurements Corporation, offer you the perfect solution.

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INFORMATION RETRIEVAL NUMBER 24

Timekeeping—from caveman to engineer

More than 50 centuries have passed since the caveman first attempted to keep track of time by simply pushing a stick into the ground. When the stick's shadow reached a certain point, the caveman knew it was time to get back into his cave for supper. But today the art of timekeeping has reached a degree of sophistication and accuracy not dreamed of even a generation or so ago.

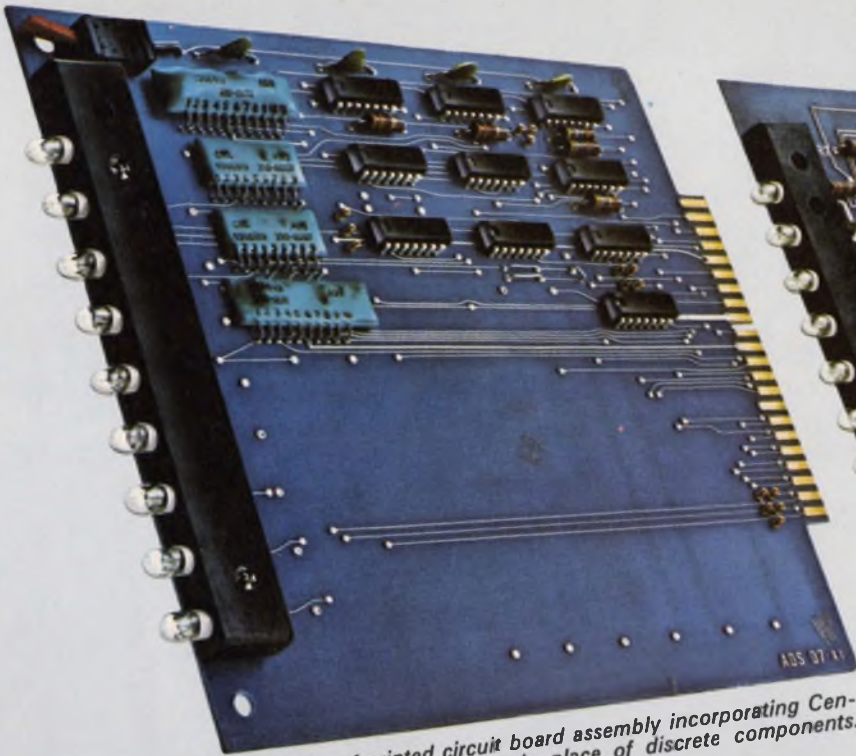
Standards for time, according to John Carpenter, vice president of the Electronics Div., Bulova Watch Co., New York City, have always been based on a periodic event—in particular, the rotation of the earth. Until well after World War II, the most accurate observatory timekeepers were gigantic pendulum clocks on heavy foundations, operating in a controlled temperature and atmosphere. Just when the quartz clock became more accurate than the pendulum type, the atomic clock appeared on the scene, displacing both as a primary time standard.

These are just a few of the interesting facts that Jim McDermott, East Coast Editor, learned while digging up material for his story on electronic wristwatches (p. 25).

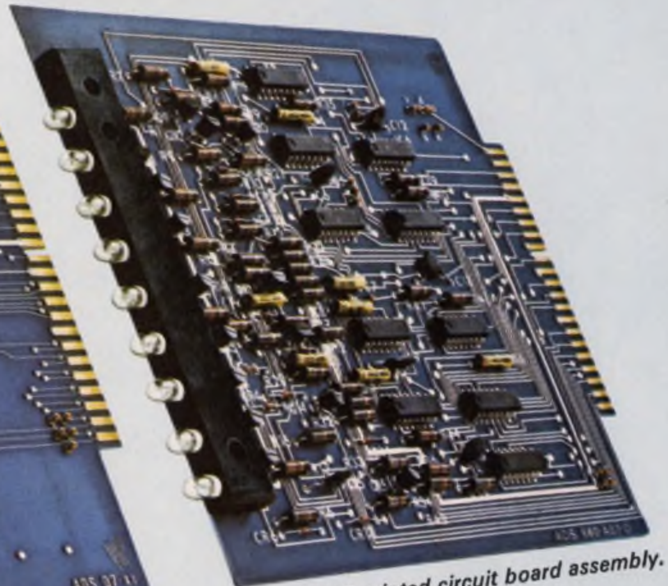
EE finds writing right down his line

Is it hard to write tech articles? Not for Mitchell P. Marcus, senior engineer of IBM Corp., Systems Development Div., Endicott, N. Y. He's had 26 articles in various publications, and the 26th appeared in Electronic Design's 26th issue of 1969. Called "Single-Map Method Speeds Design," it discusses sequential logic circuits.

INFORMATION RETRIEVAL NUMBER 26 ▶



Redesign of printed circuit board assembly incorporating Centralab hybrid microcircuits in place of discrete components.

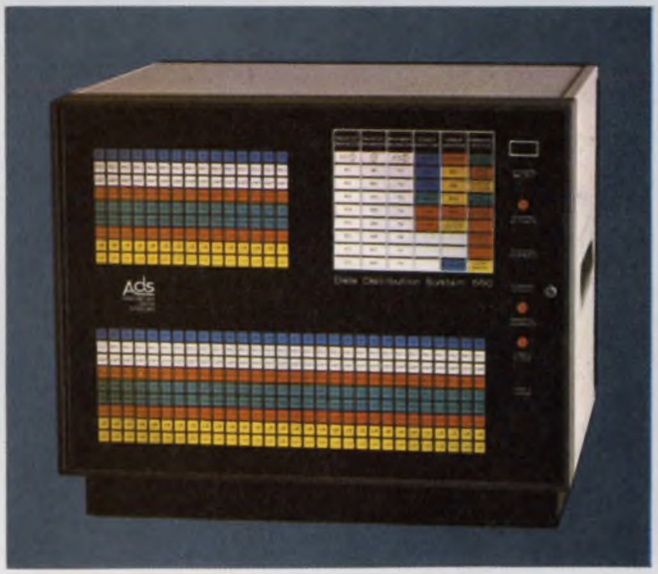


Initial ADS printed circuit board assembly.

Centralab makes a difference for

AMERICAN DATA SYSTEMS

Microcircuitry simplifies assembly, improves performance



ADS-660 time-division-multiplexer provides for the transmission of several low-speed data circuits over a single high-speed voice grade line.

American Data Systems is a new company, just a little over one year old, experiencing a meteoric growth in data communications equipment. The heart of their ADS-660 Data Distribution System is a number of printed circuit board modules. These card modules are compatible with a variety of low-speed data terminal devices.

Initially, these plug-in boards were assembled as shown on the right — using discrete components. ADS, with help from Centralab Electronics Division, was able to redesign using thick-film hybrid circuits. The four blue hybrid microcircuits (shown on the board at the left) have replaced 9 diodes, 48 resistors, 16 transistors and 5 capacitors. The change resulted in lower circuit assembly time, fewer rejects due to faulty assembly, and increased the reliability of performance — all contributing to a significant cost saving for ADS.

Centralab capability in customer design-specified microcircuits has helped improve the performance and reliability of the data communications products of American Data Systems. For information on how Centralab hybrid microcircuits might benefit your products' reliability, write: Sales Manager, Centralab Electronics Division, Globe-Union Inc.

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Symbolic electronic signal undistorted by EMI—photographed by Howard Sochurek

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INFORMATION RETRIEVAL NUMBER 27

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EDITORIAL

Are you your own worst enemy?

Work, work, work. Attend that meeting, schedule that project, design that circuit . . . But are you taking on too much?

Industry managers tell us that many engineers do. They allow themselves to be overloaded. They take on so much technical work and responsibility that their duties become drudgery, and their performance lags. And if work is drudgery, creativity is at a pretty low ebb.

If you are overloaded and harried, if you don't have a moment to spare and you're keeping track of five projects at once, you probably can't perform any of your work to your own satisfaction. So your personal reward from your work is minimal. What's worse, you may not be impressing your management. To your boss you may just seem tired and disorganized.

Sure, performance counts and you want that promotion, but you may be emphasizing quantity in your work at the expense of quality. And your management expects quality. Remember the law of diminishing returns? Added effort, past a certain point, may not show much in your over-all performance.

What's the answer? Planning. Start planning now for next month, and next year. Examine your daily schedule realistically. Does it allow for communication, a few moments of conference with your boss and with other engineers? Does it allow time to keep up with your technical reading, with expanding your knowledge? Can you attend the odd lecture? Does your daily routine allow time for simple, creative thought?

And how about broadening your interests? Do you have time to develop the nontechnical side of your life? Can you spend some time with your family, so that they are as happy about your career as you are?

Your company needs managers who are happy, confident, dynamic and well-rounded. And you can be all of these—if your schedule permits. Plan it carefully.

RAYMOND DANIEL SPEER

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 2: Type II converter based on standard resolver bridge

The first portion of this Practical Design Guide (ED 6 March 15, 1970) introduced resolver-to-digital angle converters, described octant selection circuitry and detailed Type I converters which require precision RC networks for stable operation.

Unlike the Type I design, the Type II converters presented here require octant selection circuits. This method of encoding resolver output signals is based on the operation of standard resolver bridges. It is also referred to as the automatic or self-balancing resolver bridge.[10 to 17]

The type II converter's octant selection network generates V_X' and V_Y' (resolver bridge inputs), plus ϕ_C (the three most significant bits of digital angle ϕ) while the remaining circuitry provides ϕ_F (the n-3 significant bits of digital angle ϕ). Note that $\phi = \phi_C + \phi_F$ (Fig. 11).

The output signals of a resolver, V_X and V_Y, can be converted into a digital angle ϕ in the following way. ϕ_F is processed into two signals, $\sin\phi_F$ and $\cos\phi_F$, by two function generators. These function generator outputs are multiplied with the outputs of the resolver. Since V_X is proportional to K $\cos\theta$ and V_Y is proportional to K $\sin\theta$, the outputs of the two multipliers are

$$V_1 = K\cos\theta\sin\phi_F \quad \text{and} \quad V_2 = K\sin\theta\cos\phi_F \qquad (18),(19)$$

where θ is the resolver shaft angle and ϕ the output of the converter. V_1 and V_2 are then subtracted to give the error voltage

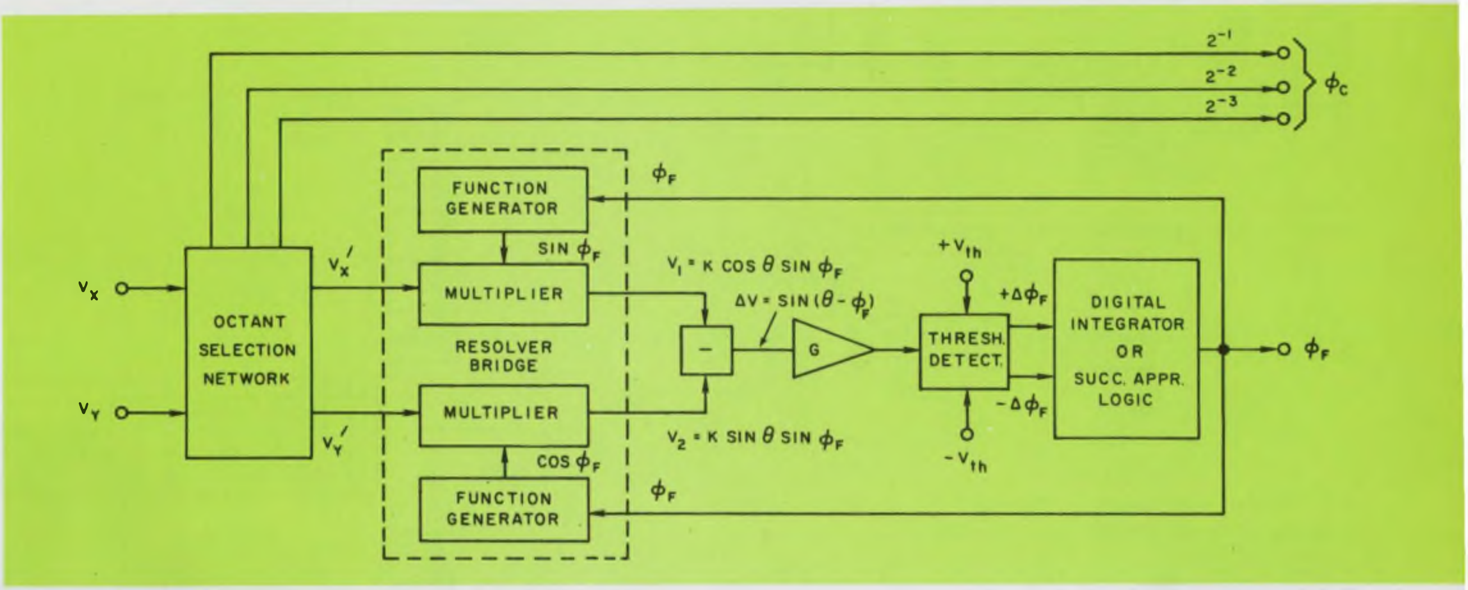
$$\Delta V = V_1 - V_2 = K\sin(\theta - \phi_F) \qquad (20)$$

From Eq. 20 it can be seen that if the output angle ϕ_F is larger than the resolver angle θ, presented by V_X and V_Y, ΔV will be negative, or if ϕ_F is smaller than θ, ΔV will be positive. The error voltage, ΔV, indicates whether the digital number representing ϕ_F must be increased, decreased, or is a correct presentation of the resolver angular position.

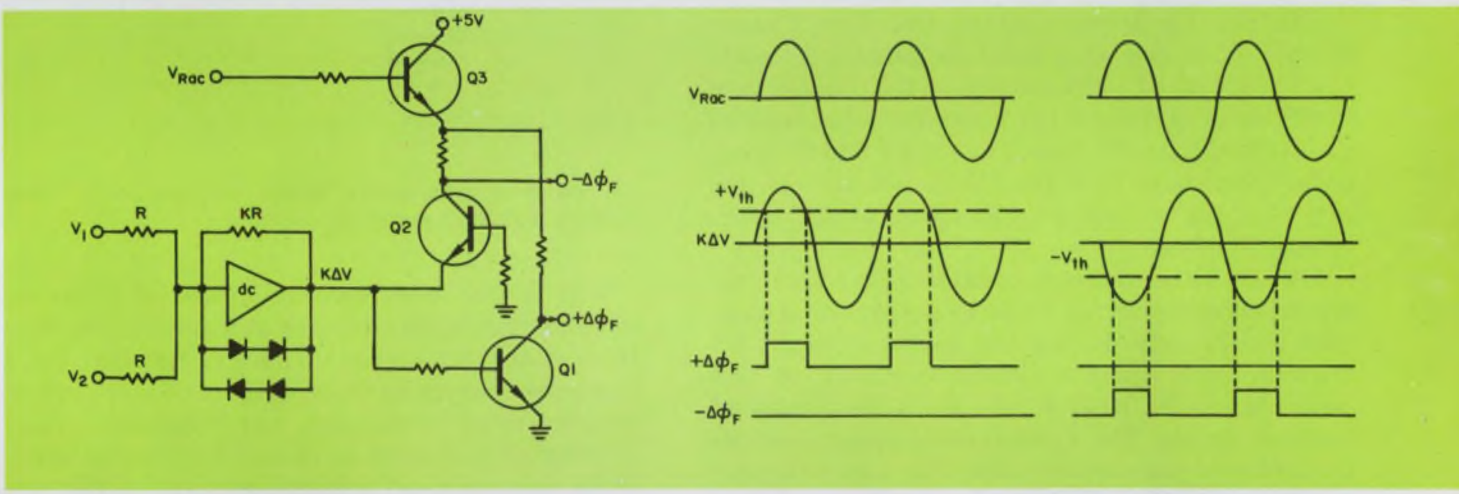
Numerous implementations of this basic principle are possible. Each incorporates an octant selection circuit, resolver bridge, amplifier, threshold detector and digital logic circuits. Because these five basic circuits can be built in several ways and the number of alternate combinations is large, only the important variations in the basic principle will be described here.

To produce the binary number ϕ_F, the error voltage ΔV, must be converted into the digital error signals $+\Delta\phi_F$ and $-\Delta\phi_F$. ΔV can be either a dc or an ac voltage. The method described here assumes that ΔV is an ac voltage.

The circuit in Fig. 12 sums the multiplier output voltages V_1 and V_2 into the error voltage, ΔV, with a conventional operational amplifier, which also multiplies ΔV by a constant, K. K is chosen so that the magnitude of the threshold voltages, V_{Th}, di-



11. **Type II converter** employs resolver bridges in an analog/digital feed back system.



12. **Digital error generation** is provided by summing multiplier output voltages V_1 and V_2. Q_1 and Q_2 are threshold detectors providing $+\Delta\phi_F$, and $-\Delta\phi_F$ as output signals.

vided by K is equal to the magnitude of one least-significant bit of output signal. For example, if the resolution of the converter is 12 bits and the maximum value of the input signal 10 V, then the least-significant bit is equal to 2.5 mV.

With $V_{Th} \approx 750$ mV, the gain of the ac amplifier must be approximately 750 mV/2.5 mV = 300. The output of the ac amplifier drives the two threshold detectors, Q_1 and Q_2. When the ac voltage $K\Delta V$ is larger than +0.75 V, Q_1 turns ON; when $K\Delta V$ is smaller than –0.75 V, Q_2 turns ON; and when $K\Delta V$ is between +0.75 V and –0.75 V, both transistors are turned OFF.

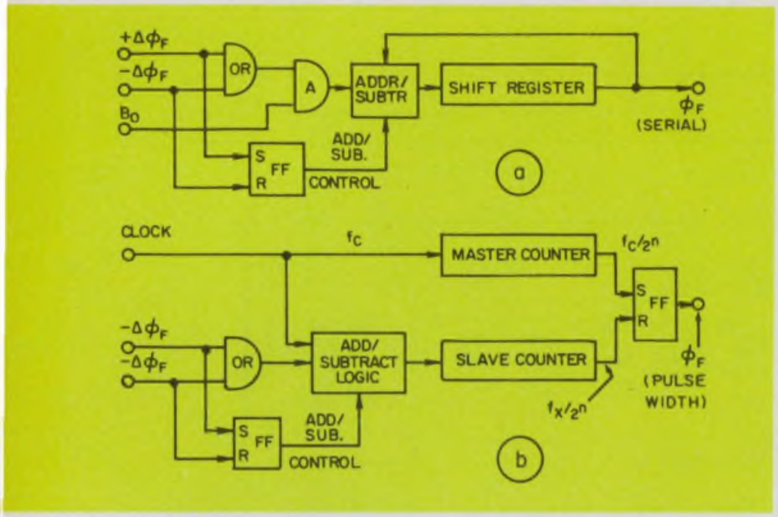
The design must assure that $+\Delta\phi_F$ does not become ONE during the positive portion of the sine wave and that $-\Delta\phi_F$ does not become ONE during the negative portion. To account for this, Q_3 connects the +5-V power supply to both Q_1 and Q_2, but only during the positive half of the ac reference voltage. The three transistors now perform as a phase-sensitive error detector. In addition, the ON-time of the digital error signals, $+\Delta\phi_F$ and $-\Delta\phi_F$, will change as a function of the ΔV amplitude (Fig. 12). This means the error detection circuit maintains proportional control. If ΔV is large, the $\Delta\phi_F$ ON time will be large; if ΔV is small, the $\Delta\phi_F$ ON time will be small.

The following methods process the threshold detector output into the binary number ϕ_F.

■ *The digital integrator method.* The simplest method of generating a binary number ϕ_F from the digital error signal $\Delta\phi_F$ is to accumulate the error signals in a digital integrator, so that

$$\phi_F = \Sigma \Delta\phi_F \Delta t \qquad (21)$$

where Δt is a basic time unit, such as the period of



13. **Digital integration** is provided by (a) adder-register counter and (b) master-slave counter.

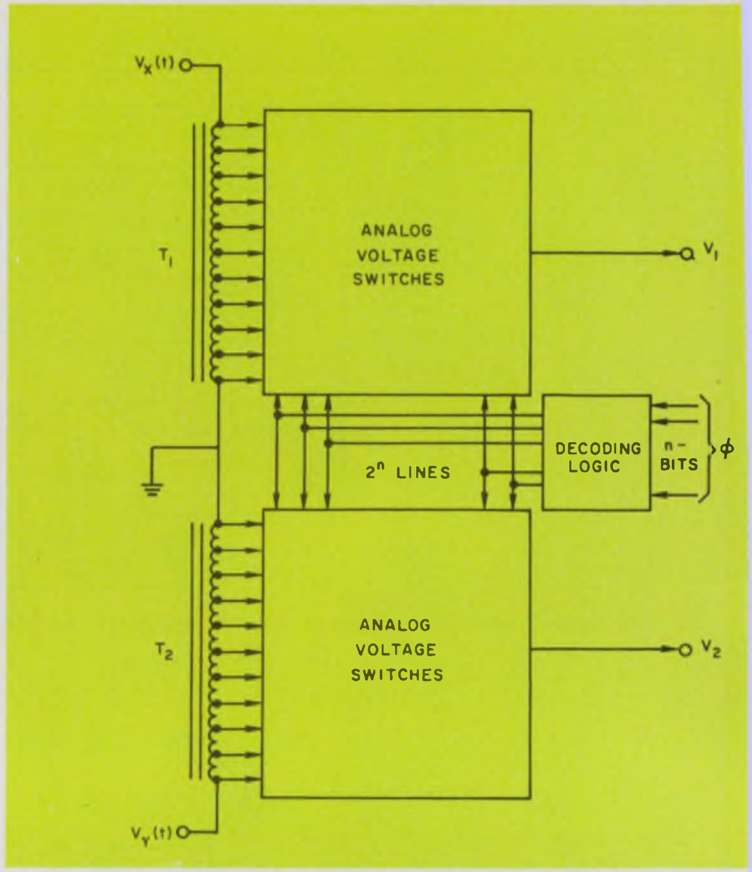
a clock pulse. At least three types of counting systems which serve as digital integrators are available. They are the Up/Down, adder-register, and master-slave.

For the Up/Down counter the digital error signals $+\Delta\phi_F$ and $-\Delta\phi_F$ must be gated with some clock frequency f_c. The content of the counter then increases or decreases (by a number of counts) as determined from the magnitude of ΔV and the clock pulse frequency. With the Up/Down counter, the digital angle ϕ_F will be generated as a parallel binary number.

For an adder-register counter (Fig. 13a), the digital error signal $\Delta\phi_F$ must be gated with a pulse that occurs only during the least-significant bit position. The count frequency (speed) of this device is only $(1/n)(f_c)$, where n is the number of register stages. The advantage of speed sacrifice is a reduced parts count. With the adder-register counter, the output signal ϕ_F is in serial binary form.

For the master-slave counter combination (Fig. 13b), $+\Delta\phi_F$ and $-\Delta\phi_F$ can be utilized directly the way they are. Although this method of integrating has severe frequency limitations, it is fast enough for this application since error signals are generated only once every cycle. Because this type of integrator has a pulse-width signal output, it can be used only when the sine and cosine function generators can accept pulse-width signals as input.

■ *The successive-approximation method.* All of the circuit designs using digital integrators can follow small input signal changes quickly, but become slew-limited with large input signal deviations. The successive-approximation approach overcomes this difficulty by comparing the internally generated angle ϕ_F with the data representing the resolver angle θ on a bit-by-bit basis, starting with the most significant bit first. With this technique a resolver output signal can be encoded in a fraction of one ac cycle.



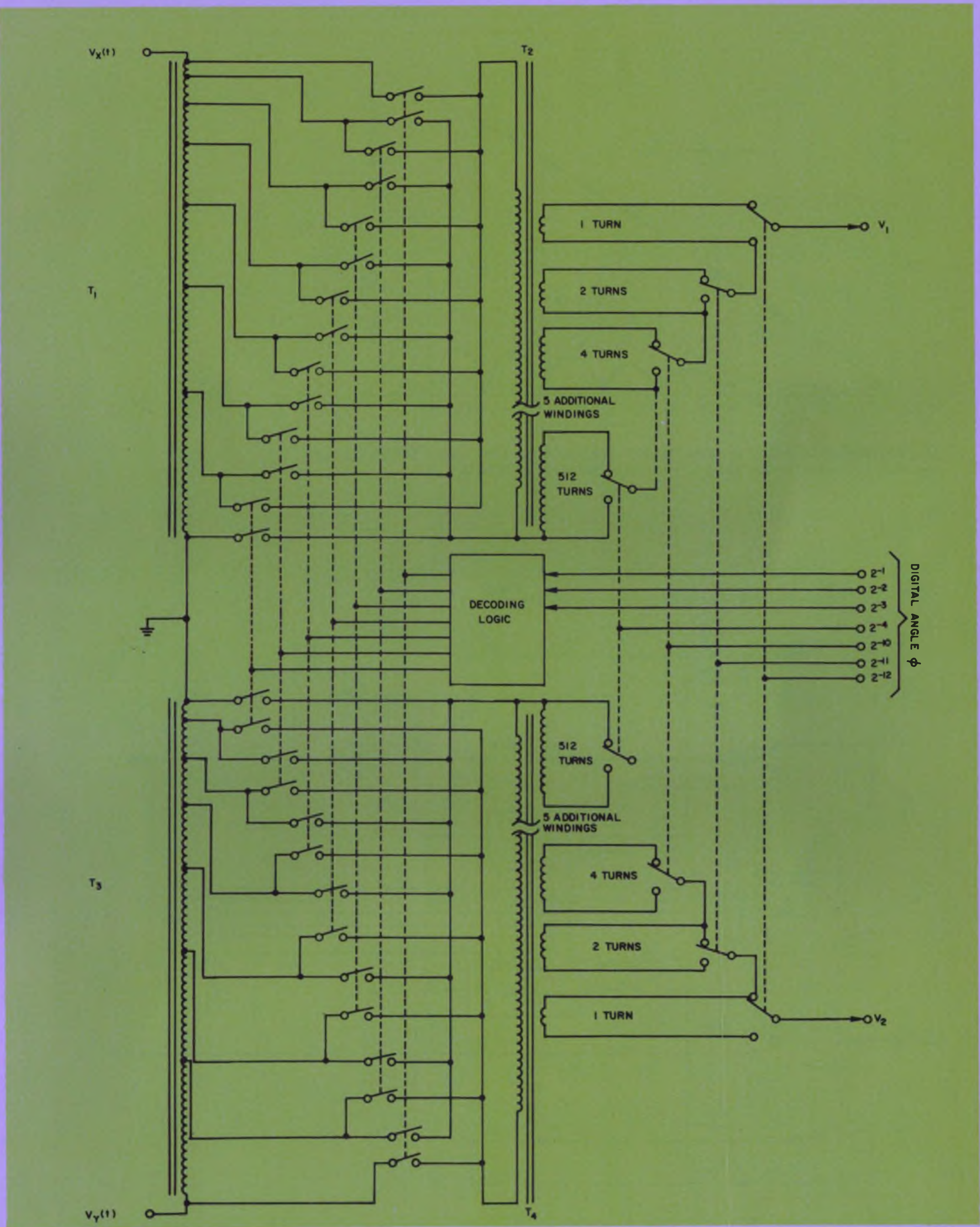
14. **Inductive sine/cosine bridge** employs only transformers and analog voltage switches.

Why is high-speed conversion needed if the resolver output signal changes at a rate of less than 100 radians per second? There is no need for a high-speed converter if the outputs of just a single resolver must be encoded, but frequently many resolver signals must be changed to digital form. If the encoder speed is high compared to the rate of change of the resolver signals, one a/d converter can be time-shared between all resolver output signals, thus reducing the cost per conversion.

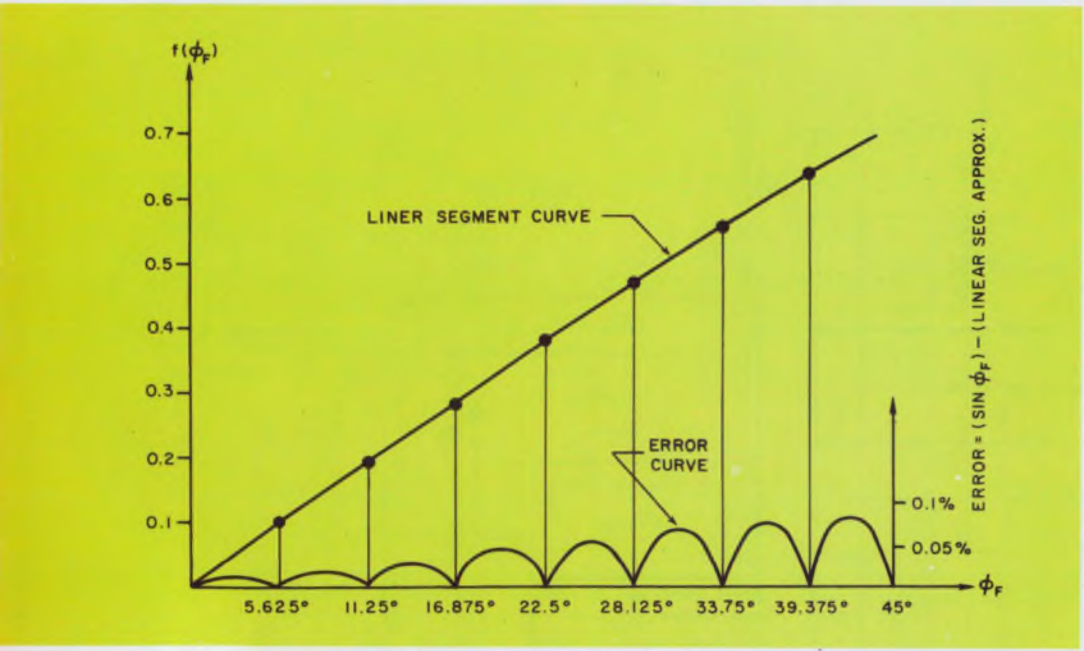
For further processing of the resolver output signal, a resolver bridge is required. The inductive sine/cosine bridge, resistive sine/cosine bridge and tangent bridge can all perform this task. Tradeoffs between accuracy, stability and size determine the designer's final choice.

Resolver bridge produces error voltage

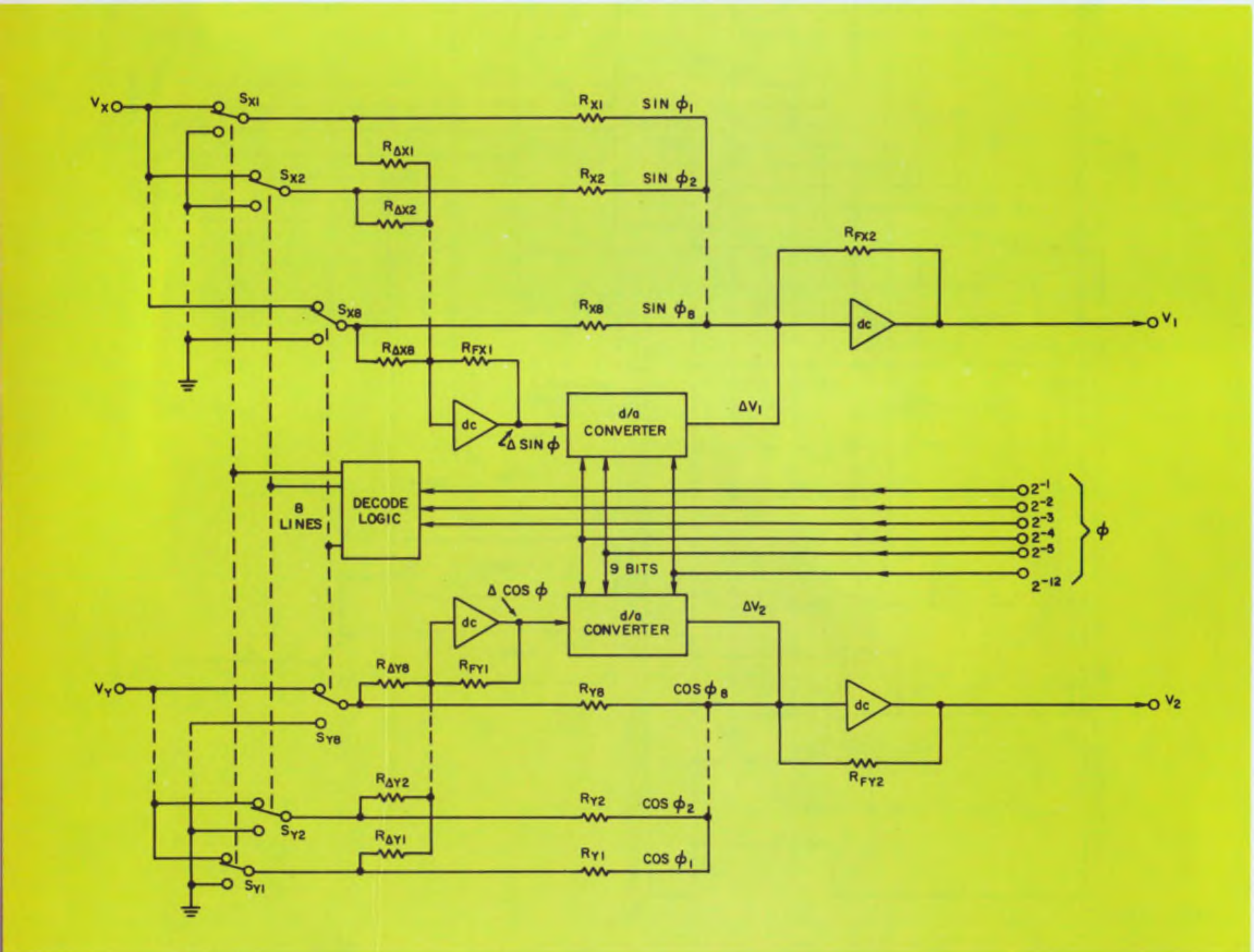
The purpose of the automatic resolver bridge is to process the octant-selected resolver output signals $V_X' = K\cos\theta$ and $V_Y' = K\sin\theta$, into voltages V_1 and V_2, which represent the trigonometric cross products defined in Eqs. 18 and 19, respectively. These two voltages are then added or subtracted to produce the digital error voltage ΔV. The automatic resolver bridge is comprised of two function generators and two multipliers (Fig. 11). Normally, one function generator and one multiplier



15. **Linear interpolation** between neighboring tap voltages on the primary transformer (T_1, T_3) is provided by interconnection with the multiwinding transformer (T_2, T_4).



