VOL. 17 NO. 19

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

SEPT. 13, 1969

Counter doubles as data terminal for programmed test systems. As a counter, the unit provides all conventional counting and timing functions. And in a system, it becomes a universal data terminal with programmable storage and display capability. Features include computing ability and dual-channel multiplexing. For details see p.126.

TRW/Globe sells motion

Application #5: mechanical motion

Anyone can sell you a motor. But the output of a high speed motor usually isn't much use all by itself. That's why TRW/Globe has spent over 20 years developing total systems which match motor capabilities precisely to your needs.

At TRW/Globe, we don't trust the manufacture of the critical mechanical components to other people—components like gear trains, clutches, brakes. We design and build our own. We even make our own gears of high density powdered metal to assure greater strength, uniformity and system reliability.

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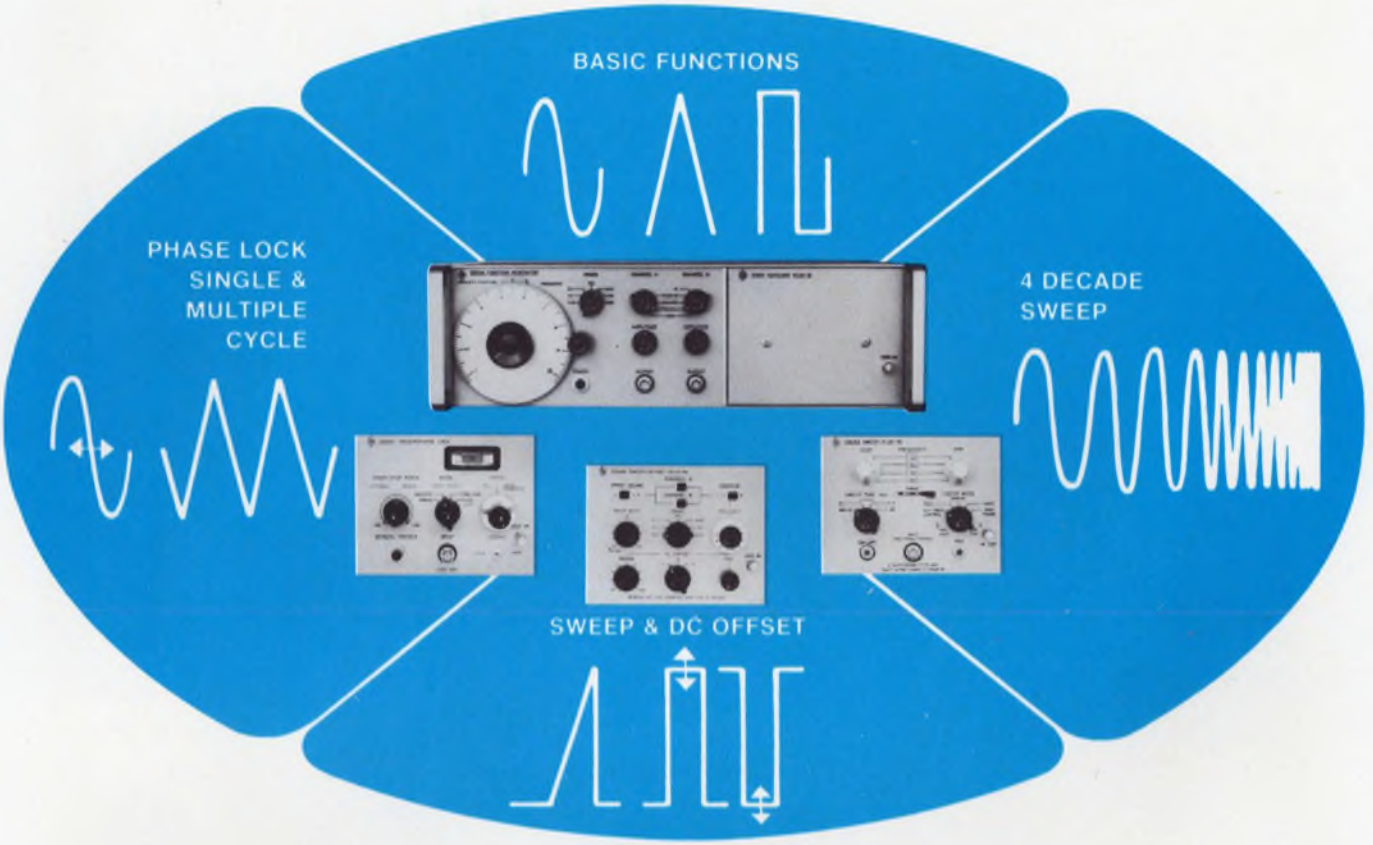
Contact Globe Industries Division of TRW Inc., 2275 Stanley Ave., Dayton, Ohio 45404. Phone (513) 228-3171.

TRW®

INFORMATION RETRIEVAL NUMBER 232

Customize this HP Function Generator to fit your Measurements



Start with the basic ability of the HP 3300A Function Generator—add the capability of its plug-ins—and you get a function generator that fits your specific needs. It's equally at home performing ordinary day-to-day lab tests or providing a sweeping signal that can be used to measure the impedance of an ape's brain. No matter what the task, you get the reliability and accuracy you need to get the job done.

The HP 3300A Function Generator gives two simultaneous outputs (sine, square or triangle) across a frequency range of 0.01 Hz to 100 kHz. Mix or match your output signals with individually selectable function and amplitude controls. Price, $650; HP 3301A Auxiliary plug-in, $30.

The HP 3302A Trigger / Phase-Lock plug-in lets you phase-lock any two functions to an external periodic signal. Phase can be controlled over a 360° range. Control single or multiple bursts with an external signal or the front panel manual trigger. Price, $225.

The HP 3304A Sweep/Offset plug-in provides a linear sweep adjustable in frequency and width within any decade over the entire frequency range. Variable dc offset of ±16 Vdc is provided for each function including the internally generated sawtooth—makes hard-to-get driving functions readily available. Price, $265.

The HP 3305A Sweep plug-in lets you sweep up to four decades without switching ranges. It sweeps logarithmically in any of three overlapping ranges for narrow or wide band testing between adjustable start/stop limits. Use the manual sweep for close inspection of any portion of the trace or for accurate frequency identification.

The 3305A's continuously adjustable sweep time of 0.01 to 100 seconds is slow enough for accurate response testing of high-Q devices and fast enough for good visual displays of wide band response. For ease of automated testing, either the frequency or the sweep trigger can be externally controlled. Price, $975.

Get the function generator that best fits your measurements. Consult your catalog and order by calling your nearest HP order desk. For data sheets, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

099/15

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SIGNAL SOURCES

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You can control the pulse train with external gating pulses, produce complementary outputs for duty cycles approaching 100%, set the baseline at exact ground with a switch, and reduce rep rate to 10 Hz for low-speed testing.

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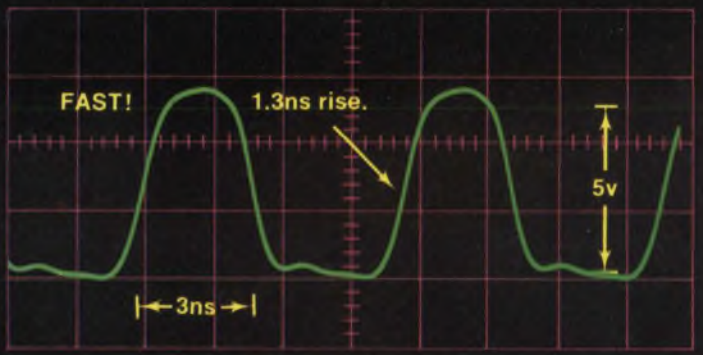
Why buy a high-priced 100 MHz pulser? Here's 125 MHz for $1595!

Oscilloscope photo. 2ns/div, 2v/div.



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- Time code generators
- Data generators
- Analog computers
- Digital panel meters
- Microwave signal generators
- Laboratory magnets
- Data acquisition systems
- Microwave test sets

VOL. 17 NO. 19

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

SEPT. 13, 1969

NEWS

TECHNOLOGY

PRODUCTS

Departments

Cover Photo by William Skeahan
for Beckman Instruments, Inc., Electronic Instruments Div., Richmond, Calif.

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. 77,523 copies this issue.

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pL4G10C pL4G10AC(2)	Hex 2 input NOR + 2 inverters Hex 2 input NOR + 2 inverters
pL4G11C pL4G11AC(2)	Dual 4 input NOR + dual 5 input NOR Dual 4 input NOR + dual 5 input NOR
pL4G12C pL4G12AC(2)	Dual 9 input NOR Dual 9 input NOR
pL4S16C	16 channel multiplexer
pL5R32C	Dual 8/16-bit shift register
pL5R40C	Dual 20-bit shift register
pL5R100C	Dual 50-bit shift register
pL5R96C	Dual 48-bit shift register
pL5R128C pL5R128AC(3)	Dual 64-bit shift register Dual 64-bit shift register
pL5R250C pL5R250AC(3)	250-bit shift register 250-bit shift register
pL5R256C pL5R256AC(3)	256-bit shift register 256-bit shift register
pM1024C	1024-bit read-only memory

(1) Clock rate 500KHz (2) Clock rate 2MHz
(3) Clock rate 5MHz

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2N5656		300	@	@	@	100 @ 200V	.90
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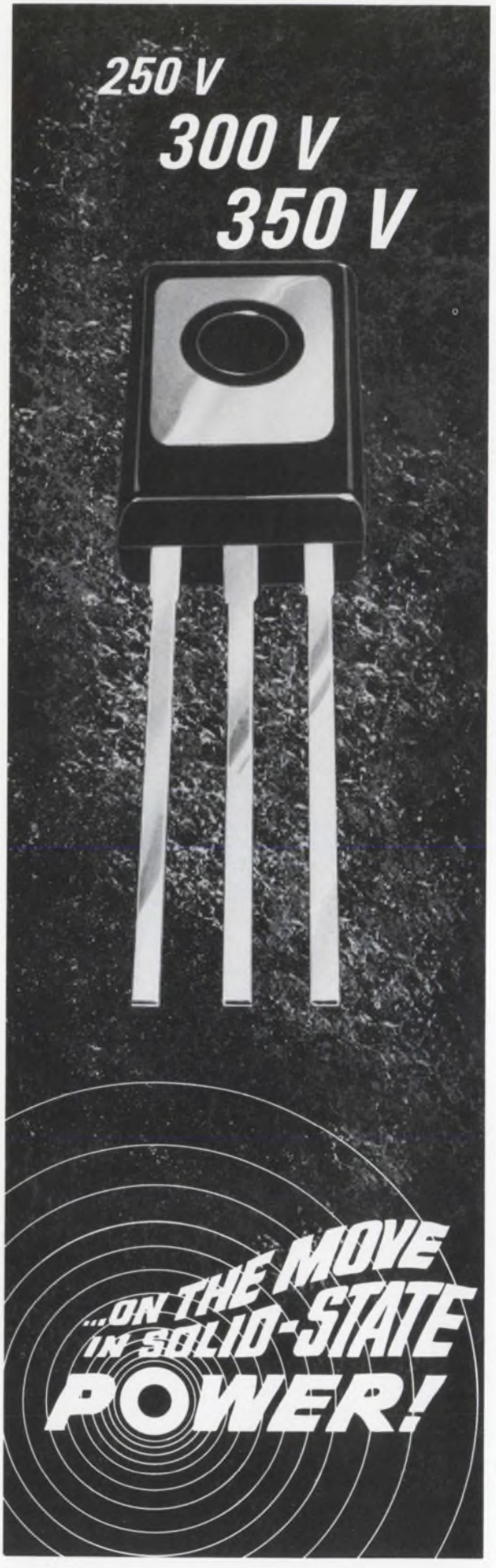

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Designer's Datebook

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30						

For further information on meetings, use Information Retrieval Card.

Oct. 6-8
Canadian Electronics Conference and Exposition (Toronto) Sponsor: IEEE, R. DeBuda, International Electronics Conf., 1819 Yonge St., Toronto 7, Canada

CIRCLE NO. 421

Oct. 13-19
International Astronautical Federation Congress (New York City) Sponsor: AIAA, American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, New York, N.Y. 10019

CIRCLE NO. 422

Oct. 21-23
Thermionic Energy Conversion Conference (Carmel, Calif.) Sponsor: IEEE, W. E. Harbaugh, RCA, Electronic Components, Lancaster, Pa. 17604

CIRCLE NO. 423

Oct. 26-30
Mathematical and Computer Aids to Design Conference (Anaheim, Calif.) Sponsor: IEEE, ACM, SIAM, J. F. Traub, Computing Science Research Center, Bell Telephone Laboratories, Murray Hill, N. J. 07974

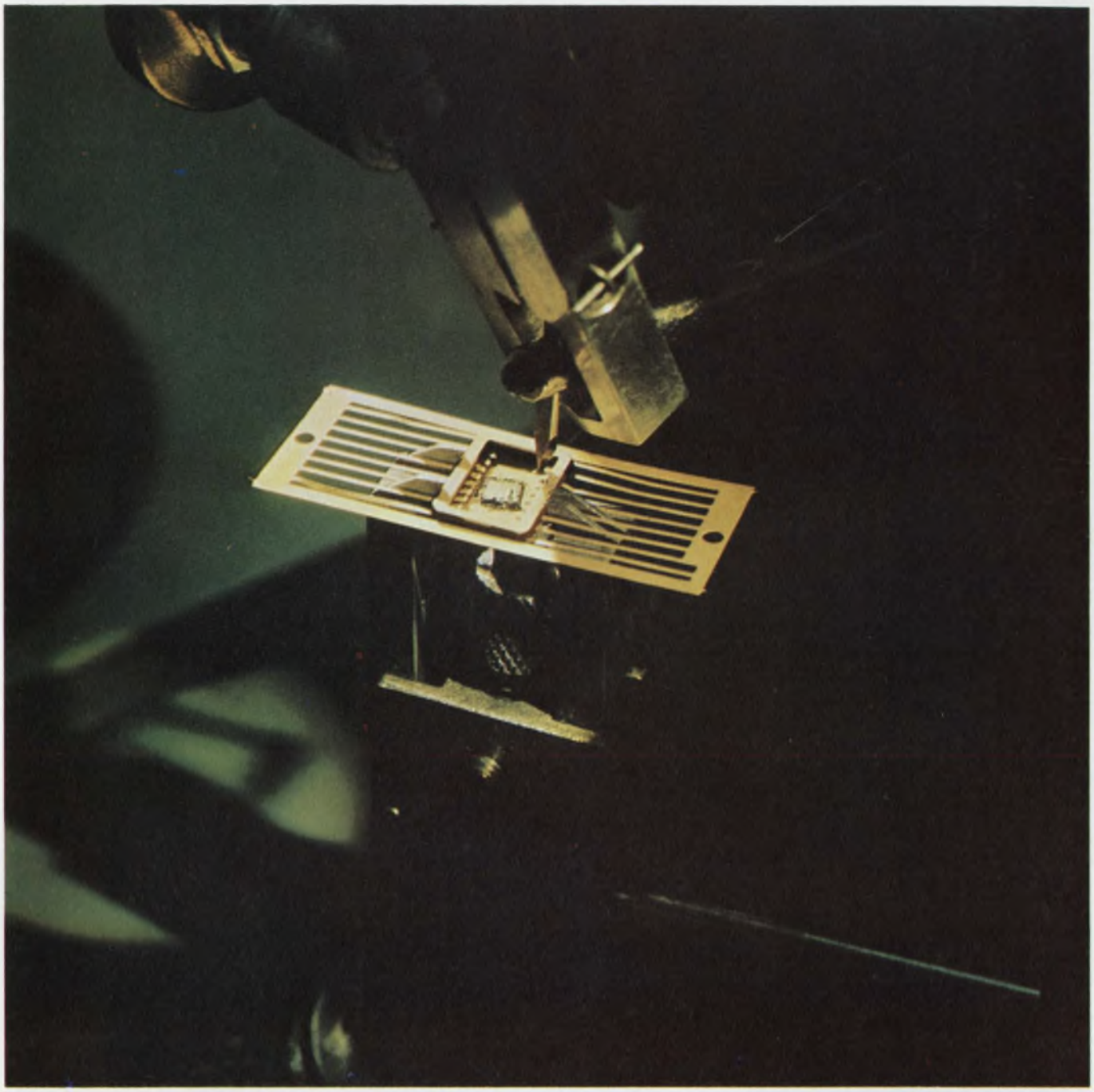
CIRCLE NO. 424

Oct. 27-29
Southeastern EMC Symposium (Atlanta, Ga.) Sponsor: IEEE, D. Vrooman, P.O. Box 331, Smyrna, Ga. 30080

CIRCLE NO. 425

Oct. 27-29
Electronic & Aerospace Systems Convention (EASCON) (Washington, D.C.) Sponsor: IEEE, H. P. Gates, Jr., Sect. of Army for Southeast Asia Matters, The Pentagon, Washington, D.C. 20310

CIRCLE NO. 426



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INFORMATION RETRIEVAL NUMBER 13

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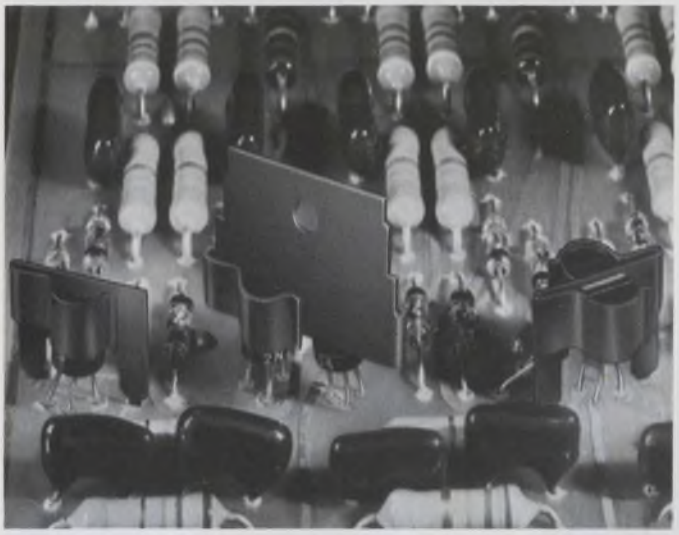

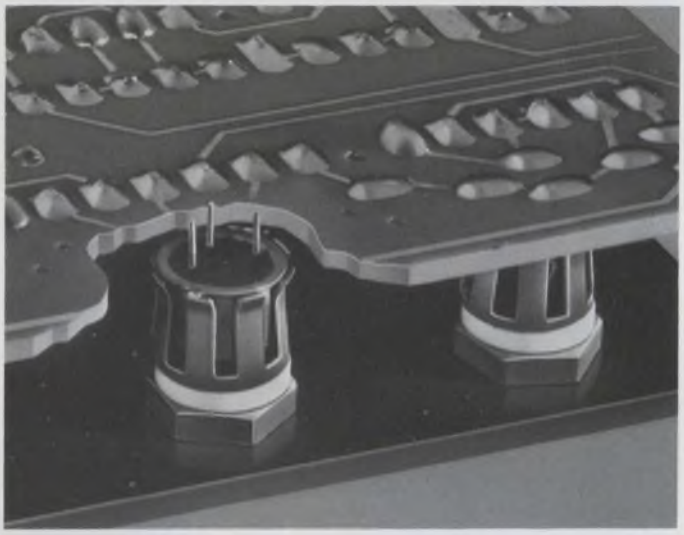

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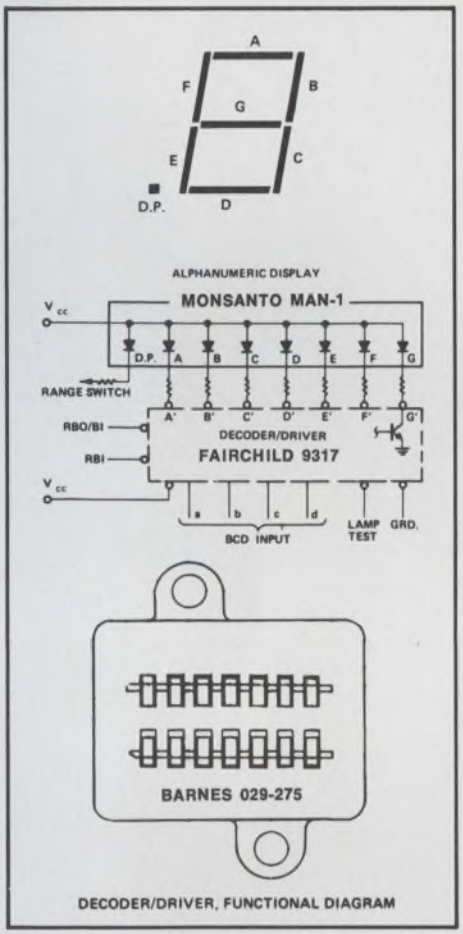
ED-869

HAPPENINGS IN ELECTRONICS

September, 1969

Design your own Decoder-Driver-Display Unit

You can do it with a minimum of devices and a maximum of ease thanks to MSI*. Follow these four steps:



DECODER/DRIVER, FUNCTIONAL DIAGRAM

1. Acquire a Fairchild MSI 9317. This device will decode four binary coded decimal (BCD) lines and convert them into a seven line output suitable for illuminating a seven-segment display unit. The 9317 will drive directly the segments of the display unit without the need for discrete transistors.

2. Acquire a Monsanto MAN-1. This unit is a solid-state seven-segment matrix display used for representing the decimal numbers 0 to 9. It will provide you with a visible red numeric readout of high brightness with single plane, wide angle viewing, and shock resistant, long operating life. For a booklet describing Monsanto's MAN-1, circle No. 241.

3. To properly mount these two devices, acquire two Barnes sockets: 029-275-11 for the Monsanto unit and 029-275-12 for the Fairchild unit. The Barnes sockets have large tapered lead entrances to facilitate the insertion of multiple leaded devices as well as having flanges for chassis mounting applications. (They are also available without flanges for printed circuit boards at same cost.)

4. Acquire seven Mepco Green Line resistors RN55C1210F. Now you are ready to wire. For full information on complete package circle No. 242.

*Medium Scale Integration.

Type No.	Prices		
Fairchild	**1-24**	**25-99**	**100+**
U6B931751X (Mil. Temp.)	28.00	22.40	18.80
U6B931759X (Com'l. Temp.)	14.00	11.20	9.40
Monsanto	**1-9**	**10-99**	**100+**
MAN-1	48.00	44.00	38.00
Barnes	**1-49**	**50-99**	**100+**
029-275-11 (14-pin)	1.70	1.55	1.40
029-275-12 (16-pin)	1.90	1.70	1.55
Mepco			
RN55C1210F	12¢ each when ordered with package.		

Three more jump aboard Schweber's Chip Bandwagon

In our June issue we announced the availability of Motorola Zener diode chips from Schweber stock for use primarily in hybrid circuits. This month Schweber announces three more chip lines which should interest companies with in-house capabilities in thin and thick film hybrid circuits:

1. Semiconductor & I/C Chips from Union Carbide

Schweber will supply in chip form a broad selection from Union Carbide's silicon integrated circuits and discrete semiconductors. Single FETs, dual FETs, monolithic dual bipolar transistors, linear integrated circuits, and MOS devices are available in chip form. All Union Carbide chips are of silicon epitaxial planar construction. Special chip carriers enable parameter testing without removal from carrier. Circle No. 243.

2. Ceramic Chip Capacitors from Vitramon

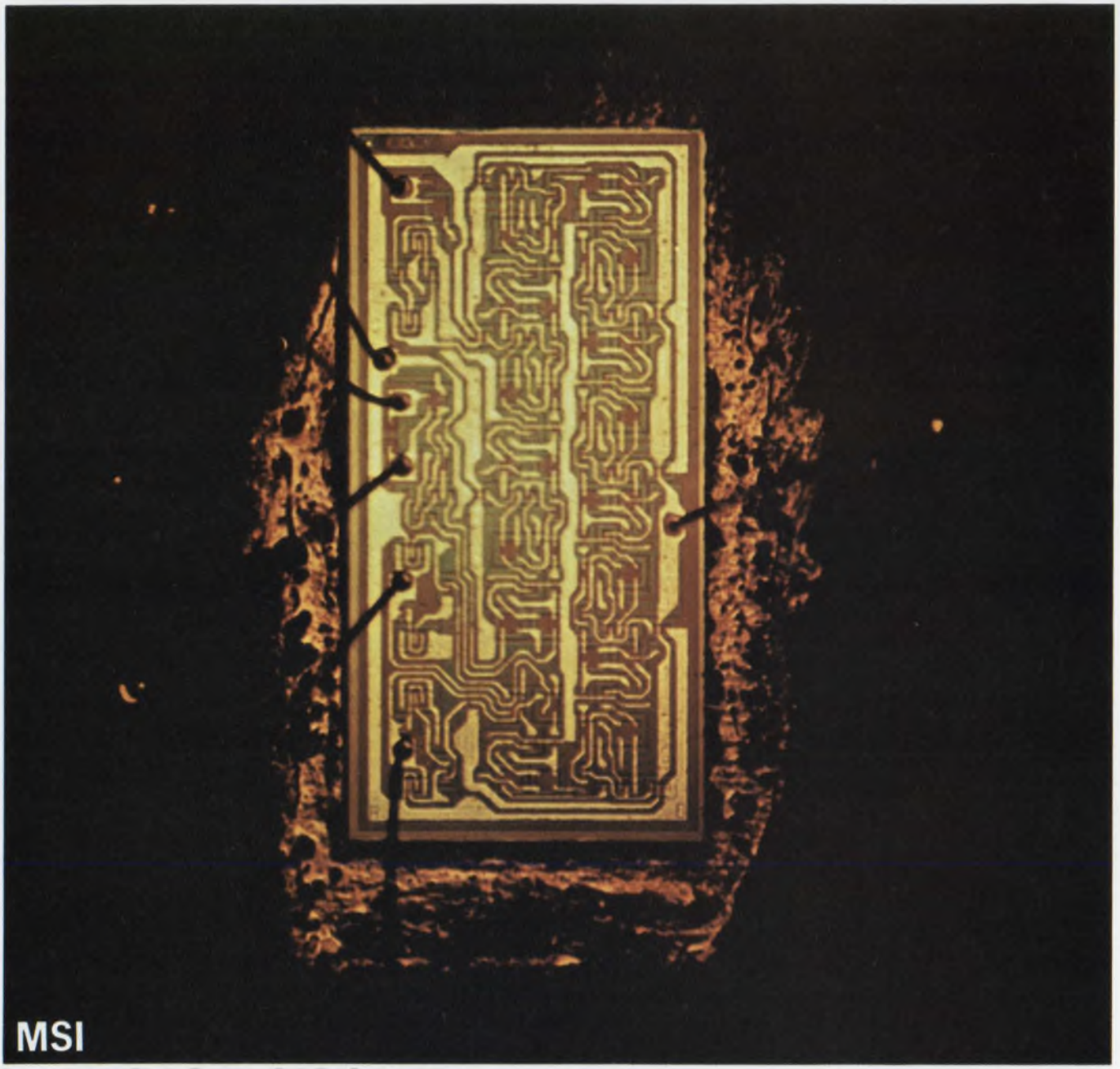
Monolithic ceramic chip capacitors in a capacitance range of 10 to 470,000 pf in ten physical sizes from .050" x .040" through .220" x .240" are now in Schweber stock. They have noble metal terminations providing a high degree of solderability. Voltage rating @ 85°C is 100 VDC and @ 125°C is 50 VDC. Temperature range −55°C to +125°C. Circle No. 244.

3. Solid Tantalum Chip Capacitors from Kemet

Solid tantalum capacitors in chip form complement ceramic chip capacitors by extending the capacitance range all the way to 100 uf. Its high volumetric efficiency is an ideal virtue in any application where the name of the game is microscopic size. Add to this, stable parametric performance and extended storage and operating temperature capabilities and you know you have a device that is made for the hybrid field. Circle No. 245.

SCHWEBER ELECTRONICS

Latest news on new products and prices from Schweber Electronics, Westbury, N.Y. 11590 (516) 334-7474 . . . Edited by Sam Kass



Sprague Series 54/74 ICs. Illustration: 54/7491 8-Bit Shift Register

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Design is easier. Package count and costs go down. Equipment gets smaller, neater, simpler. Simply because you get more inside every DIP or flatpack with Sprague Series 54/74 arrays.

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Divide-By-Twelve Counter	54/7492	8-Bit Shift Register	54/7491
4-Bit Binary Counter	54/7493	BCD Decoder/Driver	54/7441
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2-Bit Binary Full Adder	54/7482		

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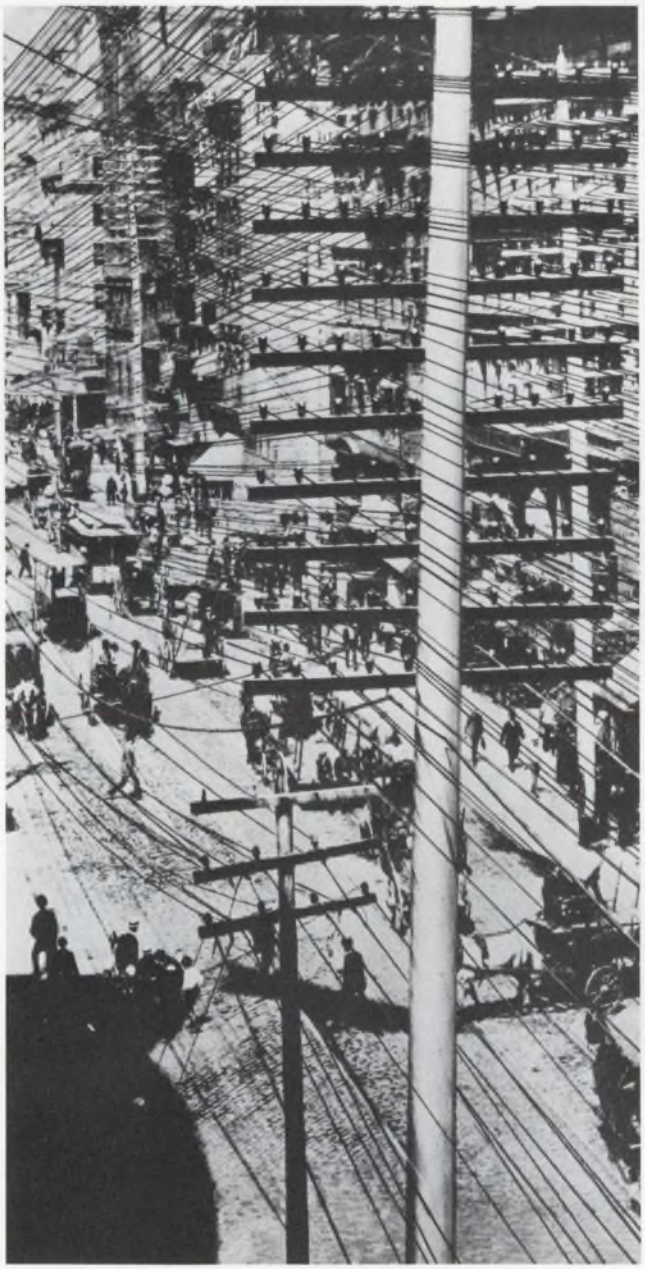
News



The nation's telephone system may be faced with problems as confusing as this maze of wires in an early New York street scene. p. 25

To speed up rescue, the Army is adding uhf to pilots' homing beacons and the Air Force is improving direction finders. p. 32.

S-3A carrier-based, antisubmarine warfare aircraft will have integrated avionics, computer-operated sensors, selective displays. p. 38.

Also in this section:

News Scope

FAA takes steps to automate airways

The Federal Aviation Administration is taking the first steps toward getting rid of a bag full of problems that have plagued the agency and the nation for a long time. With new equipment under contract, it hopes eventually to decrease the workload of the long-suffering and nearly mutinous air traffic controllers, as well as to tighten up—with increased safety—the spacing between aircraft during final approach. This would, of course, cut down landing delays that have been a growing nightmare for air travelers and the airlines for the past few years.

FAA plans to achieve these improvements in two steps:

- It will add at 64 big-city airports data-processing equipment that will enable controllers to put tags on all aircraft on the screen whether the aircraft are equipped with radar beacons or not.
- It will provide equipment to patch radar inputs from two or more ground radars onto one controller's screen—giving him a mosaic picture of a larger area.

At present the only alphanumeric tags on the controller's screen are those automatically generated by radar beacons. Most commercial aircraft are equipped with such beacons, but few business and private planes have them. Those without beacons are to the controller unidentified, hazardous blips on his screen. He can identify them by voice interrogation, but without tagging them alphanumerically he soon forgets which one is which.

With the new modular unit, he will interrogate the pilot and then tell the computer to give the blip a tag that will follow it wherever it goes.

Enroute radars now being installed between airports already have this capability built in. Unfortunately, the data-processing units used on them are not adequate for the terminal radars because of the extra load these busier radars must handle.

Under contract to design these modular units for the big airports is the Univac Federal System Div. of Sperry Rand Corp., St. Paul, Minn. The initial letter contract to make a preliminary design amounts to $85,000. The second phase will begin by December, 1970, and this calls for a developmental model—hardware and software. Phase 3 will be awarded for procurement of general-purpose components needed for testing. After this a production award will be made.

Next, in FAA's long-awaited improvement program, will be a follow-up contract with Univac for feeding computerized data from two or more radars to a single TV-like radar screen. The advantages of a mosaic picture of this kind are that the controller gets a view of a larger hunk of airspace, plus the assurance of radar coverage by at least one radar if another one should fail.

A facility for multiprocessing is necessary for this operation—that is, two or more computers are needed to digest and piece together the mosaic picture. This will entail still another contract, also with Univac.

World electronics sales to triple by 1980

The world electronics original equipment market (EOEM) will soar to $90-billion by 1980, compared to the $33-billion level for 1967, according to Hugh D. Kennedy, vice president of Ness International, Palo Alto, Calif. The non-U.S. segment will account for $43-billion in 1980, a sharp increase over the 1967 level of $12-billion.

Today exports account for one-third of the market served by the U.S. electronics firms; by 1980, about half of the industries' output will be slated for overseas sales.

To illustrate the trend, Kennedy cited that, during the past three years, U.S. electronics exports have grown by 75% with the largest gains garnered by semiconductors (142%), computers (122%) and broadcast equipment (115%).

The U.S. market is expected to expand from $21-billion to $47-billion in 1980 with $7-billion for consumer products, $21-billion for military/NASA and $19-billion for the industrial market.

Kennedy urged U.S. firms to expand their overseas marketing horizon beyond Europe and Japan and to pay particular attention to small, underdeveloped countries where electronics would eventually be in heavy demand.

Automated MOS design from Collins Radio

Automated MOS design and fabrication are now offered by Collins Radio Co., Newport Beach, Calif. Bob Johnson, vice president and general manager, has announced that a Collins customer can now communicate directly with the Collins automated MOS/LSI design facility via remotely located computer terminals. Inputs to the system can be in the form of logic, equations or FORTRAN statements.

The customer, Johnson says, in effect commands Collins' entire MOS process during design and production. His instructions to the system, called the C-System, may be input from terminals located in Collins facilities, or from a terminal installed in his own plant.

Johnson says that Collins' capability at present is 100 designs per month, with turnaround, at a cost of $8,000 to $12,000 for a sample quantity. The company can now turn out 10,000 chips/month, and expect to increase this capacity to 100,000 chips/month by December, 1969. Chip size can go as large as 160 × 160 mils.

Electrical parameters, logic and supply levels are all fixed by the Collins process, although process

News Scope CONTINUED

types and some functional variables can be specified by the customer. The system incorporates logic simulation, automatic placement, routing, and interconnect programs and automatic graphic display of the array design. Mask generation is automatic, by means of a computer-controlled variable-aperture camera.

Federal research funds may move from campus

Government-supported applied research, much of it of an electronic nature, may soon begin a drift away from university campuses, thanks to the actions of militant and dissident students. And the shift may prove a bonanza in the form of federal research funds for electronics companies.

So said Charles A. Anderson, president of Stanford Research Institute, during an address at the recent WESCON Sponsors Luncheon. But the shift will not be without its unpleasant side effects, says Anderson.

". . . when federal research funds come into your plants and facilities you might be well advised to see if there are militants close behind. Just as the projects follow the researchers, so the militant students and their tactics will follow. In short, gentlemen, your companies could well be the next targets."

Based on his experience at Stanford Research Institute, which is now terminating its long-standing affiliation with Stanford University as a result of dissident student activities, Anderson suggested three basic preparatory steps for industry management:

- Through your actions and public posture make it quite clear to those who might be planning harassment that you cannot and will not condone violence, and that you will not tolerate disruption of your work. You should make it clear that when laws are broken the civil authorities will be asked to take appropriate and swift action so you can go about your business.
- Get the people in your organization conditioned to the fact that harrassing tactics from small, well-organized and tenacious groups could be forthcoming in your plants and offices.
- Seek the understanding and support of groups and individuals in the communities in which you operate.

Electron-beam masking ups yields, cuts costs

Electron-beam mask generation will eliminate the problems of contact printing, raise yields and cut costs in IC manufacturing, according to Stephen J. Angelo, consultant with Westinghouse Research Laboratories, Pittsburgh, Pa.

The new process, developed at Westinghouse with Air Force funding will avoid the yield losses due to wafer damage and the low mask lifetime characteristic of the present contact printing methods, according to Angelo. IC patterns, in the new process, are printed directly on sensitized silicon wafers by means of electron-beam projection.

Dr. Hugle, president of Hugle Industries Inc., which participated in the development and has exclusive rights to manufacture and market the system, says, "A ninefold reduction in yield losses is possible by going to the new system, and the system can provide up to an 8.5-to-1 cost advantage.

The electron-beam system is also said to offer greater potential resolution, by a factor of five, than optical systems, and a much greater depth of focus. The high resolution may result in greater chip complexity. First deliveries of the system are expected in the last quarter of 1970.

Electronic thermostat offers portability

For the homeowner or commercial-building owner who thinks he has everything, a Brooklyn, N.Y., laboratory has introduced "the world's first wireless, portable electronic thermostat for central heating and air-conditioning."

The thermostat, called Space-Temp 100, works this way, according to an announcement by its developer, Kimco Laboratories, Inc.:

"It sends an electronic signal to the responder unit at the furnace or air-conditioner, commanding it to produce the exact heat or cool air required. Then, it automatically monitors the temperature electronically to make sure it's continually on target."

There are these advantages, the developer says: The thermostat can be moved from room to room, "guaranteeing accurate control of the temperature wherever it is located." And since it's all circuitry, with no moving parts, "it is unaffected by external factors such as dirt, dust, moisture and other afflictions that cause service problems with conventional thermostats.

Giant telescope to probe sun's secrets

Next month on a dry and cloudless mountaintop in New Mexico, Air Force scientists will try out the most elaborate solar telescope in the world. With the $3.3-million, 365-foot-high facility they will unveil secrets of solar disturbance that have long fouled up man's communications on earth and his delicate instruments in satellites. Now it endangers man himself as he goes farther into space.

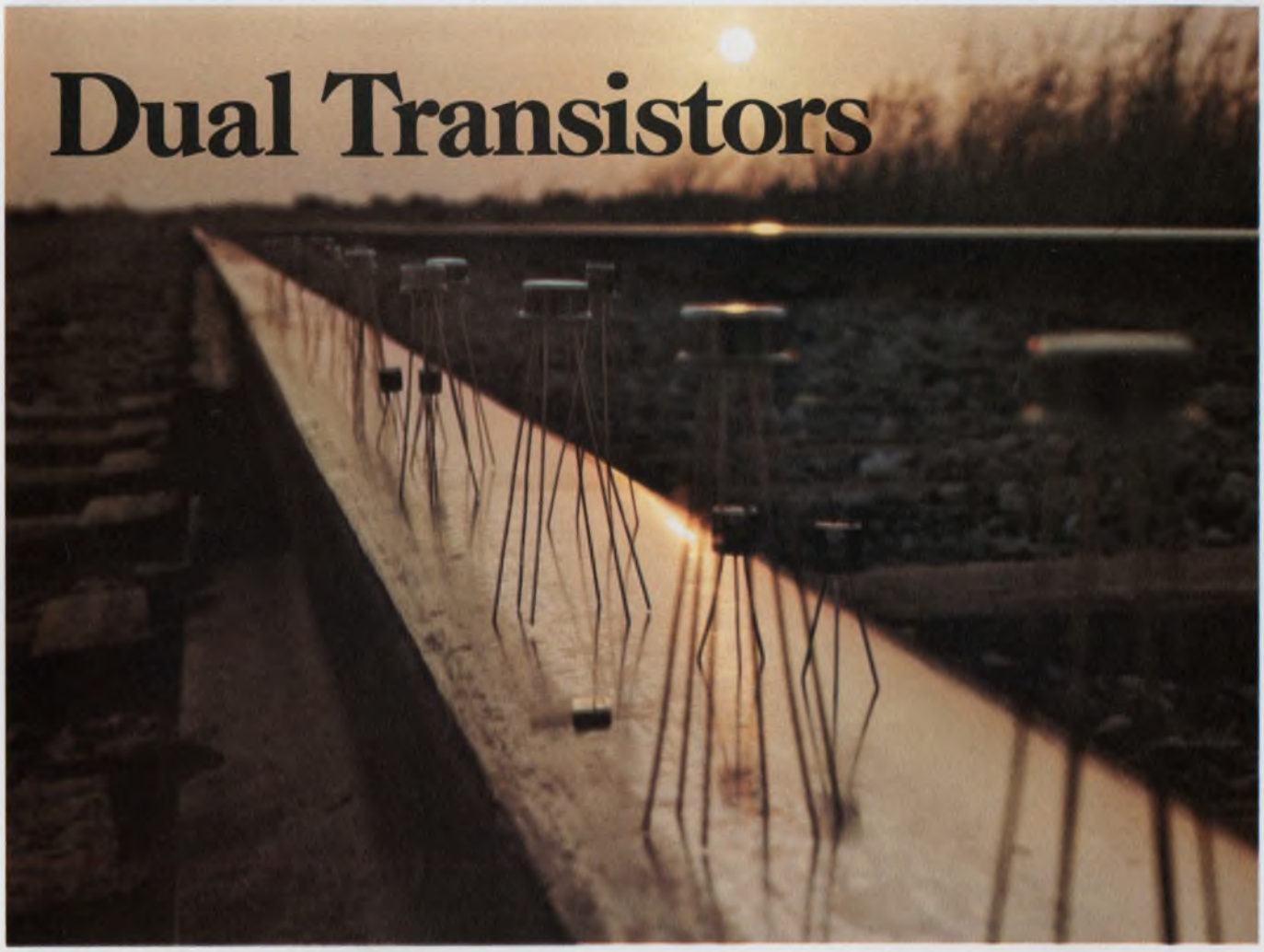
Central core of the telescope is a 321-foot cylinder—227 feet of which is underground—with a maximum diameter of 10 feet. The cylinder weighs 250 tons and is evacuated to 250 torr, a pressure equivalent to that at an altitude of 180,000 feet. It is suspended like a pendulum, floating on a 11-ton pool of mercury.

The mercury provides a friction-free bearing for the entire core assembly, which rotates to follow the sun at one revolution per minute.

The telescope contains three evacuated spectrographs, each 68 feet long with diameters of five feet.

The telescope is operated by stored programs in an SDS-Sigma 2 computer.

Air Force Cambridge Research Laboratory sponsored the development of the project.



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TIS92M*	NPN	TO-18 SILECT**	2N2977	NPN	TO-71
TIS93†	PNP	TO-18 SILECT**	2N2979	NPN	TO-71
TIS93M†	PNP	TO-18 SILECT**	2N3350	PNP	TO-77
2N2060	NPN	TO-77	2N3680	NPN	TO-77
2N2223	NPN	TO-77	2N3838	NPN/PNP	FLAT PACK
2N2639	NPN	TO-77	2N4854	NPN/PNP	TO-77
2N2642	NPN	TO-77	2N5045	N-CH. FET	TO-71
2N2643	NPN	TO-77			

They're part of TI's line of preferred semiconductors, selected after months of computer demand analysis to save you time and money in specifying discrete devices.

To obtain data and specifications on preferred dual and matched-pair transistors, write for TI's *Preferred Semiconductors and Components* Catalog: Texas Instruments Incorporated, PO Box 5012, MS 308, Dallas, Texas 75222. Or just circle reader service card number 115.

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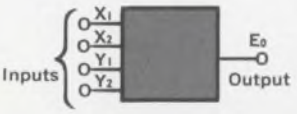

Two new 4-quadrant units capable of performing multiplication, division, and square-rooting . . . and of accepting both differential or single-ended inputs. Both units have good power supply rejection, high input impedance and require no external trimming.

- 1% accuracy* unit priced at $49.00 in 100 quantity.
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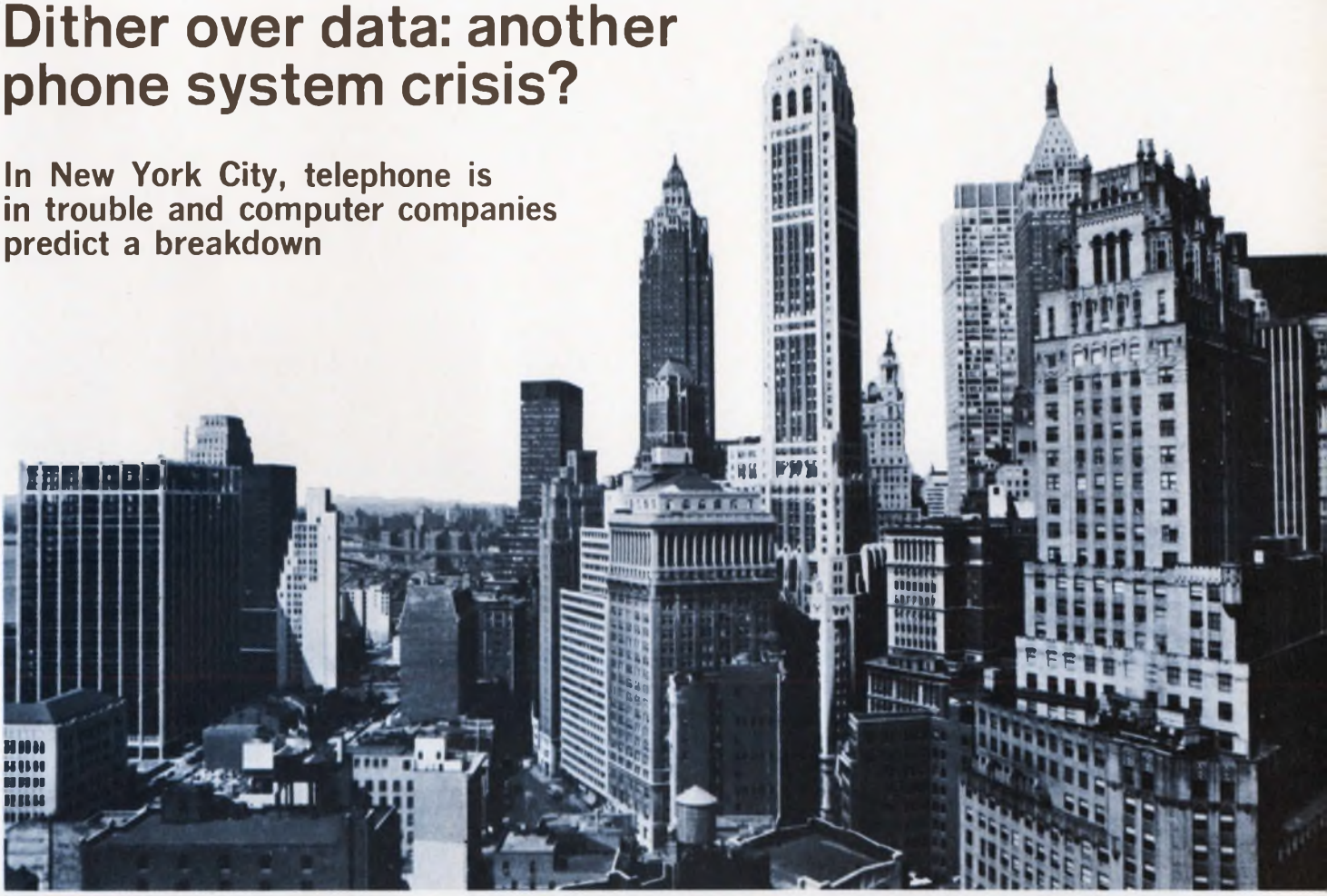
Dither over data: another phone system crisis?

In New York City, telephone is in trouble and computer companies predict a breakdown



John N. Kessler
News Editor

Telephone systems in urban areas are in trouble, and the question is: With the data communications explosions just beginning, will the phone company be able to handle intercity data transmission?

The problem was dramatically illustrated in New York City recently when an electronic switching system went "down" three times for about 50 minutes each. The response of the public was immediate: three companies took ads in *The New York Times* to complain about the service — and the city's Department of Consumer Affairs says that if customers don't get service, they don't have to pay their bills.

How do the problems in New York City relate to computer services? Lewis C. Clapp, president of Dial Data, Inc., of Englewood, N.J., told ELECTRONIC DESIGN that his company "was advised confidentially by people within the phone company that a serious overload problem was developing in Manhattan and that we should try to stay out of the area."

Telephone blackout predicted

Clapp predicts that "unless drastic and dramatic measures are taken to correct and improve the situation now, then by 1972 we will be experiencing national telephone blackouts." Dial Data is typical of the numerous computer design and consulting firms that use the telephone switched network to transmit data to their customers.

William B. Quirk, AT&T marketing director — data communications, was quoted in *The New York Times* (August 20) as saying that the computer data transmissions over telephone lines now account for about 3 per cent of all telephone time consumed in the United States. "By 1980," he predicted, "we figure it will probably grow to somewhere around 5 per cent."

Yet in a recent speech, president Paul A. Gorman of Western Electric said that "data information transmitted in 1980 will equal that of all voice communications." Back in 1967, former AT&T president F. R. Kappel said, "In a few year's time, data communications will actually exceed in sheer volume the communications of speech." Referring to that speech, Stanley Damkroger, an AT&T assistant vice

(**telephone,** *continued*)

president, said, "Some may have doubted that (Kappel's) prediction, but at the rate data communications is growing in the private line field this may have happened."

James M. Freeman, director of press relations of AT&T, explains that the Gorman and Kappel estimates of usage have to do with volume of information, not the amount of circuits or circuit time.

However, neither Freeman nor his counterparts at Bell Laboratories and at Long Lines could tell ELECTRONIC DESIGN how much data is being sent over telephone lines. The Bell System, it was explained, has worked hard to make telephone service able to accommodate both voice and data. But if such information is unavailable can the phone company be assured it can handle future data transmission?

Dial Data Inc. estimates that by 1975, more than 30 per cent of the revenues of the telephone companies will come from computer-related data transmission. "Companies such as Dial Data," says President Clapp, "provided the phone companies with detailed projections going several years into the future."

A. D. Little and Stanford Research Institute estimated that by 1975 more than 70 per cent of all computer use would involve time-sharing and that this would place heavy demands on the telephone system.

In an article in *Scientific American* (September, 1966) John R. Pierce, executive director, research, Communication Sciences Div. at Bell Telephone Laboratories, charts the growth of interstate phone circuits for voice and non-voice. Back in 1945, the total number of all interstate circuits totaled about 10,000 with 1000 for facsimile, TV and data. But according to Pierce, non-voice circuits "are expected to exceed message circuits next year (1967)."

By 1970, Pierce forecast there will be nearly 600,000 circuits for the Long Lines Co. (a division of AT&T) and that conventional telephone messages should constitute about one-third of the total use.

Data transmission over the telephone network is a particularly touchy subject because the hearings now before the FCC will determine who will carry data in the future. And AT&T lost an important decision when the FCC voted to permit a small independent company, Microwaves Communications, Inc., of Washington, D.C., to set up a private- line point-to-point microwave link between St. Louis and Chicago. (See ED 18, Sept. 1, 1969, p. 21.)

There are 150 time-sharing computer companies in the U. S., and their number is growing, particularly in urban areas like New York, Boston, Atlanta and Detroit.

Long Lines cable—part of network of 300,000 interstate telephone circuits. The cost per circuit mile is now down to $12.00.

The complaint is cost

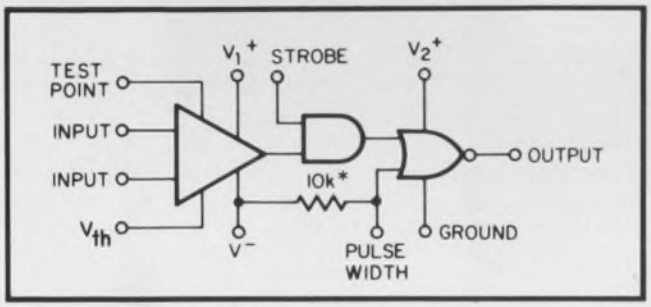
A major complaint of these companies is costs. Martin Cooperstein, executive vice president of Data Architects, Inc. of Waltham, Mass., says that the cost of data Communication where telephone lines are 90 miles or more exceeds the cost of computer service itself.

Cooperstein contends that "certain remote-access computer businesses are not coming into being because of communications costs."

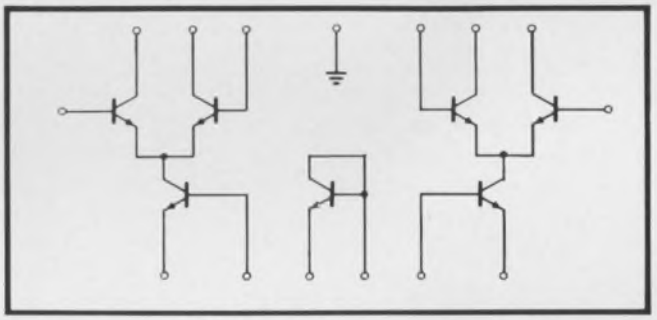
What are the costs to those companies? The same as the costs to everybody else. But the difference is that most telephone customers use their phones relatively infrequently. A computer expert says that the call volume from computer companies is 100 to 1000 times greater than from individual telephone customers or businesses.

Four ways to improve your memory:

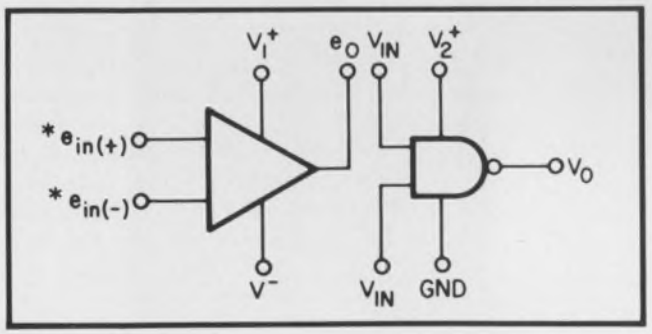
1. Improve your computer's memory with Linear Circuit 525. It's the one, the only high-speed core memory sense amplifier of its type that lets you set the threshold internally. (Or externally; take your pick.) More unforgettable features: 1) uncertainty range, ±4mV; 2) propagation delay, 30 ns; 3) low power consumption: 110mW; 4) high common mode range: +4.5V −3.5V.



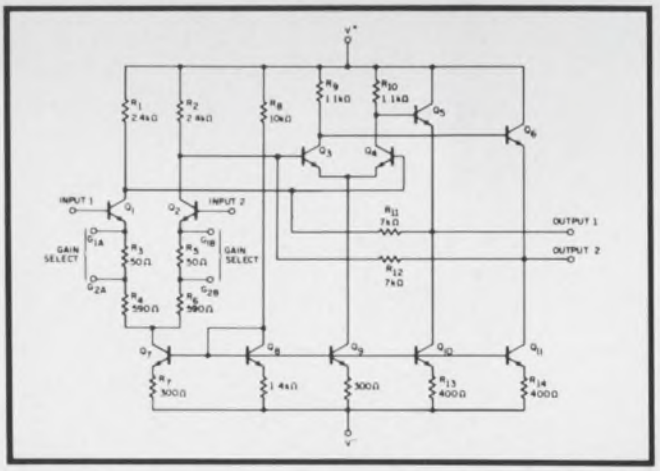
2. Improve your computer's memory with Linear Circuit 511. This one's a versatile transistor array. It's also a pre-amp — with DC characteristics that are 50 to 100% better than competing devices! Other memorable points: 1) low offset voltage ±2mV; 2) low offset current; 3) single power supply; 4) AGC capability.



3. Improve your computer's memory with Linear Circuit 526 — the high-speed comparator that's beyond compare! (Do you know of another comparator with a propagation delay of 30 ns?) Other features to remember: 1) operates from ±5V supplies; 2) overdrive recovery, 20 ns; 3) fanout of 10; 4) high gain operation; 5) output compatible with DCL, DTL and TTL.



4. Improve your computer's memory with Linear Circut 5733. It's the video amplifier that operates over — are you ready? — 120 MHz band width! Differential in/differential out with minimal phase distortion, too. And as a pre-amp in computer applications, don't forget: 1) 10 ns rise time; 2) fixed gains of 10, 100, 400 available (variable between 10 and 400 with a single, external resistor); 3) internally compensated (no external frequency compensation components required.)



P.S. We almost forgot: all four of these monolithic linear circuits are available right now — in production quantities. So are all the specs, facts, figures. Send for them today — before you forget!

Signetics

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INFORMATION RETRIEVAL NUMBER 16

(**telephone,** *continued*)

When Southern Bell requested an increase in rates because the message volume from computer companies used up a large number of its trunks in the Atlanta area, the regulatory commissioner asked the phone company to expand its flat-rate calling area. When the phone company complied, the computer companies increased in number.

Computer companies are concerned over the possibility of a rate increase that would apply to them because their holding times are supposed to be longer than other customers. "Actually," says Clapp, "the average holding times for computer traffic have been dropping steadily over the last two years."

In many remote computer inquiries over the telephone line, a data customer wants to find a specific fact, such as a credit balance for an account. In such cases, says, Clapp, the holding time is much less than that for normal voice use.

Clapp says that in some areas the telephone company has requested a 50 percent increase in rates for computer time-sharing customers. But a spokesman for New Jersey Bell says he has heard of no such plans and in fact took the position that if rates went up for the computer companies they would be singled out unfairly.

The Bell System is not engineered for all its phones to be in use 24 hours a day. But to make best use of communication channels this is just what a company should do, especially where there is a flat fee for service. Cooperstein says, "If we buy higher cost services we'd like to share the cost of the services with other people, but this is restricted. This poses a problem because we can't make 100 per cent use of these channels."

Another complaint of the computer companies is the modem used to couple computers and terminals to the telephone network. Lewis Clapp of Dial Data says, "This device costs a user about $25 a month. The unit probably doesn't cost more than $100 to manufacture. Our average computers use 40 lines. This means we have to rent 40 of these modems a month."

There are other ways to couple to the telephone network. Acoustic couplers have been on the market for several years. These units cost between $200 and $400 a piece. According to Clapp, their biggest advantage is economy and portability. And they can be purchased off the shelf.

Charles Carter, engineering director-methods, at Long Lines, says that the increasing use of customer-provided modems "is complicating our line testing." The Bell System is required to service such equipment, but customers are still accustomed to going to Ma Bell to help them out.

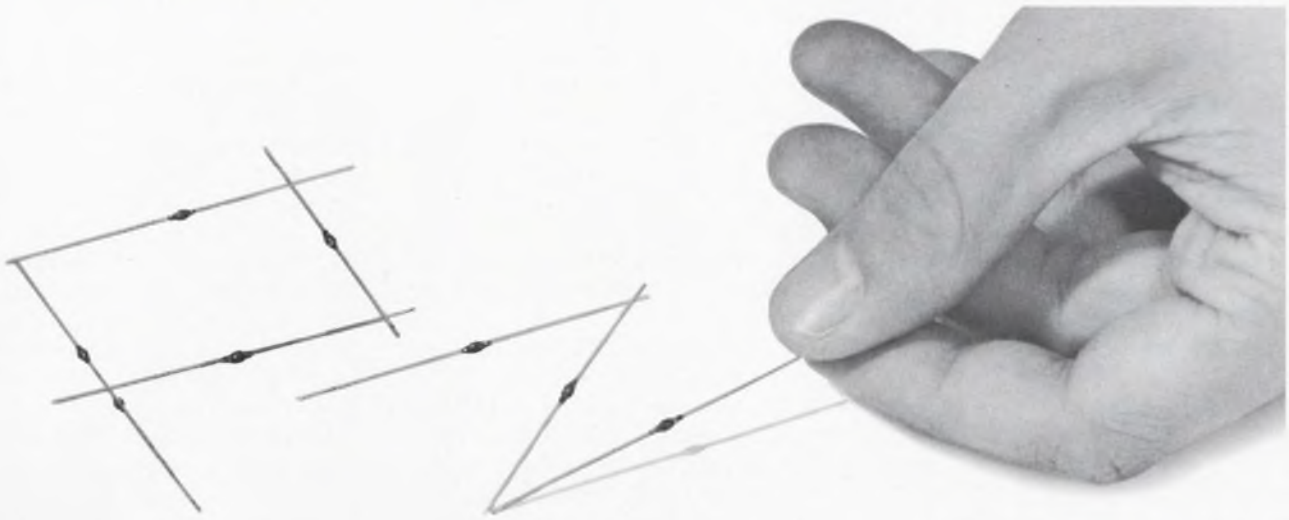
Politics may be another factor affecting telephone service, Clapp says that "Ninety per cent of all time-sharing users use the Teletype. But the FCC is exerting pressure on the phone company to sell its TWX service to Western Union. Consequently, the phone company is not interested in investing in teletypewriter equipment."

Carter of Long Lines, while agreeing that "the Bell System does have a limited line of data terminals — all manufactured by Teletype — also points out that a new printer has been developed. It is called Data Speed and operates at 1050 words a minute, with transmission between paper tape and paper tape. Carter says a printer for this system will soon be available, and it will print at the 1050 rate. This Inktronic system squirts jets of ink at the paper and deflects each droplet electronically.

Slow processing of orders is another complaint from the computer companies. But a spokesman for New Jersey Bell points out that it's difficult to get sufficient lead time to provide telephone equipment and switching facilities for new companies. "This is increasingly true," he says, "of -time shared computer companies that often operate secretively and jump into an area to get a specific group of customers. And they use phone lines at a very heavy rate."

New Jersey Bell says that only about 1 per cent of its telephone usage is for non-voice. But this usage is not evenly spread out. "It's a small percentage, but when demands increase in localized areas, there is a capacity problem, particularly when we have a little lead

Master control center for New York Telephone Co.'s electronic switching system, one of five in the city. It handles 40,000 calls an hour and serves about 10,000 telephone customers.



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INFORMATION RETRIEVAL NUMBER 17

time to anticipate the needs of these companies."

Phone company sees no problem

In considering Clapp's prediction of a telephone blackout, an AT&T spokesman said that during the great northeast power failure in 1965, it was Ma Bell who supplied all her vital services. In testifying before the Public Service Commission, William G. Sharwell, New York Telephone vice president said, "There never has been, nor are we now faced with, a massive communications failure of wide-scale telephone network breakdown."

But the telephone system is an entity that is sympathetic to every part of it. "If one city is in trouble," says Carter, "you feel it throughout the network." An organization at Long Lines has been set up especially to handle sudden overloads or catastrophic failures caused, for example, by Hurricane Camille.

In situations where telephone plant has been damaged, "the general bogey," says Carter, "is to get the first master group (600 lines) working within 10 minutes. This is the objective we have set for ourselves, and we aim to lower that bogey."

There are eight Long Lines restoration control centers in the U.S. These are the extensions of the network management group. Each center has a preplanned routine for restoring service in the fastest possible way. This system is manually operated and attended now, but Long Lines has plans for a computer system that would speed up restoration service for a master group to about three minutes, says Carter.

Long Lines now has about 300,000 circuits for handling interstate telephone traffic. In 1968, it added 9000 circuits. This year, it will add 25,000. And there are new transmission systems that will greatly augment present facilities.

The newest coaxial cable — L4 — carries 32,000 lines. This is more circuit capacity than the entire Long Lines network in 1959. By 1973, it will have installed between Pittsburgh and St. Louis an improved coax — L5 — that can handle 90,000 circuits. The field trial for this cable will begin in New Jersey next year.

Carter says that millimeter-wave transmission systems won't be ready or required for use until about 1978. But Long Lines has a trial program set for a millimeter-wave system between Netcong and Chester, N.J., for 1974. It lies along the Boston-Philadelphia route so that it can be placed into service at a later time. Millimeter waveguides will have a capacity of about 250,000 lines, according to Carter. The system will be digital; it will transmit 64,000 bits per second for every one of its voice channels.

Radio relay tower for Bell's TH3 microwave system. TH3 transmits 10,800 simultaneous telephone conversations.