16. **Reasonable accuracy** is possible with the inductive sine/cosine bridge. Linear-segment and error curves show a maximum deviation of 0.08%.



17. **Resistive sine/cosine bridge** is compact but lacks the accuracy and stability of transformer designs.

are combined into a single unit.

For the purpose of illustration, assume that the cosine-function generator and its multiplier are replaced by a sine-function potentiometer, and that the sine-function generator and its multiplier are replaced by a sine-function potentiometer. Both potentiometers are connected to the same shaft ϕ. If V_X is now connected across the sine potentiometer and V_Y across the cosine potentiometer, then the wiper outputs are:

$$V_1 = V_X \sin\phi, \qquad V_2 = V_Y \cos\phi \qquad (22), (23)$$

This is another form of writing Eqs. 18 and 19.

Practical automatic resolver bridges are just electronic analogies of this sine and cosine potentiometer arrangement.

The inductive sine/cosine bridge

One popular approach, the inductive sine/cosine bridge employs only transformers and analog voltage switches (Fig. 14). In its simplest form, an inductive divider is an autotransformer, permitting the selection of precise, predetermined ratios of output to input voltage.

Taps are provided on each transformer so that obtainable ratios are related to each other by the sine or cosine function. Since the number of usable taps is limited, additional resolution must be obtained by connecting a multiwinding transformer, or a resistive voltage divider, across two adjacent taps of the first transformer (Fig. 15). This permits linear interpolation between the voltages of two neighboring taps of the primary transformer. With the voltage on each tap representing the breakpoint of the linear-segment curve or the value of the function, $f(\phi_i)$ at some fixed argument ϕ_i, any ratio set up on the second transformer will perform linear interpolation, since

$$f(\phi) = f(\phi_i) + \Delta\phi_i \frac{f(\phi_{i+1}) - f(\phi_i)}{\phi_{i+1} - \phi_i} \qquad (24)$$

where $\Delta\phi_i$ is defined as $\phi - \phi_i$. With this technique reasonably accurate sine and cosine functions can be generated from linear segments, as shown in Fig. 16.

Arranging the taps on auto transformer T_1 according to a sine function and the taps on auto transformer T_3 according to a cosine function, with V_X across T_1, and V_Y across T_3, produces voltages at the taps that can be expressed as

$$V_{1i} = V_X \sin\phi_i \quad \text{and} \quad V_{2i} = V_Y \cos\phi_i. \qquad (25)\ (26)$$

As a compromise between practical design and high resolution, assume ϕ_i takes on the values of 0°, 5.625°, 11.25°, 16.875°, etc. up to 45°. Each primary of multiwinding transformers T_2 or T_4, can be connected across any adjacent pair of T_1 or T_3 autotransformer taps by energizing one of the seven pairs of single-pole switches. The voltages produced across the T_2 or T_4 primaries are

$$V_{P1} = V_{1(i+1)} - V_{1i} = V_X (\sin\phi_{i+1} - \sin\phi_i) \qquad (27)$$

$$V_{P2} = V_{2(i+1)} - V_{2i} = V_Y (\cos\phi_{i+1} - \cos\phi_i). \qquad (28)$$

The multiwinding transformers are similar to those used in digital-to-ac converters where the turns ratios between the secondary windings are 1, 2, 4, 8, etc. The two multiwinding transformers in Fig. 15 are assumed to have nine secondary windings with 1, 2, 4, . . . to 512 turns. Any combination of these windings can be interconnected with the nine single-pole, double-throw switches, to generate any desired fraction of the primary voltage within the nine-bit resolution. If the nine least-significant bits of the digital angle ϕ are expressed as $\Delta\phi$, then the voltage *across* the selected combination of secondary windings becomes

$$\Delta V_1 = V_{P1}\,\Delta\phi, \qquad \Delta V_2 = V_{P2}\,\Delta\phi. \qquad (29), (30)$$

Substituting Eqs. 25, 27 and 29 into Eq. 24, and assuming that $\phi_{i+1} - \phi_i = 1$, gives

$$V_1 = V_X [\sin\phi_i + \Delta\phi (\sin\phi_{i+1} - \sin\phi_i)] \qquad (31)$$

which can be approximated by $V_1 \approx V_X \sin\phi$.

Similarly, substitution of Eqs. 26, 28 and 30 into Eq. 24 gives

$$V_2 = V_Y [\cos\phi_i + \Delta\phi (\cos\phi_{i+1} - \cos\phi_i)] \qquad (32)$$

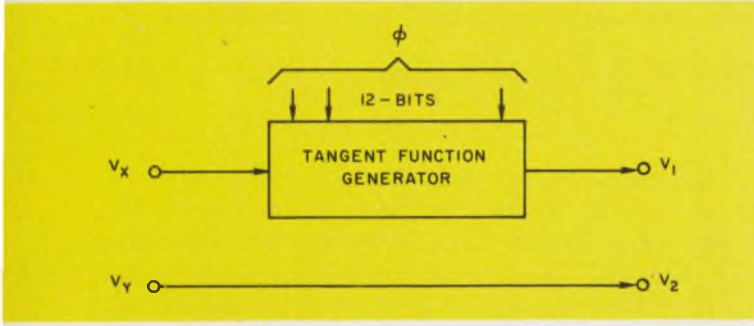
or $V_2 \approx V_Y \cos\phi$.

So it has been proved that a pair of switched transformers can perform the operation of a function generator and multiplier. Extremely high accuracies are possible with the inductive resolver bridge if precision toroidal transformers and matched transformer-coupled switches with low ON resistance are used. Accuracies of 1 part in 20,000 are claimed[18].

The resistive sine/cosine bridge

Figure 17 illustrates that the resolver-bridge function can also be performed with resistors and analog voltage switches. Due to the inherent tolerances, plus temperature, life and load instabilities, a bridge circuit using resistors can never be as accurate and stable as a design using transformers. The resistive bridge does have size and weight advantages, especially if thin film resistors and MOSFET switches are used.

The resistive bridge consists of two linear-segment function generators with parallel-binary input and analog output. Each of these linear-segment function generators is comprised of two resistor groups. One resistor group (R_{X1} to R_{X8} or R_{Y1} to R_{Y8}) generates the values of the function $f(\phi_i)$ at the breakpoints on the linear segment curve, and the other resistor group ($R_{\Delta X1}$ to $R_{\Delta X8}$ or $R_{\Delta Y1}$ to $R_{\Delta Y8}$) determines the slope between adjacent breakpoints.



18. **Tangent resolver bridge** eliminates half the hardware associated with sine/cosine bridges.

Two sets of switches (S_{X1} to S_{X8} and S_{Y1} to S_{Y8}) connect the input voltages (V_X and V_Y) to the four resistor networks. Only one switch is closed in each set at a time, so that V_X and V_Y are connected to just one resistor in each group. The two sets of eight switches are controlled from the three most-significant bits of the parallel binary word that represents the digital angle ϕ. The three bits are converted into octal form, by conventional decoding logic. The logic outputs are eight switch control lines, of which only one is energized at a time.

Each junction of the four resistor sets is connected to the summing point of an operational amplifier. The current flowing into each summing point and the associated amplifier output voltage is a function of the selected resistor value and the amplitude of V_X or V_Y. The values of R_{Xi} and $R_{\triangle Xi}$ are chosen to generate amplifier output voltages representing the breakpoints and slopes of an eight-segment sine function. The values of R_{Yi} and $R_{\triangle Yi}$ are selected to generate the cosine-function breakpoints and slopes.

The slope voltages $[f'(\phi)]$ must first be multiplied with $\Delta\phi$ before they can be added to the breakpoint voltages $[f(\phi_i)]$ since

$$f(\phi) = f(\phi_i) + \Delta\phi\, f'(\phi) \qquad (33)$$

where $\Delta\phi$ is defined again as

$$\Delta\phi = \phi - \phi_i. \qquad (34)$$

The multiplication of $f'(\phi)$ by $\Delta\phi$ is executed by the d/a converter, where $f'(\phi)$ is the analog input (usually the reference voltage) and $\Delta\phi$ is the nine-bit parallel digital input. The output of the d/a converter is an analog voltage (ΔV_1 or ΔV_2) that can be added directly to $f(\phi_i)$ by connecting it to the summing point of the operational amplifier. Adding ΔV_1 or ΔV_2 to the function's breakpoint value allows the desired interpolation between breakpoints.

The two linear-segment function generators (Fig. 16) generate the sine and cosine functions while performing the multiplications $(V_X)(\sin\phi)$ and $(V_Y)(\cos\phi)$, regardless of whether V_X and V_Y are ac or dc voltages. The output voltages of this resistor bridge are

$$V_1 = K_X V_X \sin\phi, \qquad V_2 = K_Y V_Y \cos\phi \quad (35), (36)$$

where K_X and K_Y are scaling constants determined by the feedback resistors of the four amplifiers.

The tangent resolver bridge

Almost half the hardware required to build either the inductive or resistive sine/cosine bridges can be eliminated if the sine and cosine function generators are replaced with one tangent generator. [14, 15]

A tangent-function generator is no more complex than a sine or cosine-function generator if the argument ϕ is kept between 0° and 45°. In this range the tangent is well behaved and varies between zero and unity. Use of the tangent-function generator can be justified by dividing the expression for V_1 and V_2 by $\cos\phi$ hence

$$V_1 = V_X \sin\phi/\cos\phi = V_X \tan\phi \qquad (37)$$

$$V_2 = V_Y \cos\phi/\cos\phi = V_Y. \qquad (38)$$

As illustrated in Fig. 18, the only resolver output signal V_X is processed by the tangent-function generator, whereas V_Y is the output signal V_2. The tangent function generator can be designed with transformers (Fig. 15) or with resistors (Fig. 17).

The linear resistor bridge

In the sine/cosine resolver bridge just described, considerable effort was spent generating precise sine and cosine functions. The exact values of the sine and cosine functions, however, are not critical. Of great significance is the ratio of these two functions since this ratio contains the transmitter information. This ratio is a tangent function that must be determined with high precision. The theory behind this approach says the bridge needs to be accurate only when the digital angle ϕ becomes equal to the resolver angle θ. That is when

$$\cos\theta \sin\phi - \sin\theta \cos\phi = 0 \qquad (39)$$

or when

$$\frac{\sin\theta \cos\phi}{\cos\theta \sin\phi} = \frac{\tan\theta}{\tan\phi} = 1. \qquad (40)$$

The problem is finding two functions $f_1(\phi)$ and $f_2(\phi)$ that can be generated by linear circuit means and that satisfy the condition

$$f_1(\phi)/f_2(\phi) = \tan\phi. \qquad (41)$$

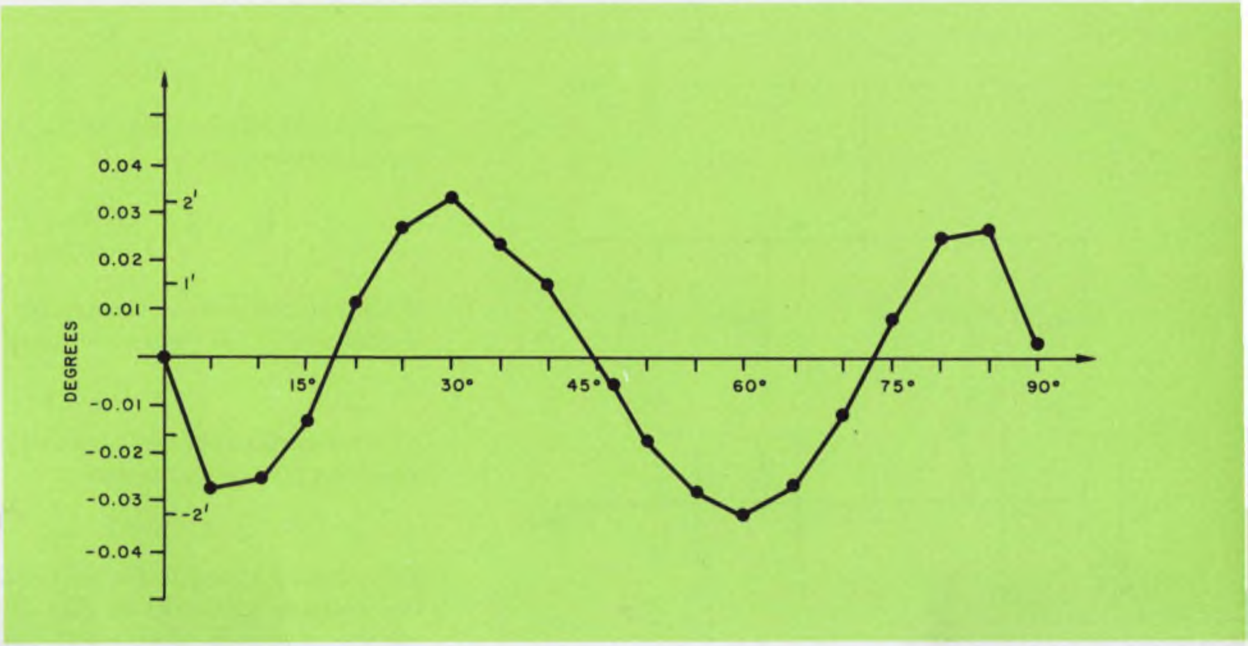
Intuition predicts that

$$f_1(\phi) = \frac{1}{1 + 1/K\phi} \qquad (42)$$

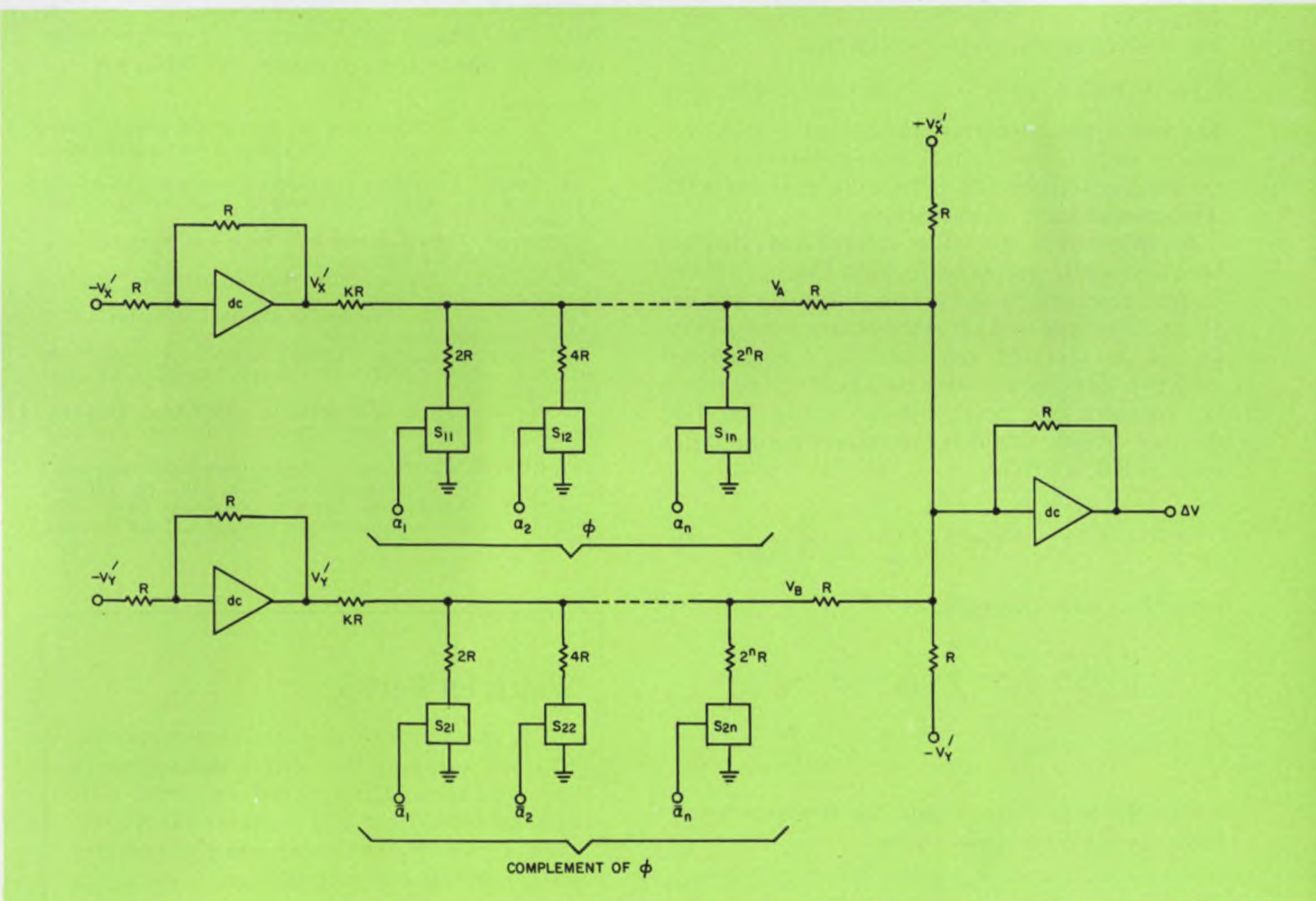
and

$$f_2(\phi) = \frac{1}{1 + 1/[K(90° - \phi)]} \qquad (43)$$

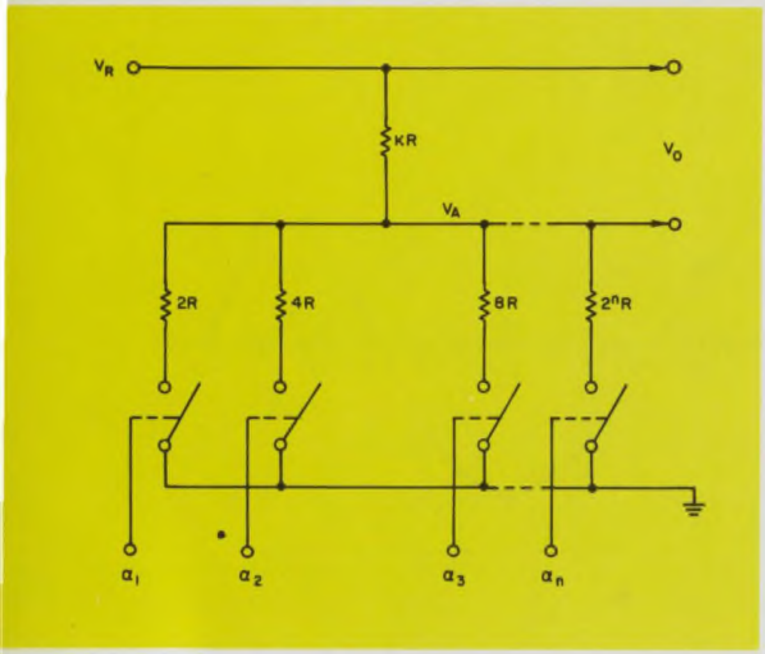
are two such functions, because their ratio is 0, 1 and ∞ when ϕ equals 0°, 45° and 90° (regardless



19. **Tangent function is approximated** within ±0.03° with K=0.006 per Eqs. 42 and 43.



20. **Single resistor and shunt switch** are all that's required for each bit in the binary word φ with this design.



21. **Resistive voltage divider** of Fig. 19 is shown in simplified form.

of the value of K). Selecting the value of K in Eqs. 42 and 43 equal to 0.006 approximates the tangent function to within ±0.03° from $\phi = 0°$ to $\phi = 90°$ (Fig. 19).

The derivation above also implies that

$$f_1(\phi) \approx K \sin\phi \quad \text{and} \quad f_2(\phi) \approx K \cos\phi. \qquad (44), (45)$$

Therefore, the linear resistor bridge is still comprised of one sine-function generator and one cosine-function generator. The difference lies in the implementation of these functions.

Ingenious implementation of $f_1(\phi)$ and $f_2(\phi)$ has been devised by Reeves Instrument Corp.[16, 17] Their design requires just one precision resistor and one shunt switch for each bit in the binary word ϕ (Fig. 20). In this circuit $f_1(\phi)$ and $f_2(\phi)$ are generated with two identical resistive voltage dividers, which are redrawn in simplified form in Fig. 21. This resistor divider output is the voltage across series resistor KR, which is

$$V_{o1} = V_R - V_A = V_R\left(1 - \frac{R_\phi}{R_\phi + KR}\right) \qquad (46)$$

where $R\phi$ can be expressed as

$$\frac{1}{R_\phi} = a_1 \frac{1}{2R} + a_2 \frac{1}{4R} \ldots + a_n \frac{1}{2^n R}$$

$$= \frac{1}{R}(a_1 2^{-1} + a_2 2^{-2} \ldots + a_n 2^{-n}) = \frac{\phi}{R} \qquad (47)$$

where the expression inside the brackets represents the digital angle ϕ. Hence

$$R_\phi = R/\phi \qquad (48)$$

substituting Eq. 48 into 46 gives

$$V_{o1} = V_R\left(1 - \frac{R/\phi}{R/\phi + KR}\right) = \frac{K\phi}{1 + K\phi} \qquad (49)$$

which is the same as Eq. 42. In a similar fashion it can be shown that

$$V_{o2} = V_R \frac{K(\phi_{max} - \phi)}{1 + K(\phi_{max} - \phi)} \qquad (50)$$

if the complement of the binary number (i.e., $\bar{\phi}$) is controlling the shunt switches, S_1 to S_m, and if

$$\bar{\phi} = \phi_{max} - \phi \qquad (51)$$

where ϕ varies between zero and unity, the complement can also be written as

$$\bar{\phi} = 1 - \phi. \qquad (52)$$

Substituting this into Eq. 50 results in Eq. 43. The two resistor networks in Fig. 20 are thus proved capable of generating the two functions $f_1(\phi)$ and $f_2(\phi)$.

Because the outputs from the two voltage dividers (V_{o1} and V_{o2}) appear across the series resistors KR_1 and KR_2, the subtraction $\Delta V = V_{o1} - V_{o2}$ requires special handling. The simplest method is to subtract V_X' from V_A and V_Y' from V_B by connecting $-V_X'$ and $-V_Y'$ to the voltage dividers (Fig. 20). The voltages $-V_X'$ and $-V_Y'$ are the buffer amplifier inputs and are readily available. ■ ■

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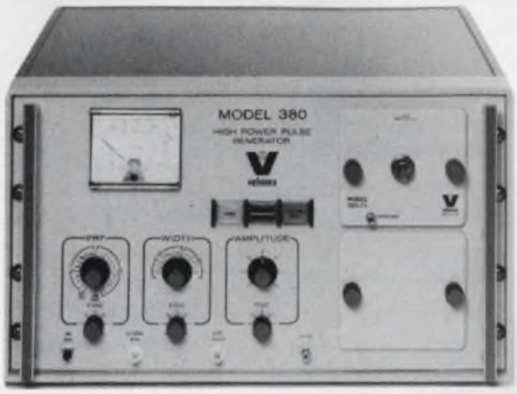
Watch for Part 3

The third part of this Practical Guide for Synchro-to-Digital Converters will appear in our next issue, ED 8, April 12, 1970. This coming installment will continue the discussion of resolver-to-digital angle converters with Type III converter design.

HIGH POWER PULSE GENERATORS



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50 to 500 V @ 10 A 100 Amp @ 50 V 1 KV @ 5 A	**Output Voltage (Pulse)**	0 to 2,100 V @ 10.5 A 400 Amp @ 40 V 19 KV @ 0.95 A
5 KW	**Output Power (Peak)**	22 KW*
<8 NS†	**Rise Time**	<30 NS†
< 11 NS†	**Fall Time**	<50 NS†
25 NS to 25 μS	**Pulse Width**	0.1 μS to 300 μS
<3% @ max. pulse width	**Droop**	<3% or 0.05% per μS
<5%	**Overshoot**	<5%
Negligible	**Ripple on Pulse Top**	Negligible
1% @ 5 KW peak	**Duty Factor**	1% @ 22 KW peak, 5% @ 4.2 KW peak
3 pps to 400,000 pps, plus manual (single pulse)	**Pulse Repetition Rate**	3 pps to 100,000 pps (for high duty-factor bursts, ask about Model 570)
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INFORMATION RETRIEVAL NUMBER 34

System design means trade-offs,

as shown by this one designer's approach to a state-of-the-art airborne computer.

The system designer is faced with the problems of system requirements, design philosophy and cost and delivery schedules. And the tools he uses to solve these problems include an evaluation of trade-offs between conflicting needs based on the current state-of-the-art.

An example of how the system engineer approaches his job is the design of a master computer for the Short Range Attack Missile (SRAM). Although a military system design of this type contains unique features not usually found in commercial systems, such as environmental and reliability specifications, the design process is similar in many respects.

The primary mission of this particular airborne digital computer is to perform aircraft navigation and missile fire-control computations. However, it must also incorporate enough design flexibility to be able to accept new mission requirements, and it must interface with other avionic components. Because of this last requirement, the first design decision made was to separate conversion electronics from the central computer.

System trade-offs required

Among the many compromises to consider were the number of modules vs volume and weight; memory capacity vs physical size; word length vs precision and efficient use of memory; and arithmetic operations vs speed of computation. In most cases speed or precision or some other aspect of computation is limited by a non-computational requirement such as size or cost. But in this case the computer must also fly. It is up to the system designer to find the answer.

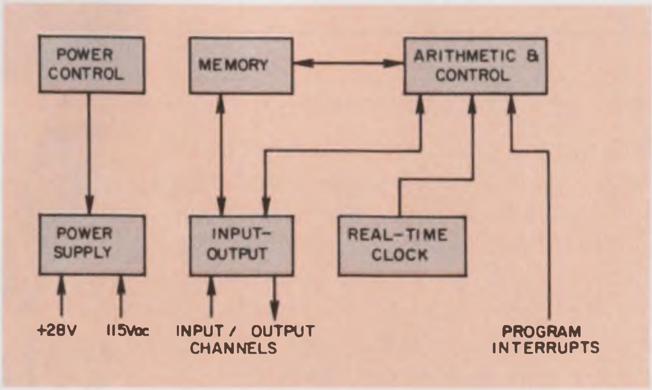
The first computer characteristic to be determined is word length. This choice is influenced by both instruction and data word-length requirements, and the two may not always be compatible. The instruction word length depends upon the number of different instructions, largest block of memory to be accessed directly, and indexing and indirect addressing. Data word length is primarily a function of computational precision required. Since the memory has by far the strongest influence on the cost and complexity of an aerospace computer, the prime objective in the choice of the word length is to minimize total memory capacity through efficient use of the memory.

Jaak Jurison, Autonetics Div., Supervisor, Computer Requirements, North American Rockwell Corp. Anaheim, Calif.

An analysis of guidance and control functions has shown that data word length in the range of 24 to 32 bits is adequate. With a 24-bit word most computations can be performed in single precision, requiring only a small percentage of double precision computations. A 32-bit data word permits practically all computations to be performed in single precision, but, since most computations do not require such high precision, a 32-bit word would result in inefficient utilization of computer memory.

The designer has two basic choices: he can have the instruction word length identical to the data word length, or he can shorten it to half the size of the data word and pack two instructions into each memory word.

The latter scheme, generally referred to as a split-word or half-word instruction, may appear to offer some savings in storage and has been adapted in some aerospace computer designs. However, the number of bits in the instruction



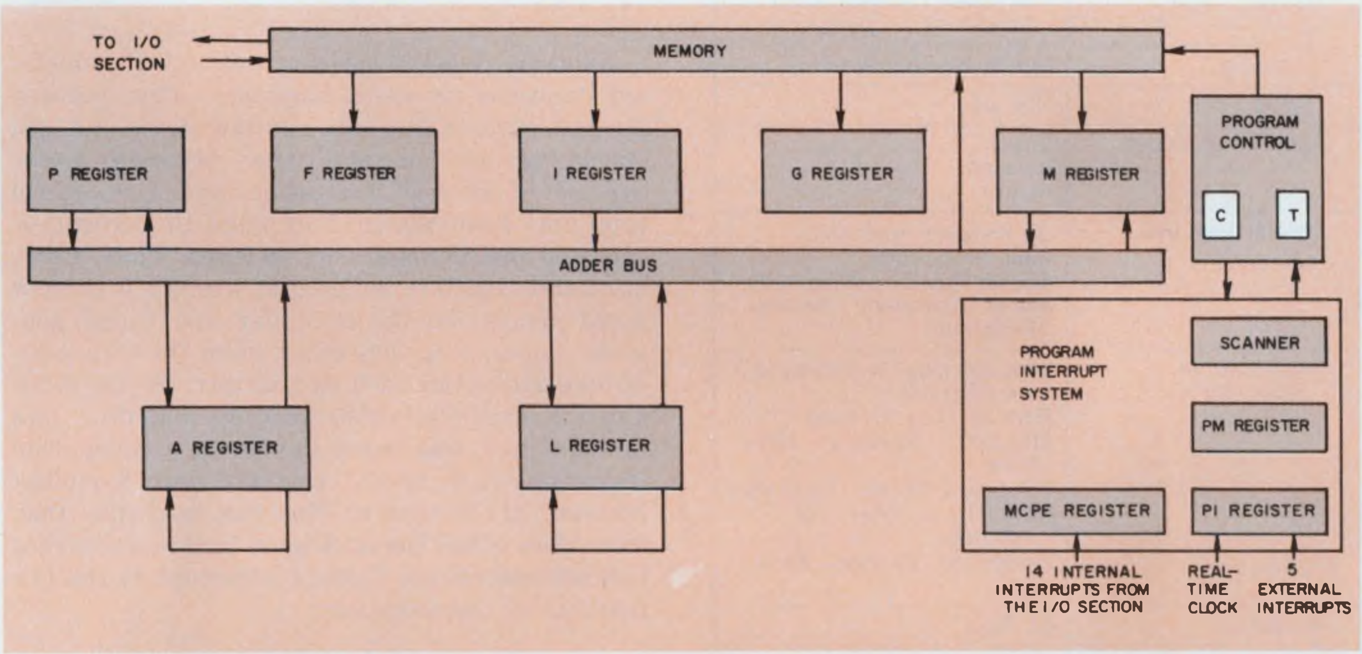
1. **All components of the computer system** are interrelated in this over-all block diagram.

is limited. As a result, such designs have several shortcomings: the number of instructions is limited; only part of the memory can be addressed directly; and address modification options such as multiple indexing or indirect addressing are limited. These serious programming constraints add more instructions to the total program, thus reducing the expected memory savings and increasing the software costs due to programming complexity.

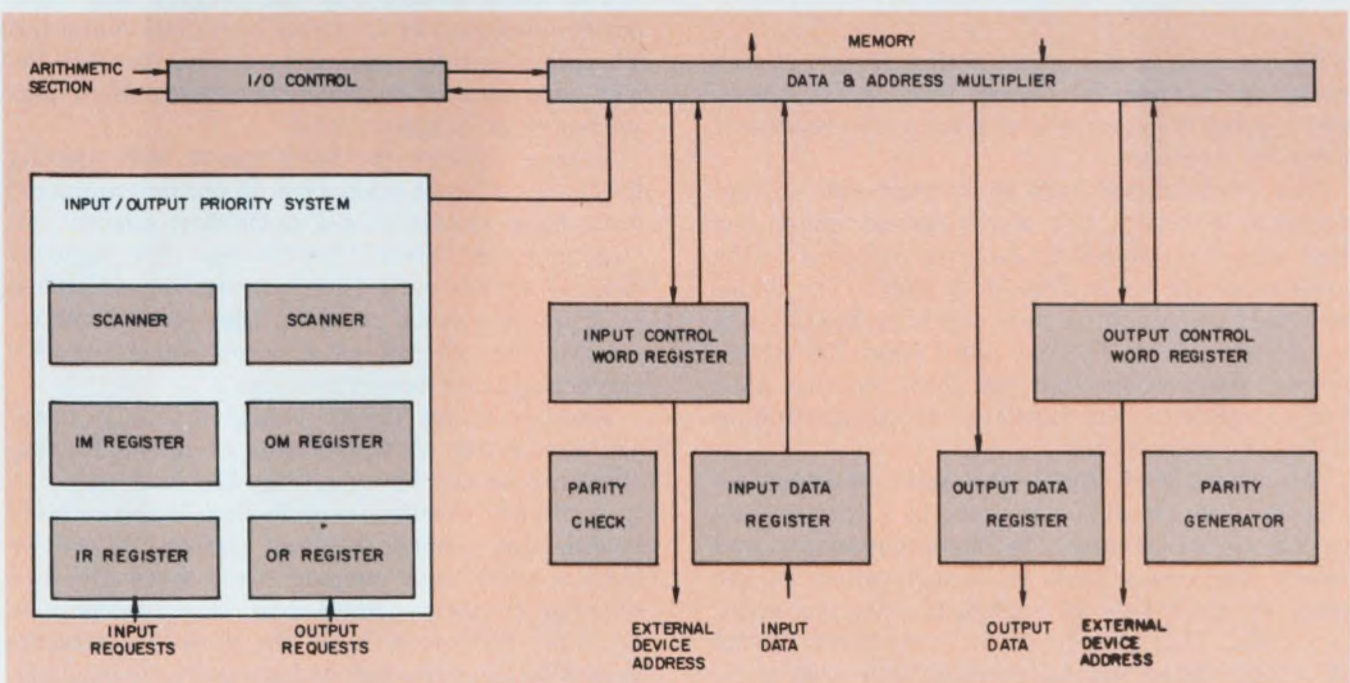
Thus, for this design a 24-bit instruction and data word length was chosen. Double precision arithmetic for add, subtract, store and fetch operations was incorporated to provide adequate speed for operations requiring more than 24 bits of data.

Design the central processor

Once the word length was chosen, the detailed design of the central processor was initiated. The design goal was to provide an efficient arithmetic and control section capable of meeting typical inertial navigation and fire-control requirements. A basic arithmetic and control section with an adequate instruction set was defined



2. **The central processor of the computer** is made up of the arithmetic and control section and the memory.



3. **The input/output block** is the interface between the central processing unit and the outside world.

Table 1. Computer parameters

Organization	General purpose parallel processor
Number System	Binary, Fixed Point 2's Complement
Word Length	24 Bits, Including Sign
Instruction Format	24 Bits, Single Address
Number of Instructions	67
Execution Times Add/Subtract Multiply Divide	 7.2 μs 15.3 μs 30.6 μs
Memory Type	Coincident Current DRO Core
Capacity	Up to 32,768 Words
Cycle Time	3.6 μs
Addressing Modes	Direct Indexed Indirect
Special Features	20 Program Interrupts Real Time Clock Double Precision Arithmetic Power Transient Memory Protection
Input/Output Processor	Simultaneous & Independent Operation Parallel Data Transfer 100,000 Words/s Data Rate 7 Input, 7 Output Channels Internally or Externally Initiated Prioritized Channel Structure
Weight	52 lbs.
Volume	0.85 cu .in.
Power	225 Watts

Table 2. Comparison of gates

	TTL	DTL
Speed (Gate Propagation Delay)	13 ns	25 μ
Power (per gate)	10 mW	8.5 mW
Noise Margin (at maximum fan-out)	400 mV	375 mV
IC's Required (per system)	N	1.3 N

with low cost as the prime design factor. It was designed for parallel binary fixed point operations, using 2's complement notation to represent negative numbers.

The organization was of conventional design, centered around a full word parallel adder bus that was time-shared by various registers in the system, as shown in Figs. 1, 2 and 3. The adder was fast enough to permit carry propagation to take place within the one clock time, 0.9 microsecond. Instructions that can share existing logic and contribute substantially to programming efficiency were added.

An example of this is the add-to-memory instruction which adds a number in a specified location in the memory to the accumulator and stores the result back in that location in the memory. Each time it is used, it saves one memory cycle. This instruction is particularly useful in accumulating partial computations and incremental accelerometer data.

Another trade-off decision was to utilize memory locations as index registers. This reduced hardware costs but also slowed down indexed operations by an additional memory cycle. Studies of several navigation and fire-control programs have shown that only 10 percent of executed instructions were indexed. Thus, memory index registers imposed at worst a 5 percent speed penalty on the computer and would generally impose less, depending upon the frequency of long operations such as multiply. On the other hand, a multiply mechanizations handling two bits at a time was found to provide a substantial improvement in speed requiring only a modest increase of hardware. The fast multiply then more than offset the additional time required for indexed operations. Table 1 summarizes the key features of the computer.

Consider memory design

The main memory is the largest and most costly subsystem of an airborne digital computer. Therefore, careful trade-offs in the memory design are essential in order to achieve high performance at minimum cost.

Figure 4 shows the basic speed and capacity limits of different memories. It became apparent from these charts that a coincident current 3D core memory offered lowest cost for memory systems with a cycle time requirement in excess of 2 microseconds. A cycle time of 3.6 microseconds was chosen as a compromise between speed and good design margins.

Another major design consideration is memory modularity. A wide range of memory capacities can be met by expanding the memory from a small basic memory module size. If the selected module size is small, the total system cost will be high because each module must have its own selection circuitry, which could be made common in larger memories. Since the computer was expected to be employed in high-performance avionic systems, memory capacities of less than

Table 3. Modules

Module type	No. of modules per computer
Arithmetic	1
Control	1
Power control & clock	1
Digit	3
Selection	2
Current source & timing	1
Input/Output #1	1
Input/Output #2	1
Total	11

12K were not considered. A 16,384 (2^{14})-word design with a single core stack appeared to offer best economy. It required less selection circuitry than several small stacks and was the lowest in cost.

The expansion of up to 32,768 words for future growth was found to be cheapest if additional memory was added in a separate package. Thus, users with minimal memory requirements would not be penalized for size and weight if spare space were left in the computer chassis.

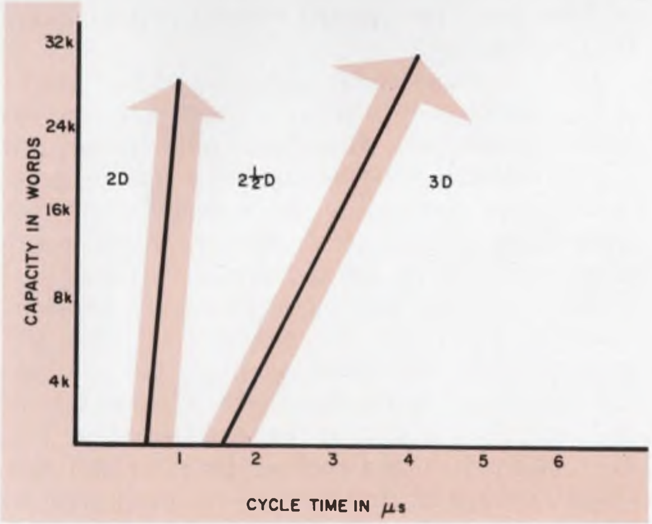
Experience has shown that space is always at premium in an aircraft installation, and, by the time programs have outgrown the original memory capacity, space may not be available in close proximity to the computer. Therefore, spare space and interconnections were provided in the computer chassis for a line drive/receiver module, which could provide means of reliable communication over long data lines with an external memory without any redesign of the existing computer and without the cost penalty for these line drivers and receivers in the 16,384-word system. The approach offered an additional advantage in that the user would have the freedom of specifying the external memory in the desired modularity, size and shape necessary to meet his requirements.

In order to operate over the temperature ranges encountered in military aircraft, a wide temperature 30-mil core was selected, and a temperature-compensated current source was designed. The drive current for the X and Y drive lines were staggered to offer adequate design margins over temperature and worst-case tolerances. The drive-current rise and fall times were also controlled to minimize drive-line kickback voltage. Sense lines were grouped in 4096-word quadrants to provide good signal-to-noise characteristics.

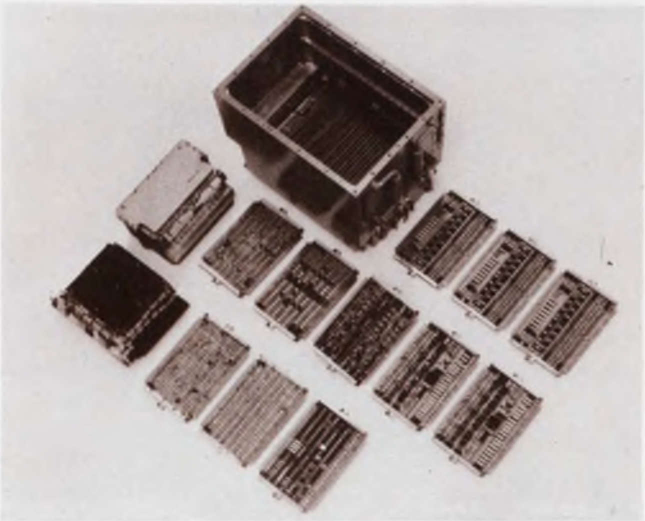
Choose logic and module design

The logic circuit selection is normally based upon cost, speed, power, noise margin and availability of logic functions. DTL and TTL met system speed requirements with adequate production and second source capability. RTL and RCTL logic circuits were eliminated due to fan-out, noise margin and speed limitations. Table 2 is a summary of the trade-offs. In the final selection TTL was chosen because it offered minimum parts count and thus lower cost, higher reliability and greater speed margin.

Module choice was among two layer modules, four layer modules and multilayer modules. Although the module cost increases as the number of layers increases, it was found that the multilayer approach minimized the number of modules and therefore was the most cost-effective. With the use of multilayer boards, the number of integrated circuits could be increased to an average of about 250 per module, while allowing



4. **Core memory organization** is one of the choices that must be made. This diagram defines the ranges of core types as functions of memory size and cycle time.



5. **The logic is organized** onto 11 circuit cards of eight different types as shown in this photorgaph of the computer.

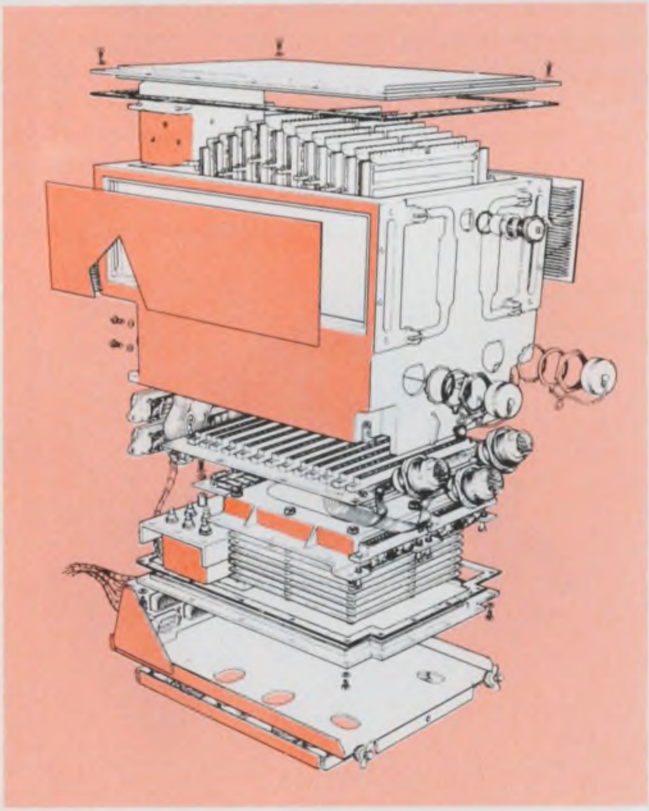
an adequate number of test points to be brought to the top of each module. This permitted the system designer to apportion the logic to reduce the number of interconnections between modules. The number of interconnecting layers on individual modules varied from six to 10.

Operational needs are important . . .

Aerospace computers of older vintages have been frequently limited in their efficiency of handling real-time control problems because of lack of adequate program interrupt. A powerful and flexible program interrupt system was considered a necessity for the computer system under consideration.

Twenty interrupts were provided in the system, grouped into three types in order of descending priority: real-time clock, external and internal interrupts. The real-time clock interrupt establishes a precise periodic reference for real-time computations and facilitates efficent interleaving of computer subroutines. Five external interrupts and the real-time clock interrupt can be enabled or disabled by selectively setting corresponding bits in the interrupt mask register. In addition, the capability to test the contents of the interrupt, as well as the interrupt mask register, are provided.

The remaining 14 interrupts are internal to the computer and are generated by the input/output section upon completion of a message or in case of a persistent parity error. The enabling or disabling of these interrupts is controlled by the input/output control word.



6. **Relative locations of all the components** are shown in this exploded view of the computer. Note the three connectors (center) that contain 198 test points.

The primary power sources in an aircraft experience many transients. It is, therefore, essential that the computer operation and its memory contents be protected from any malfunction due to these power transients. The computer has two protective features designed to prevent loss of memory contents and system malfunction. First, a voltage sensing circuit in a power supply detects the loss of primary ac power and switches the computer to a secondary dc supply. If the power transient ends in less the 7 ± 2 seconds, the switching circuitry will switch the operation back to ac power when it is restored to normal. However, if the power transient lasts longer than 5 to 9 seconds, battery switching circuitry will initiate shut-down cycle. When power returns, the memory operation is inhibited by a timing circuit until all secondary voltages are within proper tolerances. Program operation is then started at a predetermined memory location.

. . . so are nonoperational needs

Maintainability was considered early. Functions were grouped to minimize the number of different modules and the number of interconnections. Grouping also facilitated localizing of malfunctions. The task was complicated by power dissipation and noise considerations. After several trade-offs, the logic was divided between a total of 11 modules of eight different types, as shown in Table 3 and Fig. 5. All arithmetic registers were located on one module, while the control logic was placed on a second module. All identical memory modules were made fully interchangeable so that the core stack, as well as all modules, could be replaced without requiring any field adjustments.

Also important was the selection of test points. It was impractical to bring all test points to external connectors. Therefore, only those test points necessary for computer performance monitoring were brought to the external connector while the test points for further malfunction isolation were left on the individual modules.

Three external test connectors were provided with a total of 198 test points, while 262 test points/module were made available for monitoring by removal of the top cover. The location of the test points is seen in the exploded view, Fig. 6. It should be noted that all modules and subassemblies can be inserted or removed without the use of a soldering iron. The system designer must consider even these minor requirements if he wants his design to be complete. ■■

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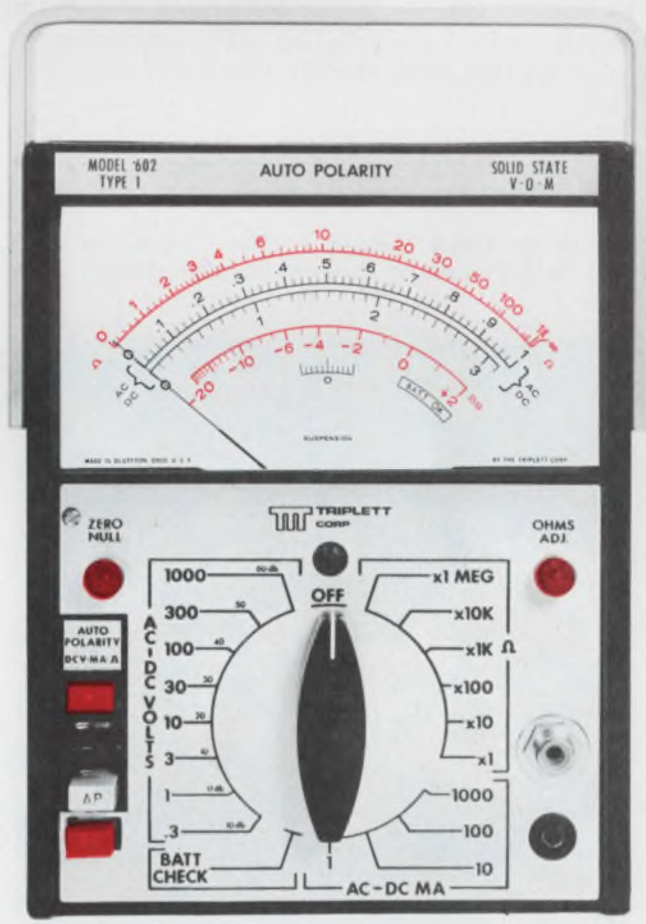

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INFORMATION RETRIEVAL NUMBER 35

Check flip-flops automatically.

Measure preset times and thresholds accurately with this new closed-loop system.

Manual tests of IC flip-flop preset times, clock thresholds and input-gate thresholds are extremely difficult. The behavior of the circuit changes with temperature, and the internal temperature of the IC changes with time and depends on the state of the output. If results are to be repeatable, the tests must be done quickly and accurately. Manual testing is not fast, and it is often not accurate.

But simple digital test circuits can do the job extremely well. (Fig. 1). The key circuits to this system are an integrator and a voltage-controlled one-shot. They are arranged in a closed-loop system with the flip-flop under test to provide an automatic means of setting the data input, the clock amplitude, or the dc gate-input voltage to the point where the flip-flop will toggle intermittently. At this point the flip-flop has a 30-to-40% duty cycle instead of the normal 50% duty cycle it would have if it were not connected in the closed-loop system.

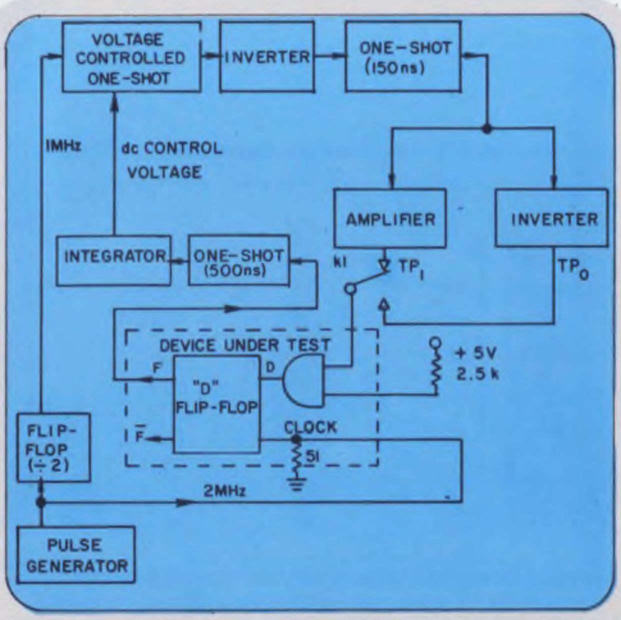
Schematics and operating curves of the integrator and voltage-controlled one-shot are shown in Figs. 2 and 3.

Kenneth C. Waine, Design Engineer, Honeywell Electronic Data Processing Division, Waltham, Mass.

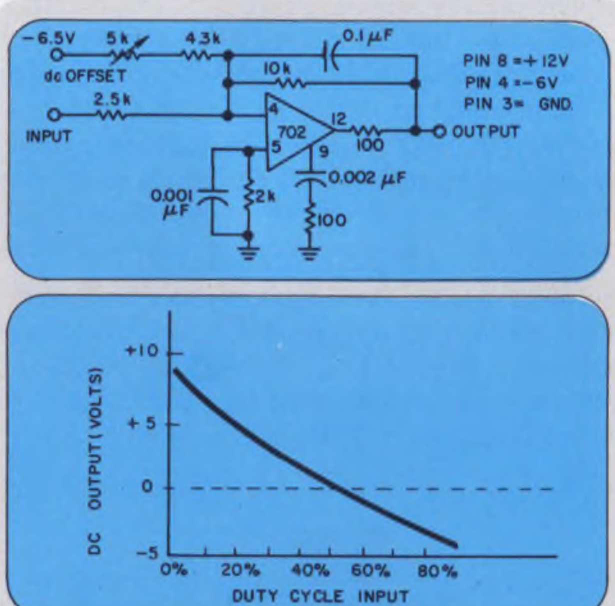
Examine the closed loop

Consider first the preset time test circuit (Fig. 1). If power is turned on and the flip-flop under test is removed from the test socket, the following conditions exist:

- The 500-ns one-shot is not triggered, and the input to the integrator is a logic ZERO, corresponding to a 0% duty-cycle signal.
- Due to the 0% duty-cycle input to the integrator, its output is at a maximum positive dc voltage (approximately +8 V).
- The voltage-controlled one-shot is continuously triggered by the 1-MHz input. Its pulse width, controlled by the dc output voltage of the integrator, is at a minimum value of approximately 385 ns.



1. **A simple digital closed-loop** system tests for preset times by adjusting the data input time until the flip-flop under test toggles intermittently. The result is accurate, repeatable dynamic measurement under operating conditions.



2. **The integrator is a simple circuit** composed of an op amp and a few discrete components. It provides an output, inversely proportional to the input duty cycle, which is used to control the pulse width of the voltage-controlled one-shot.

The output of the voltage-controlled one-shot is inverted, and it triggers the 150-ns one-shot on the falling edge of its output pulse. (Fig. 4). The output of the 150-ns one-shot is fed to an amplifier and an inverter (to provide inversion for the Tp_0 measurement). Either the amplifier (preset ONE measurement) or the inverter (preset ZERO measurement) output is selected by the relay (K1) and applied to the flip-flop under test as the data input.

For our purpose, Tp_1 (preset ONE) time is defined as the minimum amount of time that data may switch to a ONE before the rising edge of clock time and still be recognized as a ONE, thus setting the flip-flop. Tp_0 (preset ZERO time) is defined as the minimum amount of time that data may switch to a ZERO before the rising edge of clock time and still be recognized as a ZERO, thus resetting the flip-flop if it was set. The preset times are measured between the rising or falling edge of data input to the rising edge of clock input.

Note that in Fig. 4 the conditions for a 0% duty-cycle signal from the 500-ns one-shot (and flip-flop under test) is such that data input (positive-going or negative-going pulse) is centered over the rising edge of every other clock (labeled 1) for either preset condition selected. Thus, when a flip-flop is inserted into the test socket, it will start switching at a 1-MHz rate.

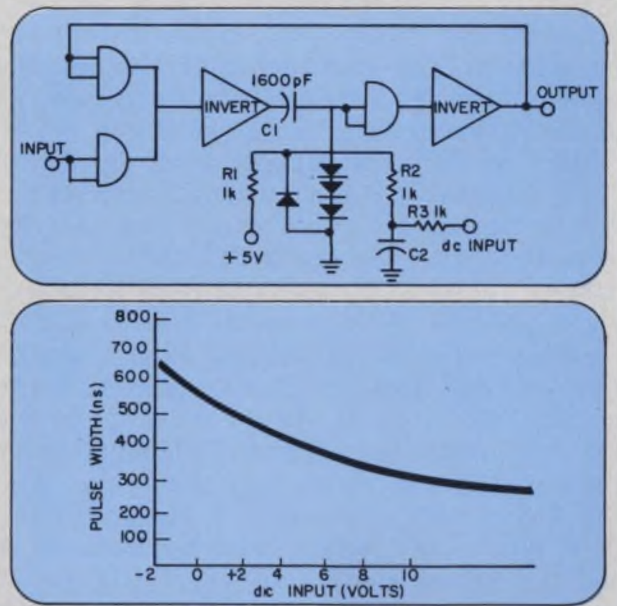
However, since the duty cycle of the flip-flop (and 500-ns one-shot) is no longer 0%, but 50%, the integrator's output will begin to decrease. And as the dc input to the voltage-controlled one-shot decreases its pulse width increases.

As its pulse width increases, the 150-ns one-shot is triggered later with respect to its initial condition, thus moving data to the right with respect to the rising edge of clock. For a preset ONE condition the rising edge of the data pulse approaches the rising edge of the clock. For a preset ZERO condition the falling edge of the data approaches the rising edge of clock (labeled 1).

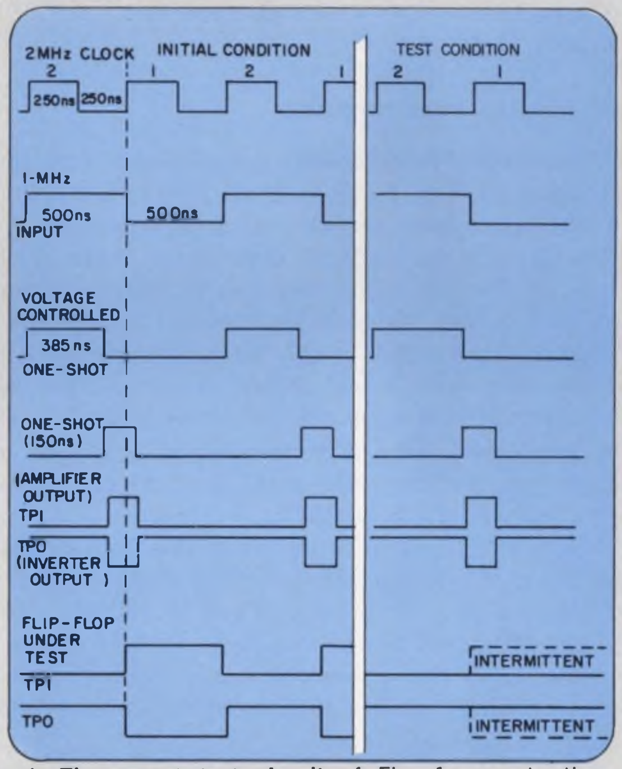
Check your flip-flop's preset

For a preset ONE measurement, then, the flip-flop will continue to toggle until data is moved to the right, past the preset time of the flip-flop, so that it represents a logic ZERO input. When this happens the flip-flop will cease to toggle and its output will have a 0% duty cycle.

The resulting 0% duty cycle input to the integrator will cause its output voltage to begin to increase, decreasing the pulse width of the voltage-controlled one-shot and moving data to the left with respect to the clock, to a point where the flip-flop begins to toggle again. This closed-



3. **The voltage-controlled one-shot provides** pulses with width inversely proportional to the dc voltage received from the integrator, and is essential to the operation of the feedback loop.



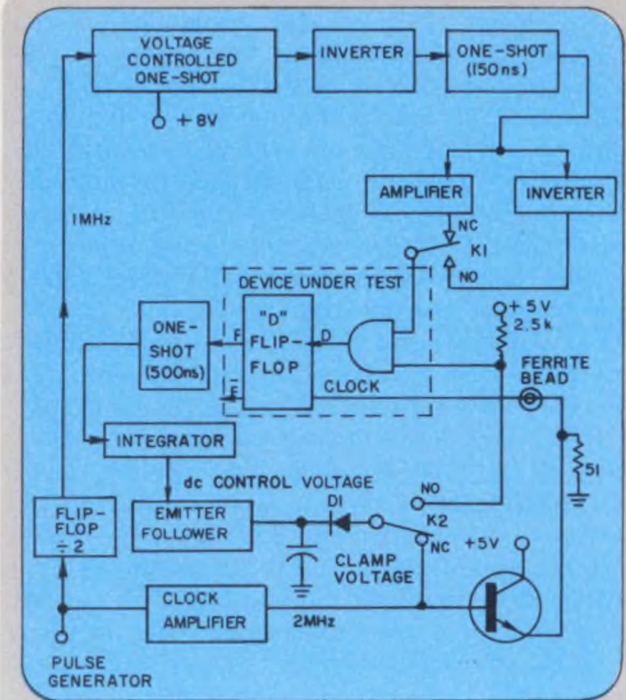
4. **The preset test circuit** of Fig. 1 accepts the 2-MHz clock, divides it down to 1 MHz, and applies the result to the voltage-controlled one-shot. The output of this one-shot, after inversion, triggers the 150-ns one-shot on its falling edge. Thus the rising edge of the output of the 150-ns one-shot is delayed from the 1-MHz clock by an amount determined by the voltage-controlled one-shot (VCOS). This delay is adjusted by the circuit until the flip-flop under test ceases to toggle.

loop system, operating like a servo-mechanism system will hunt continuously back and forth about the point where the flip-flop under test is intermittent. The operating stability is controlled by the integrator's time constant and gain, and any additional filtering in the closed loop.

Once the loop has adjusted itself so that the flip-flop operation is intermittent, the preset time can be measured between data input and clock with any high frequency oscilloscope.

For a preset ZERO condition relay K1 is energized and the flip-flop under test is initially toggling, but resetting on clock pulse 1 and setting on clock pulse 2. This is opposite to the preset ONE condition. As the data is moved to the right, the falling edge of the data approaches the rising edge of every other clock pulse. When the falling edge of the data is recognized as a ONE input, the flip-flop under test remains set and the 500-ns one-shot no longer triggers. Its output is a 0% duty-cycle signal, which is the input to the integrator. The integrator's output voltage increases, forcing the data back to the left. The flip-flop operation becomes intermittent again, as in the preset ONE condition.

In the normal testing of flip-flops they are not inserted into the test socket with power on, of course. This description was used solely for the purpose of simplification.



5. **In the clock threshold test circuit** the integrator output is used to adjust the clock amplitude applied to the flip-flop. The clock amplitude is decreased until the flip-flop toggles intermittently.

Measure the clock threshold

The clock threshold tests are performed by the circuitry of Fig. 5. Note that +8 V is applied to the voltage-controlled one-shot, causing the data input to be centered over every other clock pulse. If the flip-flop under test is removed from the test socket, the 500-ns one-shot is not triggered and the input to the integrator represents a 0% duty-cycle signal. Thus, the dc output of the integrator is approximately +8 V, and D_1 is reverse-biased. The maximum clock amplitude is determined by the clock amplifier and should be in the range of 3.5 to 4.5 V.

When the flip-flop is placed in the test socket, the input conditions are such that it will initially toggle at a 50% duty cycle. Thus the 500-ns one-shot is triggered at the flip-flop rate and the input signal to the integrator has a duty cycle of 50%, causing the integrator output voltage and clamp voltage to decrease.

As the clamp voltage drops below the initial clock amplitude, D_1 becomes forward-biased and the clock amplitude is clamped to the value of the clamp voltage, which is derived from the integrator. Once the clock amplitude decreases below the clock threshold value, the flip-flop stops toggling, the 500-ns one-shot is no longer triggered and the integrator output voltage begins to increase.

As in the preset testing, the flip-flop becomes intermittent and the clock amplitude is clamped to the clock threshold value. Again, a high frequency oscilloscope of good quality can be used to measure the clock threshold.

A ferrite bead will normally have to be added to the clock input wire to cancel out the inductance of the line to eliminate ringing and overshoot. The size of the ferrite bead is determined experimentally.

Test for gate-input thresholds

The operation for gate-input threshold testing is similar to the clock threshold test. Relay K2 is energized and the clamp voltage is applied to the flip-flop input through D_1, along with the data input. The data remains centered over every other clock pulse, and the amplitude of the clock pulse returns to the initial value of 3.5 to 4.5 V. The flip-flop becomes intermittent, and the dc gate-input voltage is clamped to the gate threshold voltage.

The 150-ns and 500-ns one-shots for the test circuits can be constructed in the same manner as the voltage-controlled one-shot. All that is required is to remove R_2, R_3, and C_2 from the voltage-controlled version and change the values of C_1 to approximately 330 pF and 1200 pF, respectively. ■■

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Management is in metamorphosis

says this research director. A knowledgeable generation, he notes, is replacing experience-based administrations.

Richard L. Turmail, Management Editor

This is the first of a three-part series on the management of change in technology, including (1) changes in management style; (2) managing the generation gap; and (3) exploring the management of technology. Because methods of technical management today change almost as often as technology itself, we think our readership will be interested in knowing what the current and projected trends in technical management are.

For decades the vitality of the American economy has testified to its superiority in managment methods. The traditional experienced-based management style, whereby orders are given with an expected immediate, highly disciplined response, has been instrumental in giving the U.S. an extraordinary leadership in business. That style is now becoming unfashionable, at least in the area of technology, according to Charles Anderson, president and chief executive officer of Stanford Research Institute, Menlo Park, Calif. He explains that engineering is moving from experienced-based to knowledge-based management not only because of the increasing complexity of technology but because the younger generation requires it.

These young people feel the need:

- To express themselves.
- To participate in establishing company policies and guidelines earlier in their careers than they have in the past.
- To revitalize their educational process.
- To participate in an activity of social benefit that they believe to be important, not only to society but to themselves as well.

These needs are going to have to be recognized by management if the jobs that need doing are to be filled.

Contrasts in styles

Anderson says that 15 to 20 years ago the executive organization of most industries was made up of people who had many years of experience. They had demonstrated their reliability and dependability under a variety of circumstances, and had proved they could be counted on. But more and more businesses, particularly those related to higher technology, are requiring the inputs of people who have new knowledge to contribute.

"I certainly don't want to suggest that experience in engineering isn't useful, desirable and a necessary component," Anderson says. "What I am suggesting is that the acquisition and effective utilization of new knowledge is becoming so important that the successful company is the one that can take this new knowledge and use it without having to wait for an engineer to get 20 years of experience. I suggest that this increased emphasis on knowledge, as distinct from experience, requires a management that embraces imagination, flexibility and creativity."

To enhance his argument, Anderson cites the contrasts of his own management experience:

"Before coming to Stanford Research Institute I was chief executive officer of a farm and construction-equipment manufacturing business, a company that evolved and grew largely as a result of experience—the experience of its people and its organization.

"SRI, on the other hand, is an organization that is almost exclusively knowledge-based. Its only mission is the application of knowledge to the needs of our society. The people here are knowledge workers. Thus, I am experiencing the contrasting management requirements of yesterday's industry with that of tomorrow. I find the contrast to be very significant."

Needs of a new generation

Anderson continues, "I see the trend setting in around SRI. The real hot comers are guys that are charged up with the new kind of technology. They want to get it to work. In some respects they're difficult to work with. They don't have a lot of respect for some of the traditions of an organization, because this has not been a part of their experience.

"For example, some months ago a young SRI staff member walked into my office and wanted to know why the staff had not been consulted about a fence that was being erected at one of

SRI and the demonstrations—a brief inquiry.

ELECTRONIC DESIGN: Mr. Anderson, why did Stanford University students demonstrate against SRI last spring?