Circuit costs dropping

In recent testimony to the FCC, Long Lines indicated that 75 per cent of the circuits it will have in operation in 1980 have yet to be built. And while Long Lines' total plant investment is now about $5 billion, the increase over the years will not be proportionate. The costs per circuit mile have been decreasing rapidly. Carter says that the cost per circuit mile is now about $12. Part of the reason is that Long Lines has a program of retrofitting installed facilities to increase system capacity.

In the area of switching, Carter expects to see a brand-new electronic switching system. "It will probably be called TESS — the total ESS," and it will handle from 10,000 to 30,000 circuits.

AT&T and Long Lines with Comsat have presented to the FCC a plan for a multipurpose domestic satellite system. This would intermix space communications with present ground facilities. But the domestic satellites system — what Carter calls "an electro-political question" — is still up in the air.

Why can't I make a trouble-free long-distance call? "That's a local exchange problem," says Carter ■■

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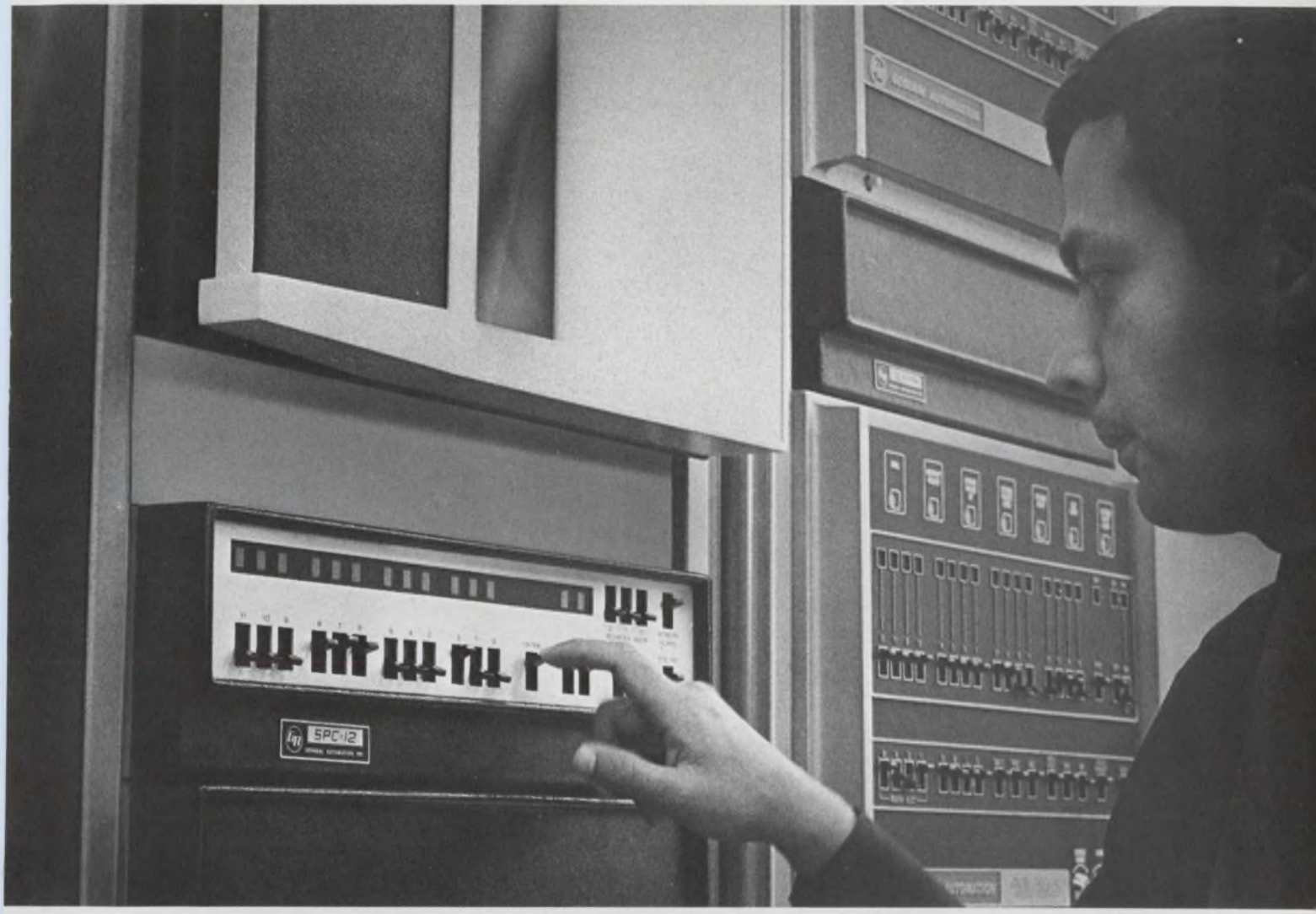

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INFORMATION RETRIEVAL NUMBER 18

Search for downed pilots made easier

Air Force and Army testing more sensitive direction finders and improved homing beacons

David N. Kaye
West Coast Editor

The Air Force and the Army are both testing ways to improve their methods of locating pilots who are shot down.

All pilots in combat carry radio homing beacons in their emergency kits but, according to the Air Force, they only bring a rescue aircraft within a mile of the downed man. (The Army claims its rescue aircraft do a little better.) Then, the rescue pilot has to search by eye. If the stranded pilot is wounded or concealed by high grass, he might not be found.

The Air Force hopes to remedy this by installing more sensitive airborne direction finders in its aircraft. Air Force engineers are evaluating one now produced by Cubic Corp., San Diego, Calif. It is called the ELF (for electronic location finder) by the company, and is designated AN/ARD-21 (XAI) by the military. The device is being tested by the Limited War Office, Aeronautical Systems Div., Wright-Patterson Air Force Base, Ohio.

Four antennas get signals

The system consists of four flat spiral antennas that mount on the bottom of a helicopter and a 6 × 7 × 10-inch receiver-processor that mounts inside. The antennas, which weigh about 20 pounds, have beam widths of 120 degrees. According to Wayne Taylor, Cubic's project engineer, "The side beam width is necessary in order for the helicopter to detect a signal regardless of where the downed pilot is."

During a rescue mission, the antennas receive signals transmitted by a pocket-sized radio carried by all airmen. The phase difference between the signals received by two of the antennas gives the X coordinate of the airman's position and the phase difference between the signals received by the other two antennas gives the Y coordinate.

The receiver-processor translates the phase information into a standard localizer display of the type carried in most rescue helicopters. The display consists of a circle and two cross-hairs. When the circle is centered over the junction of the cross-hairs, the helicopter is right over the target.

Sling cuts through foliage

After locating the downed airman with the ELF system, a 250-foot rescue sling that will cut through dense foliage is lowered to the ground. Taylor says that "at an altitude of 200 feet, ELF will allow the sling to be dropped less than 10 feet from the target."

Four, flat, spiral antennas, with beam widths of 120 degrees, will lead rescue aircraft to downed pilot's radio homing beacon. Maximum error is 3 degrees.

At any altitude, the maximum error in location is about 3 degrees.

ELF can find a target, regardless of the type of modulation on the transmitter. "An early problem in the development of ELF," says Taylor, " was what to do when the helicopter tilted, or did not remain stable. The solution is to feed back gyro information to the processor, which automatically adjusts the pilot's display to correct for the tilt."

With an all-weather capability, ELF functions in darkness, fog, rain, over water and heavily wooded or rough terrain with a high degree or accuracy.

"During the hovering period," says Taylor, "when pickup is being executed, the ELF system cannot be jammed by other nearby radio beacons."

Army tests rescue beacon

The Army is also looking for ways to upgrade its airborne direction finders. But its first goal is to add channels to the rescue beacon so that more aircraft will be able to hear its signal.

The radio beacon it uses now sends out a distress call on vhf/fm only, which limits its reception to Army aircraft. A new beacon being tested also transmits — as well as receives—on uhf/am, the band used by Air Force and Navy aircraft. Its range is 10 miles.

The Army wants to improve this range as well as the homing accuracy of the airborne equipment.

Designated AN/URC-68, the beacon being tested was developed by the Magnavox Co., Fort Wayne, Ind., under the technical direction of the Avionics Laboratory of the Army Electronics Command, Fort Monmouth, N. J.

The radio is undergoing environmental and electromagnetic compatibility tests at the Electronic Proving Ground, Fort Huachuca, Ariz. ■■

Integrated Circuit IDEAS FROM SYLVANIA

How SUHL ICs keep track of trains.

Automatic car identification system uses 28 different varieties of SUHL TTL integrated circuits.

By 1970, every freight car in the United States will be carrying a label similar to that shown at the lower right. It's all part of an automatic car identification system called KarTrak*. The KarTrak ACI system was designed and developed by Sylvania and has been adopted for use by the Association of American Railroads.

Heart of the KarTrak ACI system is an electronic scanner that reads the color coded strips on the label. The basic decoder unit utilizes 9 integrated circuit boards each containing 40 SUHL TTL packages for a total of 360 integrated circuits. The decoder section processes the information from the labels as they are scanned on a passing train. This data includes identification of the owning railroad, and the car number. Other information such as car weight can also be included.

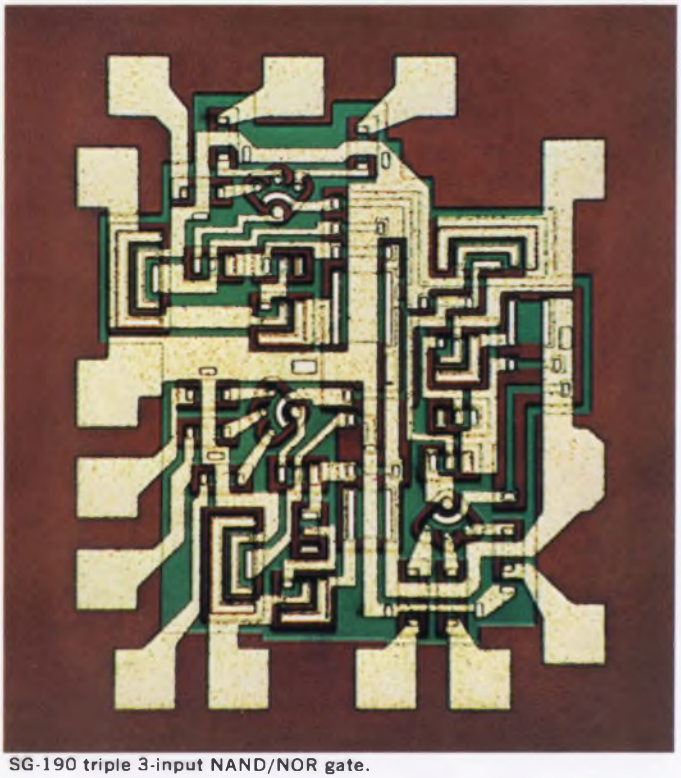
The SUHL integrated circuits have to work in an extreme environment. The trackside scanning units are placed in open areas all over the United States and have to bear the heat of summer as well as the cold of winter. No special precautions were taken with the SUHL circuits. They are all standard off-the-shelf units. In addition to the basic decoder section, SUHL circuits are used in other portions of the system. A message generator that gives information on complete trains uses 60 SUHL TTL integrated circuits. A core memory storage section uses 360 SUHL TTL circuits.

Also available are five communications interface options, only one of

continued next page

*Trade Mark

This issue in capsule



SG-190 triple 3-input NAND/NOR gate.

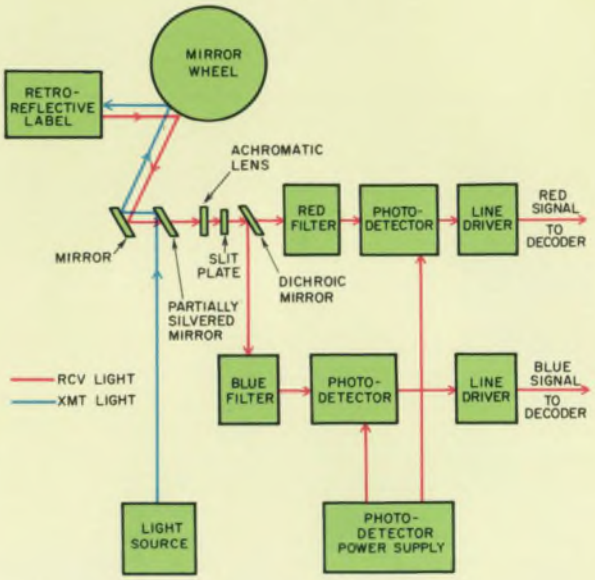
which is used at a time in a given system. Each interface unit consists of three circuit cards containing 40 SUHL ICs for a total of 120 circuits per system.

A read-only memory is also available as an option. This unit converts numeric input to alphanumeric output information. The read-only memory is made up of four circuit cards, each carrying 25 SUHL TTL ICs.

One of the main reasons that SUHL IC logic was selected for the KarTrak ACI system is the large numbers of logic forms available in the family. SUHL logic has the broadest line in the industry. More than 28 different types of SUHL circuits are used in the KarTrak ACI system.

This wide range of device types enabled the design engineers to tailor the system to the optimum configuration. Package count was kept to a minimum and actual design was simplified.

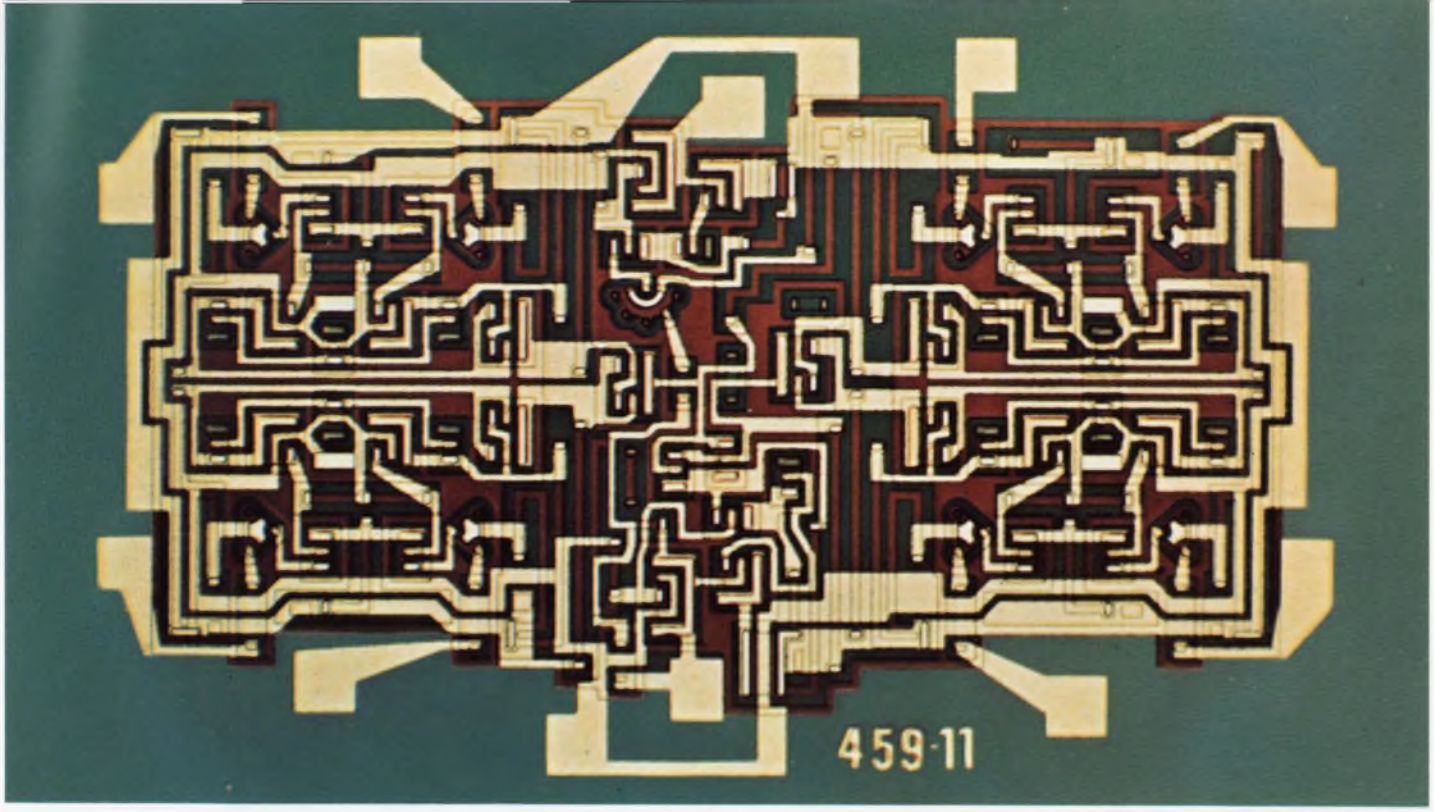
CIRCLE NUMBER 300



How the KarTrak ACI system works.

The KarTrak car label is made up of a series of colored strips of retroreflective material. The strips are arranged one on top of the other in a color sequence. Each strip is divided into two parts whose colors represent discrete numbers to the trackside scanner.

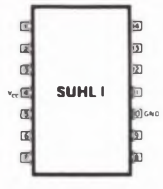
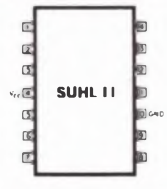
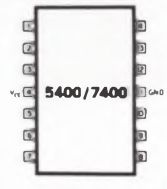
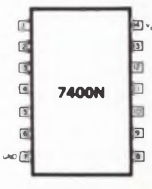
The KarTrak scanner is mounted alongside the railroad track. When a train passes, light from a 9,000 Watt xenon lamp scans the side of the train. Light from the label is reflected back into the scanner where it passes through a partially silvered mirror. From here the light is focused through a lens to create an image of the label. The image is transmitted through a slit plate to a dichroic mirror. At this point the light is optically filtered into two broad spectra defined as red and blue. Here, photomultipliers change the optical signals into coded electrical pulses for input to the decoder.



SM-120 parity generator/checker.

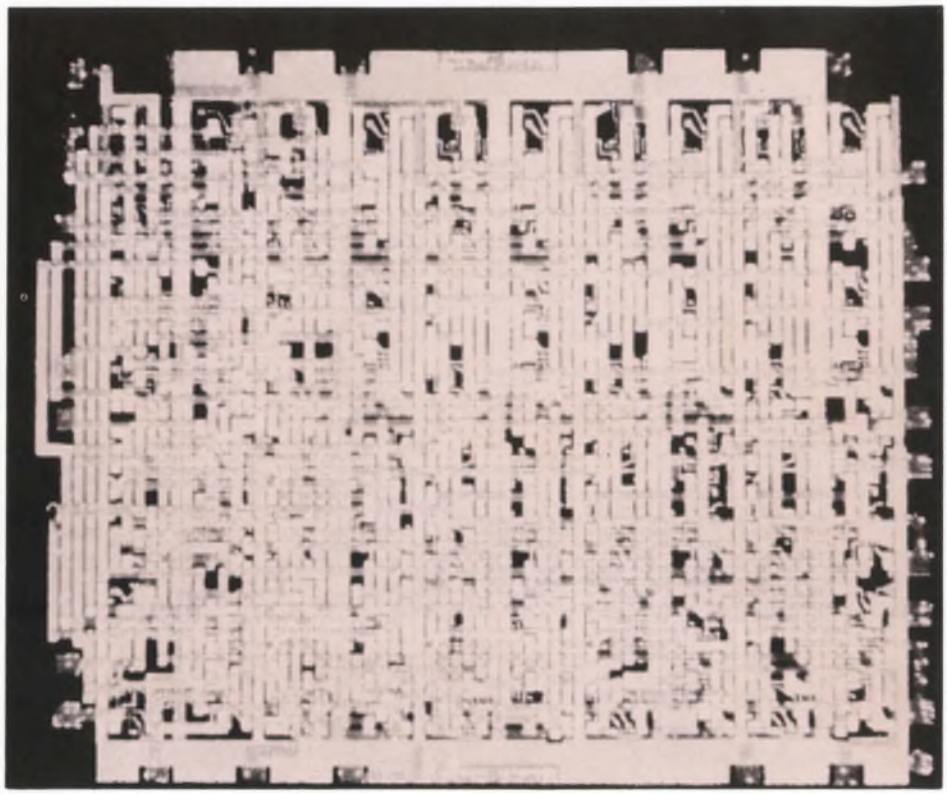
Sylvania TTL Integrated Circuits

Function	SUHL I	SUHL II	5400/7400	7400N
Dual 4-Input NAND/NOR Gate	SG40, 41, 42, 43	SG240, 241, 242, 243	SG5420, SG7420	SG7420N
Single 8-Input NAND/NOR Gate	SG60, 61, 62, 63	SG260, 261, 262, 263	SG5430, SG7430	SG7430N
Expandable Single 8-Input NAND/NOR Gate	SG120, 121, 122, 123	SG200, 201, 202, 203		
Dual 4-Input Positive NAND Buffer	SG130, 131, 132, 133		SG5440, SG7440	SG7440N
Quad 2-Input NAND/NOR Gate	SG140, 141, 142, 143	SG220, 221, 222, 223	SG5400, SG7400	SG7400N
Triple 2-Input Bus Driver	SG160, 161, 162, 163			
Triple 3-Input NAND/NOR Gate	SG190, 191, 192, 193	SG320, 321, 322, 323	SG5410, SG7410	SG7410N
Expandable 4 Wide 2-Input AND-OR Invert Gate	SG50, 51, 52, 53	SG250, 251, 252, 253	SG5453, SG7453	SG7453N
4 Wide 2-Input AND-OR Invert Gate			SG5454, SG7454	SG7454N
Dual 2 Wide 2-Input AND-OR Invert Gate	SG70, 71, 72, 73	SG310, 311, 312, 313	SG5451, SG7451	SG7451N
Exclusive OR with Complement	SG90, 91, 92, 93			
Expandable Triple 3-Input OR Gate	SG100, 101, 102, 103	SG300, 301, 302, 303		
Expandable Dual 4-Input OR Gate	SG110, 111, 112, 113	SG210, 211, 212, 213		
Quad 2-Input Lamp Driver	SG351, 353		SG5401, SG7401	
Quad 2-Input Positive NOR Gate	SG330, 331, 332, 333	SG340, 341, 342, 343		SG7402N
Hex 1-Input Inverter	SG370, 371, 372, 373	SG380, 381, 382, 383		
Dual Pulse Shaper/Delay AND Gate	SG80, 81, 82, 83			
Dual 4-Input AND-OR Gate	SG280, 281, 282, 283			
Dual 4-Input AND Expander	SG180, 181, 182, 183			
Quad 2-Input OR Expander	SG150, 151, 152, 153	SG230, 231, 232, 233		
Dual 4-Input OR Expander	SG170, 171, 172, 173	SG270, 271, 272, 273		SG7460N
Expandable Dual 2 Wide 2-Input AND-OR Invert Gate				SG7450N
Single Phase SRT Flip Flop	SF30, 31, 32, 33			
J-K Flip Flop (AND Inputs)	SF50, 51, 52, 53	SF200, 201, 202, 203		
J-K Flip Flop (OR Inputs)	SF60, 61, 62, 63	SF210, 211, 212, 213		
Dual D Flip Flop	SF80, 81, 82, 83	SF90, 91, 92, 93	SF5474, SF7474	SF7474N
Dual 35 MHz Flip Flop (Separate Clock)	SF100, 101, 102, 103	SF120, 121, 122, 123		
Dual 35 MHz Flip Flop (Common Clock)	SF110, 111, 112, 113	SF130, 131, 132, 133		
J-K Master Slave Flip Flop				SF7472N
Dual J-K Master Slave w/Clear				SF7473N

Pin Basing Available Packages	SUHL I	SUHL II	5400/7400	7400N
				
	Flat Pack Plug In	Flat Pack Plug In	Flat Pack	Plug In

The Unicell approach to large-scale integration.

Basic cellular method gives a high degree of flexibility to design of LSI circuits.



Adaptive 4-bit shift register uses 3-layer metallization.

Our research into large-scale integration has centered on a method of realizing arrays of a complexity of from 50 to 150 gates while retaining the design flexibility usually associated with less complex circuits.

We call our approach "Unicell." In our method, twenty to forty components are diffused in a fixed repetitive pattern resulting in a series of very small area cells. Cell can be made into gates, buffers, flip-flops or other logic elements simply by selecting the proper metallization pattern.

Assume you have a system requiring X number of 8-input gates, Y number of 4-input gates, and Z number of flip-flops. Further, assume that these elements must be interconnected to form a system function.

Here's how we go about it. The first step is to isolate enough cells on the wafer to provide a sufficient number to produce the needed logic elements. This group of cells becomes an array. Now the entire wafer has been divided into a series of arrays, each consisting of many cells (Fig. 1).

Next, the components in each cell are interconnected to form the required number of 8-input gates, 4-input gates, and flip-flops. The result is a series of arrays containing the required number of functional elements, but as yet the cells have not been interconnected with each other. That comes in the next series of steps.

At this point in the process, the entire wafer is covered with insulation. Then, windows are opened and the cells within each array are connected to each other in the vertical direction. Another layer of insulation is put down, windows opened, and interconnections are made in the horizontal direction (Fig. 2).

Thus, we have about one hundred identical arrays on a wafer, all internally interconnected to perform a system function. All that remains to be done is to test and package the individual arrays.

To accommodate the large number of functions built into each array, packages with 24, 36 or more leads are necessary.

Another feature of the Sylvania approach to LSI is that each cell can be designed for either high speed or low power operation. Characteristics of typical circuits are shown in the table. The low power logic cells have a power dissipation of 3.5 mW and a propagation delay of 10 ns. The high speed logic cells dissipate 12 mW and have a propagation delay of 3 ns.

The finished arrays interface well with SUHL, TTL and DTL integrated circuits having the same drive capability, loading factors and noise margins.

Some of the advantages of LSI can be seen from one logic system we designed on an experimental basis. One Unicell LSI package replaced 43 standard integrated circuits and 500 wired interconnections. The reduction in power dissipation over the IC breadboard version was a factor of three. Improve-

Unicell characteristics

	HIGH-SPEED CELL			LOW-POWER CELL		
	LOGIC GATE	DRIVER GATE	BUFFER INVERTER	LOGIC GATE	DRIVER GATE	BUFFER INVERTER
1. LOGIC (POSITIVE NAND)	$\overline{A \cdot B \cdot C \cdot D} = E$	$\overline{A \cdot B \cdot C} = D$	$A = \overline{A}$	$\overline{A \cdot B \cdot C \cdot D} = E$	$\overline{A \cdot B \cdot C} = D$	$A = \overline{A}$
2. POWER DISSIPATION	12 MW	15 MW	15 MW	3.5 MW	12 MW	15 MW
3. PROPAGATION DELAY	3 NS	8 NS	5 NS	10 NS	10 NS	5 NS
4. LOGIC FAN-IN	4 (EXP.)	3 (EXP.)	1 (EXP.)	4 (EXP.)	3 (EXP.)	1 (EXP.)
5. LOGIC FAN-OUT	10 4 (W/O)	10 4 (W/O)	10	10 8 (W/O)	20 4 (W/O)	20

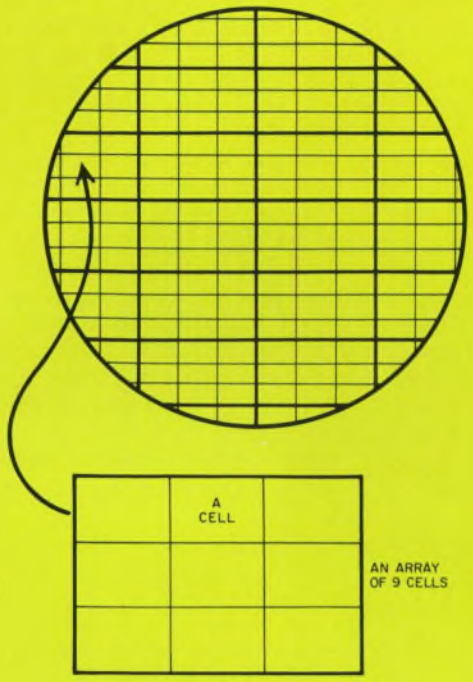


Fig. 1. Wafer is divided into a series of arrays, each consisting of many cells.

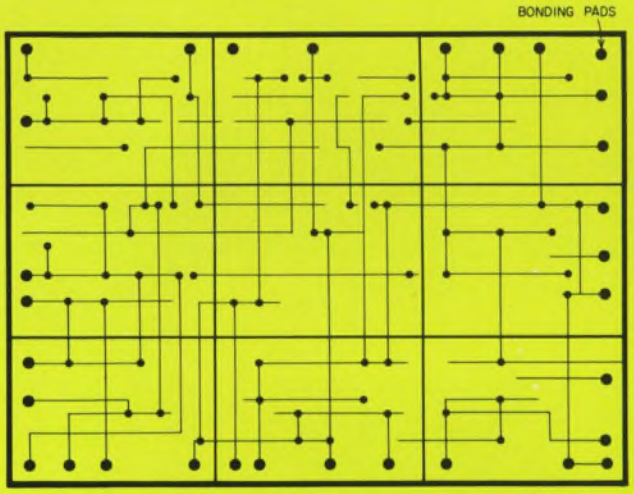


Fig. 2. Interconnections between cells are made by separate horizontal and vertical metallizations.

ment in propagation delay through the longest gate chain was a factor of two.

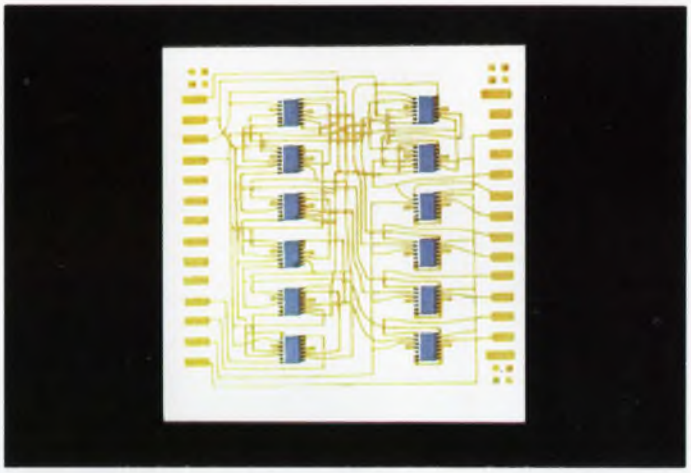
Improvement in speed/power product by a factor of 5 to 10 over standard integrated circuit families have been realized in other arrays that have been produced.

If you're considering LSI for your next design project, talk to Sylvania's engineers. They'll show you how to get high-level performance without losing design flexibility.

CIRCLE NUMBER 302

Hybrid shift register has many advantages.

Monolithic MSI on ceramic substrates provides complex logic functions without problems of LSI.



Hybrid 48-bit shift register uses 4-layer ceramic substrate.

Our new 48-bit shift register uses Sylvania MSI integrated circuits and a 4-layer ceramic substrate to obtain many advantages over large-scale integration systems and conventional printed-circuit board approaches.

The new design gives packing densities 8 to 10 times greater than can be obtained using printed circuits and flat packs. Because of the smaller size, short, narrow film conductors reduce interwiring capacitances to typically 1/5 to 1/10 that of multilayer printed circuit boards. Short lead lengths result in greater system speed.

The use of high purity alumina substrates also has advantages in thermal control. Thermal conductivity is about 100 times that of glass epoxy boards. Thermal resistance from junction to substrate is better than for conventional flat packs mounted on a printed-circuit board. The ceramic substrate is stable under prolonged exposure to temperatures up to 150°C.

The high-speed printing techniques used to make the ceramic multilayer logic arrays are inherently less expensive than photoetching, plating and laminating steps required for multilayer printed circuit board constructions.

In comparison to large-scale integrated circuit approaches our hybrid design has many advantages, too. For one thing, initial tooling cost is 1/10 to 1/100 the cost for monolithic LSI devices. Production costs are also far lower because the monolithic MSI integrated circuits used in our hybrid shift register are standard off-the-shelf items produced in high volume.

The hybrid approach also gives you design flexibility. Changes are easier to make. You can combine bipolar, MOS and other devices on the same ceramic substrate. And they can all be off-the-shelf devices.

We've also increased the reliability of our shift register by using beamlead ICs. In connections alone, use of beamleads has reduced the number from 42 man-made joints to 12 machine-made joints per IC.

With all of these advantages, wouldn't it pay you to investigate our hybrid shift register for your next application problem?

CIRCLE NUMBER 303

Up-down counters run at speeds up to 20 MHz.

High-speed devices cut package count, reduce wiring, and lower power drain.

Our new SM-183 and SM-193 up-down counters are functional arrays that contain four J-K flip-flops. Both are 4-bit synchronous up-down counters capable of speeds up to 20 MHz. The SM-183 is a binary counter and the SM-193 provides a binary coded decimal output. A mode control input switches internal gating to select up or down counting. An additional advantage that both the SM-183 and SM-193 have over conventional 4-bit counters is that appropriate flip-flop outputs are internally ANDed with the clock input. This provides a decoded clock signal to trigger the next counter stage for near synchronous systems operation.

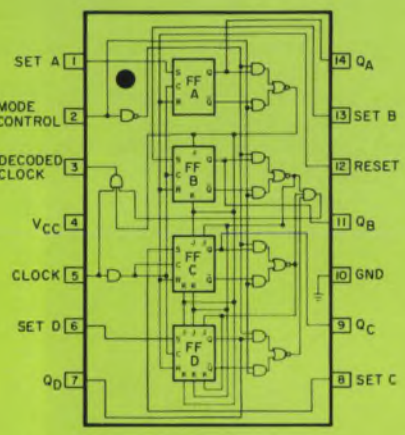
The SM-183 binary up-down counter (1248 code) is designed for computer applications. Its decoded clock goes high with the clock input when the counter is counting up and is in the "1111" state or when the counter is counting down and is in the "0000" state.

The SM-193 binary coded decimal counter is suitable for use in display devices or anywhere a coded decimal output is required. The decoded clock of the SM-193 goes high with the clock input when the counter is counting up and is in the "1001" state or when the counter is counting down and is in the "0000" state.

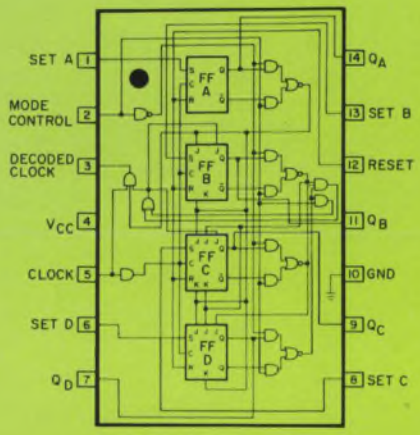
Each flip-flop in the counters has an external Q output, an asynchronous SET input and a common reset input. A logic "0" at the RESET input causes all four flip-flop outputs to go to a logic "0". A logic "0" at any SET input causes the corresponding output to go to a logic "1".

The SM-183 and SM-193 up-down counters are compatible with SUHL I and SUHL II integrated circuits as well as other Sylvania arrays. They are immediately available for operation over the industrial temperature range of 0°C to +75°C in your choice of 14-lead hermetic packages, flat packs or dual in-line packages.

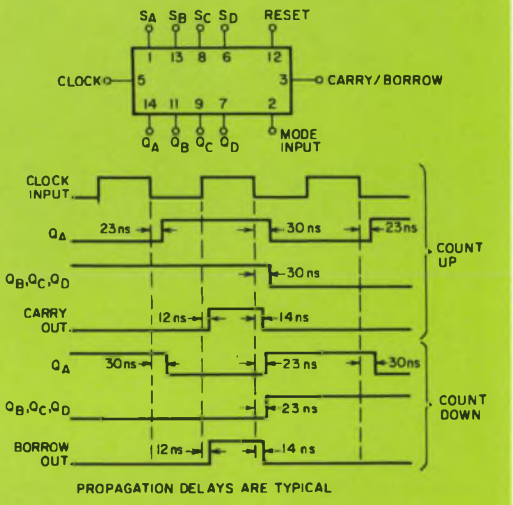
CIRCLE NUMBER 304



Logic diagram of SM-183 binary up-down counter.

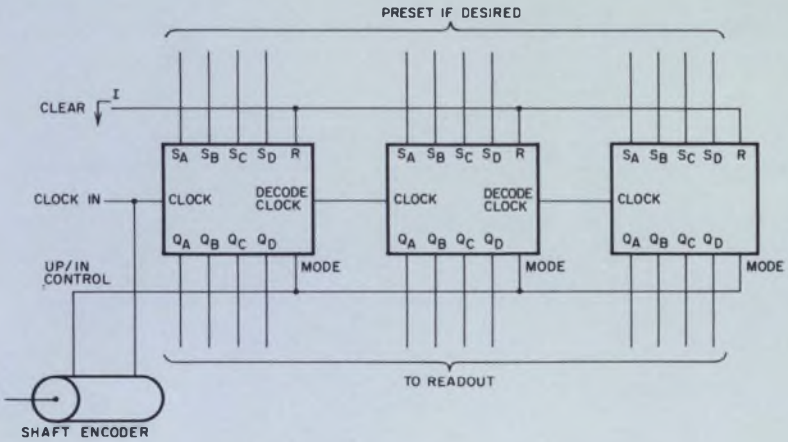


Logic diagram of SM-193 decade up-down counter.



PROPAGATION DELAYS ARE TYPICAL

Typical operating characteristics of counters.



Using up-down counters with shaft encoders

Internal gating provided in the package makes the SM-183 and SM-193 especially useful in applications requiring both up and down counting. An example of this could be an X/Y plotter which would have shaft encoders on each axis. To keep track of the position of the plotter, all that is required from the encoder would be a direction of motion signal and a clock pulse for each unit distance of travel. Thus, if the Up-Down Counters were reset to zero at the 0 0 coordinates of the plotter, the counters could count up for displacement in the positive direction and count down for displacement in the negative direction.

If the encoder provided a pulse for every micron of distance traveled, the Up-Down Counters would always contain the value in microns of displacement from the 0 0 position.

Isylithic beamlead ICs rival discrete components.

Isolation process eliminates parasitic capacitances, gives 1 to 2 nanosecond switching speeds.

Sylvania is now developing an Isylithic beamlead process for making integrated circuits that are a match for the best discrete components in most respects and are even better when it comes to speed.

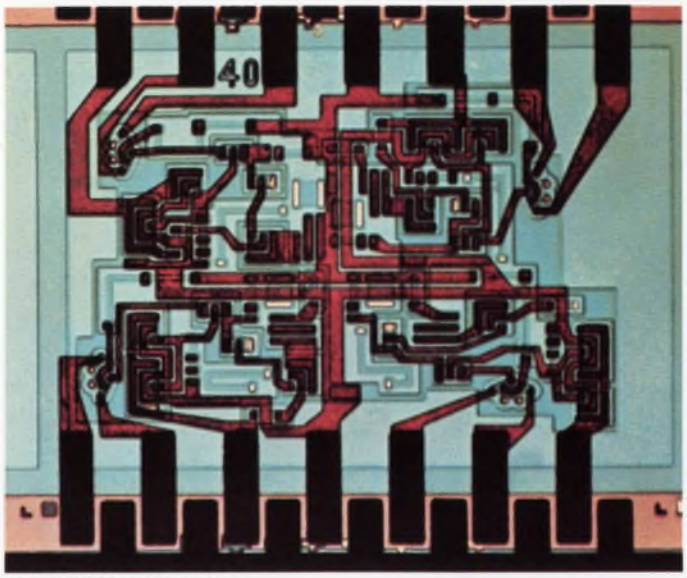
In Isylithic devices, circuit elements are air isolated from each other. This eliminates parasitic capacitances and permits performance equal to discrete device systems. The use of beamlead construction permits closer interconnection of components and lower lead inductance. This makes possible switching speeds in the 1 to 2 ns range.

Isylithic devices are made in a manner similar to the process for ordinary integrated circuits except that the buried layer and isolation diffusion steps are eliminated. After the diffusion processes have been completed a thin-film metallization pattern is deposited and heavy gold beamleads are electroplated on top of the metallization. Isolation of the circuit elements is obtained by selectively etching the back of the wafer to provide air isolation between the elements.

The finished integrated circuit is now ready for face bonding into film hybrid or microstrip circuits.

Sylvania has been working with beamlead devices for over three years and finds that they have definite advantages over other types of flip chip mounting.

Among the chief advantages of beamlead are the visibility of the bonds for inspection, reliability of the metallurgy, and the possibilities for low-cost assembly. The beams are about 0.5 mil thick and extend about 6 mils from the edge of the circuit. The beams can be bonded directly and simultaneously to a metallized substrate. The resulting bonds can be inspected, tested and even individually repaired if needed.



Isylithic beamlead device.

The beams, being flexible, will tolerate differences in height of the substrate metallization. This can be an important factor in their use with thick-film circuitry where silk-screened metallization always has a certain degree of irregularity.

Our Isylithic devices are passivated with silicon nitride. This provides a chip that is completely protected against ion migration and requires only mechanical protection.

For assembly of beamlead Isylithic devices, we are developing computer controlled automatic equipment that will position the substrate, position the Isylithic device on the substrate and simultaneously bond all connections. This equipment is the forerunner of a completely automated assembly line.

Although the Isylithic process is still in the development stage at Sylvania, we are producing beamlead devices for use at microwave frequencies.

CIRCLE NUMBER 305

MANAGER'S CORNER

What does MIL-STD-883 really mean?

There has been a lot of confusion surrounding MIL-STD-883 and what its purpose is and how it can be most effectively used. This publication is the first attempt at codification of a military standard for test methods and reliability specifications especially for microelectronics. It was prepared by Rome Air Development Center with suggestions and recommendations being made by major suppliers in the industry prior to publishing.

The genealogy of MIL-STD-883 can be traced through a long line of military specifications including MIL-E-1, MIL-STD-202, MIL-S-19500 and MIL-STD-750. Many of the test procedures in "883" are similar to or identical to methods previously used in these earlier specifications; often, only the method numbers being changed.

MIL-STD-883 is similar to its predecessors in that it offers a wide variety of options as to stress levels and alternate methods for performing many of the tests. Thus, the phrase often used by some customers that their ICs must be processed, in accordance with "883", is completely meaningless unless specific procedures and stress levels are called out. If the customer is not sure which procedures and stress levels he needs, assuming he has already determined that one of our standard Sylvania test plans is inadequate, he should discuss his requirements with our Field Engineering and Quality Control groups prior to requesting a quotation.

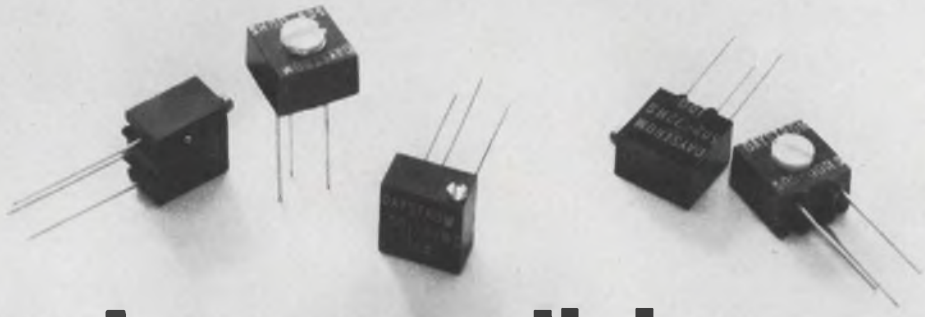
In addition to the standard types of environmental, mechanical, electrical and life tests, "883" contains some new and relatively controversial methods on Internal Visual (Precap) Inspection (2010), Screening Procedures (T5004) and Lot Qualification Inspection (T5005). These and other procedures are often the heart of many high reliability specifications. Sylvania has developed alternative precap and screening procedures which are less costly but still provide the desired level of reliability.

For our part, we believe firmly in the concept of "building the quality in" and have tried to develop in-process Quality Control procedures that are aimed more at corrective rather than weed-out techniques. We have adopted and have been using since its inception, many of the procedures in "883". For example, our monthly life and design (Group B and C) tests are exactly the same as those specified in Method T5005 Qualification Inspection. We have also developed many of our own methods which are completely compatible and consistent with them. These procedures are generally spelled out in our Reliability Brochure (SM-1057-9P) and in detail in our Integrated Circuit Quality Control Manual.

In summary, the value of any specific procedures can be assessed only in the light of the intended application for the device; however, we at Sylvania heartily endorse "883" as a good first step in the right direction toward much needed standardization in the integrated circuit industry.

D. M. Russell
Manager, Quality Assurance and Reliability

Four big reasons why you need



The Immersibles.

There are many reasons why our Daystrom 501 thru 505 series industrial potentiometers have become a favorite of design engineers. Their space-saving 5/16" size, for one. Weston's patented wire-in-the-groove construction, 5% standard tolerance, superior resolution, low noise and low cost, to name a few others. Now, with the option of total immersibility, we're offering you four more —complete protection against water, cleaning solvents, flux, and encapsulating compounds. All five configurations are available O-ring sealed to meet MIL-STD-202, Method 106, moisture resistance requirements. And at a price you'd expect to pay for unprotected pots. Play it safe and specify The Immersibles. Your choice of 15-turn or single turn types, top or side adjustable, in our standard 10 ohm to 20K range are in stock now at selected distributors. Higher values on request. Write today for data sheets and evaluation samples. WESTON COMPONENTS DIVISION, Archbald, Pennsylvania 18403, Weston Instruments, Inc.

a Schlumberger company

WESTON®

INFORMATION RETRIEVAL NUMBER 19

We make components for guys who can't stand failures.

We make our capacitors and resistors to perform like 40 million people were watching in on the count down.

And we build an extra measure of performance into all of them, to let you make sure your equipment delivers all you designed into it. Because like you and the guys who use your equipment, we can't stand failures either.

Take our glass capacitors, for instance. There's only one reason why they've been designed into the Surveyor, Minuteman, Gemini, Apollo, Saturn, Titan, Syncom, Sparrow, Hawk, and a number of other major aerospace and missile projects. With our glass capacitors, circuit designers could get the proven stability and reliability that these important systems demanded. U.S. Air Force tests have established that our glass capacitors have much better stability and much higher insulation resistance than ceramic and mica capacitors can deliver.

And take our precision tin oxide resistors. They're the best of the metal film class. Because the resistive tin film is completely oxidized and molecularly bonded to the glass substrate, our tin oxide resistors are impervious to moisture and environmental degradation. No other resistor can deliver the same stability and reliability over load life. They offer guaranteed moisture resistance across all ohmic values to set a standard of reliability that can't be matched by metal film, wire wounds, carbon comps or metal glaze resistors. After a 56-day-long heat test in an environment of extremely high humidity, our tin oxide resistors showed a resistance change of just 0.2 per cent. And in an ambient temperature test—now in its ninth year—not one of the 600 tin oxide resistors being tested has exceeded a resistance change of 1.5 per cent.

But don't only think of Corning for aerospace and other precision applications. We've got something to offer when economy and value are the prime considerations. At Corning we've been active in improving these important capacitor and resistor characteristics, too.

We've developed the Glass-K™ capacitor to give you the volumetric efficiency and economy of monolithic ceramic capacitors, but with the much improved stability and reliability that only a glass dielectric can add.

In resistors, our tin oxide resistors already offer long term economy over metal film, precision wire wound and metal glaze resistors. And our new C3 resistors, in addition to giving you a small case size, compete costwise with carbon comps.

At Corning we make components for guys who can't stand failures. Guys like your most important customers. Guys like you. So, next time you're designing a system, reach for your CORNING® capacitor and resistor catalogs and call your local Corning authorized distributor for off-the-shelf delivery. They'll help you design-in that extra measure of performance.

If you don't have our catalogs, ask your Corning distributor for copies or drop us a line at: Corning Glass Works, Electronic Products Division, Corning, New York 14830.

CORNING
ELECTRONICS

INFORMATION RETRIEVAL NUMBER 20

Automated lab to transmit Antarctic data

We can get three-day delivery on samples of moon rock, but it takes up to 12 months for raw data to arrive from the Antarctic. Scientists need the Antarctic data to fill in their knowledge of the earth—its changing magnetic fields, its earthquakes and its weather. But no telemetry exists, and the weight and cost of flying the data by air transport is high. Hundreds of pounds of charts and magnetic tape are carted by ships during the brief "summer season" from November to February.

To update this sled-and-husky approach to data acquisition, an automated geophysical observatory is being built, and the first components will be installed near Byrd Station by the end of this year. A six-foot-high, cylindrical aluminum capsule to house the instruments, a six-foot dish antenna and a tubular pyramidal mount to hold the installation 15 feet above ground (see photo) will be put in place in the snow and ice. If the structure survives the whipping polar winds and meets all test specifications, the observatory will probably be fully instrumented for experimental duty in December, 1970, says John Katsufrakis, project leader, Stanford University (which designed the unit for the National Science Foundation).

Nuclear power supply considered

Instrumentation will include a data encoder, command receiver, transmitter, power conditioners and other subsystems. Nickel cadmium batteries recharged by windmills would provide power the first year or two, says Katsufrakis, but as soon as possible this source would be replaced by a nuclear power supply of the type planned to be put on the moon by one of the early post-Apollo flights.

If the pilot test station is successful, says Katsufrakis, it could lead to a whole system of commercially produced, automated observatories throughout the Antarctic. The information would be telemetered to synchronous satellites above the Atlantic and Pacific oceans and these would relay it to stations in the United States.

Antarctic observatory capsule and its 15-foot-high pyramidal mount are getting finishing touches.

Katsufrakis estimates that all the equipment needed to set up an automated observatory could be carried in two plane flights. After that, one flight a year would suffice to maintain it, check out its instruments and make needed changes. By contrast it takes 68 flights a year to supply fuel alone to Byrd station today.

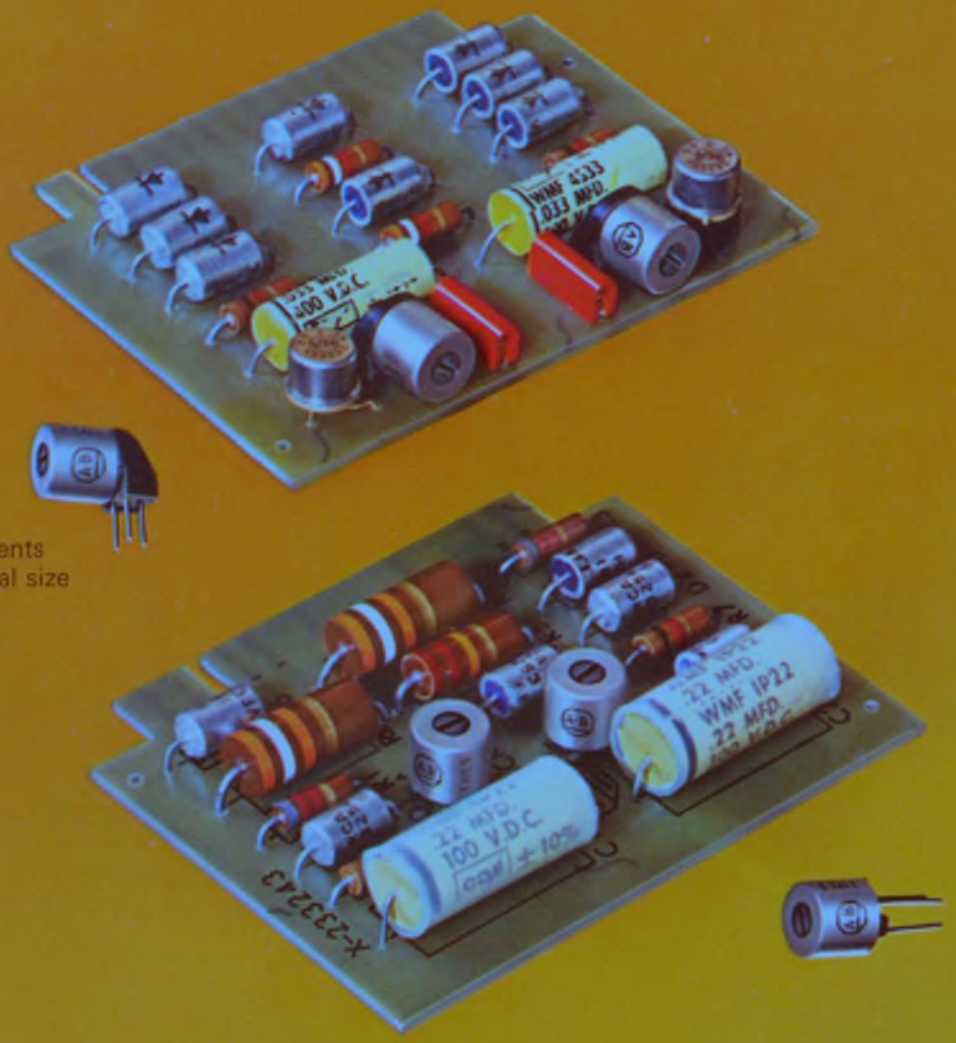
Spinoff from space

The instrumentation and techniques to be used in the observatory represent a spinoff from the space program, Katsufrakis says. "In effect, we are taking a satellite and providing an interface between it and the earth's atmosphere," he notes. In the Antarctic this atmosphere is more harsh for instruments to withstand than the temperature extremes and occasional flying rocks encountered in space. Although the Antarctic temperature never reaches the absolute zero of shady spots in space, it is cold for instruments—minus 80°F—and the winds are 100 mph.

Such winds not only challenge the mechanical design of the support structure, Katsufrakis points out, but they also make it difficult to dissipate the heat generated by the instruments inside the capsule. "You can't just open a louvre as you would in a space satellite," he notes. If you did that, the winds would whip through the opening and deposit snow on the instruments. The snow would melt inside the warm capsule, and the instruments would be in water.

To let out the heat without letting in the wind and snow, a special passive pipe has been designed. It transfers heat by successive evaporation and condensation of a working fluid.

Snow is a slower-working enemy of instruments than wind, but it is just as relentless. It piles up with every storm, and it never melts in the Antarctic. Consequently the level rises steadily about two feet every year. No structure can survive longer than a few years before being buried in a snowbank. This is one of the most severe problems encountered in manned stations now. These stations provide food, fuel and living space for several men, Katsufrakis points out, and they are therefore too large and heavy to be lifted out and set on the surface every few years. By contrast, the support structure of the unmanned observatory would be relatively inexpensive, and a new one could be put on top of the snow when the old one became submerged. ■■



Only the new Allen-Bradley Type S cermet trimming resistors have all these features

The Allen-Bradley Type S is a one turn cermet trimmer in which you will find incorporated a wider range of features than in any other trimmer now on the market. Here are a few of the more important features.

- **COMPACT**—body is ⅜" dia.
- **BUILT FOR EITHER TOP OR SIDE ADJUSTMENT**
- **50 OHMS THRU 1 MEGOHM**
- **THE SEALED UNIT** is immersion-proof
- **TEMPERATURE COEFFICIENT** less than 250 ppm/°C over *all resistance values* and *complete temperature range*
- **UNIQUE ROTOR DESIGN** provides exceptional stability of setting under shock and vibration
- **SMOOTH CONTROL,** approaches infinite resolution
- **PIN TYPE TERMINALS** for use on printed circuit boards with a 1/10" pattern
- **VIRTUALLY NO BACKLASH**
- **WIDE TEMPERATURE RANGE** from −65°C to +150°C
- **RATED** ½ watt @ 85°C
- **EXCEPTIONAL STABILITY** under high temperature or high humidity
- **MEETS OR EXCEEDS ALL APPLICABLE MIL SPECS**
- **COMPETITIVELY PRICED!**

You'll find the new Type S trimmer equal to the traditional Allen-Bradley quality. You really ought to know more about the Type S. Won't you write for detailed specifications? Allen-Bradley Co., 1201 S. Second Street, Milwaukee, Wis. 53204. Export Office: 1293 Broad Street, Bloomfield, New Jersey, U.S.A. 07003. In Canada: Allen-Bradley Canada Limited.

5672-B

A-B QUALITY

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

S-3A to get totally integrated avionics

Navy's most advanced antisub aircraft to employ computer-operated sensors and advanced displays

John F. Mason
Military-Aerospace Editor

The Navy's S-3A antisubmarine warfare aircraft, now being developed by Lockheed Aircraft Corp., "will have the most totally integrated avionic system the Navy has ever built," Lt. Cmdr. Frank J. Quigley told ELECTRONIC DESIGN. Commander Quigley, a 34-year-old electronics engineer, is avionics system project officer for the carrier-based, two-engine aircraft.

The manager for the whole program, which began with a $461-million research and development contract that will run into the billions when production begins, is Capt. Fred H. Baughman. Captain Baughman is 43 years old, a graduate of the U.S. Naval Academy with long experience as an ASW patrol plane pilot. Under his easy-going affability lies a firm determination to make his program a technological and economic success.

Computer heads the show

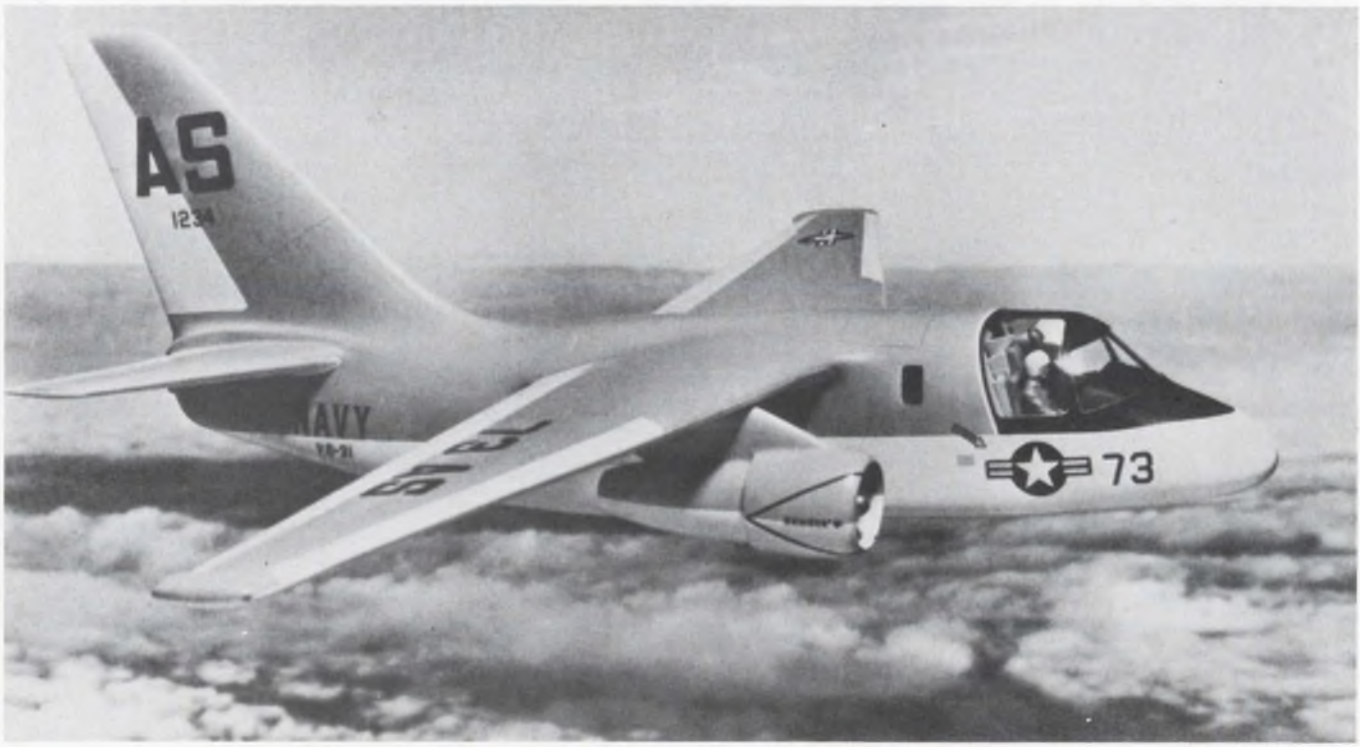
The S-3A will carry a formidable array of sub-hunting sensors, such as high-resolution radar, forward-looking infrared, sonobuoys, magnetic anomaly detectors, and photographic cameras.

"The aircraft's dual-processor, general-purpose digital computer will almost run the whole show," Commander Quigley says. "The sensors feed information into the computer which interprets it and sends it on to the display system. Then the operator decides what to do, tells the computer, which in turn takes action. This may mean activating other sensors to get more information, it may compare the instructions with stored data, it might suggest firing weapons, or it could repeat the whole sensor operation to get a new reading."

Captain Baughman adds: "The computer has tremendous control. When it receives important information from a sensor it flashes a warning to the man in charge of making the sub-fighting decisions on the aircraft, the tactical coordinator. When the coordinator has time, he can ask the computer to show him what it's learned."

The other members of the four-man crew are the pilot, copilot and sensor operator, and each one has a set of integrated controls with which he can talk to the computer and turn sensors on or off.

The computer is going to aid the crew in detecting and identifying a submarine. "Every object in the sea that returns sound has a unique signature," Commander Quigley says. "We're going to try to store signatures of interest in the general-purpose computer memory with the hope that they will



S-3A will carry a formidable array of sub-hunting sensors when it takes off from its carrier base. It will use high-resolution radar, forward-looking infrared, sonobuoys and magnetic anomaly detectors.

ALLEN-BRADLEY
Metal-Grid resistor networks
combine a new measure of

precision, stability and performance in a sealed, compact package

Precision Metal-Grid resistor network shown approximately 1½ times actual size

The advanced capabilities—developed from years of manufacturing Allen-Bradley Metal-Grid resistors—are now applied to a new line of resistor networks. This technology enables the production of complex resistive networks on a single substrate.

Allen-Bradley's exclusive simultaneous deposition method is used to obtain the best resistance tolerance and temperature coefficient matching. The reliability of interconnections on the common resistance plane is incomparable. Uniformity and quality are inherent in A-B networks. To illustrate, 2 PPM temperature tracking is normal.

A-B Metal-Grid networks offer a wide range of values—with individual resistances as low as 25 ohms and as high as 2.0 megohms. Both the inductance and capacitance are low, permitting efficient operation at high frequencies.

A-B engineers will be pleased to cooperate in developing networks for your specific need. For additional details, please write to Henry G. Rosenkranz, Allen-Bradley Co., 1201 S. Second St., Milwaukee, Wis. 53204. Export Office: 1293 Broad St., Bloomfield, N.J., U.S.A. 07003. In Canada: Allen-Bradley Canada Ltd.

BRIEF SPECIFICATIONS

Resistor Networks

Tolerances: ±1.0% to ±0.01%
Resistance Matching: to 0.005%
Temperature Range: −65°C to +175°C
Temp. Coef.: to ±5 ppm/°C
Load Life (Full load for 1000 hr @ 125°C): 0.2% maximum change

Ladder Networks

Full Scale Accuracy: 10 bits or less, better than ±¼ least significant bit. More than 10 bits, better than ±½ least significant bit.
Frequency Response: Less than 100 nanosecond rise time or settling time
Temp. Coef.: Less than 10 ppm/°C
Temperature Range: −65°C to +175°C

ALLEN-BRADLEY
QUALITY ELECTRONIC COMPONENTS

CC 662

(S-3A, *continued*)

tell the operator when he's got a real target."

An in-flight performance monitoring program constantly checks the whole system. If we detect a fault in any of the black boxes," says Commander Quigley, "we can call for the diagnostic routine to isolate the malfunction. With this system we cannot pinpoint the malfunction down to a specific module, but we can get it down to a given black box."

The computer, which will be furnished by the contractor, is a Univac 1832. "It is essentially two input-output controllers that address a series of core memories," the commander says. "The reason for having two is for redundancy. The P-3C land-based ASW aircraft has only one processor, a Univac 1830.

Choose your displays

"We are going to be able to choose the information we want displayed in this system," Commander Quigley states. "For example, surface ships are sometimes very important for the sensor operator to know about, but at other times, they just clutter up the display. On the S-3A the operator will be able to ask to see certain things and eliminate others."

The pilot and copilot both have their own small cathode-ray-tube display and a key set to ask for specific tactical information. All the sensors in the aircraft are operated through key sets similar to the ones the pilots have.

The system has two kinds of radar displays: a scan-converted plan-position-indicator (PPI) and a B-scan. The PPI shows the whole area being surveyed in a TV picture-like rendition. The B-scan "takes a chunk of the area between two limits of range and between two azimuth lines and presents just that. It's like a zoom lens on a camera," Commander Quigley explains. "With this equipment we can automatically track a target. We can ask its range, bearing and how long it will take to fly to it."

The system has an elaborate supply of alphanumerics to annotate almost anything that occurs in the tactical situation.

Seeing with sound

The primary sensors for finding submarines are acoustic devices. Sonobuoys are ejected by the aircraft to form a pattern in the sea, and they transmit to an acoustic processor in the aircraft the information they pick up. The processor is capable of handling such advanced sonobuoys as DIFAR (directional low-frequency analyzer and ranging), which can detect, classify and pinpoint submarines. It can also handle CASS (command activated sonar source), a system that activates sonobuoys to ping, measures the time to echo, calculates the range and radios the results to the plane. The S-3A's processor can handle more channels than the one in the P-3C.