ANDERSON: We were harassed because some of our research is in defense work. Both students and faculty members tried to achieve control of SRI's research programs in order to concentrate them on areas they felt would be morally acceptable to them. Needless to say, research could not be conducted very well under the watchful eye of a morality review board, and SRI's professional and scientific staff flatly rejected such a suggestion. In the midst of the uproar, the Stanford Board of Trustees decided to terminate the formal ties between SRI and the university—a decision fully supported by SRI.

But then the dissidents, seeing their opportunity to achieve control over SRI's research policies fading, turned to lawlessness. This led to a rather serious confrontation, with considerable damage to one of our buildings, before local police could restore order.

ELECTRONIC DESIGN: How many engineering students took part?

ANDERSON: Almost none. The engineering students with whom I come into contact constitute a very important anchor on the campus. Their background, career objectives, and training give them a more realistic view about solving world problems.

ELECTRONIC DESIGN: Why do other parts of the campus community hold such dissident views?

ANDERSON: The radicals are intent upon tearing down our society's institutions because they have no confidence in them. They believe those institutions are not responsive to their own interests and objectives, but they haven't quite decided what to replace them with. I had a discussion with an SDS leader, a brilliant mind, and I tried desperately to find out what it was they wanted to do. He said, "I don't know what we would do if we got you guys out of business, but I can tell you one thing—we wouldn't screw it up as badly as you have." He felt that, with all the hunger and war in the world today, he and his kind wouldn't have to try very hard to improve on the record of the establishment.

I know I can't reason with the radical. I am more concerned about the moderate group of students with constructive objectives. I think it's extremely important that we communicate with these people. It's difficult to do so in a hysterical environment.

ELECTRONIC DESIGN: Have college administrations changed their policies to meet a changing world?

ANDERSON: University administrators have been faced with a more difficult problem than our society has realized. Frequently the college president has been caught between faculty, public and alumni. He has less authority to deal with these problems than most administrators because the traditions of the university usually allow the faculty to exercise a very high degree of control on campus activities. In many instances there is a good deal of sympathy for the students by the faculty. I'm not suggesting that this is wrong, but I do think faculties have not always taken the leadership to help find constructive solutions.

Important processes are, however, taking place on many campuses providing a nonviolent way of meeting the requirements of students, such as the development of judicial systems. I don't think we are over the crisis, but I do think progress is being made.

Stanford demonstrators ignite police barricade last May in protest against SRI defense projects.

our facilities in Menlo Park. In some ways this was amusing, in some ways disconcerting, but I can assure you that this would not have happened at the tractor works."

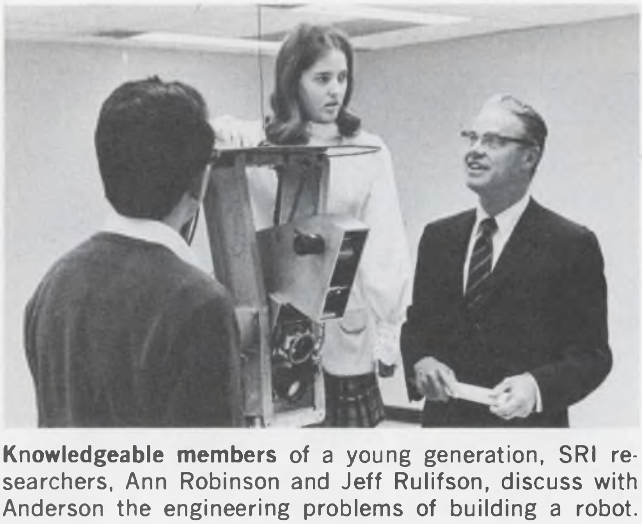
The differences between running the tractor works and SRI, Anderson points out, relate to the people involved, and he suggests that the people he is now dealing with at SRI are the types that the electronics industry relies on to provide the manpower and brainpower to run its companies. What are they like? And what does it take to manage them?

According to Anderson, today's students have been reared in affluence and don't worry much about economic security; they see it as a right. Instead, they have had time to concentrate on social and political problems.

When Dr. Joseph Katz, Executive Director of the Institute of Human Problems at Stanford, talked to an SRI conference last year, he noted: "There is an increasing erosion of respect for that authority which rests primarily on status, whether it be that of university president, faculty member, political leader, or the corporation president. There is no erosion if that authority is based on a competence, particularly if the competence is relevant to the lives of the young." They do not reject authority, he pointed out, but rather make an attempt to participate in it. He observed further that "as former students enter professional and business life, they are apt to try to continue their ways in their new environments."

Anderson summarizes briefly the traits and characteristics of today's students and young employees:

- Because they're young, knowledge is more important to them than experience.
- They are highly trained and specialized.
- Their views of authority tend to be quite different from the traditional concepts. They don't "dig" the "organization man," they are likely to have more loyalty to their profession or academic discipline than to the organization with which they happen to be associated.
- They feel a commitment to do something about our society.
- They want to see their professional capabilities devoted to this end, and this may be more important to them than contributing to your earnings per share. Indeed, because management's job is concerned with earnings per share it tends to breed mistrust. This is a manifestation of the differences in value systems.



Knowledgeable members of a young generation, SRI researchers, Ann Robinson and Jeff Rulifson, discuss with Anderson the engineering problems of building a robot.

"The management process required to coordinate the efforts and energies of such a group," Anderson says, "is clearly different from that needed at the tractor works. But the rewards will be great for those organizations that can develop a management style that can both accommodate the needs of the knowledgeable professional and benefit economically and commercially from his efforts."

Patience with the precocious

In an attempt to explain how to manage the new generation, Anderson says that you can't deal with the precocious employee by putting him in a disciplinary straitjacket. The more creative and industrious he is the less successful is that tactic.

Give him an atmosphere that allows him to express himself, and pretty soon he learns that life is a little more complicated than he originally thought. It has been his experience here and elsewhere says Anderson, that after you've provided a means for people to express themselves, even though they disagree with your objectives, policies and plans, they'll support them much better. They feel that they're qualified to give an input, and management should back them up wherever possible.

Management must have patience with these new engineers, he believes, and put them in an environment where others will listen to them. "Soon, and I've seen this happen," he says, "the young employee will understand the need for exercising some discipline and will eventually become part of the team. Each one has to decide for himself whether or not he is going to be part of the team, and he must be in a comparatively free climate to do so. And the company must be very demanding—the young respect firmness. It's harder as a management process because it takes more time and patience than many of us have used. Talking to people and especially listening to people is a very difficult exercise."

Anderson concludes: "My favorite philosopher, Charlie Brown of the Peanuts comic strip, says: 'The world is filled with people anxious to function in an advisory capacity.' And it seems as if there are more of them every day." ■■

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INFORMATION RETRIEVAL NUMBER 37

Use a complementary stage to extend IC output level

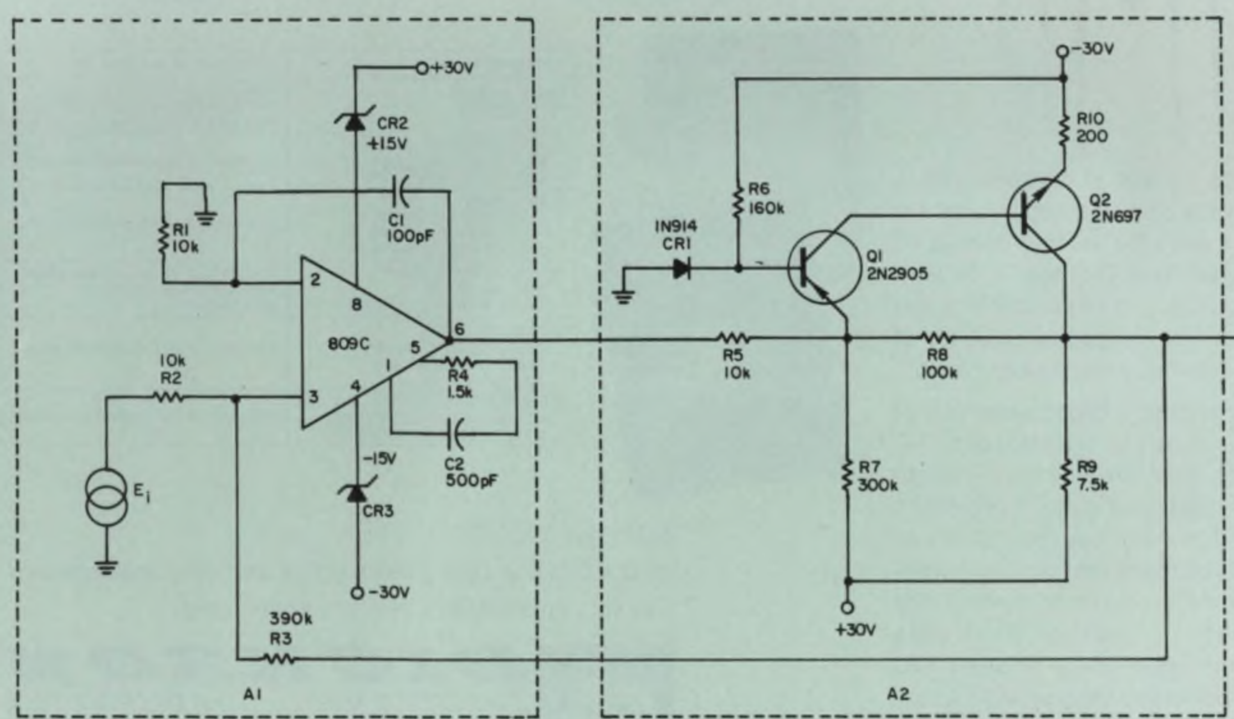
Most IC operational amplifiers can deliver output satisfactorily up to about ±10 V. If an application appears where a ±20-V output is needed, the designer usually discards the integrated circuits for a new design using discrete components or buys a packaged op amp. An alternative solution is to use the IC in combination with some additional circuitry.

As shown in the figure, an IC (A_1) is used to drive A_2, a discrete amplifier. A_2 is a simple complementary pair dc amplifier[1] using ±30 V as its supply. Diode CR_1 is used to compensate for V_{be} of Q_1. The overall gain of A_2 is set by R_5 and R_8. This amplifier is equivalent to an op amp in the inverting connection.

A_1 is an 809C IC dc amplifier with feedback applied at the noninverting input, since A_2 provides a phase inversion. R_2 and R_3 set the overall gain to 39. C_1, C_2, and R_4 are used to stabilize the system against oscillations.

A breadboard of this circuit had a voltage gain of 39, input impedance of 10 KΩ, dc offset of 0.2 V, E_o of ±20 V into a 6-KΩ load, and a bandwidth of 40 kHz.

This amplifier was primarily designed for low cost and thus lacks higher power output and



Two-transistor complementary amplifier is used to extend the voltage output of a linear IC.

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INFORMATION RETRIEVAL NUMBER 38

greater bandwidth. Using an IC of higher quality and a suitable modification of the output stage would improve these parameters.

Reference:
1. Mollinga, T., "D. C. amplifier design," *EEE*, February, 1969.

Jerome Lyman & M. Wenstein, Senior Electronic Engineers, Servo Corp. of America, Hicksville, N. Y.

VOTE FOR 311

Solid-state isolation relay has nonpolarized terminals

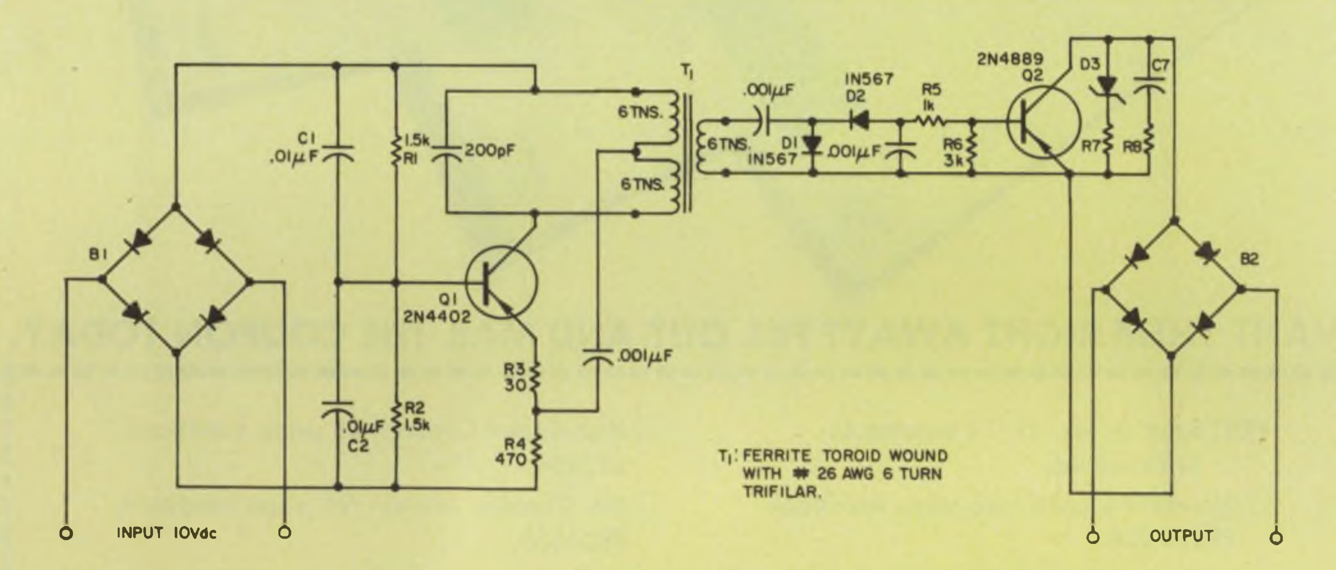
The circuit shown provides the equivalent to an electromechanical spst relay. High isolation is provided between input and output terminals by means of a ferrite transformer.

Diode bridge B_1 routes the dc input signal to Q_1 so that the input terminals are nonpolarized. Q_1 functions as a Hartley oscillator (at about 10 MHz). Oscillations are controlled by the input signal. The oscillator output is coupled to a rectifier/voltage doubler through the secondary of transformer T_1 which is wound on a small ferrite toroid.

The filtered dc output of the rectifier is used to switch Q_2 on. R_6 provides a return for the I_{cbo} of Q_2. Diode bridge B_2 provides nonpolarized output terminals. The additional components D_3, C_7, and R_7, and R_8 are used to protect Q_2 when the circuit controls inductive loads, such as teletype equipment.

Charles A. Herbst, Consultant Engineer, Dumont, N. J.

VOTE FOR 312



Two transistor circuit functions as an spst relay. Input and output terminals are nonpolarized.

Etching improves multilayer board soldering

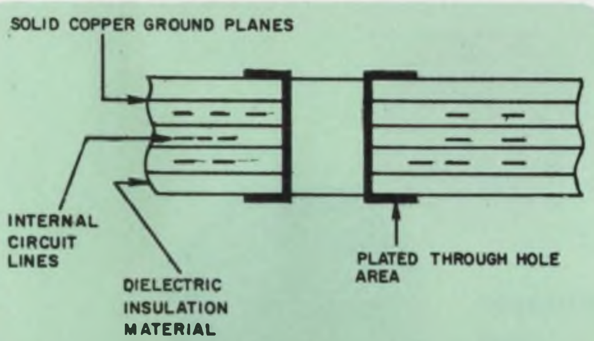
Due to the mass of copper in multilayer interconnection board (MIB) ground/voltage planes acting as a heat sink, soldering to these points can produce weak, poorly formed connections. Applying extra heat can burn or delaminate the MIB or printed-circuit cable.

But copper can be etched away from two annular areas around the mounting location in the ground/voltage plane, thus reducing heat dissipation. Retention of heat at the component

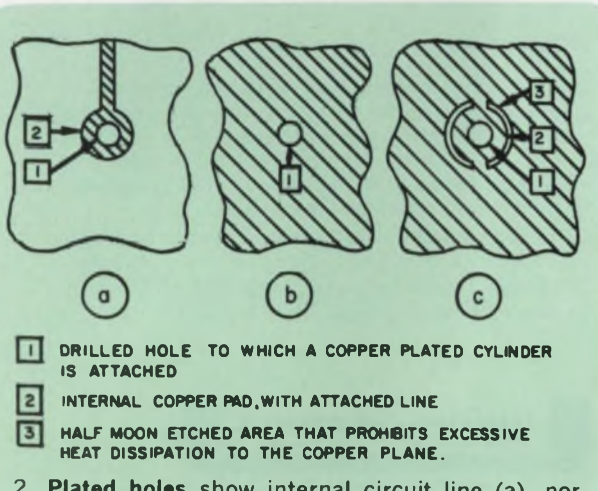
mounting location means that a shorter soldering-iron dwell time is required to achieve a good solder joint, thus preventing damage.

MIBs must supply a capacitance and impedance match between external components and must shield low power circuits from stray noise and transient pickup. The normal industrial method used to make a noise-free matched impedance MIB is shown in Fig. 1.

With a ground or shield plane or copper above and below each layer of circuit lines, the capacitance and impedance can be adjusted, and the lines are shielded from external noise. Horizontal transients (line-to-line on the same layer) can be controlled by ground-line placement. MIBs of this type have up to six copper ground planes. These are connected to each other by plated-through holes.



1. **Embedded copper-shield planes** are shown in cutaway view. Interconnection is made by plated holes.



2. **Plated holes** show internal circuit line (a), normal ground/voltage plane (b), modified ground/voltage plane (c).

Standard practice in connecting a plated-through hole to a solid copper plane is to drill through the MIB, then copper-plate the drilled hole. This will create a 360° connection between the copper-plated cylinder and the copper ground shield. The soldering of component leads into the plated-through hole is an exacting process, whether soldering is automatic or manual. Due to the heat-sinking characteristics of a ground plane in comparison to a circuit line, the two configurations will not accept solder at the same rate when subjected to identical time/temperature soldering applications.

The ground plane will dissipate heat away from the plated-through hole at a much greater rate than will a circuit line. Ground planes can dissipate heat in a 360° direction from the hole over the entire size of the MIB, but heat dissipated by a circuit line is slower because it must follow a restrictive path defined by the width of the circuit line.

The solution to this problem lies in restricting the amount of heat dissipated by the ground planes so it remains in the plated-through hole area. Making an acceptable solder connection without damaging the insulation is then possible. A minor change to the ground-plane artwork was incorporated which permitted two half-moon areas to be etched through the copper during the manufacturing process.

This special etching reduces the heat-dissipation area from 360° (Fig. 1b) to approximately 72° (Fig. 2c). The only path available for heat dissipation to the solid plane is through the two connections between the plane and internal pad. The heat-dissipation area for a normal internal circuit line (as shown in Fig. 2a) is 36°.

By retaining the heat in the plated-through hole area, soldering problems have been greatly reduced. Cold solder joints and poor solder penetration are no longer a major concern when soldering to a plated-through hole with two or more attached ground planes.

Peter Burke, Component Engineer, IBM Electronics Systems Center, Oswego, N.Y.

VOTE FOR 313

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INFORMATION RETRIEVAL NUMBER 40

Program determines worst-case part values

Instead of using your time to compute parameter values for computer aided worst-case analysis, why not let the computer do the whole job?

This program calculates the effective tolerance due to the temperature range and temperature coefficient, sums this with the purchase tolerance plus variations allotted for aging effects, and applies the total deviation factor to the nominal parameter value, thus determining the worst-case minimum and maximum.

The program is written in Fortran II. To use this material, first load it into a memory address at a computer terminal. Thereafter, when worst case parameter determinations are to be made, one simply dials in, supplies data the computer requests, and is then furnished with the desired component values in a well organized manner.

Table 1 is a typical computer output from the program in which worst-case parameter values have been determined for a MIL-type resistor. Other worst-case component parameters are determined in a similar way. After each colon, the user has typed in the information requested by the computer, and at the bottom of the computer output the worst-case parameter values are presented.

The only restrictions inherent in the program (listed in Table 2) are: tolerances and temperature coefficients are assumed to be plus or minus values; five or less alphanumeric characters must be used for the first two entries (see Table 1); and the program assumes a nominal temperature of 25°C.

William J. Budt, Design Engineer, Communications Development Center, Honeywell, Inc., St. Petersburg, Fla.

VOTE FOR 314

Table 1

```
WORST-CASE PARAMETERS FOR:  R1

     PART TYPE:  RN
     NOMINAL VALUE:  1E3
     PURCHASE TOLERANCE (%):  1
     AGING DEGRADATION (%):  1
     MAXIMUM TEMPERATURE COEFFICIENT (PPM/°C):  25
     TEMPERATURE RANGE (LOW, HIGH):  -55,125
     AGING DEGRADATION FOR TEMPERATURE COEFFICIENT (%):  1
     SUMMING THE WORST-CASE TOLERANCES, AND APPLYING THE
       SUM TO THE NOMINAL VALUE, THE FOLLOWING WORST-CASE
       VALUES ARE OBTAINED.
     LOW TEMP. MIN.  LOW TEMP. MAX.  HIGH TEMP. MIN.  HIGH TEMP. MAX.
        .9780E3         .1022E4         .9775E3          .1023E4
```

Table 2

```
  TYPE 1
 1 FORMAT (///////$WORST-CASE PARAMETERS FOR:$)
  ACCEPT 2,A
 2 FORMAT (A)
  TYPE 3
 3 FORMAT ($-----------------------------$,//)
  TYPE 4
 4 FORMAT (5X,$PART TYPE:$)
  ACCEPT 5,B
 5 FORMAT (A)
  TYPE 6
 6 FORMAT (5X,$NOMINAL VALUE:$)
  ACCEPT 7,C
 7 FORMAT (E)
  TYPE 8
 8 FORMAT (5X,$PURCHASE TOLERANCE (%):$)
  ACCEPT 9,D
 9 FORMAT (E)
  TYPE 10
10 FORMAT (5X,$AGING DEGRADATION (%):$)
  ACCEPT 11,E
11 FORMAT (E)
  TYPE 12
12 FORMAT (5X,$MAXIMUM TEMPERATURE COEFFICIENT (PPM/C):$)
  ACCEPT 13,F
13 FORMAT (E)
  TYPE 14
14 FORMAT (5X,$TEMPERATURE RANGE (LOW, HIGH):$)
  ACCEPT 15,G,H
15 FORMAT (2E)
  TYPE 16
16 FORMAT (5X,$AGING DEGRADATION FOR TEMPERATURE COEFFICIENT (%):$)
  ACCEPT 17,P
17 FORMAT (E)
  FF=F*(1.0+1.0E-2*P)
  AA=FF*1.0E-4*(25.0-G)
  BB=FF*1.0E-4*(H-25.0)
  TYPE 18
18 FORMAT (5X,$SUMMING THE WORST-CASE TOLERANCES, AND APPLYING THE$/)
  TYPE 19
19 FORMAT (7X,$SUM TO THE NOMINAL VALUE, THE FOLLOWING WORST CASE$/)
  TYPE 20
20 FORMAT (7X,$VALUES ARE OBTAINED.$/)
  TYPE 21
21 FORMAT (5X,$LOW TEMP. MIN. LOW TEMP. MAX. HIGH TEMP. MIN.
+ HIGH TEMP. MAX.$/)
  TYPE 22
22 FORMAT (5X,$--------------- --------------- ---------------
+ ---------------$/)
  CC=AA+D+E
  CC=AA+D+E
  DD=BB+D+E
  A1=C*(1.0-CC*1.0E-2)
  A2=C*(1.0+CC*1.0E-2)
  B1=C*(1.0-DD*1.0E-2)
  B2=C*(1.0+DD*1.0E-2)
  TYPE 23,A1,A2,B1,B2
23 FORMAT (5X,E10.4,$     $,E10.4,$     $,E10.4,$     $,E10.4,/)
END
```


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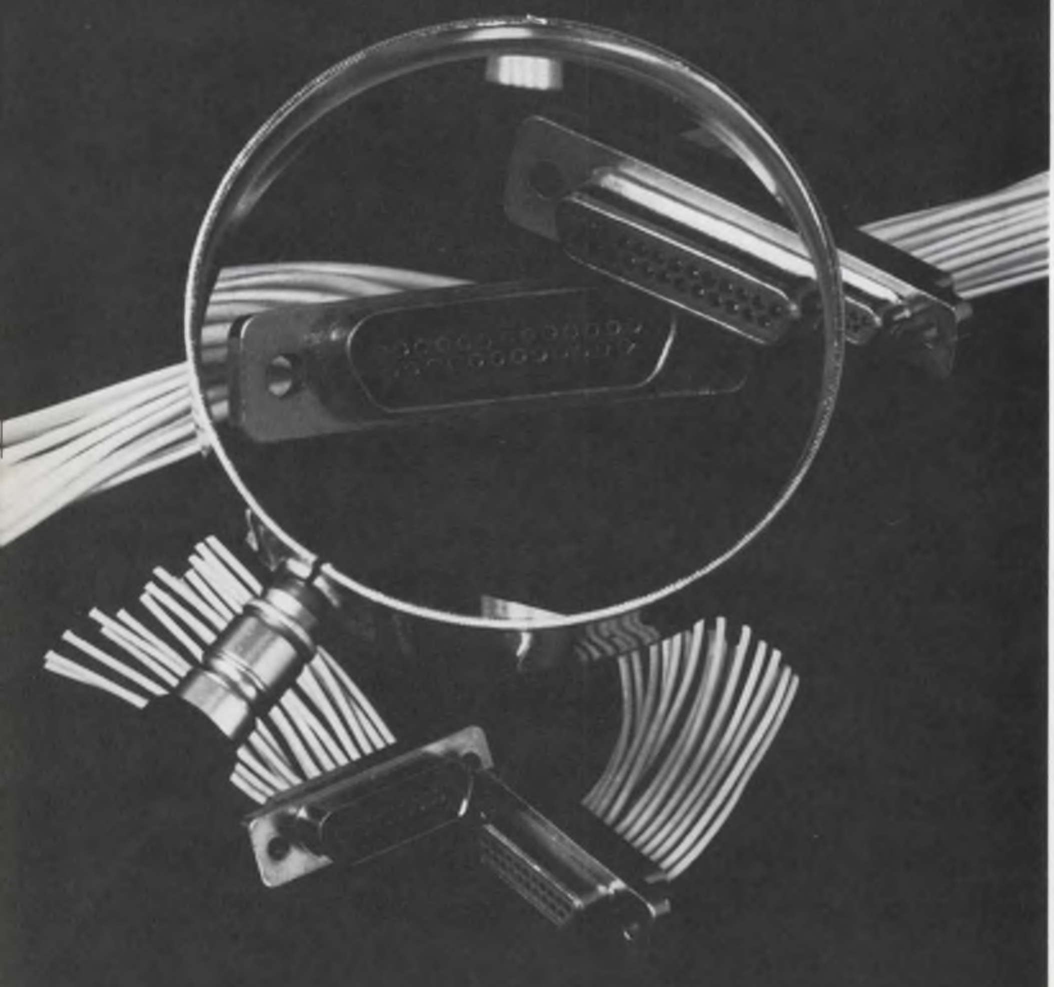

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Product Source Directory

Multitestors

This Product Source Directory, covering Multitesters, is the tenth in a continuing series of product selection data that will list comparative specifications and prices for products frequently purchased by design engineers. All categories will be arranged according to some primary parameter so that items having similar functional capabilities can be instantly compared.

How to use the tables

The tables in this section list the specifications for multitesters. The following abbreviations apply to all instruments listed:

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

An index of models by manufacturer is included at the end of each table.

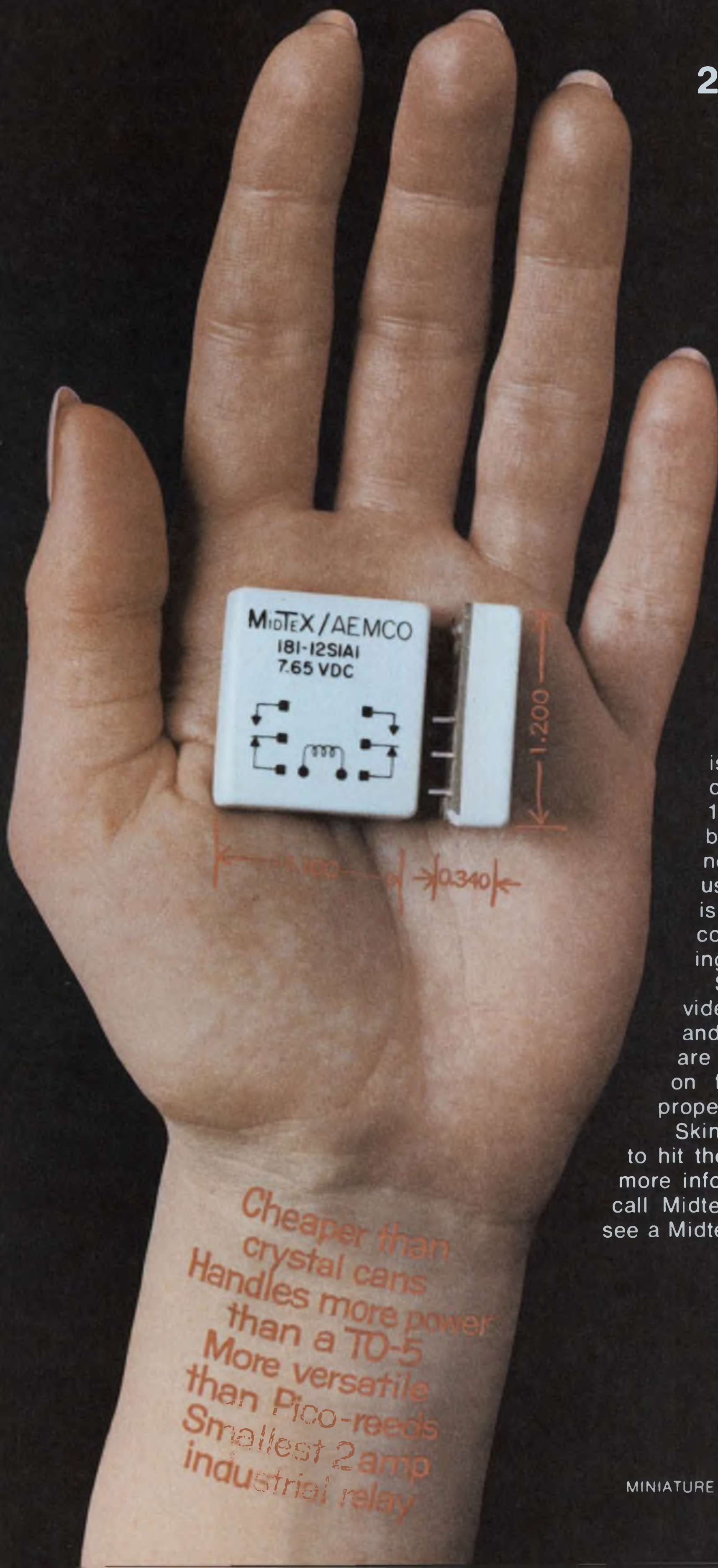
For each table, the instruments are listed in ascending order of one major parameter. The column containing this parameter is color-coded white, and arranged by ascending order of dc sensitivity. Manufacturers are identified by abbreviation. The complete name of each manufacturer can be found in the Master Cross Index.

Abbrev.	Company	Reader Service No.
AUL	AUL Inc. 139-30 34th Rd. Flushing, N.Y. 11354 (212) 886-0600	**460**
AVO	AVO Gencom Div. 80 Express St. Plainview, N.Y. 11803 (516) 433-5900	**461**
Connolly	Connolly & Co., Inc. 914 N. Ringstorff Ave. Mt. View, Calif. 94040 (415) 967-6988	**462**
Heath	Heath Co. Benton Harbor, Mich. 49022 (616) 983-3961	**463**
Inst Labs	Instrument Labs. Corp. 315 W. Walton Pl. Chicago, Ill. 60610 (312) 642-0123	**464**
Keithley	Keithley Instrument Corp. 28775 Aurora Rd. Cleveland, Ohio 44139 (216) 248-0400	**465**
Millivac	Millivac Instrument Inc. 1100 Altamount Ave. Box 997 Schenectady, N.Y. 12301 (518) 355-8300	**466**

Abbrev.	Company	Reader Service No.
RCA	RCA Electronic Components & Devices Harrison, N.J. 07029 (201) 485-3900	**467**
R-S	Rohde & Schwarz 111 Lexington Ave. Passaic, N.J. 07055 (201) 773-8010	**468**
SEP	Scientific Educational Products Corp. 30 E. 42nd St. New York, N.Y. 10017 (212) 867-9480	**469**
Sigma	Sigma Instruments International Instruments Div. Braintree, Mass. 02185 (617) 843-5000	**470**
Simpson	Simpson Electric Co. 5220 W. Kinzie St. Chicago, Ill. 60644 (312) 379-1121	**471**
Triplett	Triplett Electrical Instrument Co. 286 Harmon Rd. Bluffton, Ohio 45817 (419) 358-5015	**472**
Yokagawa	Yokogawa Electric Works Inc. 1995 Palmer Ave. Larchmont, N.Y. 10538 (914) 834-3550	**473**

				VOLTAGE RANGES				CURRENT RANGES					OHMS RANGES				
	Mfr.	Model		Sensitivity kΩ/V	Min. V	Max. kV	No.	Acc. %	Min. mA	Max. A	No.	Acc. %	Min. kΩ	Max. MΩ	No.	Misc Features	Price $
MT 1	AVO	12	dc	0.2	3.6	0.036	4	1	3600	900	6	1	0.0005	0.01	2	ac	135
			ac	0.09	9	0.36	4	2.25									
	Inst Labs	102	dc	1	1	0.5	6	2	1	25	7	2	1	100	2	d	195
			ac	1	5	0.5	5	3	250	25	4	3					
	Triplett	666R	dc	1	10	5	5	3	10	1	3	3	3	3	3	aj	46
			ac	1	10	5	5	4	n/a	n/a	n/a	n/a					
	Simpson	209	dc	1.66	0.06	0.6	5	1.5	120	12	4	1.5	0.001	0.2	2	jq	68
			ac	1.66	12	0.6	4	2.5	6	12	6	2.5					
	Simpson	208	dc	10	0.6	0.6	6	1.5	0.6	3	6	1.5	0.005	1	2	jq	72
			ac	10	12	0.6	4	2.5	0.6	3	6	2.5					
	Triplett	310-C	dc	20	3	0.6	5	3	0.6	0.25	4	3	20	20	4	j	56
			ac	15	3	0.6	5	4	n/a	n/a	n/a	n/a					
	AVO	20	dc	20	0.1	1	8	1	0.1	3	10	1	0.002	100	4	a	99
			ac	2	1	1	7	1	3	3	7	1					
	Simpson	160	dc	20	0.25	1	8	2	0.05	0.5	6	2	0.001	30	5	j	55
			ac	5	2.5	0.1	6	3	n/a	n/a	n/a	n/a					
	Simpson	255	dc	20	0.05	1	8	2	0.05	0.5	5	2	0.2Ω	20	3	jt	90
			ac	5	2.5	1	6	3									
	Simpson	250	dc	20	0.05	1	8	2	0.05	10	6	2	0.2Ω	20	3	j	70
			ac	5	2.5	1	6	3	n/a	n/a	n/a	n/a					
MT 2	Triplett	310	dc	20	3	1.2	5	3	0.6	0.25	4	3	20	20	4	j	44
			ac	5	3	1.2	5	4	n/a	n/a	n/a	n/a					
	Triplett	631	dc	20	3	1.2	5	3	0.06	12	6	3	1.5	150	4	j	86
			ac	5	3	1.2	5	4									
	Sigma	VOM-22	dc	20	5	1.5	5	3	0.5	0.5	4	3	2	2	4		45
			ac	15.5	15	1.5	5	5									
	Connolly	Super 55	dc	20	0.25	2.5	8	1	50	10	8	1	2	20	3	a	90
		MkII	ac	2	2.5	2.5	7	2.25	25	10	6	2.25					
	AVO	8 MkIII	dc	20	2.5	2.5	8	2	0.05	10	7	1	0.0005	20	3	a	115
			ac	1	2.5	2.5	7	2.25	100	10	4	2.25					
	Triplett	800	dc	20	0.3	3	7	1.5	0.12	12	6	1.5	1	100	6	agj	116
			ac	10	1.5	3	6	3	n/a	n/a	n/a	n/a					
			dc	10	0.6	6	7	1.5	0.06	6	6	1.5					
			ac	5	3	6	6	3	n/a	n/a	n/a	n/a					
	Simpson	263	dc	20	0.15	3	9	1.5	0.075	7.5	6	1.5	0.05Ω	50	6	js	97
			ac	10	2.5	0.75	5	3	n/a	n/a	n/a	n/a					
			dc	10	0.3	6	9	1.5	0.15	15	6	1.5	0.05Ω	50	6	j	
			ac	5	5	1.5	5	3	n/a	n/a	n/a	n/a					
	Triplett	630-NA	dc	20	0.3	3	7	1.5	0.06	6	6	1.5	1	100	6	j	98
			ac	10	1.5	3	6	3	n/a	n/a	n/a	n/a					
			dc	10	0.6	6	7	1.5	0.12	12	6	1.5					
			ac	5	3	6	6	3	n/a	n/a	n/a	n/a					
	AVO	9 MkII	dc	20	3	3	8	2	0.05	10	7	1	0.0005	20	3	a	115
			ac	1	3	3	7	2.25	10	10	4	2.25					
	Simpson	262	dc	20	1.6	4	7	3	0.08	8	7	3	0.05Ω	50	6	j	83
			ac	5	3	0.8	6	4	n/a	n/a	n/a	n/a					
MT 3	RCA	WV-38A	dc	20	0.25	5	8	3	0.05	10	6	3	0.2Ω	20	3	a	55
			ac	5	2.5	5	6	5									
	Simpson	261	dc	20	0.25	5	7	1.5	0.05	10	6	2	0.2Ω	20	3	gjw	73
			ac	5	2.5	5	6	3									
	Simpson	260-5	dc	20	0.25	5	7	2	0.05	10	6	2	0.2Ω	20	3	jr	65
			ac	5	2.5	5	6	3									
	Simpson	270	dc	20	0.25	5	7	1.25	0.05	10	6	2	0.2Ω	20	3	gju	78
			ac	5	2.5	5	6	2	n/a	n/a	n/a	n/a					
	Heath	MM-1	dc	20	1.5	5	7	3	0.15	15	5	3	0.01	0.01	3		32
			ac	5	1.5	5	7	3	n/a	n/a	n/a	n/a					
	Triplett	630-L	dc	20	2.5	5	6	ina	0.1	1.2	5	1.5	1	100	4	aj	69
			ac	5	3	5	6										
	Triplett	630-APLK	dc	20	2.5	5	6	1.5	0.1	10	5	1.5	0.1Ω	100	4	aj	110
			ac	5	3	5	6	3									
	Triplett	630-APL	dc	20	2.5	5	6	1.5	0.1	10	5	1.5	1	100	4	aj	75
			ac	5	3	5	6	3	n/a	n/a	n/a	n/a					
	Triplett	630-PLK	dc	20	2.5	5	6	2	0.1	10	5	2	1	100	4	aj	98
			ac	5	3	5	6	3									
	Triplett	630-PL	dc	20	2.5	5	6	2	0.1	10	5	2	1	100	4	j	64
			ac	5	3	5	6	3	n/a	n/a	n/a	n/a					
MT 4	Triplett	630-A	dc	20	3	6	6	1.5	0.06	12	5	1.5	1	100	4	j	75
			ac	5	3	6	6	3	n/a	n/a	n/a	n/a					
	Triplett	630	dc	20	3	6	6	2	0.06	12	5	2	1	100	4	j	64
			ac	5	3	6	6	3	n/a	n/a	n/a	n/a					
	Simpson	256	dc	25	0.1	5	10	1	0.1	5	7	1	0.001	50	4	jrs	105
			ac	2	0.5	5	9	1.5	0.5	5	7	1.5	20	50	1		
	SEP	30061	dc	50	0.25	1	7	2	0.025	10	5	2	20	200	5	k	61
			ac	10	2.5	1	6	3	200	10	1	3					

Meet Skinny Mini.



The first 2 amp 2PDT relay skinny enough to mount on 0.5 PCB centers.

Never has anything so flat caused so much excitement . . . since Twiggy.

Here she is, the skinniest, miniest 2 amp 2PDT relay in captivity. Only 0.340 inches maximum off the board height.

Cheaper than a crystal can! Handles more power than a TO-5 relay! Has versatility of Form C compared to Pico-reeds! And is smaller than all other 2 amp industrial relays!

Now Skinny Mini, or as she is sometimes affectionately called, Midtex/AEMCO Type 181, with its maximum off-the-board height of 0.340, mounts neatly on printed circuit boards using 0.5 centers. The height is also compatible with semiconductor component mountings.

Skinny as it is, the 181 provides 1/16″ clearance through air and ⅛″ over surface. Terminals are 0.025″ pins. The relay mounts on four raised pads to permit proper PCB cleaning and soldering.

Skinny Mini . . . the skinniest news to hit the relay market this year. For more information about Mini, write or call Midtex/AEMCO, 507 388-6288, or see a Midtex/AEMCO representative.

MIDTEX
INCORPORATED
AEMCO DIVISION

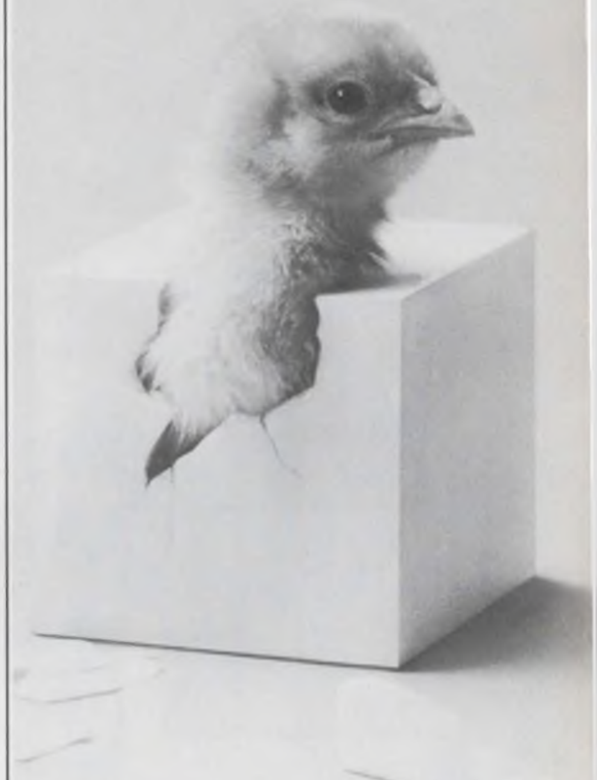
10 STATE STREET
MANKATO, MINNESOTA 56001

PROGRAMMERS/TIME DELAY RELAYS
MINIATURE COAXIAL RELAYS/INDUSTRIAL RELAYS
MERCURY-WETTED CONTACT RELAYS

				VOLTAGE RANGES					CURRENT RANGES				OHMS RANGES				
	Mfr.	Model		Sensitivity kΩ/V	Min. V	Max. kv	No.	Acc. %	Min. mA	Max. A	No.	Acc. %	Min. kΩ	Max. MΩ	No.	Misc Features	Price $
	Yokogawa	3201	dc	100	0.3	1.2	8	2	0.012	1.2	6	2	2	20	3		56
			ac	10	3	1.2	6	3									
	Simpson	269	dc	100	1.6	4	8	1.5	0.016	8	7	1.5	0.2Ω	200	6	i	98
			ac	5	3	0.8	6	2.5	n/a	n/a	n/a	n/a					
	Simpson	257	dc	100	0.1	5	9	1.5	0.01	1	8	1.5	0.001	500	4	jr	95
			ac	20	10	1	4	2.5	n/a	n/a	n/a	n/a	20	50	1		
	Triplett	630-NS	dc	200	0.3	0.6	6	1.5	0.005	12	7	1.5	1	100	6	j	116
			ac	20	1.5	0.6	5	3	n/a	n/a	n/a	n/a					
M			dc	100	0.6	1.2	6	1.5	0.06	6	6	1.5					
T			ac	10	3	1.2	5	3	n/a	n/a	n/a	n/a					
5	R-S	URI	dc	m	0.02	0.3	6	2	n/a	n/a	n/a	n/a	5Ω	1000	3	mn	595
			ac		0.1	0.3	6	4	0.1	1	7		4				
	R-S	URU	dc	m	5	30	8	6	n/a	n/a	n/a	n/a	0.5Ω	3000	7	m	595
			ac		0.1	1	5	3									
	Triplett	630-M	dc	1000	0.3	0.15	5	1.5	0.001	12	7	1.5	1	100	6	jx	231
			ac	20	1.5	0.6	5	3									
	AVO	EA113	dc	1000	0.01	1	11	1.25	0.001	3	8	1.25	0.001	100	5	b	250
			ac	10MΩ	0.01	1	11	1.25	0.01	3	7	1.25					
	AUL	TVOM4	dc	3000	0.15	1.5	7	3	1.5μA	1.5	5	3	10Ω	1	4	g	55
			ac	ina	1.5	0.5	5	5	n/a	n/a	n/a	n/a					
	AUL	TVM4	dc	3000	0.15	1.5	9	3	0.15	1.5	9	3	10Ω	1	6	g	70
			ac	ina	1.5	1.5	7	5									
	AUL	TVOM3	dc	3000	0.5	5	7	3	0.01	1	5	3	20Ω	0.2	4	g	44
			ac	ina	10	5	5	4	n/a	n/a	n/a	n/a					
	Triplett	310-FET	dc	Zin 10M	0.3	0.6	6	3	0.12	.0012	2	3	5	50	3	ij	74
			ac	5	3	0.6	5	4									
	Simpson	303	dc	Zin 10M	1.2	1.2	6	3	n/a	n/a	n/a	n/a	0.0002	1000	6	hj	92
			ac	275k	1.2	1.2	6	5									
M	Triplett	601	dc	Zin	0.1	1	9	2	0.01	0.01	4	3	1	1000	7	dgj	158
T			ac	11M	0.01	1	11	3	0.01	0.01	4	4					
6	Heath	IM-17	dc	Zin 11M	1	1	4	3	n/a	n/a	n/a	n/a	0.01	10	4		22
			ac	1M	1	1	4	5									
	AUL	DM-1000	dc	Zin	1	1	4	1	0.1	10	6	3	0.1	100	7	ghn	reg
			ac	11MΩ	1	1	4	2	0.1	10	6	4					
	Heath	IM-25	dc	Zin 11M	0.15	1.5	9	3	0.015	1.5	11	4	0.01	10	7		85
			ac	1M	0.15	1.5	9	5	0.015	1.5	11	5					
	Heath	IM-16	dc	Zin 11M	0.5	1.5	8	3	n/a	n/a	n/a	n/a	0.01	10	7		47
			ac	1M	0.5	1.5	8	5									
	Triplett	850	dc	Zin	0.5	1.5	11	3	n/a	n/a	n/a	n/a	1	1000	7	gj	98
			ac	11M	1.5	1.5	7	3									
	RCA	WV-500B	dc	Zin 11MΩ	0.5	1.5	8	3	0.5	1.5	8	3	0.2Ω	1000	7	j	88
	RCA	WV-98C	dc	Zin	0.5	1.5	8	±3	n/a	n/a	n/a	n/a	0.2Ω	1000	7	i	99
			ac	11MΩ													
	Heath	IM-18	dc	Zin 11M	1.5	1.5	7	3	n/a	n/a	n/a	n/a	0.01	10	7		30
			ac	1M	1.5	1.5	7	5									
	RCA	WV-77E	dc	Zin	1.5	1.5	7	3	n/a	n/a	n/a	n/a	0.2Ω	1000	7		63
			ac	11MΩ													
M	Triplett	600	dc	Zin	0.4	1.6	10	3	n/a	n/a	n/a	n/a	1	100	6	gj	86
T			ac	11M	4	0.8	7	3									
7	Simpson	312	dc	Zin 16M	0.5	1.5	8	3	n/a	n/a	n/a	n/a	0.2Ω	1000	7	jp	95
			ac	Zin 1M	1.5	1.5	7	3									
	RCA	WV-510A	dc	Zin	0.5	1.5	8	3	0.5	1.5	7	3	0.2Ω	1000	7	gjm	128
			ac	21MΩ	1.5	1.5	7	3									
	Simpson	311	dc	Zin 22M	1.5	1.5	7	3	n/a	n/a	n/a	n/a	0.0002	1000	7	jp	91
			ac	Zin 2.2M	1.5	1.5	7	5									
	Millivac	MV-852A	dc	Zin 10-100MΩ	10μV	1	17	1	10pA	0.01	19	2	n/a	n/a	n/a	f	625
	Millivac	MV-952A	dc	Zin 10-100MΩ	10μV	1	17	1	10pA	0.01	19	2	n/a	n/a	n/a	gh	695
	Millivac	MV-07C	dc	Zin 1-200MΩ	10μV	1	17	1	10pA	0.001	17	2	n/a	n/a	n/a	f	575
	Millivac	MV-964A	dc	Zin 10-200MΩ	0.0001	1	15	1	0.0001	1	15	2	0.0001	5000	9	gh	525
M T	Millivac	MV-864A	dc	Zin 10-200MΩ	0.0001	1	15	1	0.0001	1	15	2	0.0001	5000	9	fg	445
8	Millivac	MV-77B	dc	Zin 10-200MΩ	0.001	1	13	1	0.001	1	13	2	0.001	5000	16	g	475
	Keithley	602	dc	10^{14}	0.001	0.01	9	1	10^{-11}	0.3	28	2	0.1	10^{7}	23	e	695
	Keithley	600B	dc	10^{14}	0.01	0.01	7	2	10^{-10}	0.3	26	3	1	10^{7}	21	e	445
	Keithley	610C	dc	10^{14}	0.001	0.1	11	1	10^{-11}	0.3	28	3	0.1	10^{8}	3	e	615

a. Overload protection.
b. Center zero.
c. Special probes available for automotive application.
d. Pushbutton switching.
e. Sensitivity: This is the specified input resistance over all voltage ranges.
f. Requires 105-125V ac, 60 Hz.
g. Solid state.
h. Battery or line power.
i. Measures peak to peak values.
j. Battery operated
k. Overload protection.
m. Input resistance, dc, 500kΩ; ac, 150 kΩ.
n. Also differential voltmeter.
p. Also measures p-p.
q. Illuminated scales for use as a continuity checker.
r. Model 256, 257 accuracy 2.5% and 5% respectively on 5000 V range. Can measure capacitance and ac resistance with use of external ac voltage from 100-240V, 60 Hz.
s. Dual sensitivity, 1.5% accuracy to 1500V, 2.5% accuracy 3000-6000V.
t. Also measures temperature 100-1050°F.
u. Full scale voltage accuracy at 5000V dc 2.25%, ac, 3%.
w. Full scale voltage accuracy at 5000V dc, 2.5%, ac, 4%.
x. 0.6-300V at 200 kΩ/V sensitivity, 5 ranges. 0-1200V at 125 kΩ/V, 0-600V at 250 kΩ/V, dc; AC, 3-1200, 5 ranges 10 kΩ/V.

Name	Model	Code
AUL	DM-1000	MT6
AUL, Inc.	TVM4	MT5
	TVOM3	MT6
	TVOM4	MT5
AVO	8MkIII	MT2
Avo, Gencom Div.	9MkII	MT2
	12	MT1
	20	MT1
	EA113	MT5
Connolly	Super 55 MkII	MT2
Connolly & Co. Inc.		
Heath	IM-16	MT6
Heath Co.	IM-17	MT6
	IM-18	MT7
	IM-25	MT6
	MM-1	MT3
Inst Labs	102	MT1
Instrument Labs Corp.		
Keithley	600B	MT8
Keithley Instrument Corp.	602	MT8
	610C	MT8
Millivac	MV-07C	MT8
Milivac Instrument Inc.	MV-77B	MT8
	MV-852A	MT7
	MV-864A	MT8
	MV-952A	MT7
	MV-964A	MT8
RCA	WV-38A	MT3
RCA, Electronic Components & Devices	WV-98C	MT7
	WV-500B	MT7
	WV-510A	MT7
R-S	URI	MT5
Rohde & Schwarz	URU	MT5
SEP	30061	MT4
Scientific Educational Products Corp.		
Sigma	VOM-22	MT2
Sigma Instruments, International Instruments Div.		
Simpson	160	MT1
Simpson Electric Co.	208	MT1
	209	MT1
	250	MT1
	255	MT1
	256	MT4
	257	MT5
	260-5	MT3
	261	MT3
	262	MT2
	263	MT2
	269	MT5
	270	MT3
	303	MT6
	311	MT7
	312	MT7
Triplett	310	MT2
Triplett Electrical Instruments Co.	310-C	MT1
	310-FET	MT6
	600	MT7
	601	MT6
	630	MT4
	630-A	MT4
	630-APL	MT3
	630-APLK	MT3
	630-L	MT3
	630-M	MT5
	630-NA	MT2
	630-NS	MT5
	630-PL	MT3
	630-PLK	MT3
	631	MT2
	666R	MT1
	800	MT2
	850	MT6
Yokagawa	3201	MT5
Yokagawa Electric Works Inc.		



When you can't afford a "wrong number"...

Symbolic representation of the TV, voice, ranging data and biomedical telemetry signals from the moon. Photograph courtesy of NASA.

bring ERIE in early.

Where are they? How are they? What do they see... and say? NASA and the world want to know. And, the only way to find out is over the special Motorola S-band equipment on both the Command and Lunar Modules. Once the Apollo Astronauts are over 30,000 miles out, it's their *only* communications link with Earth. It simply can't fail. That's why Motorola called on ERIE TECHNOLOGICAL to develop the EMI filters and Monobloc capacitors that would help this equipment perform flawlessly on every Apollo mission since Motorola has been involved. Proof, once again, that it pays to bring ERIE in early.

INFORMATION RETRIEVAL NUMBER 44

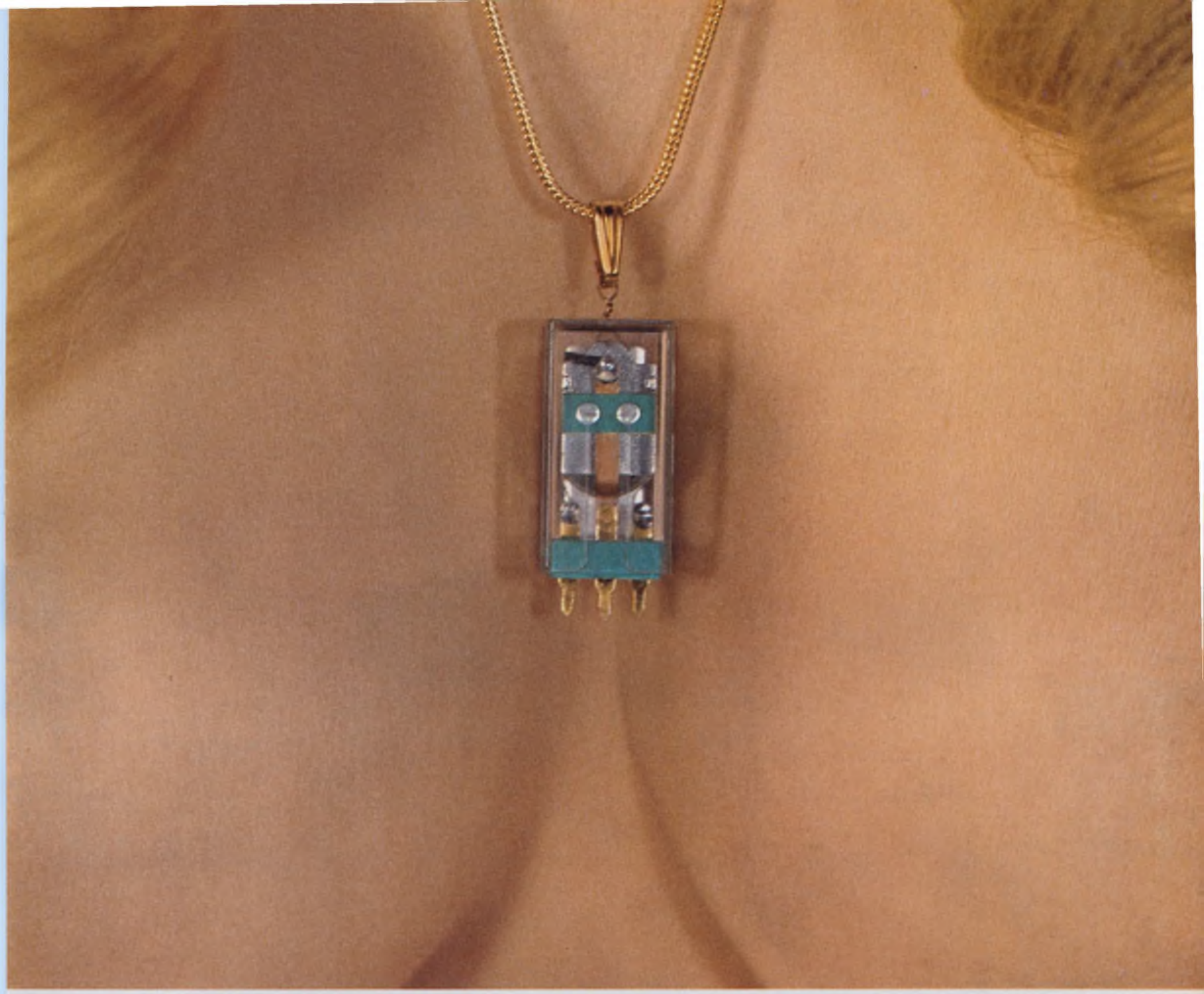
ERIE TECHNOLOGICAL PRODUCTS, INC.
644 West 12th Street, Erie, Pennsylvania 16512
(814) 456-8592

Electronic Design presents the 'top-ten' winners

The following pages display the 10 outstanding advertisements that appeared in our Jan. 4 issue, which featured the "Top Ten" contest. The contest attracted thousands of readers who attempted to match their ratings of the 10 most memorable advertisements with the "recall-seen" scores from ELECTRONIC DESIGN's regular Reader-Recall survey.

The winning advertisements combine attractive colors, tasteful design and well-written copy. The result: impact. The winners, in order of highest Reader-Recall score, are as follows:

1. **Comar Electric Co.**
2. **Sylvania General Telephone & Electronics**
3. **Monsanto**
4. **Magnecraft Electric Co.**
5. **Erie Technical Products, Inc.**
6. **Corning Glass Works, Electronic Products Division**
7. **Burroughs Corp.**
8. **Kurz-Kasch, Inc.**
9. **Centralab Electronics Div., Globe Union, Inc.**
10. **Potter & Brumfield Div. of American Machine and Foundry**



One-track mind.

Only need one make-and-break?
Now that's all you have to buy:
this new one-pole relay by Comar.
Gives you the exact number
of poles needed.

If you only need one or two
functions performed,
specify the single-pole relay.

Need two makes-and-breaks?
Specify the two-pole relay.
Same for the three-pole relay.

They're all the same compact size:
$1\frac{1}{4}''$ x $\frac{5}{8}''$ x $\frac{59}{64}''$.
They're compatible with one another
so that two three-pole relays
placed side by side, for example,
will give you six poles . . .
in less space than you needed
before for two 4-pole relays.

Less expensive than the 4-pole
relay too. Better balanced.
Yet built with the same exacting
quality that Comar builds
in all their relays.

If you've designed a circuit
that has but one function in mind,
try our one-track mind.
The CR-2 single-pole relay.

Complete with dust cover.
Socket available.

Contact Rating: 4 amps at 120 volts A.C. resistive and 4 amps at 30 volts D.C. resistive.
Coil Voltage Range: Up to 115 volt D.C.

COMAR
ELECTRIC COMPANY

3349 Addison Street/Chicago, Ill. 60618
Phone: (312) JU 8-2410

Send me one free!
☐ Single-Pole ☐ Double-Pole ☐ Three-Pole
Available to qualifying purchasing agents and engineers. Please fill in completely.

Name

Title/Function

Company Phone

Address

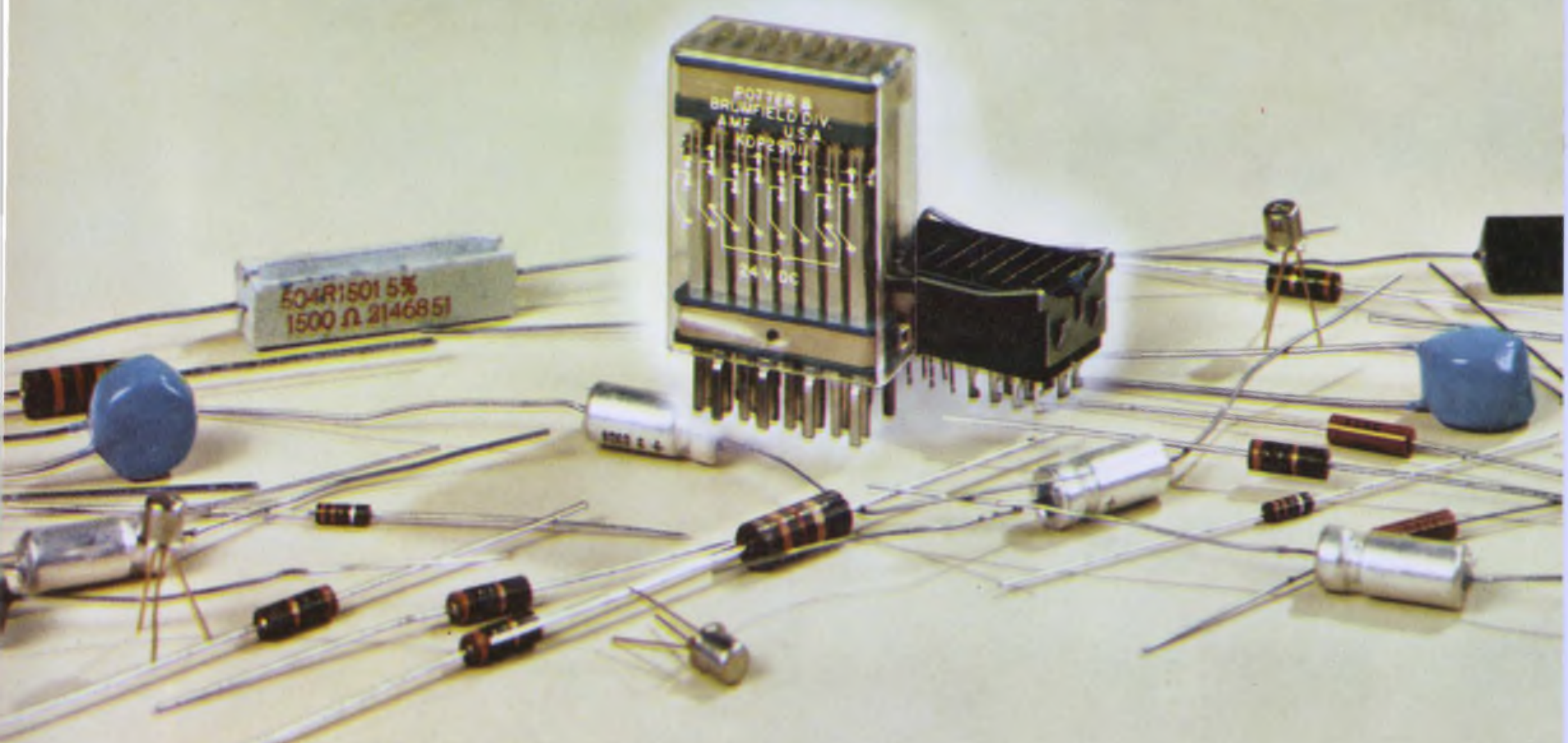
City State Zip

Your Product Line

New! Comar CR-2 Relays • Single-Pole • Double-Pole • Three-Pole

INFORMATION RETRIEVAL NUMBER 47

Try to do this with semiconductors



Where else can you get 8 Form C switching in a package that measures just over a cubic inch and costs less than 50¢ per pole?* You can't with semiconductors. You'd wind up with a much larger, more expensive array.

Speaking of cost, the KDP has a single lot price of $9.35. The list price, by the way, is less than two of our most popular 4-pole relays.

The compact KDP is ideal for logic circuits where a single input will give you a fan-out of eight. Open-minded engineers will find that a strong case for this relay over solid state switching. Remember, too, you get electrical isolation on both the input and switching sides.

Bifurcated contacts are rated at 1 ampere at 30V DC or 120V AC, resistive. Standard relays have an 8 Form C contact arrangement. Combinations of Form C and Form D (make-before-break) are available on special order. Coil voltages range from 6 to 48V DC.

Order prototype models today from your local P&B representatives or call us direct. Potter & Brumfield Division of American Machine & Foundry Company, Princeton, Indiana 47570. 812-385-5251.

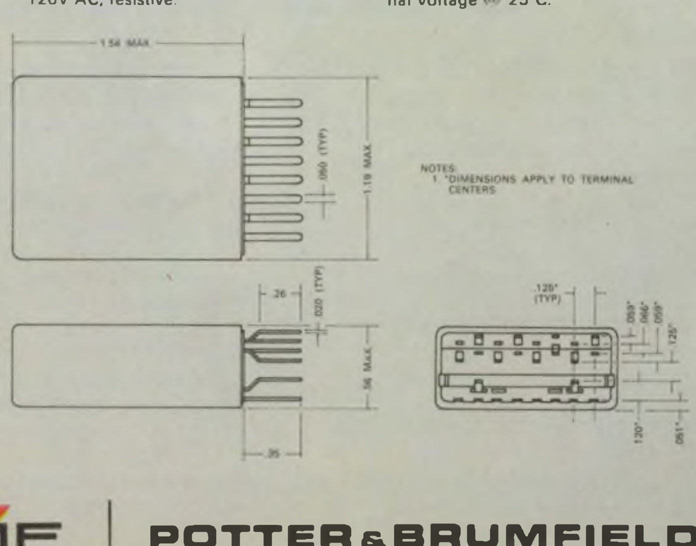
*Maximum discount

KDP SPECIFICATIONS

General
Temperature range −45° to +70°C.