The system will carry bathythermograph buoys to provide the operator with a temperature vs depth profile of the sea.

Low-light-level television, which has been used with success on combat aircraft in Southeast Asia and is going into the P-3C, will not be used on the S-3A.

Instead, a forward-looking infrared (FLIR) sensor will be used. "FLIR," Commander Quigley notes, "has the potential for enabling the operator to detect submarines, as well as to identify them. Low-light TV is useful only to identify one after it's spotted."

Prime contractor Lockheed has not yet chosen a FLIR, but is looking at units built by Hughes Aircraft, Aerojet-General and Texas Instruments.

MAD (magnetic anomaly detector), which is the most reliable sensor for confirming the presence of a submarine, will of course, go into the S-3A. The same unit, AN/ASQ-81, is already in the P-3C. The set is built by Texas Instruments.

The S-3A's radar, Texas Instruments' AN/APS-116, will use two tricks to detect snorkels and small periscopes in a rolling, choppy sea. Pulse compression, to make shorter pulses and improve resolution, is one; the agile frequency technique —skipping from one frequency to another with the hope that one frequency will ignore the sea clutter and reveal the periscope—is the other.

"Tests have shown us," Commander Quigley says, "that this radar is orders-of-magnitude better than any previous radar used for this purpose."

The aircraft will be equipped with a photographic camera controlled by the computer.

Know where you are

The CAINS (carrier aircraft inertial navigation system), being built by Litton, will provide precise navigation for the S-3A—"more accurate than the system on the P-3C," Commander Quigley says. "A unique aspect of CAINS is that it can be aligned by information from the ship's inertial system by data link instead of cable. This will make alignment simpler, as well as faster—five minutes as opposed to 30 with cable."

Here Captain Baughman adds, "Incidentally, all the ASW carriers are going to be equipped with SINS, the extremely accurate ships inertial navigation system used on Polaris submarines."

Commander Quigley resumes, "In addition to the inertial system, we will have Omega—to update the inertial, doppler, Tacan and a low-frequency radio direction finder. We haven't decided on a specific doppler unit yet."

"The avionics system is even more integrated than the one going into the Navy's F-14 fighter aircraft now being developed, because we're multiplexing our internal subsystem connections," the commander says. "Instead of having a bunch of wire bundles running from one black box to another, we send our control monitoring signals over coaxial runs, or twisted pairs of wires. We use both time and frequency multiplexing.

"We're using solid-state logic," he adds. "This does away with relays or switching devices. We have silicon control switches and rectifiers, and logic matrices to perform the various relay functions. This increases reliability and cuts down the size."

Captain Baughman ends the description of the S-3A on a note of satisfaction: "There won't be a tube on the aircraft. We're using a lot of ICs, LSIs and MSIs." ■■

Is your passive component supplier as reliable as his components?

He's fine at meeting industry specifications. Even exceeding them. But what about customer service? Does he sometimes act as if that's a necessary evil? ☐ And have you been telling yourself that you have to put up with this kind of an attitude in order to be sure of getting components that are truly reliable?

☐ Then it's time you learned about us. We're one of the leaders in component reliability—and we deliver in every other area as well. You bet we meet deadlines—speed samples—maintain competitive prices—and provide prompt technical assistance. ☐ If this kind of extra reliability would be a nice innovation, why not put us to the test. Give us an urgent request for technical assistance. Or an urgent order. Write AIRCO SPEER ELECTRONIC COMPONENTS, St. Marys, Pennsylvania 15857. ☐ Then watch us perform.

The passive innovators at AIRCO Speer

Speer resistors ☐ Resistor and conductor paste ☐ Jeffers JC precision resistors ☐ Jeffers JXP precision resistors and networks ☐ Jeffers inductors ☐ Jeffers capacitors ☐ PEC variable resistors and trimmer potentiometers.

For 14 months we would have said "no"

to even the President of the United States.

"Sorry, Mr. President."

That's what we would have said.

When we got into the MOS business in 1967, we resolved not to follow the over-enthusiastic marketing practices of the industry.

So we didn't sell to *anybody* until our products were fully tested, documented, and deliverable in volume.

That's why you didn't hear from us until February of this year—14 months after we began our operations.

Electronic Arrays is a volume producer of state-of-the-art MOS products. That's all we do.

We work with no other technology.

We have the know-how to manufacture complex circuits at low cost by packing a lot of electronic function into tiny silicon chips.

Our EA 3500, a 2560 bit Read-Only Memory, for example, is made with 3000 transistors all contained in a chip of silicon .065 inches by .094 inches—about as small as the head of a pin.

Our experience with MOS integrated circuits goes way back. In fact, Gene Stephenson, our director of manufacturing operations, designed the very first MOS circuit in 1964. Others on our staff account for the next three, along with many current designs.

Our plant is already over 27,000 square feet. Production standards are impeccable. This year, we will deliver about 100,000 circuits. And next year, many times this number.

We worked a long time behind the scenes. Now we're delivering.

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To the left is our EA 1200, the industry's only Quad 32 bit shift register. Other products include dynamic and static registers, random access read/write and read-only memories and logic arrays.

electronic arrays, inc.

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INFORMATION RETRIEVAL NUMBER 24

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BIFILM

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Available in ⅞", 1 1/16", 2" diameters! Each potentiometer can be ganged up to 10 cups in increments of only 0.2"!

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Complete details on the new, versatile *Bee-Line* are available from the factory, your local Bourns Sales Office or representative.

***BiFilm is Bourns new, low TC Conductive Plastic**

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Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

Helicopter has radome antenna

Chopper antenna for Tacsatcom

A radome-enclosed antenna to be installed above the rotor of a helicopter is being designed for use with the RCA-developed super-high-frequency global tactical satellite communications system (TACSATCOM) of the Defense Dept.

Bell Aerosystems Co., a Textron Division, won out with its above-rotor design over a below-rotor configuration as a means to avoid the "chopping" effect of rf transmissions caused by the rotor blades when located between the antenna and an orbiting satellite. Bell developers note that placement of the antenna above the helicopter blades greatly increases structural design problems because of the severe vibration environment. But Bell engineers concluded in their feasibility studies that they can design round the problem and minimize vibrations through use of an "advanced gyro-stabilization" technique.

The nearly $500,000 contract was revealed by the Air Force, which also noted that the R&D effort is sponsored by the USAF Avionics Laboratory, Wright-Patterson AFB, Dayton, Ohio, and the Army Satellite Communications Agency, Fort Monmouth, N.J.

The first flight test is expected by the end of this year aboard a Bell UH-IF helicopter (see photo).

New FCC chairman sought

Who will succeed Rosel H. Hyde who is retiring as chairman of the Federal Communications Commission? The Nixon Administration needs a successor who will be acceptable both to industry and to the Congress. In fact it may need two successors, for James J. Wadsworth, another of the seven-man commission, has indicated his desire to resign to join the International Telecommunications Satellite Consortium.

Both men—the 69-year-old Hyde and the younger Wadsworth — are Republicans, and both have been conservative influences with the Commission. For some time, the so-called conservative element has dominated FCC decisions and been strongly supported by the broadcast industry. The names of at least two members, who are considered liberals—Kennedy Cox and Nicholas Johnson—are not high up on the list of potentional candidates for commission chairman.

Some of those now being considered for the job are: Dean Burch, former Republican party chairman in 1964; Frank Shakespeare, head of the U.S. Information Agency and a former vice president of CBS; William Safire, White House speech writer; and Mark Evans, a Metromedia TV official and former TV-radio broadcaster. It is believed that Burch currently heads the list, though many others are known to be quietly seeking the position.

NASA picks up the glory tab

NASA is fast discovering that, along with the success of the Apollo 11 moon landing, comes a high price tag. For example, as part of its celebration honoring the July 20 moon landing, the Manned Spacecraft Center in Houston held a luncheon for its personnel early in August—and the tab, $2800. Now if you add to that the price of the subsequent dinner called for by the President

at the Century Plaza Hotel in Los Angeles, the total runs somewhere between $80,000 and $100,000.

The Space Agency may not yet quite understand the proceedings, but somehow or other it has managed to get stuck with nearly every charge associated with the well-publicized state dinner honoring the three astronauts and their wives. To start off, the White House is expected to direct NASA to pay most of the $75,000 dinner tab at the Century Plaza. Then, to send several hundred NASA space officials and their wives to Los Angeles for the affair and bring them back by chartered aircraft cost another $19,343. On top of this, Congressman George P. Miller (D-Calif.), chairman of the House Space Committee, forced NASA to pick up the Air Force charge of $5,522 for flying 32 members of his committee and their wives to the West Coast and back. (Defense Secretary Melvin R. Laird, it is reported, flatly turned down any suggestion that DOD pick up the flight expense.)

Volpe endorses international air show

Offers of national support for a permanent U.S. biannual international air show and exhibition has been triggered by the highly successful Second National Air Exposition held last month at Dulles International Airport near Washington, D.C.

John A. Volpe, secretary of the Transportation Dept., not only declared a need for such a continuing U.S.-sponsored exhibition "to report flight advances to the nation," but he added: "Many leaders of Congress have . . . asked the Dept. of Transportation to endorse such a program. We not only endorse the concept but we are ready to assume responsibility for its organization and management if the Congress acts favorably on proposed legislation which is now awaiting consideration.

During the two public-attendance days at the recent air show it is estimated that nearly 500,000 viewed the ground and aerial displays. The air show featured exhibits by the nation's aerospace and avionics manufacturers, nearly two miles of civil and military aircraft displays from four nations, and daily aerial demonstrations.

Sound-flame studied by Air Force

Its discovery that by passing an electrical impulse through fire, an audible sound can be reproduced and amplified with high-fidelity quality, has brought United Technology Center, a division of United Aircraft Corp., a contract from the Air Force Office of Scientific Research for further study on the subject.

The division, more usually associated with the development of solid propellant fuels, has pioneered work on the amplification of sound through flame for several years since its initial discovery. The concept is referred to by UTC as electrothermal sound and has been dubbed "the singing flame." Sounds transmitted by the flame are emitted omnidirectionally.

The division, located at Sunnyvale, Calif., is now attempting to produce ultrasonic sound at high intensity in air. It is also seeking commercial application for the acoustical output for use in high-speed data transmission and in a new form of super-high-fidelity amplifier system.

UTC also notes the technique may serve as a means for introducing sound into the combustion chambers of rocket motors to determine or measure combustion stability. It may also prove useful as a means for obtaining acoustical recording of the combustion process itself.

Our new all solid-state keyboard. It makes even fast operators operate faster.

A big part of developing our new keyboard was in helping the operator operate faster. Without goof-ups.

Here's what we came up with:

Two-key rollover. This allows "burst-speed" typing. An electronic interlock eliminates errors when two keys are pushed at the same time.

That old typewriter feel. Key spacing is the same as on office typewriters. And spring loading simulates typewriter touch.

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They're all part of another thing we came up with, the world's first use of an integrated circuit as a keyboard switching element.

This micro-miniature circuit eliminates mechanical linkages. Electromechanical parts. Moving contacts. Black boxes. And a big price tag.

But it retains the reliability of our other keyboards. Proven by tens of thousands of operators, in hundreds of applications.

"Condensed Keyboard Guide" briefly discussess MICRO SWITCH keyboards and options. Become a fast operator.

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MICRO SWITCH

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Intech takes on the Op Amp Boys.

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So does Philbrick/Nexus, Analog, Burr-Brown, et cetera, et cetera.

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Don't believe us, or our engineers, though. In this business specifications, performance, and price are the considerations. A test is worth a thousand words.

For more information on our operational amplifier line, contact your nearest Intech representative, or call or write us direct.

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

Letters

Engineers look to unions to improve their Lot

No representation— no recognition

Sir:

Please refer to the letter, "I flatly refuse to work for my dog" in your July 19, 1969 issue. I believe the point that engineers need representation is particularly well taken because all other professional groups (teachers, doctors, lawyers, etc.) have representation that is very effective in advancing their goals (usually at the expense of the rest of the community). Without representation, engineers and scientists will not receive the recognition and the rewards that are due them.

Hermann F. Schmid
Research Engineer
Stanford Electronics Laboratories
Stanford, Calif.

Challenging tasks or ill-considered proposals?

Sir:

In answer to "Baltimore Engineer's" letter I wish to make the following comments, based on nearly twenty years of observations as a graduate engineer who has served both staff and line functions.

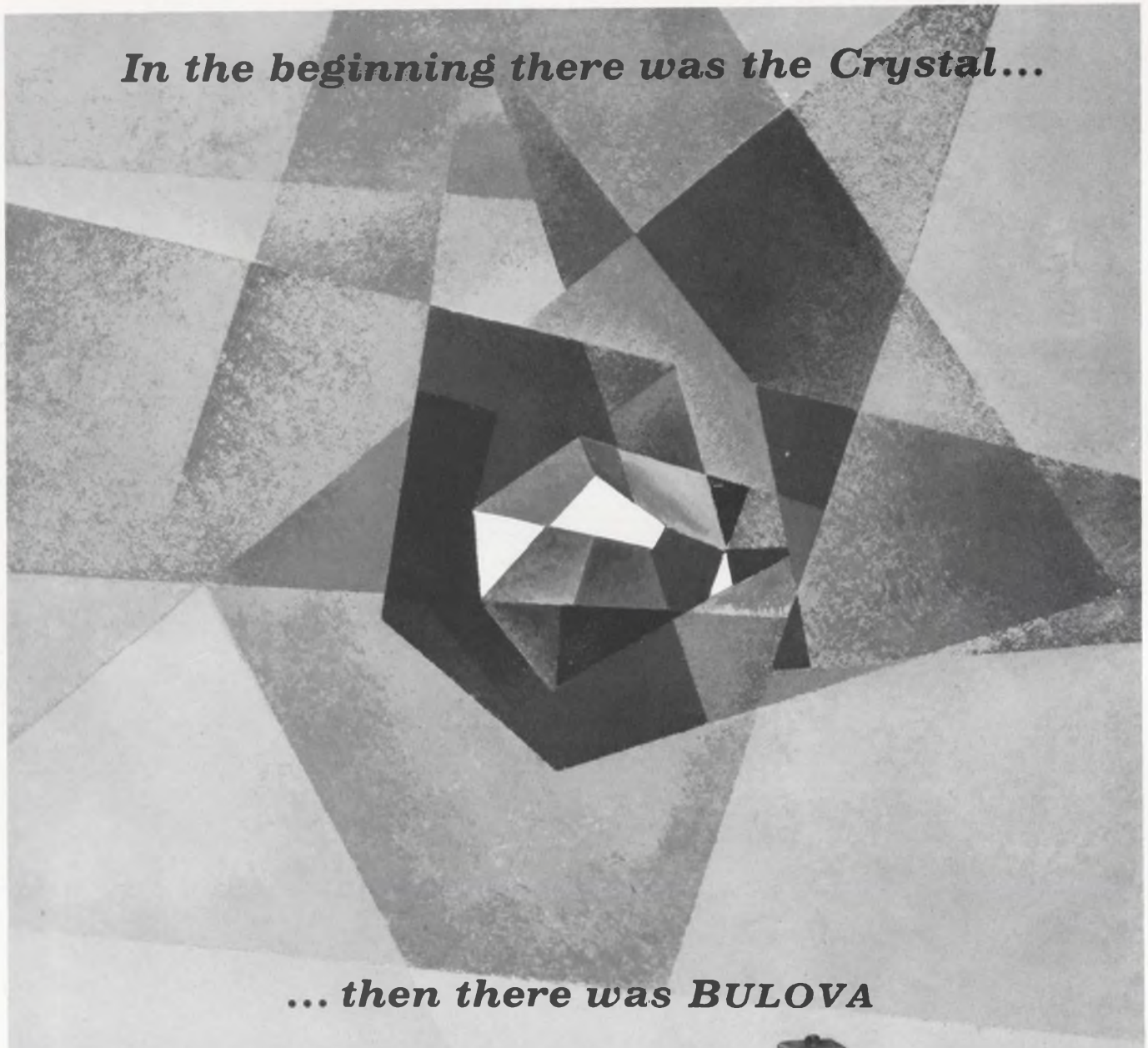
1. The "challenging" tasks are too often the result of ill-considered and hastily prepared proposals and plans that have been based on an unfounded optimism by higher level managers, or a hope that *this* time the engineers will receive divine guidance or that a specialist can be hired.

2. In this period of large scale contracting the great majority of engineers work for a living—not for personal gratification, entrepreneur's benefits, or professional recognition. Even then, recognition is not a goal in itself. It is sought because it can lead to increased income from the present employer or a new one.

3. Engineers problems *are* real. The abuse of the term "professionalism" falls in three categories. First, it is too often equated with the willingness to work unlimited unpaid overtime; also, the lack of recognition of educational status, or need of special working conditions is legend. Very few people, for instance, can continually meet the demand to think creatively in noisy, dirty, or crowded environments. Second, salaries subject to the sacred employe/company relationship are actually controlled by local labor market, personnel salary curves, and level of contract backlog. Many engineers are fed-up with so called merit reviews which do not even keep pace with the cost-of-living. Only unfavorable comparisons result from viewing incomes of truck drivers, plumbers, and electricians. Third, working hour demands are often unreasonable because of deliberate underbidding of costs in contract work, excessively optimistic performance promises, and unrealistic delivery time schedules.

I find the decreasing enrollment in engineering schools perfectly understandable. The effort and expense of a college degree is better justified as an investment in a true profession. I would not encourage any youth to enter engineering. A few years ago, even the concept of an engineers' union resulted in my violent opposition. Today, I view engineers as viewed by most companies—not as junior members of management, not as professional employees, but as a form of trade labor differing only in type from machine operators and assemblers. Yes, engineers do work for a living, for the opportunity to do interesting work, and to achieve some degree of recognition. The union

(continued on p. 53)



In the beginning there was the Crystal...

... then there was BULOVA

The silicone dioxide mineral that nature created Bulova refined, shaped and put to use. Today, our expertise in crystals extends from the raw stone to the finished crystal device.

With the quartz chosen by a trained eye and cut with near-surgical precision, Bulova specialists in circuit design and thermodynamics add their talents. This knowledge is correlated with selective computer programming for optimum circuit performance.

The result is a crystal capability that should be on your side when you tackle frequency control problems.

CRYSTALS

A full line of crystal cuts and enclosures in both low and high frequencies . . . from 2KHz to 33MHz fundamental and 150-MHz overtone . . . in every type of packaging — Coldweld, Glass-sealed, Solder-seal metal holders. New Coldweld line of miniaturized packages available in TO-5 Series, HC-6/U, HC-18/U, HC-25/U and TO-8 cans, in tolerances as close as ±.0005% from −10°C to +60°C.

CRYSTAL FILTERS

A complete capability from 4KHz to 30MHz for such typical use areas as — Band Pass / Linear Phase / Time Delay / Single Side Band. Computer Programs determine design tradeoffs quickly and economically — A staff of application and production engineers provide in-depth experience in the following crystal filter designs: 1. Butterworth, 2. Butterworth-Thompson, 3. Chebyshev, 4. Bessel, 5. Elyptic, 6. Lerner, 7. Gaussian (Transitional), 8. Image Parameter.

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Choice examples of our capability are . . . PCOXO-101, a high stability crystal oscillator, with an output frequency of 1MHz or 5MHz, an aging rate of $1PP10^9$ per day, and a frequency stability of $\pm 1PP10^8$ over an ambient temperature of −55°C to +70°C and TCXO-30, a temperature compensated crystal oscillator, in a frequency range of 3 to 5MHz, has a stability of $\pm 5PP10^7$ over a temperature range of −55°C to +85°C.

For further technical data on crystals, crystal filters or crystal oscillators, call (212) 335-6000, see EEM Section 2300, or write —

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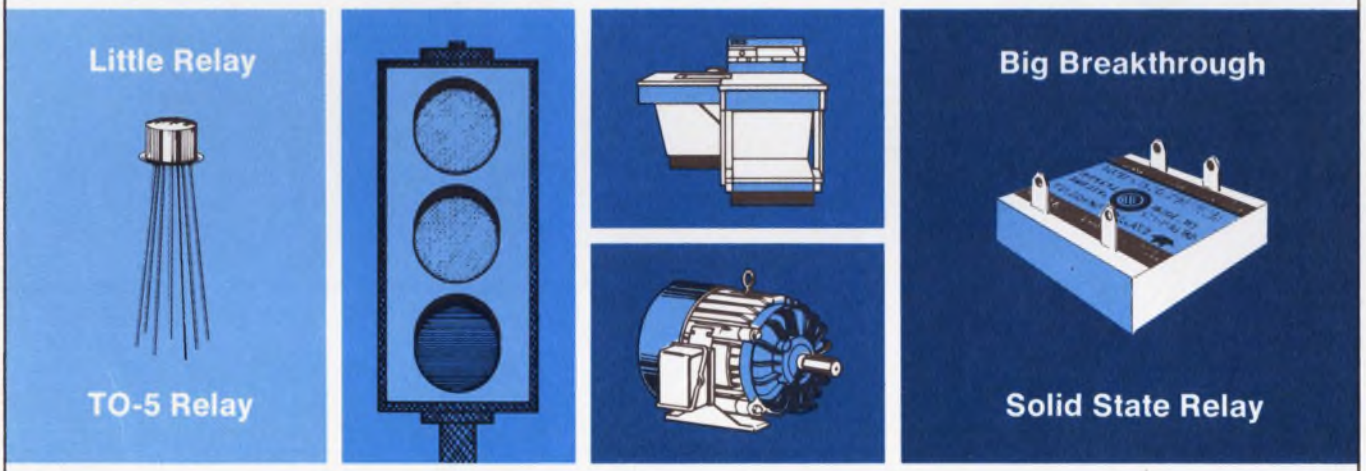
INFORMATION RETRIEVAL NUMBER 28

Solid State Relays

Another **big** breakthrough from the "little relay" people



We got our nickname "little relay" people because we usually put our *big* breakthroughs in *small* packages. (Our success started when we introduced the TO-5 relay.) Now, we've made another breakthrough . . . a completely solid state, four terminal relay with enormous power gain. Only 1 milliwatt switches up to 5 KVA, and it can be resistive, inductive, capacitive, tungsten or quartz lamp loads.

Our new relay operates on inputs up to 280 VAC or from 3.5 to 300 VDC (either polarity) permitting direct interface with TTL logic. Input-output isolation is 10^{11} ohms "coil" to "contact" and "coil" to mounting plate. Dielectric is 2000 VRMS. Output characteristics include contact ratings up to 21 amperes, 280 VAC, 60 Hz. Surge current ratings of 200 amperes, and "contact" resistance as low as 50 milliohms. And, . . . these are real *breakthroughs* for a relay which doesn't have "coil" or "contacts."

Available options include zero voltage switching for RFI suppression and lamp life extension.

Prices start as low as $18.30 in quantities of 100. For complete technical data on our Series 6 Solid State Relay . . . contact us . . . the "little relay" people.

TELEDYNE RELAYS
A TELEDYNE COMPANY
3155 West El Segundo Boulevard Hawthorne, California
90250 Telephone: (213) 679-2205

INFORMATION RETRIEVAL NUMBER 29

Now you can revise your thinking about the size of latching relays!

KUL Relay

New P&B magnetic latching relay cuts mounting space in half

KUB Series

KB Series

KBP Series

Our new KUL takes up only about half the chassis area of mechanical interlocking latchers. Only one relay is used, not two. The price (starting at $6.05) is a lot less, too.

The secret? A unique magnetic circuit design. Voila! A small latching relay with excellent memory stability . . . one designed for continuous duty but which will stay latched without power on the coil. And remember, there are no mechanical interlocking members to wear out.

Single or dual-wound (polarized) coils are available for DC operation to 110 volts. Single coil, two-input, AC units (to 120 volts) employ diodes for pulse separation. Contact arrangements up to 3 Form C are available for switching 5 or 10 amperes. Quick-connect/solder terminals fit nylon socket rated for 10 amperes.

KUL relays are recommended for a host of commercial applications such as process controls, business machines, alarm systems, battery chargers and the like.

Wide Choice of Other P&B Latching Relays

KUB SERIES. Latching relay employs two KU relays. Quick-connect/solder terminals. Coils operate on same or different voltages. Exceptionally rugged, die-cast zinc base.

KB/KBP. Two KA relays with mechanical interlocking feature. Solder terminals (KB) or octal-type plug and nylon case (KBP).

Need more information? Call your local P&B sales engineer or the factory direct. Potter & Brumfield Division American Machine & Foundry Company, Princeton, Indiana 47570. Telephone: (812) 385-5251.

AMF | POTTER & BRUMFIELD

(continued from p. 49)

trend is increasing; in five years it will be widespread. The professional associations are not serving this function; contrast the American Medical Association!

(name withheld by request)

Pay may not be first but it ranks high

Sir:

Baltimore Engineer's belligerence and exaggerations rather overshadow a few valid points. Effective representation of engineers in industry, of the type afforded teachers by the National Education Association, for example, is desirable and fairly rare. Reasonable working hours, yes, but three months vacations and early retirement are pie in the sky.

Mr. Speer's assertion in the ED 26, Dec. 19, 1968 editorial that "Pay, by itself, often ranks low on the list of rewards that such workers seek," is, I feel, inaccurate. Pay may not rank first with the majority, but it surely ranks high. A pay increase enhances an individual's feeling of being appreciated as well as his material well-being. Also, his advice to project managers on sharing the involvement, etc. seems hardly necessary. Surely, any competent project manager knows this.

(name withheld by request)

Engineers are treated as common workers

Sir:

In comment to the letter written by a "Baltimore Engineer," I must admit a total agreement. I think the key word, which seems to be missing from his letter, is "professional."

Unfortunately, too many engineers are treated as common workers when it comes to rewards and working hours, and I like professionals only when it comes to making sacrifices for "the company." Hopefully, as more engineers start fighting for their rights, as does our friend from Baltimore, a pleasant environment with decent benefits and salaries will be obtainable.

If articles I have read are true, management and some companies are giving their engineers a fair shake. Possibly industry should look at the success of one of these companies, Signetics Corp.

Gerald Goldschein

New York

Individuals play against a stacked deck

Sir:

The author of the letter "work for my dog" seems to be more of a philosopher than an engineer, but he hit the nail right on the head. He gives us a classic example of the Modern American Tragedy—the Rat Race!

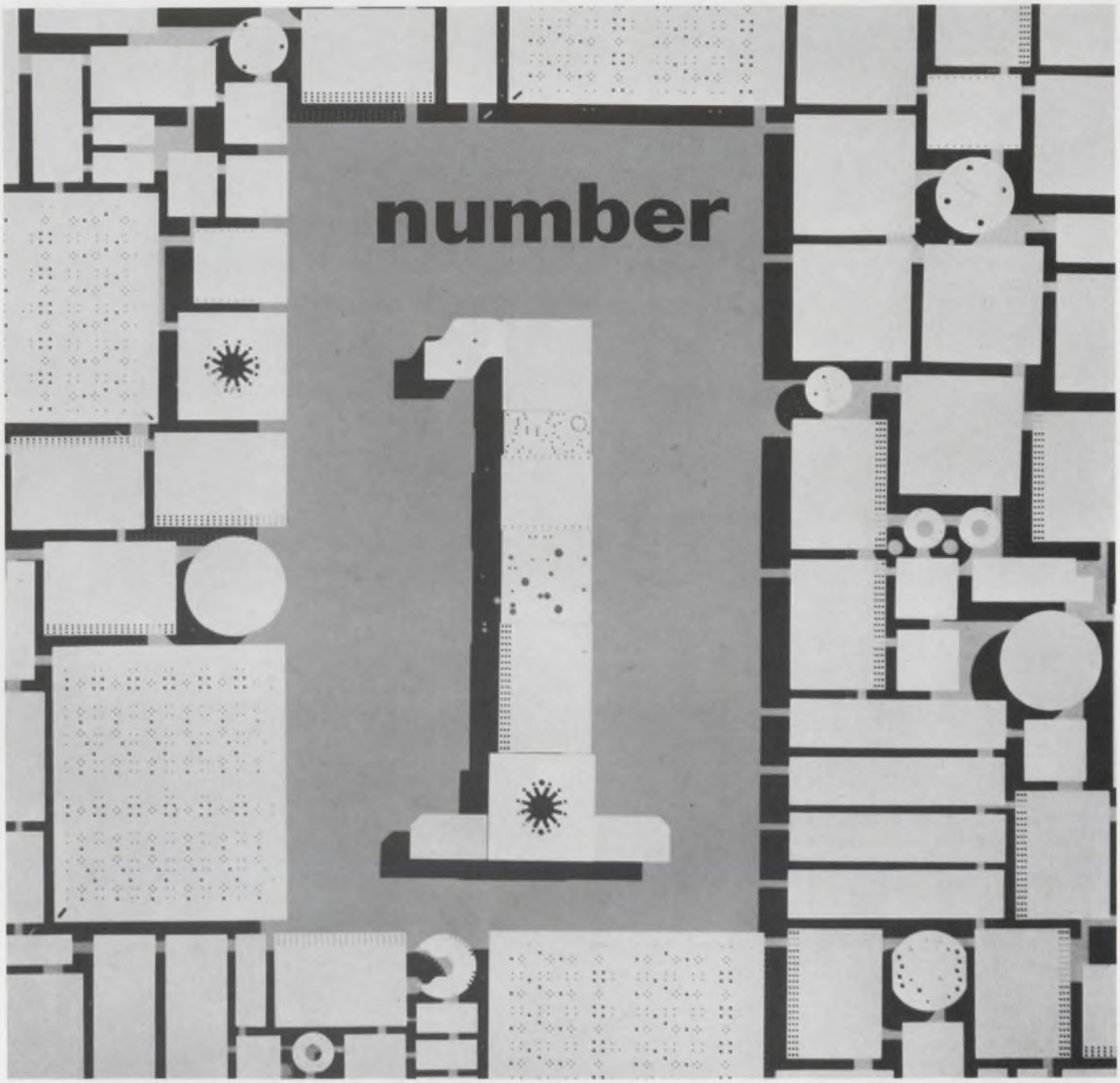
The working hours, holidays, vacations, and retirement age in most foreign countries puts us to shame. Even the Russians, who are supposedly competing with the West, went to a 30-hour week a few years ago. I see no reason why a dog should lead a more comfortable life than his master. Progress is not solely more business mergers and higher corporate profits, but an easier life.

Fortunately, our predicament is not entirely hopeless. The Generation Gap spells doom for the architects of the Rat Race. Corporate profits will go down, but the quality of life in America will surely go up.

As far as engineering unions are concerned, I feel that dealing with a company (organization) on an individual basis is like playing against a stacked deck. The individual is no match and will always come out on the bottom. It takes an organization to deal with another organization if the outcome is to be fair to both sides.

In view of the present general situation, an engineering union is essential for our very economic and social survival!

(name withheld by request)



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LOW COST—Whether your substrate order is large or small, you'll always find fair, competitive prices at Coors.

QUICK DELIVERY—Large-quantity substrate orders normally require only 6 to 8 weeks to complete. Small orders and prototype quantities usually take 2 weeks or less. Stocked blanks are shipped within 48 hours.

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Coors can produce substrates to your specifications from either glazed or unglazed 96% alumina ceramic or unglazed 99.5% alumina ceramic. Both of these ceramics are dense, impervious, resistant to high temperatures, easily metallized, and have excellent electrical-insulation characteristics and good heat-transfer properties.

For details on Coors ceramic substrates, send for Bulletin 1400. Coors Porcelain Company, 600 Ninth Street, Golden, Colorado 80401.

9/2

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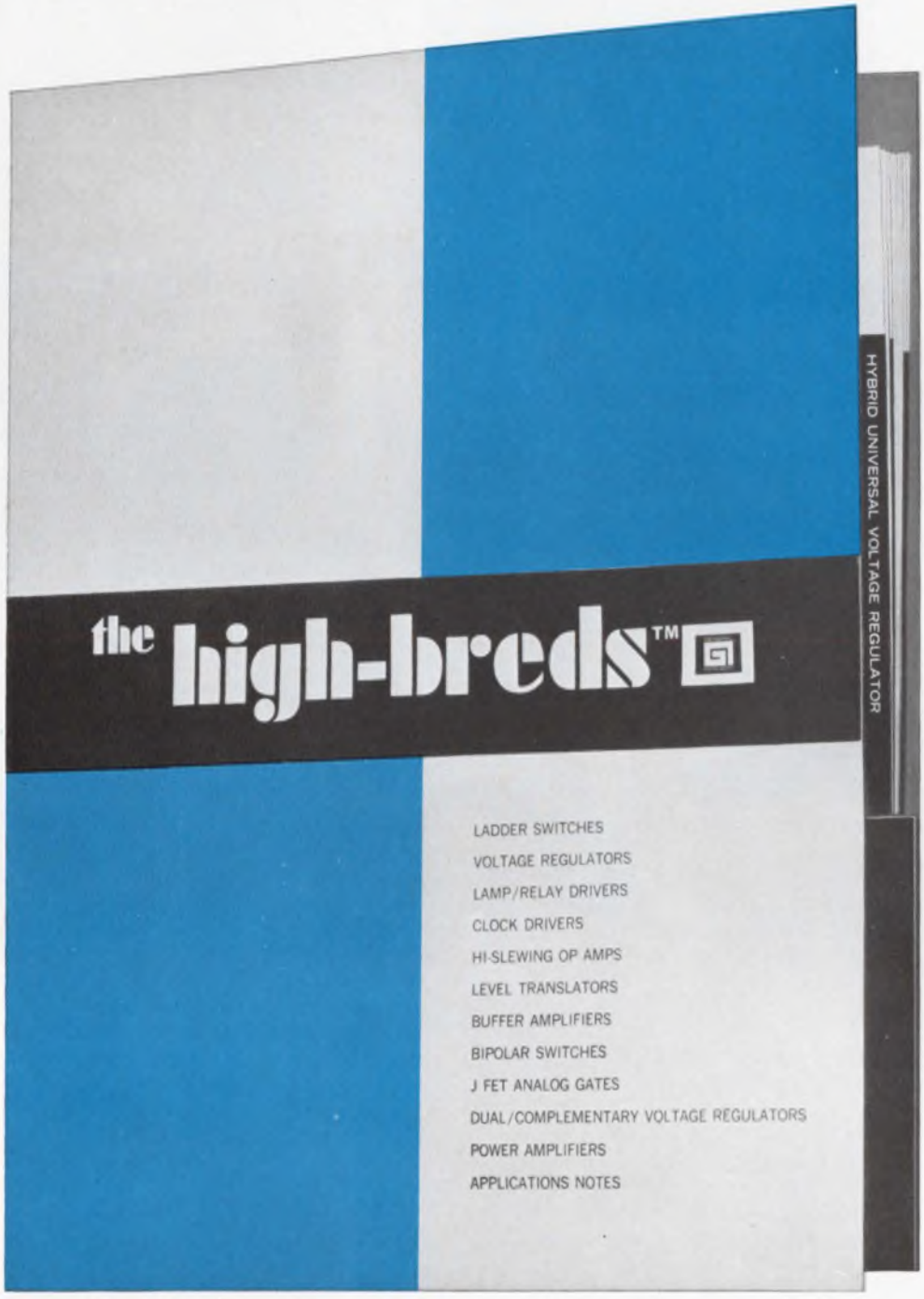

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GENERAL INSTRUMENT

INFORMATION RETRIEVAL NUMBER 33

It's what's up front that counts!

Bright, legible displays, telling it precisely like it is . . . that's what counts. Whatever the application, IEE has a readout and mating driver/decoder geared to deliver unsurpassed displays, up front . . . *where the action is.*

1. nimo™, single-decade — Single plane, 10 gun CRT. Displays numbers, letters and words with unsurpassed brightness and clarity. Driver/Decoder with BCD input.

2. nimo™, 4-decade display — 1.13″ dia; ⅜″ high characters. $3.50/decade. Various Driver/Decoders, MSI/LSI compatible.

3. nimo™, 6-decade display — Ideal for instrument use, read bright and clear at 75 F.L. — low, $2.90/decade. Highly compatible electronic interface cards.

4. Series 860 Cue Switch — Unique readout and data input unit; displays up to 24 messages. Depressing viewing screen/switch initiates or changes inputs. Hexadecimal applications.

5. Series 345 — Superb miniature readout with ½″ w x ¾″ h screen. 20′ viewing distance, 175° viewing angle. Matching miniature Driver/Decoder assures optimum performance.

6. Series 10H — World's most popular rear-projection readout. Projects any numeral, character, message, color, etc. High performance Driver/Decoder.

7. Series 120H — Miniature readout, only 1″ wide, presents ⅝″ h characters. Readability unmatched at 30′. High reliability potted Driver/Decoder for military application.

8. Series 220H — Optimum clarity even under high ambient light conditions. Front plug-in capability: press viewing screen, remove insert. New IC Driver/Decoder.

9. Series 360H — Jumbo size (2″) characters, clearly visible from 50′. Unit is 3″ h x 2″ w; mounts on 2″ centers for minimum panel space. Various Driver/Decoders.

10. Series 160H — Has 1.56″ h x 1.12″ w message area, readable at 30′. Lamps are decoded and driven by one of three styles of IEE Driver/Decoders, 14 models in all.

11. Series 880 — Compact, sub-panel readout offers 0.50″ message area, choice of 12 Driver/Decoders, with or without data storage, plus many options.

12. Series 80 — The "Big Boy" (3⅜″ h characters). Suited to many annunciator applications, control boards, etc. Easily read from 100′. New Driver/Decoders.

13. Bina-View — Unique readout utilizing up to 64 character plates. Accepts any binary code up to 6 bits. Self decodes and displays in any color.

14. Status Indicator — Back lighted multimessage indicator. Displays one or all (12) messages simultaneously. Ideal for sequential instructions or operational procedures.

The World's broadest line of rear-projection readouts.

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INFORMATION RETRIEVAL NUMBER 34

The day Electronic Design out-jinxed a jinx

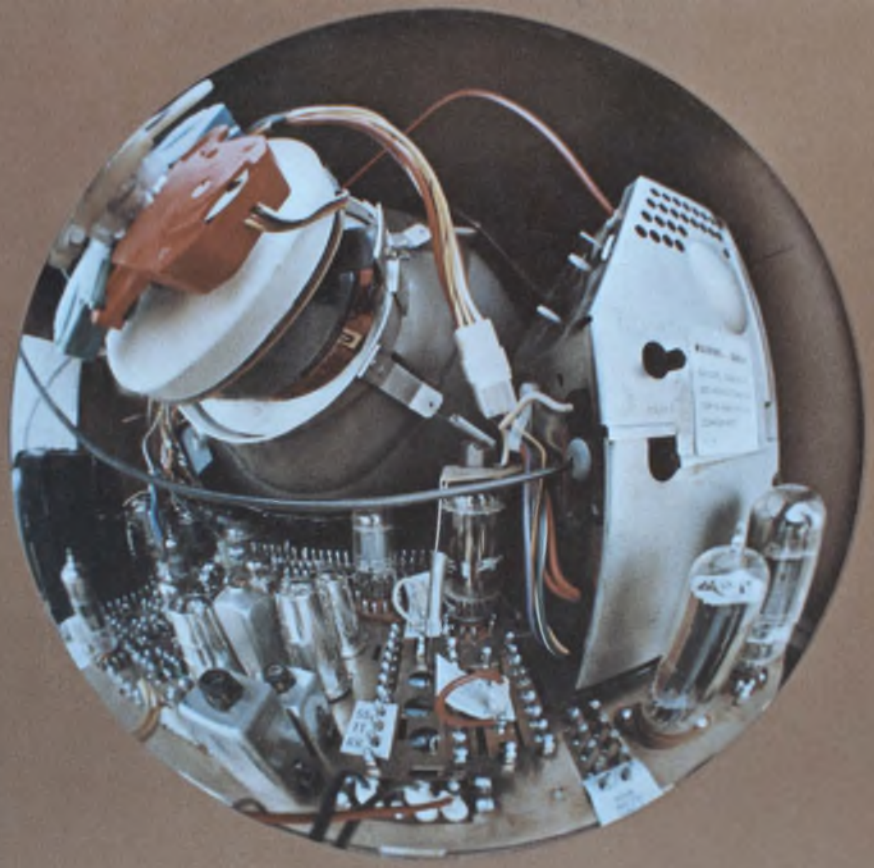
Aug. 13, 1969. If you're superstitious, you take special precautions on any day with a "13" in it. Like avoiding cats, ladders or broken glass. If you've got a bad case, you stay home in bed, maybe, with the covers over your head. You *don't* go fishing, because, as any fool knows, when you're a fisherman, you're courting luck. So . . . with technical-minded aplomb and thorough disregard for the conventions of superstition, ELECTRONIC DESIGN's editorial staff stayed away from the office on Aug. 13, 1969—and went fishing.

Led by Editor Howard Bierman and Managing Editor Frank Egan, the staffers turned up wide-eyed at 7 a.m. at Sheepshead Bay in Brooklyn, N. Y., where the jolly boat Mako II is based. In a day on the bounding Atlantic off Jersey's north shore, the editors and writers learned several interesting things. Like: Bluefish don't have a very efficient sensor system; they think wiggling yellow plastic tubing a half inch in diameter is a fish. And wouldn't it be nice if people had built-in gyroscopes?

Hard luck? None to speak of. Art Director Cliff Gardiner slept all day. Too much Dramamine. But nobody broke a leg or wrapped a fishhook around a colleague. In all, the staff caught about 50 pounds of fish—21 blues. Maybe it was because Aug. 13, 1968, was a Wednesday instead of a Friday?

(P.S.: *There was fishing for ideas on the trip, too. It's our way of getting the staff away from the office routine a couple times a year to discuss freely and openly ways of improving the magazine. We believe that on occasion you can mix business and pleasure.*)

August 13 was an unlucky day—but only for the bluefish in the picture. ELECTRONIC DESIGN's editorial staff took the day off to go fishing—for ideas as well as blues.



It takes guts to build a TV set

Lots of 'em. Dozens of assemblies and sub-assemblies and components. Each as important as the other. From plug to picture every item must perform. And perform well. The customer buys what he sees. And what he sees is determined by what he does not see. That's the guts of the story.

Stackpole makes more than a dozen types of components for black and white and color television receivers. Since 1947 mostly. But even before that we produced millions of high quality fixed composition resistors for the booming radio market. Still are, in fact.

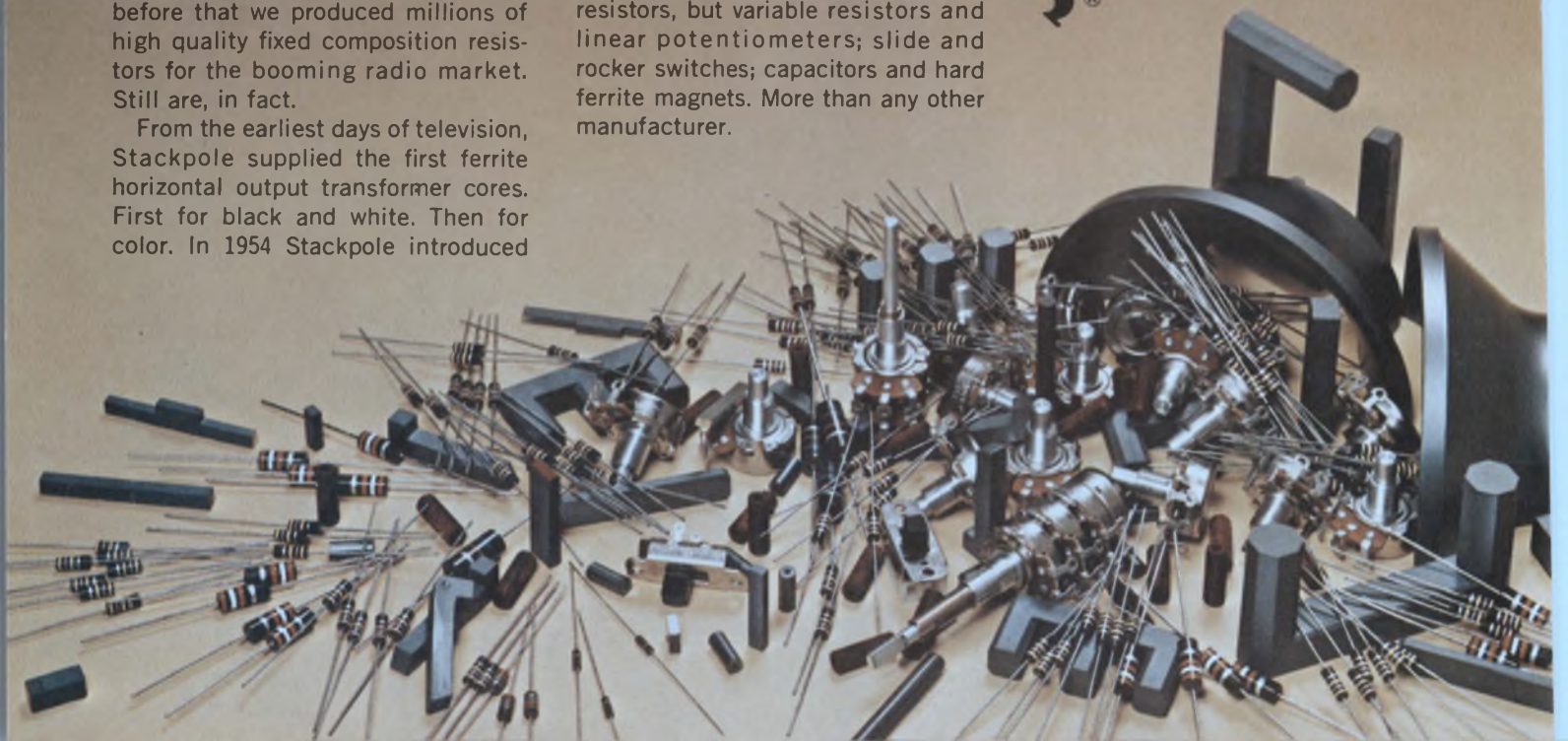
From the earliest days of television, Stackpole supplied the first ferrite horizontal output transformer cores. First for black and white. Then for color. In 1954 Stackpole introduced Ceramag® ferrite components for the 70° color deflection system. And again in 1964, the 90° color components. Today we're working on the color 110°. In addition, we've been involved with such major television advances as Automatic Pincushion Correction.

Stackpole engineering and production know-how has contributed much to the technology of television. Our components can be found in every domestic TV set. Not only ferrites and resistors, but variable resistors and linear potentiometers; slide and rocker switches; capacitors and hard ferrite magnets. More than any other manufacturer.

Have you got what it takes to build a good TV set? Be sure. Specify Stackpole electronic componentry wherever possible. You'll get the value and performance you need. Write or call: Stackpole Carbon Company, Electronic Components Division, St. Marys, Pa. 15857. Phone 814-834-1521. TWX: 510-693-4511.

STACKPOLE

ELECTRONIC COMPONENTS DIVISION



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Are engineering unions really needed?

Engineers are growing more and more uneasy about their salaries, job security, and professional recognition, and many are pushing for union representation to cure all the ills. But are unions really necessary?

A Baltimore engineer, for instance, assures us that he flatly refuses to work for his dog. He disagrees with our editorial "Who does a man really work for . . . ?" (ED 26, Dec. 19, 1968) in which we suggested that engineers are more interested in challenging work and professional recognition than in salary. In his letter (see Letters, ED 15, July 19, 1969) he tells us he has a nice house, nice wife, nice kids, wall-to-wall carpeting, two cars and a boat, but that he is working all the time and only his dog is home to enjoy the good life. He says that he doesn't strive first in his work for personal growth, cultural broadening, or recognition from his peers. He wants money, not challenges, and extended vacations, not overtime. And he looks for union representation to get it for him.

We have received letters from a number of other engineers who support his view, in whole or in part (see Letters, page 49). They want higher salaries, more job security, shorter workweeks, professional recognition and interesting work. And they say repeatedly that they want union representation.

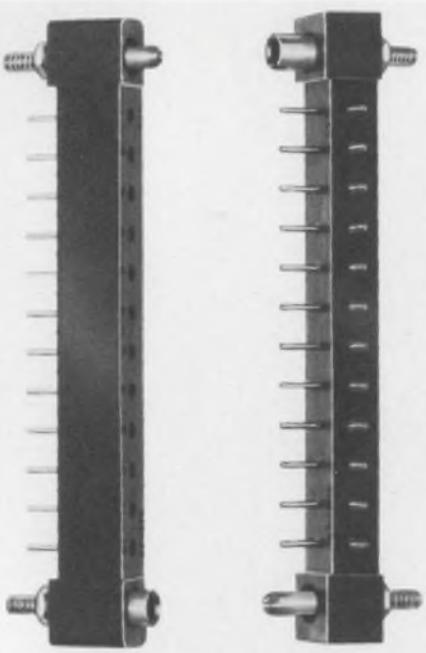
No one argues—higher salaries would be great. But if an engineer is not satisfied with his salary perhaps he should ask himself if he's really worth the extra money to his company. If he is, why does he need a union to ask for it? And if his company doesn't share his view, shouldn't the onus be on him to find more rewarding work? Shouldn't he look for more responsibility with a different company?

Some argue against this idea. They say they have mortgages and kids in school and they can't afford to move. So they want union action to force salaries up in the job they now hold. But are an engineer's personal obligations and commitments really the company's responsibility? Should they ever be?

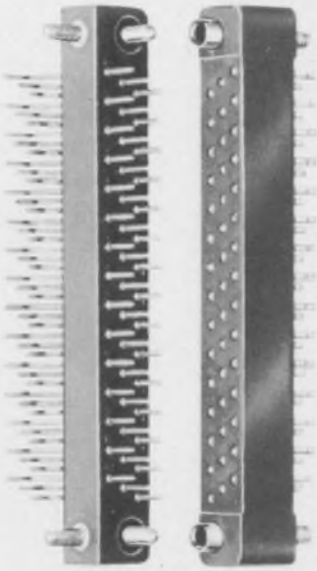
And is it realistic to demand job security through union action in an industry such as aerospace, which is by its nature dependent on uncertain contracts? Don't aerospace engineers receive higher salaries in lieu of job risk? (The Engineers Joint Council data indicates that they do—engineers are more highly paid in L.A. than in, say, the south-central states). Surely, to ask for guaranteed employment when contracts cannot be obtained throws an unreasonably heavy burden on the company.

These points can easily be forgotten in the heat of argument. Shouldn't they be more carefully considered?

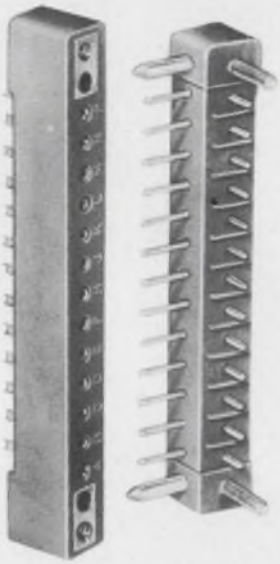
RAYMOND D. SPEER



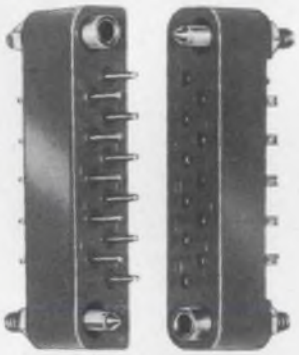
683-12 Right Angle Pin & Socket



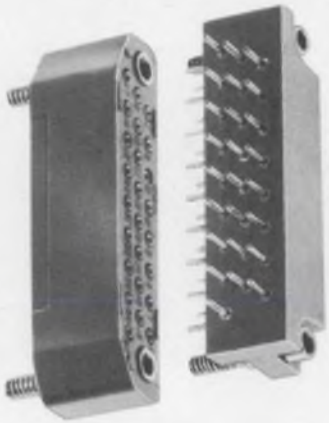
600-1-45 Right Angle Pin & Socket



600-70 Right Angle Pin & Socket

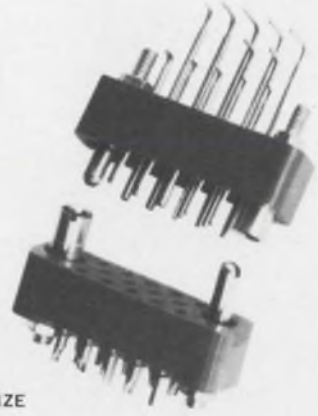


145-5 Right Angle
Pin & Socket



MMM 25 Right Angle
Pin & Socket with Crimp
Removable Contacts

1800-16-26 Plug with
Right Angle Pin;
MM 26-22S-Socket



145-14 Right Angle
Pin & Socket

ALL ILLUSTRATIONS ACTUAL SIZE

For connectors that meet MIL-E-5400K...

Continental has the right angles

FOR PRINTED CIRCUIT BOARDS

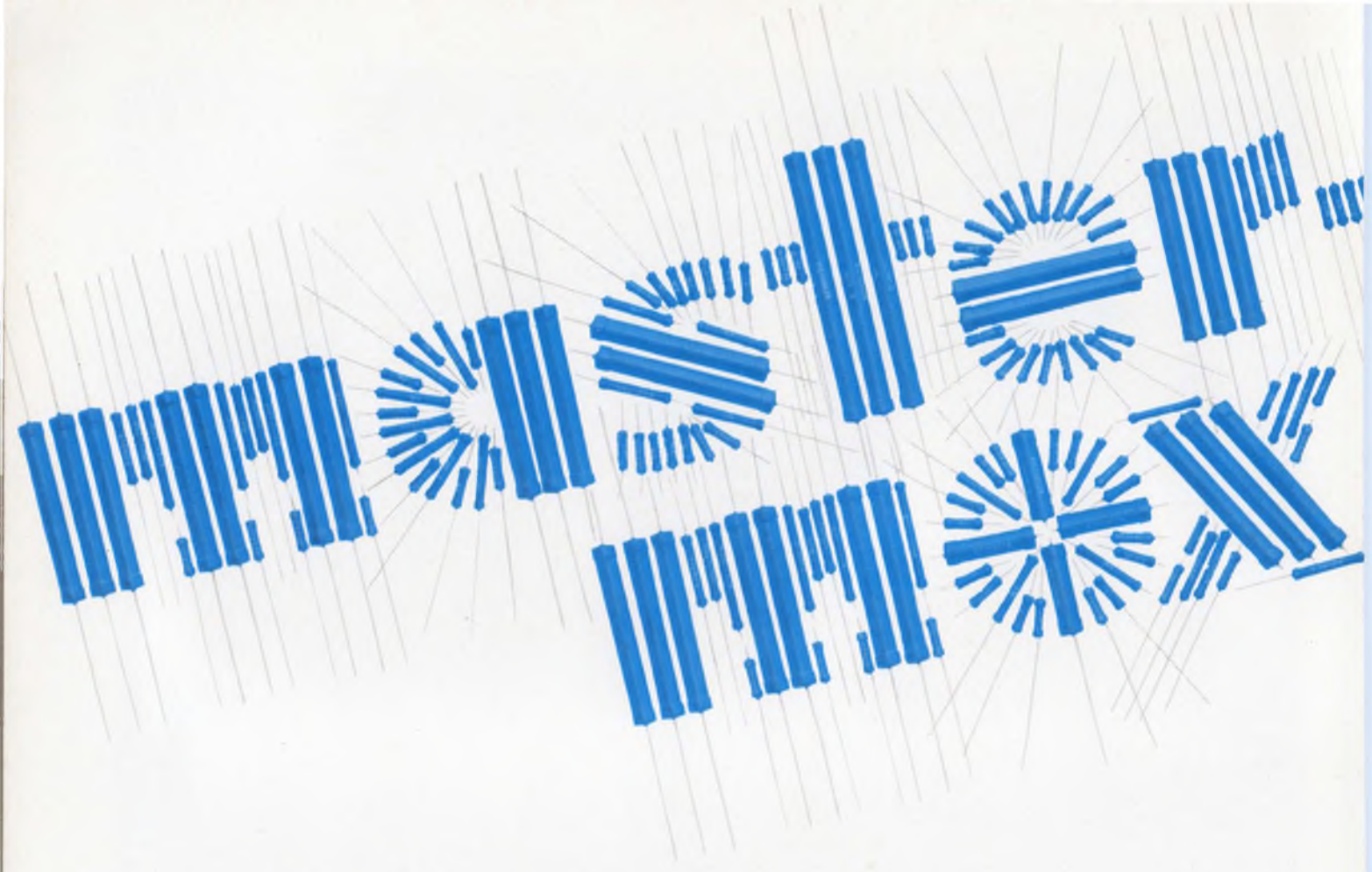
The MIL-E-5400K specifications for airborne electronic equipment do not permit the use of printed circuit board plug-in connectors. Continental's right angle connectors meet all the design requirements of this revised Mil spec—dip soldering directly to the PC board or flexible cable. A broad range of right angle, microminiature, removable contact and flexible cable connectors are available for you to choose from. Call or write us today for complete information.

For the Sales Representative Nearest You, See Our Listings in EEM and VSMF Directories.

CONTINENTAL CONNECTORS

CONTINENTAL CONNECTOR CORPORATION ▪ WOODSIDE, NEW YORK 11377

INFORMATION RETRIEVAL NUMBER 47



A Mastermox is something more than a metal film.

A Mastermox is a metal oxide glaze resistor. Mastermox resistors combine metal powders with molten glass to bring resistor technology to a new high. Revolutionary design creates high resistance range accuracy — 10K ohms to 10,000 Megohms. Space-savings too. Provides more watts per cubic inch.

Stability? Drift as low as 1% full-load in 2000 hours. On the shelf — less than 0.1% drift per year. Changes in voltage and temperature barely influence Mastermox performance.

Obtain Mastermox critical capability in high voltage dividers and bleeders, meter multipliers, high voltage probes, oscilloscopes and vacuum tube voltmeters, plate load resistors, pulse forming networks, and similar applications.

Mastermox. Victoreen's master resistor.

Model	Resistance Range	Power Rating @ 70°C	*Max. Oper. Volts	Length Inches	Diameter Inches
MOX-400	1 - 2500 megs	.25W	1,000V	.420±.050	.130±.010
MOX-750	1 - 5000 megs	.50W	2,000V	.790±.050	.130±.010
MOX-1125	1 - 10000 megs	1.00W	5,000V	1.175±.060	.130±.010
MOX-1	10K - 500 megs	2.50W	7,500V	1.062±.060	.284±.010
MOX-2	20K - 1000 megs	5.00W	15,000V	2.062±.060	.284±.010
MOX-3	30K - 1500 megs	7.50W	22,500V	3.062±.060	.284±.010
MOX-4	40K - 2000 megs	10.00W	30,000V	4.062±.060	.284±.010
MOX-5	50K - 2500 megs	12.50W	37,500V	5.062±.060	.284±.010

*Applicable above critical resistance. Maximum operating temperature, 220°C. Encapsulation: Si Conformal. Additional technical data in folder form available upon request. Or telephone: (216) 795-8200.

VICTOREEN INSTRUMENT DIVISION
10101 WOODLAND AVENUE • CLEVELAND, OHIO 44104
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VICTOREEN

INFORMATION RETRIEVAL NUMBER 49

INFORMATION RETRIEVAL NUMBER 50 ►

We make our frequency components too good rather than merely good enough. Because sometime, somewhere, it might make a difference.

Motorola's dependable, precision frequency components are now available.

Many of our frequency components are used in emergency communications equipment. That's one reason why we will not compromise our insistence on quality.

And now, for the first time in 30 years, you and other designers and OEM manufacturers can take advantage of Motorola's experience and large production capabilities for frequency components: crystals, filters, oscillators, tone modules, and resonant reeds.

You can choose from an extensive line of off-the-shelf precision components. Or we'll gladly design and produce your devices on a custom basis. If you need it, you'll get application assistance. And all components are made under clean room conditions.

Whatever application you have in mind for our frequency components, you can count on one thing. All are designed with the same precision, the same quality, the same dependability. Because we won't settle for second best.

And neither should you.

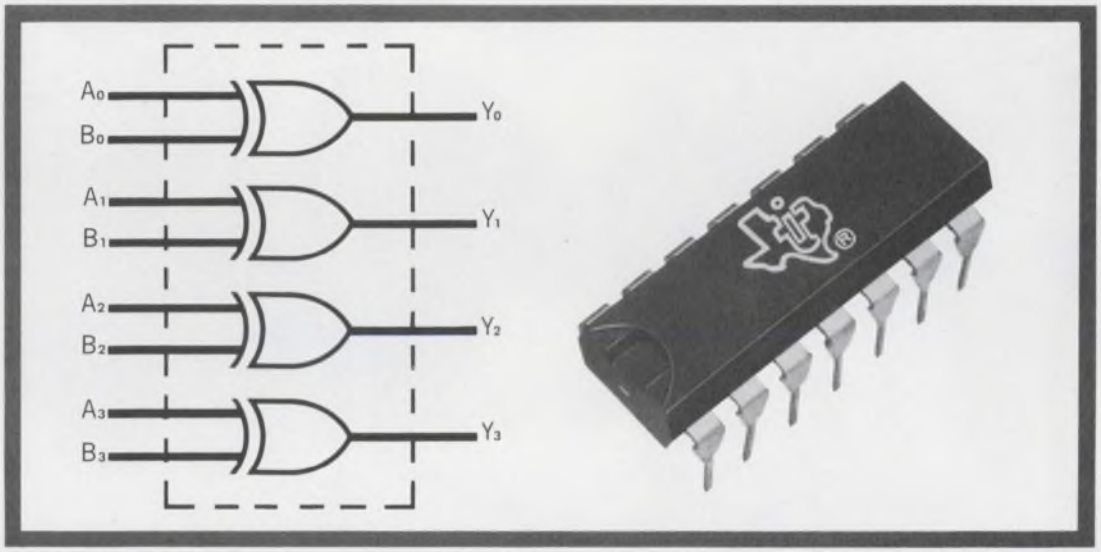
Send for Bulletin TIC-3401. Write Component Products Dept., Motorola Communications & Electronics, Inc., 4501 W. Augusta Blvd., Chicago, Illinois 60651.

MOTOROLA TOTAL COMMUNICATIONS

The Choice is TTL.

$Y = A \oplus B$

TI's new MSI SN5486/SN7486 does it fast.

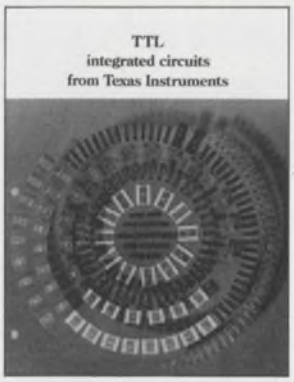


(And easy on the pocketbook.)

Typical propagation delay of this new TI monolithic quadruple 2-input exclusive-OR gate is 12 ns. Power dissipation per exclusive-OR function is only 39 mW. In 100-999 quantities, the plastic dual-in-line carries a $3.00 price tag.

TI's low-power version, SN54L86/SN-74L86, will help ease your critical power dissipation situations. Power dissipation: 3.75 mW per exclusive-OR function. Propagation delay: 58 ns. Cost: $3.41 for the plastic dual-in-line.