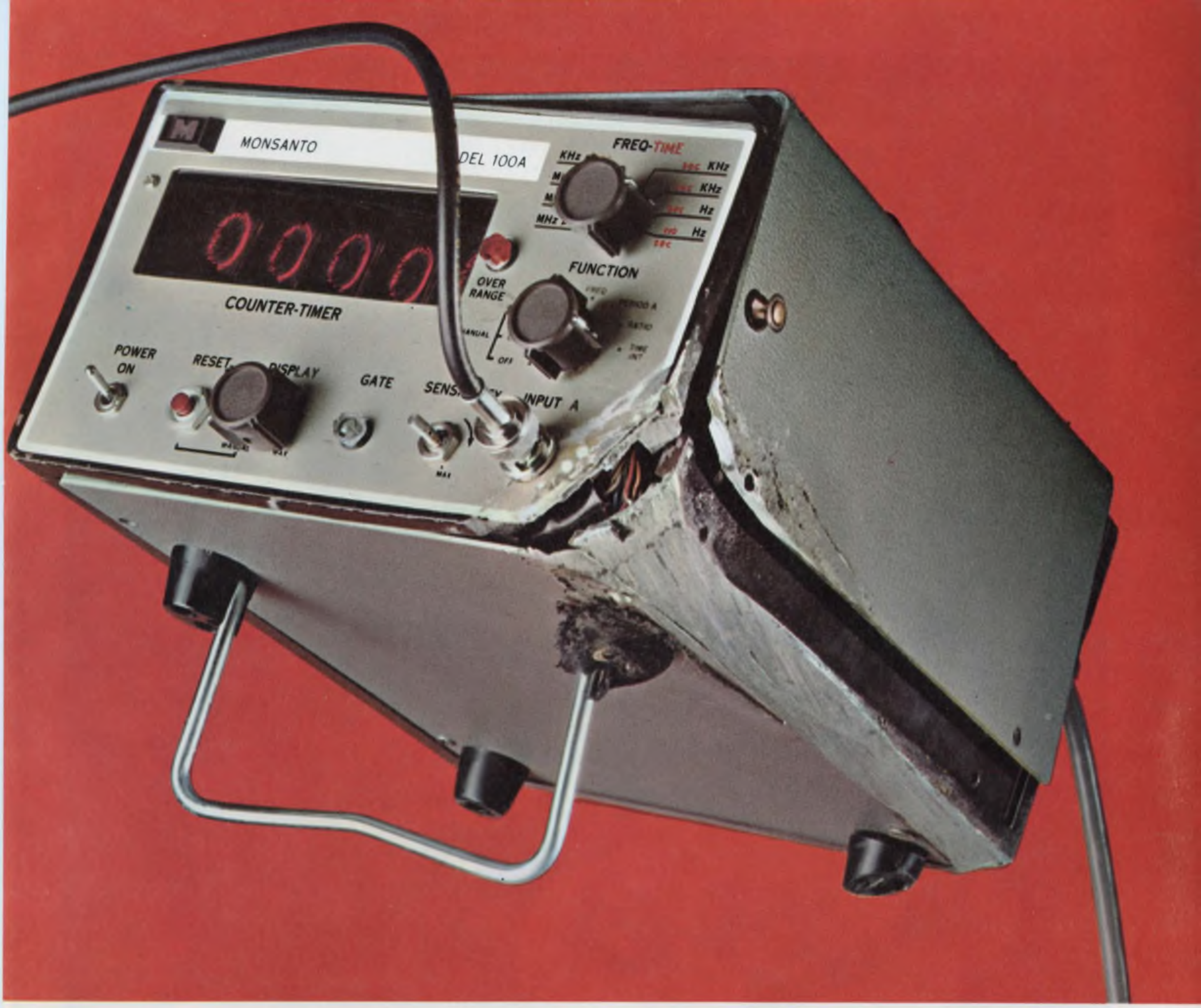
Contacts
Arrangements: 8 Form C (8PDT).
Rating: 1 amp at 30V DC or 120V AC, resistive.

Coils
Voltages: To 48V DC
Duty: Continuous
Pick-up @ 25°C: DC, 75% of nominal voltage.
Operate Time: 15 ms maximum at nominal voltage @ 25°C.



AMF | POTTER & BRUMFIELD

INFORMATION RETRIEVAL NUMBER 48



This counter fell off a plane. It didn't need service (but when one does, we're ready).

This Model 100A Counter-Timer was enroute to a customer. A freight handler laid it on the wing of the airplane—and forgot it. The package finally slid off as the wheels left the runway. Instantly freed of its container, the "Small Wonder," as our customers sometimes call it, chased the plane for about a hundred yards, then ground-looped.

Our nearby Service Center, bored with inaction, brightened at the thought of a real challenge when it was brought in. But they were disappointed: electrically, the "Small Wonder" picked up right where it left off in Final Inspection. (Of course, *mechanically* there were a few abrasions to take care of, as you can see.)

Please help us keep our 37 Service Centers with their factory-trained technicians alive and well. Call the one nearest you anytime you feel that a Monsanto instrument requires service or calibration . . . or even verification of its performance. In addition to their expertise and factory specified test equipment, all carry a complete stock of spare parts. If there should be a defect in materials or workmanship during the 2-year warranty period, it won't cost you anything.

Monsanto Company, Electronic Instruments, West Caldwell, New Jersey 07006.

INFORMATION RETRIEVAL NUMBER 49

Monsanto

EEM FILE SYSTEM • SEC. 4500

MOST DIVERSIFIED LINE OF 512 STOCK RELAYS FOR CUSTOM APPLICATIONS

general purpose • telephone type • dry reed • mercury-wetted contact • industrial power • plug-in coaxial • hermetically sealed • time delay • solid state • printed circuit • latching • high voltage

Magnecraft®

STOCK RELAYS

CATALOG NO. 271

Specifying relays? You need our new catalog of 512 stock relays for immediate delivery. Send for it!

MAGNECRAFT ELECTRIC CO. • 5575 N. LYNCH AVE. • CHICAGO, ILL. 60630 • 312 282-5500 • TWX 910-221-5221

MAGNECRAFT'S CATALOG INSERT WAS ONE OF THE TOP TEN WINNERS!

1945-1970

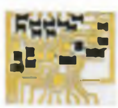
A quarter century of technology on your side

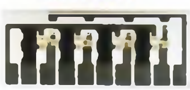
First use of Centralab's thick film microcircuit

Centralab pioneered thick film microcircuitry in 1945 when we developed a miniature oscillator-amplifier circuit for a mortar shell proximity fuse. This first-of-a-kind unit, admittedly crude by today's standards, consolidated carbon composition resistors, silver-ceramic capacitors and silver circuit paths screened onto a ceramic substrate, which met tough shock requirements. The completely sealed unit was about 3 inches in diameter and 4 inches long.

100,000,000th microcircuit

This assembly, which became known as a Packaged Electronic Circuit (PEC), opened the door to an entirely new technology. By 1959, we had produced our 100,000,000th unit. A plaque commemorating this historic production is on permanent display at the Smithsonian Institute, a milestone in the electronic industry.





Centralab's new thick film chip hybrid

PECs are still being used extensively for industrial, military and consumer applications. But continued technological developments have brought a new degree of sophistication to the art of thick film microcircuitry. So we've developed our new thick film chip hybrid microcircuits. Chip active devices — diodes, transistors, and ICs — are combined with fired on resistors, wiring and capacitors to provide a reliable circuit module. These are smaller, harder working, more sophisticated devices that are custom designed for specific applications.

We're uniquely qualified to provide thick films because our 25 years of experience have given us an intimate knowledge of materials, technology, design, production and service. Following, in more specific terms, is what we mean:

Materials to service: The Centralab capability

Basic to the ultimate performance of thick film chip hybrid microcircuits is the evaluation, selection and development of materials that will withstand sophisticated manufacturing processes as well as demanding applications. The Centralab Material Sciences Group of specialized technical personnel determines what materials will best support the special requirements of our design and production facilities.

Materials developed specifically by Centralab

One example of the work of this group is the ceramic substrate used in our thick film circuits. To meet design parameters for maximum thermal conductivity and mechanical strength, as specified by our engineers, an exclusive thin sheet ceramic production process was developed that produces substrates of unexcelled surface finish and reliability. These are so superior to others available, that Centralab is a leading supplier to other microcircuit manufacturers. Our ceramic capability has also provided high performance hermetic packages.

Centralab substrates and packages

Another joint effort of our materials and engineering development personnel resulted in a monolithic chip capacitor (Mono-Kap) that has virtually eliminated pin holes that destroy capacitor reliability and long life.

Micrographs of Mono-Kaps and competitive units

Mono-Kap — Competitor A — Competitor B — Competitor C

We've also produced molybdenum/gold substrates with amazingly complex pattern geometry. These substrates, and our proprietary process (patent applied for) for producing them, permit thicker gold deposits and are ideally suited to ultrasonic and thermocompression bonding methods.

Molybdenum/gold substrates

Our computer-aided design and circuit analysis services can provide optimum design to minimize failures, enhance performance, and reduce cost. Our comprehensive thick film background gives us another head start in being able to program our computer so that improved design is assured at the most reasonable cost.

All of our experience and technological skills are reflected in the design and production of Navy Standard Hardware Modules. These plug-in modules combine circuit functions to constitute a complete electronic system that is reliable, flexible and economical.

Navy Standard Module

One more thing. With all our capabilities, we realize that speed is often the most important criteria for judging a thick film microcircuit manufacturer. That's why we are geared to provide production samples to your specifications in as little as three weeks; production quantities eight weeks after prototype approval.

It all adds up to one fact: No other manufacturer is better qualified to help you find the most efficient use of thick film chip hybrids in your circuit design. And if you'd like to find out precisely how we can help you, send your requirements or circuit design to Centralab Application Engineering. There's no better way to get into the thick of it.

CENTRALAB

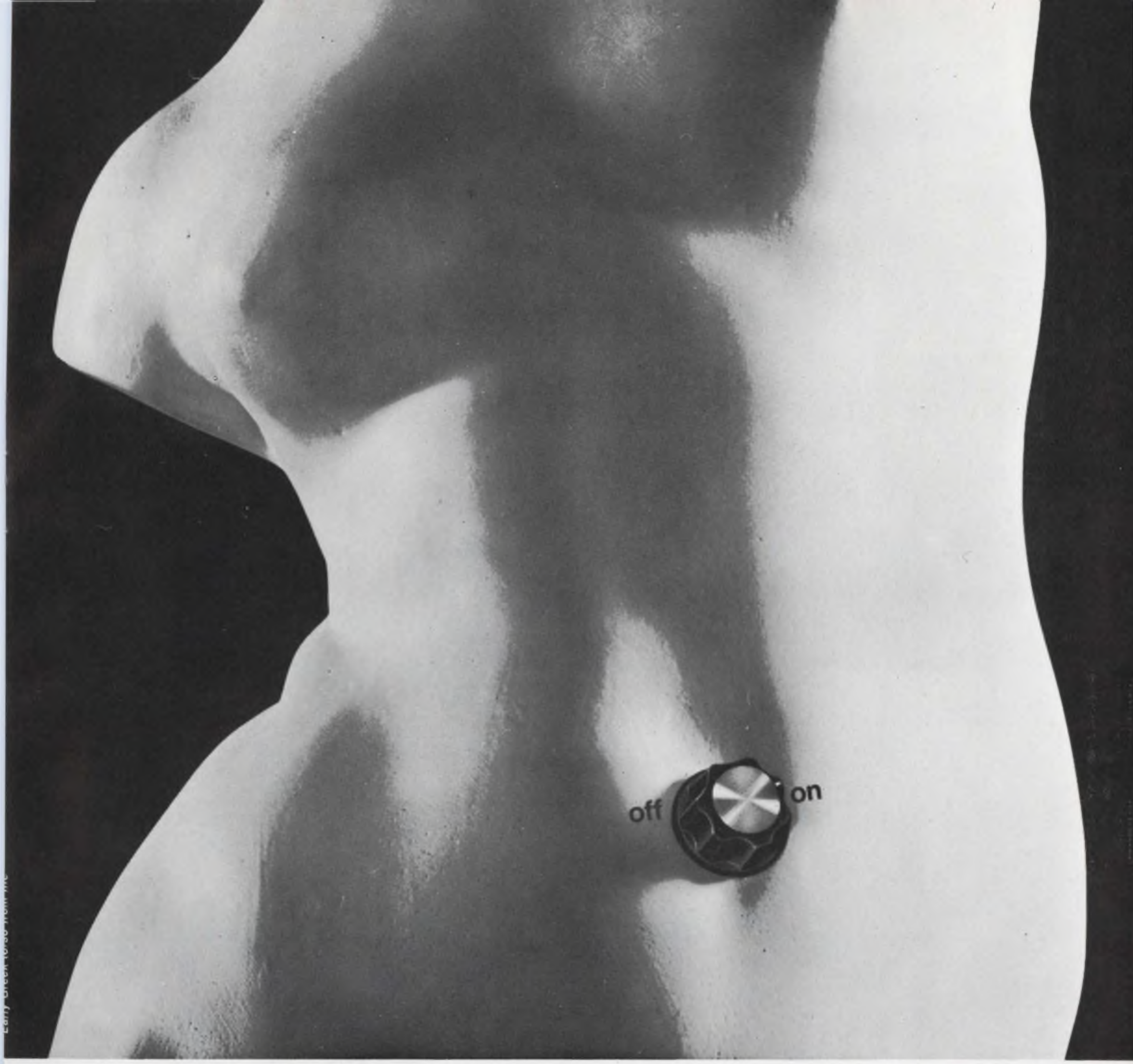
Electronics Division

GLOBE-UNION INC.

5757 NORTH GREEN BAY AVENUE

MILWAUKEE, WISCONSIN 53201

Printed in U.S.A.



Kurz-Kasch instrument knobs turn the action on!

A knob is to start something. Or stop it. Or make it faster or or slower. Or more or less.

But a well designed knob on a well designed piece of equipment (electronic or otherwise) does more than this. It not only turns the equipment on—it turns the user on!

After all, the knobs are what an equipment user (and buyer) sees first, last, and most often. If they don't do more for him than turn the equipment on, the whole design leaves him cold.

Kurz-Kasch knob designers know this. They've put together a line of 347 instrument knobs in a variety of sizes, colors and thermosetting plastic materials. Each one is calculated to turn the action on—with *your* equipment, *your* users, *your* buyers.

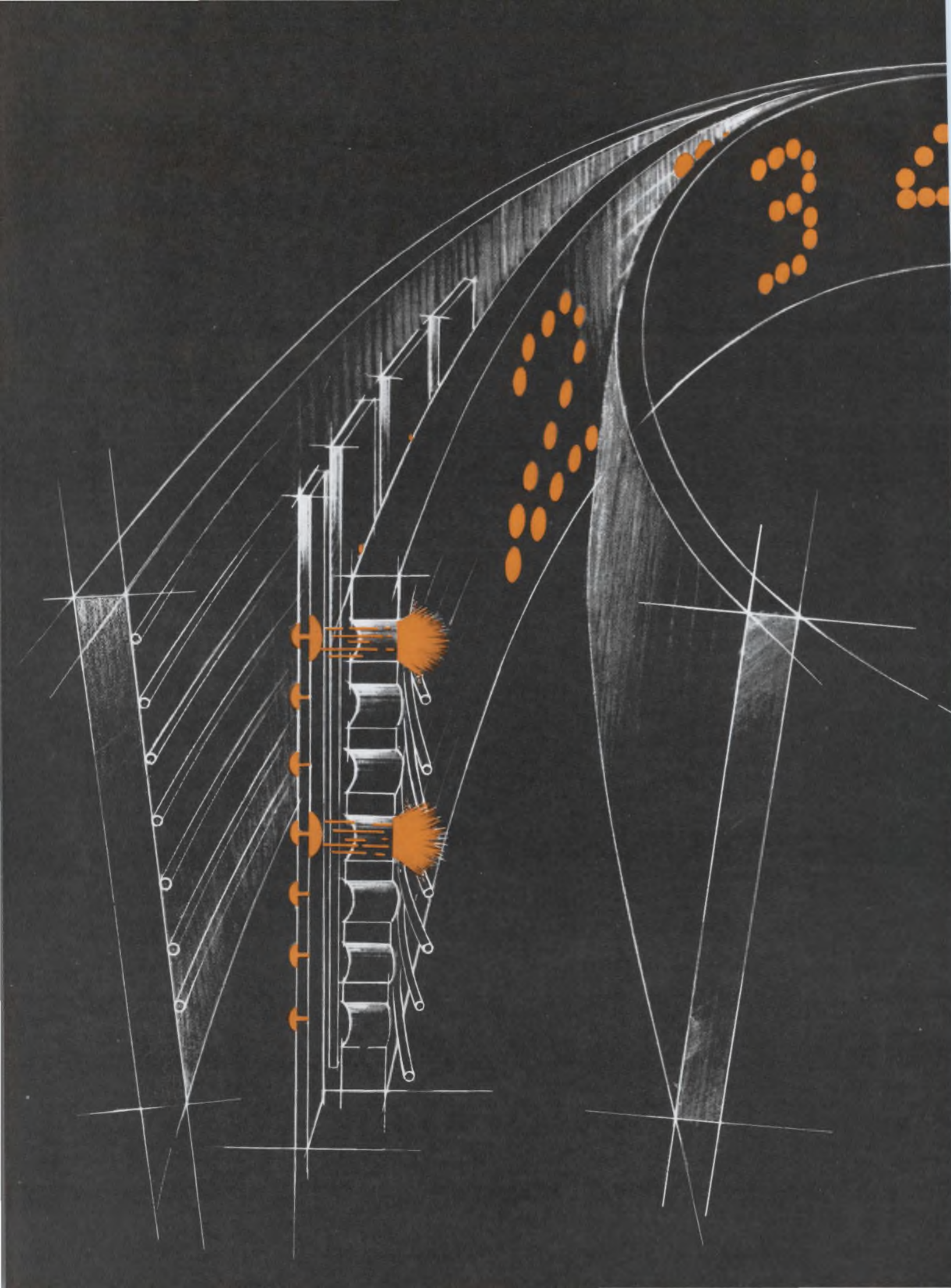
You can join 4,000 action oriented original equipment manufacturers who already turn on with KK Knobs. Write today for free Kurz-Kasch Designer Catalog.

Write for new catalog and free knob samples.

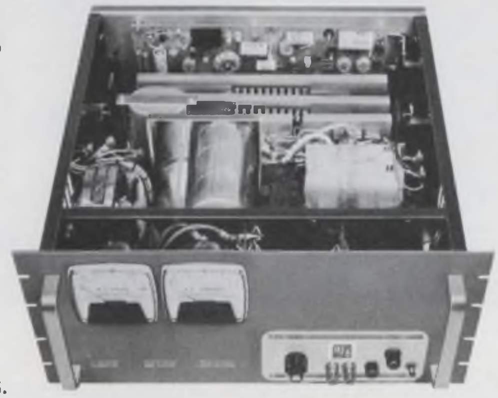
Kurz-Kasch, Inc.

Standard Parts Division • Dayton, Ohio 45401

INFORMATION RETRIEVAL NUMBER 52



Frequency converters
50-60 cps to 400 cps



TFC Line
FC Line

DESIGN CONCEPT: Completely solid state, Silicon power rectifiers, silicon zener diode reference, germanium control and power transistors.

Model No.	OUTPUT: AC Volts	OUTPUT: * Volt. Amps	OUTPUT: △ Freq.	400 CPS OUTPUT CHARACTERISTICS: Distortion	400 CPS OUTPUT CHARACTERISTICS: Ampli-Mod.	Static Regulation: Load	Static Regulation: Line	Static Regulation: Freq.	TRANSIENT RESPONSE: Recovery NL-FL	TRANSIENT RESPONSE: Recovery FL-NL	TRANSIENT RESPONSE: Over Shoot	TRANSIENT RESPONSE: ±10% Line	INPUT POWER: Volts Single Phase	INPUT POWER: △ Freq.	INPUT POWER: Max. Amps.	DIMENSIONS: H x W x D	App. Ship. Wgt.	Price
TFC-26-100	24-30	0-100	380-420	5%	3%	±1%	±½%	±½%	30MS	10MS	5 volts	2%	105-125**	50-60	3.5	4½" x 8" x 14⅜"	30	$ 420.
TFC-26-200	24-30	0-200	380-420	5%	3%	±1%	±½%	±½%	30MS	10MS	5 volts	2%	105-125**	50-60	7	5¼" x 19" x 16⅝"	60	640.
TFC-115-100	105-130	0-100	380-420	5%	3%	±1%	±½%	±½%	30MS	10MS	15 volts	2%	105-125**	50-60	3.5	4½" x 8" x 14⅜"	30	410.
TFC-115-200	105-130	0-200	380-420	5%	3%	±1%	±½%	±½%	30MS	10MS	15 volts	2%	105-125**	50-60	7	5¼" x 19" x 16⅝"	60	630.
FC-26-500	24-30	0-500	380-420	5%	3%	±1%	±½%	±¼%	100MS	30MS	5 volts	2%	105-125**	50-60	15	8¾" x 19" x 16⅝"	150	1180.
FC-115-500	95-135	0-500	380-420	5%	3%	±1%	±½%	±¼%	100MS	30MS	15 volts	2%	105-125**	50-60	15	8¾" x 19" x 16⅝"	150	1120.
FC-115-1000	95-135	0-1000	380-420	5%	3%	±1%	±½%	±¼%	100MS	30MS	15 volts	2%	188-228†	50-60	17	17½" x 19" x 16⅝"	300	1920.

* All output ratings are given for unity power factor loads. Ratings may be increased linearly to 125% for FC models and to 140% for TFC models at zero lagging power factor loads.

△ CONTACT NJE SALES DEPT. FOR OTHER INPUT AND OUTPUT FREQUENCY REQUIREMENTS.

** Available with 210-250 Volts input at half input current shown in chart above (no extra charge). When ordering specify model number followed by (-230) suffix, i.e. TFC-26-200-230.

† Available with 198-242 Volts input at 15 amps input current at no extra charge. When ordering specify FC-115-1000-220.

VOLTAGE STABILITY: After a ½ hour warm up with constant load and constant ambient temperature, the voltage will not drift more than 0.1% for an 8 hour period.

VOLTAGE TEMPERATURE COEFFICIENT: After a ½ hour warm up with constant load the average temperature coefficient will not exceed 0.1%/°C.

FREQ. STABILITY: After a ½ hour warm up with constant load, and constant ambient temperature, the frequency will not drift more than 0.2% for an 8 hour period.

FREQUENCY TEMPERATURE COEFFICIENT: After a ½ hour warm up with constant load, the average temperature coefficient will not exceed 0.05%/°C.

METERS: Ammeter and voltmeter furnished. Meters are accurate to 3% of full scale rating.

POLARITY: All supplies can be floated up to 500V peak off ground. Either line may be grounded to the chassis ground terminal provided.

DUTY: Continuous at unity power factor at ambient temperatures from 0° to 45°C for FC models and 0° to 40°C for TFC models (35°C at 50 cps input). FC models may be operated above 45°C provided that the output current is derated linearly to zero at 60°C. Consult factory for derating characteristic on TFC models.

REMOTE SENSING: The FC Supplies are provided with circuitry to sense and regulate the voltage at the load rather than at the output terminals, eliminating the otherwise unavoidable load regulation due to the resistance of the wire connecting the supply to the load.

REMOTE PROGRAMMING: The output voltage and/or frequency may be accurately controlled from a remote point, if desired, by inserting a resistance across "Remote Program" terminals provided on rear.

OUTPUT ADJUSTMENT: Output Voltage and Frequency adjustments are accomplished by a dual potentiometer on front panel.

EXTERNAL SYNCHRONIZATION: All models may be synchronized to an external standard by the use of terminals on rear of chassis.

TERMINATION: A barrier type terminal strip is provided at the rear of the unit for all input, output, sensing, remote programming and external synchronization connections. Output is also available on the front panel through binding posts.

PROTECTION: During overloads or short circuit the load is electronically disconnected on FC models and electronically limited on TFC models. If the overload persists on TFC models, the load is disconnected from the supply by a fuse. Internal components are protected by an automatic resetting thermal switch.

MOUNTING: All Models supplied with full dust cover. All Models except the two 100VA units are supplied as 19" rack equipment: The 100VA units are supplied for laboratory bench use. Rack mounting is obtainable by means of the following rack adapter panels.

- RP1 — 5¼" high. 19" wide, with cutout for one unit.
- RP1A — Same as RP1 except cutout is offset to leave half of panel blank.
- RP2 — 5¼" high. 19" wide, with cutouts for two units.

FINISH: Front Panel finished in dark grey enamel equivalent to FED STD 595 Chip No. 26132. Marking is white. All other finishes are appropriate paint, plating or chemical film as required.

INSPECTION: MIL-I-45208A.

OPTIONAL FEATURES:

The following optional features are available on any given unit. Consult Field Representative for option prices not provided on price page.

MULTIPHASE OPERATION: Single phase models can be combined to produce a three phase 4 wire or two phase 4 wire output, by using the multiphase adapters which have a maximum phase shift of 2.5° per phase and maximum line to line output distortion of 3%. When operating in the multiphase mode the single phase regulation and VA specifications become the line to neutral specifications.

TUNING FORK: For frequency stability up to 0.005%. Can be mounted within units on all models except 100 VA units.

Bench Adapter: Available for all 19" rack models up through 8¾" panel sizes. Add suffix (-B) to model number.

Power Cord: All models available with power cord. Add suffix (-P) to model number.

427

NJE CORPORATION
A Subsidiary of CONDEC Corporation

20 BORIGHT AVENUE, KENILWORTH, N. J. 07033
Phone: (201) 272-6000 / Telefax: FFP / TWX: (710) 996-5967

INFORMATION RETRIEVAL NUMBER 54

TTL quad flip-flop with three logic states eliminates need for OR gates on output

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. Phone: (408) 732-5000. P&A: $9.60; stock.

Actually a three-logic-state digital circuit, a new TTL flip-flop can assume one of three output conditions — low-impedance ON, low-impedance OFF, or a high-impedance state. This means that the DM8551 quad D flip-flop can be wire-OR'd (its four outputs can be joined together directly without using an OR gate).

Now designers can get an extra gate function at no extra cost since the DM8551 is cost-competitive with previous techniques and offers simplified circuitry. In addition, there is no sacrifice in gate speed or fanout. The device also has the advantage of TTL-type switching, and can drive active loads.

Normally, when a TTL circuit is in the logical 1 state, the pull-up transistor is ON and the pull-down transistor is OFF. When the circuit is in the logical O state, the pull-down transistor is ON and the pull-up transistor is OFF.

Besides the conventional low-impedance ON and low-impedance OFF logic states, the DM8551 has a third high-impedance output state in which both of the output transistors are OFF. This third state is made possible by a third output transistor that is connected to the phase-splitting internal transistor, but actually has no external connection.

In the DM551, the third transistor is placed so as to divert base current from both of the output transistors, thus turning them both OFF. Since these transistors are the only two outputs, the outside world sees a high impedance.

The third transistor will normally be ON. Stored data will not appear at the output unless it is specifically addressed with the output enable lines.

The logical structure of the DM-8551 is shown in the figure. The output enable lines lead into a NOR gate, so that there will be a pulse to enable the output only when both inputs are at O. In effect, there is a single-pole single-throw switch between the output transistors and the output pads.

Fully compatible with the rest of National Semiconductor's series 54/74 circuits, the new quad flip-flop lets the user run many subsystems with a minimum number of lines, inside or outside of a computer. It is a 4-bit interface latch intended for use where information is being handled in word-serial and bit-parallel formats.

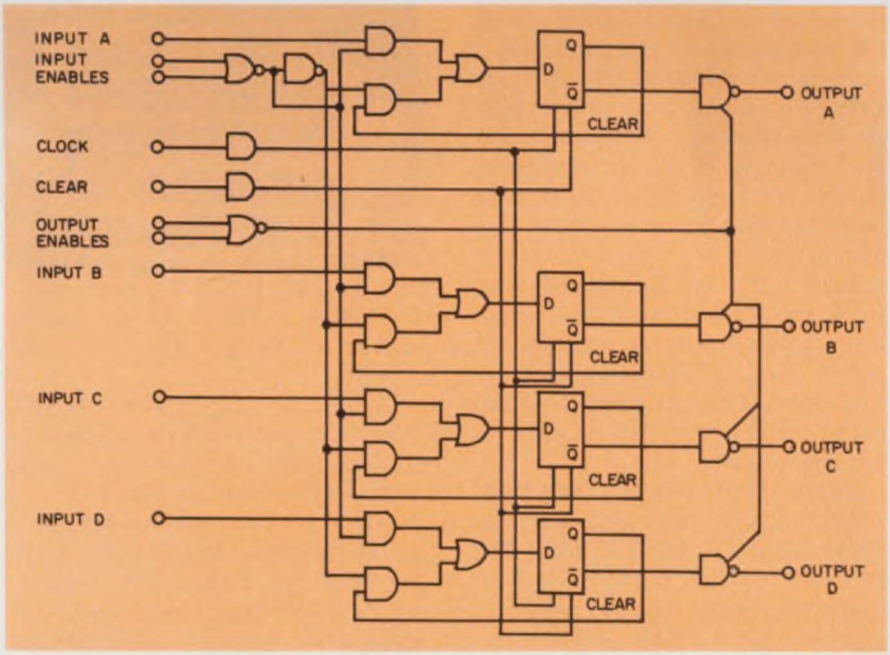
One set of input and output enable lines control all four flip-flops, and all four are clocked simultaneously. It is possible to tie together (wire-OR) as many as 40 packages and still have the full fanout of 10 on the other side of the drive line.

By including input enable circuitry, the DM8551 greatly simplifies its application. In a D flip-flop such as this one, with a single data entry line, an output will appear at Q one clock pulse after the data has been entered.

Normally, the designer must inhibit the clock to prevent the device from changing states at each clock pulse. This can unnecessarily complicate a system; and if the clock control is skewed even slightly, the circuit will switch falsely anyway.

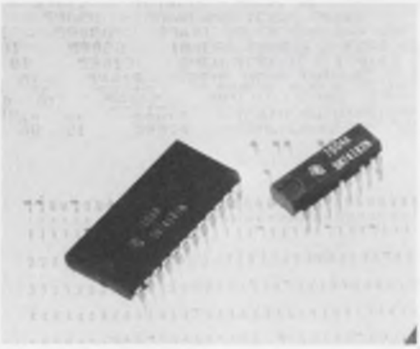
The DM8551's input enable circuitry, however, frees the designer from all concern about clock control. In a sense, the circuit will simply sample itself until the proper signals are applied to the input enable lines. When that happens, the Q feedback will be blocked from its AND gate, and only new data will enter the flip-flop.

The DM8551 quad D flip-flop has an operating temperature range of 0 to 70°C.



TTL quad D flip-flop with three logic states lets its outputs be tied together directly, without using an OR gate. A third transistor on each of its outputs makes possible a high-impedance state besides the conventional low-impedance ON state and low-impedance OFF state. **CIRCLE NO. 250**

Low-cost TTL MSI IC pair enhance arithmetic logic



Texas Instruments Inc., Components Group, 13500 N. Central Expwy, Dallas, Tex. Phone: (214) 238-3741. P&A: $16.50, $3.63; stock.

Two new low-cost TTL MSI integrated circuits producing a fast arithmetic-logic-unit / function-generator are the SN54/74181 arithmetic-logic unit and the SN54/74182 carry look-ahead generator.

The SN54/74181 unit features 75 equivalent gates on a single chip and does 16 binary arithmetic manipulations on two 4-bit words. Manipulations include adding, subtracting, decrementing and direct transfer. Typical addition/subtraction time is 24 ns.

It can also perform 16 logic functions of two Boolean variables consisting of NAND, AND, NOR, OR and Exclusive OR functions.

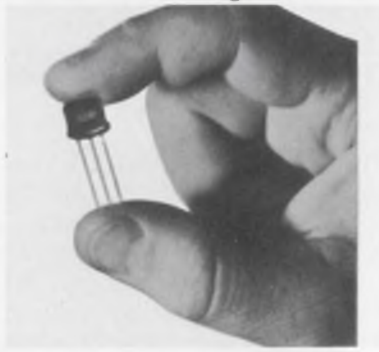
To reduce addition time, one 54/74182 look-ahead generator is needed with four 54/74181 logic units. For example, a 16-bit arithmetic section consisting of four logic units and one look-ahead unit can add in 36 ns.

Both units can be expanded up to 64-bit sections with full carry look-ahead capability and no external gating. The ladder unit incorporates a ripple carry function to minimize count when speed is not important.

Power dissipation for the SN54/74181 is 455 mW and for the SN54/74182 it is 180 mW. The former comes in a 24-pin dual-in-line plastic case, and the latter in a 16-pin dual-in-line plastic case. Both units can be supplied to operate over the temperature range of −55 to +125°C or 0 to 70°C.

CIRCLE NO. 251

Hermetic SCRs boast 70¢ tag

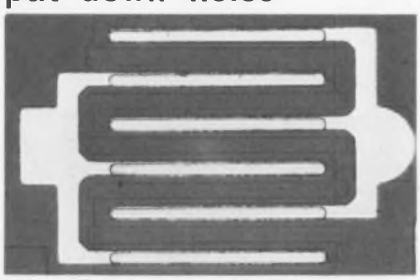


Unitrode Corp., 580 Pleasant St., Watertown, Mass. Phone: (617) 928-0404. P&A: from 70¢; stock.

With prices starting at 70¢ each for 1000-unit quantities, series ID200 hermetically sealed industrial SCRs offer voltage ratings from 50 to 200 V at a continuous forward dc current of 1.6 A and a case temperature of 70°C. The devices, which are packaged in a TO-39 metal can, have a gate trigger current of 200 μA maximum. They can replace relays and drive lamps.

CIRCLE NO. 252

Junction FETs put down noise



Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. Phone: (408) 257-5450. P&A: $2.75 to $20; stock.

A new series of low-noise field-effect transistors, types 2N4867 to 2N4869, has an equivalent input noise voltage of less than 5 nV/$Hz^{1/2}$ at 1 kHz, and 10 nV/$Hz^{1/2}$ at 10 Hz. Since excess noise at 10 Hz rises only 2 dB/octave, the new FETs contribute less than the equivalent thermal noise of the signal source from 100 Hz to 10 kHz, for generator resistances from 5 kΩ to 10 MΩ.

CIRCLE NO. 253

Silicon transistors switch 150-W pulses

Mullard, Mullard House, Torrington Pl., London, W.C.1, England.

Three new silicon planar transistors can switch 150-W pulses having durations that do not exceed 50 μs and with a duty factor of 0.1. Types BDY60, BDY61 and BDY62 also provide saturation voltages of 0.9 V maximum and a continuous power rating of 15 W. Applications include high-frequency inverters and converters, and use as pulse modulators in communications and radar systems.

CIRCLE NO. 254

Npn/pnp power pairs can carry up to 20 A

Solitron Devices, Inc., Semiconductor Div., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311. Availability: stock.

Particularly suitable for amplifier and switching applications, industrial complementary silicon power transistors cover current ratings from 1 through 20 A. These general-purpose npn/pnp power pairs include: types 2N2033 (npn) and 2N3740-41 (pnp) rated at 1 A, and types 2N3771-72 (npn) and 2N5737-44 (pnp) rated at 20 A.

CIRCLE NO. 255

Transistor chips match to 10 μA

Dionics Inc., 65 Rushmore St., Westbury, N.Y. Phone: (516) 997-7474.

A new line of npn silicon matched-pair transistor chips for hybrid circuits and differential amplifier circuits offer a close parameter match from 10 μA to 1 mA. Types 4044/4878, 4100/4879 and 4045/4880 have collectors that are isolated from each other, and from the bottom of the chip. The chips are gold-backed, permitting conventional eutectic die-bonding techniques.

CIRCLE NO. 256

Intech's trimming their sales.

It may be nautical nonsense, but our customers are helping us do just that.

Using creative technology and a firm below-the-market standard price, we've launched another flagship: the A-125. With its ultra-low bias current, it's creating quite a wake for the competition.

Advantages? A low noise, high common mode rejection, junction FET input stage with less than 0.5 pA (0.2 typ.) bias current through either input.

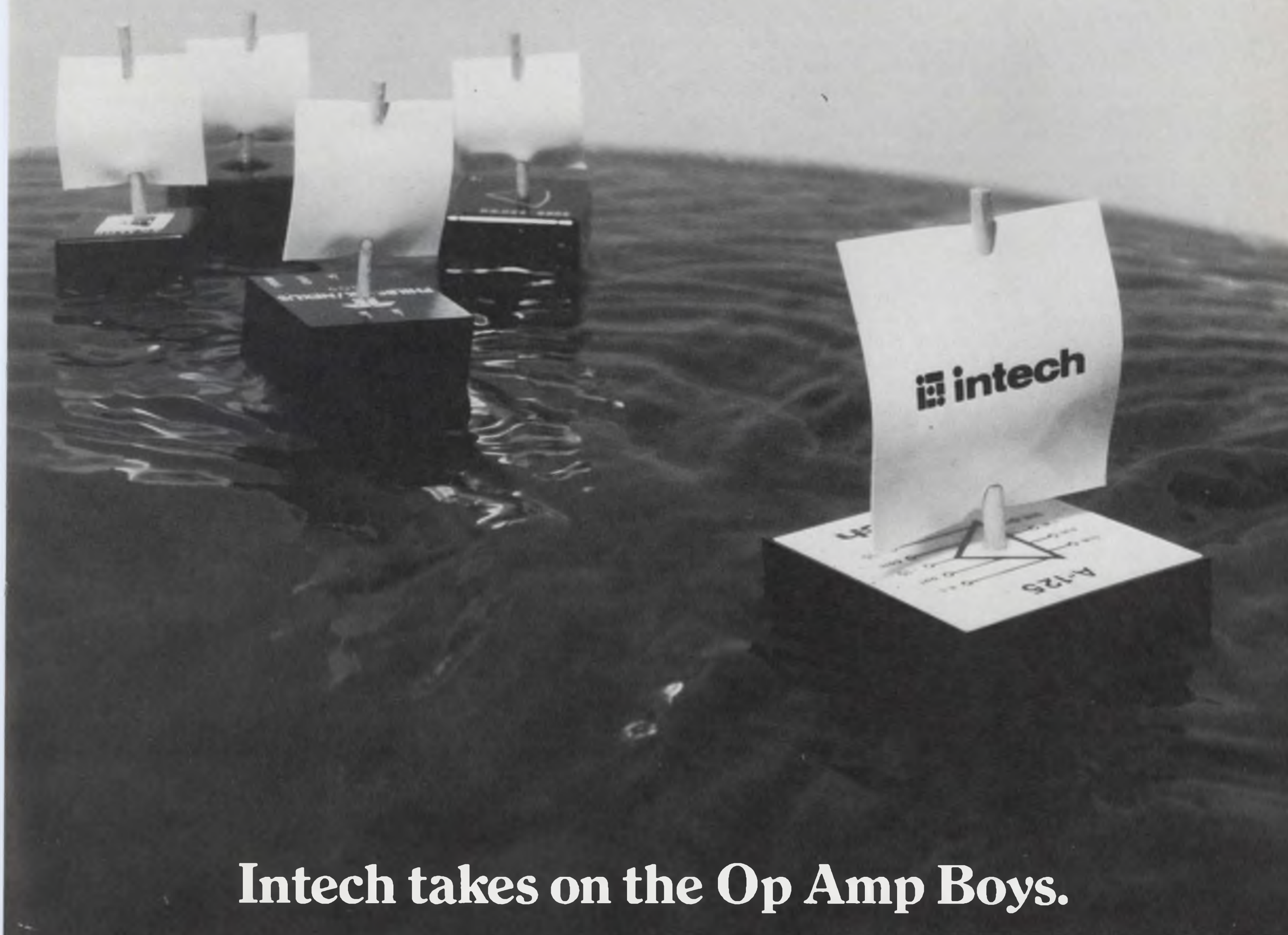
This capability-in-a-package enables the A-125 to take over where electrometer or MOS-FET amplifiers used to excel. And watch the improvement in noise, thermal stability and reliability.

Try us out, even if you think our sails are full of wind. We would like nothing better. Then you'll see why Intech's trimming the sales of the Op Amp Boys.

The A-125 is $95.00 and it is immediately available from stock. Quantity discounts available on request.

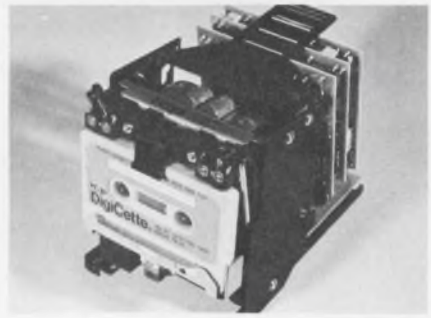
For more information on our high performance modular products, contact your local Intech representative, or write us directly.

Intech Incorporated, 1220 Coleman Avenue, Santa Clara, California 95050
Phone: (408) 244-0500
intech



Intech takes on the Op Amp Boys.

Cassette transport separates channels

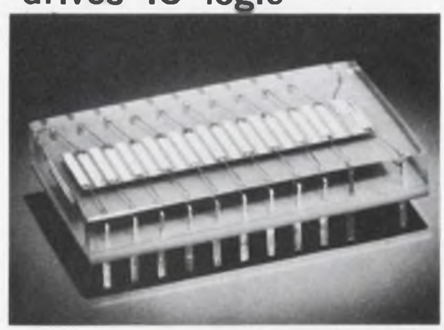


International Computer Products, Inc., P.O. Box 34484, Dallas, Tex. Phone: (214) 239-5381. Price: $300.

Intended for small computer and computer terminal applications, a new cassette tape transport has two independent bit serial data recording channels that may be operated simultaneously or independently in various modes. Digi-Deck minimizes tape wear through the use of a spindle drive. Writing speed is 7000 bits per second and reading speed is 20,000 bits per second.

CIRCLE NO. 257

Read/write memory drives IC logic



Litton Industries, Poly-Scientific Div., 1111 N. Main St., Blacksburg, Va., Phone: (703) 552-3011.

Able to be altered as desired, a new non-destructive non-volatile digital read/write memory is capable of directly driving high-impedance low-level integrated-circuit digital logic. Write time is several microseconds for write voltages of 90 to 360 V. Inquire pulses can be 10 to 90 V peak for pulse, square-wave or sine-wave functions.

CIRCLE NO. 258

CRT video terminal plugs into Teletype

Alphanumeric Data Corp., Princeton-Hightstown Rd., Cranbury, N. J. Phone: (609) 799-1559. P&A: $3500; 45 to 60 days.

Developed for time-share and small-computer users, a new data-window video terminal features 25 lines of 72 characters each, and complete plug-to-plug compatibility with the ASR-33 Teletype machine. Actually a video teletypewriter, Model DW-33 offers rapid file access, editing flexibility, and complete functional and software compatibility.

CIRCLE NO. 259

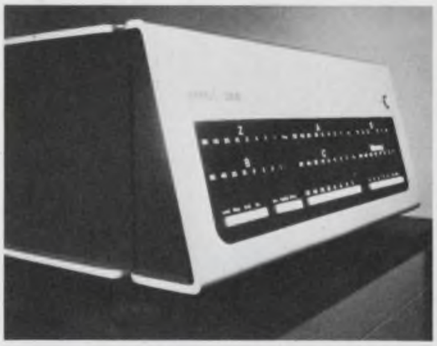
Asynchronous coupler converts Teletypes

Source Data, 664 N. Michigan Ave., Chicago, Ill. Price: $305.

The model 101 asynchronous coupler converts any Teletype model 33 into a data terminal that uses standard voice-grade lines for error-free transmission of digital data. This all-integrated-circuit unit features active filtering and a carrier-detect circuit that eliminates Teletype chatter prior to hook-up. Either full or half-duplex operation is possible. The self-contained coupler can be installed without special tools.

CIRCLE NO. 261

Low-cost minicomputer operates 16 terminals

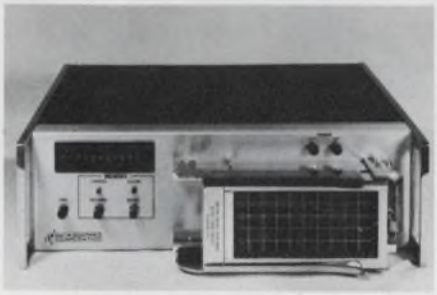


Wang Laboratories, Inc., 836 North St., Tewksbury, Mass. Phone: (617) 851-7311. Price: from $15,250.

Accommodating up to 16 terminals, the model 3300 BASIC is a low-cost minicomputer time-sharing system that includes a central processor and two teletypewriter terminals. The central processor, which is an 8-bit computer, features a 1.6-μs full-cycle memory in 4k units expandable to 65k, binary and decimal arithmetic, and a repertoire of 70 instructions.

CIRCLE NO. 263

Data transfer system stores and decodes



Data Graphics Corp., 8402 Speedway Dr., San Antonio, Tex. Phone: (512) 342-9486.

After accepting data from any digital output device, a new universal data transfer system stores the data in memory, decodes it, and then presents it to a recording device (i.e. keypunch, typewriter, magnetic tape recorder). Model DGC-300 has a 200-point program patch panel that allows data to be recorded in any sequence. Programming is done via jumper wires.

CIRCLE NO. 260

Portable calculator does not cut corners

Singer Co., Friden Div., 2350 Washington Ave., San Leandro, Calif. Phone: (415) 357-6800. P&A: $495 to $695; April, 1970.

Weighing just eight pounds and fitting easily into an attache case, a new electronic calculator incorporates all the necessary features of a fully automatic heavy-duty office machine. The 1115 performs a wide range of calculations, including chain multiplication and division functions without the need for pre-setting.

CIRCLE NO. 262

Textured tape safeguards itself

3M Co., 3M Center, St. Paul, Minn. Phone: (612) 733-5426.

Designed to safeguard itself and recorded information, Black Watch Scotchbrand 700 computer tape protects itself against physical damage—both on the transport and in transit—through an exclusive textured substrate. This substrate resists windowing and cinching, and virtually eliminates scratching. In addition, an electrically conductive backing protects against static hang-ups and reduces dropouts.

CIRCLE NO. 264

Measuring system eases interfacing

Julie Research Laboratories, Inc., 211 W. 61st St., New York, N.Y. Phone: (212) 245-2727. P&A: $19,900 complete; 120 days.

Without degrading instrumentation accuracy, the ATS-106/20 automated measuring system allows universal interfacing of programmable precision instruments, regardless of the manufacturer and available computer-oriented system hardware. This new interface data terminal enables users to take full advantage of their instrument capabilities, whether used in automated, programmable or conventional operations.

Simple cable connections are all that are necessary to interconnect a system using the ATS-106/20; no additional interface engineering is required. The new terminal can be used with any equipment employing 10-line decimal or BCD program format.

The ATS-106/20 includes a modified Teletype keyboard, an automatic paper-tape punch and reader, and special digital logic cards for interfacing the instrumentation and an external computer system. **CIRCLE NO. 265**

Five-digit panel meter counts ±39999 at $695

Electro-Numerics Corp., 2191 Ronald St., Santa Clara, Calif. Phone: (408) 248-5020. P&A: $695; 2 to 4 wks.

With a five-digit capacity, a new digital panel meter displays a count of ±39999 for under $695. The model 3412 offers a choice of three voltage ranges from ±3.9999 V to ±399.99 V full scale, and five current ranges from 39.999 μA to 399.99 mA full scale. It also has five resistance ranges from 3999.9 Ω to 39.999 MΩ. **CIRCLE NO. 266**

Digital clocks can be cascaded

Starmark Electronics, 3710 Main St., Kansas City, Mo.

Able to be cascaded in multiple units, series 200 digital stop-watches are now available in a wide range of full-scale values and resolutions. All models feature easy-to-use remote-control provisions, plus convenient front-panel controls. They come equipped with either a precision internal or external 60-Hz time base. A BCD data output and resolutions to 0.001 seconds are also standard. **CIRCLE NO. 267**

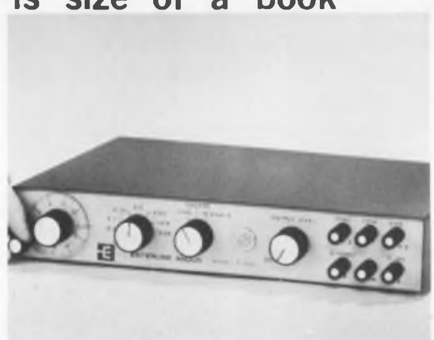
Lightweight probes checkout flatpacks

Data Display Systems, Inc., Willow Grove, Pa.

Designed specifically for testing flatpacks and dual-in-line packages, a new family of small general-purpose test probes can grip and retain their hold on individual device leads. Available in several models, the probes are lightweight to reduce the risk of damage to the test module. In addition, the strength of their connecting mechanism allows them to hold their position while the user controls the amount of force.

CIRCLE NO. 268

Function generator is size of a book



Esterline Angus Div., Esterline Corp., P.O. Box 24000, Indianapolis, Ind. Phone: (317) 244-7611. Price: $310.

Costing only $130, a new book-sized function generator supplies one of three waveforms—sine, square or triangle—over the frequency range of 0.01 Hz to 100 kHz. Model F-1000 performs with less than 1% amplitude change from 0.01 Hz to 1 kHz, and less than 4% amplitude change at 100 kHz. Output voltage level is adjustable.

CIRCLE NO. 269

DMM selling for $545 resolves 1 μV/digit

Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, Ohio. Phone: (216) 248-0400. Price: $495 or $545.

Costing only $545, a 3-1/2-digit dc multimeter features a resolution of 1 μV per digit. Model 160 can measure dc voltages to ±1000 V, currents to ±2A, and resistances to 2000 MΩ. For all ranges, the instrument has an accuracy of ±1 digit or ±1% of reading. Also available is the 163 digital voltmeter for $495.

CIRCLE NO. 270

Function generator has log/lin sweep

Wavetek, Box 651, San Diego, Calif. Phone: (714) 279-2200. P&A: $695; stock.

Sine, square and triangular waves are available in the model 135 sweep generator with linear or logarithmic sweeping. Six operating modes are available: continuous, triggered, gated, toneburst, continuous-sweep and triggered-sweep. They can be swept over a 1000:1 ratio over their full frequency range of 20 Hz to 20 kHz.

CIRCLE NO. 271

Sine wave generator dials Hz digitally

J & J Instruments, 8141 Engineer Rd., San Diego, Calif. Phone: (714) 277-2471. Price: $495 or $595.

Model 2000 digital oscillator is a 10-Hz-to-12-MHz sine wave generator that uses digital front-panel switches for frequency selection, thereby achieving good repeatability and spectral purity. The unit also has a multi-phase output that allows a 180-degree phase change in the output signal. A fully programmable model, the 2010, is also available.

CIRCLE NO. 272

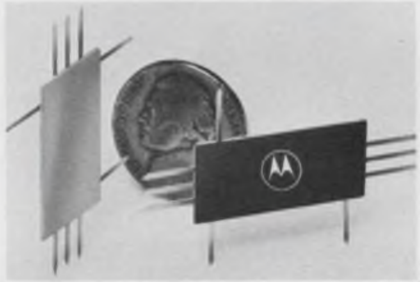
Tiny X-band source spans 8.5 to 10 GHz

Engelmann Microwave Co., Skyline Dr., Montville, N. J. Phone: (201) 334-5700. Availability: stock to 30 days.

Developed for klystron replacement applications, a miniature solid-state X-band source spans the frequency range of 8.5 to 10 GHz. It delivers a minimum of 10 mW of output power from −30 to +70°C at a stability of ±0.2%. Tuning is over ±100 MHz and output power is delivered through an OSM connector or a waveguide flange.

CIRCLE NO. 273

Solid-state duplexer handles 40-W inputs

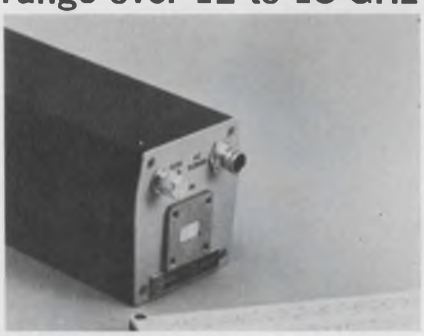


Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Ariz. Phone: (602) 273-6900. Price: $13.50.

Operating at frequencies between 400 and 500 MHz, a new microwave solid-state duplexer accepts input powers as high as 40 W. Model MCH-5890 features a typical 0.1-dB transmit-mode insertion loss and a typical 25-dB transmit-mode isolation figure. This spdt device was primarily developed for use as a transmit/receive switch.

CIRCLE NO. 275

Low-noise TWT amplifier range over 12 to 18 GHz



Varian, TWT div., 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000. Availability: 30 to 60 days.

Incorporating a single-reversal-permanent-magnet focusing structure, two new low-noise TWT Ku-band amplifiers span the range of 12 to 18 GHz. The VTU-4490P1 and VTU-4490H1 devices offer noise figures of 8.5 and 10 dB and output powers of +14 and +15 dBm, respectively. They have integral power supplies and produce low external magnetic fields of 30 to 50 gauss.

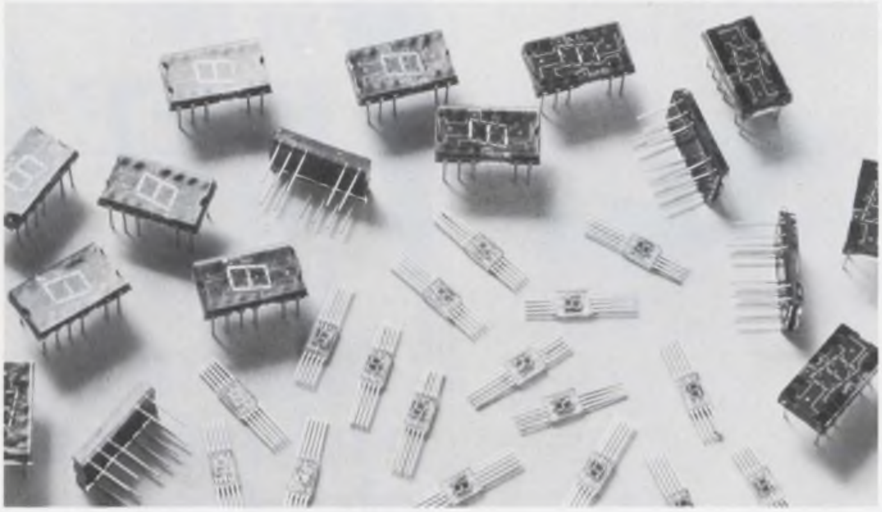
CIRCLE NO. 274

Bandpass filter units dial 50 to 4000 MHz

Texscan, Technical Products Div., 4610 N. Franklin Rd., Indianapolis, Ind. Phone: (317) 454-6481. P&A: $320 to $510; 2 to 3 wks.

Ranging over 50 to 4000 MHz is a series of bandpass filters that are tunable with a calibrated dial. Models of the VF series filters are available with a three or a five-section response. Bandwidth at the 3-dB points is 5% and insertion loss is 0.2 to 1.5 dB. Indicated center frequency on the dial is within ±1/2%.

CIRCLE NO. 276

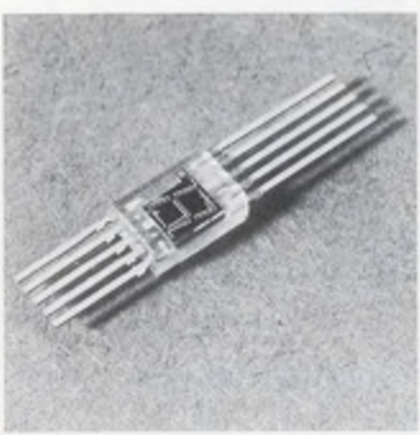


Monolithic LED numeric competes with Nixie prices

Monsanto Electronic Special Products, 10131 Bubb Rd., Cupertino, Calif. Phone: (408) 257-2140. P&A: $12.45; stock.

Available for the first time is a monolithic light-emitting-diode numeric display that you can really go out and buy—and that gives you solid-state performance at Nixie-tube prices. The MAN-3 seven-segment readout with decimal point costs only $12.45 in single-unit quantities and $7.55 in 1000-unit quantities. For orders in the 20,000-unit range, the new numeric is expected to be comparably priced with Nixies.

Like its discrete-type MAN-1 predecessor, the monolithic MAN-3 requires an external decoder/driver, which costs approximately $5. Both of these readouts are seven-segment numeric displays, while the MAN-2 is a discrete-type 35-dot LED array with alphanumeric capabilities.



Monolithic numeric readout with decimal point matches price tag of Nixie tubes. The chip is housed in a clear cast epoxy package.

The planar active areas of the MAN-3 are formed by zinc diffusion into n-type gallium arsenide phosphide. Each of the seven segments consists of five light-emitting diodes, which are interconnected by evaporated aluminum.

This interconnecting aluminum layer divides each diode into two equal halves. When the diodes are lighted, each segment appears as 10 distinct lights. Each of these lights measures 0.0035 by 0.0015 in.

Tilted 10 degrees from the vertical position, the numeral itself can be seen over a viewing angle of 150 degrees. Its dimensions are 0.116 × 0.067 in.

Housed in a clear cast epoxy housing, the IC-compatible MAN-3 measures only 0.24 × 0.168 × 0.09 in. This allows a packing density of at least five numerics per inch.

Readout brightness, which is directly proportional to input current, can be varied from 50 to 500 foot-lamberts by applying 1 to 10 mA per segment. Light wavelength ranges from 6300 to 7000 Å.

CIRCLE NO. 277

Seven-segment readout holds down power drain

Legitron Corp., 3118 W. Jefferson Blvd., Los Angeles, Calif. Phone: (213) 733-9105. P&A: $5.50; stock.

The DG-12H is a seven-segment digital indicator that provides low-voltage and low-current drain in a planar-readout device. Its digits, symbols and letters are composed of highly efficient phosphor-coated segments providing clarity between digits up to 40-foot distances. A wide spectral bandwidth makes available different color outputs with the use of proper filtering.

CIRCLE NO. 278

Binary resistance unit trims in decades

Consolidated Resistance Instruments, Inc., 44-46 Prospect St., Yonkers, N. Y. Phone: (914) 963-5900. P&A: from $14; stock to 6 wks.

Supplying resistances from 0.01 to 2.5 MΩ, a new trimmer combines its characteristics with those of a decade. The Verni-step has 6 to 16 wire-wound resistors in series, each connected in a binary sequence and shunted by adjustable switches. The user adjusts the trimmer by shorting its resistances.

CIRCLE NO. 279

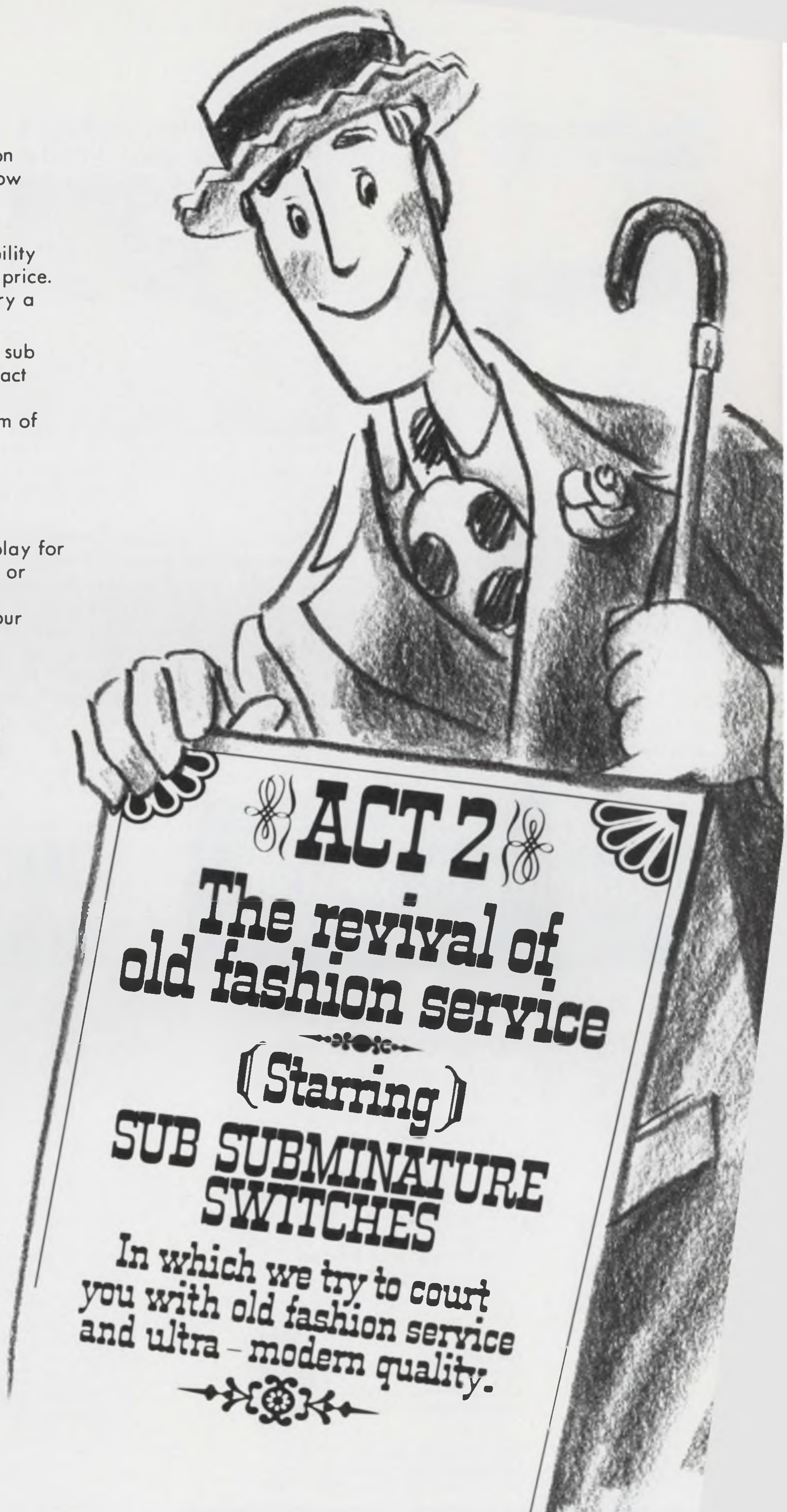
In our first act we introduced our precision miniature line of snap-action switches. Now comes a beautiful new addition—the sub subminiature line.

All we ask is a chance to prove our ability to give you real quality at a competitive price. With old-time service and on-time delivery a part of the deal. We invite comparisons.

For example. The unique design of our sub subminiature incorporates a floating contact blade and a low stressed C-spring which provides an overtravel tolerance minimum of .010 inch. Less than half as critical as competition.

And it has a minimum electrical life of 50,000 operations—at rated load.

As you can see, we're making a real play for your next switch order. Sub subminiature or miniature. Let your Cutler-Hammer Sales Engineer or Switch Distributor give you our product/service story. He could bring down the curtain on your old supplier.



CUTLER-HAMMER

SPECIALTY PRODUCTS DIVISION Milwaukee Wis. 53201

INFORMATION RETRIEVAL NUMBER 61

Our SS10KT40 with gold contacts is one of the many stars in our sub subminiature line.
16 switches, all U.L. listed. 4 terminal variations (single turret, double turret, pin, and quick connect). 6 industry standard external actuators (leaf, reverse leaf, roller leaf, reverse roller leaf, lever, and roller lever). Gold contacts. Switches in stock for immediate delivery.

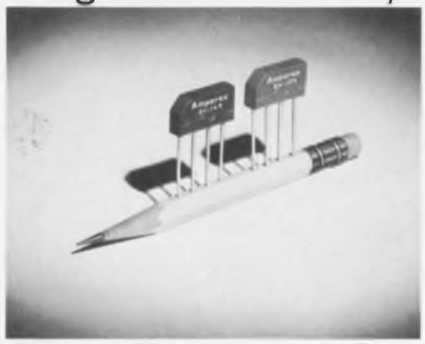
Tiny fiber-optics CRT shows a 1.5-in. face

Panasonic Div., of Matsushita Electric Corp. of America, 200 Park Ave., New York, N.Y. Phone: (212) 973-5700.

Containing a fiber-optics faceplate, a new miniature cathode-ray tube measures only 1.5 in. across its face. The model MTT-130 is designed for use in direct printing of TV images and graphic displays. It uses magnetic deflection and electrostatic focusing. Its heater requires a minimum amount of operating power.

CIRCLE NO. 280

Plastic bridge rectifiers bring down cost to 51¢



Amperex Electronic Corp., Semiconductor Div., Slatersville, R. I. Phone: (401) 762-9000. Price: 51¢, 56¢.

Two new plastic-encapsulated bridge rectifiers provide increased input and output ratings at low unit costs of 51¢ (BY164) and 56¢ (BY179) in thousand-lot quantities. The BY164 provides an output of 1.2 A at 45 V and the BY179 provides an output of 1 A at 255 V. Both units operate into resistive-inductive loads.

CIRCLE NO. 281

Fast multi-scan tube makes alphanumerics

Gencom Div. of Varian/EMI, 80 Express St., Plainview, N. Y. Availability: 3 to 4 wks.

The Printicon 9788 is a small electrostatic low-voltage tube designed for the electrical generation of alphanumeric symbols at high speeds. Character scanning can be in a sawtooth, sinewave or zig-zag form. In the standard array 64 characters are arranged in an 8 × 8 matrix. Any number or style of characters can be manufactured to particular specifications.

CIRCLE NO. 282

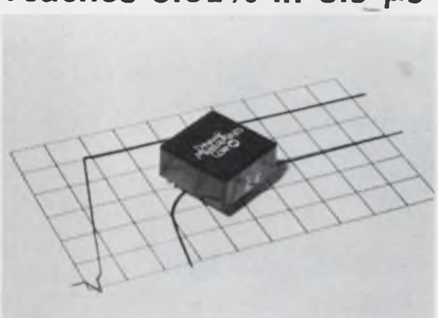
Low power-drain op amp consumes but 100 μA

Polytron Devices, Inc., 844 E. 25 St., Paterson, N.J. Phone: (201) 523-5000.

Operating over a wide voltage range, a new operational amplifier features a current drain of only 100 μA at $\pm$15 V dc. The P213-9 operates from $\pm$2 to $\pm$22 V dc. Among its other characteristics are a bias current of .5 pA and voltage drift of 3 μV/°C. Input impedance is 10^{12} Ω, and frequency compensation is 6 dB/octave. Case dimensions are 1.12 $\times$ 1.12 $\times$ 0.45 in.

CIRCLE NO. 283

Fast-settling op amp reaches 0.01% in 0.9 μs

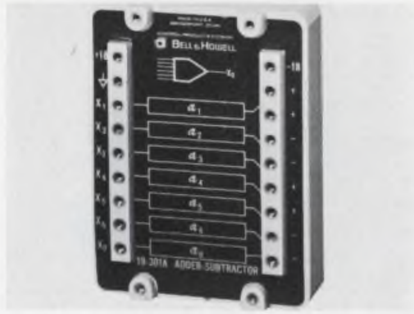


Dynamic Measurements Corp., 108 Summer St., Arlington, Mass. Phone: (617) 648-3610. P&A: $33; stock.