You can get both versions promptly



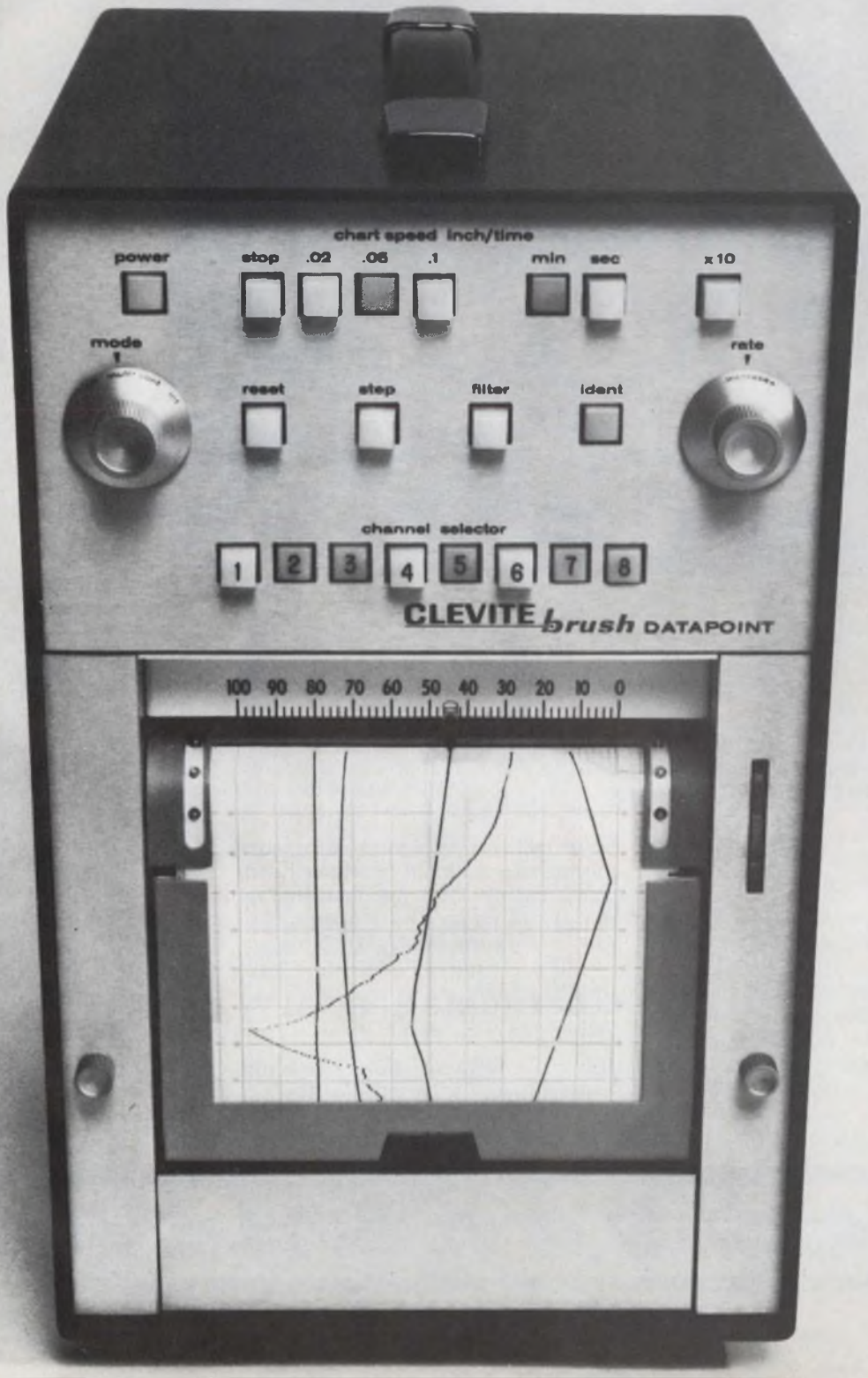
and both are fully compatible with TI's growing family of Series 54/74 integrated circuits.

For all the facts, fast and easy, get our data sheet on the SN5486/SN7486. We'll also send along our new 80-page brochure on our Series 54/74 ICs. Circle 190 on the Reader Service Card or write Texas Instruments Incorporated, P.O. Box 5012, M. S. 308, Dallas, Texas 75222. Or call your nearest authorized TI Distributor.

TEXAS INSTRUMENTS
INCORPORATED

Meet Datapoint. It's 20 times faster than other multipoint recorders.

And infinitely more versatile.



This new high-speed multipoint recorder by Brush runs off as many as 20 samples per second on 2 to 8 channels. So it's great for monitoring fast-changing variables in temperature, flow, pressure, strain, chemical processes, displacement dynamics and the like.

Datapoint handles mixed inputs from high and low level inputs. All on one chart. Recordings come out clear, crisp, uncluttered. And Z-folded. You've got a choice of 12 chart speeds, pushbutton controlled.

About that versatility. Datapoint works in three modes: multipoint sampling, intensified sampling, for channels of high dynamic content, or continuous single channel recording. So you get much more than just a fast multipoint recorder. Without paying more to get it.

And Datapoint is accurate, too. A full 99.5%, enforced by a non-contact position-feedback system. It's a first in this type of recorder. (But a proven success in countless Brush direct writing oscillographs.)

Speed. Versatility. Accuracy. These make Datapoint a new concept in recording. There's never been anything like it. You'll find more proof in the Datapoint brochure. Send for your copy today. Clevite Corporation, Brush Instruments Division, 37th and Perkins, Cleveland, Ohio 44114.

CLEVITE **BRUSH**

now!
minimum current switching

in a low-cost relay

New Electronic Specialty 79N, all-welded military-type, crystal can, dry circuit to 3-amp relay, per MIL-R-5757D/10C.

Put the new 79N relay into your circuit . . . you'll get reliable minimum current switching and cut costs at the same time.

This new relay gives you the same reliability in switching of minimum current as dry circuit or load current . . . and at prices competitive with conventional relays. A unique contact design lets the 79N meet the 100,000-cycle, no-failure military requirements for minimum current previously found only in higher cost, more exotic relays.

If you're designing state-of-the-art circuitry with 100 mA to .5 A switching requirements, as well as dry circuit and load current to 3 amps, you should know all about the 79N.

For complete information—or assistance in solving your switching problems with 2 & 4 pole 10 amp, or 2, 4, & 6 pole dry circuit-to-3 amp relays contact your nearest Electronic Specialty representative. Or write:

ELECTRONIC SPECIALTY CO.
PORTLAND ELECTRONICS DIVISION
Dept. ED • 18900 N. E. Sandy Boulevard
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A COMPLETE LINE OF MINIATURE MILITARY RELAYS WITH PROVEN PERFORMANCE

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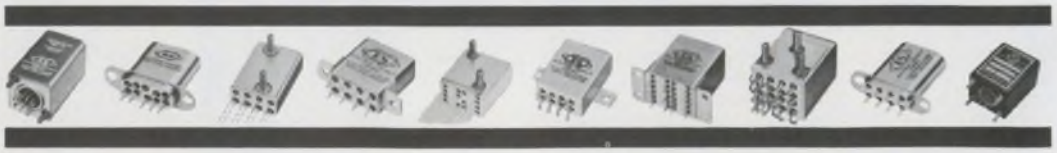
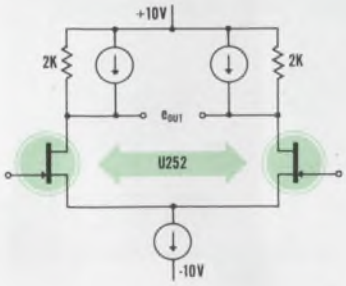


INFORMATION RETRIEVAL NUMBER 53

Applications Power*

HF DUAL FETs
for wideband diff amps, and balanced RF circuits

Wideband Differential Amplifier Ideal for a preamplifier where high input impedance and low noise over a wide frequency range is desired. At 25 MHz the input impedance is approximately 250K in parallel with 3 pF.

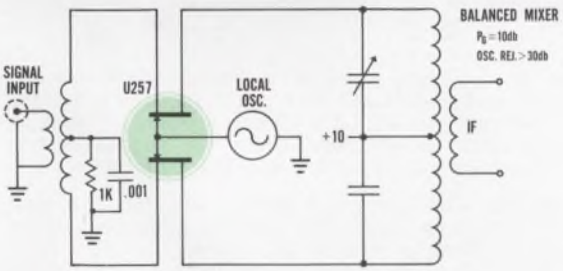


WIDEBAND DIFFERENTIAL AMP
A_v = 20db
BANDWIDTH = 25mHz

CHARACTERISTIC	SYMBOL	MIN	MAX	CONDITIONS
Transconductance	g_{fs}	5,000 μmho		V_{DG} = 10V I_D = 5 mA
Input Capacitance	C_{iss}		5 pF	
Offset Voltage	$\|V_{GS1} - V_{GS2}\|$		10 mV*	
Differential Voltage Drift	$\|V_{GS1} - V_{GS2}\|/\Delta T$		20 μV/°C*	

* The U253 has an offset of 20 mV and a differential drift of 40 μV/°C Max.

Balanced Mixer The FET's square law characteristic allows this mixer to handle large dynamic signal power while producing low spurious products. Oscillator power drive requirements are extremely low, thanks to the FET's high input impedance.



BALANCED MIXER
P_G = 10db
OSC. REJ. > 30db

CHARACTERISTIC	SYMBOL	MIN	MAX	CONDITIONS
Transconductance	g_{fs}	5,000 μmho		V_{DG} = 10V I_D = 5 mA
Input Capacitance	C_{iss}		5 pF	
Offset Voltage	$\|V_{GS1} - V_{GS2}\|$		100 mV	

These high frequency duals may be used up to 450 MHz depending upon the application and performance desired. If your present design situation is VHF or UHF, if you want instant applications information, call the number below. It's a direct line to our applications group. **That's applications power.*

Our new address . . .

Siliconix incorporated

2201 Laurelwood Road • Santa Clara, Calif. 95054
Phone (408) 246-8000 Ext. 201 • TWX: 910-338-0227

. . . in Europe Siliconix Ltd.
Siliconix House
Sketty Park
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Swansea, U.K.

here's a new waveform generator that'll still be new in '72

P5001 Main Frame/ Power Supply Regulator section is Plug-In 5010

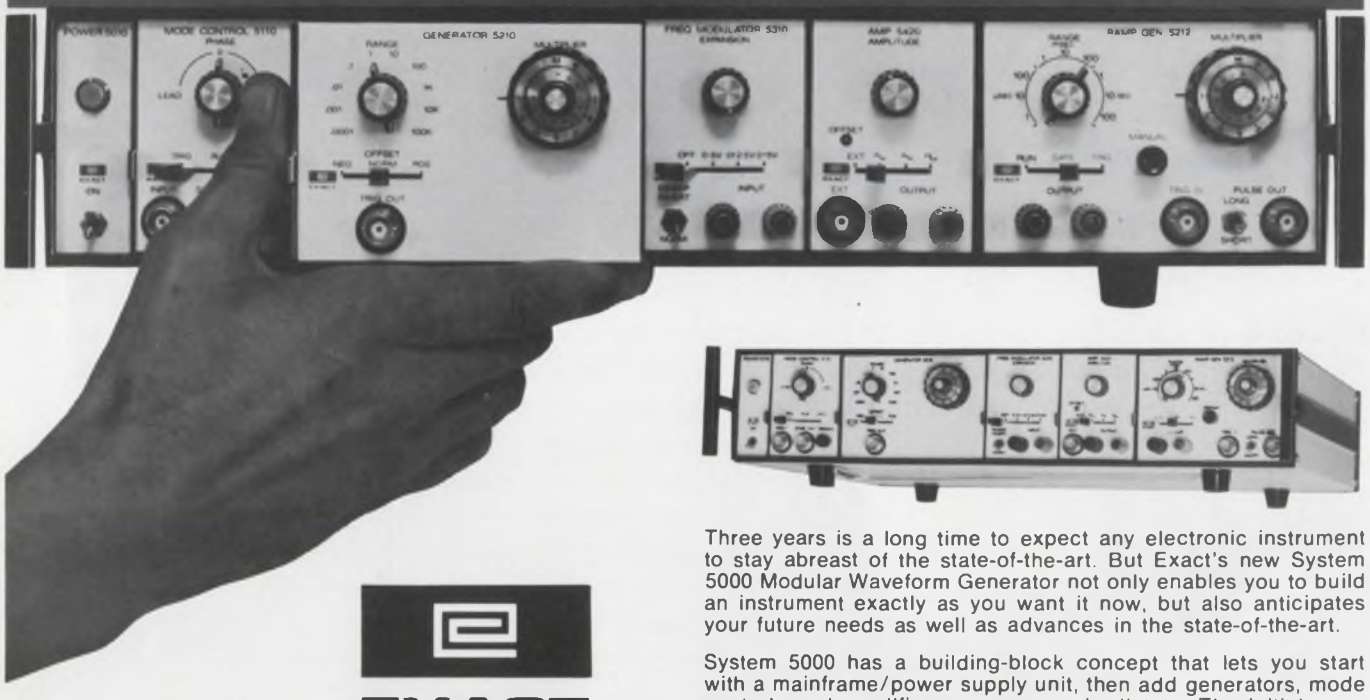
Mode Control 5110 provides gating and triggering to generator; variable start/stop; adds haversine and havertriangle to generator.

Generator G5210 produces square and triangle waveforms from .0001 Hz to 1 MHz; 2 MHz in positive or negative offset. Triangle used for sine shaping in A5420.

Frequency Modulator M5310 adds voltage-controlled frequency to G5210. Features sweeping direction and expansion control, with input signal conditioning.

General Purpose Amplifier A5420 with square, triangle and sine outputs. Features built-in sine shaper and external input capability.

Generator G5212: Ramp generator, with a range from 1000 sec. to 1μ sec., can be used to drive M5310 for sweeping operation. Two 5212's make a simple X-Y system.



EXACT
electronics, inc.

Box 160
Hillsboro, Oregon 97123
Telephone (503) 648-6661

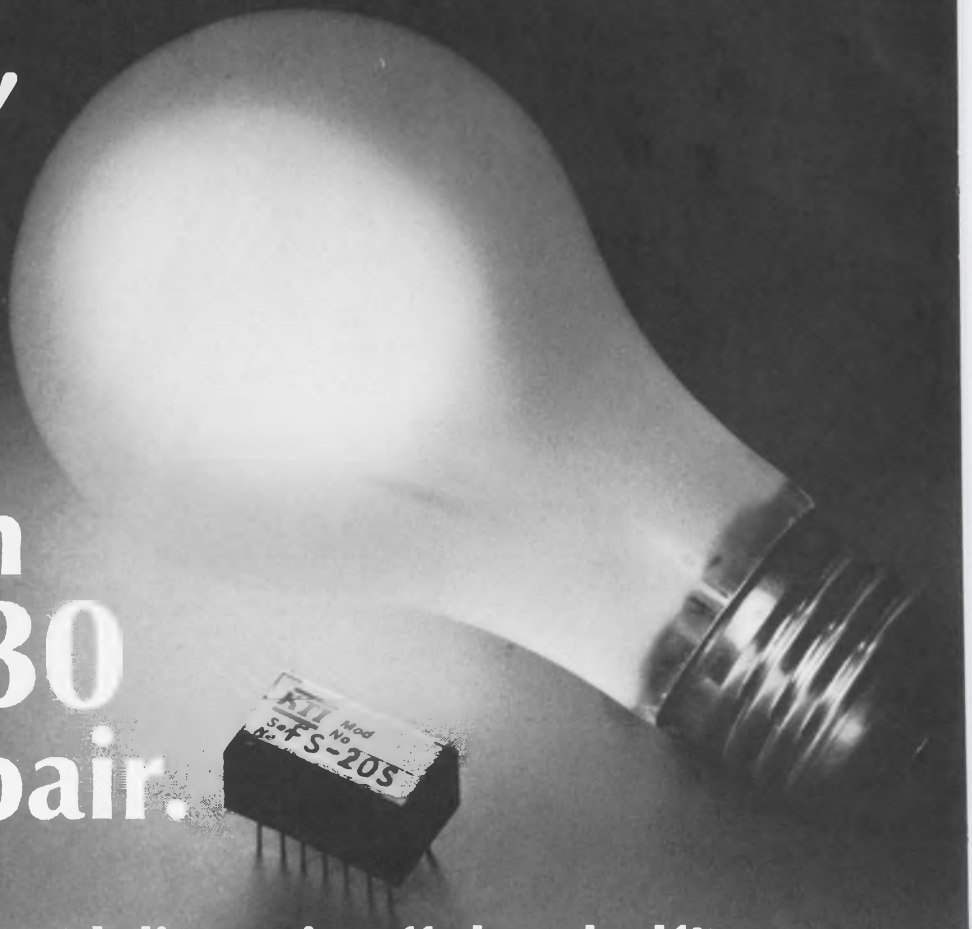
Three years is a long time to expect any electronic instrument to stay abreast of the state-of-the-art. But Exact's new System 5000 Modular Waveform Generator not only enables you to build an instrument exactly as you want it now, but also anticipates your future needs as well as advances in the state-of-the-art.

System 5000 has a building-block concept that lets you start with a mainframe/power supply unit, then add generators, mode controls and amplifiers as your needs dictate. The initial complement of plug-in modules includes a mode control unit, three generators, a frequency modulator and three amplifiers.

Packaged in a compact, 3½-inch-thin cabinet, the System 5000 features a convenient new module ejector device, smart black-and-white styling and a tilt stand.

INFORMATION RETRIEVAL NUMBER 55

If Hybrid IC Active Filters with passive filter stability could solve your problems, you'd probably pay more for them than $30 per pole pair.



Try our FS-20 (delivery is off the shelf!)

■ Here's what you get: Band-pass, high-pass and low-pass outputs simultaneously ■ Any desired form of the second order transfer function ■ Complex zeros anywhere in the S-plane ■ Multi-loop negative feedback for added stability ■ F_c and Q of basic unit can be tuned by adding external resistors ■ Frequency range from DC to 50 kHz ■ Q range from 0.1 to 500 ■ Voltage gain is adjustable to 40 dB ■ Supply voltages from ±9V to ±15V with 250 mW power consumption ■ Dimensions: (14-pin DIP) 0.804" x 0.366" x 0.474".

Gentlemen at KTI:
Please send me more information on:
☐ FS-20 ☐ All Active Filters ☐ Hybrid Subsystems
☐ Put me on your permanent mailing list

Name_____

Company_____

Address_____

City_____

State_____ ZIP_____

My applications are:_____

PRICES:	1-5	$47	26-99	$37
	6-10	$42	100-999	$35
	11-25	$39	1000-2000	$28

KTI

KINETIC TECHNOLOGY, INCORPORATED
17465 Shelburne Way, Los Gatos, California 95030
(408) 356-2131 TWX: 910-597-5390
The name to remember for Hybrid Integrated Systems and Active Filters . . .

You say you want a

low-profile snap-in mounting push button switch or matching indicator that is interchangeable with most 4-lamp displays . . . available in a full range of cap colors . . . with a choice of bezels with or without barriers in black, gray, dark gray or white.

and a

legend presentation that's positive (like this one) or negative (like the one below) or just plain (like the one above) . . . one that's white when "off" and red, green, yellow (amber), blue or light yellow when "on" . . . or colored both "on" and "off."

and a

highly reliable switch proven in thousands of installations . . . available in momentary or alternate action . . . N.O., N.C. or two circuit (one N.O., one N.C.) . . . that accommodates a T-1¾ bulb with midget flanged base, incandescent, in a range of voltages from 6—28V.

etc.
etc.
etc.

Now, Dialight gives you custom panel designing with a standard line of push-button switches and matching indicators

Dialight offers a broader range of switch and indicator possibilities than you'll find anywhere in a standard single-lamp line. Sizes: ¾" x 1", ⅝" square and round. Send today for our new full-color catalog L-209.

DIALIGHT

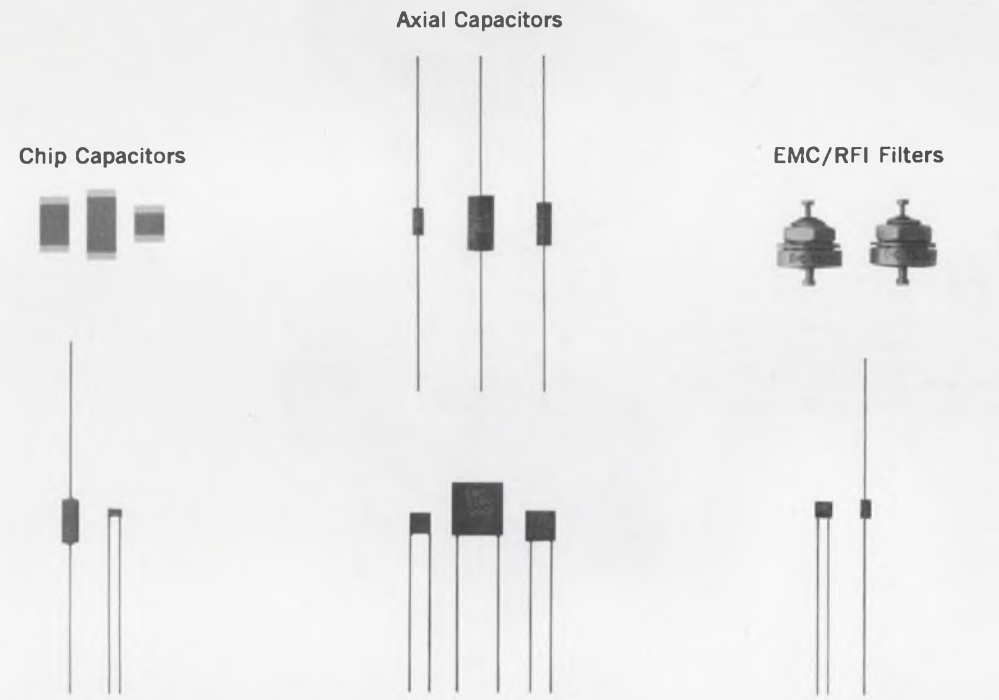
Dialight Corporation, 60 Stewart Ave., Brooklyn, N.Y. 11237

DT-124

INFORMATION RETRIEVAL NUMBER 58

◄ INFORMATION RETRIEVAL NUMBER 57

We spent a bundle developing these filters and capacitors.



Information about them is free.

Electro Materials
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Represented by COMPAR

INFORMATION RETRIEVAL NUMBER 59

INFORMATION RETRIEVAL NUMBER 60 ►

10 KHz — 115 MHz Sweep Plug-In

50 KHz — 110 MHz Sweep Synthesizer

KAY

50 KHz — 110 MHz Sweep & Marker Generator

3 accurate 110 MHz sweepers!

Require no markers!

For those with uncalibrated vision:

- VARIABLE PULSE MARKERS
- VARIABLE BIRDIE MARKERS
- CRYSTAL PULSE MARKERS
- CRYSTAL BIRDIE MARKERS
- HARMONIC MARKERS
- VERTICAL MARKERS
- HORIZONTAL MARKERS
- RF TURN-OFF MARKERS

10 KHz — 115 MHz SWEEP PLUG-IN • Log Sweep To Below 10 KHz • Two Band Sweep Function • Residual FM 100 Hz	50 KHz — 110 MHz SWEEP GENERATOR • Plug-In Markers • Companion to 159C 300 MHz Wide Sweep
All three all solid-state 100 MHz wide sweeps Full-time controls	50 KHz — 110 MHz SWEEP SYNTHESIZER • Phase Locked Sweep & CW • Drift < 5PPM/min. < 20PPM/hr. • Residual < 10 Hz @ 10 MHz < 40 Hz @ 70 MHz

KAY ELECTRIC COMPANY

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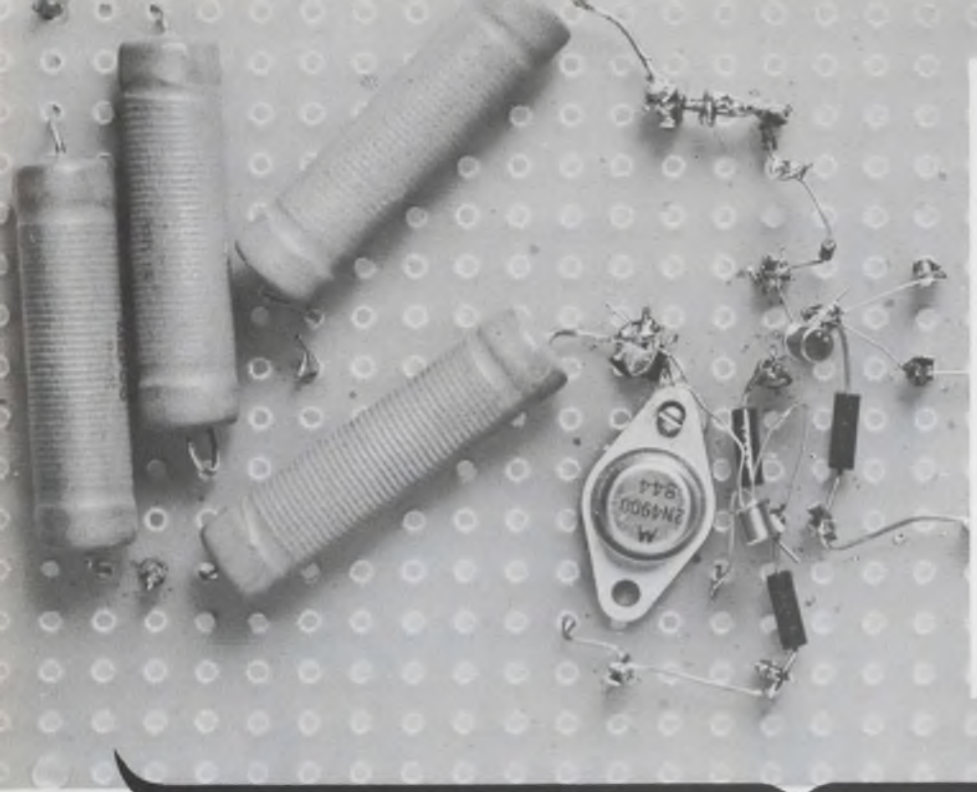

#6 OF A SERIES

Standard Circuit of the Month

SPECIFICATIONS:

- **Compatible with DTL/TTL logic levels**
- **Built-in 2-input expandable AND gate**
- **Delivers 40W to load**
- **Built-in flyback protection for inductive loads**
- **Load connected from output to ground**
- **Full military temperature range**

Relay, Lamp, Core Driver

Maximum ratings:

Power Dissipation: 1.0W (continuous ON)
Operating Temperature: −55°C to +125°C
Storage Temperature: −65°C to +175°C
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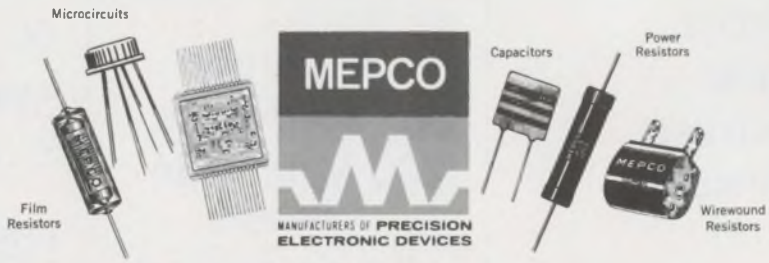

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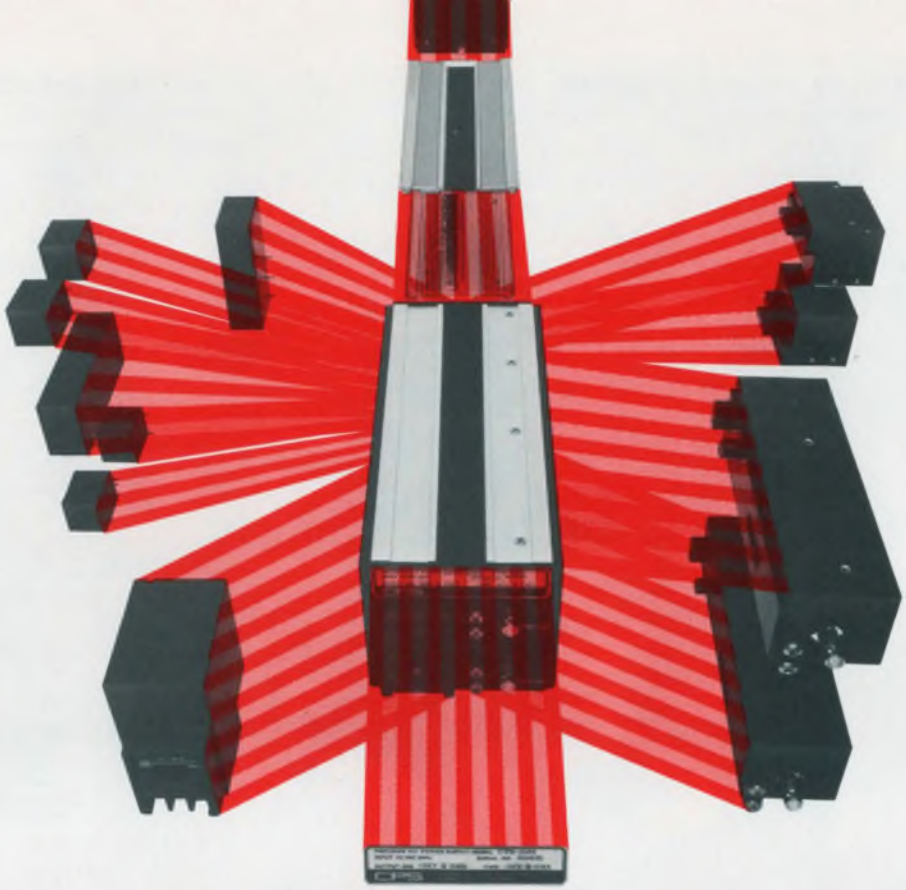

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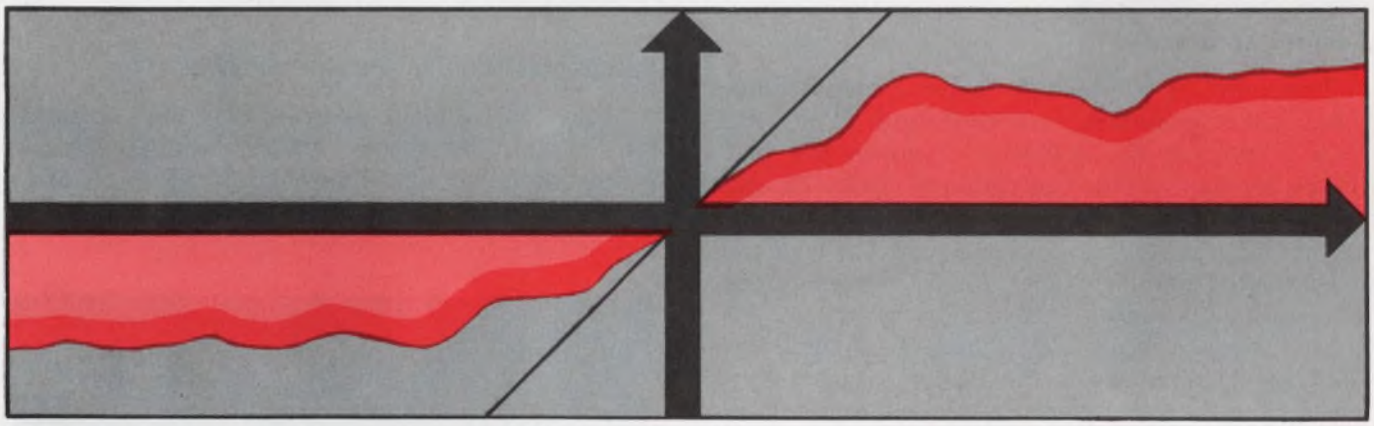
Technology

John Greenbaum, GE project engineer, tells how to make op-amp linear models. p. 92.

Reduce stray reactances with the boundary method of layout. p. 98.



Nonlinear control systems can be analyzed by Popov's method, giving conditions that are sufficient for stability independent of the shape of the nonlinearity. p. 84.

Also in this section:

Try active overload protection for your dc voltage regulator. This versatile sampling technique provides automatic restart and minimum power dissipation.

Protection of a dc voltage regulator against overloads caused by line transients or load malfunctions is usually a power-supply design requirement. Such protection can be provided by fuses, circuit breakers or various circuit techniques,[1] but usually at a sacrifice of precision or speed, or at the cost of high power dissipation.

All the desirable characteristics of overload protectors, however, can be attained by using an active sampling technique that can provide rapid sensing and current limitation, current interruption, automatic reset and low overload power dissipation. In addition, this technique can be readily applied to most series or shunt voltage regulators, so that the regulation circuit best suited to the load requirements can be selected. Furthermore, an integral overload indicator can easily be added to provide a visual trip-out signal.

Test for an overload

The sampling overload protector operates somewhat like a monostable multivibrator. When the load is normal the protector assumes the rest state, similar to the untriggered state of the monostable. Upon sensing an overload, the protector disconnects the regulator from the load for a controlled period of time; it then re-examines the load and permits a return to normal operation if the overload is no longer present. If the overload persists, however, the regulator is disconnected for the same period of time and again re-examines the load.

This cyclic sampling of the load conditions continues until the overload is cleared. The interruption interval during which the load and regulator are electrically isolated is similar to the triggered state of the monostable. The repetition frequency for cyclic sampling and the sampling interval can be selected to achieve optimum performance from the power supply/load combination.

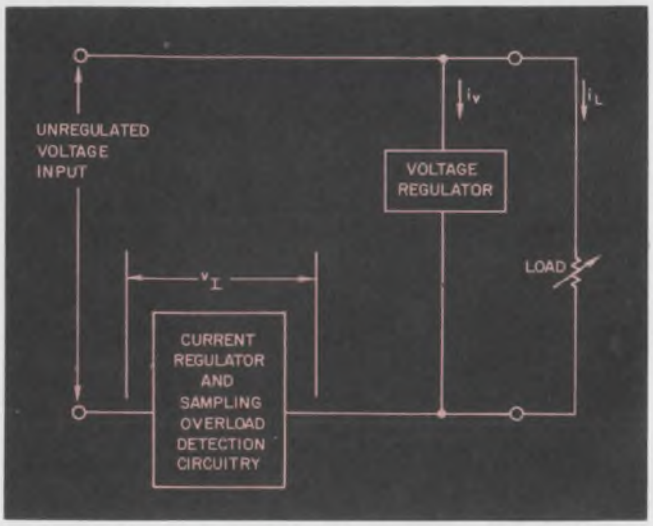
From a system standpoint, many overload protection methods are difficult to use. This technique, however, is versatile. For example, where transient or short-term overloads are part of normal operation, circuit time-constants can be adjusted to suppress reaction to this type of overload.

Large capacitive loads offer a different problem. After an overload has occurred and the regulator is attempting to turn on, large regulator currents are required to charge the load capacitance. Here, either the sampling pulse width or peak current can be increased to charge the load capacitance.

The trip-out of one voltage in a multivoltage power-supply system as a result of a fault may require several other voltages to be turned off. The use of a protection technique controlled by a common sampling pulse generator enables easy adaptation to this requirement.

Design protection for a shunt regulator

Figure 1 is a block diagram of a high-voltage, low-current, shunt-type voltage regulator power supply designed to deliver 500 V dc at 10 mA. It uses a sampling overload protector.



1. **In the shunt regulator** the sampling circuit operates in series with the load.

Paul A. Kaden, Senior Staff Engineer, Hartman Systems Co., Inc., Huntington Station, N. Y.

The unit maintains the total current (voltage regulator current i_v, plus load current i_L) constant over the normal operating range of load impedances. The voltage drop, v_l, across the current regulator is therefore constant over this range (assuming no variation in power-supply input voltage).

When the load impedance drops below the minimum normal value, the shunt regulator is no longer able to maintain a constant total current, and the voltage drop across the current regulator increases. This increase in voltage drop is used to initiate overload protection.

A complete schematic diagram of the regulator is shown in Fig. 2. Transistors *Q4*, *Q5* and *Q6* constitute a conventional shunt voltage regulator, and *Q3* is the current regualtor.[2] *Q1* is normally cut off. The voltage appearing across zener diode *CR10* and the total resistance in the *Q3* emitter circuit determine the *Q3* collector current.

In the event of an overload, the increased voltage drop across *Q3* is applied to the base of *Q1* by the voltage divider R_2, R_4, and R_8, thus causing *Q1* to conduct. (Diode CR12 provides temperature compensation for *Q1*). The base current of *Q3* rapidly decreases to near zero, causing the load current to also drop. The bistable pair, *Q1* and *Q3*, is now in a stable OFF state, and *Q3* power dissipation is reduced to a low value.

A means must be provided to trigger *Q3* ON to provide for sampling of the load. This is accomplished by unijunction transistor *Q2*, which is connected as a relaxation oscillator.[3] Interbase voltage for *Q2* is supplied from zener diode *CR9*.

When *Q3* is on the OFF state, capacitor C_2 charges through R8 until the Q2 emitter voltage reaches the peak-point value. The emitter is then forward biased, and C_2 is discharged through the *Q3* emitter-base junction, momentarily turning *Q3* on. Capacitor C_2 is connected so that the discharge path is through R_7. This limits the peak pulse current of *Q3* when the load is a short circuit.

If the overload is still present, *Q3* returns to the OFF-state and the sampling cycle repeats at intervals determined primarily by the values of R_6 and C_2. The duty cycle of the *Q3* ON time during an overload can be made quite small, thus lowering the average *Q3* power dissipation.

Once the overload is removed, *Q3* remains in the ON condition after a sampling pulse, and the current regulator returns to normal operation.

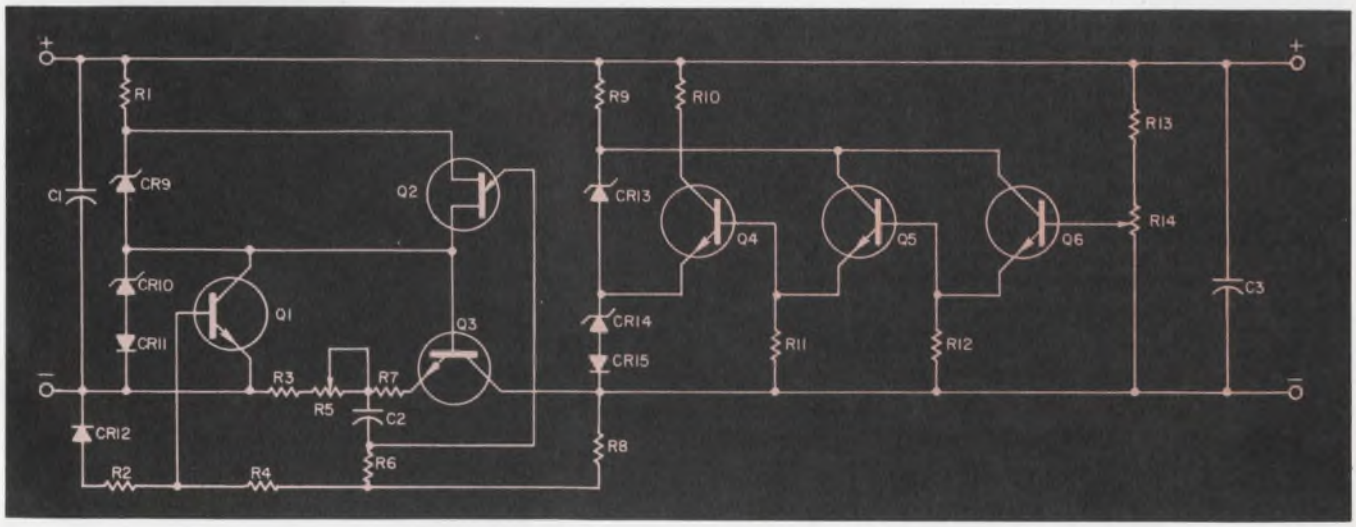
The addition of the unijunction transistor, *Q2*, converts the bistable pair of *Q1* and *Q3* into a monostable circuit as long as a fault remains on the load. The *Q2* relaxation oscillator does not operate when the load current is within design limits.

Transistors *Q1*, *Q2*, and *Q3* can be connected in a variety of configurations. However, since this is a high-voltage power supply, care must be exercised. Should the load be short-circuited, *Q3* is OFF and must withstand the full rectifier output voltage. It is, therefore, desirable to maintain a low-resistance path from the base to the emitter of *Q3* to avoid the possibility of excessive leakage. For this reason, *Q1* is connected in parallel with the *Q3* base-emitter circuit.

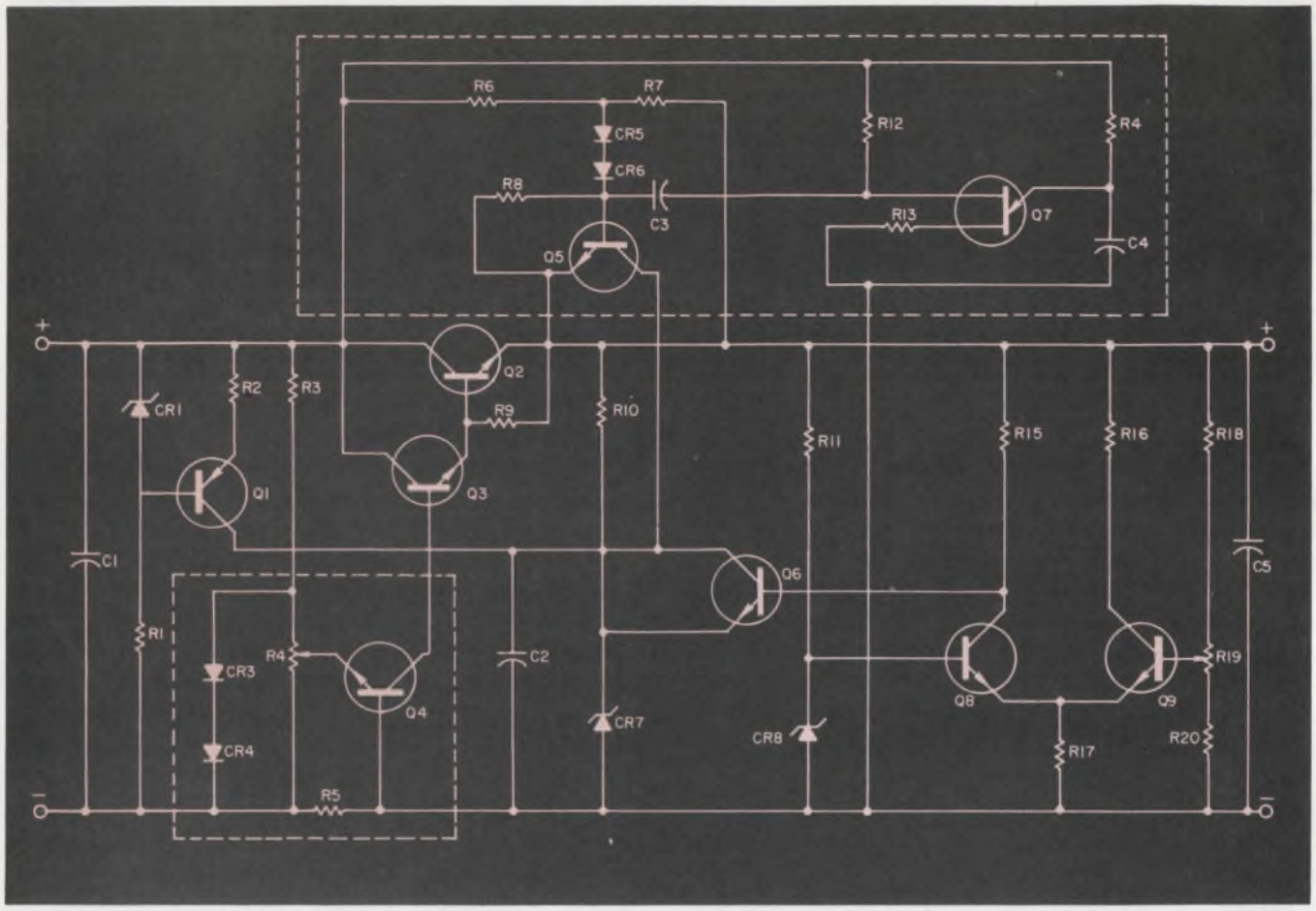
. . . and for a series regulator

The sampling overload protector shown in Fig. 3 is used to protect a low-voltage, high-current, series type of voltage regulator. The protection circuit consists primarily of resistors R_5, R_6 and R_7 and transistors *Q4*, *Q5*, and *Q7*.

Normally, the voltage across R_5 is insufficient to cause *Q4* to conduct. However, when a predetermined load current is reached, *Q4* begins con-



2. **Relaxation oscillator Q2** is the key component in the active sampling circiut of this shunt regulator.



3. **The series regulator** also uses a unijunction transistor, Q7, to iniate sampling of the load condition.

ducting, increasing the voltage drop across the series regulating transistors, *Q2* and *Q3*. A further increase of load current causes most of the unregulated input voltage to appear across the series regulating transistors.

When this occurs, *Q5* is saturated by voltage divider R_n and R_7 and thus applies a high voltage to the emitters of the series regulating transistors. These, in turn, stop conducting because their base-to-emitter junctions become reverse-biased. And this condition continues until relaxation oscillator *Q7*, which operates continuously, triggers *Q5* OFF, permitting the series regulator to sample the condition of the load.

If the overload remains, the series regulator rapidly returns to the OFF state and awaits the next sampling period, as controlled by the relaxation oscillator *Q7* triggers *Q5* OFF, permitting tion oscillator time-constant. If the voltage across R^* and the load have returned to normal, the regulator will assume its proper operation.

The sampling technique of overload protection can be adapted to regulators having a wide range of current and voltage ratings. The use of the technique not only permits automatic restart of the regulator when the overload is removed but also minimizes power dissipation in the regulated supply during overload ■■

References:
1. "Silicon Transistor Voltage Regulator Overload Protection," *Texas Instruments Application Note*, June, 1960.
2. E. C. Wilson and R. T. Windecker, "DC Regulated Power Supply Design," *Texas Instruments Application Note*, August, 1960.
3. *Transistor Manual*, Seventh Edition, General Electric, 1964, p. 312.

Test your retention

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

1. What are the disadvantages of commonly used overload protection techniques?

2. What special problem occurs in a multi-voltage power supply?

3. Which component provides the recycle capabilities of the sampling protection circuit described?

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Analyze nonlinear control systems

using Popov's method. It gives sufficient conditions for stability independent of the shape of the nonlinearity.

Although a great deal of material has been published on the stability analysis of nonlinear control systems, only one technique has emerged that is general enough to be useful to most engineers. This technique—destined to equal in importance the Bode and Nyquist criteria—is the Method of Popov.

Popov, a Russian, in 1961 developed a criterion[1] that gives sufficient (but not necessary) conditions for a nonlinear system (Fig. 1) to be stable *independent of the exact shape of the nonlinearity.*

This is quite remarkable considering that, previously, it was believed no general method of analysis of nonlinear systems was possible. Because of the usual time lag between theoretical developments in one country and practical applications in another, few books on nonlinear control systems[2,3] discuss the applications of Popov's method.

The method applies to any feedback system that can be reduced to the form of Fig. 1. It is assumed that $G(s)H(s)$ is of the form $P(s)/Q(s)$, where $P(s)$ and $Q(s)$ are polynomials in s with no repeated roots, and that $G(s)H(s)$ is open-loop stable; that is, $Q(s)$ has no roots in the right half of the s-plane. The nonlinearity is described by the functional relationship $n[x(t)]/x(t)$. Thus, if the input to the nonlinear element is $x(t)$, the output is $\{n[x(t)]/x(t)\}x(t) = n[x(t)]$.

Two requirements must be met

Two conditions are imposed on the nonlinearity in order for Popov's method to work:

$$(1)\ 0 < \frac{n[x(t)]}{x(t)} < k, \text{ and}$$

$$(2)\ n(0) = 0.$$

The first condition says that the nonlinearity must exist in a sector $(0, k)$ bounded by the x-axis and a straight line with slope k passing through the origin. Since k is positive, this restricts the nonlinearity to the first and third quadrants.

The second condition simply states that, when no input is applied to the nonlinear element, no output should be obtained.

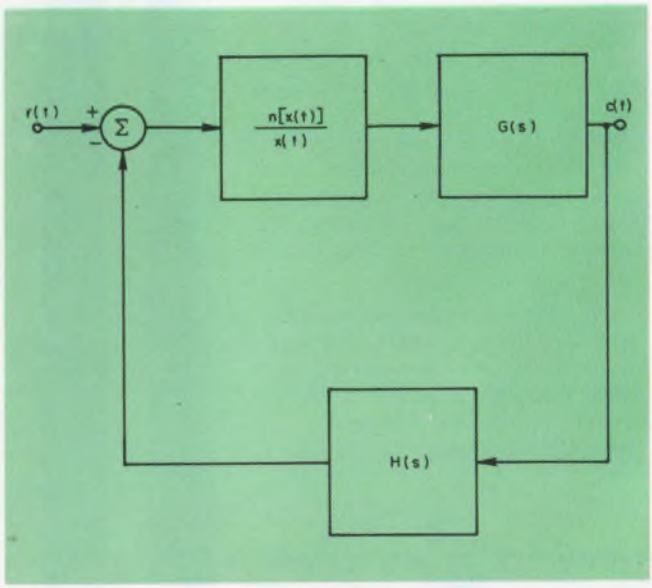
The conditions are made clear by the graphs of a diode (A) and a saturating amplifier (B) in Fig. 2.

The Popov stability criterion can be stated as follows for physical systems that can be placed in the form of Fig 1[4]:

> If a straight line (known as the Popov line) can be drawn to intersect the $\mathrm{Re}[G(j\omega)H(j\omega)]$ axis at $-1/k$ so that the locus of all points of the curve of $\omega\mathrm{Im}[G(j\omega)H(j\omega)]$ vs $\mathrm{Re}[G(j\omega)H(j\omega)]$ lies entirely to the right of this line for all $\omega > 0$, then the system is stable for all nonlinearities in the sector $(0,k)$.

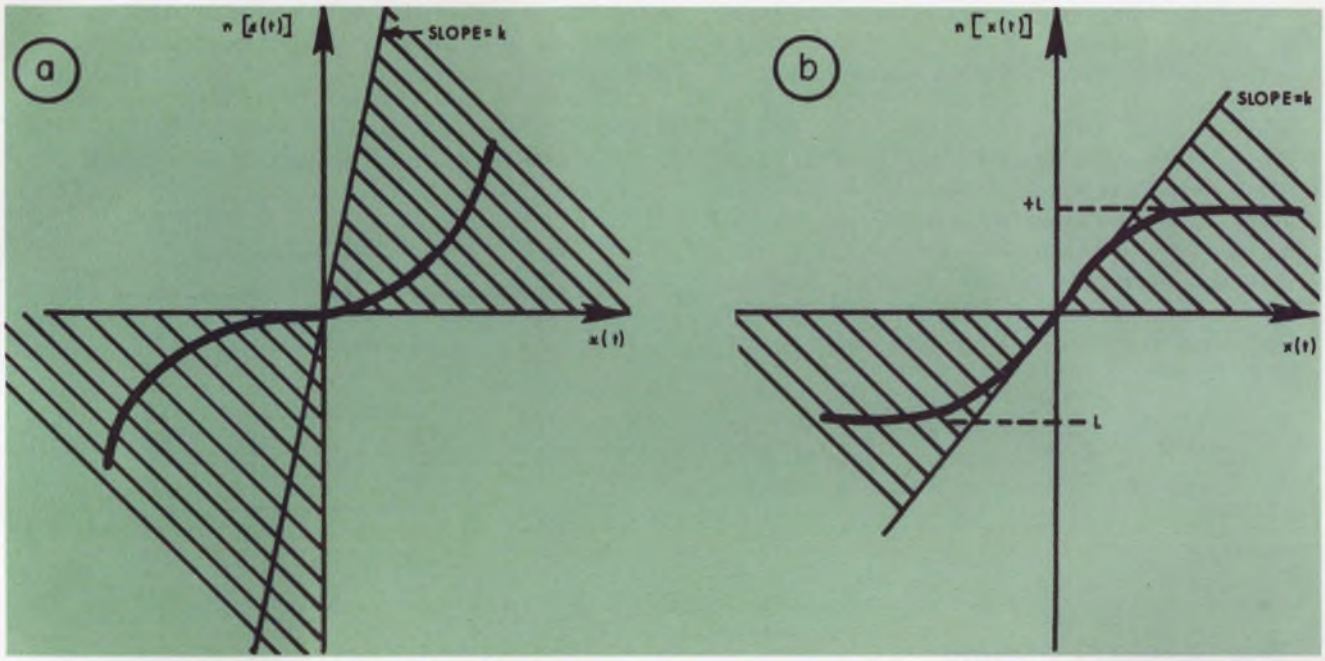
To see how the method is applied, let's reexamine the linear system analyzed in Box 1 and see what effect a nonlinear element would have on it.

We recall that the open-loop transfer function $G(s)H(s)$ is given by $(s+5)/s(s+2)$. For con-



1. **Nonlinear feedback systems** like this can be analyzed for stability by using the Popov method.

John D. Markel, Electrical Engineering Dept., University of California at Santa Barbara.



2. **The two Popov conditions are satisfied** by these curves. Graph (a) represents a diode and graph (b) represents an amplifier with saturation level L. The sector (0, k) is shaded in both cases.

venience, let $G(s)H(s) = M(s)$.

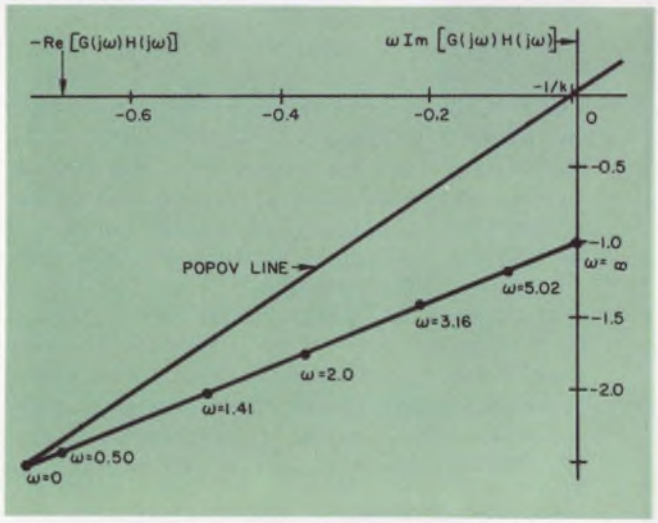
To apply Popov's criterion, we must calculate $\mathrm{Re}[M(j\omega)]$ and $\omega\mathrm{Im}[M(j\omega)]$. A little algebraic manipulation reveals that:

$$\mathrm{Re}[M(j\omega)] = -3/(\omega^2 + 4) \text{ and}$$
$$\omega\mathrm{Im}[M(j\omega)] = (-\omega^2+10)/(\omega^2+4).$$

By plotting these two quantities against each other for all ω from zero to infinity, the graph of Fig. 3 is obtained. The Popov line shown in the diagram can clearly be drawn arbitrarily close to the origin; thus $-1/k$ can approach arbitrarily close to zero. This means that k can approach infinity. Infinite k implies that for any nonlinearity contained in the first and third quadrants and passing through the origin, the system will be stable.

Computers lighten the load

With higher-order systems the stability analysis calculations, though simple, become rather



3. **The Popov line** can cross the abscissa arbitrarily close to the origin in this example. Thus, the system is stable for all nonlinearities contained in quadrants I and III and passing through the origin.

1. Linear control system analysis

The stability condition

Since an understanding of linear system stability analysis is a prerequisite for the study of nonlinear systems a brief review is provided.

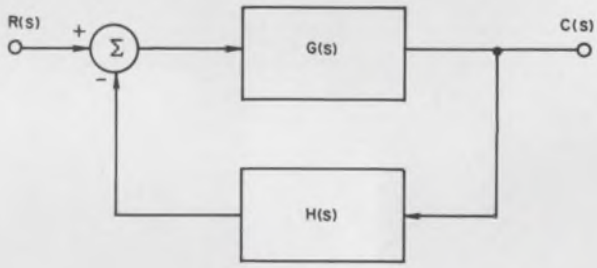
To most engineers, a stable system is one that does not oscillate. And translating this definition into mathematical terms is the first step in formulating a linear theory.

The block diagram is a general representation, in Laplace notation, of a single-input single-output (SISO) linear feedback system. All SISO linear systems can be placed in this form by applying block diagram reduction techniques or Mason's gain formula.[5,6] (We consider only SISO systems here mainly because of their wide usage. Multiple input/output systems can be handled by state variable techniques.[6])

In this form, $H(s)$ is the feedback element, $G(s)H(s)$ is defined as the open-loop transfer function and $C(s)/R(s)$ is defined as the closed-loop transfer function.

From the diagram, $C(s)/R(s) = G(s)/[1 + G(s)H(s)]$. The demoninator, known as the characteristic equation of the system, contains all of the information required to determine whether or not the system is stable. Recall from Laplace transform theory that negative roots (poles of $C(s)/R(s)$ or zeros of $1 + G(s)H(s)$ in the left half of the s-plane) imply decaying exponentials in the time domain, roots on the $j\omega$-axis mean sinusoidal variations in output response, and roots in the right half of the s-plane mean increasing exponentials in the output response. Thus stability can be defined mathematically as follows:

The closed-loop systems $C(s)/R(s)$ will be stable if, and only if, there are no zeros of $1 + G(s)H(s)$ in the right half of the s-plane.



The Nyquist criterion

The Nyquist criterion is based on a result from complex-variable theory, and it states:

If $G(s)H(s)$ is analytic within a closed contour, except for a finite number of poles and zeros, then the number of times that $-1 + j0$ in the $G(s)H(s)$ plane is encircled in traversing the closed contour equals the number of zeros of $1 + G(s)H(s)$ minus the number of poles of $1 + G(s)H(s)$ in the right half of the s-plane.*

If $G(s)H(s)$ is a minimum-phase function (no poles or zeros in the right half plane) then by plotting a graph of $\mathrm{Re}[G(j\omega)H(j\omega)]$ vs $\mathrm{Im}[G(j\omega)H(j\omega)]$ for $0 < \omega < \infty$ and shading to the right of the path as $G(j\omega)H(j\omega)$ is traversed from $\omega = 0$ to $\omega = \infty$, the system will be stable if $-1 + j0$ is not enclosed. Otherwise, the system will be unstable.

Only minimum-phase systems are considered in this article. The reader is referred to other books[5,6] for discussion of the nonminimum cases.

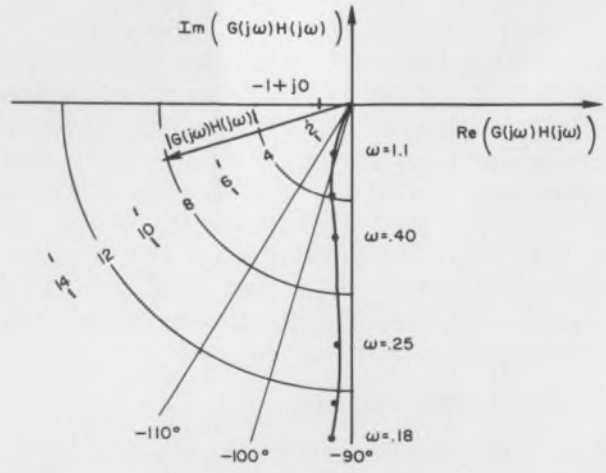
As an example of the application of the Nyquist criterion, consider a unity feedback system defined by $G(s) = (s+5)/s(s+2)$ and $H(s) = 1$.

The Nyquist plot is formed by the locus of points $G(j\omega)H(j\omega)$ as ω varies from zero to infinity. Separating the expression into its real and imaginary parts, we get

$$G(j\omega)H(j\omega) = (j\omega+5)/j\omega(j\omega+2)$$
$$= -3/(\omega^2+4) + j(\omega^2+10)/\omega(\omega^2+4).$$

Substituting various values of ω in this expression, we form the Nyquist plot shown. It is apparent that the $-1+j0$ point is not encircled by shading to the right of the path; hence the linear model is stable.

*The poles of $1 + G(s)H(s)$ are the same as the poles of $G(s)H(s)$, which therefore may be used for this computation.



The Bode plot

The Bode plot conveys the same information as the Nyquist criterion for the minimum-phase case under consideration. (The general statement of the Nyquist criterion must be invoked for nonminimum-phase cases.) The advantage of the Bode diagram is that it is relatively easy to sketch without performing detailed calculations as in the Nyquist case. And the approximate closed-loop system response can be obtained if the system has unity feedback, $H(s) = 1$.[6] In addition, cascade compensation of linear systems[5] is easily studied with the Bode diagrams.

The diagram is drawn by plotting the following two quantities:

$20 \log_{10}|G(j\omega)H(j\omega)|$ vs $\log \omega$

Angle $[G(j\omega)H(j\omega)]$ vs $\log \omega$.

Clearly this job can be considerably simplified by using semi-log paper.

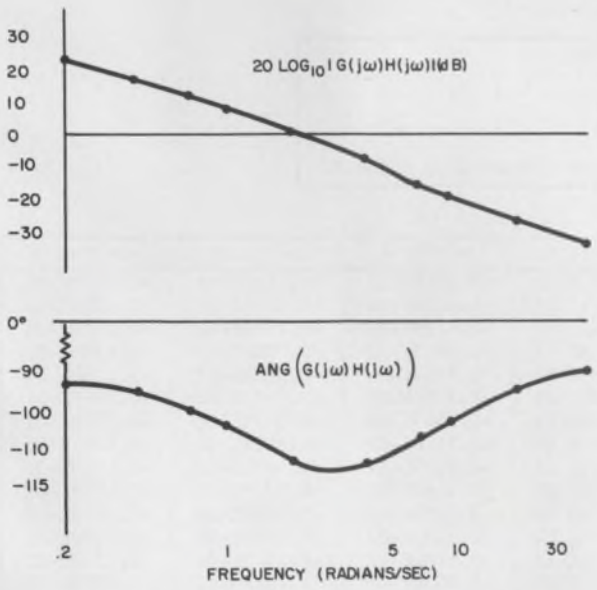
Applying the Bode plot approach to the same problem that we treated with the Nyquist approach, the first step is to place $G(j\omega)H(j\omega)$ in normalized form:

$$G(j\omega)H(j\omega) = \frac{2}{5}\left(\frac{1 + j\omega/5}{j\omega(1 + j\omega/2)}\right)$$

Then, $20 \log_{10}G(j\omega)H(j\omega) = 20 \log_{10}(2/5) + 20 \log_{10}[1+(\omega/5)^2]^{1/2} - 20 \log_{10}\omega - 20 \log_{10}[1+(\omega/4)^2]^{1/2}$

and $\text{Angle}[G(j\omega)H(j\omega)] = \tan^{-1}(\omega/5) - \pi/2 - \tan^{-1}(\omega/2)$.

Each term is plotted individually, and they are all then summed to give the final result. The phase margin is 180 degrees plus the phase shift existing at the frequency at which the magnitude plot crosses the 0-dB line. The gain margin is 0 dB minus the magnitude at the frequency at which the angle plot crosses the minus 180° line.



tedious. Because of the similarity between the various frequency domain methods presented, it is possible to develop a rather concise Fortran computer program to carry them out. The program shown in Box 2 can:

- Analyze nonlinear systems with Popov's method.
- Analyze linear systems with Nyquist diagrams.
- Analyze linear systems with Bode diagrams.
- Calculate the closed-loop frequency response of linear systems.

It can evaluate any rational function $F(s)$ for $s=j\omega$. The function $F(s)$ is given by

$$F(s) = \frac{A_1 s^{KN} + A_2 s^{KN-1} + \cdots A_{KN+1}}{B_1 s^{KD} + B_2 s^{KD-1} + \cdots + B_{KD+1}}$$

The program inputs and outputs are defined in Box 2.

To use an example, consider a nonlinear feedback system in which the limited dynamic range of the system amplifiers can be modeled by the function

$$y(t) = \frac{n[x(t)]}{x(t)} \cdot x(t) = L \tanh \frac{kx(t)}{L}.$$

This function is a good mathematical model for a saturating amplifier with gain k and limit level L, as can be seen in Fig. 2B.

Let's let the linear portion of the system be described by

$$G(s) = \frac{s + 2}{s(s+5)(s^2+3.2s+64)}$$

and $H(s) = 1$.

Expanding $G(s)H(s)$ as the ratio of two polynominals,

$$G(s)H(s) = \frac{s + 2}{s^4 + 3.7s^3 + 65.6s^2 + 32s}$$

This is the function of $F(s)$ for the computer program.

The problem is to determine how large the gain k can be with a fixed limit level L while insuring stability. The roots of $G(s)H(s)$ are 0, -5, and $-1.6 \pm j7.8$, which satisfies the condition that $G(s)H(s)$ is open-loop stable and the poles are nonrepeated. (The pole at $s = 0$ is considered as being in the left half plane, since physical systems can only approximate the mathematical representation $1/s$ by a term of the form $1/(s+\epsilon)$, where $\epsilon > 0$ and ϵ is very small with respect to other time constants of the system.)

The input data to the computer is determined as follows: The degree of the numerator polynominal is 1, thus $KN = 1$; the degree of the denominator polynominal is 4, thus $KD = 4$. There is no rule stating what the upper and lower limits of frequency should be. A large enough range should be obtained so that the shape of the curve is apparent. (The exact values at $\omega = 0$ and $\omega = \infty$ can easily be obtained analytically from $F(s)$.) Somewhat arbitrarily the range of ω is

2. Automating Popov's method

Fortran Program Listing (Main Program)

```
      DIMENSION A(15),B(15),W(2000)
1     READ(5,10)KN,KD,KL,KU,NP
      C1=180./3.1415927
      C2=ALOG(10.)
      MN=KN+1
      MD=KD+1
      M=KU-KL
      NPTS=M*NP+1
      READ (5,20)(A(I),I=1,MN)
      READ (5,20)(B(I),I=1,MD)
      WRITE(6,10)KN,KD,KL,KU,NP
      WRITE(6,20)(A(I),I=1,MN)
      WRITE(6,20)(B(I),I=1,MD)
      DO 30 I=1,M
      DO 30 J=1,NP
      K=J+(I-1)*NP
30    W(K)=10.**(I+KL-1)*EXP ((J-1)*C2/NP)
      W(NPTS)=10.**KU
      DO 40 I=1,NPTS
      CALL EVAL(W,I,KN,A,FRN,FIN)
      CALL EVAL(W,I,KD,B,FRD,FID)
      FMAG=SQRT((FRN*FRN+FIN*FIN)/(FRD*FRD+FID*FID))
      FDB=20.*ALOG10(FMAG)
      CALL ANG(FRN,FIN,FRD,FID,ANGLE)
      FANG=C1*ANGLE
      FRE=FMAG*COS(ANGLE)
      FIM=FMAG*SIN(ANGLE)
      WFIM=W(I)*FIM
      FREQ=W(I)/6.2831854
40    WRITE(6,20)W(I),FREQ,FMAG,FDB,FANG,FRE,FIM,WFIM
10    FORMAT(5I10)
20    FORMAT(8E11.4)
      GO TO 1
      END
```

Fortran Program Listing (Subroutines)

```
      SUBROUTINE EVAL(W,I,N,C,XR,XI)
      DIMENSION W(2000),C(15)
      XR=0.
      XI=0.
      K=1
      NN=N+1
      DO 10 JJ=1,NN,2
      J=JJ-1
      K=K+1
      XR=XR+C(N+1-J)*W(I)**J*(-1)**K
      IF(N-J)10,10,20
20    XI=XI+C(N-J)*W(I)**(J+1)*(-1)**K
10    CONTINUE
      RETURN
      END
```

```
      SUBROUTINE ANG(FRN,FIN,FRD,FID,ANGLE)
      XRE=FRN*FRD+FIN*FID
      XIM=FIN*FRD-FRN*FID
      IF(XRE)1,2,3
1     ANGLE=ATAN(XIM/XRE)-3.1415927
      GO TO 5
2     IF(XIM)6,6,7
6     ANGLE=-1.5707963
      GO TO 5
3     ANGLE=ATAN(XIM/XRE)
      GO TO 5
7     ANGLE =1.5707963
5     RETURN
      END
```

Input definitions

- *KN* — Degree of numerator polynomial
- *KD* — Degree of denominator polynomial
- *KL* — The lower limit of ω is 10^{KL}.
- *KU* — The upper limit of ω is 10^{KU}.
- *NP* — Number of points per decade to be used in evaluating $F(j\omega)$. (Must be a multiple of 10.)
- *A(I)* — The coefficients of the numerator polynomial. *I* runs from 1 to $KN+1$ for decreasing powers of s.
- *B(I)* — The coefficients of the denominator polynominal. *I* runs from 1 to $KD+1$ for decreasing powers of s.

Output definitions

- *W(I)* — The radian frequency, ω, equally spaced on a logarithmic scale from *KL* to *KU*.
- *FREQ* — Frequency in Hertz ($FREQ = W(I)/2\pi$.)
- *FMAG* — Magnitude of $F(j\omega)$
- *FDB* — 20 $\log_{10}$ $|F(j\omega)|$
- *FANG* — Phase angle of $F(j\omega)$
- *FRE* — Real part of $F(j\omega)$
- *FIM* — Imaginary part of $F(j\omega)$
- *WFIM* — ωIm $[F(j\omega)]$.

Input Data Set

```
Column Number   11        22        33        44        55
                10        20        30        40        50
Card 1 ——       1         4         -3        3         20
Card 2 —— 0.1000E 01 0.2000E 01
Card 3 —— 0.1000E 01 0.3700E 01 0.6560E 02 0.3200E 02 0.0000E 00
```

Portion of Output Data for above Input Data Set

ω (rad/sec)	f (Hz)	|F(jω)|	20 $\log_{10}$ |F(jω)|	ANG [F(jω)]	Re [F(jω)]	Im [F(jω)]	ωIm [F(jω)]
0.1778E 01	0.2830E 00	0.1333E-01	-0.3750E 02	-0.1280E 03	-0.8208E-02	-0.1051E-01	-0.1868E-01
0.1995E 01	0.3176E 00	0.1140E-01	-0.3886E 02	-0.1271E 03	-0.6875E-02	-0.9099E-02	-0.1816E-01
0.2239E 01	0.3563E 00	0.9838E-02	-0.4014E 02	-0.1261E 03	-0.5798E-02	-0.7948E-02	-0.1779E-01
0.2512E 01	0.3998E 00	0.8568E-02	-0.4134E 02	-0.1252E 03	-0.4939E-02	-0.7002E-02	-0.1759E-01
0.2818E 01	0.4486E 00	0.7545E-02	-0.4245E 02	-0.1244E 03	-0.4267E-02	-0.6222E-02	-0.1754E-01
0.3162E 01	0.5033E 00	0.6727E-02	-0.4344E 02	-0.1239E 03	-0.3756E-02	-0.5581E-02	-0.1765E-01
0.3548E 01	0.5647E 00	0.6085E-02	-0.4432E 02	-0.1238E 03	-0.3389E-02	-0.5054E-02	-0.1793E-01
0.3981E 01	0.6336E 00	0.5600E-02	-0.4504E 02	-0.1243E 03	-0.3158E-02	-0.4624E-02	-0.1841E-01
0.4467E 01	0.7109E 00	0.5264E-02	-0.4557E 02	-0.1257E 03	-0.3073E-02	-0.4274E-02	-0.1909E-01
0.5012E 01	0.7977E 00	0.5083E-02	-0.4588E 02	-0.1285E 03	-0.3162E-02	-0.3979E-02	-0.1994E-01
0.5623E 01	0.8950E 00	0.5075E-02	-0.4589E 02	-0.1336E 03	-0.3498E-02	-0.3678E-02	-0.2068E-01
0.6310E 01	0.1004E 01	0.5260E-02	-0.4558E 02	-0.1429E 03	-0.4196E-02	-0.3172E-02	-0.2002E-01
0.7079E 01	0.1127E 01	0.5511E-02	-0.4518E 02	-0.1602E 03	-0.5186E-02	-0.1863E-02	-0.1319E-01
0.7943E 01	0.1264E 01	0.5094E-02	-0.4586E 02	-0.1885E 03	-0.5038E-02	0.7523E-03	0.5976E-02
0.8912E 01	0.1418E 01	0.3541E-02	-0.4902E 02	-0.2179E 03	-0.2795E-02	0.2173E-02	0.1936E-01

chosen as $10^{-3} < \omega < 10^{3}$; thus $KL = -3$ and $KU = 3$. The main requirement on NP, the number of frequency points per decade, is that sufficient resolution must be obtained to accurately draw the locus of $F(s)$. Usually 10-20 points per decade is sufficient. For this problem $NP = 20$ is required to point out the rather strange behavior of the locus near the origin.

This data is typed on the first data card (see Box 2) in the order just mentioned. The numbers are integers and are typed flush to the right-hand side of each group of ten columns.

The second card contains the coefficients of the numerator polynomial in descending powers of s. The format statement allows seven coefficients (sixth-degree polynomial) to be read in on one card. If polynomials of higher order are incurred, one simply continues listing the coefficients in descending order on the next card, and so forth. The numbers are specified in the form $a.bE \pm c$ which means $a.b\ 10^{\pm c}$. The coefficients must be listed in descending powers of s every eleven columns (placing zeros for missing powers of s). Within the eleven columns the coefficients can be placed anywhere as long as a decimal point is used after the number preceding E.

The third data card has the denominator coefficients typed according to the same rules listed. The formats of all three data cards for this problem are shown in Box 2, along with a partial printout of the results. The graph of Fig. 4 was drawn from the complete printout.

The Popov line intersects the real axis at $-1/k = -2.6 \times 10^{-2}$, thus $k = 38.5$. Since all of the requirements of Popov's method have been met, we know that the gain of the saturating amplifier can be varied between zero and 38.5 without causing the system to become unstable. Note that the limit level, L, is not included in the result; therefore the system is stable in this region, independent of the value of L.

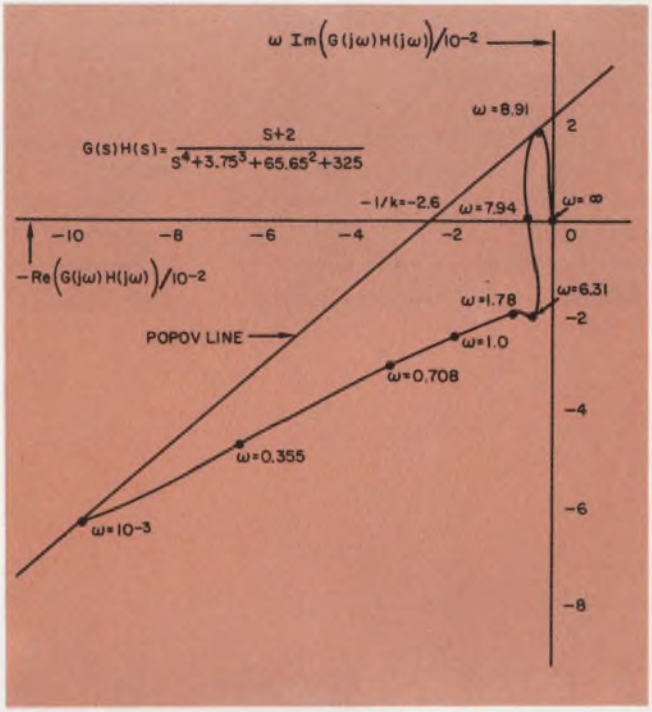
Do linear analyses as well

To perform analyses of linear systems using the Bode and Nyquist methods, the quantities $20\log_{10}|F(j\omega)|$, Angle$[F(j\omega)]$ and $|F(j\omega)|$ are needed. As can be seen from the sample printout, these quantities are provided by the program.

The closed-loop frequency response of a linear system can also be calculated by using this program. Whereas the rational function $F(s)$ was used to represent $G(s)H(s)$ in the stability calculations, it must now represent $C(s)/R(s)$—the system transfer function. A little algebraic manipulation shows that, in this case,

$F(s) = C(s)/R(s) = G(s)/[1+G(s)H(s)]$.

Thus the program can be quite useful for a variety of calculations for which the quantity of interest a rational function. ■■



4. **The computer program provided the data** for this graph. The Popov line crosses the abscissa at -2.6×10^{-2}. Thus, k = 38.5. Note that the saturation level, L, does not enter the picture.

References:

1. V. M. Popov, "Absolute Stability of Nonlinear Systems of Automatic Control," *Automation and Remote Control*, Vol. 22, No. 8, August, 1961, p. 857-875.
2. Rajko Tomovic, *Introduction to Nonlinear Automatic Control Systems*, John Wiley and Sons, New York, 1966.
3. Solomon Lefschetz, *Stability of Nonlinear Control Systems*, Academic Press, New York, 1965.
4. R. W. Brokett and J. L. Willems, "Frequency Domain Stability Criteria—Part I," *IEEE Transactions on Automatic Control*, July, 1965.
5. Stanley M. Shinners, *Control System Design*, John Wiley and Sons, New York, 1964.
6. Distefano, III et al, *Feedback and Control Systems*, Schaum Publishing Co., New York, 1967.
7. D. G. Schultz and J. L. Melsa, *State Functions and Linear Control Systems*, McGraw-Hill, New York, 1967.

Test your retention

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

1. What are the two conditions that a nonlinearity must meet for Popov's method to work?

2. State the Popov stability criterion.

3. Does this criterion provide necessary conditions for stability or merely sufficient ones?

4. What condition is imposed on the function $G(s)H(s)$ for Popov's method to work?

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INFORMATION RETRIEVAL NUMBER 65

Make linear models of op amps

for computer-aided design by a simple technique that uses gain-frequency curves to obtain accurate equivalent circuits.

Thanks to their versatility, operational amplifiers are used in an extraordinary variety of applications. And as computer-aided design becomes more universal, the need for accurate models of op amps grows increasingly critical.

By applying a simple, yet reliable, technique, very serviceable linear ac models of integrated-circuit and hybrid op amps can be established. These models, derived from the op-amp gain-frequency curves, are usable with CORNAP,[1] INAP,[2] SCEPTRE,[3] and other designer-oriented computer programs. In these programs the circuit to be analyzed is described topologically to the computer, and only a minimal knowledge of computer programing is required of the designer.

Op amps are complex

Simplicity is desirable in the models because op amps are extremely complex devices. To obtain the desired gain, frequency response and stability, as many as 18 active devices (transistors and diodes) and an equal number of resistors are often required in a single package. On the other hand, many computer circuit analysis programs limit the number of elements that can be entered. This requires the op amp to be modeled as a unit, as simply as possible, while retaining the operational characteristics of the device.

The ideal op amp has infinite open-loop gain, input impedance and bandwidth, and zero output impedance. It is generally represented as an amplifier with an output that is proportional to the voltage across a resistor placed across the input terminals of the device (Fig. 1).

Unfortunately, this representation provides satisfactory results only when the magnitude of the gain (dc or low-frequency operation) or the effects of external components are of primary interest. This ideal circuit representation is inadequate where frequency response, transient effects, phase or impedance relationships must be taken into account. At higher frequencies and for decreasing open-loop gain, the effects of both the error factor and the input impedance assume increasing importance.

All of the limitations can be avoided by using the gain-frequency curve technique.

John R. Greenbaum, Project Engineer for Computer Aided Design, General Electric Co., Syracuse, N. Y.

Models illustrate the method

Practical models are developed by locating the op-amp break-frequency points from the manufacturer's gain-frequency curves and choosing appropriate lead and lag networks to provide the poles and zeros (Fig. 2). To get the approximate pole and zero locations, the linear portions of the gain-frequency curves are extended to where the 0-dB/decade, 20-dB/decade or 40-dB/decade extensions intersect (Fig. 3).

The ease of this method is apparent when we synthesize models for three typical op amps—Analog Devices' 202 and 180 and the μA709.

The first op amp, the Analog Devices' 202 (Figs. 3 and 4), is modeled by cascaded voltage equivalent (Thevenin) circuits. As shown in Fig. 3 there are three break points in the gain-frequency curve occurring at approximately 0.004 Hz, 2 Hz, and 20 kHz.

To model the first pole, at 0.004 Hz a value $RA = 5$ kΩ is selected (Fig. 4); then the value of CA is found from the relation:

$$f_1 = \frac{1}{2\pi(RA)(CA)} = \frac{1}{(6.28)(5)(10^3)(CA)}$$

≈ 0.004 Hz, and

$CA = 0.008$ farad.

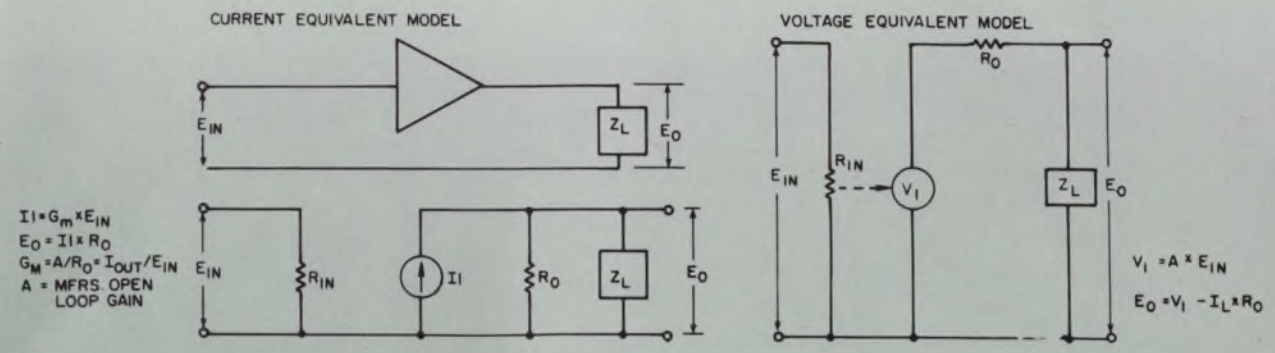
To model the first zero at 2 Hz, values for RB and CA are selected to satisfy the condition:

$$f_2 = \frac{1}{2\pi(RB)(CA)} = \frac{1}{2\pi(RB)\ 8\ (10^{-3})}$$

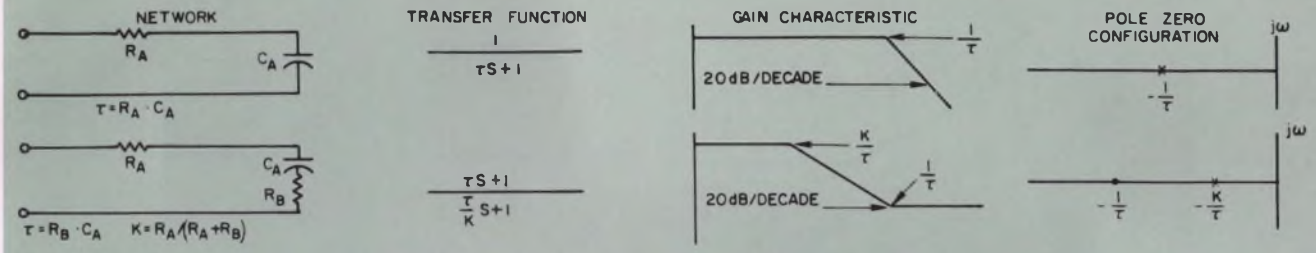
≈ 2 Hz, and

$RB = 10\ \Omega$.

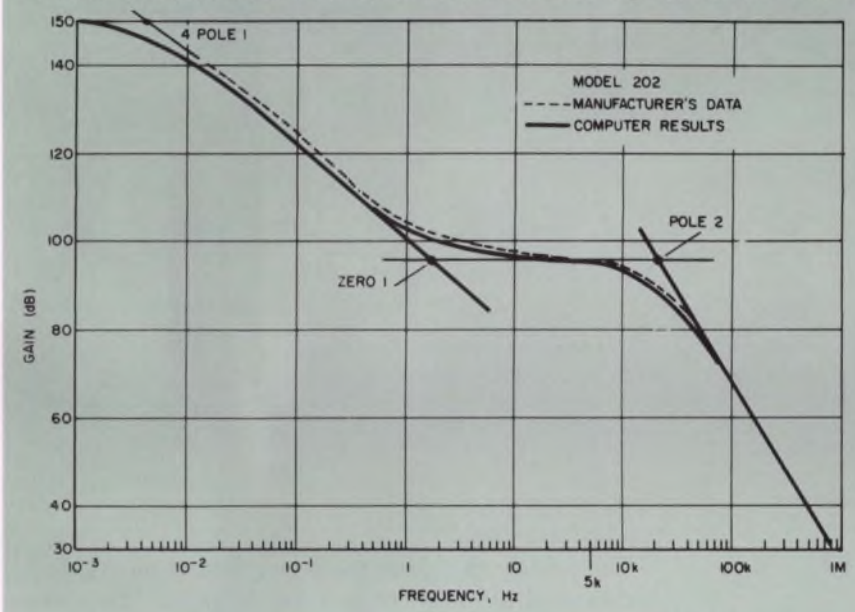
Note that a -20-dB/decade slope has now been obtained from 0.004 to 2 Hz and a 0-dB slope above 2 Hz. To obtain the -40-dB/decade slope above 20 kHz, RB and CB, and RC and CC are selected to have the same value and thus provide two identical poles. Here,



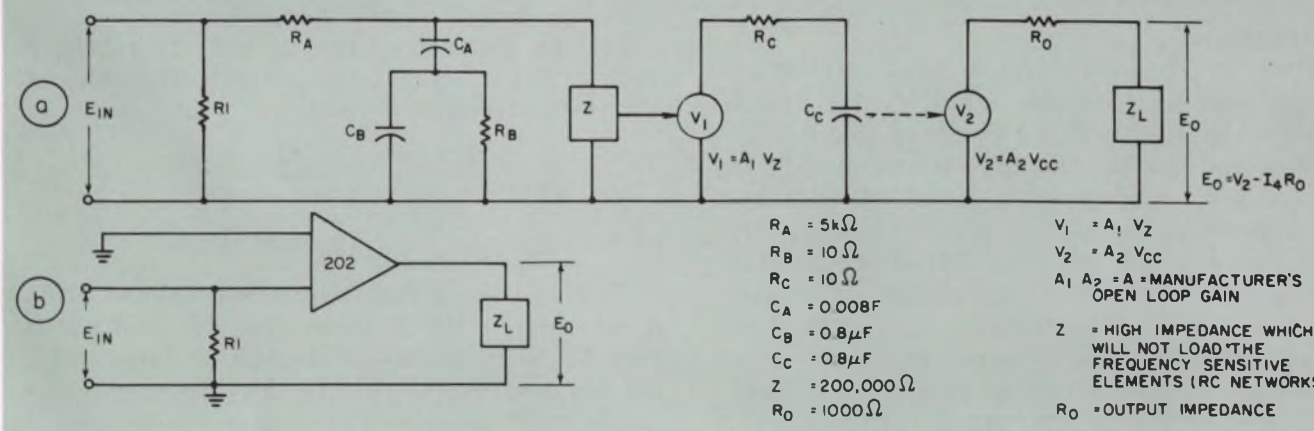
1. **Ideal models are inadequate** where frequency response and transit effects, must be dealt with.



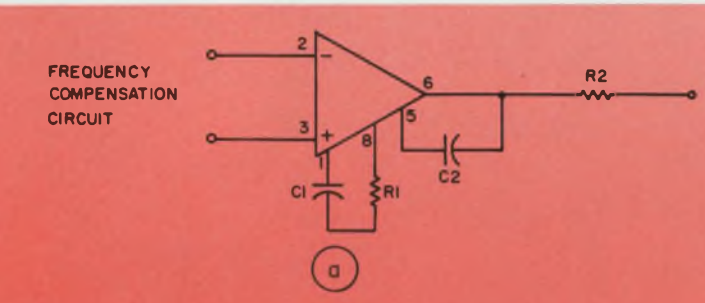
2. **Gain characteristics** serve as the basis for choosing appropriate lead-lag networks.

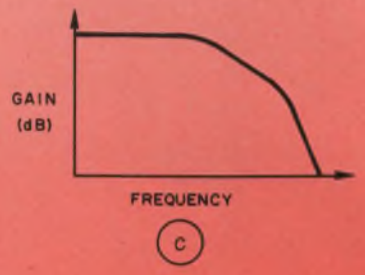


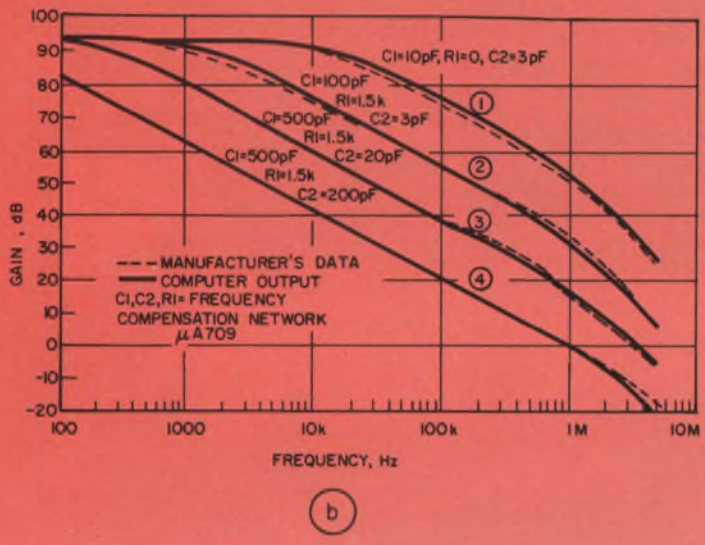
3. **Use the break frequency points** to choose appropriate lead-lag networks. This curve was used to develop the model for Analog Devices' 202 op amp.

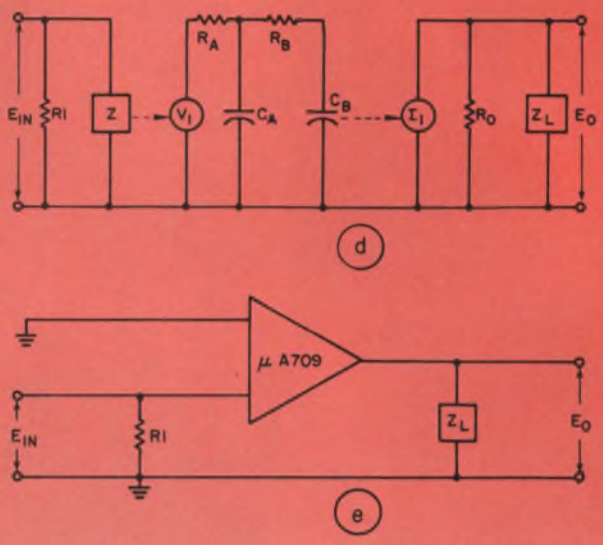


4. **The Thevenin (voltage equivalent) network** (a) shown above was used to model the Analog Devices' 202 op amp (b) for the CORNAP (Cornell Network Analysis) program discussed in the text.









	①	②	③	④
RA	750 Ω	7500 Ω	50 kΩ	400 kΩ
RB	10 MΩ	10 MΩ	5 MΩ	50 MΩ
CA	0.016 μF	0.016 μF	0.016 μF	0.016 μF
CB	0.016 pF	0.016 pF	0.016 pF	0.016 pF

Z = 400,000 Ω
R_O = 150 Ω
OPEN LOOP GAIN: 25,000
70,000
$V_I = I \times V_Z$

$I_I = G_m \times V_{CB}$
$g_m = \frac{I_{OUT}}{E_{IN}} = A/R_O$
A = MFGR OPEN-LOOP GAIN
$E_O = I_I \times R_O$

5. **Frequency compensation circuits (a)** are required to obtain the open-loop response curves shown in (b). The typical curve (c) is used as the basis of equivalent voltage/current model (d) of the μA 709 op amp (e). This model was designed for use with the CORNAP (Cornell Network Analysis) CAD program.

$$f_s = \frac{1}{2\pi(RB)(CB)} = 20 \times 10^3$$

$$= \frac{1}{(6.28)(10)(.8)(10^{-6})} = 20 \times 10^3, \text{ so}$$

$CB = 0.8\ \mu F$

Extremely close matching to the manufacturer's data over the frequency range 10^{-3} Hz $< f <$ 1 MHz was obtained with the model of Fig. 4.

The second specific example covers one of the most popularly used op amps, the μA709 (Fig. 5). It is modeled by means of a hybrid (voltage/current) cascaded network (Fig. 5d). The amplifier must be used with frequency compensation circuits[1] (Fig. 5a). Manufacturers' frequency response curves for four different frequency compensating networks are shown in Fig. 5b. (Curve 4 of 5b also represents the response of the μA741, a second-generation op amp in which the frequency compensation has been incorporated into the op amp itself.)

To model the frequency-compensated circuit corresponding to Curve 1 of Fig. 5b, the two break points at 13.3 kHz and 1 MHz are represented by means of two poles.

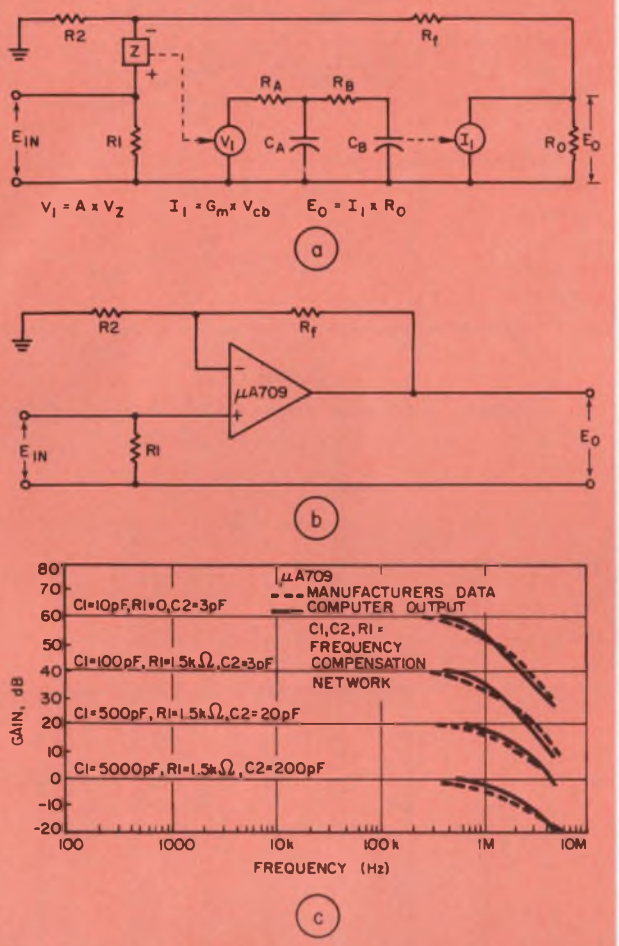
For the lower-frequency pole, at 13.3 kHz, a value of $RA = 750\Omega$ is selected first. The value of CA is then computed from

$$f_1 = \frac{1}{2\pi(RA)\ (CA)} = 13.3 \times 10^3$$

$$CA = \frac{1}{2\pi \cdot 13.3 \times 10^3 \cdot 750} = 0.016\ \mu F.$$

To model the upper frequency pole of 1 MHz, a value of 10 MΩ is chosen for RB, and CB is then found in the usual manner. A large value for RB is chosen so that the high-frequency circuit will not load down the low-frequency circuit and thus shift the pole location.

When a degenerative feedback loop is added



7. **Open-loop op-amp** model of Fig. 5d is used (a) to represent the μA 709 (b) in closed-loop applications. Computer results based on the model closely match the manufacturer's data (c).

around the op amp, a second set of gain-frequency curves applies. These are also provided by the manufacturer, as shown in Fig. 7 for the μA709 model for the μA709, shown in Fig. 5d, is still used, modified to include provision for the feedback (Fig. 7b).

The values of R_1 and R_2, added externally, are as follows:

dB	R_1(kΩ)	R_2(kΩ)
60	1000	1
40	100	1
20	10	1
0	100	deleted

In simple circuit applications of the μA709 the gain of the total package is determined by R_1 and R_2. Gain variations due to elevated temperatures can therefore be compensated (in CAD applications), if required, by changing the values of R_1 and R_2.

Watch the phase margin

However, it is the phase-shift frequency relationship within the device that is important. The phase-margin, which is the amount of phase shift at the unity-gain frequency that would just produce instability, is the indicator of the circuit sensitivity to minor transient perturbations. It helps measure whether the circuit will oscillate or respond in an undesirable manner.

Experience with these models in circuit-analysis applications has demonstrated that the phase-frequency analysis results obtained from the computer provide an excellent indication of the phase margin. An example of the value and accuracy of the phase computations provided by the computer is seen by examining the phase and gain relationships of Fig. 8. The dashed curve represents the circuit when the frequency compensation was appropriate for obtaining the results shown for Curve 1 of Fig. 5b.

Use series inductor for transient response

Operational amplifiers do not produce an exact replica of the input signal when operated under transient or step input signal conditions. Generally, one of two situations occurs: either the slew rate limits the device response time by a considerable amount, or a minor delay is observed between the input and output signals, with a small overshoot in the output signal.

For either of the two conditions, the models previously described are not satisfactory. For the slew-rate situation, the RC time constants are too short. For the overshoot condition, the RC constants do not allow the voltage to overshoot.

To permit the model to duplicate the manufacturer's published response to a step input signal, it is necessary to provide a circuit that will change the frequency response of the model under the conditions described. By providing a tuned circuit, one sensitive to high frequencies, the model will provide proper response to step input signals but still retain the gain-frequency relationships required for linear applications at lower frequencies. This result (Fig. 9) is obtained by adding an inductance, *L1*, in series with capacitor *CB* in the model of Fig. 5d. As long as the impedance at the resonant frequency, determined

by *CB* and *L1*, is at least one order of magnitude greater than that determined by *RB* and *CB*, the circuit is generally insensitive to additional changes in the value of the inductance. To meet the above requirements, a 0.001-MHz inductor was selected for this model.

Can models be simplified?

Experience has indicated that some simplification of the models is possible, but considerable judgment is required to determine the degree of simplification permitted in any particular application.

For example, it can be seen from Fig. 5b that if a μA709 is to be used at frequencies below about 5 kHz, elimination of the high-frequency pole network would probably cause no inaccuracy in the computed results. However, for the model 202, with its low-frequency poles and zeros, and the 40-dB/decade response above 10 kHz, it is recommended that no simplification be undertaken, unless it is certain that circuit response above about 100 Hz is not important. Then the higher frequency poles can probably be eliminated without major inaccuracies in the computed results.

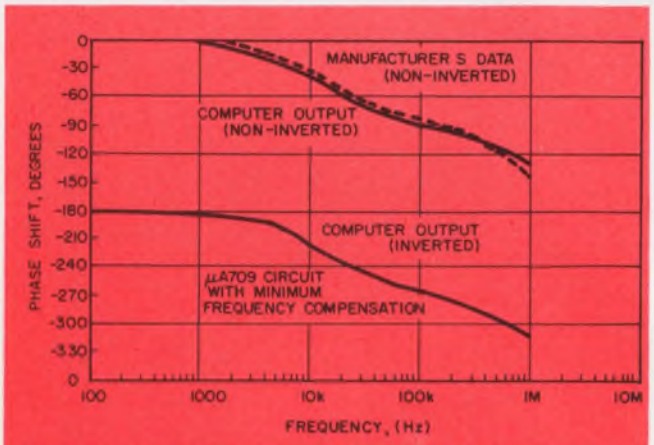
Experienced judgment is especially necessary if the designer is attempting to use the op amp at gains and frequencies that approach the device limits. Since the saving of a few components and/or nodes that may result from this simplification is generally not significant in arriving at the limits of the capacity of the programs or computers to handle the circuits, the total model should nearly always be used. ■■

References

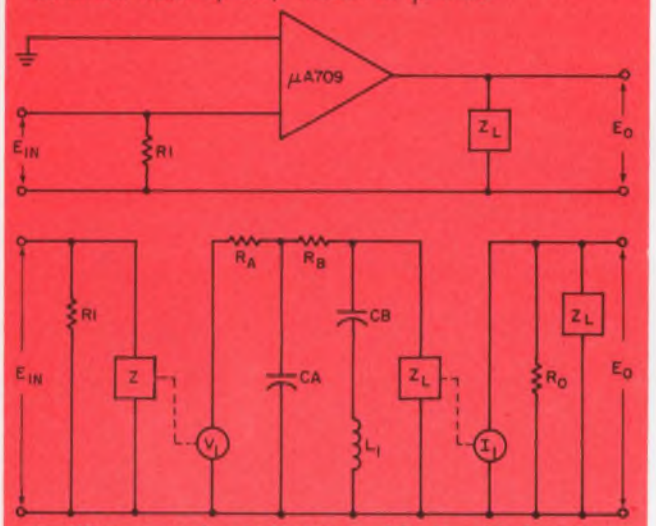
1. C. Pottle, "Comprehensive Active Network Analysis by Digital Computer—A State Space Approach," Proceedings of the Third Allerton Conference, Urbana, Ill., October, 1965.
2. D. A. Calahan, "Linear Network Analysis and Realization Digital Computer Programs: An Instruction Manual." University of Illinois, Urbana, Ill., Engineering Bulletin 472, College of Engineering, approx. 1967.
3. H. W. Mathers, S. R. Sedore, and J. R. Sents, "Automated Digital Computer Program for Determining Responses of Electronic Circuits to Transient Nuclear Radiation, (SCEPTRE)." Oswego, N. Y., IBM Corp., Technical Report No. AXWL-TR-66-126, Vols. 1 and 2, February, 1967.
4. J. N. Giles, "Linear Integrated Circuits Handbook," Fairchild Semiconductor, Mountain View, Calif., 1967.

Acknowledgment

The author wishes to thank A. W. Hamilton for his aid, advice, and encouragement in the preparation of this paper.



8. **Accurate open-loop phase-shift information** is obtained from op-amp model of μA709.



9. **When a series inductance, L1, is added** to the equivalent circuit of Fig. 5d, the resulting model accurately duplicates the transient performance of the μA709.

Test your retention

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

1. How are appropriate lead or lag networks chosen in making the op-amp models decribed?

2. What basic types of equivalent circuit are used?

3. What modification must be made in the equivalent circuit to obtain a model that will accurately represent the behavior of the operational amplifier when it is operated under transient conditions?

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Reduce stray reactances at vhf and uhf

The boundary method of printed-circuit layout provides a remedy. Component and circuit selection also help.

Radio-frequency circuits, particularly of the vhf and uhf types, always seem to be trying to trip up their designers. It is very rare for one of them—even a simple one—to work properly the first time it is tested. Yet the cause is well known: it is stray reactances.

While it may be impossible to eliminate these strays, there are three basic areas in which improvements can be made:

- Physical circuit layout.
- Component selection.
- Electrical circuit configuration.

Boundary layout reduces strays

There are two big problems in the physical layout of a circuit: Interconnecting leads give rise to stray series inductances, and component placement to stray capacitances.

Point-to-point wiring, the traditional method for minimizing these effects, unfortunately requires substantial skill on the part of the assembler and does not lend itself to automated production.

Printed-circuit boards, on the other hand, are easily adaptable to automatic assembly, but the resulting circuits are often inferior to the hand-wired models. This is usually caused by errors in layout.

The boards are often made too large. Too many circuits are placed on a single board in an effort to reduce the number of boards in the final assembly. And the interconnecting lines on the boards are often made too thin.

For best results at vhf and uhf, the individual boards should be kept simple—usually just one circuit per board. Connections between boards should be made with coaxial cable unless the distance is so short (about 3/8-inch) that the cable cannot be practically handled. In that case, connections can be made with a piece of buss wire or a component.

Ronald W. Hankins, Sr. Engineer, and **Harry W. Lamberty,** Staff Engineer, Communications Section, Martin Marietta, Orlando, Fla.

Each power and control lead should be brought into the board at one point only. A single distribution board would then provide for the interconnection of these leads between the various rf circuits.

The interconnecting lines should be as wide as possible. When they are too thin, they introduce excessive series inductance between the components.

These stray inductances can be virtually eliminated by using a boundary method of layout. The principal goal of this method is to leave as much foil as possible on the board. A boundary is drawn through the various components to separate the current nodes of the circuit, and foil is removed only along the boundaries. This leaves large islands of foil connecting the components (Fig. 1).

The board is a map of the node areas, with essentially no inductance between the components tied to a common node. The stray capacitances across the boundaries are kept small by making the gaps wide compared with the thickness of the foil. Because of the large node areas, a single-sided board must be used to prevent the buildup of stray capacitances through the board. This does not impose a restriction on the designer if the boards are kept simple and the power and control leads are on a board of their own.

The boundary method of layout is particularly valuable when used with transistor circuits. Vhf and uhf transistors have very low input and output impedances, and an additional series component, even a small one, is quite disruptive. Small shunt capacitances, by contrast, are not very troublesome in these low-impedance circuits.

Component selection is important

A second area where stray reactances arise is in the circuit components themselves. At vhf and uhf the true complex nature of components becomes painfully apparent. And the effects of stray reactances are an overriding consideration in the component selection at these frequencies.

Capacitors have a small series inductance as

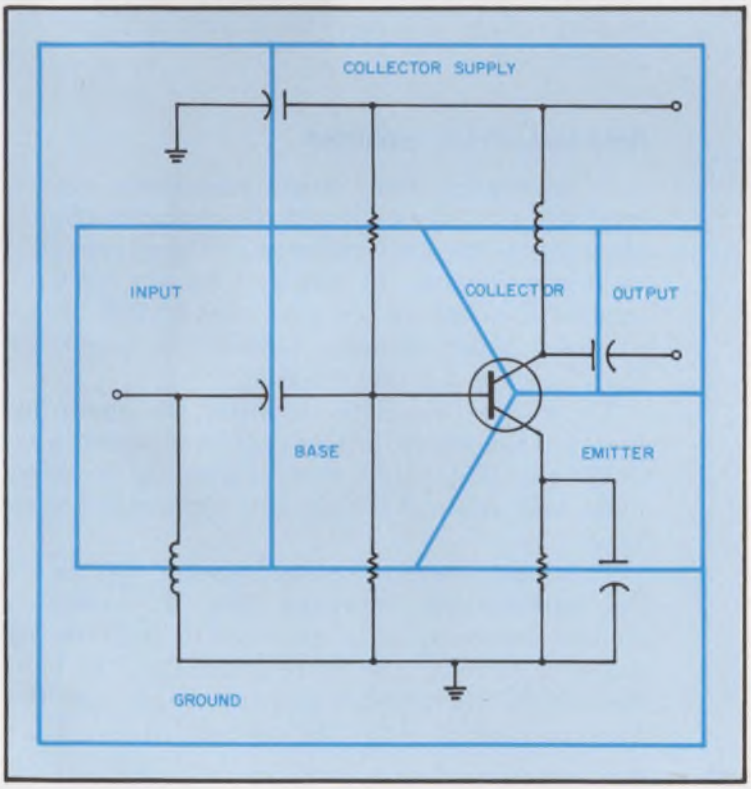
a stray reactance, and inductors a small shunt capacitance. Both display a resonance because of these strays, and good design practice demands that these components should be operated well below their self-resonant frequencies.

Table 1 shows representative resonant frequencies for some standard capacitors and chokes. Values such as these have been found to be quite consistent (within 10%) for units from one manufacturer, but they vary substantially between others. Actually, the chokes don't vary by more than about 10% from one manufacturer to another, but the capacitors do. For example, 1000-pF capacitors from one source resonated at 80 MHz, while those from another resonated at 100 MHz. Both were MIL type CK05. The table, in all cases, reflects the lowest frequencies observed.

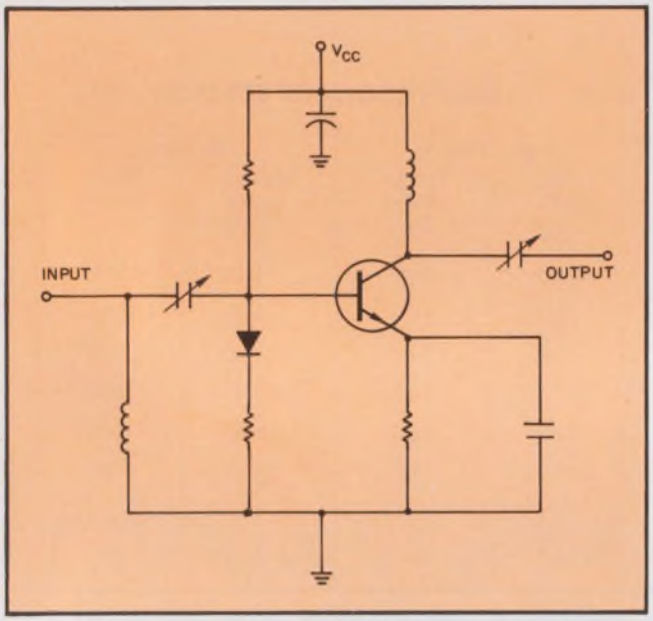
Table 1. Self-resonant frequencies

Capacitors		Inductors	
Cap. (pF)	Freq. (MHz)	Induct. (μH)	Freq. (MHz)
100	320	1.0	400
150	245	1.5	200
220	200	2.2	150
330	175	3.3	140
470	140	4.7	120
680	100	6.8	100
1000	80	10.0	70
MIL type CK05 capacitors with leads cut off 1/8 inch long and soldered together.		MIL type LT4 chokes (body size 0.095" dia by 0.025" lengths) with leads cut 1/4 inch long.	

Measurements made with Measurements Corp. Model 59 Megacycle Meter



1. **Lead inductance is reduced** by the boundary method of layout. Boundaries are drawn through the circuit components (left); then foil is removed along the boundaries, leaving large conducting islands (right).



2. **The disadvantage of the three-resistor method** of biasing is that the emitter is not grounded. This not only unnecessarily limits the dynamic range of the circuit; it creates bypassing problems as well.

Table 2. Resistor reactances

Resistance (ohms)	Inductance (mH)	Capacitance (pF)
15	8.0	—
22	8.5	—
33	9.0	—
47	9.0	—
68	9.5	—
100	10.0	—
150	8.0	—
220	5.0	—
330	—	0.1
470	—	0.2
680	—	0.2
1000	—	0.2
10,000	—	0.2

Resistors from 15 ohms to 68 ohms are MIL type RC07; those of 100 ohms or greater are MIL type RN60. Measurements were made with a Boonton Radio Corp. Type 250-A RX Meter.

Since the self-resonant frequency of a component is not a generally specified parameter, you will either have to measure it yourself or specify it when ordering parts. You should also remember that the characteristic resonant frequency is strongly affected by additional strays introduced by the installation of the component into the circuit. Capacitors are principally influenced by lead length, which increases the series inductance, and inductors by proximity to metal, which increases the stray shunt capacitance.

Resistors are characterized by both a series inductance and a shunt capacitance. The inductance is more significant for low values of resistance and the capacitance for the high values. Table 2 shows this effect for various values of resistance at 100 MHz.

It is important to realize that these reactances are inherent in the construction of the component. A 100-pF capacitor bypasses at 300 MHz better than a larger value, and often several in parallel must be used to achieve adequate bypassing where a larger value just will not do the job.

Keep that emitter grounded

A third area where stray reactances can be combated is in the design of the circuit configuration itself. The configuration of the rf circuitry is largely dictated by external factors such as impedance-matching considerations. The selection of a biasing scheme, however, is largely at the discretion of the designer.

The biasing circuitry stabilizes the operating points of the active devices against changes in dc conditions that result from variations between units and from changing environmental conditions.

The most commonly used biasing scheme is the three-resistor approach (Fig. 2) in which emitter degeneration is employed to stabilize the collector current. The current through the base bleeder resistors is made large compared with the base current to keep the voltage at the base terminal constant. A diode in the bleeder chain compensates for variations in V_{BE} due to temperature.

Changes in collector current cause corresponding changes in the voltage drop across the emitter resistor. This, in turn, varies the base current in the direction that tends to counteract the original change in collector current. The heavier the base bleeder current and the larger the emitter resistor, the better the stability.

Unfortunately, because of component limitations, it is very difficult to do an effective job of bypassing at vhf and uhf. This is especially true of the emitter terminal of a transistor since a small impedance at this point has a considerable effect on the operation of an amplifier.

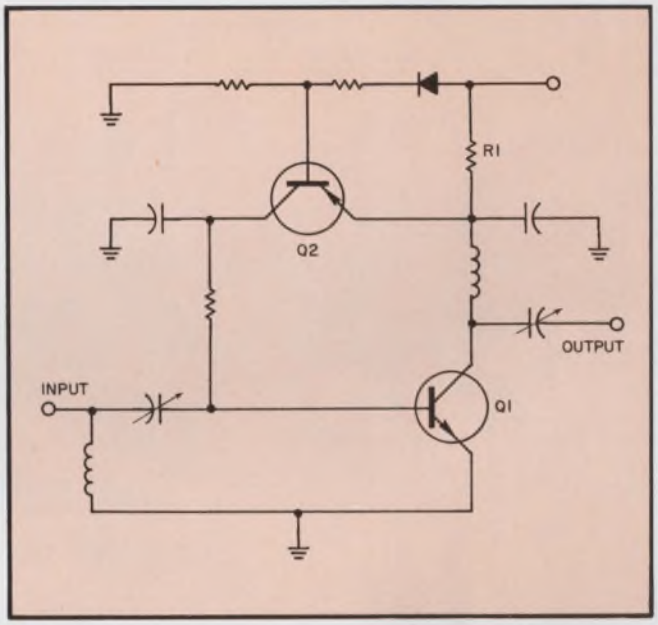
Thus, if the three-resistor approach is used, gain will suffer because of bypassing difficulties. A further objection is that the dynamic range of the amplifier is reduced by the voltage across the emitter resistor since it subtracts from the available collector swing.

A way out of this difficulty* is to operate the rf transistor with its emitter grounded, and to use a second transistor as a feedback amplifier to stabilize the collector current (Fig. 3).

Stability is achieved by sampling the current in R_1 and amplifying the changes with *Q2*. This, in turn, changes the base current of *Q1*, which reduces the change in *Q1* collector current.

Since the variations in collector current are controlled by the product of the betas of the two transistors, the series resistor (R_1), can be made much smaller than it could be with the three-resistor method for the same degree of stability. The dynamic range of the amplifier is thus increased.

This increase, however, is just a by-product of the biasing system. The primary goal is the elimination of stray reactances associated with bypassing of the emitter resistor in the three-the resistor method. ■■



3. **By employing feedback** to stabilize the collector current, this design permits the emitter of Q1 to be grounded. Transistor Q2 is the active element in the feedback loop whose input is the voltage across R_1.

Test your retention

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

1. How does the boundary method of layout reduce stray inductances in rf circuits?

2. Is it advisable to use double-clad board when employing the boundary method?

3. What rule should be applied to the selection of components in an rf circuit?

4. Why is it desirable to operate rf transistors with their emitters grounded?

5. How can a transistor be biased for Class A operation when its emitter is grounded?

*Editor's Note: This technique was developed independently and approximately concurrently by the authors and Horwitz (Ref. 1).

Reference:

1. Jerome H. Horwitz, "Design Wideband Uhf Power Amplifiers," *Electronic Design* (ED 11), May 24, 1969, p. 75.

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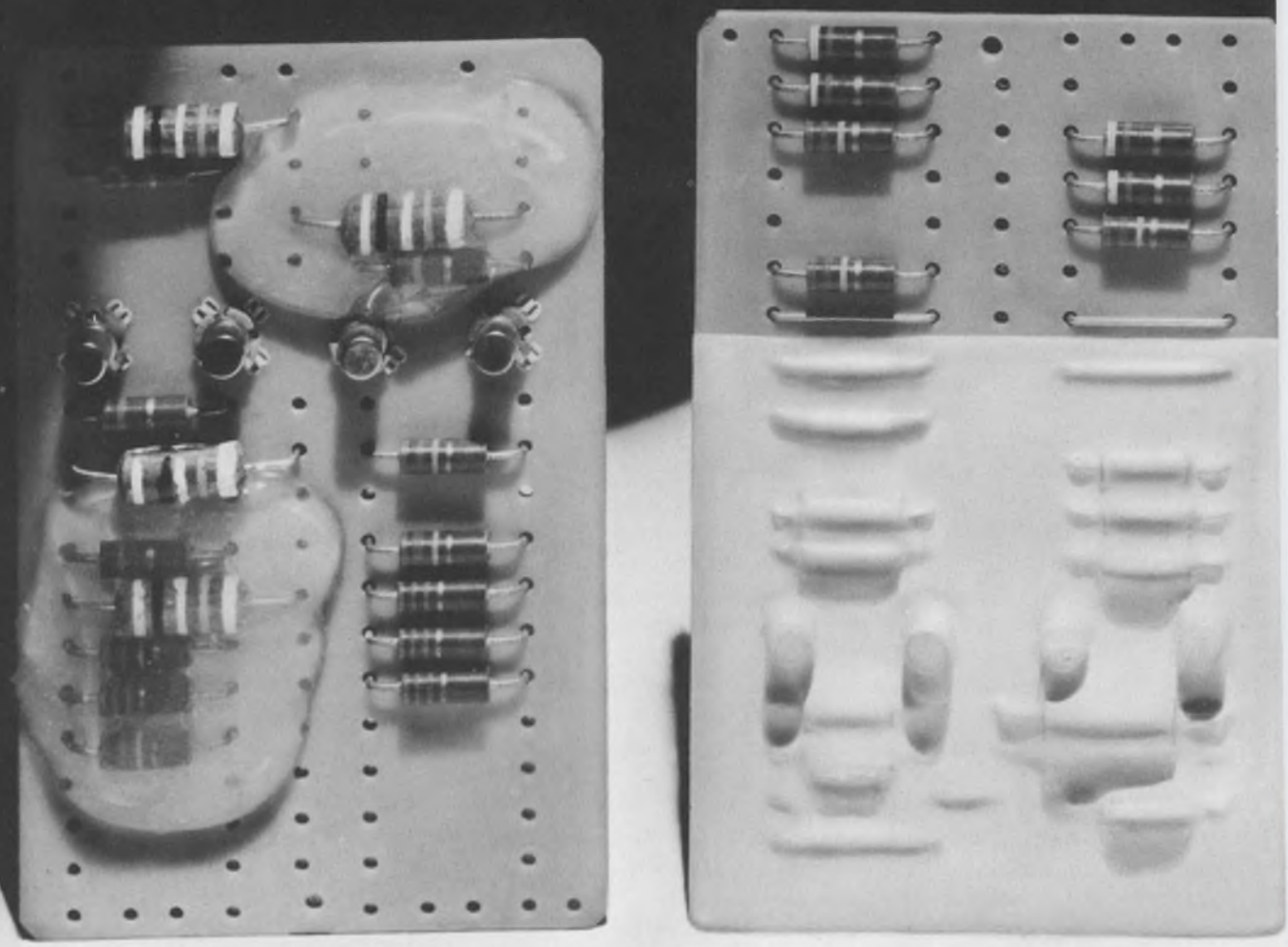

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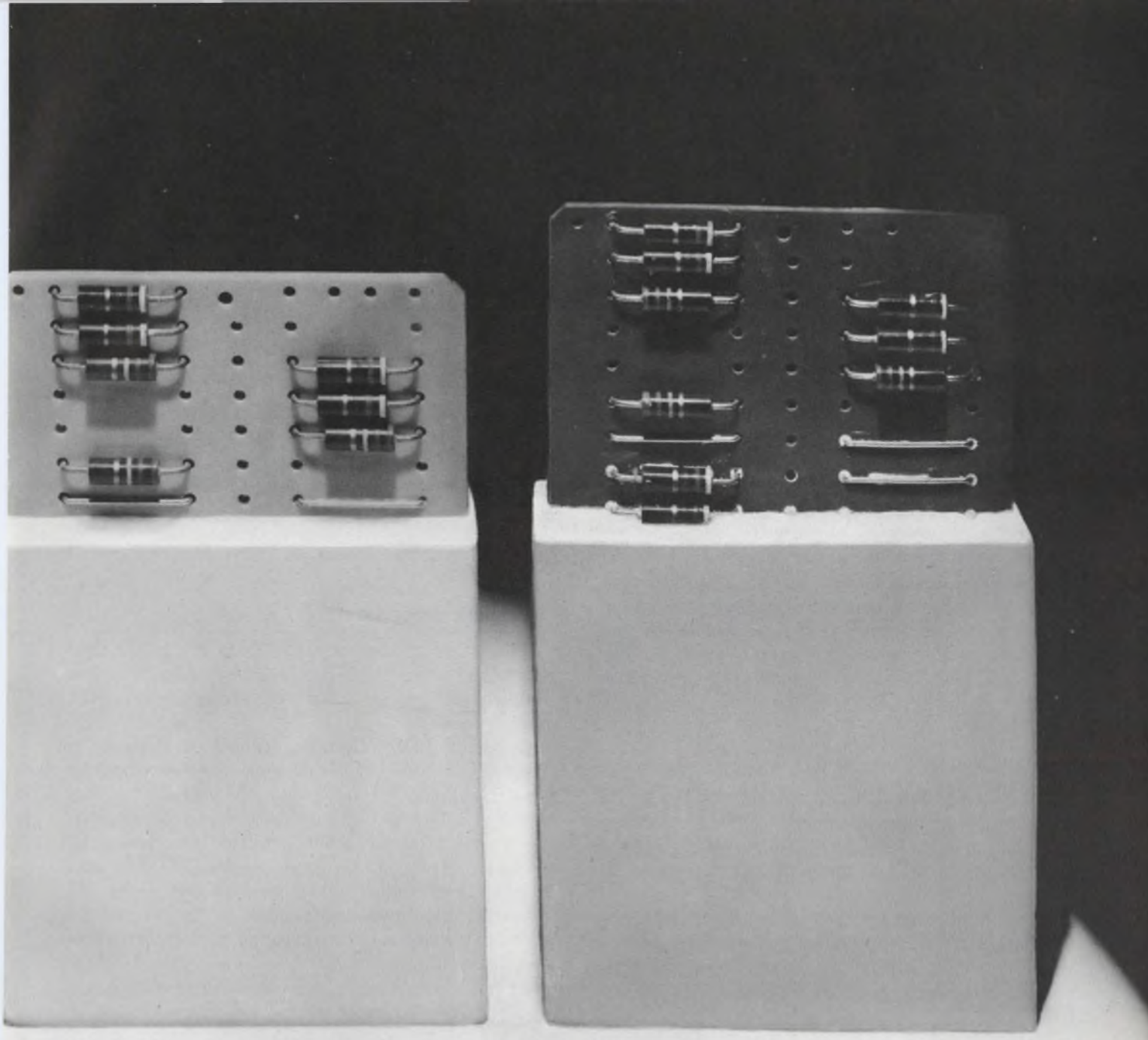

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INFORMATION RETRIEVAL NUMBER 67

Join the 'experts'—publish!

This author-engineer offers pointers designed to familiarize the engineer with the publication process.

One of the most direct roads to professional recognition is the one marked "Publication." The company man who has articles, or technical papers published on a regular basis becomes an "expert," whose opinions have been recognized. And this recognition is to management roughly equivalent to watching one's wife receive an appreciative glance from a stranger.

If publication does not affect attitudes very much where you are presently employed, watch a prospective employer take interest when you show him a collection of your printed work. The published article is usually acceptable evidence that one is dealing with an expect in technology.

The natural barriers to writing

If being published, then, is a promising route to fame, why haven't more engineers written technical articles? Perhaps they would if they weren't stymied by the natural barriers to writing.

Inertia and *procrastination* are two of the highest obstacles the unpublished author has to overcome. The man who wants recognition and promotion, however, must be willing to exact the price from his limited budget of time and physical capacity.

Another barrier for potential authors is the one they build for themselves when they decide that their ideas are *not worthy of publication*. This attitude is based on the notion that a technical magazine should communicate only specialized information from the frontiers of technical research. Alas, only so many people are capable of manning those frontiers. The rest of us must concern ourselves with the small piece of technology we have carved out for ourselves.

Too often, the prospective author decides that his offerings, which might not be sufficiently theoretical for the scientific journals, are "unworthy." How often have you been unimpressed with a feature article in a business publication simply because you felt that you could have written the same article yourself? And you probably could have, because someone with a background similar to yours did. We assume that what we know is common knowledge to everyone working in our field, but an idea does not have to be new to be publishable, if it is given a special and different treatment.

Roger M. D'Aprix, Manager, Management Communications, Xerox Corp., Rochester, N. Y.

The publication 'maze'

One of the most prevalent barriers to writing is unfamiliarity with the seeming "maze" of the publication process. But the steps are simpler than you think.

Assume that you have decided you want to publish an article. First, look for help within your company. If you work for a company progressive enough to recognize the enormous publicity potential of good articles and technical papers, search out the man responsible for that activity and follow his advice to the letter. If no such department exists, talk to the company's technical writers or advertising and public-relations specialists.

If you cannot get help from your company, you can help yourself providing that you:

- Determine the significance of your subject by asking yourself if you, as a technical man in your specialty, would be interested in reading about it. More important: Will this information be helpful to the reader in performing his job? (This, incidentally is a major criterion of business-magazine editors in judging manuscripts.) If you can honestly say that your idea is interesting, helpful, and as far as you know, not previously treated in just this way, then the subject is probably appropriate for publication.

- Determine if your potential subject lends itself to magazine treatment. To do this you must define the subject matter so that you can complete your article within a limit of about 2000 to 5000 words. That range is not rigid. Some magazines will serialize an important and interesting subject. And there is always space for the one-page or shorter feature items.

PROOFREADERS' MARKS

Marks	*Explanation*	*Marks*	*Errors Marked*
	Take out letter, letters, or words indicated.		He marked the proof.
	Insert space where indicated.		He marked theproof.
	Turn inverted letter indicated.		He marked the proof.
	Insert letter as indicated.		He maked the proof.
	Set in lower-case type.		He Marked the proof.
	Wrong font.		He marked the proof.
	Broken letter. Must be replaced.		He marked the proof.
	Reset in italic type the matter indicated.		He marked the proof.
	Reset in roman (regular) type the matter indicated.		He marked *the* proof.
	Reset in bold-face type word, or words, indicated.		He marked the proof.
	Insert period where indicated.		He marked the proof
	Transpose letters or words as indicated.		He the proof marked.
	Let it stand as it is. Disregard all marks above the dots.		He marked the proof.
	Insert hyphen where indicated.		He made the proofmark.
	Equalize spacing.		He marked the proof.
	Move over to the point indicated. [if to the left; if to the right]		He marked the proof.
	Lower to the point indicated.		He marked the proof.
	Raise to the point indicated.		He marked the proof.
	Insert comma where indicated.		Yes he marked the proof.
	Insert apostrophe where indicated.		He marked the boys proof.
	Enclose in quotation marks as indicated.		He marked it proof.
	Replace with a capital the letter or letters indicated.		He marked the proof.
	Use small capitals instead of the type now used.		He marked the proof.
	Push down space which is showing up.		He marked the proof.
	Draw the word together.		He ma rked the proof.
	Insert inferior figure where indicated.		Sulphuric Acid is HSO.
	Insert superior figure where indicated.		$a^2 + b^2 = c$
	Used when words left out are to be set from copy and inserted as indicated.		He proof.
	The diphthong is to be used.		Caesar marked the proof.
	The ligature of these two letters is to be used.		He filed the proof.
	Spell out all words marked with a circle.		He marked the 2d proof.
	Start a new paragraph as indicated.		reading. The reader marked
	Should not be a separate paragraph. Run in.		marked.
	Query to author. Encircled in red.		The proof was read by
	This is the symbol used when a question is to be set. Note that a query to author is encircled in red.		The proof read by
	Out of alignment.		Who marked the proof
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	2-em dash.		He marked the proof
	En dash.		He marked the proof.
	Indent 1 em.		He marked the proof.
	Indent 2 ems.		

The next step to being published is to select a target publication and to dress up your idea for submission:

Zero in on your target

- Make a list of the business magazines you find particularly useful, and establish an order of preference for the submission of your idea.
- Determine the basic objective of the article, and make an outline. It will help you decide what information should be included or left out, and how to reach the most readers.
- Next, make a few very rough sketches of the material you feel must be presented visually and, if possible, include any relevant photographs.
- Get your outline typed and write a short abstract (150-200 words) of the article.
- Find out what your company's policy is on publication clearances. Even if there is no formal approval mechanism, you would be well advised to show the material to your immediate manager and get his approval in writing. Approval routines protect the author and the company against the release of proprietary or classified information or simply "sensitive" information.
- When all the company approvals are in, put the whole preliminary package together and send it to your first choice of publishers as an exclusive offering.
- Do not send the same article outline simultaneously to six or seven editors. What would you do if they all accepted it? An editor is much more inclined to look favorably on an article idea if it carries an "exclusive" tag.

Don't be discouraged

The elapsed time from the preparation of your outline to publication of the complete article can be anywhere from three months to more than a year. The two most common reasons for the delay is that either the magazine has a large backlog of manuscripts, or the editor has not yet made a decision about your material.

Some magazines normally acknowledge receipt of outlines and make decisions within a month or less. On the other hand, some publications do not acknowledge receipt of submitted material and may take as long as two or three months to decide if they want it.

If your outline is turned down, don't be discouraged until you've received a few rejections. You may simply be trying the wrong magazines.

Let the editor polish it

Once an editor expresses interest he will usually work with you, indicating where he feels you might improve your outline. He will also set a tentative date for submission of the manuscript. Follow his directions as carefully as you can and comply with the deadline that's set. Publication schedules are not very flexible, and you can put your editor in an embarrassing position if you leave him with three or four pages of his magazine to fill at press time.

In preparing the manuscript, concentrate on the information you are communicating. Give the maximum amount of well organized information per page, and leave the polishing to the editor. You're the technical expert, he's the writer. If he does his job well, your manuscript will probably be edited rather heavily. You may not even recognize the style as yours when he finishes, but it will be concise and readable.

Assembling the package

When you submit your company-approved manuscript to the editor, send him an original copy typed double or triple-spaced on good white bond paper. Leave wide margins. The first page should include the title of the article, your name, and company affiliation. Keep at least one copy as insurance against loss.

Any photos submitted should preferably be 8 by 10 glossy prints for good reproduction. Drawings need be only penciled sketches, but be sure they are sharp and well labeled, and separate them from the manuscript. Include captions on a separate sheet keyed to the illustrations and the text.