Featuring an input current drift of 100 pA/°C, a new operational amplifier settles to 0.01% of its final value in only 0.9 μs. The model FST-102B has a slewing rate of 25 V/μs and an offset voltage drift of 5 μV/°C. Its gain is 250,000 and its bandwidth is 12 MHz. A common-mode rejection of 90 dB is also featured. The unit measures 1.12 $\times$ 1.12 $\times$ 0.57 in.

CIRCLE NO. 284

Adder/subtractor offsets to 2.5 mV

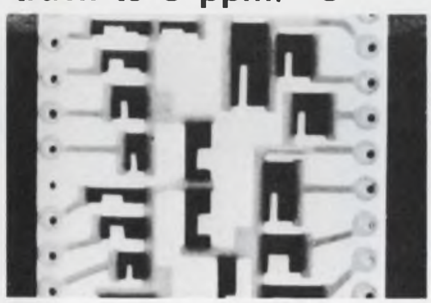


Control Products Div. of Bell & Howell, 706 Bostwick Ave., Bridgeport, Conn. Phone: (203) 368-6751. P&A: $110; 2 to 4 wks.

The model 19-301A is an adder/subtractor that features high accuracy with the use of 0.01% scaling coefficients and an amplifier offset voltage of 2.5 mV. It contains two microcircuit op amps that feature a thermal voltage offset error of 20 μV/°C. Bias current error is 5 nA/°C and long-term drift for each amplifier is 50 μV/month, non-accumulative.

CIRCLE NO. 285

BCD 3-decade ladders track to 3 ppm/°C

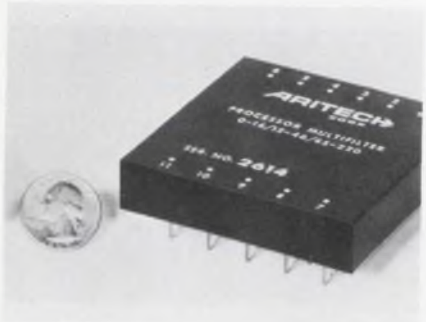


Helipot Div., Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 871-4848.

Designed for FET switching, the series 862 three-decade 12-bit BCD ladder networks track to 3 ppm/°C. These cermet thick-film units are offered in four models depending on the required temperature range. Standard resistance values are 50 and 100 kΩ, and maximum output voltage ratio error is $\pm$300 ppm. Settling of the output voltage to 0.1% of final value is within 0.5 to 1 μs.

CIRCLE NO. 287

Matched multifilters keep noise to 25 μV



Aritech Corp., 130 Lincoln St., Brighton, Mass. Phone: (617) 254-2990. P&A: $200; 6 wks.

Exhibiting typical output noise levels of only 25 μV rms, a new series of active multifilters features amplitude matching of better than 0.25 dB and phase matching of 2 degrees. These multifilter modules contain combinations of low-pass, high-pass, band-pass and band-reject filters, packaged together in a single shell, for frequencies from 0.01 Hz to 100 kHz.

CIRCLE NO. 288

IC signal conditioner varies voltage widely

Integrated Controls, Inc., Box 17296, San Diego, Calif. Phone: (714) 453-5800. P&A: $85; stock.

Designed for amplifying remote mounted passive and active transducers, a new self-powered IC signal conditioner varies its voltage gain continuously from 1 to 1000. The BA 05 allows threshold levels of 5 μV from source impedances up to 10 kΩ. Its input impedance is 100 MΩ on lower gain ranges and its input overvoltage capability is ±30 V dc continuously.

CIRCLE NO. 289

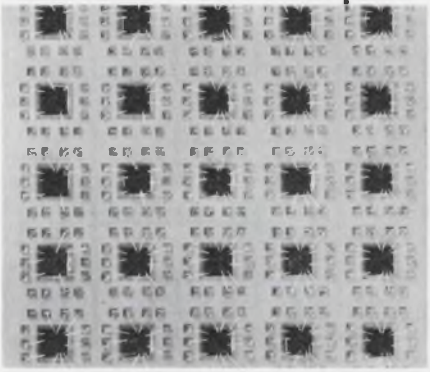
Unity-gain amplifiers are accurate to 0.03%

Intech Inc., 1220 Coleman Ave., Santa Clara, Calif. Phone: (408) 244-0500. Price: $18 or $28.

In an IC-compatible dual-in-line package, the A-190 and A-191 FET unity-gain amplifiers guarantee accuracies of 0.1% and 0.03%, respectively. Maximum initial offset voltage is less than 5 mW for the A-190 and 3 mW for the A-191; input voltage drift is 50 and 25 μV/°C, respectively. For both units, typical common-mode rejection is 86 dB.

CIRCLE NO. 290

Hybrid IC substrates interconnect 36 chips

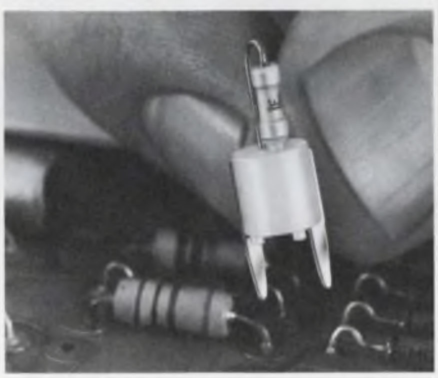


Microelectronics Corp., Regional Technology Park, 4901 Stenton Ave., Philadelphia, Pa. Phone: (215) 329-8681.

Measuring only 1-in. square, large-scale hybrid IC substrates allow interconnection of as many as 25 to 36 chips, either beam lead or wire bonded. Using thick-film screening techniques to interconnect several layers of metalization, these substrates can have up to 11 conductive planes, each dielectrically isolated from adjacent layers.

CIRCLE NO. 291

Miniature fuse holder plugs into PC boards

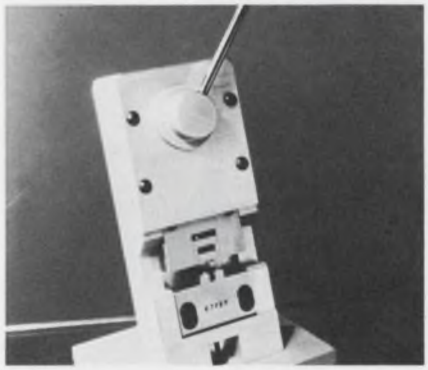


Littelfuse, Inc., sub. of Tracor, Inc., 800 E. Northwest Highway, Des Plaines, Ill. Phone: (312) 824-1188.

Able to mount directly on printed circuit boards, a new subminiature fuse holder measures only 0.25 in. in diameter by 0.236-in. high. The unit is rated at 10 A maximum, 125 V ac. Nominal pin contact insertion force is 500 grams. There are four supporting legs molded in the base of the body for mounting stability.

CIRCLE NO. 292

Flatpack forming tool handles 5/8-in. devices



Electronic Tool Co., 3324 White Plains Rd., Bronx, N.Y. Phone: (212) 231-7760. Price: from $560.

Using many different-size dies that can be interchanged in only minutes, a new tool will cut, bend or stagger-bend any flatpack up to 5/8-in. wide. Model 8023 has a large throat clearance that speeds loading and unloading. Staggered packs are automatically isolated from the dies after bending for quick and easy removal. The unit leaves burr-free lead ends.

CIRCLE NO. 293

Extractor for TO-5 cans prevents board damage

Ungar, Div. of Eldon Industries, 223 E. Manville St., Compton, Calif. Phone: (213) 774-5950.

Assuring quick safe removal of TO-5 cans, a spring-loaded automatic extractor prevents board damage during desoldering. Model 6983 fits over the TO-5 can and locks on by lever action; as soon as the solder on all leads is melted, it automatically pops off the board. Board damage is prevented by the extractor's metal clamps that act as an effective heat sink.

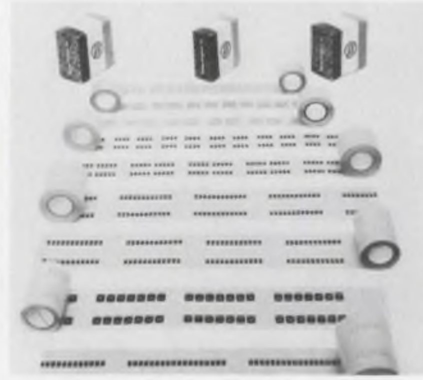
CIRCLE NO. 294

Evaluation Samples

Knurled indicator knobs

Series KNS straight knurl machined aluminum knobs feature an aluminum skirt, an engraved arrowhead indicator, and a contrasting natural top for distinctive appearance. They are available with #6-32 set screws in two places. Knob body sizes are 0.5 and 0.75 in. with 1/8 or 1/4-in. shafts. The new knobs, which normally retail for $1 (the KNS-501) or $1.15 (the KNS-701), are now available to the readers of ELECTRONIC DESIGN as free evaluation samples. Alco Electronic Products, Inc., Alcoknob Div.

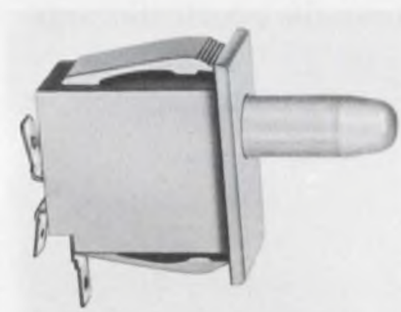
CIRCLE NO. 295



DIP artwork patterns

Matching the latest dual-in-line packages, a new line of multi-pad artwork patterns include all 8, 10, 14, 16, 24 and 36-lead configurations. There are eight different drafting styles to meet specific circuitry requirements. All these pressure-sensitive patterns come in 1:1, 2:1 and 4:1 scales, and in opaque black, and photographically compatible transparent red and transparent blue. Free evaluation samples are available. Bishop Graphics, Inc.

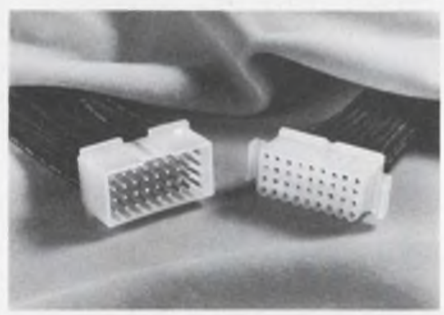
CIRCLE NO. 297



Push-button switch

A free evaluation sample of a new molded nylon snap-in panel-mount push-button switch is now available. Model E69-00A is rated at 10 A, 125 or 250 V ac. Primarily intended for use as a door interlock and machine start switch, the unit is housed in a long-life white molded nylon case. This basic momentary-action device is supplied in single-pole double-throw or single-pole single-throw configurations, normally open or normally closed. Cherry Electrical Products Corp.

CIRCLE NO. 296



Nylon connector

Accommodating as many as 36 circuits, a new miniature connector is ideal for applications in business machines, computers, home entertainment units and appliances. Designated the 1625-36, the unit has a nylon body with integrally molded mounting ears on both the plug and receptacle, plus a positive-lock design. It accepts crimp-type terminals, which may be tin-plated brass, phosphorus bronze, and gold or silver-plated brass. A free evaluation sample is available. Molex Products Co.

CIRCLE NO. 298

Design Aids

Programmer's calendar

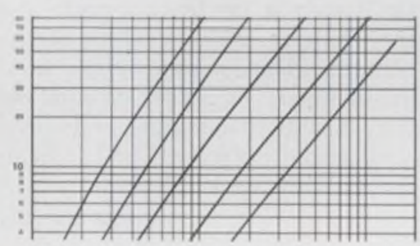
Devised especially for computer users is a new calendar that is being offered free. It features machine-tested, change-maker subroutine, data finder, and even slot-machine simulator programs. This 8-1/2 × 11-in. calendar includes program flow charts each month on the front monthly page and instructions and related information on the reverse side of the page. Limited quantities are available. Spiras Systems, Inc.

CIRCLE NO. 299

Line conditioning guide

Characteristics and requirements for unconditioned, C1, C2 and C4 conditioned telephone channels are available in a free easy-to-read sturdy slide chart. It shows specifications for communications channels as described in AT&T's Bell Systems Practices and FCC Tariff 260. For those who are involved in data communications, this guide offers a proper understanding of line requirements for effective utilization of communications channels. Rixon Electronics Inc.

CIRLCE NO. 301

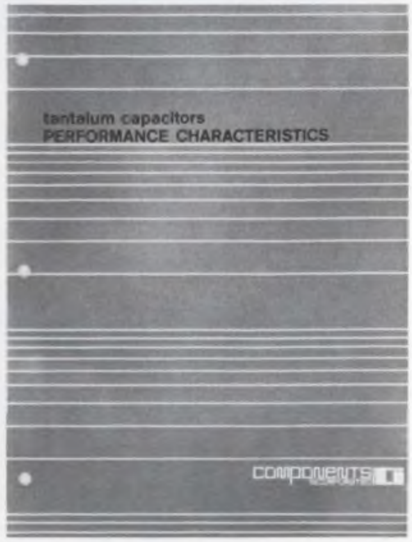


Core loss curves

A new four-page folder illustrates high-frequency core loss curves for nickel-iron strip-wound cores. Data for the curves, which are supplements to existing design manuals, was obtained by recording the voltage and current waveforms across a one-turn winding on a representative miniature tape-wound core. Rather than representing maximum or minimum values, the core loss curves show typical losses for ultra-thin nickel-alloy tape-wound cores. Magnetics div. of Spang Industries, Inc.

CIRCLE NO. 300

Application Notes



Tantalum capacitors

The performance characteristics of tantalum capacitors is the subject of a new eight-page booklet. It is crammed with 29 characteristic curves that include voltage versus temperature, minimum and maximum ripple voltage and dc leakage. Other characteristic curves show impedance, capacitance change and frequency. A complete review of tantalum construction and basic parameters is also included. Components, Inc.

CIRCLE NO. 302

Inductive elements

Applications information for transformers, inductors and delay lines is contained in a new 33-page manual. It begins with a definition of terms and symbols, test methods and design aids, and follows up with three sections for applications. The first section is on transformers and delay lines, the second is on instrumentation and the third is on power supplies. The sections contain calculations, nomographs, specification preparations and circuit selections. Circuits illustrated are arranged in groupings. Methods for specifying and testing core and winding performances are also included. Pulse Engineering Inc.

CIRCLE NO. 303

SCR/triac triggering

A new application bulletin entitled "Selecting a Trigger Transformer for SCR/triacs" is available. It describes in practical terms the methods and steps in selecting the proper pulse transformer for coupling trigger pulses into the gates of SCRs and triacs. A six-step summary shows how to select a transformer, with additional design footnotes included. This application information eliminates the mysteries of pulse transformers that have plagued the designers of motor controls and process control equipment. Aries Technology.

CIRCLE NO. 304

Adhesive application

Selection guidance for the proper method and equipment to use when applying liquid adhesives is provided in an illustrated 20-page booklet. Considered are such factors as: the size and shape of the parts to be bonded, the areas to which the adhesive is to be applied, the number of assemblies to be produced, the required production rate, and the property characteristics of the adhesive. The booklet covers manual methods of adhesive application, machine techniques and spray application equipment. USM Chemical Co., div. of USM Corp.

CIRCLE NO. 305

Pulse code modulation

The basics of pulse code modulation telemetry are thoroughly explained in a 12-page article reprint. It starts off with the explanation of pulse code modulation and the processes involved in a pulse code modulation system. This is followed with a discussion on how a typical system operates from a source to a display. The discussion is fortified with several illustrations and block diagrams. Data-Control Systems, Inc.

CIRCLE NO. 306

INFORMATION RETRIEVAL NUMBER 71

New Literature

Series 54/74 ICs

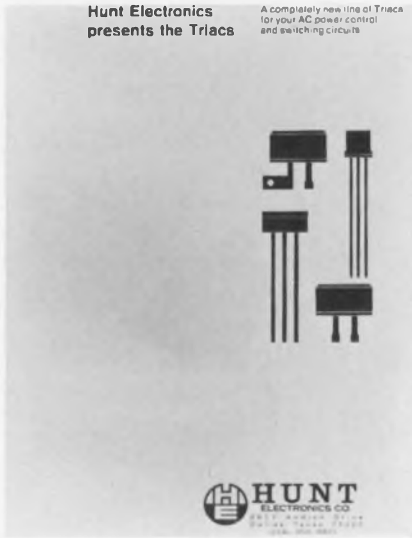
A 32-page brochure describes integrated circuits of the 5400 and 7400 TTL series. The publication covers the first 24 products in the series and indicates the recommended operating conditions for these circuits. Descriptions of the circuits include information about electrical characteristics, switching characteristics, logic diagrams and pin configurations. Illustrations are abundant, with nine pages devoted to diagrams and schematic drawings showing test circuits and voltage waveforms. Additional illustrations show packaging dimensions and provide parameter measurement information. Fairchild Semiconductor

CIRCLE NO. 307

Display switches

Miniature lighted push-button display switches are illustrated in a 12-page brochure. They provide control flexibility and display versatility and are adaptable to military and commercial applications. The brochure describes matrix or single-mounted switches with front-of-panel replacement for both switches and lamps. Also listed are dimensions, terminal options, display-color options, lamp data, legending information and ordering and pricing data. Micro Switch, div. of Honeywell.

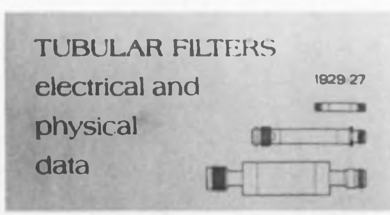
CIRCLE NO. 308



Triacs

Specifications for 88 devices of a line of triacs for ac power control and switching circuits are detailed in a new catalog. The triacs are available in a wide range of voltages and currents and feature static power switching with no contact bounce, arcing or replacement. A wide variety of packages to fit most specifications are shown. Applications, electrical characteristics, and mechanical specifications are listed. Hunt Electronics Co.

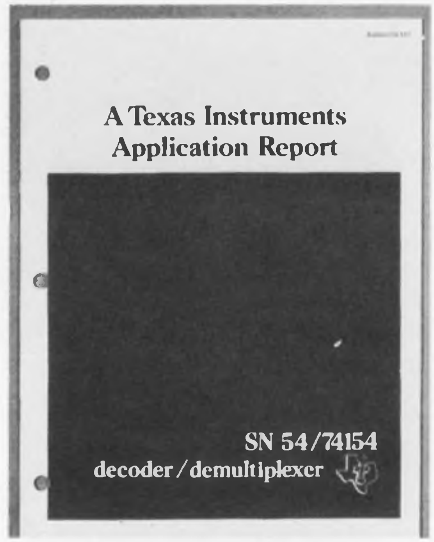
CIRCLE NO. 309



Tubular filters

Electrical and physical characteristics for over 2000 tubular filter designs are compiled in a catalog supplement. Included are such data as filter function (band-pass, high-pass, low-pass), insertion loss, center or cutoff frequency, bandwidth, number of elements, impedances, and attenuations at several points. Graphs illustrate frequency-attenuation and VSWR characteristics. Physical dimensions include body diameter and length. I-TEL, Inc.

CIRCLE NO. 310



Decoder/demultiplexer

A new application report on the SN54/74154 decoder/demultiplexer TTL/MSI integrated circuit is available in an eight-page publication. It discusses the ICs internal logic design and performance capabilities. Included are the circuit's logic description, block diagram, a switching characteristics chart, and a truth table listing all 16 outputs plus enable and data inputs. Additionally, the report covers its applications as a decoder, minterm generator, code decoder, and as a demultiplexer. Texas Instruments Inc.

CIRCLE NO. 315

Thick-film coatings

Data sheets and reprints of a recent paper describing screen-printable thermistor coatings are available. These unique new coatings are described in a paper "Improved NTC Thermistor Thick Film Coatings" which was presented at the 1969 Hybrid Microelectronics Symposium. A data sheet lists available resistivity ranges, and typical resistor temperature coefficients. It also gives processing instructions for producing printed-in-place negative temperature coefficient thermistors on ceramic substrates. Electro-Science Laboratories, Inc.

CIRCLE NO. 316

Electronic calculators

The series 1600 electronic scientific/engineering calculators are shown in a 24-page catalog. Described are display, programming and printing calculator models. General descriptions, specifications and display and decimal systems are included. The various calculater keyboards are discussed in detail with respect to operations. Three pages in the back of the catalog are devoted to sample program sheets. The Monroe Calculator Co., a Div. of Litton Industries.

CIRCLE NO. 317

Single-turn pots

Twenty-four standard models and 96 variations of the new B-Line series of single-turn precision potentiometers are described in detail in a six-page brochure. The series comes in 7/8-in., 1-1/16-in. and 2-in. diameters with servo or bushing mounts, in a choice of four elements. They offer a standardized thin profile for a new concept in interchangeability that allows designing for a specific package size without concern for the type of potentiometric element used. Bourns Inc., Trimpot Products Div.

CIRCLE NO. 318

Rf coils

Fourteen different series of molded variable and fixed coils in all sizes and shapes for rf applications are listed in a new 16-page catalog. Tables of information include such data as inductance values, Q, resonant and testing frequency, dc resistance, and current ratings and core material. All dimensions are fully illustrated for each series. A separate page includes a list of distributors and sales representatives. Delevan Electronics Div, A.P.I.

CIRCLE NO. 319

BNC connectors

A new comprehensive 48-page catalog lists a BNC series of rf coaxial connectors. Construction and cable group data are given for 658 items. They include a wide variety of adapters, jacks, panel jacks, bulkhead jacks, plugs, angle plugs, panel and bulkhead receptacles, terminations and accessories. Each item is photo-illustrated and pertinent dimensions are indicated. Kings Electronics Co.

CIRCLE NO. 320

Storage tube data

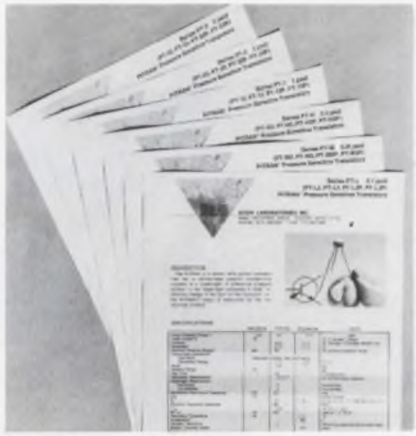
Technical data for a 4-1/2 × 5-1/2-in. rectangular direct-view storage tube is included in an eight-page brochure. The tube, which can be operated in black-and-white or in half-tone storage modes, provides a resolution of 150 television lines per inch. It includes a viewing screen brightness of 150 foot-lamberts, and meets the requirements for displaying graphical and alphanumerical information. Hughes Aircraft Co.

CIRCLE NO. 321

Hewlett-Packard Journal

The February 1970 issue of the Hewlett-Packard Journal is available. This 24-page publication is devoted to a discussion of a system for automatic network analysis. It begins with a description of the system and discusses its applicable software. Articles on developing the system's accuracy specifications and typical applications are also included. Hewlett-Packard Co.

CIRCLE NO. 322



Pressure transistors

Six new complementary data sheets for a recently released eight-page brochure on pressure-sensitive transistors are available. These data sheets detail information on pressure-sensitive transistors with six different pressure ranges. Stow Laboratories, Inc.

CIRCLE NO. 323

Electronic applications

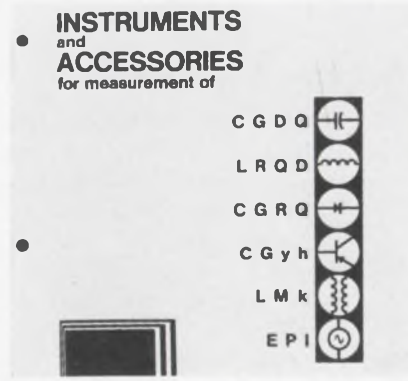
"Technical Communications," Vol. 10, No. 93, is a 120-page publication that contains a thorough discussion of several applications involving semiconductors and ICs. Applications such as infrared heat-locator and intruder-alarm detectors, and fire alarm systems are described. Also included are discussions on thermometers for high-temperature and room-temperature radiation, infrared microscopes and closed-circuit television systems. The booklet has pertinent schematic layouts, equations and graphical information. Mullard, Inc.

CIRCLE NO. 324

Integrated circuits

Linear ICs, FET-switch drivers and driver/switch combinations, and FET chips are described in detail in a new catalog. Applications information is included in right-hand columns of the catalog's pages. The left-hand columns contain electrical and physical specifications and the device model numbers. This facilitates IC device selection by application as well as by number. Siliconix Inc.

CIRCLE NO. 325



Measurement instruments

Twenty-four instruments and their related accessories are listed on unique selector charts in a new eight-page abridged catalog. An engineer can now quickly select and find the instruments and accessories needed to measure a wide variety of parameters for many electronic components. Summarized specifications of all instruments and accessories are provided, each with its current price. Boonton Electronics Corp.

CIRCLE NO. 326

Communications devices

A wide line of standard-size and miniature terminals, plate caps and sockets are described in a 16-page bulletin. It details and illustrates high-voltage feed-through safety terminals, binding posts, ceramic insulators and crystal sockets. Also shown are special industrial sockets for large tubes such as thyratrons, insulated plate caps, hold-down clamps, coil sockets and aluminum shield cans. James Millen Mfg. Co., Inc.

CIRCLE NO. 327

IC testing

An analogical-circuit test instrument and a line of its accessories are described in a 12-page brochure. The bench-top instrument is card-programmed for testing digital ICs. Though primarily an incoming-inspection system, it is readily adapted for engineering use through the addition of such accessories as an analog programmer, an evaluation test deck, and a pattern control unit. Teradyne, Inc.

CIRCLE NO. 328

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Worldwide, "Pass the AVO" means someone wants the most accurate, most reliable multimeter . . . anywhere. Twenty four ranges for AC and DC current, voltage and resistance. Full meter protection includes fuse, velocity actuated mechanical cutout and diode protection for meter movement.

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Check your application(s). Then ask us to tell you how magnetic detection can solve your problems at low cost . . . or suggest a new application for OPMAG in the space below. We'll send you a free copy of our newly-published "Magnetics Handbook" (Retail price $1.25).

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INFORMATION RETRIEVAL NUMBER 75

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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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175

When Non-Standard Capacitors are Needed

This brochure outlines Electro-Cube's capability to design to requirements, or produce to specifications, capacitors in a wide variety of shapes, sizes and values. Typical information on seven dielectrics including electrical ratings, are presented. Typical sizes for wrap and fill, epoxy, metal and hermetic sealed cases are also given. Representative examples of 4,000 standard Electro Cube capacitors, in addition to custom units, are presented. Copies of the six-page brochure are available on request.

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Manufacturers

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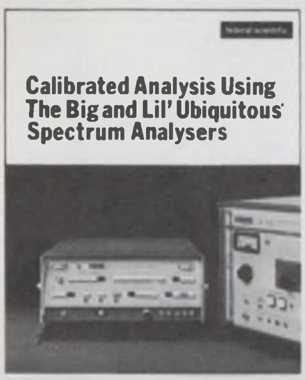
New Portable Real-Time Analyzer



The new 200-line UA-10, the lil' Ubiq™, is compared to the 500-line UA-6A Ubiquitous® Spectrum Analyzer, highlighting savings possible for less demanding production and field applications. On-line frequency domain measurements of vibration, noise, underwater signals, and machine signatures are described. UA-10 is 100 times faster than traditional sweeping systems and has greatly increased resolution over 1/3-octave. The UA-10 is specially designed for accurate testing by inexperienced operators. Advantages of the big precision UA-6A for R&D requiring higher resolution and wider dynamic range are included.

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Design Guide for Auto. PC Board Assembly

Send for Universal Instruments' 16-page Bulletin 600B . . . comprehensive design guidelines for automatic insertion of electronic components into printed circuit boards. Covers axial lead components (fixed and variable center span insertion), dual in-line package integrated circuits (DIPs), transistors (axial and radial lead forming), and component sequencing. Fully applicable to pantograph, N/C, and new mini-computer controlled systems. Guide liberally illustrated with photos, diagrams and drawings. An important educational reference for both design and assembly engineers.

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Advertisers' Index

INFORMATION RETRIEVAL NUMBER 77

Product Index

Information Retrieval Service. New Products, Evaluation Samples (ES), Design Aids (DA), Application Notes (AN), and New Literature (NL) in this issue are listed here with page and Information Retrieval numbers. Reader requests will be promptly processed by computer and mailed to the manufacturer within three days.

New Literature

Application Notes

Design Aids

Evaluation Samples

Programmable, of course

DC to 1.3 MHz

Resettable with 0.01 Hz resolution over total range

Less than 20 μsec switching time from any frequency to any frequency

Calibrated output level

AM or FM—or both simultaneously

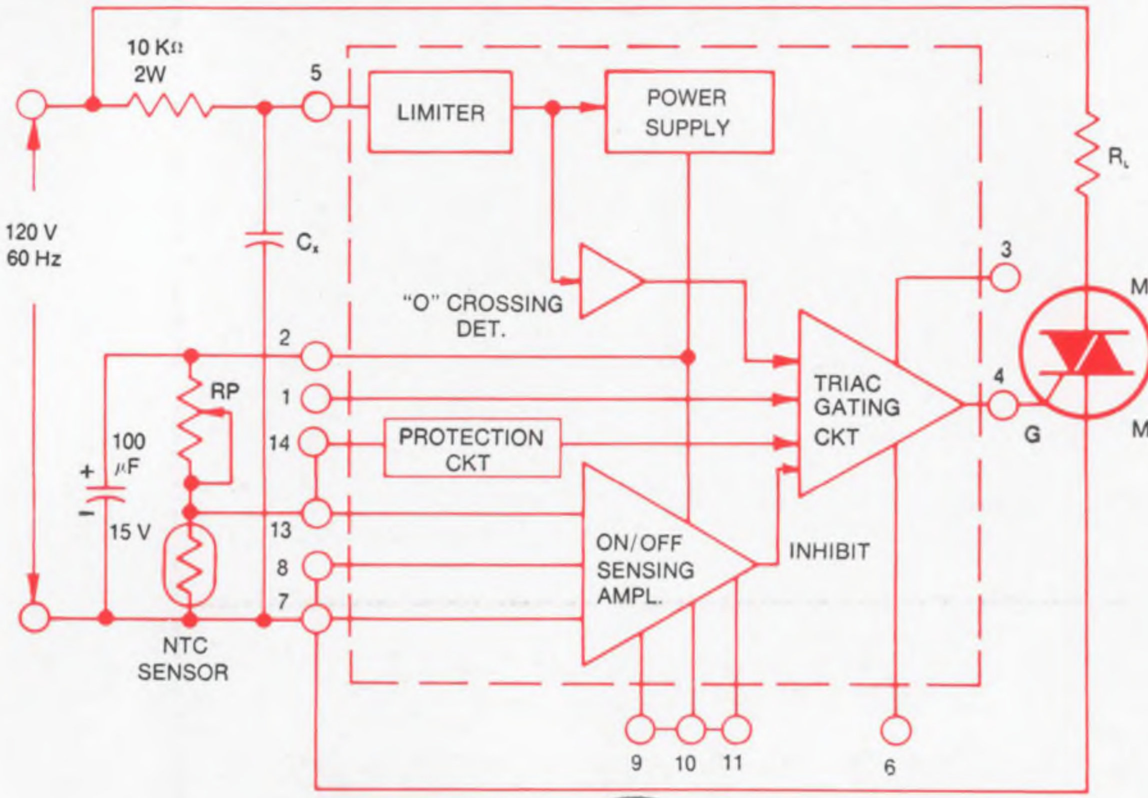
Here is the sinewave source of the future . . . all the accuracy, stability and resettability that only a frequency synthesizer can give you, plus such signal generator advantages as accurately calibrated output level, AM or FM modulation capability (or both), and built-in sweeps with provision for sweeping externally.

Now add digital programmability of frequency, analog programmability of output level and the benefits of computer-aided IC design, and you see a classic example of Monsanto's "4th generation" instrumentation.

The Model 3100A-016 Programmable Frequency Synthesizer is $4950. Our non-programmable version, Model 3100A, is $4250. An 8-page Technical Bulletin fills out the story. For your copy write: Monsanto Company, Electronic Instruments, West Caldwell, N. J. 07006.

Monsanto

New IC Switch from the Triac Leader



RCA-CA3059 Zero-Voltage Switch for New Economy, New Simplicity in Thyristor Trigger Circuits $1.95 (1000-unit level)

Here's RCA's economical, new approach to Thyristor triggering—the CA3059 monolithic zero-voltage switch, at $1.95 (1000 units). For efficient triggering of Triacs and SCR's with current ratings to 40 amperes—in applications such as electric heating, motor on/off controls, one-shot controls, and light-flashing systems—CA3059 offers these important new design advantages:

- Triggers Thyristors at zero-voltage crossing for minimum RFI in applications at 50, 60, 400 Hz.
- Self-contained DC power supply with provision for supply of DC bias current to external components.
- Built-in protection against sensor failure.
- Flexible connection arrangement for adding hysteresis control or proportional control.
- External provisions for zero-current switching with inductive loads.
- On/off accuracy typically 1% with 5 kΩ sensor; 3% with 100 kΩ sensor.
- Triacs in RCA's 2.5—40 Amp, 100—600 Volt series, Types 40693—40734, are selected to operate over the entire CA3059 temperature range.
- 14-lead DIP pkg. for —40°C to +85°C operation.

For further details, check your local RCA Representative or your RCA Distributor. For technical data bulletin, file no. 397, and Application Note ICAN4158, write RCA Electronic Components, Commercial Engineering, Section ICG4-1/CA0014, Harrison, N.J. 07029. In Europe, contact: RCA International Marketing S.A. 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

RCA Integrated Circuits