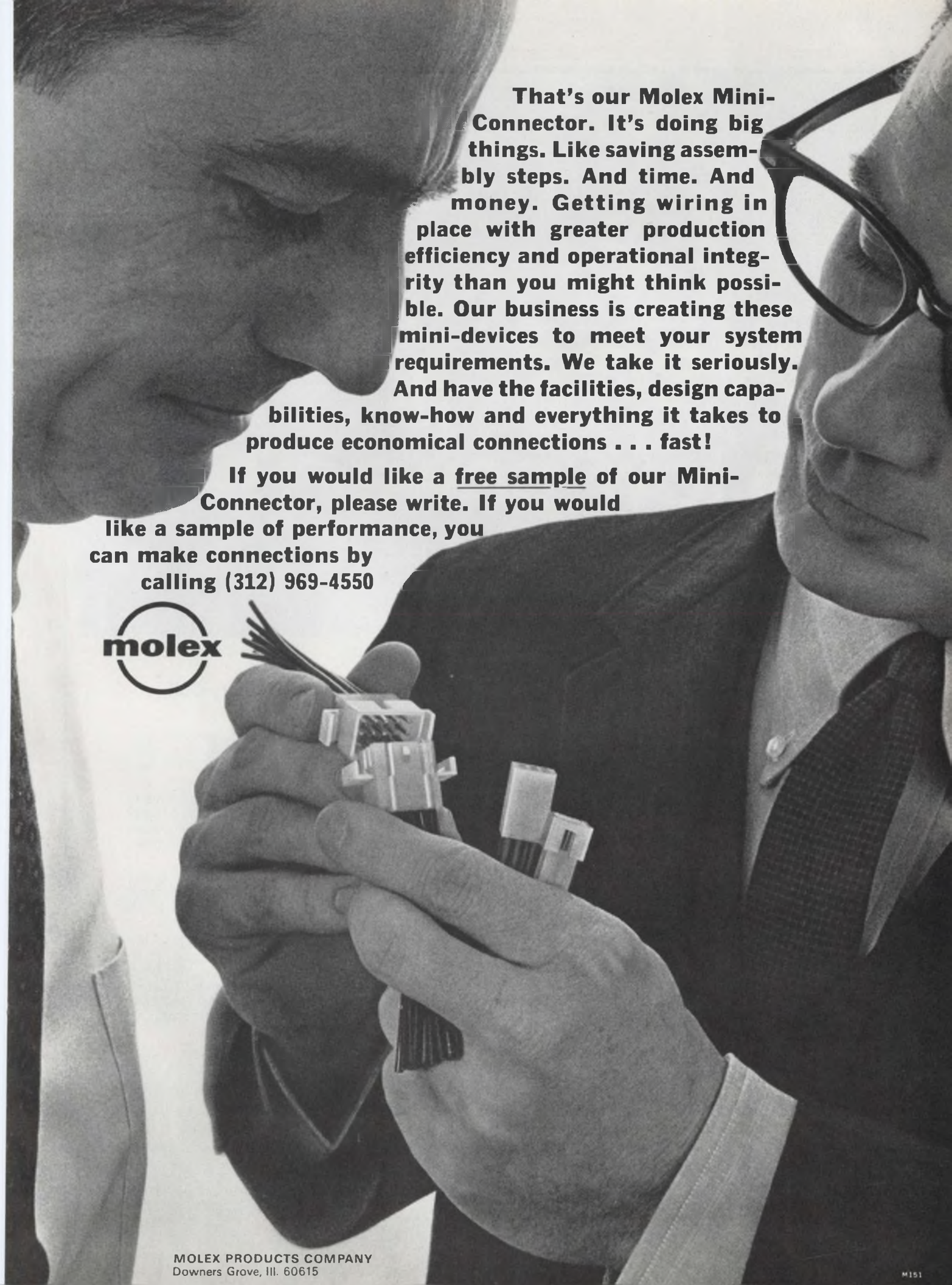
In most cases the editor will give you an opportunity to review his version of your manuscript before publication. He wants you to check for technical accuracy to be sure he has not misunderstood and changed your idea. And this is exactly the way you should review the manuscript: Change only the misleading or inaccurate statements.

Don't hold out for your original style, or you may very well find a polite rejection letter returned to you with your manuscript.

Recognition is the payoff

When the final package is submitted, you have nothing to do but sit back and wait for the published article—and perhaps a modest check if the magazine pays its authors an honorarium. This payment, which is strictly a fringe benefit, usually runs anywhere from $75 to $150 for an average-length article. The fee is not intended to be payment for your time and effort; it is simply a token sum in appreciation for your contribution.

The payoff for you, personally and professionally, is the recognition you will receive from the magazine's readers and from your own company and colleagues. ■■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Send for complete technical data on these exciting new Transitron developments.

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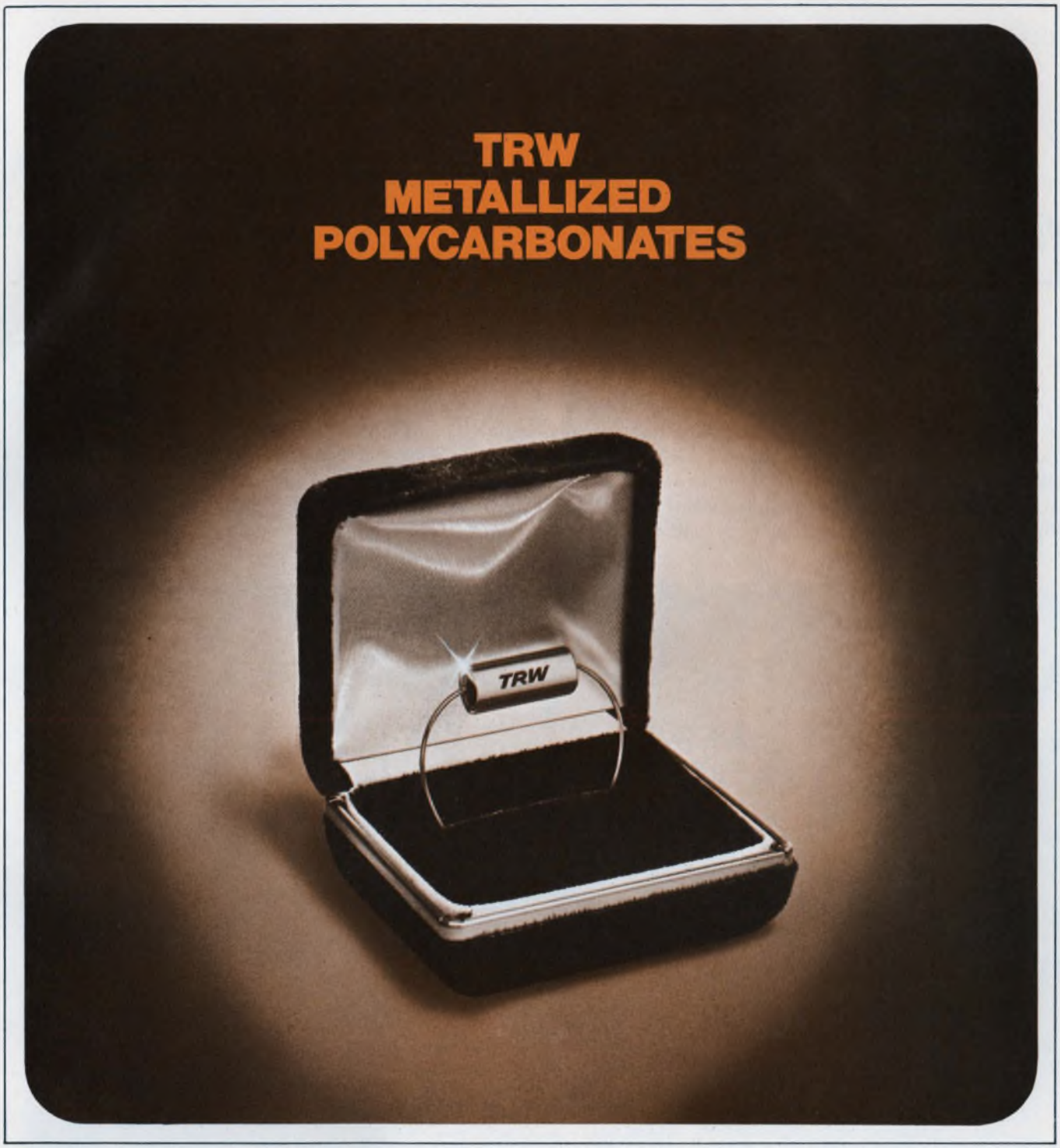

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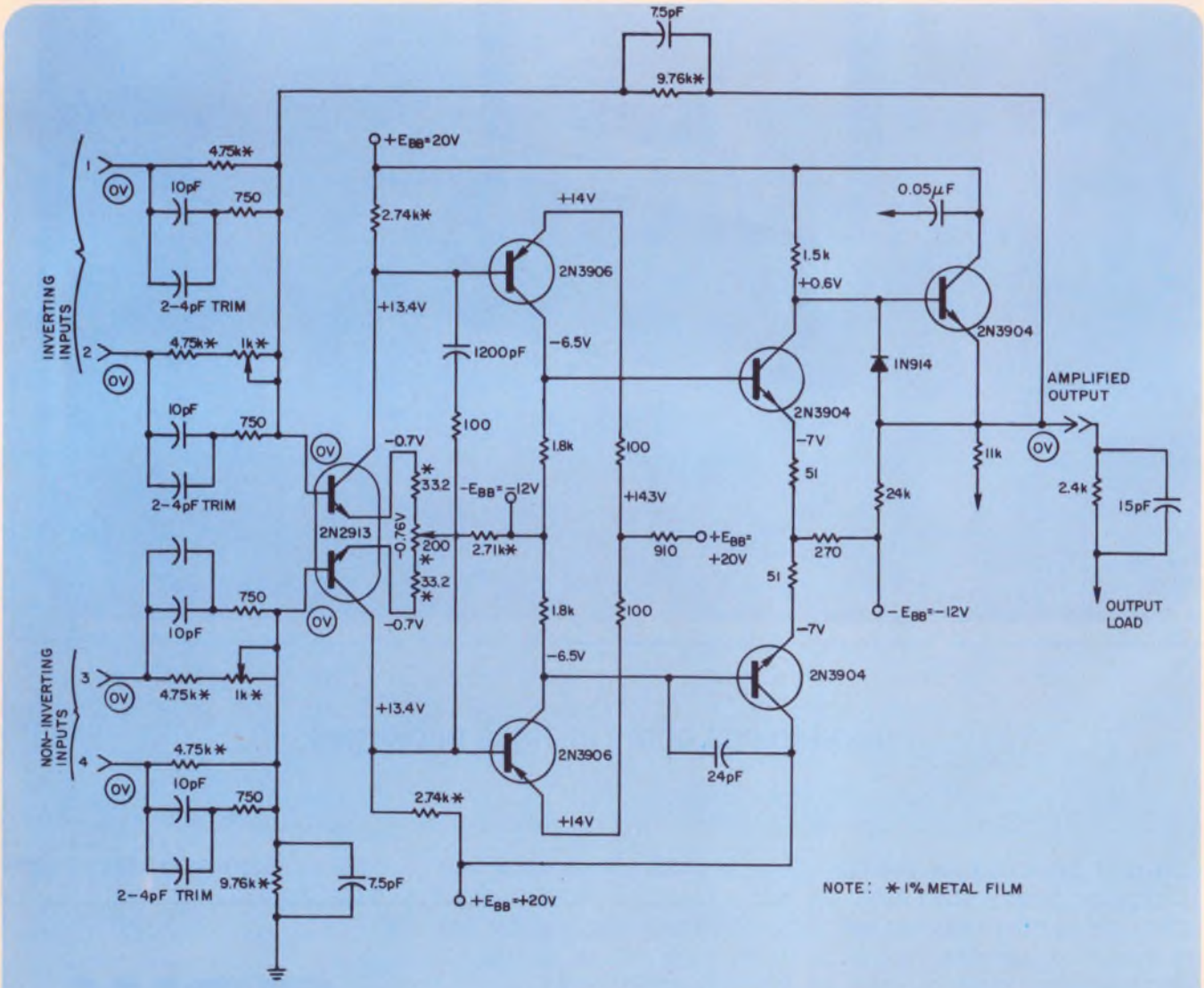
Fast differential amplifier has high slew rates

A direct coupled fast differential operational amplifier has a higher slew rate than is available in IC or packaged form. The amplifier has an inverting and non-inverting input.. All input resistors and the feedback resistor are frequency compensated to give good differential gain and high common mode rejection to a fast step input with a minimum of leading edge degradation and no apparent droop. With plus and minus 15 Vdc power supplies, the maximum output signal swing is over 13 volts positive and 6 volts negative from either input. A larger signal swing may be achieved with higher power supply voltages.



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INFORMATION RETRIEVAL NUMBER 71

The operational resistors are set up for a voltage gain of 6 dB. The delay through the circuit to a fast step at any input is less than 30 nanoseconds with little signal deterioration. Output level and gain adjustment potentiometers are included. The 2 to 4 pF capacitors across the 10 pF input network capacitors are set to trim the output response.

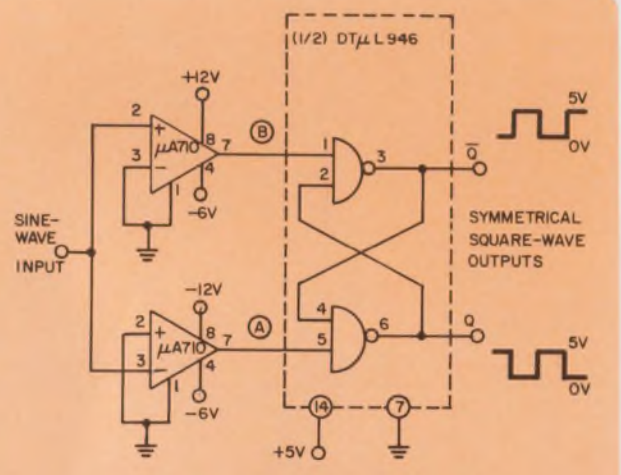
Final balance and response trimming is not critical. However, good circuit techniques, power filtering, and a ground plane should be used. The output offset voltage is on the order of 80 microvolts/°C. This is not exceptional and may be improved if the dual input transistor (2N2913) is replaced by a dual with better matched characteristics. Also the resistors shown by "*" can be replaced with units with lower temperature coefficient. Heat sinking to the ground plane is used on all transistors.

To obtain a greater gain than 6 dB the input resistor values may be reduced to increase the feedback input resistor ratio. More input resistors than two may be assumed on each input. Remember to keep the resistance into the inverting and non-inverting inputs equal and to properly compensate them. This insures that the absolute value of gain from either input to output is equal. The input resistors values shown were chosen to make the loading presented to the input drive circuitry similar to a large variety of switching circuitry. For practical purposes this amplifier can be treated as either a linear circuit or as a logic "black box." When used as a logic element it has the advantage of allowing logic signals to be added, subtracted, inverted, amplified, or offset. Signals to be processed are applied at inputs 2 and 3 while constant offset voltages are applied at inputs 1 and 4.

D. A. Paris, Design Engineer, Andersen Labs., Inc., Bloomfield, Conn. VOTE FOR 311

Symmetrical threshold converter operates over wide conditions

The requirements for precise conversion of a sine-wave input to symmetrical square-waves under large variations of both temperature and input amplitude may pose a difficult problem for the circuit designer. Present techniques for such conversion are adequate under limited and specified conditions; generally, though, they suffer when applied in an environment of widely fluctuating temperature or input amplitude.



1. **Symmetrical square-wave outputs** are produced over a wide range of sine-wave input amplitudes and temperature fluctuations.

The simple circuit shown in Fig. 1 provides accurate sine- to square-wave conversion even when the input amplitude varies from a few millivolts to many volts peak (assuming limit protection) and under mil-spec temperature ranges. Two μA710 comparators and a DTμL946 logic element (wired as a set-reset flip-flop) are used in the circuit, which makes full use of the advantage of the IC comparators, and even makes use of an undesirable feature—input offset.

Due to the inherent matching of the comparators, their quiescent as well as dynamic offsets closely duplicate and track each other. By operating the comparators in a complementary fashion, symmetry is preserved, since the phase shift caused by the negative offset is added to that caused by the positive offset (Fig. 2). This is implemented by having the set-reset action occur with the *leading* edges of the comparator outputs.

Random pairing of four sets of μA710s with a common flip-flop, and operating the circuit at 1 kHz, revealed a maximum symmetry error of under one per cent when: (1) the sine-wave input was varied between 300 mV and 10 V,

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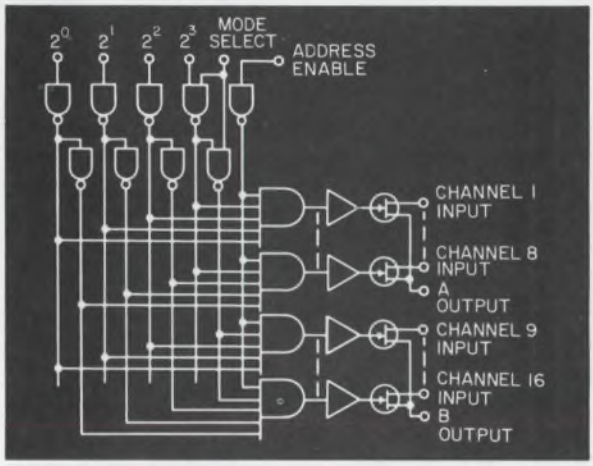

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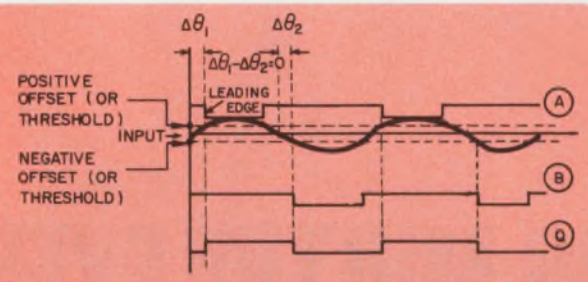


2. **Symmetry of the output at Q** results because the positive and negative offsets, which are essentially equal and opposite in polarity, produce equal but opposite phase shifts.

peak-to-peak, at ambient temperature, and (2) the temperature was varied from 0° to 60°C in an oven with the input amplitude held at 1 V, peak-to-peak. Selective matching of the μA710s for offset parameters should yield far smaller symmetry errors.

Although the source impedance should be kept as low as possible to allow maximum input-amplitude range, the effects of input bias current are negligible. This is again due to the complementary operation.

The circuit can be modified easily to include threshold adjustments for any degree of noise immunity without affecting output symmetry. Threshold adjustments may also be incorporated without affecting symmetry.

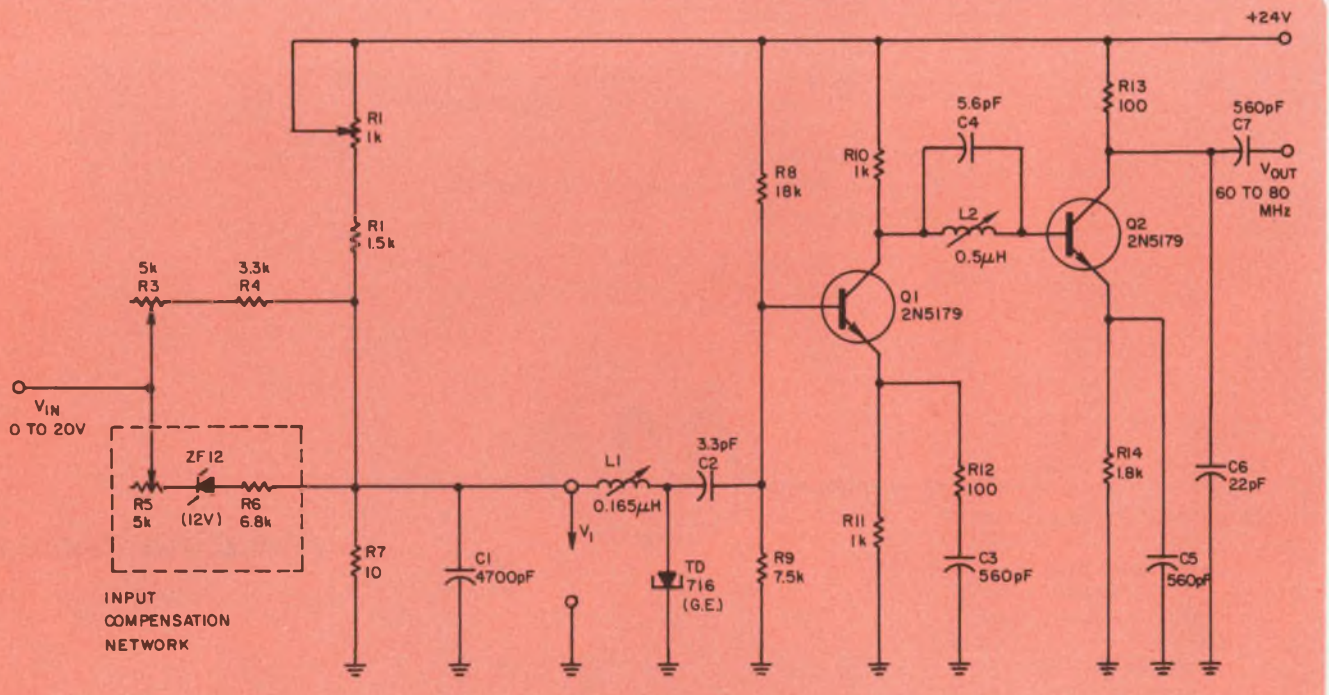
The frequency range of the circuit extends from virtually dc to approximately 6 MHz. It is worth mentioning that—due to the nature of the circuit—its construction on a single monolithic IC chip could render it a near-ideal device.

George Oshiro, Consulting Engineer, Los Angeles, Calif. VOTE FOR 312

Tunnel-diode VCO is both linear and inexpensive

Voltage-controlled oscillators (VCOs) for high frequencies are usually built with varicap-tuned oscillators. However, the output frequency of such units is not linear with varicap voltage. Complicated nonlinear networks are, therefore, needed at the input.

These difficulties can be overcome by using a tunnel-diode oscillator for the VCO. A circuit of this type, which can be tuned from 60 to 80 MHz, is shown in Fig. 1.



1. **Tunnel diode oscillator** forms the basis of this linear VCO. The output voltage level is constant within ±2%.

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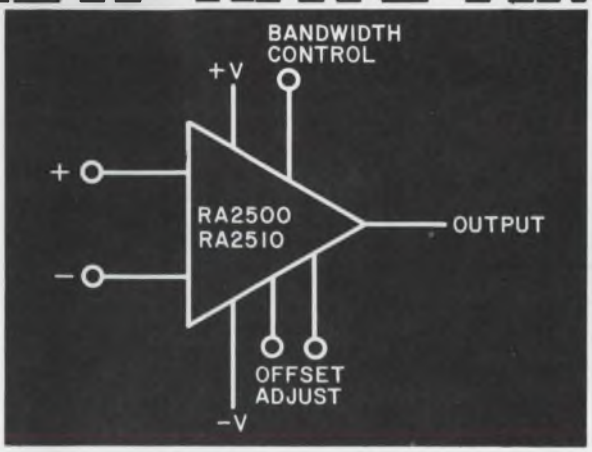

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• Gain Bandwidth	15 mHz	15 mHz
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In the circuit, the tunnel diode and inductance L_1 function as a relaxation oscillator. The tunnel diode is a low-cost type, and has a 5 mA peak-point current. For an input control voltage V_1, the output frequency is given by:

$$f = K \times \frac{V_1}{L_1 (I_p - I_v)} \times \frac{V_v - 0.8 \times V_1}{V_v} \quad (1)$$

where V_p and I_p are the peak-point characteristics and V_v and I_v are the valley-point characteristics of the tunnel diode. K has a value between 0.6 and 0.8. Oscillation occurs at

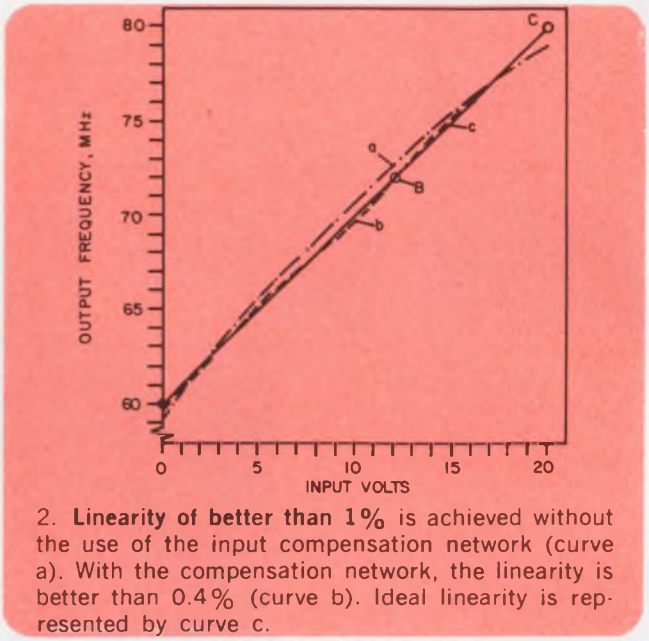
$$V_p < V_1 < V_v \quad (2)$$

Since $(V_v - 0.8 \times V_1)$ is the nonlinear term in Eq. 1, V_1 should be chosen as small as possible.

For a limited sweep width of 30%, a linearity of better than ±1% can be obtained, as shown in Fig. 2. Potentiometer R_1 adjusts the starting point at low frequencies (point A in Fig. 2), and R_3 sets the frequency-voltage ratio of 1 MHz/V.

An additional input network, containing R_5, R_6 and zener ZF-12 can be used to improve the linearity-error to better than ±0.4%, as shown by curve c in Fig. 2. The function of R_1 in this case is the same. The portion A-B of curve b in Fig. 2 can be adjusted by R_5, and the portion B-C by R_5.

Stages $Q1$ and $Q2$ make up a buffer amplifier that isolates the oscillator from the output. The input time constant of the buffer is determined by capacitor C_2, to compensate for the voltage drop of the oscillator at high frequencies. The higher harmonics of the relaxation oscillator are damped by a π-lowpass filter, consisting of L_2 and C_4, together with the output impedance of $Q1$ and the input impedance of $Q2$.



2. **Linearity of better than 1%** is achieved without the use of the input compensation network (curve a). With the compensation network, the linearity is better than 0.4% (curve b). Ideal linearity is represented by curve c.

The output voltage level from the circuit is 0.1 V rms, ±2%, over the entire frequency range.

Willi K. Rychetsky, Dipl.-Ing., Institut fuer Allgemeine Nachrichtentechnik, T. H. Darmstadt, Germany

VOTE FOR 313

Schmitt trigger and comparator combine to form window detector

Window detectors are used to pass signals when a control voltage is between two preset levels. A Schmitt trigger and a differential comparator, when combined, allow independent adjustment of the on and off levels.

Transistors Q1, Q2 and Q3 with associated resistors form a complementary Schmitt trigger with a differential input (Fig. 1). This configuration provides good temperature stability of the trigger level set by R9. R3 allows adjustment of the hysteresis from millivolts up to about one volt according to requirements.

Transistors Q5, Q6 and associated components make up a differential comparator Q4 acts as a switch. The comparator is similar to the Schmitt, but it has no positive feedback and no hysteresis.

Initially Q3 is held on by the V_1 level set at its base and Q6 is held on by V_2. When V_{in} reaches V_1, Q2 conducts and switches Q1 on and Q3 off, allowing the supply voltage to appear at the output terminal. V_{in}, continuing to increase, reaches the reference level V_2 which is greater than V_1. Q5 conducts and switches Q4 on and Q5 off, allowing the supply voltage to appear at the Q4 collector. This increases V_1 above V_{in} causing Q3 to conduct and cutting Q2 and Q1 off. The output voltage falls to zero.

Thus V_{out} is zero until V_{in} becomes greater than V_1 where upon V_{out} becomes 15 volts. V_{out} remains at 15 volts until V_{in} becomes either greater than V_2 or less than V_1 at which point V_{out} reverts to zero. The window is "open" as

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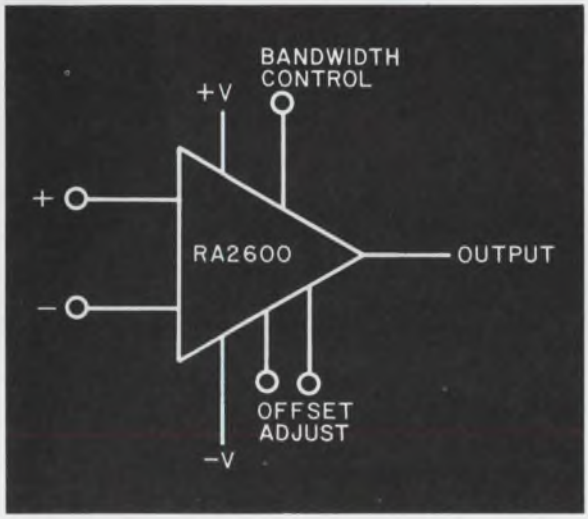

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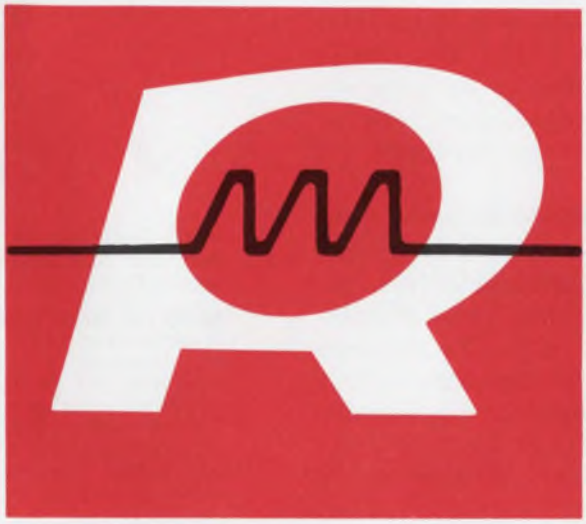

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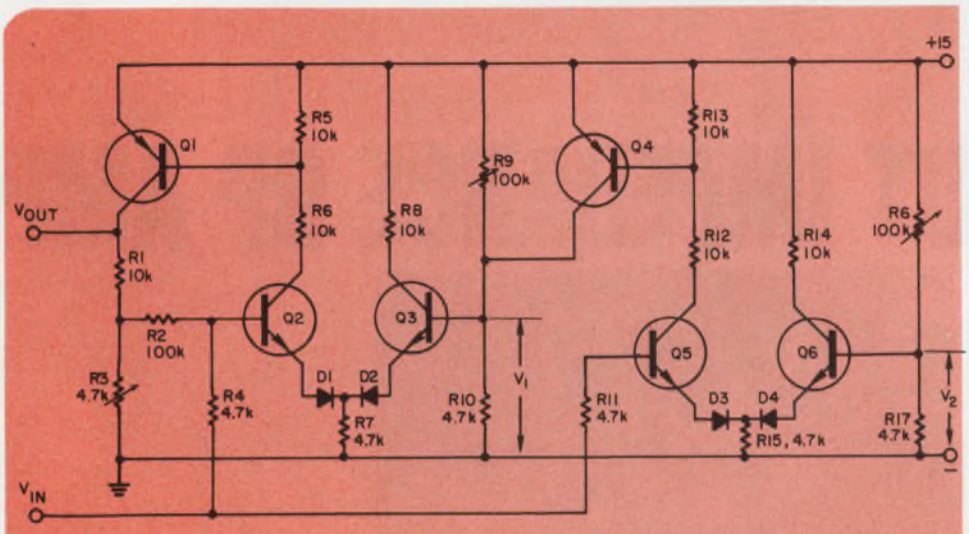
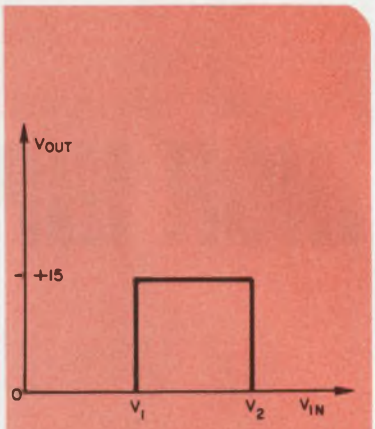


1. **The Schmitt trigger circuit,** Q1, Q2, Q3 and the differential comparator, Q4, Q5, Q6 set the lower and supper switching levels.



2. **The window is "open"** when V_{in} is between V_1 and V_2.

long as V_{out} is high.

A plot of V_{out} vs V_{in} is shown in Fig. 2. Several differential comparators similar to the Q4, Q5, Q6 circuit can be cascaded allowing several windows (or gaps) to be detected. Diodes, D1, D2, D3, D4, protect the emitter-base junctions of transistors from reverse breakdown.

Convenient semiconductors are 2N2219 or 2N1711 for Q2, Q3, Q5, Q6, 2N2905 for Q1 and Q4 and 1N914 for the diodes.

Robert L. Billon, Design Engineer, U N I T E C, Grenoble, France. VOTE FOR 314

Reduce common mode voltage in multiplexed systems

In a data handling system one of the main problems is the reduction of stray capacitance between the amplifier input terminals and ground. A typical installation is shown in Fig. 1A and is redrawn as a bridge in Fig. 1B. The capacitance between the transducer leads and the cable shield is not shown in Fig. 1B. This is because the shield is connected to the common mode voltage also and the capacitance between it and the leads is therefore bootstrapped.

If $\frac{R_1}{R_2} = \frac{C_2}{C_1}$ the bridge is unbalanced and common mode will be fed into the amplifier to be amplified along with the genuine signal thereby reducing the signal to noise ratio. The problem is particularly acute when a multiplexing switch is being used to switch a number of transducers to the same amplifier as it is difficult to completely screen the multiplexer. A solution is shown in Fig. 2.

The common mode voltage, taken from the shield, is amplifier by a non-inverting amplifier with a gain of two and applied via capacitors C_3

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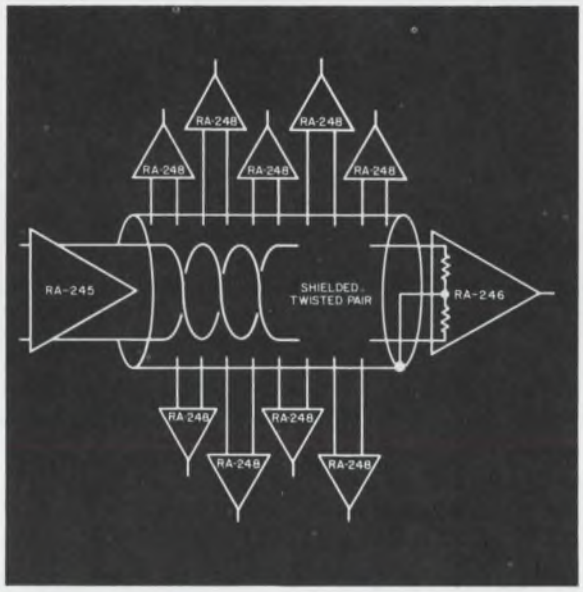

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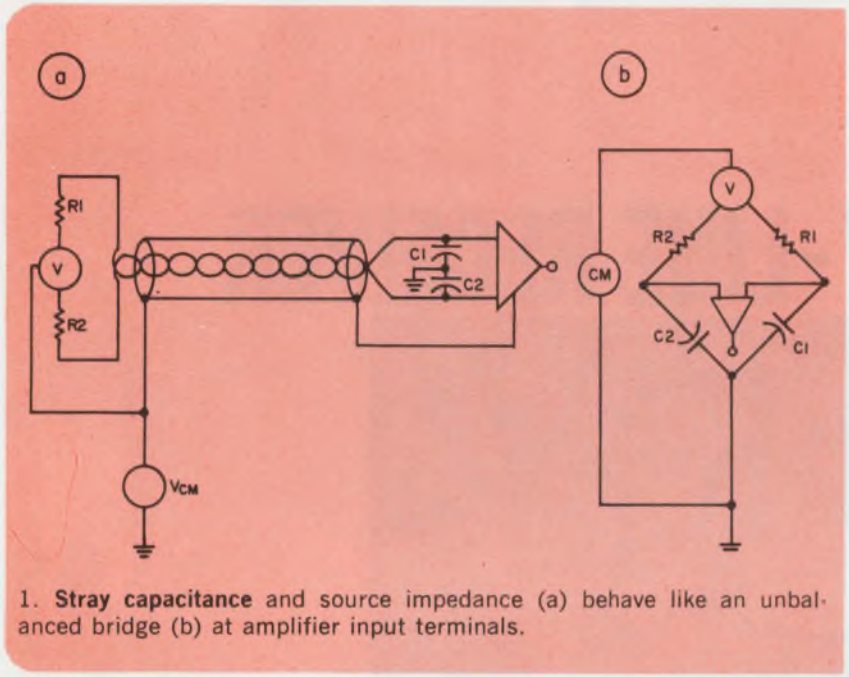
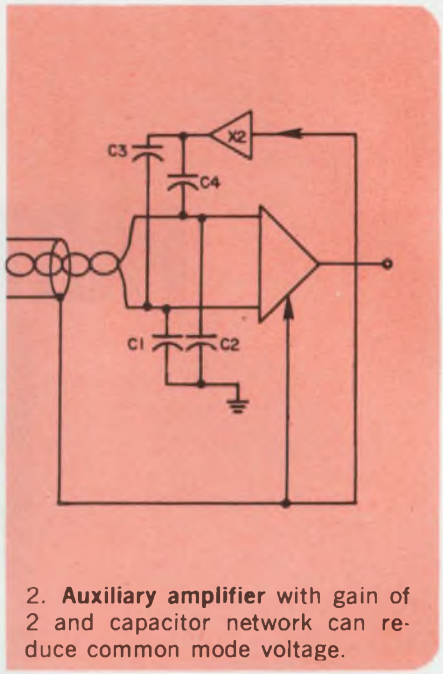


1. **Stray capacitance** and source impedance (a) behave like an unbalanced bridge (b) at amplifier input terminals.



2. **Auxiliary amplifier** with gain of 2 and capacitor network can reduce common mode voltage.

and C_1 to the amplifier inputs. The ac currents which were formerly drawn from the transducer are now supplied from the X 2 amplifier.

In practice the gain of the X 2 amplifier is not critical and it does not need, in view of the final ac coupling, to be level stabilized. It is set to approximately X 2, a 1000 ohm assymetry is introduced into one side of the input and C_1 and C_3 are empirically determined as that value giving minimum common mode at the amplifier output. The procedure is repeated for C_2 and C_4 at the other input pole.

A 40 channel multiplexer using FETs as switching elements was constructed and found to have a common mode ratio of 80 dB at 60 Hz with a 1000 ohm assymetry. The use of the above circuit enabled this to be increased to more than 100 dB.

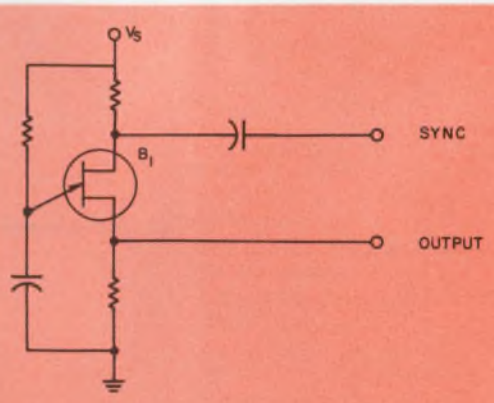
G. Harries, Design Engineer, St. Mande, France. VOTE FOR 315

Sync signal controls frequency of UJT oscillator conveniently

Applying a sync signal to a UJT oscillator can be difficult due to the unreasonable impedances involved. As shown in the diagram, applying the sync signal to B_1 presents a reasonable impedance, and controls the oscillator frequency by varying the firing threshold. The polarity of the sync signal determines which way the frequency is pulled, while the magnitude determines how far the frequency is pulled.

This scheme is presently used to eliminate power line transients and commercial clock sync signals, (3 and 6 kHz) from a real-time clock input. The UJT oscillator is set to free-run at 60 Hz, and a 3-volt sine wave is applied at B_1 for sync.

M. C. Middleton, Circuit Design Engineer, General Electric Co., Phoenix, Ariz. VOTE FOR 316



Applying a sync signal to base 1 provides a convenient method for controlling the frequency of the UJT oscillator.

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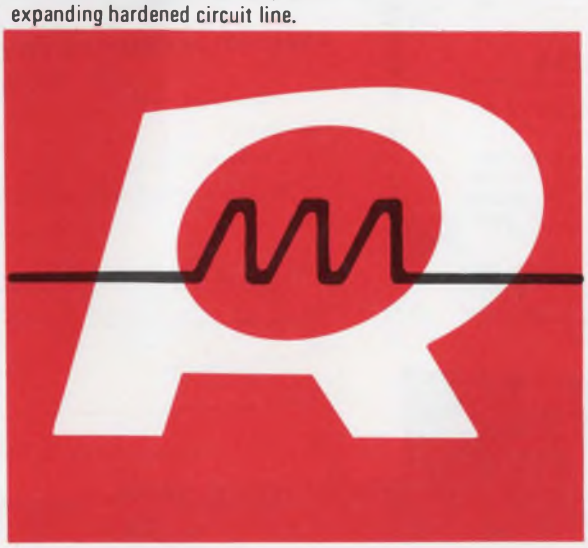

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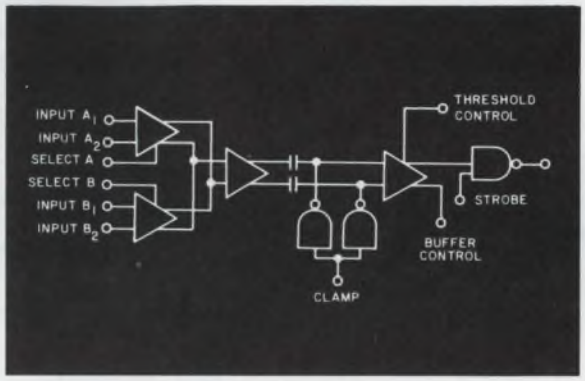

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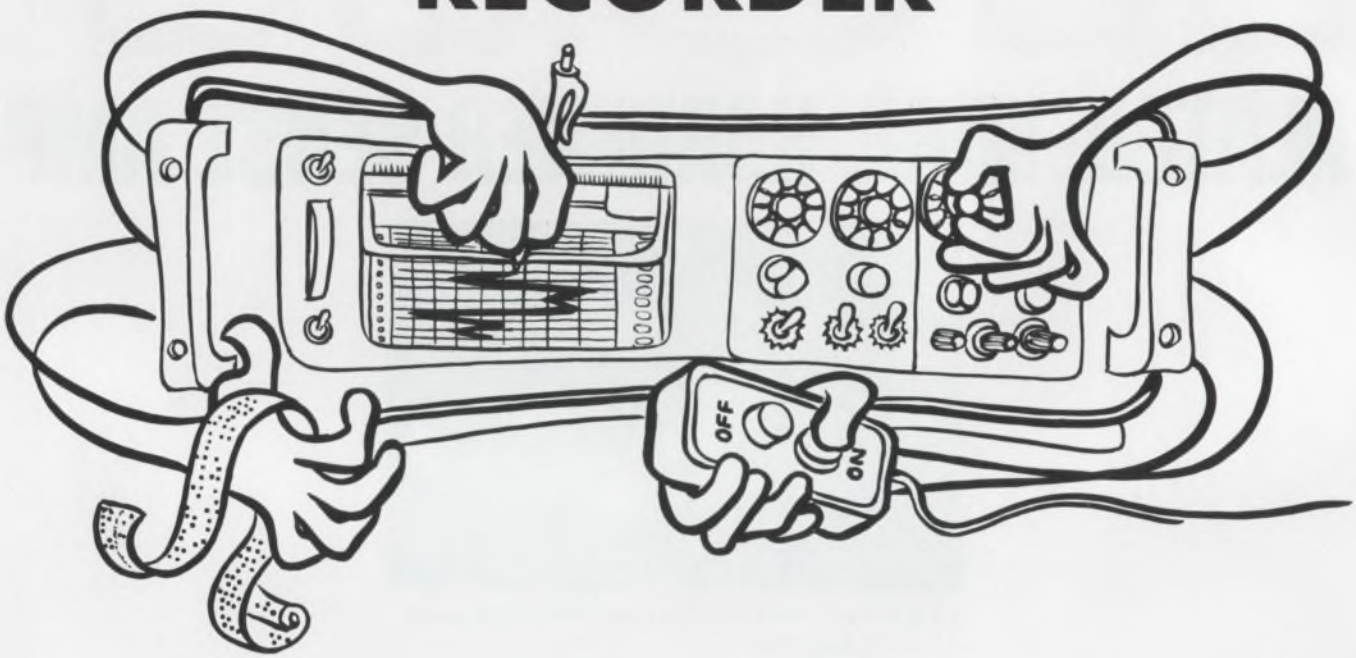
INFORMATION RETRIEVAL NUMBER 78

Introducing -

THE AMBIDEXTROUS RECORDER



Designed with Systems in Mind.

A high-speed dc strip-chart recorder
. . . that can be remotely programmed
. . . and can program itself automatically
. . . and can program other devices, controls, and processes

Adding hands to this recorder couldn't have made it a more versatile and unique systems component.

The 1522 recorder can be remotely programmed. Simple switch-closure commands will select one of 18 chart speeds, start the chart in forward or reverse and stop it; lift the pen; and actuate two event markers.

Or, the 1522 recorder can program itself. Control marks along the chart paper's edge are sensed photoelectrically for automatic internal control of any of the above recorder functions.

Or, the 1522 recorder can program other devices such as sort/select mechanisms. It can activate go/no-go systems or warning signals if plotted information exceeds preset high or low limits. It can be used to program additional test equipment and synchronize other 1522 recorders.

That's not all. The 1522 by itself is a superb dc recorder. It writes with a pen speed of 65 inches per second – it takes only 70 milliseconds for full-scale traverse. Linearity is ¼% of full scale; accuracy is ½% of full scale. Eighteen paper speeds from 2 inches per second to 1 inch per day to accommodate both rapid plotting and continuous monitoring of long processes. There are 15 dc voltage ranges and 18 dc current ranges from 2 mV or 0.2 μA per inch to 100 V or 100 mA per inch.

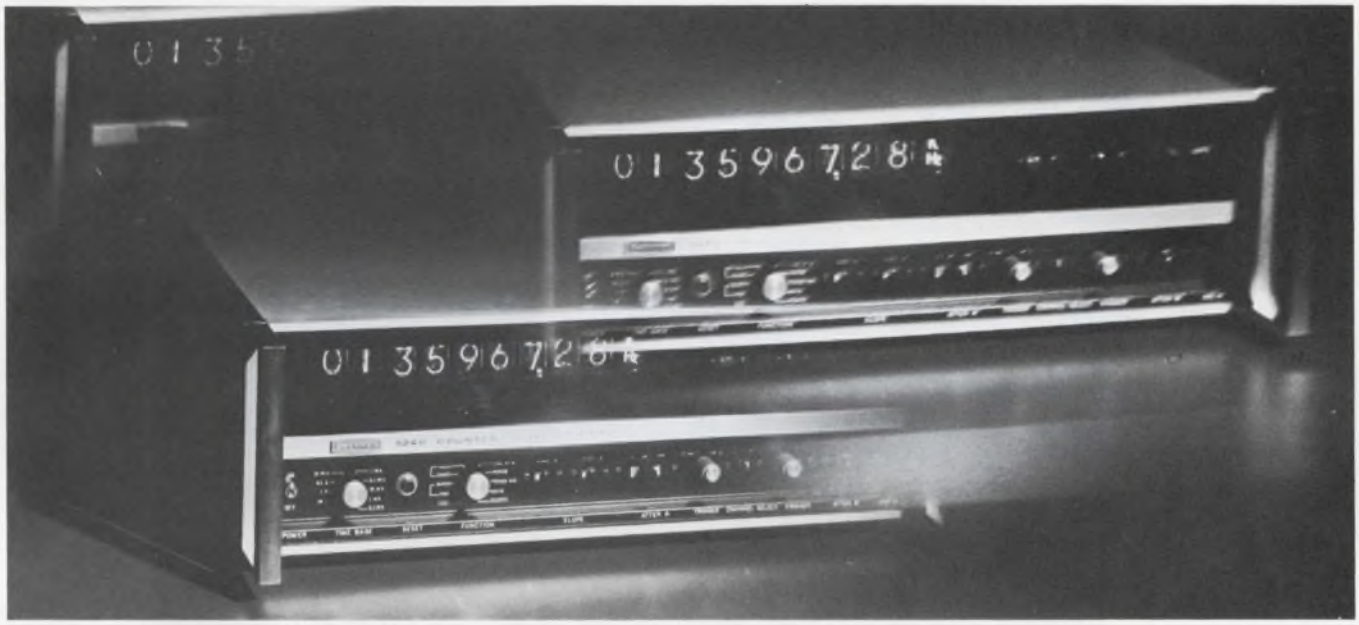
The 1522 adds "hands" to your system. We don't claim it to be smarter than any other machine. It's just a darn good worker and you can put the 1522 on your payroll for $1915 in the U.S.A.

For complete information, write General Radio, W. Concord, Massachusetts 01781; telephone (617) 369-4400. In Europe: Postfach 124, CH 8034, Zurich 34, Switzerland.

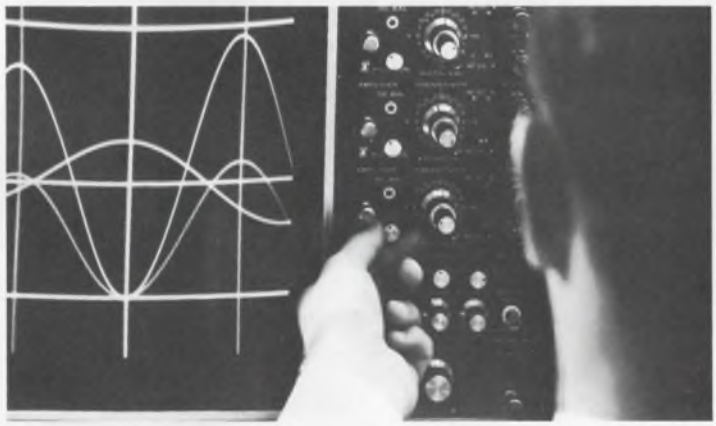
GENERAL RADIO

INFORMATION RETRIEVAL NUMBER 79

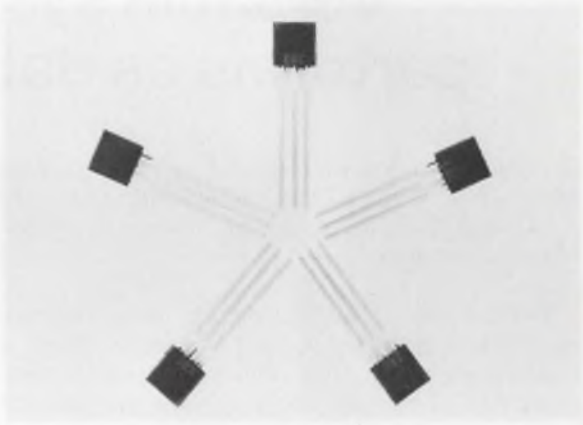
Products



Truly a universal instrument, a new electronic counter is a versatile subsystem that can also function as a data terminal, data display and data coupler, p. 126.



Tri-color CRT display system presents each of three inputs in a different color, p. 128.



Small-signal transistors in TO-92 plastic packages cost only 19¢ each, p. 144.

Also in this section:

Versatile systems counter-timer performs as data terminal and display

Beckman Instruments, Inc., Electronic Instruments Div., 2200 Wright Ave., Richmond, Calif. Phone: (415) 526-7730. P&A: $2200 basic unit, $3050 with options; 60 days.

Besides providing all of the basic measurement capabilities found in standard counter-timers, a new instrument is the first electronic counter designed primarily to be used as a systems component. This new counter data terminal can perform many new systems functions related to data manipulation for meaningful display and digital recording.

When operating as a standard counting instrument, the 1248 data terminal can measure frequencies to 136 MHz, period or period average to 100 ns, and time interval to 100 ns. In addition, it can accumulate pulses with 4-ns width and separation, as well as measure frequency ratio and the frequency of a pulse burst.

Completely addressable from external binary coded commands, the 1248 is a versatile subsystem that becomes a universal data terminal, data display and data coupler. It has the interface mobility to accept parallel or serial control and data logic of various codes and levels. BCD coded outputs are also provided.

Either of the instrument's two channels may be selected remotely. In addition, its accumulator and time base may be preset to any value from external data. This allows measurements to be offset and scaled. The storage elements also accept internal data, permitting the 1248 to act as a general-purpose display and interface to a printer.

Programing is supplied in optional blocks so that excess capability is not built into every instrument. Optional programing modules include function, time base, input attenuators, and input trigger levels.

In a small system, the new counter data terminal can result in significant savings since it eliminates the need for separate output buffers and displays. This feature also allows the 1248 to take full advantage of a system computer. It can make a frequency or time measurement, transfer this to a computer for processing, receive the manipulated data back from the computer, and display the result.

Since measurements can be offset and scaled, the 1248 can count frequency and display in other units. For example, it could measure the frequency from a temperature transducer and then display the equivalent temperature.

Under the remote control of a data processor, the new counter data terminal can be programed to accept any measurement, and the measurement can be multiplied by or added to remotely supplied quantities.

CIRCLE NO. 250

Quite simply, the most versatile preset counter ever.

It's the new 5330B Preset Counter from Hewlett-Packard. It can do about twice as much work as the second best preset counters. Yet it's priced about the same.

This 10 MHz counter can:

Normalize counted data to units such as gpm, psi and rpm.

Issue control signals when preset count or count rates are reached.

Introduce a selected offset in the reading.

Be programmed remotely by automatic systems.

Totalize, find ratios and time intervals.

The 5330B gate times can be selected by a 5-decade front-panel "N" switch to any number of time units between 1 and 100,000. With a choice of 1 μs, 10 μs, 0.1 ms and 1 ms time units ("M"). So you can get normalizing factors from 1 to 10^8.

This flexibility, together with the two limit control switches (L1 and L2), lets you virtually automate many processes such as batching. The limit switches generate output signals when the preset count is reached. These signals become the commands for your computer-run system.

The optional zero offset can be set at any number between 0 and 99,999. This lets your count start from a specific number and return to that number automatically.

All four of these functions can be remotely preset. It's also the first preset counter to offer an anti-noise option. This rejects high frequency noise that might mask low-frequency data.

You can also use this preset counter as a frequency divider. As a delay generator. Or as a precise, digitally selectable pulse generator.

If the 5330B is too versatile for you, the 5330A should be just right. It does slightly less (without limits, but zero offset option available), and costs slightly less.

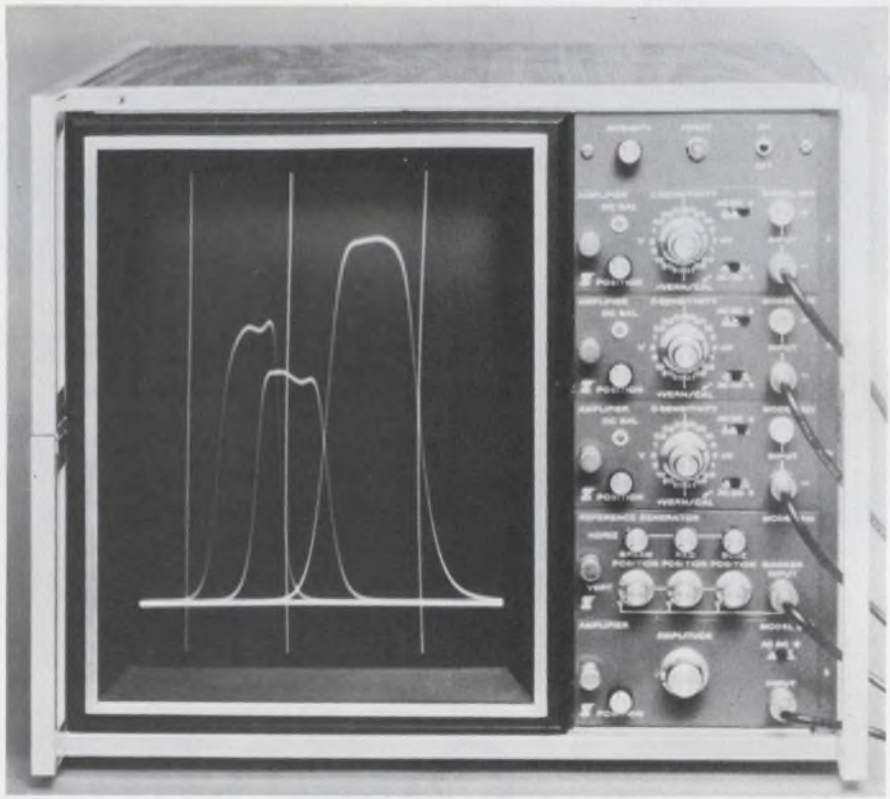
The 5330A is $1200. The 5330B is $1550. To find out just how much they can do for you, call your local HP field engineer. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

ELECTRONIC COUNTERS

02915

INFORMATION RETRIEVAL NUMBER 80



Three-channel CRT display shows inputs in three colors

Telonic Systems, div. of Telonic Industries, Inc., 21282 Laguna Canyon Rd., Laguna Beach, Calif. Phone: (714) 494-9401. P&A: $2400 to $3550; 12 wks.

Featuring tri-color presentation on a 15-in. cathode-ray tube, a new display system accepts up to three input signals and shows each in a different color—red, green and blue. Since total discrimination between signals is made possible by this multiple-color presentation, the full face of the CRT is available for all signals, further enhancing the instrument's resolution.

Model 201 tri-color CRT display system incorporates plug-in amplifiers for each input channel. These have a sensitivity of 100 μV per inch up to 100 V per inch, assuring maximum resolution regardless of the input level.

The vertical amplifiers are available in two versions: a basic unit with a sensitivity range of 100 mV per inch to 10 V per inch, and a high-gain differential model with the range mentioned above. Horizontal deflection can be provided by an external source, such as a sweep generator, or internally by an optional time-base generator, which is also a plug-in unit. A calibrated control on the time base permits sweep speeds from 1 ms per inch to 1 s per inch.

A reference line generator, another optional plug-in unit, supplies three horizontal lines and three vertical lines on the CRT in red, green and blue. These can be used for a wide variety of functions. Vertical lines, for example, could be generated by a frequency marking device to calibrate the display; horizontal lines could be limits showing high and low levels. The reference line generator plug-in has separate controls for each horizontal and vertical line, as well as an input for externally generated signals like a time or frequency marker pulse.

CIRCLE NO. 251

INFORMATION RETRIEVAL NUMBER 82 ►

OFFICE OF THE EMBASSY
18 Newbury Street, Boston, Massachusetts 02116

15 August 1969

Cmsr. Ivan Nyork
INTERSAB
1919 Blorvich Blvd.
Moscow, U. S. S. R.

Dear Comrade Ivan:

Regarding the Capitalist Imperialist capabilities in the area of power transistors:

Our sources reveal that their foremost manufacturer, SSPI, has introduced such a wide number of power transistors that we can only suspect the Americans of not knowing what they really want. SSPI offers devices rated from 300 m.a. up to 30 amps, for five different current ranges, capable of handling up to 150 watts, in 10 different packages. This wasteful display of versatility suggests that SSPI is merely showing off for the favors of the Design Engineer. The devices all display an extravagantly high and flat Beta.

As for dependability: we have tested 53,789 of them, without a single failure. However, we remain optimistic.

Actual specs and prices are documented in the attached power-transistor literature package called LITPAK-POWTRAN. (We have not yet been able to translate this word.) Comrade Petrasha obtained the document under his cover name (Comrade Hilton) by writing direct to Mr. Alex Polner at SSPI, 1 Pingree Street, Salem, Massachusetts 01970, (617) 745-2900, as the American engineers do.

My kindest regards to your wife Anna, and to your brother Alexei after his unfortunate disagreement with Department policy. I am sure that the mines, and the salt air, will be beneficial to his bronchial condition.

Faithfully,

Nikita

LITPAK
POWTRAN
SSPI SOLID STATE PRODUCTS
DIVISION OF UNITRODE CORP.

VODKA

МИНИСТЕРСТВО ПИЩ
ПРОМЫШЛЕННОСТИ
РОСГЛАВТАБ
ПАПИРО
ВЫСШЕГО СО
„БОГАТ
10

ТАБАЧНАЯ ФАБРИКА
„ЯВА"
МОСКВА

Multi-function counters divide and generate

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $1200 or $1550; October, 1969.

Providing several functions in a single package, a new preset counter can measure and control, as well as divide frequencies, and generate precision delays and pulses. Able to be programed remotely, model 5330B can measure frequencies or rates from dc to 10 MHz, totalize, find ratios, determine time intervals, and normalize all these if desired. There is also a lower-cost preset counter, model 5330A, with all the basic features of the 5330B except count limits.

CIRCLE NO. 252

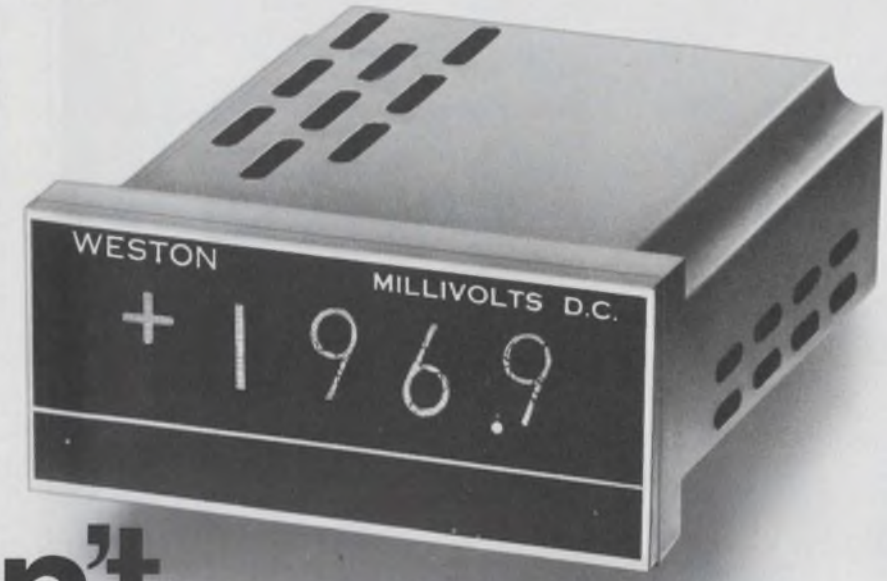
Real-time oscilloscope spans 200-MHz band

E-H Research Laboratories, Inc., 515 11th St., P.O. Box 1289, Oakland, Calif. Phone: (415) 834-3030.

Combining a 200-MHz bandwidth with a high input impedance, a new real-time oscilloscope can be used with either active or passive probes. Model SS-212 has a vertical-channel input impedance of 1 MΩ. Its horizontal deflection system features sweep speeds to 1 ns/cm with stable triggering to 200 MHz. It also offers a large 6 by 10-cm display on a front panel of only 8-1/2 by 10 in.

CIRCLE NO. 253

If this new plus doesn't grab you,



the others will.

As you can see, our latest Model 1292 DPM* is bi-polar. It's a 3½-digit compact with 100% over-range, plug-in Nixie** tubes, front panel serviceability, and 0.1% ±1 digit accuracy. Full BCD output, non-blinking storage display and Weston's patented dual slope integration are standard, of course.

What you can't see are several other new plus features designed to broaden your applications for the Model 1292. Input impedance, for example, is greater than 100 megohms on a 100 MV range, greater than 1,000 megohms on 1 volt, and 10 megohms on all other voltage ranges.

Independent references for positive and negative measurements provide extremely good stability at near zero input levels—difficult to obtain with conventional circuits.

Decimal points are "wired out" for remote control positioning.

Finally, a new range has been added to the standard ranges available—1 μa full scale giving 1 nanoamp resolution.

Add them up and we think you'll agree that the Weston bi-polar Model 1292 DPM is the world's most advanced unit. Yet it costs only a few dollars more than our 3½-digit mono-polar Model 1290 and is fully compatible also with our economy Model 1260. Get complete specifications now on this big new plus in the fastest growing line of digital panel meters.

WESTON INSTRUMENTS DIVISION
Weston Instruments, Inc., Newark, N.J. 07114.
a Schlumberger company

WESTON®

*U.S. Pat. No. 3,051,939 and patents pending.
**Registered trademark, Burroughs Corp.

Pulse generator is fully pushbutton

Applied Electronics, 877 Cowan Rd., Burlingame, Calif. Phone: (415) 697-2701. P&A: $310; stock to 3 wks.

Model 541 pulse generator features full pushbutton selection of pulse width and pulse spacing ranges, pulse polarity or a combined positive/negative pulse, and voltage range output amplitude. Pulse width and spacing are continuously variable from 10 μs to 10 s in six ranges. Voltage output amplitude is continuously variable from 0 to 0.2, 0 to 2, and 0 to 20 V.

CIRCLE NO. 254

Digital ac/dc instrument measures and calibrates

RFL Industries, Inc., Instrumentation Div., Boonton, N.J. Phone: (201) 334-3100. Price: $2995.

Providing both calibration and measurement capabilities in a single package, a new instrument is not only a digital source of ac/dc voltages and currents, frequencies and resistance, but will also measure these parameters with no loss in accuracy. Model 829G is an ac/dc and ohms calibrator with an ac accuracy of 0.05% of reading, and a dc and ohms accuracy of 0.02% of reading.

CIRCLE NO. 255

Small frequency meter can count out to 1 MHz

Beckman Instruments, Inc., Electronic Instruments Div., 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 871-4848. Price: $450.

A new digital frequency meter not only measures frequencies up to 1 MHz, but can also be used to measure time intervals from 10 μs to 10^6 s. Heart of the model 4034 is a crystal oscillator that establishes time intervals to an accuracy of $\pm 0.01\%$. Six gate periods, from 1 ms to 100 s, are available. The new instrument has a four-digit display.

CIRCLE NO. 256

Bipolar panel meter presents 1-GΩ input

Weston Instruments, Inc., a Schlumberger Co., 614 Frelinghuysen Ave., Newark, N. J. Phone: (201) 243-4700. P&A: $200; stock.

Boasting a 3-1/2-digit display, a new bipolar digit panel meter provides an input impedance of greater than 100 MΩ on a 100-mV range and greater than 1000 MΩ on a 1-V range. Input impedance is 10 MΩ on all voltage ranges. Model 1292 has separate references for both end points of the range, thus making the zero point independent of end-scale adjustments.

CIRCLE NO. 257

Lab power amplifier supplies 3 W at 110 MHz

Electronic Navigation Industries Inc., 1337 Main St. East, Rochester, N. Y. Phone: (716) 288-2420. Price: $485.

Covering the frequency range of 0.25 to 110 MHz with a maximum power output of 3 W, model 300 L broadband class A amplifier may be used to extend the power output capability of virtually all laboratory signal and sweep generators. The new amplifier is completely solid state and is untuned, making it reliable and easy to use.

CIRCLE NO. 258

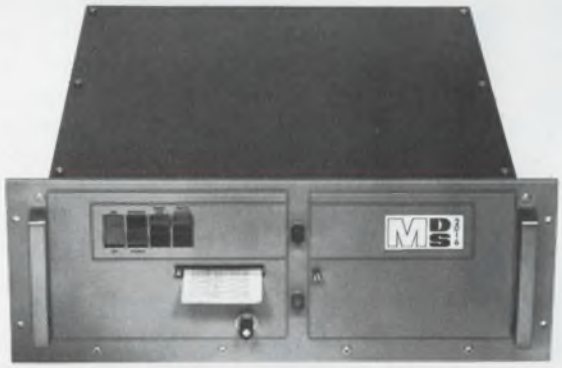
Time-interval counter resolves down to 10 ns

Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, Calif. Phone: (415) 686-4200. P&A: $1750; 2 to 3 wks.

With a resolution of 10 ns, a new 10-ns time-interval counter, model 784, provides single-event measurements of period, pulse width and pulse time. Full input signal conditioning of both start and stop inputs is also featured. This allows variable trigger point definition with 100 mV to 100 V rms in three ranges: 1, 10 or 100 V.

CIRCLE NO. 259

Relax!
MDS has done your digital strip printer homework for you.



The MDS 2016 prints 8 to 20 columns. Size is 7"H x 19"W x 17"D

Printed circuit boards, with easily accessible switches permit unusual flexibility for Programmable Zero Suppress.

Specify the **MDS 2016** Digital Lister Printer. It incorporates, as standard, most features you ordinarily order as extra-cost options.

If you're sweating out specifications for Digital Strip Printers . . . up to your neck in options, trying to get everything you need in a single unit . . . drop the whole business and call MDS.

Chances are good that our new 2016 Digital Lister Printer has everything you want . . . in the *standard* unit . . . at a price much lower than you'd expect.

You'll get Full Buffering; Programmable Zero Suppress; Asynchronous Operation; 50 or 60 cycle, user-controlled; External Paper Advance; Out-of-Paper Status Line; Format Control; Positive Logic; Operate/Inhibit Switch.

PROGRAMMABLE ZERO SUPPRESS: The variable zero suppress fields within a line of print, or the number of zero suppress positions in a field, are programmable by switches.

BUFFER provides control for lock-out, activated upon receipt of a print command. An instruction is stored, and printer is inhibited until the instruction is executed. Lock-out also is generated by out-of-paper signal, external paper feed, manual paper advance, print test and printer off-line status.

Phone or write for literature. Your Man from MDS will gladly help you make your decision. Ask about other MDS Digital Strip Printers: 120A, 800, 1200, 1600, 2200, 3200, 2015.

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INFORMATION RETRIEVAL NUMBER 88

INSTRUMENTATION

Stable noise generator pins down amplitude

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone (415) 326-7000. P&A: $775; stock.

A new audio-range noise generator synthesizes noise with a stable output level that is predictable within 0.2 dB at full amplitude. In addition, amplitude accuracy is determined primarily by the instrument's widerange output attenuator, which is accurate within ±0.5 dB. Model 8057A has a three-decade amplitude attenuator that allows the output to be set with 0.1-dB resolution over a 110-dB range.

CIRCLE NO. 260

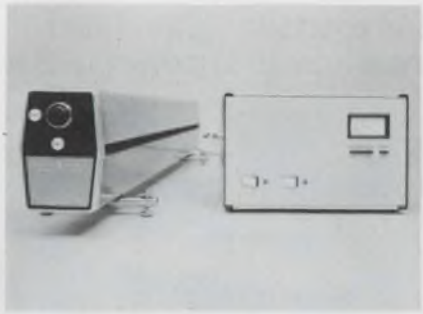
High-power pulsers deliver 6 kV at 1.5 A

Microwave Cavity Laboratories, Inc., div. of KMS Industries, Inc., 10 N. Beach Ave., LaGrange, Ill. Phone: (312) 354-4350

Series 10299B portable high-power pulse modulators offer a choice of three plug-in adjustable output voltage modules: 0 to 1.5 kV at 6 A peak, 0 to 3 kV at 3 A peak, or 0 to 6 kV at 1.5 A peak. Risetimes range from 170 to 400 ns, while falltimes vary from 200 to 400 ns, depending on the model. Maximum pulse droop is 8% at 10-μs pulse width.

CIRCLE NO. 261

He-Cd cw laser emits at 3250 Å

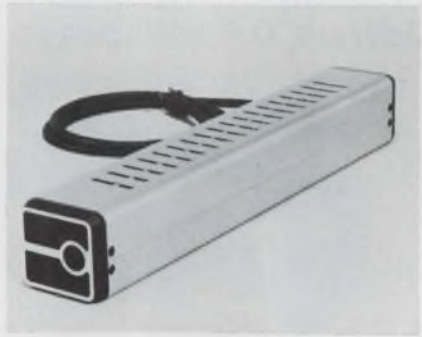


Spectra-Physics, 1250 W. Middlefield Rd., Mountain View, Calif. Phone: (415) 961-2550. Availability: 60 days.

Truly a new type of laser, the model 185 helium-cadmium laser is claimed to be the first reliable low-threshold source of continuous coherent light in the deep blue (4416 Å) and the ultraviolet (3250 Å) regions. The new unit emits more than 50 mW at 4416 Å and more than 5 mW at 3250 Å.

CIRCLE NO. 262

Kit-form He-Ne laser supplies 1-mW output



Quantum Physics Inc., 1295 Forgewood Drive, Sunnyvale, Calif. Price: $170/kit, $225.

Supplied in kit form or fully assembled, model 301 He-Ne gas laser produces a full milliwatt of uniphase optical energy at 6328 Å. The unit features an isotopic gas-filled plasma tube with long-life, cold-cathode, prealigned, integral mirror mounts. These mirror mounts contain polarizing elements that prevent mirror degradation due to the damaging effect of UV radiation impinging upon the mirror surface.

CIRCLE NO. 263

Inexpensive gas laser reaches 75% power in 2 s

Edmund Scientific, 380 Edscorp Building, Barrington, N.J. Phone: (609) 547-3488. Price: $99.50.

With a low price tag of $99.50, a new helium-neon laser delivers 75% power within two seconds after turn-on, and full power within three minutes. Model 79,004 supplies a steady 2%-ripple laser light of moderate power that is particularly useful for studies and experiments in holography, interferometry, spectroscopy, communications and diffraction.

CIRCLE NO. 264

Economy He-Ne laser delivers 0.5-mW power

Metrologic Instruments, Inc., 143 Harding Ave., Bellmawr, N.J. Phone: (609) 933-0100. P&A: $99.50; stock to 2 wks.

Selling for only $99.50, a new helium-neon laser operates at 6328 Å and emits about 0.5 mW of power (0.3 mW minimum) with a beam divergence of 0.5 milliradian. Model 310 is ruggedly housed and is simple to take apart and reassemble. Its tube, which is made of rugged coaxial glass with sealed optics, measures about 9-in. long by 1 in. in diameter.

CIRCLE NO. 265

Our new retina sees red everywhere

New photocathode responds from 300 nm to 950 nm. Best yet for GaAs laser beam detection.

The prosaic designation, S-25, for our new red sensitive translucent photocathode belies its exciting characteristics and usefulness.

With a spectral response that ranges from 300 nm to 950 nm, the S-25 needs no additional infrared source, sensing instead natural radiation such as moonlight and airglow. Fact is, under a night sky our new S-25 is 4 times more sensitive than S-1 or S-20.

Increased spectral range

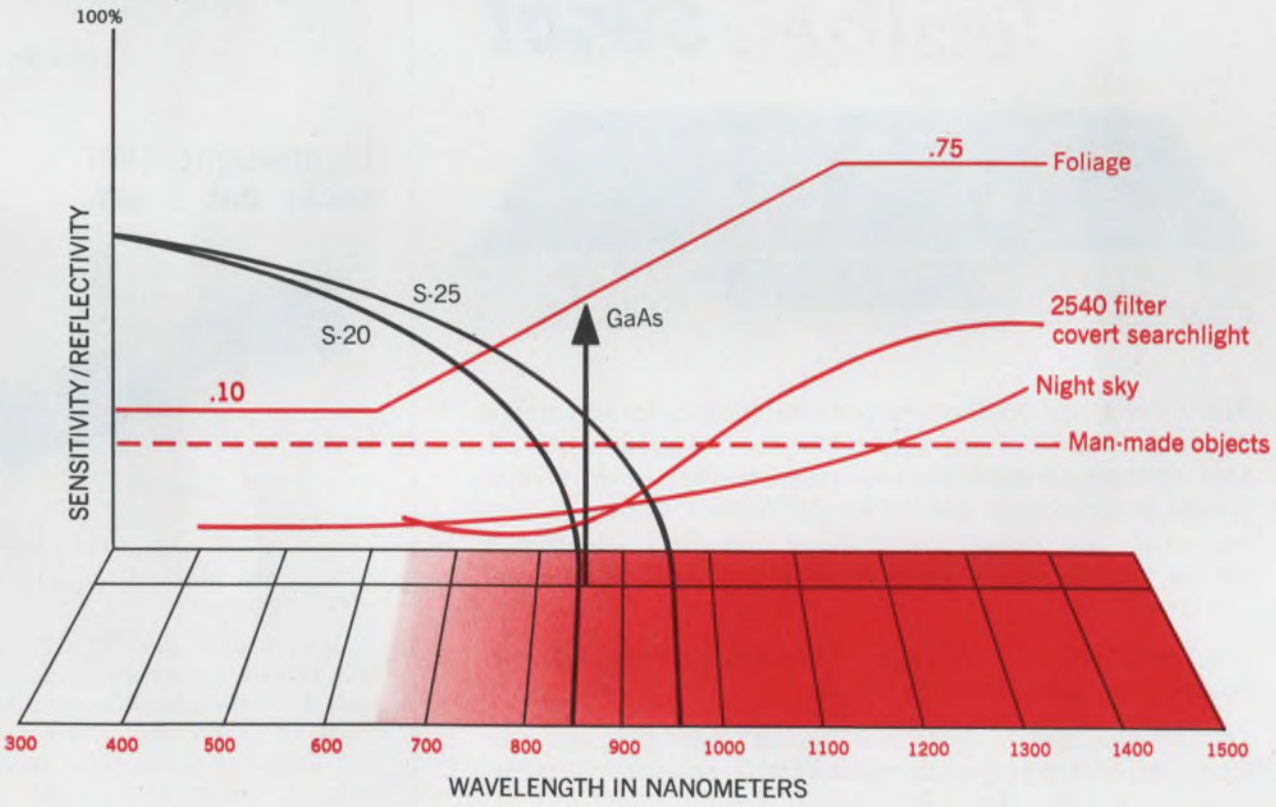
This extreme spectral range makes possible increased contrast in detecting man-made objects versus foliage. Obvious advantage: Extremely sensitive military night vision devices. Note, too, that because the response of the S-25 is particularly outstanding between 840 and 890 nanometers, it is ideal for gallium arsenide laser beam detection. A characteristic that should be of interest to those involved in distance measuring equipments for bridges and tunnels, or military range finders.

For those with scientific turn of mind, the S-25 operates well in high electric field gradients, is capable of high peak current output without electric field distortion or defocussing, and is adaptable to multibounce optical trapping for even greater sensitivity.

Configurations available

You can, of course, expect to get the S-25 photocathode in a host of phototube configurations and end-on photocathode designs such as Vidissector® camera tubes, photomultipliers, image intensifiers and vacuum photodiodes.

Want more information? Write: ITT Electron Tube Division, International Telephone and Telegraph Corporation, P.O. Box 100, Easton, Pa. 18042



ELECTRON TUBE DIVISION ITT

INFORMATION RETRIEVAL NUMBER 92

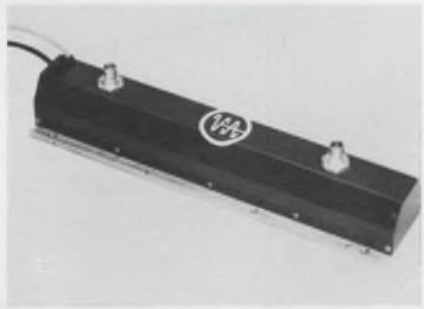
Palm-sized oscillator supplies 10 mW at 4 GHz

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $1190; 30 days.

Self-contained in its hermetically sealed palm-sized package, a new electronically tunable solid-state S-band oscillator delivers more than 10 mW from 2 to 4 GHz. Model 35009A is a YIG-tuned transistor oscillator and buffer amplifier built as a thin-film hybrid microcircuit on a sapphire substrate. When the load is 50 Ω, the output level will vary no more than 1.5 dB.

CIRCLE NO. 266

Lightweight TWT socks out 1 kW



Varian TWT Div., 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Designated as the VTC-5261J1, a new cathode-pulsed traveling-wave amplifier tube produces more than 1 kW of peak output power at an 8% duty rating from a package weighing only 4.5 pounds and measuring slightly more than 12 in. long. It is intended for use as a driver or output tube in advanced pulse-radar missile-guidance systems that operate between 5.4 and 5.9 GHz.

CIRCLE NO. 267

Vhf/uhf transistors give 20 W at 400 MHz

Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Ariz. Phone: (602) 273-6900. P&A: $4.28 to $46; stock.

Three new families of balanced-emitter transistors for uhf and vhf power applications feature outputs up to 20 W at 400 MHz with a 28-V supply (2N5637), 40 W at 175 MHz with a 28-V supply (2N5643), or 25 W at 175 MHz with a 13.5-V supply (2N5591). These new devices consist of many small transistors in parallel, with a small thin-film resistor in series with each of the emitters.

CIRCLE NO. 268

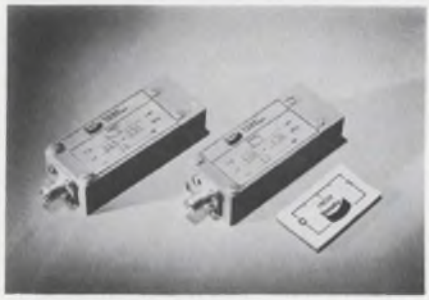
Portable emi meter goes out to 10 GHz

Stoddart Electro Systems, 2045 W. Rosecrans Ave., Gardena, Calif. Phone: (213) 770-0270. P&A: from $13,000; January, 1970.

Covering the frequency range from 1 to 10 GHz, a new portable solid-state emi meter derives its power from an integral rechargeable battery pack. Model NM-65T is ideal for determining the source and analyzing the characteristics of electromagnetic interference. Typical uses include microwave propagation studies and radiation pattern measurements.

CIRCLE NO. 269

Acoustic delay lines keep loss to 18 dB



Bendix Corp., Research Laboratories Div., 20800 10-1/2 Mile Rd., Southfield, Mich. Phone: (313) 353-3500.

Using thin piezoelectric films with a high transfer efficiency, a new series of compact microwave acoustic delay lines feature typical insertion losses of less than 18 dB at bandwidths approaching 30%. The new devices cover the frequency range of 100 to 500 MHz with delays up to 10 μs. They can be supplied in either single- or double-ended configurations.

CIRCLE NO. 270

Combline 100-W filter has 48% bandwidth

Peninsula Microwave Laboratories, 855 Maude Ave., Mountain View, Calif. Phone: (415) 969-3303.

Designed primarily for high-power telemetry radar, a new combline filter with a 48% bandwidth covers the frequency range of 1.4 to 2.3 GHz with 0.35-dB maximum insertion loss and 1.3 maximum VSWR. Model F537A has a power handling capability of 750 W peak and 100 W average. Stopbands are dc to 1 GHz and 2.6 to 8 GHz with a minimum rejection of 45 dB.

CIRCLE NO. 271

New IRC rectangulars trim circuit space and cost

Metal Glaze and Wirewound types

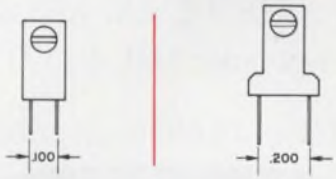
These ¾-inch-long rectangular trimmers are made and perform like bigger, more costly units. Only IRC offers a miniature general-purpose unit with these features:

- All-metal adjustment shaft that eliminates breakage or distortion, even under repeated use.
- Silver brazed terminations on Metal Glaze and Wirewound types end resistance buildup associated with pressure connections.
- Ultrasonic bonding of the housing into a one-piece unit that is free of seams or laps.
- Resistance to normal board washing. Units sealed to MIL-R-27208 are also available.

Metal Glaze Type 950 has a rugged, thick-film element that provides excellent high-frequency characteristics and infinite resolution over the entire resistance range of 100Ω to 1 megohm. ¼-watt @ 25°C. ±10% tolerance.

Precision Wirewound Type 900 has a long-wearing precious metal wiper spring that reduces noise and contact resistance. 1 watt @ 40°C. 100Ω to 20K. ±10% tolerance.

PIN CONFIGURATIONS



WIREWOUND	METAL GLAZE	WIREWOUND	METAL GLAZE
900-20 Std.	950-20 Std.	920-20 Std.	970-20 Std.
910-20 Sealed	960-20 Sealed	930-20 Sealed	980-20 Sealed

Immediate delivery from stock or from IRC Industrial Distributors. For information and prices write:

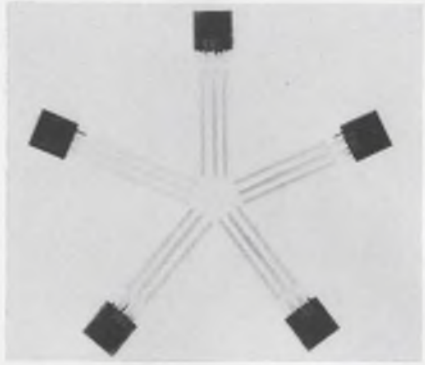
IRC St. Petersburg Division of TRW INC.
2801 72nd St., North, St. Petersburg, Fla. 33733

IRC

DIVISION OF TRW INC.

INFORMATION RETRIEVAL NUMBER 96

Plastic transistors sell for only 19¢



Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Ariz. Phone: (602) 273-6900. Price: 19¢ to 25¢.

Costing as little as 19¢ each in quantities of 100, three new small-signal silicon transistors come in TO-92 plastic packages. Types MPSA10, MPSA20 and MPSA70 are designed especially for low-level audio amplifiers and general-purpose low-frequency amplifiers, or as switches in audio, radio and television circuits. Breakdown voltage is 40 V minimum.

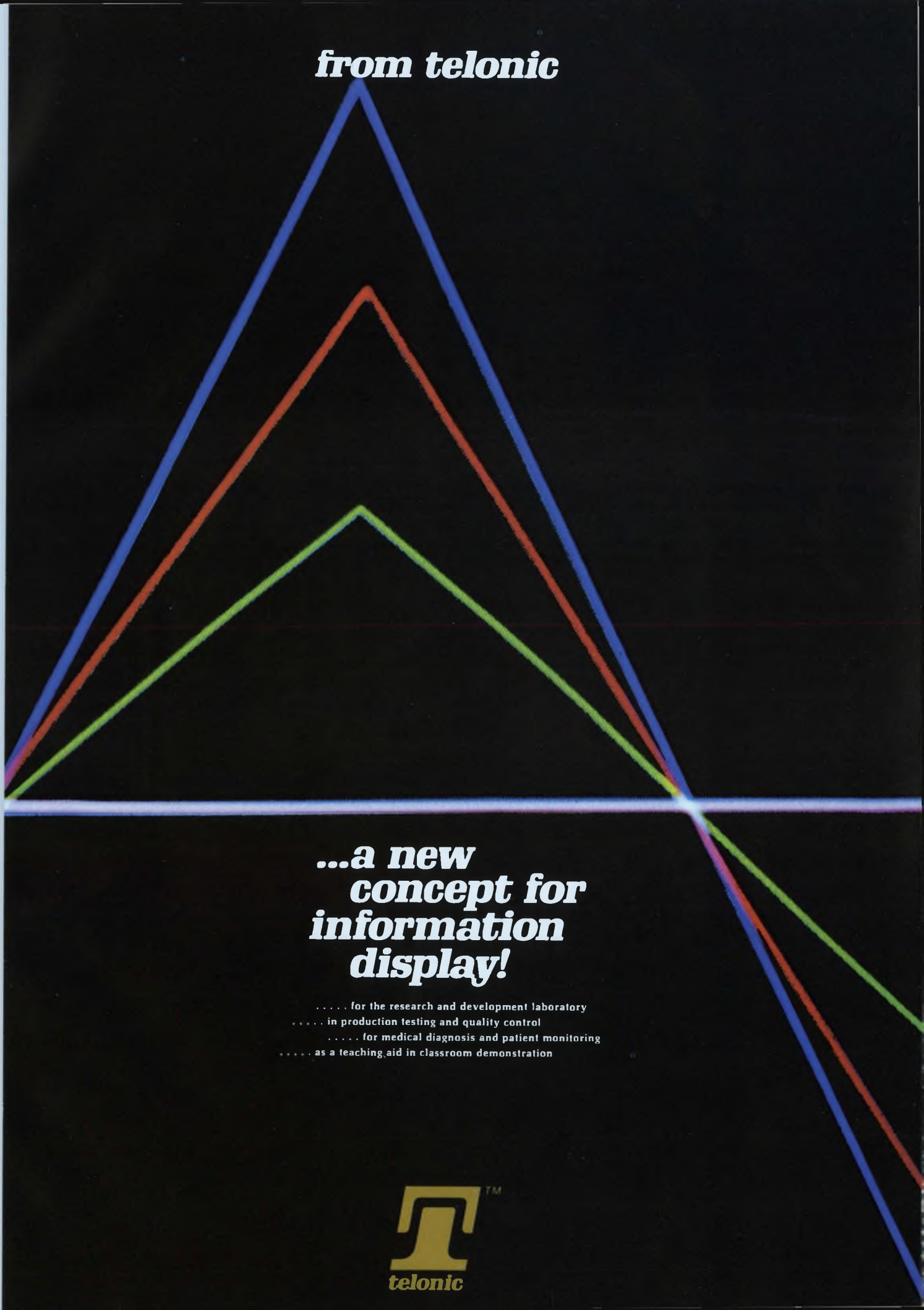
CIRCLE NO. 272

Monolithic one-shot defines trigger level

Texas Instruments Inc., Components Group, P.O. Box 5012, Dallas, Tex. Phone: (214) 238-2011. P&A: $4.40, stock to 4 wks.

A new monolithic TTL monostable multivibrator integrated circuit, the SN74121, triggers at a specific voltage level of the input pulse. Once fired, the device's inputs are inhibited and the duration of the output pulse, which is externally variable from 40 ns to 40 s, is dependent only on the value of the timing resistor and capacitor.

CIRCLE NO. 273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. . . . . in production testing and quality control
. . . . . for medical diagnosis and patient monitoring
. . . . . as a teaching aid in classroom demonstration
TM
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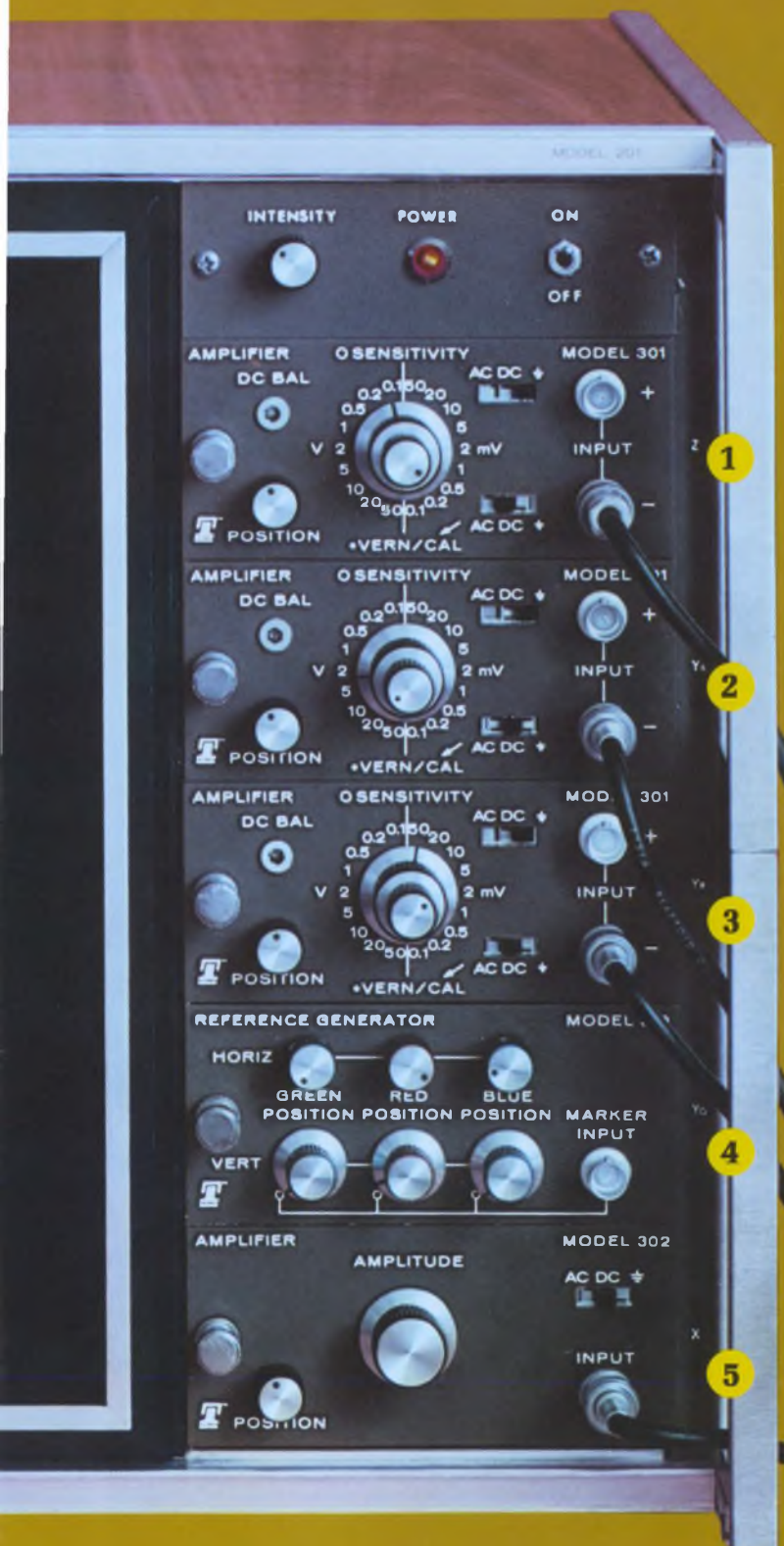


OPTIONAL TIME BASE Horizontal deflection in the 201 System is usually obtained from an external sweep signal. A calibrated Time Base is also available as an optional plug-in unit to provide sweep rates from 1 to 1000 milliseconds per inch. A vernier control extends sweep time to 10 seconds per inch.

SOLID STATE — MODULAR DESIGN The 201 System is completely solid state with the exception of the CRT. For maximum versatility, the Model 201 consists of a basic display chassis and functional plug-in units. Operating characteristics of the System are determined by the plug-in units selected.

Plug-ins presently available include vertical and horizontal amplifiers, a reference line generator, and a time base. Future units may occupy the entire plug-in area to provide the total signal processing and display functions for multiple parameter measurements.

VERTICAL AND HORIZONTAL PLUG-IN AMPLIFIERS Three vertical amplifier plug-in units 1 2 3 are required for normal operation of the 201 Display System — one for each signal channel. If horizontal deflection is to be obtained from an external signal, an additional amplifier will be required for this channel 5. The Model 320 Time Base plug-in unit can be used in place of the horizontal amplifier to provide a linear calibrated horizontal sweep.

Two amplifiers are available — the Model 301 High Gain Differential unit and the Model 302 Basic Amplifier. Both units are direct coupled, enabling display of dc levels and low frequency signals. **Either model may be used for vertical or horizontal channels.**

The calibrated deflection factor of the Model 301 differential unit is adjustable from 100 μV/inch to 50 V/inch, providing maximum versatility for both low-level and general purpose applications. The vernier control can be used to reduce the deflection factor to 100 V/inch. In differential operation, the common mode rejection is 30 dB.

The Model 302 Basic Amplifier plug-in is a general purpose unit with a continuously variable sensitivity of 100 mV/inch to 10 V/inch.

TIME BASE PLUG-IN The Model 320 Time Base plug-in is available for use in the horizontal channel 5 and provides calibrated sweep times of 1 to 1000 msec/inch in four ranges. The vernier control extends the slowest sweep range to 10 seconds/inch. The unit can be triggered by external or internal signals or by the power line. Trigger slope and level adjustments enable triggering at any point on the waveform.

REFERENCE LINE GENERATOR PLUG-IN The Model 310 Reference Generator 4 furnishes three vertical and three horizontal electronic cursors in red, green, and blue which can be positioned anywhere on the screen by independent front panel controls. These reference lines may typically be used to set min/max signal limits for both level and frequency, to compare amplitudes of various input signals, or as a "memory," enabling the user to return the signal amplitude to the original level if desired. Any one of the vertical reference lines may be triggered by an external time or frequency marker pulse.

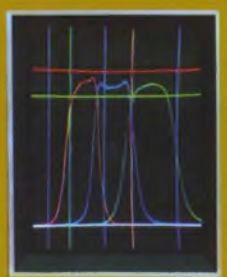


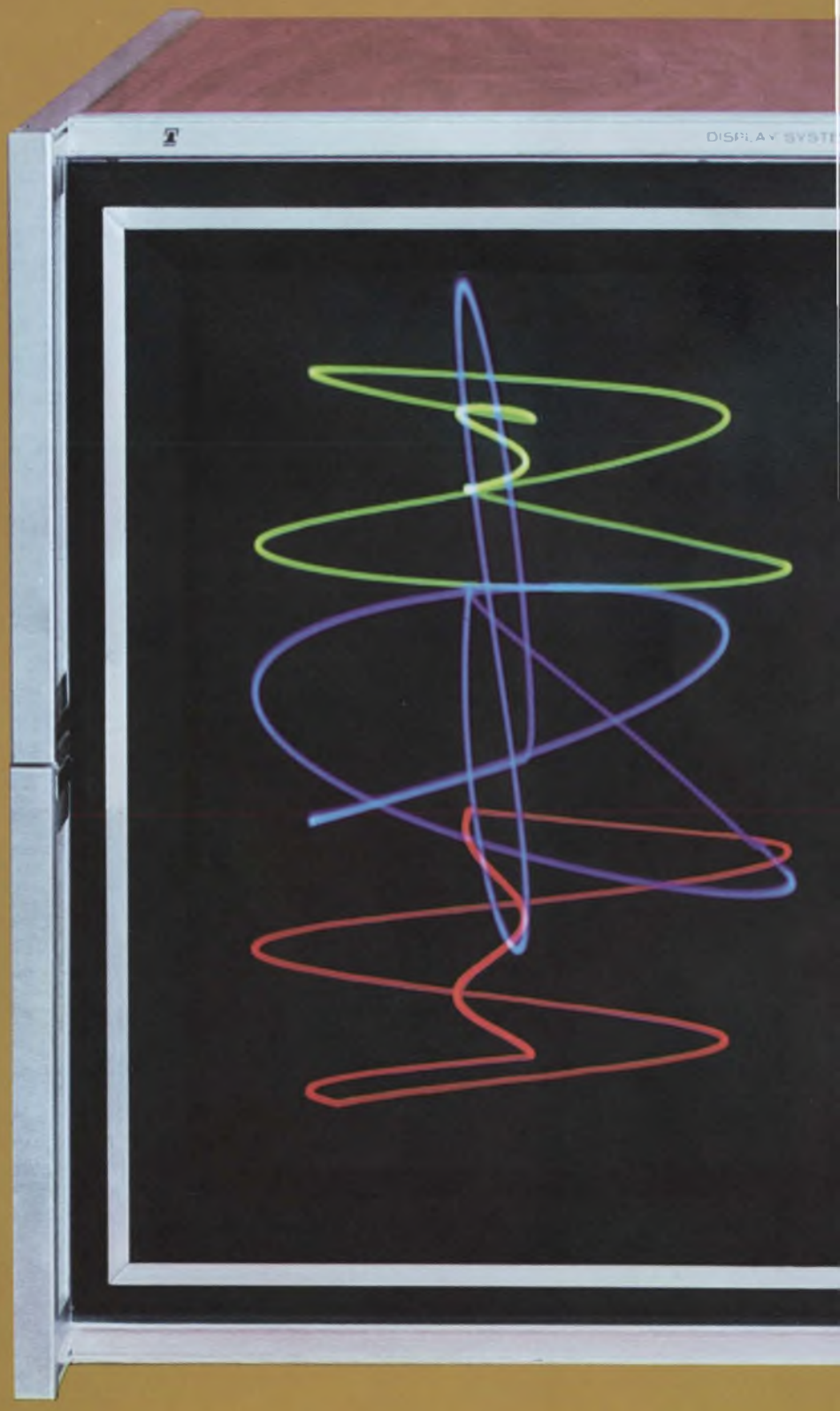
Figure 3

is illustrated in the display shown in Figure 1. The blue vertical frequency markers were triggered by a sweep generator. The red and blue horizontal reference lines represent the specification limits of the unit under test.

Phase and amplitude relationships of three signals are displayed in Figure 2.

Figure 3 illustrates the variety of data that can be presented to provide maximum information in a single display — the response characteristics of three tuned circuits, vertical frequency markers, and upper and lower limit reference lines.

the telonic model 201 tri-color display system displays up to three different input signals plus horizontal and vertical reference lines, each in a separate color with high resolution and sensitivity.



THREE-COLOR DISPLAY The 201 is a large screen, multi-channel, tri-color display unit that provides an entirely new perspective in analog presentations. Three vertical signal channels may be displayed on the 15" CRT simultaneously in red, green and blue with three vertical and three horizontal reference lines in the same colors. This multi-color presentation assures positive identification of each input, regardless of its proximity to the other signals. Even overlapping traces can be easily identified.

HIGH RESOLUTION, HIGH SENSITIVITY The unique three-color presentation also enables each signal to be displayed at **full screen height** for high resolution and accurate comparison without sacrificing trace identification. It is not necessary to restrict each signal to a separate segment of the display area.

The 201 System utilizes a separate amplifier for each input channel to provide maximum control of each signal and complete channel-to-channel isolation. Input signal sensitivity range is 100 μV/inch to 100 V/inch assuring maximum resolution regardless of input level.

ELECTRONIC REFERENCE LINES The tri-color vertical and horizontal reference lines can be adjusted to any position on the screen by individual front panel controls. A vertical reference line may also be externally triggered by a time or frequency marker pulse.

These reference lines cover the full screen, facilitating relative frequency and level comparisons between each of the input signals.

applications

The high sensitivity, direct coupling, and large screen area of the Model 201 make it an ideal display system for many applications in the fields of electronics, medicine, and education. Applications include any situation in which dc or video information is to be displayed with respect to time or frequency.

A swept frequency measurement of the gain and VSWR of a broad band amplifier

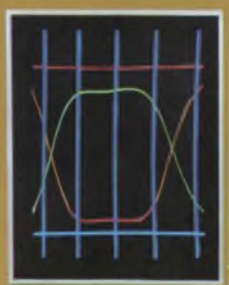


Figure 1

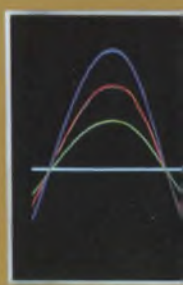
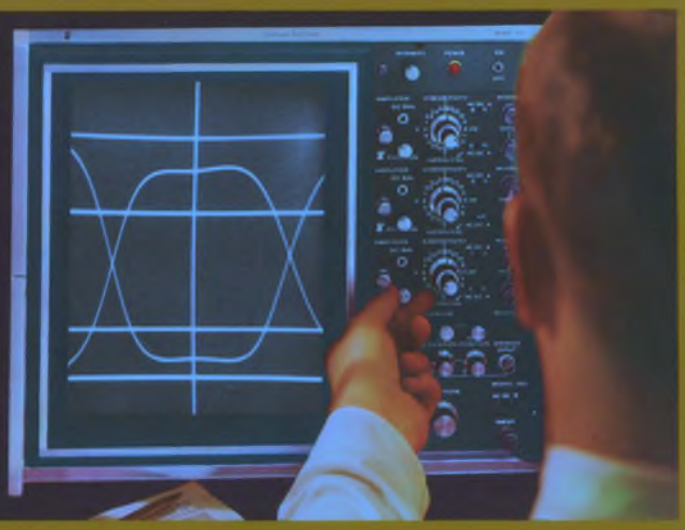


Figure 2

model 202 monochrome display system

The Telonic Model 202 Monochrome Display System provides all the features of the Model 201 with the exception of color. The advantages of a large screen display system, adjustable reference lines, and plug-in versatility are all available on the Model 202. This monochrome unit is capable of high resolution, low flicker displays with a choice of CRT phosphors. All plug-in units described are applicable to the 202 System.



specifications

GENERAL The vertical sections of the Model 201 and 202 Display Systems utilize a scan/sampling technique. The CRT electron beam is scanned vertically at a 36.2 kHz rate. During down-scan the input signals are sampled producing a dot for each signal. During up-scan the reference lines are displayed. The rapid scan rate provides a high dot density. The highest frequency that can be displayed by the vertical channels is dependent upon both the scan rate and the video bandwidth of the plug-in amplifier being used.

The frequency response of the horizontal channel is dependent upon the small signal bandwidth and the maximum undistorted slew rate. These parameters are primarily a function of the display chassis.

MODEL 201 TRI-COLOR DISPLAY CHASSIS A three channel scan/sampling system providing simultaneous display of three input signals in red, green, and blue. The Model 201 has separate facilities for vertical, horizontal, and reference line functions.
Usable Screen Area: 10.5 inches by 7.9 inches.
Vertical Scan Rate: 36.2 kHz.
Horizontal: Small Signal Bandwidth (3 dB), 50 kHz. Maximum Undistorted Slew Rate, 10 inches/msec.
Accelerating Potential: 20 kV.
Power: 115/230V, 50/60Hz, 350 watts.
Dimensions: 17" wide, 14" high, 18½" deep.
Weight: [illegible] pounds.
Price: $2100

MODEL 202 MONOCHROME DISPLAY CHASSIS A three channel sampling system provides simultaneous display of three input signals. Separate facilities for vertical, horizontal, and reference line functions. Optional long persistence cathode-ray tube available.
Usable Screen Area: 10.5 inches by 7.9 inches.
Vertical Scan Rate: 36.2 kHz.
Horizontal: [illegible] Signal Bandwidth (3dB), 50 kHz. Maximum Undistorted Slew Rate, 10 inches/msec.
Cathode-ray Tube: P4 phosphor; P7 long persistence phosphor also available.
Accelerating Potential: 15 kV.
Power: 115/230V, 50/60 Hz, 300 watts.
Dimensions: 17" wide, 14" high, 18½" deep.
Weight: [illegible] pounds.
Price: $1850 (with P4 phosphor) $1950 (with P7 phosphor)

MODEL 301 HIGH GAIN DIFFERENTIAL AMPLIFIER
Deflection Factor: 0.1 mV/inch to 50 V/inch in 18 calibrated steps, 1-2-5 sequence; accuracy ± 5%; vernier provides continuous adjustment between steps and extends the 50 V/inch step to at least 100 V/inch.
Noise, max: [illegible] μV p-p referred to input at maximum sensitivity.
Video Bandwidth (3dB): DC to 200 kHz; DC to 5 kHz at 0.1 mV/inch; DC to 9 kHz from 0.2 to 0.5 mV/inch. Maximum input frequency dependent upon video bandwidth and system scan rate.
Common Mode Rejection: 30 dB.
Input Coupling: AC, DC, or GND.
Input RC: [illegible] megohm shunted by 47 pF.
Price: $350

MODEL 302 BASIC AMPLIFIER
Deflection Factor: Adjustable from 100 mV/inch to 100 V/inch.
Video Bandwidth: 50 to 200 kHz dependent upon vernier setting. Maximum input frequency dependent upon video bandwidth and system scan rate.
Input Coupling: AC, DC, or GND.
Input RC: [illegible] megohm shunted by 47 pF.
Price: $150

MODEL 310 REFERENCE LINE GENERATOR
Marker Trigger Sensitivity: [illegible] 3V pulse, max. rise time 5 μsecs or birdy type marker.
Input Impedance: 47 kilohms.
Price: $250

MODEL 320 TIME BASE
Sweep Time: 1, 10, 100, 1,000 msec/inch calibrated to ± 5%. Vernier provides continuous adjustment between steps and extends the 1,000 msec/inch range to 10 sec/inch.
Trigger Sources: Line, external AC or DC, Internal.
Trigger Requirements: Internal, 1-inch deflection. External, ± 0.5 V to 20 V peak
Price: $300

BLANK PANELS
Blank plug-in unit panels are available for Systems not requiring all of the available plug-in units. The panel fits the space taken by one of the plug-ins listed above.
Price: $12 Model 315 Blank Panel

RACK MOUNTING
Hardware for rack mounting the 201 or 202 Display Systems is included with each chassis

how to order

1. Select either the Model 201 Tri-Color Display Chassis or the Model 202 Monochrome unit.
2. Choose the vertical amplifiers. For three-channel operation, three separate vertical amplifiers are required; for two-channel, two amplifiers, etc.
3. Order the reference generator or, if this function is not desired, a blank panel may be used in this space.
4. Select either a horizontal amplifier or time base unit for the horizontal channel.

NOTE: The Model 201 and 202 Systems must have at least one vertical amplifier and a horizontal plug-in unit installed in order to operate.

telonic systems
A Division of Telonic Industries, Inc.
21282 Laguna Canyon Rd. • Box 277 • Laguna Beach, Calif. 92652
Phone: (714) 494-9401
TWX: 910 596-1320

PATENT APPLIED FOR

Tiny flag-lead diodes complement hybrids

MicroSemiconductor Corp., 11250 Playa Court, Culver City, Calif. Phone: (213) 391-8271. P&A: from 22¢; stock.

Especially suited for use in hybrid circuits, Hybridiode diodes permit characteristics testing prior to bonding into the circuit, as well as high reliability processing and stress testing. Their flag-type leads may be used for contact to the pad by soldering, welding or thermocompression bonding. These leads can also be removed and contact made directly to top and bottom of the pellet.

CIRCLE NO. 274

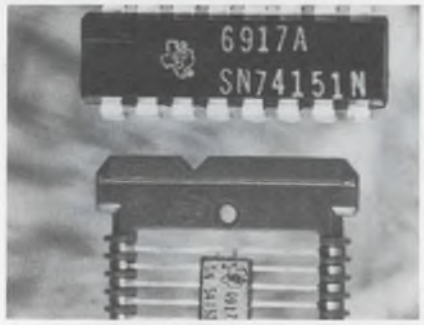
Miniature rectifiers recover in 150 ns

Solitron Devices, Inc., 256 Oak Tree Rd., Tappan, N.Y. Phone: (914) 359-5050.

Said to be the smallest units of their kind, new miniature 1-A silicon rectifiers provide recovery speeds as fast as 150 ns. Series TS A23F devices are hermetically sealed in a package measuring only 0.107 in. in diameter by 0.210 in. long. PIV voltage ratings range from 15 through 800 V and leakage currents at dc reverse voltage are 10 μA maximum.

CIRCLE NO. 275

MSI data selectors delay only 10 ns

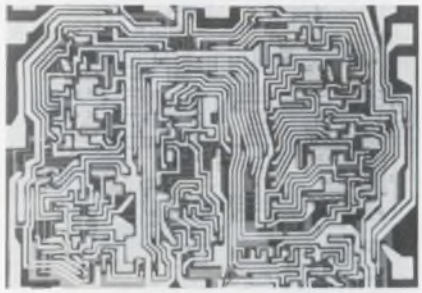


Texas Instruments Inc., Components Group, P.O. Box 5012, Dallas, Tex. Phone: (214) 238-2011. P&A: $4.83 to $12.10; 2 wks.

Offering input clamping diodes, full on-chip buffering, and typical propagation delay times of 10 ns, three new series 54/74 TTL MSI data selectors/multiplexers are now available. The SN54150 and SN-74150 are 16-bit units, and the SN-54151, SN74151 and SN54152 are eight-bit devices. These new circuits can serve as function generators, perform random or sequential parallel-to-serial conversion, multiplex, or function as memories.

CIRCLE NO. 276

MSI frequency dividers are programmable chips

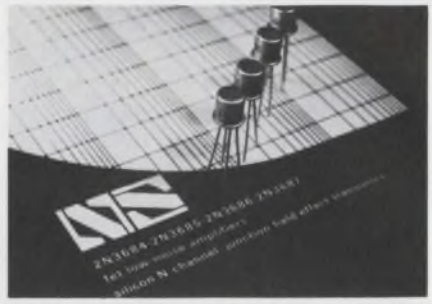


Sylvania Electric Products, Inc., Semiconductor Div., 100 Sylvan Rd., Woburn, Mass. Phone: (617) 933-3500. P&A: $8.80; stock.

Two new TTL medium-scale integrated circuits are programmable frequency dividers that produce an output frequency at a repetition rate that is the reciprocal of the applied input frequency. The SM143 binary divider can perform frequency division by any whole number up to 16; the SM153 decade divider performs frequency division by any whole number up to 10.

CIRCLE NO. 277

FET amplifier family holds noise to 0.1 dB



National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. Phone: (408) 245-4320. P&A: $1.90 to $2.60; stock.

A new series of low-noise FET amplifiers, types 2N3684, 2N3885, 2N3686 and 2N3687, provide noise figures of 0.1 dB typical and 0.5 dB maximum. In addition, leakage currents are only 100 pA maximum and pinch-off voltages are as low as 1.2 V. The new devices can be used in various dc, audio, video and rf applications.

CIRCLE NO. 278

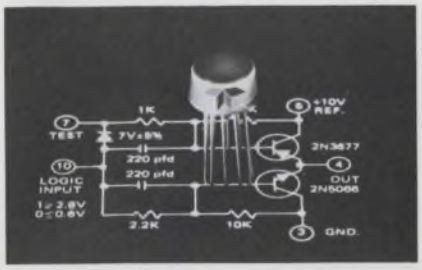
Power transistor takes 300-V video

General Electric Co., Semiconductor Dept., 1 River Rd., Schenectady, N.Y. Phone: (315) 456-2396. Availability: stock.

Packaged in silicone, a new 300-V video output transistor features a free-air rating of 1.33 W at 50°C ambient, and a 6.25 W rating at 25°C tab temperature. Model D40N is directly interchangeable with TO-5 metal-can devices and has a glass-passivated pellet. Maximum collector capacitance is 3 pF at 20 V, and unity-gain crossover frequency is 75 MHz minimum at 20 V.

CIRCLE NO. 279

Hybrid switch powers itself

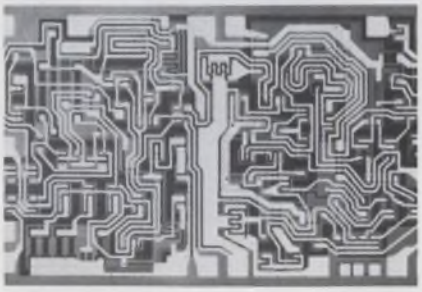


Crystalonics, a Teledyne Co., 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. P&A: $38; stock.

Designed for direct-from-logic operation in digital-to-analog converters, model CDA4 hybrid IC ladder switch requires no external power, but derives all its operating currents from the logic and reference supply. When used in conjunction with a 10-to-20-kΩ ladder network, this new switch provides a 12-bit accuracy. Settling times well under a microsecond allow high-speed operation.

CIRCLE NO. 280

Dual sense amplifier cycles in 400 ns



Fairchild Semiconductor, 313 Fairchild Drive, Mountain View, Calif. Phone: (415) 962-3563. Price: $13.50.

Achieving cycle times of less less than 400 ns, a new high-speed dual-channel sense amplifier is a subsystem containing compatible analog and digital logic functions within the same package. Model μA731 performs all memory data register functions on the chip; no external digital circuitry is needed to implement these functions.

CIRCLE NO. 281

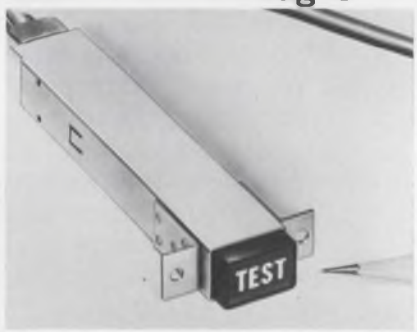
Segmented readouts can be seen in sunlight

RCA/Electronic Components, 415 S. Fifth St., Harrison, N.J. Phone: (201) 485-3900. P&A: $1.75 to $3.05; fourth quarter, 1969.

Said to be viewable in sunlight, a new family of low-cost segmented incandescent readout tubes, called Numitron, is now available. Four models initiate the family: the DR 2000 for displaying numerals 0 through 9, the DR2010 for numerals plus decimal point, the DR 2020 with numeral 1 and a plus or minus sign, and the DR 2030 displaying a plus or minus sign.

CIRCLE NO. 412

Readout switch shows 12 messages

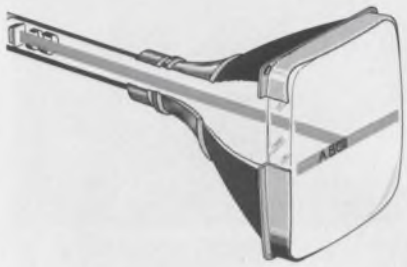


Shelly Associates, Inc., 111 Eucalyptus Drive, El Segundo, Calif. Phone: (213) 322-2374.

A new pushbutton readout switch combines a 12-message rear-projection readout with a dpdt momentary snap-action switch. The ROS-90 switch assembly is activated by depressing the viewing screen, which measures 0.65 by 0.46 in. Up to 12 messages, each 7/16-in. high, can be displayed. Messages can be projected in color or in black and white.

CIRCLE NO. 413

Multi-beam one-gun CRT intensifies brightness



Sylvania Electric Products Inc., Electronic Tube Div., Seneca Falls, N.Y. Phone: (315) 568-5881.

Designed for computer readout applications, a new seven-beam single-gun cathode-ray tube is claimed to have a potential brightness seven times that of a conventional single-beam CRT. The SC-5299 multi-beam CRT provides characters approximately 5/32-in. high. The seven electron beams are controlled by a common focus coil; each beam may be individually modulated.

CIRCLE NO. 282

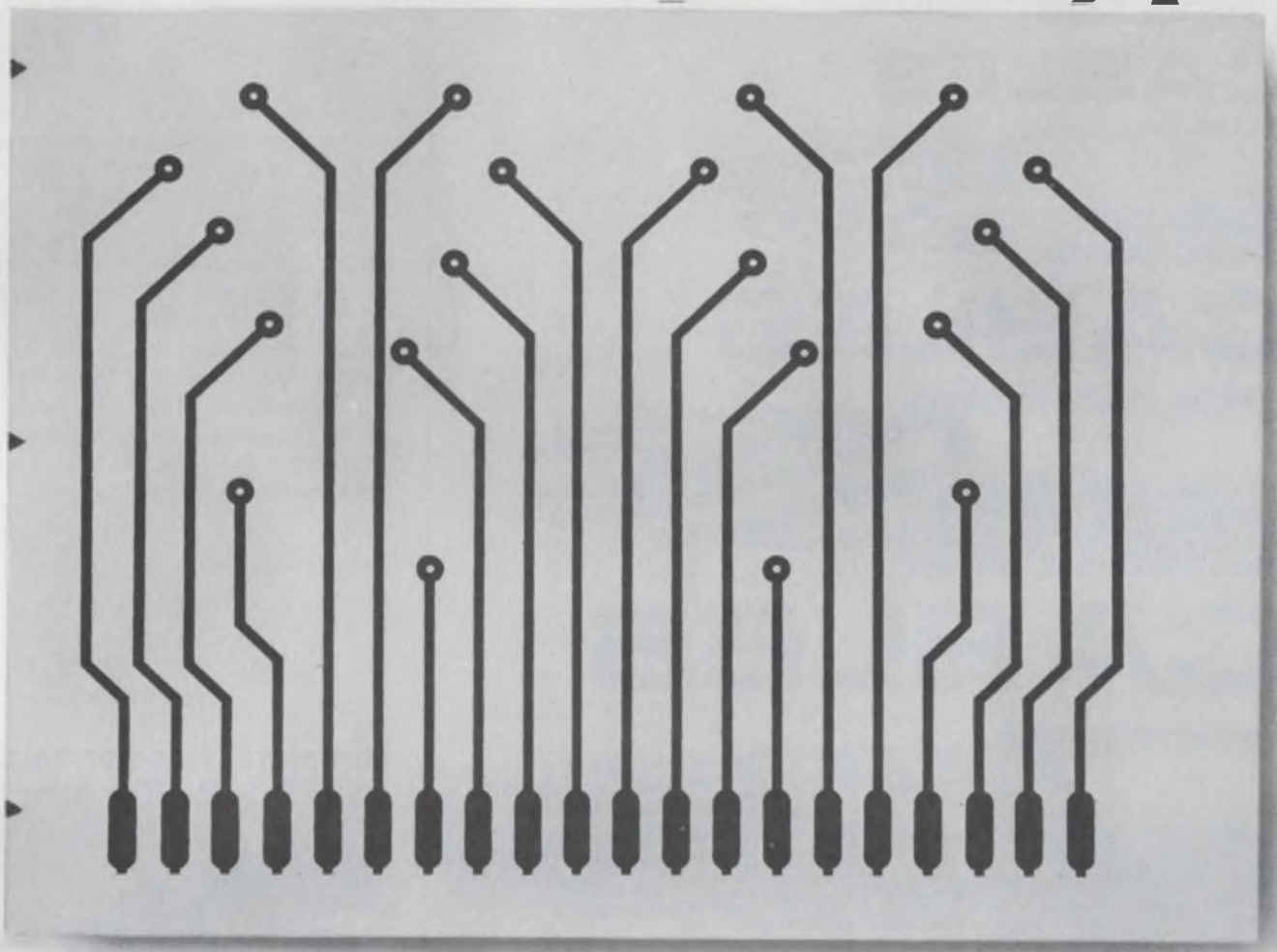
Thin-film resistors have on-chip center tap

Dickson Electronics Corp., P.O. Box 1390, Scottsdale, Ariz. Phone: (602) 947-2231. P&A: $187/kit; stock.

Featuring a symmetrical on-the-chip center tap, a new family of thin-film chip resistors encompass standard RETMA values from 33 Ω to 470 kΩ, with tolerances of ±10%. Supplied in kit form, the new chips have a typical substrate size of only 25-mil square. Their insulation resistance is 10^4 MΩ and temperature coefficient is ±50 ppm typical. Power dissipation is 250 mW maximum.

CIRCLE NO. 283

Introducing the 7½ minute prototype.



Getting prototype circuit boards used to be the biggest nuisance in design projects.

It took a lot of man-hours, expense, and a lot of space for bulky, awkward equipment.

No more. With Xerox Standard Equipment, chemical resist images can be transferred to copper-clad laminates and prepared for conventional etching—in 7½ minutes flat.

For just pennies per prototype.

And there are no wet, messy chemicals (the xerographic process is completely dry).

No air-controlled darkroom (the Xerox equipment can be set up in a small corner almost anywhere).

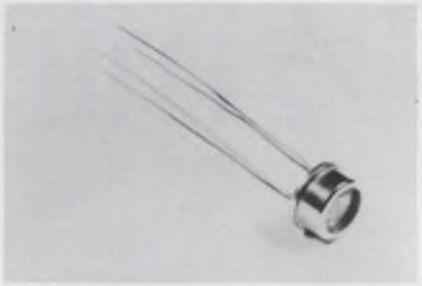
No need for highly-trained technicians (most people can learn to handle it in just 60 minutes).

Of course, the 7½ minute prototype is only one of the ways you can use Xerox Standard Equipment.

If you have another 7½ minutes, we'll explain some of the others. Write Dept. BC14, Xerox Corporation, Rochester, New York 14603.

XEROX

Dual photocell tracks to ±5%



Vactex, Inc., 2423 Northline Industrial Blvd., Maryland Heights, Mo. Phone: (314) 432-4200.

Consisting of two matched isolated photoconductive elements on a common ceramic substrate, a new TO-5 photocell provides close tacking of ±5% from 0.5 to 50 footcandles and close matching from ±5 to ±20%. Model VT 334/2 can be illuminated by incandescent, neon, or fluorescent light, or by light-emitting diodes.

CIRCLE NO. 284

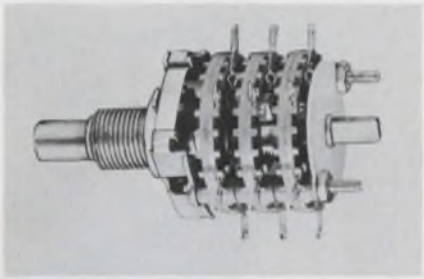
Miniature transformers span 0.1 to 700 MHz

Relcom, 2329 Charleston Rd., Mountain View, Calif. Phone: (415) 961-6265. P&A: $13 to $30; stock.

A new line of miniature wideband transformers operate over the frequency range of 0.1 to 700 MHz and have an insertion loss of less than 0.5 dB. Impedance transformations include 50 ohms to 12.5, 25, 50, 100, 200 and 800 Ω. They are packaged in either a high-temperature epoxy container or a hermetically sealed TO-5 metal can.

CIRCLE NO. 285

Small switches cycle 10^5 times



CTS Electronics, Inc., 1010 Sycamore Ave., South Pasadena, Calif. Phone: (213) 254-9141. Availability 4 to 5 wks.

Measuring only one inch in diameter, series 223 rotary switches feature a detent rotational life of 100,000 cycles, through 12 positions and return at 10 cycles per minute. The units have standard contacts of silver-plated brass; solid silver alloy contacts are available. All the switches meet the performance specifications of MIL-S-3786C.

CIRCLE NO. 286

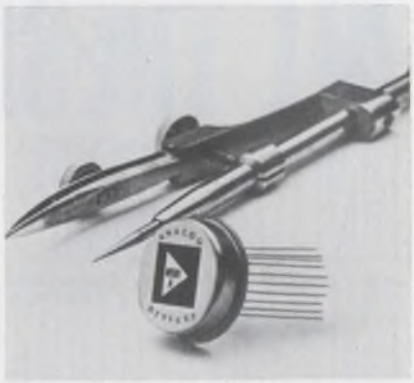
Pushbutton switches offer flexibility

Oak Electro/Netics Corp., Oak Manufacturing Co. Div., Crystal Lake, Ill. Phone: (815) 459-5000.

Offering expanded contact and switching capacity in less panel space, series 800 Econo-Line pushbutton switches provide circuit flexibility in five switching configurations, including momentary, push-push, interlock, blockout and any combination of these. Using double-wiping silver-plated brass contacts, the units are rated from 0.5 A at 28 V dc to 0.25 A at 110 V ac for resistive loads.

CIRCLE NO. 287

Military op amp has 10-pA bias

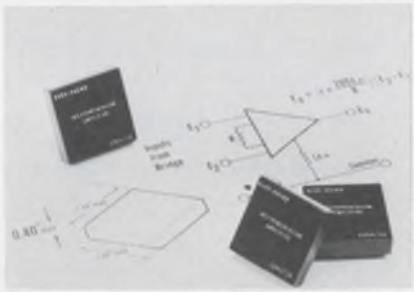


Analog Devices, Inc., 221 Fifth St., Cambridge, Mass. Phone: (617) 492-6000. P&A: $35; stock.

Hermetically sealed in a miniature TO-8 package, a new military-grade hybrid operational amplifier uses FET input circuitry to provide a 10-pA maximum bias current drift. Model M501 matches most conventional monolithic IC op amps in physical size. Its small-signal bandwidth is 4 MHz and full-power bandwidth is 70 kHz.

CIRCLE NO. 288

Low-cost amplifiers are compact modules

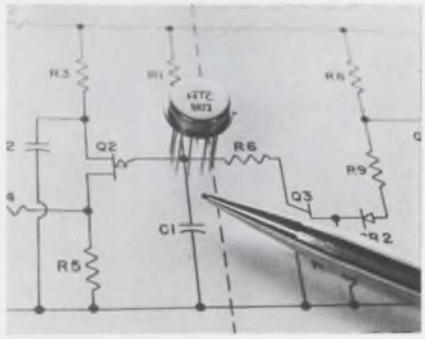


Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. Phone: (602) 294-1431. P&A: $39 or $59; stock to 4 wks.

Two new low-cost instrumentation amplifiers, which measure only 0.4-in. high by 1.5-in. square, can be mounted on a PC board or inserted into a mating connector. Model 3264/14 has a maximum input voltage drift of ±10 μV/°C, while model 3263/14 offers a maximum voltage drift of only ±3 μV/°C over the entire temperature range of −25 to +85°C.

CIRCLE NO. 289

TO-8 timing module delays 0.1 to 100 s

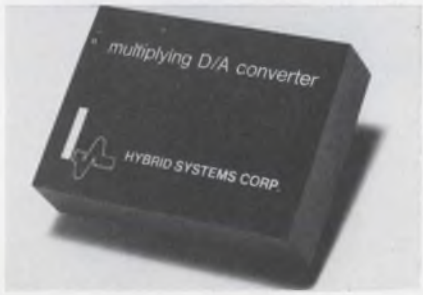


Hi-Tek Corp., Electronics Div., 2220 S. Anne St., Santa Ana, Calif. Phone: (714) 540-3520. P&A: $25; 3 to 4 wks.

Occupying less than 1/20 the space of a compact time-delay relay, a new miniature TO-8 timing module provides delays from 0.1 to 100 seconds with an accuracy of ±3% and a repeatability of ±2%. Model 333-3500 features an SCR output rated at 0.5 A at 28 to 32 V dc. It operates with voltages between 18 and 32 V dc.

CIRCLE NO. 290

D/a converter multiplies too



Hybrid Systems Corp., 95 Terrace Hall Ave., Burlington, Mass. Phone: (617) 272-1522. P&A: $350; stock to 2 wks.

Performing with an accuracy of 0.025%, a new 12-bit multiplying d/a converter allows an externally supplied reference to be ac as well as dc. Because of the multiplying aspect, model 302 can be used to digitally modulate a signal, to act as a digitally gain controlled amplifier, or to operate with analog and digital signals.

CIRCLE NO. 291

take the headaches out of designing

by putting this

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to your task—

*power slide switch—Type 23-021-012 illustrated.

Outperforms and outlives any switch sold in competition.

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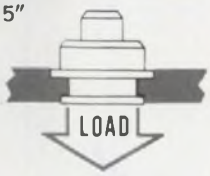

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INFORMATION RETRIEVAL NUMBER 113

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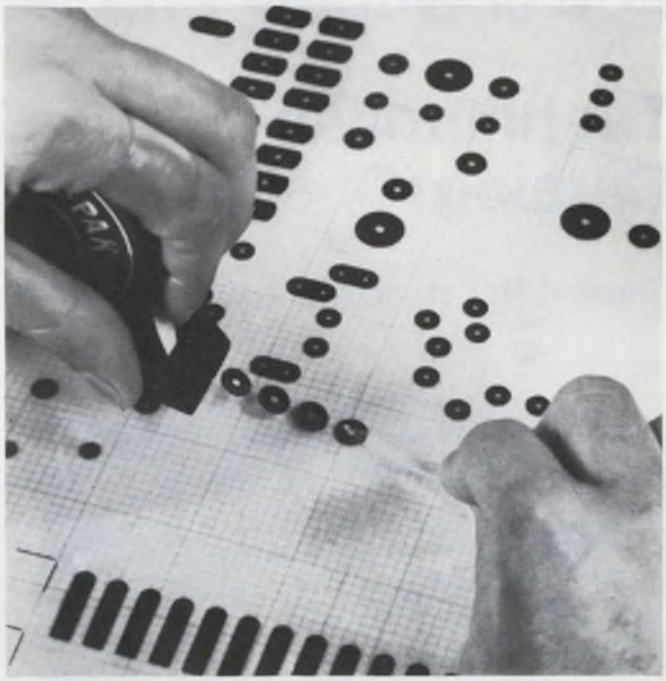

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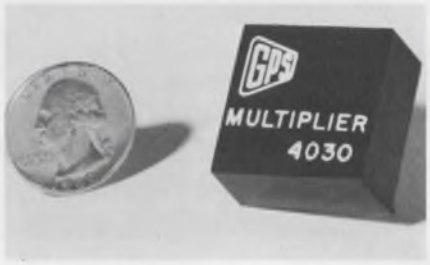
INFORMATION RETRIEVAL NUMBER 114

Wideband multiplier works independently



GPS Instrument Co., Inc., 14 Burr St., Framingham, Mass. Phone: (617) 875-0607. P&A: $95; stock to 1 wk.

Operating without external amplifiers, a new small hybrid multiplier features a total accuracy of 1%, including errors due to linearity, scale factor and offset. Model M-4030 has a bandwidth of 1.5 MHz with a slewing rate of 15 V/μs. Feedthrough is less than 30 mV pk-pk at 50 kHz, output noise is below 1 mV rms, and drift is below 0.02%/°C. The device measures 1.12 by 1.12 by 0.4 in.

CIRCLE NO. 292

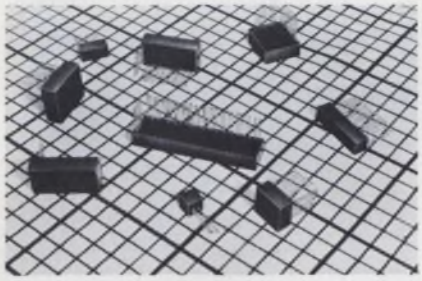
Dc-to-dc converters occupy just 3 in.^{3}

MIL Electronics, Inc., Dracut Rd., Hudson, N.H. Phone: (603) 889-6671. P&A: $79; stock to 10 days.

Operating from 12, 24 or 28 V dc, series S dc-to-dc converters deliver 3 W of output power in less than three cubic inches. Single outputs are available from 5 to 250 V dc; dual outputs from ±5 to ±100 V dc. The new units feature ±1% regulation as well as overvoltage and reverse polarity protection. Their operating temperature range is 20 to 71°C.

CIRCLE NO. 293

Diode matrix modules substitute for gates



Info-Lite Div., Cartelli Technology, Inc., 41-10 102nd St., Corona, N.Y. Phone: (212) 334-6070. P&A: 15¢ to 35¢/bit; stock to 4 wks.

Able to replace gate networks, a new line of diode matrix modules can be employed in such applications as: read-only memories, BCD encoders, decimal-to-seven-bar encoder/drivers, process control programing, alphanumeric encoder drivers and trigonometric/logarithmic function memories. Package density ranges from 81 to 100 bits per square inch.

CIRCLE NO. 294

Thick-film hybrid eliminates noise

Hybrid Electronics, Inc., Bedford, Mass. Phone: (617) 275-7110.

Basically a highly efficient oscillator that is transformer-coupled to a rectifier, filter, and transistor switch, a new thick-film hybrid circuit eliminates interference to data transmission in noisy environments. The Digital-Isolator removes ground-loop and common-mode line noise to end one of the most common sources of erratic digital system operation. It is directly driven from logic signals.

CIRCLE NO. 295

Desktop calculator has mosaic readout

Dictaphone Corp., 120 Old Post Rd., Rye, N.Y. Price: $875 or $1075.

Providing solutions on a visual display incorporating mosaic lamps, a new electronic calculator is a 14-digit machine with a 10-key system and a single memory unit. Model 1420 is also equipped with a floating decimal and a decimal control and placement system. A second model, the 1620, offers 16 digits and two memory banks, and provides keys for automatic square root and percentages.

CIRCLE NO. 296

Data terminal varies coupling

Data Access Systems, P.O. Box M418, Landing, N.J. Phone: (201) 398-2345. P&A: $1595; stock.

A new input/output terminal for communications and time-sharing applications allows both hardwire coupling and acoustic coupling to standard telephone circuits. Designated the Multi-Mode model DF33ASR-1, the new system insures completely distortion-free transmission in any environment while hardwired. The same unit may be used with any available telephone.

CIRCLE NO. 297

Multiplexer/converter accepts 256 channels

EMR-Telemetry, A Schlumberger Co., P.O. Box 3041, Sarasota, Fla. Phone: (813) 958-0811.

The 2076 analog multiplexer accepts up to 64 analog channels and time-multiplexes the data for remote entry into its companion 2705 analog-to-digital converter. The 2705 converter, which can be positioned as far away as 1000 feet, accommodates four 2706 multiplexers, thereby providing a remote multiplexing capability of up to 256 channels.

CIRCLE NO. 298

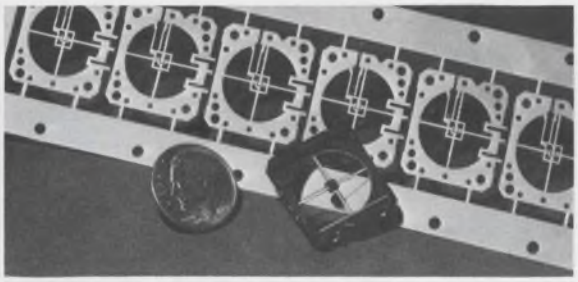
Multiplexing system handles 45 terminals

American Data Systems, 20747 Dearborn St., Chatsworth, Calif. Phone: (213) 882-0020.

Designated the ADS-660 data distribution system, a new data concentrator is capable of simultaneously multiplexing up to 45 (or more) remote terminals over a single telephone line. Designed specifically for time-sharing applications, the new multiplexer can intermix up to three baud rates at the same time. Channel capacity is determined by the baud rate speeds of the terminal devices used and the transmission speed of the telephone line modems.

CIRCLE NO. 299

Lead Frames for I. C. Packaging



Etched lead frames for integrated circuits. Any configuration can be made adequately framed for support. Leads are flat ribbons down to 0.002 inches wide and from .002, .004, .005 and .010 inches thick. We etch kovar, nickel, alloy 42, copper, aluminum and other metals for microcircuit packaging.
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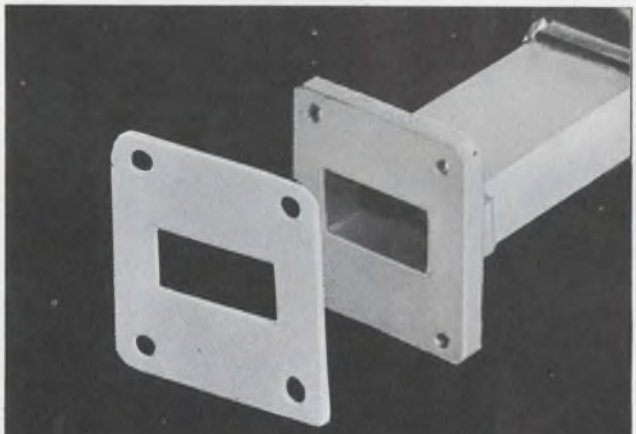
INFORMATION RETRIEVAL NUMBER 118



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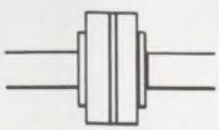

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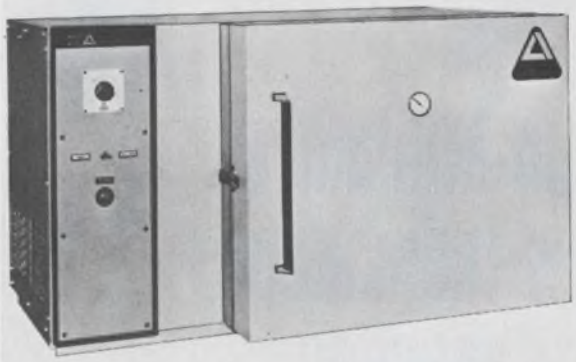
INFORMATION RETRIEVAL NUMBER 119

no lower price for mechanical refrigeration to -100° F



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- **indicating thermometer in door**
- **combination hinged and removable door**
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INFORMATION RETRIEVAL NUMBER 120

LID package eases assembly

Circa Tran, Inc., P.O. Box 832, Wheaton, Ill. Phone: (312) 858-3727.

Completely tested and ready to be assembled into thick- or thin-film hybrid microcircuits, a new ceramic-cup leadless semiconductor package will not change its electrical parameters during normal circuit assembly. The new package, Circap CT-1, is said to be able to accommodate virtually any type of semiconductor.

CIRCLE NO. 340

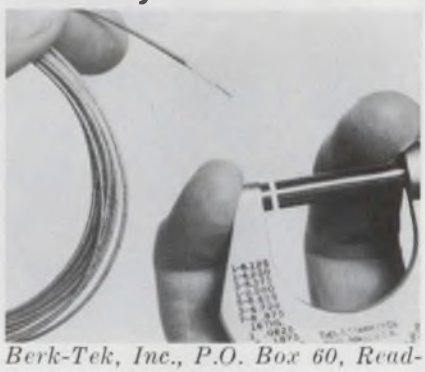
PC lamp socket lowers profile

Display Devices Inc., Second & E Sts., Encinitas, Calif. Phone: (714) 753-0113. P&A: 15¢; stock.

Using conventional mounting tools, a new bayonet-base socket for T-3-1/4 lamps mounts with minimum protrusion on the back side of a panel. The unit rests firmly and flatly on single-sided 0.062-in. printed circuit boards. It is available with either cadmium- or gold-plated contacts.

CIRCLE NO. 341

Microminiature coax has only 0.04-in OD

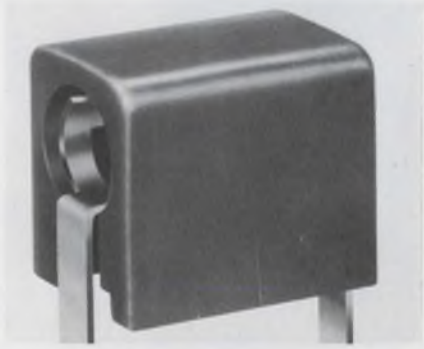


Berk-Tek, Inc., P.O. Box 60, Reading, Pa. Phone: (215) 376-8071.

With an outside diameter of only 0.04 in. and a AWG #32 center conductor, a new microminiature coaxial cable features a solid center conductor and solid drain wire that can readily be used in wire-wrap operations. This coaxial cable transmission line has a 50-Ω characteristic impedance in the air and on a ground plane. Cross talk is minimized by the use of an aluminized Mylar shield. The dielectric is Teflon and the jacket is nylon.

CIRCLE NO. 342

Miniature PC jack mounts horizontally



E. F. Johnson Co., Components Div., Waseca, Minn. Phone: (617) 278-1715.

Measuring just 0.203 in. high (mounted) by 0.208 in. long by 0.15 in. wide, a new horizontal printed circuit jack accepts a 0.08-in. diameter tip plug at either end. It has maximum current capacity of 5 A and an operating voltage of 1500 V rms at sea level. Contact resistance is less than 2 mΩ; capacitance between adjacent jacks is less than 1 pF at 1 MHz.

CIRCLE NO. 343

TRUE SOLID-STATE RELAY

Opening New Relay Applications in Multiplexing, Isolated Sensing, High Speed Isolated Control, etc. Offered in A - B - C Contact Configurations for Direct Replacement of Mechanical Types.

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- Contact Open Resistance . . . 10^9 ohms
- Contacts Capable of switching DC to 4 M HZ
- Non-Polarized Effective Coil
- Effective Coil Accuate/Release Voltage Hysteresis . . . less than 10 mV . . .
- Non-Polarized Contacts
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INFORMATION RETRIEVAL NUMBER 122

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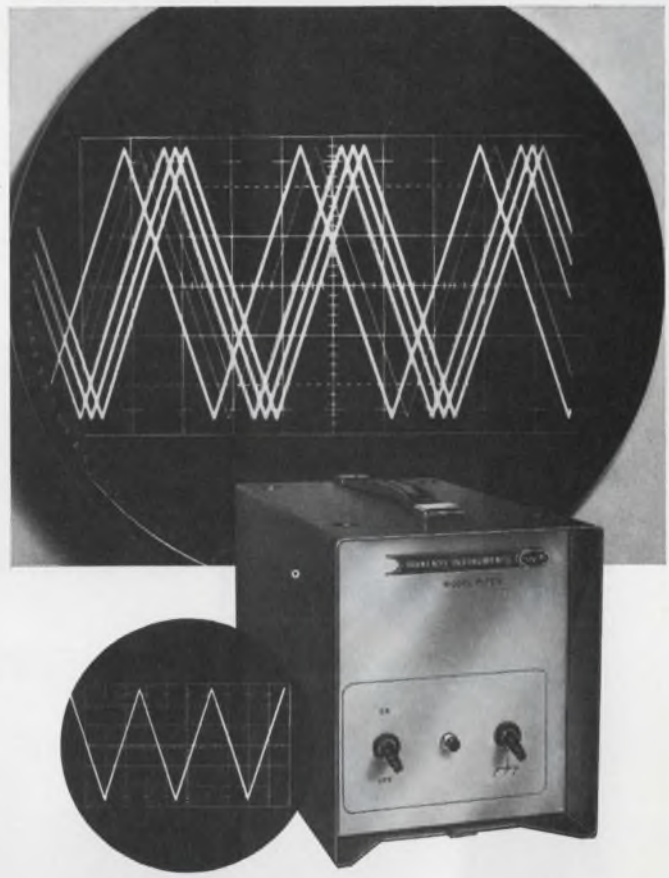

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INFORMATION RETRIEVAL NUMBER 123

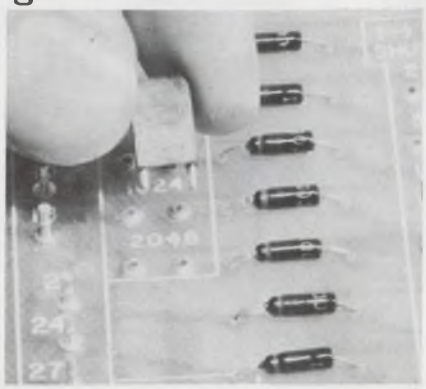
Machinable ceramic withstands 1100°C

Aremco Products, Inc., P.O. Box 145, Briarcliff Manor, N.Y. Phone: (914) 762-0685. Availability: stock to 1 wk.

Aremcolox grade 502-1100 machinable ceramic, which delevops the hardness of tool steel after curing, can be used for a variety of processes at temperatures as high as 1100°C. Readily machined with conventional machine shop tooling, the ceramic cures by heating it to 2000°F in an air oven.

CIRCLE NO. 344

PC-board sockets ignore lead size



SAE Advanced Packaging Inc., 1357 East Edinger Ave., Santa Ana, Calif. Phone: (714) 547-3935. P&A: 5¢ to 15¢; stock.

Providing excellent maintainability of PC-board components, a new line of sockets accepts component and connector leads of varying diameters. Cirkut sockets are installed in circuit boards by a simple swaging operation, and then wave or bit soldered. When installed, they project only 0.04 in. above the board surface.

CIRCLE NO. 345

Aerosol cleaner is safe for plastics

DCMC International Inc., 239 Great Neck Rd., Great Neck, N.Y. Price: $1.95.

Intended for use on electronic and delicate equipment, a new cleaner and lubricant in aerosol form contains a blend of special solvents with extremely high grease removing power but which do not attack most plastics. Known as electronic switch cleaner and lubricant No. 825, the new aerosol contains a silicone oil that provides an inert long-lasting lubricant and corrosion inhibitor.

CIRCLE NO. 346

Conductive epoxies minimize drift

Amicon Corp., Polymer Products Div., 25 Hartwell Ave., Lexington, Mass. Phone: (617) 861-9600.

New high-conductivity silver-filled Uniset epoxies do not drift in conductivity after prolonged exposure to high temperatures or strong electrolytes. When heat cured, these conductive epoxies can be soldered using 60/40 solder. They cure rapidly at temperatures 100°F lower than minimum cure temperatures for previous one-part epoxies.

CIRCLE NO. 347

Cermet pastes retain shape

Electro-Science Laboratories, Inc. 1133 Arch St., Philadelphia, Pa. Phone: (215) 563-1360. Availability: 10 days.

A new series of noble-metal high-performance resistive cermet pastes is intended for use in tight-tolerance applications or where reduced sensitivity to geometrical variations is required. Series ESL3800 materials are relatively insensitive to minor changes in firing profile and may be fired at peak temperatures between 980 and 1050°C.

CIRCLE NO. 348

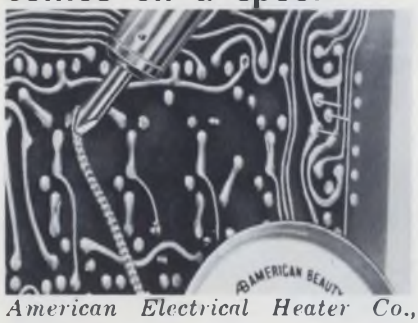
Contact burnisher cleans all metals

Jonard Industries Corp., Precision Tools Div., 3047 Ribbett Ave., Bronx, N.Y. Phone: (212) 549-7600. Price: $3.90.

Originally designed for the communications, telephone and electronic industries, using relay-actuated equipment, a new pocket pen-type burnisher/cleaner works on all types of contacts, including silver, platinum, gold, palladium, tungsten, molybdenum, as well as precious metals. This contact burnisher leaves no grit or dust on the contact to start a new carbanaceous build-up.

CIRCLE NO. 349

Desoldering tool comes on a spool



American Electrical Heater Co., American Beauty Div., 6110 Cass Ave., Detroit, Mich. Phone: (313) 875-2505. Availability: stock.

Named Dri-Wick, a new desoldering tool desolders a typical miniature connection in about one second, at a material cost of about one cent. Supplied in spool form, the product is woven of ultra-fine copper strands, each coated with water-white rosin. To use, the operator lays Dri-Wick on the joint, applies the tip of a 30/40-W soldering iron, and then lifts away the iron and the Dri-Wick simultaneously.

CIRCLE NO. 350

Lightweight pump vacuums up solder

Swiss American Precision Imports, Inc., Dept. T2P, 505 S. Douglas St., El Segundo, Calif. Phone: (213) 772-5431. Availability: stock.

Precista T2 vacuum desolder pump is a lightweight, compact, easy-to-use tool that eliminates operating hazards and reduces waste motion in desoldering electronic circuitry. The new pump may be loaded and unloaded with one hand, and need not be in any special position. The tip is cleared of solidified solder each time the pump is loaded for use.

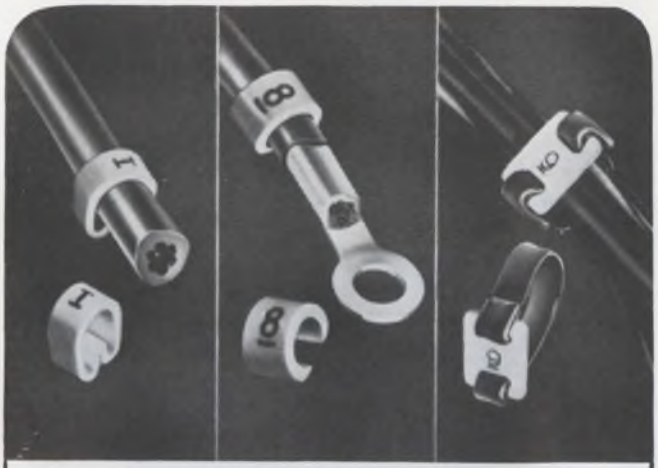
CIRCLE NO. 351

Flux dispenser maintains level

E.P.E. Corp, 6 Kane Industrial Drive, Hudson, Mass. Phone: (617) 562-9123. P&A: $5.50; stock.

Using a hydrostatic principle to minimize surface skinning, a new dispenser provides a constant level of flux for dipping leads and components prior to soldering or tinning. Model FD-1 flux dispenser, which is a three-piece assembly for ease of cleaning, is resistant to most solvents and chemicals. The flux storage level can be easily observed in the 3-in.^{3} translucent reservoir.

CIRCLE NO. 352



INDESTRUCTIBLE MARKERS

Available in three types — slip-on, clip-on, and crimp-on ---- to accommodate a wide variety of wire and cable applications. Can't rub-off, peel-off or fall-off, yet can be easily removed when necessary. Molded of indestructible PVC (polyvinylchloride) to last the life of the wire and cable under all conditions.

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Components Division
86 Hartford Ave., Mt. Vernon, N. Y. 10553
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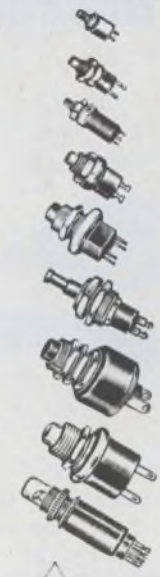
INFORMATION RETRIEVAL NUMBER 128

FOR EXCELLENCE IN PUSH BUTTON SWITCHES SPECIFY GRAYHILL



A WIDE SELECTION TO CHOOSE FROM...

- Ratings To 10 Amp.
- SPST, SPDT, DPST, DPDT
- Diameters From ¼" To ⅞"
- Behind Panel Dimension As Small As .32"
- Momentary - Push-Pull - Lighted - Alternate Action (Push-On, Push-Off)
- Wiping, Snap Action And Butt Contacts
- Solder Lug, "Faston" Or Printed Circuit Terminals
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INFORMATION RETRIEVAL NUMBER 129

Need a reversible AC hysteresis synchronous motor to fit this space?

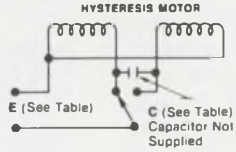
Dale has one for less than $2

Dale reversible AC hysteresis synchronous motors give you the industry's best combination of miniature size and low price. Length 1.85"... diameter 1.250"...price, under $2 in quantity. Designed for long life in continuous use, they're finding wide application in low power driving mechanisms, timing controls, blowers, etc. Output shaft and mounting to your specification.

SPECIFICATIONS

Operating Voltage: 6, 12, 24, 117 VAC or any specified
Power Input: 7.5 Volt Amperes
Output: 1800 RPM no load
Torque: 0.125 oz./in.

CIRCUIT DIAGRAM



E – VOLTAGE	NOMINAL C – CAPACITANCE	C – VOLTAGE
6	170 MFD	20
12	50 MFD	25
24	16 MFD	50
117	0.68 MFD	300

Want to try one?...Phone 605—665-9301

DALE®

DALE ELECTRONICS, INC.
SIOUX DIVISION **Dept. ED**
Yankton, South Dakota 57078
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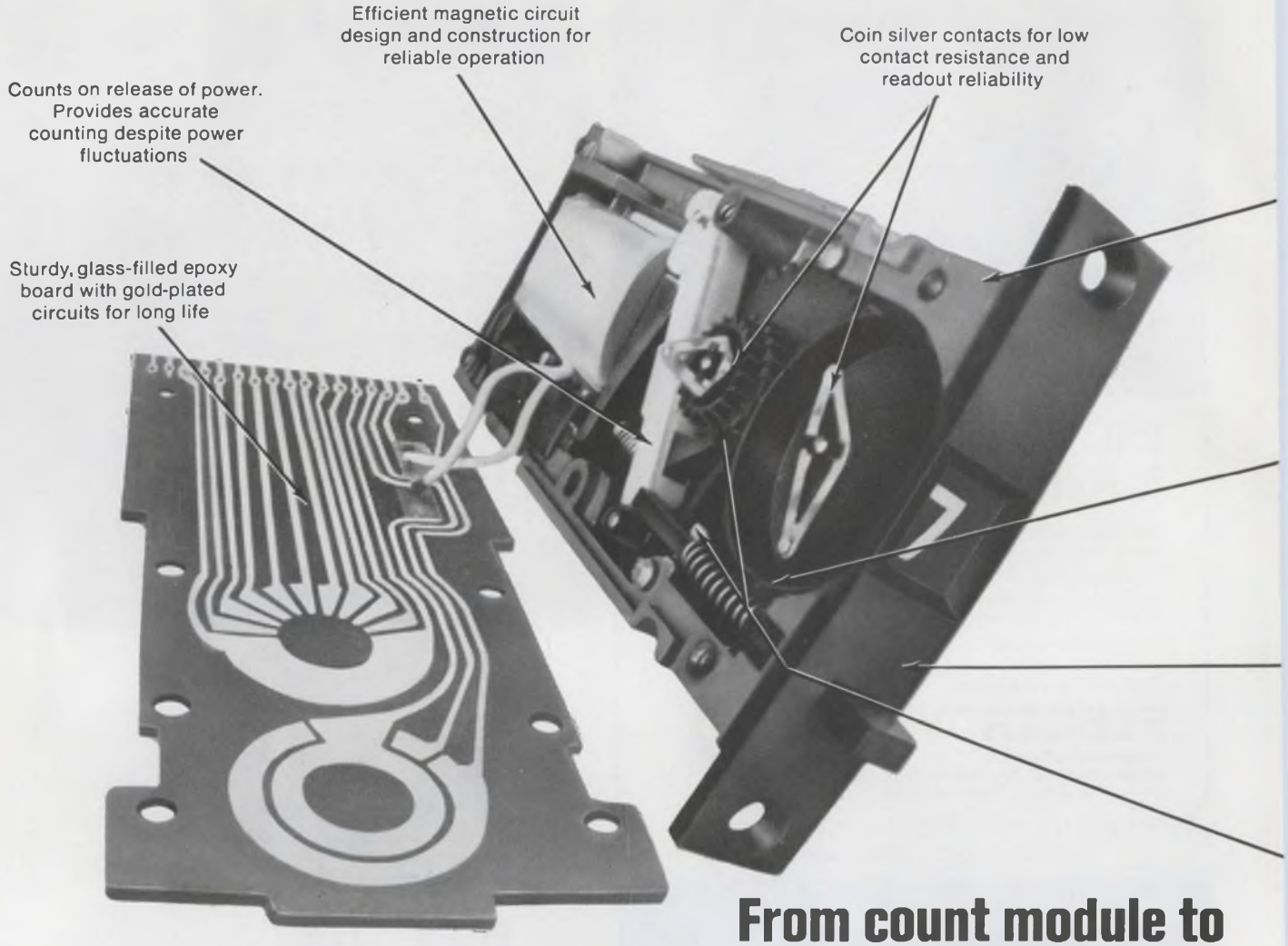
INFORMATION RETRIEVAL NUMBER 130



From count module to preassembled control package, that's the versatile Veeder Decade

You'll like the great design flexibility of the Veeder Decade*, a module that's easily stacked into a compact, multidigit counter package. It's the ideal unit for high-speed count accumulation, storage and transfer in data processing, and control equipment systems.

The Series 1969 is a single wheel electric counter with electric readout (BCD or decimal), transfer and reset, and 2400 cpm speed. It combines large figure readability with narrow width for space economy. Another Veeder Decade model, the Series 7266, offers wheel configurations for recording time and counting dozens and denominations of money.

If you're after preassembled packages, we've got those, too. For example: The Series 710810 and 20 Digi-Con* Predetermining Counters which—unlike most electronic counters—won't reset during a power failure. The Series 710830 Digi-Con Totalizer is both a self-contained

Series 710810

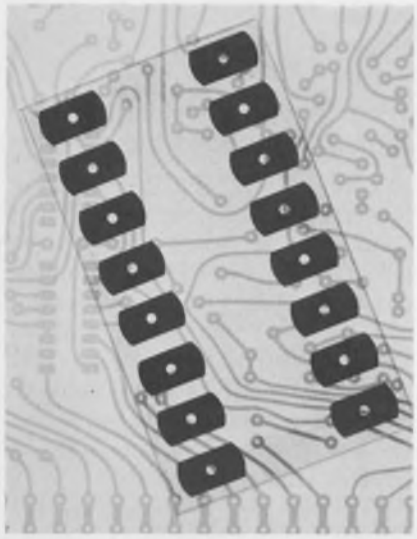
Series 710840

counter and a module for more sophisticated control systems. And the Series 710840 Digi-Clock* time display features a wide range of optional features for computer input.

For information about our complete line, write for Design Kit: Veeder-Root, Hartford, Conn. 06102.

*Trademark of Veeder-Root

Evaluation Samples



Layout patterns

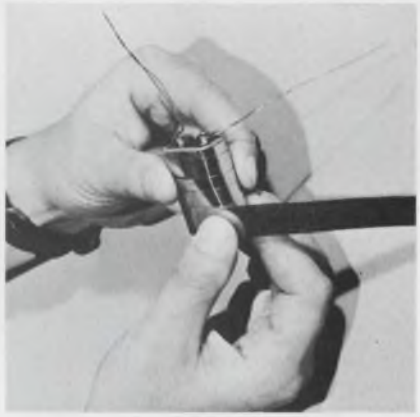
Self-sticking drafting symbols in pre-spaced configurations for integrated circuits, transistors and contact fingers feature unusual accuracy, opacity and dimensional stability, with tolerances of ±0.002 in. at a 4:1 reduction ratio. Image size and spacing are uniform from one set of layout patterns to another so that dimensions never vary, assuring accuracy and consistency of completed artwork and printed circuit. Each pattern appears on its own individual nonstatic transparent film base for easy handling and application. Free samples are supplied. W. H. Brady Co.

CIRCLE NO. 353

Gold-plated terminals

Providing the benefits of gold-plating at minimum expense, a new line of selectively plated terminals can significantly reduce costs without sacrificing connector integrity. Typical is a metal strip with only 20% of its surface coated with the precious metal and a strip of terminals made from a similar band. Only the mating surfaces have been plated. Free samples of these terminals are available. Molex Products Co.

CIRCLE NO. 354



Metal shim

Cutting peeling time in half, Lamipeel metal shim assembly easily separates from its shim lead at the outer edge using an ordinary penknife—or even with just a flick of a finger or fingernail. The loosened edge is then easily grasped and pulled off its leaf quickly and easily. Inner surfaces of Lamipeel are plastic-bonded to keep the shim assembly intact so it will not come apart in normal handling. However, the outer edges of each laminated layer in the shim are specially conditioned not to adhere to each other layer. A free sample is available. Laminated Shim Co.

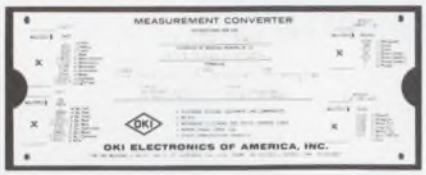
CIRCLE NO. 355

Wire-wrap leads

Containing eight standard wire-wrap leads, a new sample card includes specifications and a length of wire with various insulations. These are polyvinylchloride, Kynar, Teflon, Vylex, Teflon with Hard-coat, Kapton film, and Teflon with Kapton Film. The sample card, which is available free, affords the user an opportunity to check and test specifications and characteristics according to his own particular application. Berk-Tek.

CIRCLE NO. 356

Design Aids



Conversion slide rule

Useful to any design engineer working with lengths, weights and dimensions, a new measurement converter is now available in slide-rule form. This handy item easily tells you how many ounces there are in a kilogram, how many gills in a cubic inch, how many miles in a kilometer, and many other useful relationships. OKI Electronics of America, Inc.

CIRCLE NO. 357

Digital IC guide

Designed to speed integrated circuit selection, a six-page full-color guide graphically compares the operating characteristics of several families of digital ICs. Ideal for mounting, this selection-guide is a three-page center spread that divides, by color, Motorola's MRTL, MDTL, MTTL, MHTL and MECL families. The colors used for the chart match the respective technical data brochure for the same family. Typical illustrated characteristics include: operating temperature range, power supply range, basic gate fanout, gate dissipation, average propagation delay, flip-flop toggle frequency, and noise margins. Also shown are basic gate configurations and case dimensions. Motorola Semiconductor Products Inc.

CIRCLE NO. 358

Relay selector rule

A new selector slide-rule disc cross references relays from Cornell-Dubilier and Potter Brumfield, giving equivalent ac or dc general-purpose relays of the open or enclosed type. The relays covered have contact ratings of 10 A. Cornell-Dubilier Electronics, Div. of Federal Pacific Electronic Co.

CIRCLE NO 359

Photometry nomograph

Supplied as part of a photoconductive cell design manual, a photometry nomograph relates brightness in foot-candles and candle power to distance from an illuminated lamp. The nomograph also provides such useful definitions as lux, point source, lambert and foot-lambert. The design guide includes a discussion of light measurement, and photocell theory and applications. Clairex Electronics, Inc.

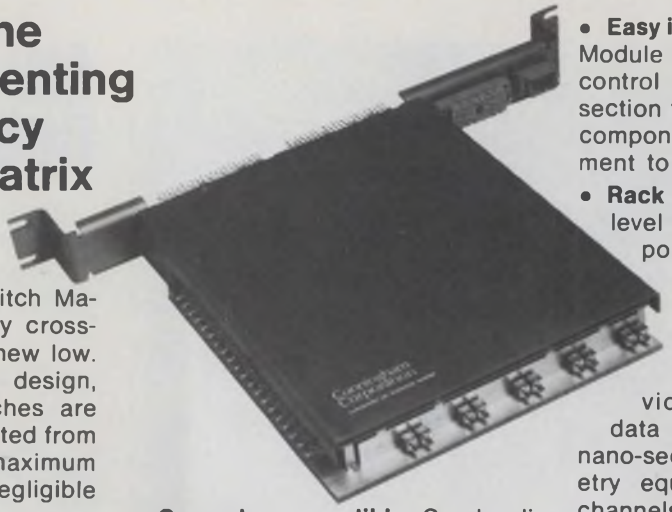
CIRCLE NO. 360

Coatings chart

Providing a concise guide to protective coatings for electronics applications, a colorful four-page chart summarizes the properties of ten frequently used Humiseal materials. The charted information includes recommended curing conditions, pot and shelf life, and thermal, physical, electrical and chemical properties. Humiseal Div., Columbia Technical Corp.

CIRCLE NO. 361

Isolation was the only thing preventing a high-frequency Reed Switch Matrix Until now.



The Cunningham Reed Switch Matrix reduces high frequency crosstalk and interference to a new low. In a unique "sandwich" design, matrix-mounted reed switches are sealed, shielded and separated from their controls, achieving maximum open circuit isolation and negligible crosstalk.

- **Excellent signal characteristics:** 50-ohm, distributed. Matches 50-ohm transmission line. Broadband handling characteristics, with excellent isolation. Very low thermal noise.
- **100% Random access:** Any number or combination of crosspoints can be set, any place, any direction, vertical or horizontal, without affecting the condition of other crosspoints in the matrix.
- **Computer compatible:** Can be directly addressed by all computers using +5 volt logic. No additional interfacing required. Single power supply.
- **One package** contains all signal switching elements and coil drivers as well as the logic required to translate the co-ordinate inputs into crosspoint address.
- **Reliability proven:** Up to 100 million operations.
- **Easy inspection and maintenance:** Module can be unplugged and the control separated from the signal section for easy access to all active components. No adjustment or alignment to perform after re-assembly.
- **Rack mounting:** Standard one-level matrix of 10x5x1 crosspoints. Plug-in and expandable to larger matrices.

The new Cunningham Reed Switch Matrix is ideal for interconnecting video channels, broadband data switching, test systems for nano-second digital pulses, telemetry equipment for multiple data channels, antenna switching, and medical data monitoring.

Write or call for Data Sheet No. 603, Cunningham Corporation, 10 Carriage Street, Honeoye Falls, New York 14472. Phone (716) 624-2000.

Cunningham Corporation

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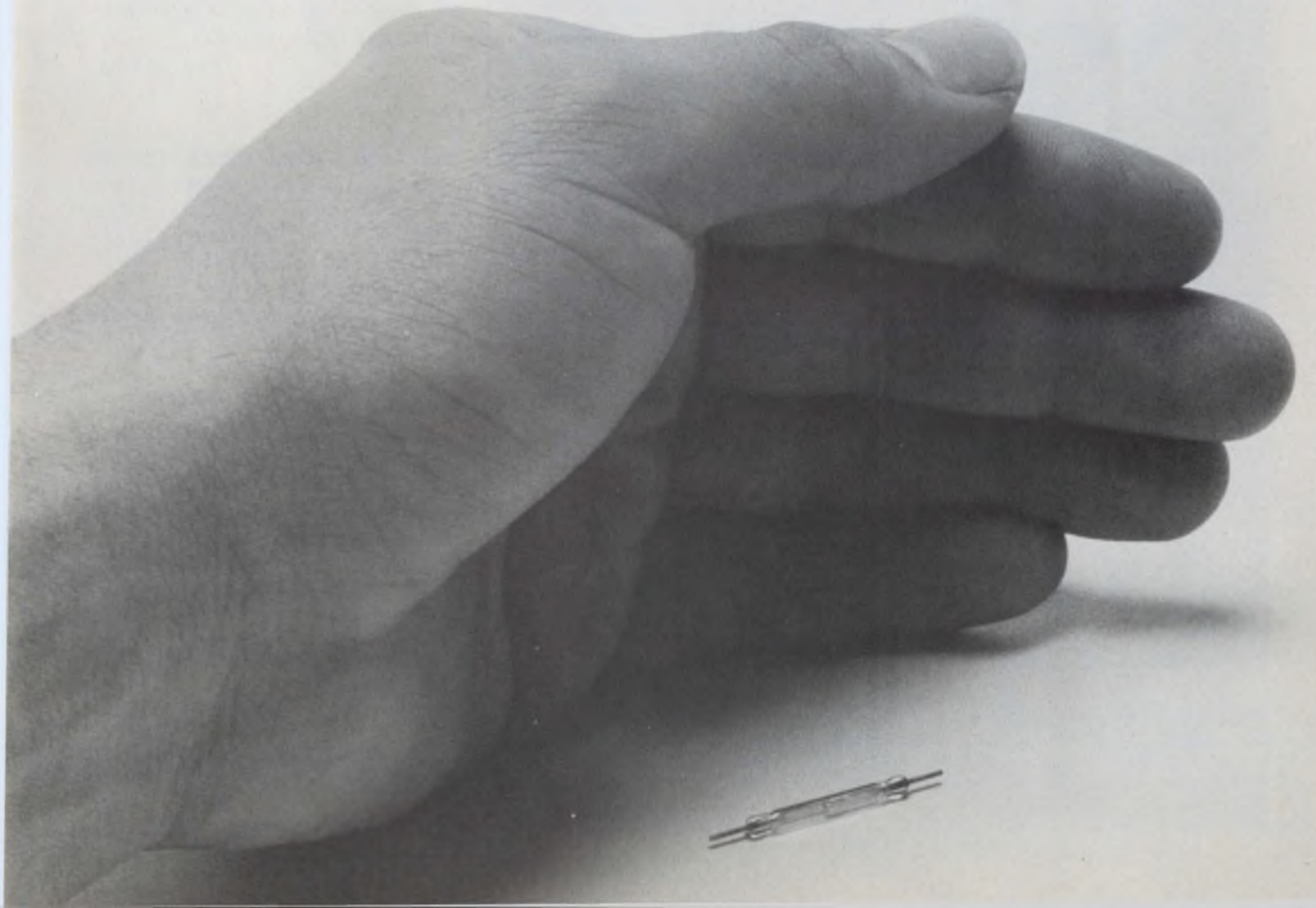


Annual Reports

Learn how to read annual reports in "How to investigate a company." For a copy, circle no. **474.**

Ampex Corp., 401 Broadway, Redwood City, Calif.: audio, video and data recording; net revenue, $300,278,000; net earnings, $13,-702,000; assets, $215,293; liabilities, $91,255,000.

CIRCLE NO. 362

Datamation Services Inc., 461 8th Ave., New York City, N.Y.: computer services; revenues, $5,613,-937; net income, $328,895; assets, $1,774,344; liabilities, $1,151,638.

CIRCLE NO. 363

Diebold Computer Leasing Inc., 35 Journal Square, Jersey City, N.J.: computer leasing; revenues, $12,813,000; net income (loss), $1,098,000; assets, $149,991,000; liabilities, $119,891,000.

CIRCLE NO. 364

Edo Corp., 1404 111th St., College Point, N.Y.: Sonar systems, electronic counter systems; sales, $38,019,420; net earnings, $1,754,-829; assets, $20,783,184; liabilities, $8,021,095.

CIRCLE NO. 365

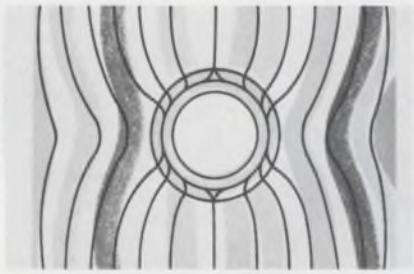
Kollmorgen Corp., Holyoke, Mass.: motors, generators, computers, colorimeters, spectrophotometers, optics; net sales, 23,052,344; net income, $855,452; assets, $11,393,-821; liabilities, $2,893,290.

CIRCLE NO. 366

Newell Industries Inc., 795 Kifer Rd., Sunnyvale, Cal.: magnetic tape systems; net sales, $58,421; net earning, $238,593; total assets, $2,721,643; total liabilities, $414,241.

CIRCLE NO. 367

Application Notes



Emi shielding manual

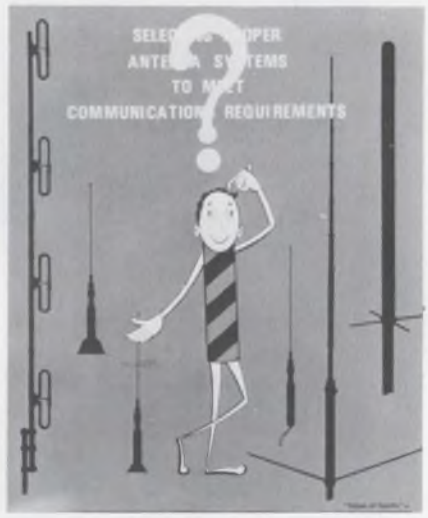
Consisting of 48 pages, a new electromagnetic shielding design manual covers all terms used in emi shielding, tells how a shield works, and shows, complete with formulas, tables and graphs, how to design an effective emi shield. The manual also discusses shielding in and shielding out, and gives calculations for shielding out. Magnetic Metals Co.

CIRCLE NO. 368

Encoder guide

Detailing encoder technology and providing extensive data on encoder applications, a new 12-page guide begins with a simplified description of how encoders convert various inputs into useable information. Discussed are analog-to-digital conversion systems, natural binary notation and conversion equivalents, the gray code, and incremental encoders. There is also a section on how to avoid ambiguity. Collectron Corp.

CIRCLE NO. 369



Antenna guide

"Selecting Proper Antenna Systems to Meet Communication Requirements" is a 28-page illustrated manual that is a basic guide for selecting the optimum antenna type for both base and mobile installations. Discussed is relative antenna efficiency, effective height, receiver sensitivity and selectivity, and transmitter power. Other sections cover the effects of transmission loss and antenna gain. Antenna Specialists Co.

CIRCLE NO. 370

Transmission lines

Featuring a graph that correlates the reduction of voltage standing wave ratio (VSWR) with decibels (dB) of attenuator pads, a new six-page application note covers trade-offs in radio-frequency (rf) measurements and line impedance selection. The graph permits optimum compromise between component isolation and power loss. A brief history and technical background on the selection of 50 Ω as the standard impedance for coaxial power transmission is also included, along with basic breakdown-voltage and power-capacity formulas for concentric lines. Bird Electronic Corp.

CIRCLE NO. 371

The new Fluke 893A will retire lots of good old Fluke voltmeters.

They won't be the only ones to go!

All kinds of differential voltmeters are likely to find quick retirement when you check out the new solid state Fluke Model 893A AC/DC Differential Voltmeter. Here's a low cost differential voltmeter with infinite resistance at null to 1100 volts, dc accuracy of 0.01%, ac accuracy of 0.05%, and integral battery pack operation.

Available in both half and full rack models, price is $995 for either. Battery operation can be added at any time for only $100. Grounded recorder output is available for $50 more.

Ranges are 1, 10, 100, and 1000 volts ac and dc with 10% overranging. Resolution is 1 ppm of range. Reference regulation is the best available. Reference stability is 15 ppm/hr.

Using the instrument in the battery mode assures portability and complete isolation from the effects of power line interference. In the ac mode, the useful frequency range is 5 Hz to 100 KHz with a 1 mv accuracy. In the TVM mode, input resistance is 100 megohms, so you get the same advantages of low source loading as with older vacuum tube differentials.

Other user features include large, in-line readout with 360° rotation of voltage dials, virtual immunity to damage by accidental overload, and automatic decimal switching with range.

Ready to make the change?
We'd like to help. Your friendly Fluke sales engineer (listed in EEM and EBG) has all the facts as well as demo equipment. Call him or contact us directly if it's more convenient.

Fluke. Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211.
TWX: 910-449-2850.
In Europe, address Fluke Nederland (N.V.), P.O. Box 5053, Tilburg, Holland.
Telex: 884-50237. In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2 4TT, England. Phone: Watford 27769. Telex: 934583.

FLUKE®

New Literature

Test equipment

Insulation test equipment, electronic test and measuring instruments, high-voltage power supplies, and automatic component testers are covered in a new 32-page catalog. Described are dielectric and voltage breakdown testers, arc-resistance testers, insulation test sets, and megohmmeters. The test and measuring instruments include kilovoltmeters, impedance bridges, Wheatstone bridges and low-range ohmmeters. Beckman Instruments, Inc.

CIRCLE NO. 372

Calibration standards

A six-page short-form brochure lists and describes calibration consoles, emf standards, potentiometers, and resistance standards and networks. The equipment described includes calibration consoles for dc voltage, current, resistance and temperature measurements. Also presented are permanently calibrated bridges, precision comparators, oil-baths for standard cells, temperature and resistance instrumentation, thermionic bridges, voltboxes, shunts, galvanometers and selector switches. Guideline Instruments, Inc.

CIRCLE NO. 373

Voltage stabilizers

Selection of unfiltered and harmonic-filtered enclosed ac line voltage stabilizers is the topic of an eight-page publication. The stabilizers are used to provide constant voltages for electronic and electrical equipment, such as industrial process, X-ray, numerical control and computer systems. The booklet includes complete descriptive information, operating characteristic curves, performance charts, connection tables, dimensions, drawings, and prices and ordering information. General Electric Co.

CIRCLE NO. 374

Ultrasonic cleaning

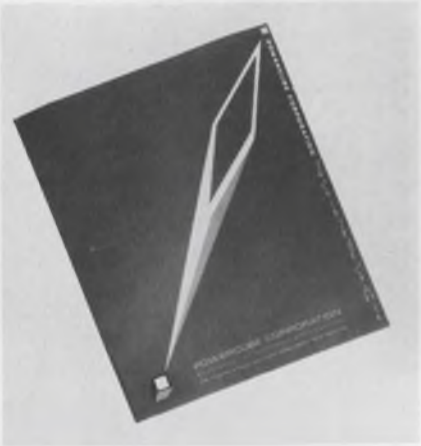
An ultrasonic wire drawing and cleaning system is described in a new four-page brochure. Designed to mount in existing drawing or cleaning tanks, the hollow-core/ultrasonic transducer allows the wire to pass through its center, thereby concentrating the high-intensity ultrasonic energy directly on the wire. The brochure lists the common solutions in which the transducer may be immersed and the recommended ultrasonic lenses for each solution. Gulton Industries, Inc.

CIRCLE NO. 375

Limericks for engineers

Authored by a gentleman who understandably prefers to remain anonymous, "Limericks for the Technologically Employed" is a pleasant 20-page diversion from the engineer's work-a-day world. Practically guaranteed to produce at least one chuckle per reader, this booklet also contains a brief appendix devoted to circuit breakers, relays, motors and protective devices. Heinemann Electric Co.

CIRCLE NO. 376



Miniature supplies

A 24-page designer's aid catalog for specifying subminiature high-power supplies is now available. It has data on a complete line of subminiature Powercube modules intended for the engineer who is faced with critical size and weight requirements. Powercube Corp.

CIRCLE NO. 377

Marking glossary

Terms associated with embossing seals, stencils, rubber stamps, marking inks and pads, and steel marking tools and dies are fully defined in a glossary of marking device terminology. The information is especially useful to purchasing agents, designers, and others working with or using marking tools. Marking Device Association.

CIRCLE NO. 378

Environmental ovens

Providing a complete selection guide, a new 48-page catalog describes and illustrates a full line of industrial ovens. The models shown cover a full scope of applications. They include gravity, forced-aid, mechanically convected, benchtop and floor types, low-skin-temperature, chromatography and vacuum ovens. Hotpack Corp.

CIRCLE NO. 379

Announcing a small breakthrough in 4-track instrumentation recorders.

At 50 pounds, our new HP 3960 is a true instrumentation tape recorder that can go just about anywhere. And starting at $3800, it's about half the price you'd expect to pay for this performance in a 3-speed, ¼" tape machine.

For instance, our instrument provides an FM signal-to-noise ratio of better than 46 dB at 15/16 ips. With it, you can record signals that would be buried in noise on the average 40 dB rated machine. This exceptional performance is achieved *without* the use of flutter compensation or external filtering. Offering direct response to 60 kHz and FM to 5 kHz, performance is equal to or better than the most expensive instrumentation recorders now available. This high performance is achieved through the use of a single casting capstan assembly, phaselock servo drive system, and HP quality electronics.

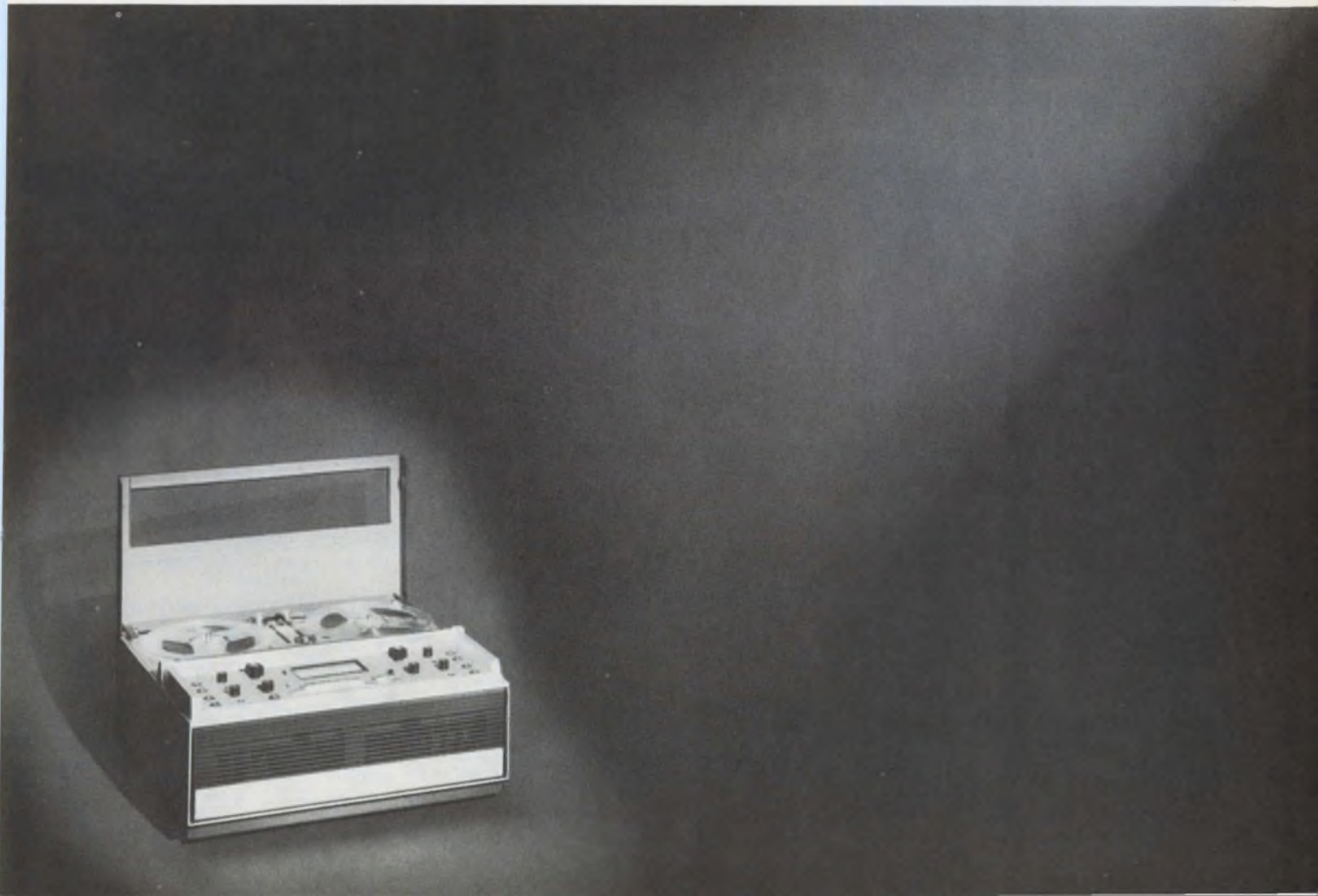
This combination of large-scale performance and small-scale portability makes our recorder the ideal instrument for work in a number of fields: vibration and stress analysis; research and clinical areas of medicine; acoustical work; oceanography, and many others. And its basic simplicity and ruggedness help it to meet stringent environmental specifications.

For a close-up of our small breakthrough in the 4-track instrumentation recorder field, just call your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

MAGNETIC RECORDERS

42904



NEW LITERATURE

Wire markers

A complete line of pressure-sensitive adhesive-backed markers for identifying wires and other items is described in a 20-page illustrated catalog. Included and illustrated in the catalog are wire markers containing numbers, letters, combinations of letters and numbers, machine-tool markers and miscellaneous electrical markers. The markers are available in a variety of materials including paper, vinyl, aluminum foil, acetate cloth, flame resistant fiberglass, polyester, and self-laminating vinyl plastic. The Thomas & Betts Co.

CIRCLE NO. 380

Epoxy coatings

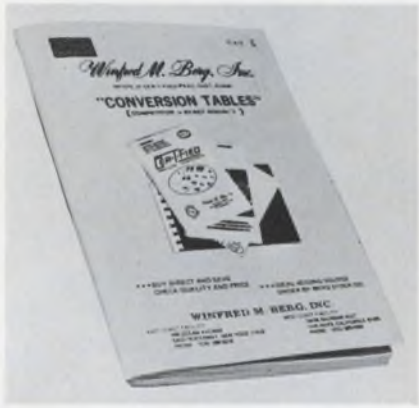
Giving full details on Corvel epoxy coating materials, a new 12-page brochure explains what they are, how they are made, and what are their uses and applications. Also discussed are the advantages of these epoxies for insulation and anti-corrosion applications. Resins Division of the Polymer Corp.

CIRCLE NO. 381

Glass components

A four-page short-form catalog lists performance characteristics, physical descriptions and military designations of glass and glass-ceramic capacitors and glass tin-oxide film resistors. Corning Glass Works.

CIRCLE NO. 382



Hardware reference

Cross-referencing the part numbers of leading manufacturers, as a second source, to meet spare parts requirements, a new 128-page catalog is now available on standardized precision instrument components. The conversion guide also includes a listing of federal stock numbers assigned to standardized components, plus a section on new products. Winfred M. Berg, Inc.

CIRCLE NO. 383

Cabling systems

Outlining proper selection, specification and termination procedures, a new six-page brochure describes in detail how connectors interface with flat cable or discrete wire to wire-wrap posts and printed circuit boards. The connectors feature simultaneous termination of 14 to 64 conductors on 0.05-in. centers. Engineering data describing contact performance during current cycle, vibration and thermal testing is included. 3M Co.

CIRCLE NO. 384

Enclosure styling

Permitting highly individualistic styling to be easily and economically applied to a variety of encolsure structural systems, a new enclosure styling system, called Interface 33, is completely described in a 12-page full-color brochure. There is a styling selector chart that illustrates how unique enclosure styling combinations can be achieved through the use of seven vertical and seven horizontal trim extrusions. Amco Engineering Co.

CIRCLE NO. 385

NEW LITERATURE

Spring washers

Intended to supplement an earlier catalog (40A), a new brochure shows additional parts for crescent, wave and Belleville style spring washers. Also included is a new section on dome washers. Seastrom Manufacturing Co. Inc.

CIRCLE NO. 386

Microwave loads

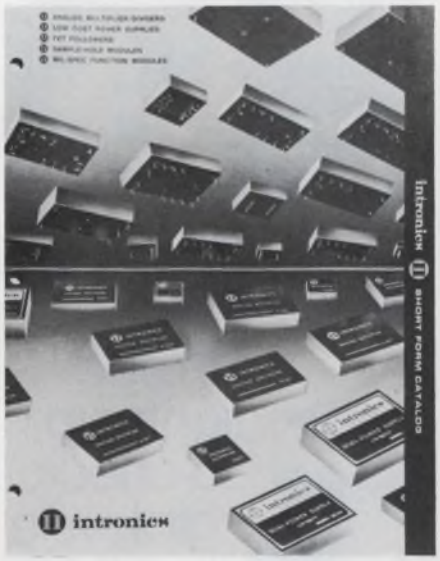
Four basic types of microwave water loads, all of which offer low VSWR, are discussed in a 16-page catalog. Described are high-power miniature loads of the ceramic block type, broadband loads of the glass tube type, high-power broadband compact loads of the Teflon wedge type, and high-power broadband coaxial loads. A description of various calorimeters, and calorimetric measurement information is also included. Varian Electron Tube and Device Group.

CIRCLE NO. 387

High-voltage supplies

Information on regulated solid-state, unregulated rf, and series-regulated high-voltage power supplies is contained in a new six-page condensed catalog. Besides miniature encapsulated modules, over 300 models of rack-mounted, portable and modular power supplies are priced and described. Spellman High Voltage Electronics Corp.

CIRCLE NO. 388



Modular components

Giving specifications, configurations, applications and prices, a new six-page catalog contains information on several types of modular components. These include dual power supplies, analog multiplier/dividers, FET followers and operational amplifiers. Intronics, Inc.

CIRCLE NO. 389

Sealed connectors

A complete line of hermetically sealed connectors is described in a new 20-page catalog. The publication contains specifications and illustrations for seven hermetic connector families, including miniature, double-ended, submarine, space and missile system units. Each series description includes data on connectors available for mating with the hermetics. Bunker-Ramo Corp., Amphenol Connector Div.

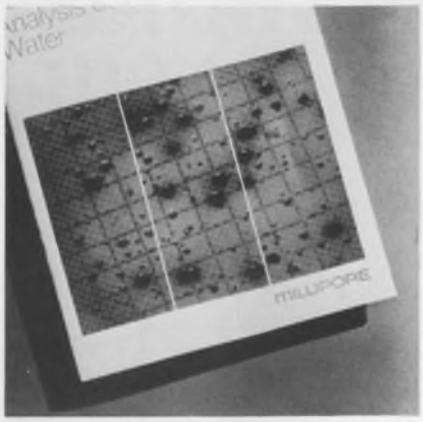
CIRCLE NO. 390

Frequency devices

The electrical and mechanical characteristics of a broad line of frequency instrumentation products are fully described in a comprehensive 10-page two-color catalog. Included are frequency synthesizers, multipliers, dividers, crystal frequency standards and precision crystal oscillators. The Hallicrafters Co.

CIRCLE NO. 391

NEW LITERATURE



Water analysis

Compiled by bacteriologists, a new 25-page manual describes membrane filtration procedures for isolating and analyzing microorganisms in municipal water supplies, swimming pools, treated sewage or in industrial process, rinse or waste water. In addition to routine coilform analyses, the manual outlines procedures for identifying such organisms as fecal coilform, fecal streptococci, pathogenic bacteria and enteric viruses. Millipore Corp.

CIRCLE NO. 392

Metal lugs

A complete line of metal lugs for stand-off, wiring, and tie-point applications is shown in a new six-page catalog. It contains outline drawings and dimensional information for all types of metal lugs including swage-type and screw-type, as well as a variety of special-purpose configurations. All these metal lugs meet or exceed the requirements of MIL-T-55155. Sealectro Corp., Components Div.

CIRCLE NO. 393

CRT data

Standard and high-resolution cathode-ray tubes that are ideal for computer terminals, video displays, and medical monitoring systems are now listed in a new four-page booklet. The CRTs are indexed according to tube type, minimum resolution (maximum center spot diameter), screen dimensions, and electrical characteristics. Westinghouse Electric Corp.

CIRCLE NO. 394

Drawn aluminum

Thousands of sizes and shapes in off-the-shelf drawn aluminum cans and covers are listed in a new 84-page design guide and catalog. Basic ordering information and complete specifications are given for square, rectangular and round enclosures. An illustrated section covers practical "how-to" information for the design engineer. Moorlee Manufacturing Co.

CIRCLE NO. 395

Instrument rental

Listing more than 200 new items, a new 42-page catalog gives monthly rates and ordering information for a wide variety of analytical instruments, electromechanical measuring devices, and electrical and electronic instrumentation. General Electric Co.

CIRCLE NO. 396

Pulse measurement

Described in a four-page application engineering bulletin is a solid-state microwave pulse height detector. The unit permits accurate observation of the average spike leakage power or observation of pulses that have excessive amplitudes. Topics include transmitter function and spike leakage effects, operating principles and performance, package options, functions, attenuator setting for measuring leakage, transmitter tube evaluation, and other applications. Varian Solid State Microwave Project.

CIRCLE NO. 397

NEW LITERATURE

Kynar applications

Technical information on the use of components made with Kynar for chemical processing systems is contained in a new 16-page brochure. Numerous illustrations show Kynar's unique applications in the aerospace, electronics, chemical and petrochemical industries. Kynar can be used as a protective coating for metal parts, as a film for packaging, and as a material that must resist aging, abrasion and biological attack. Also presented are charts, listing its important physical, mechanical, thermal and electrical design properties. Pennwalt Corp., Plastics Dept.

CIRCLE NO. 398

Electrical maintenance

A new 16-page catalog for electrical maintenance personnel provides detailed information on various types of electrical test equipment. Among the instruments covered are dc dielectric breakdown tester, low-range ohmmeter, temperature rise bridge, insulation oil tester, combustibles analyzer, ac and dc insulation testers, megohmmeters, ac and dc voltage breakdown testers, and a variety of cable-fault locators. Photographs, circuit diagrams and full specifications are given. The bulletin focuses on insulation tests and operational tests. Beckman Instruments, Inc.

CIRCLE NO. 399

Transformer design

Recent design advances in dry-type specialty transformers, with special emphasis on insulating materials, is the subject of a four-page article reprint. The article explores improved transformer design techniques over the past 25 years utilized in high-and low-voltage transformers, power distribution centers, mercury lamp ballasts, cast coils, and high-temperature insulating materials. Projections on future design trends and materials in the industry are also given. General Electric Co.

CIRCLE NO. 400

Gasket materials

Detailed information regarding tolerances for resilient gaskets, an explanation of the minimum sealing stress concept and a listing of military and government specifications can be found in a new 22-page gasket materials catalog. Charts, graphs and photographs provide easy reading and quick reference. Armstrong Cork Co.

CIRCLE NO. 401

Rotary switches

Complete technical specifications on six new series of miniature switches are detailed in an expanded engineering handbook. Included are modifications for switches designed for printed circuits and switches with coded outputs such as; decimal-to-binary units. RCL Electronics Inc.

CIRCLE NO. 402

Antenna catalog

High-frequency, very-high-frequency, and ultra-high-frequency antennas are the subject of a new six-page catalog. Presented are a detailed set of specifications along with complete operating characteristics. Antenna Products Co.

CIRCLE NO. 403

Data communications

Specifications and features of high-speed data communications equipment plus answers to typical questions on communications are available in a newly issued catalog. Described are data modems, acoustic data couplers and data interfacing equipment. RFL Industries, Inc.

CIRCLE NO. 404

NEW LITERATURE

Insulating resins

Characteristics of electrical insulating resins and factors to consider when selecting a resin are described in a four-color brochure. The advantages of different resin systems for various electrical applications are cited, along with physical and electrical properties and applications data. The resin systems, which are categorized as to type of cure include polyurethane liquid, foam-in-place epoxy, one and two-part liquid epoxies, and one-part powdered epoxies. 3M Co.

CIRCLE NO. 405

Computing multiplier

A five-digit multimeter with sixth-digit overranging is described in a four-page brochure. Using a new computing rms technique, the unit measures ac signals with an accuracy of 0.1% in 300 ms, despite the presence of distortion. Dana Laboratories, Inc.

CIRCLE NO. 406

Ac and dc motors

Fractional-horsepower ac and dc motors designed to fill a wide range of special applications are described in a new six-page publication. The dc motors are available with ratings of 1/12 to 1 horsepower for use on motor-generator sets and 32-V battery power supplies. Forty models of ac motors feature power ratings of 25 mhp to 1/8 hp, depending on frame size selected. General Electric Co.

CIRCLE NO. 407

NEW LITERATURE

Rotary switches

Complete mechanical and electrical specifications for a line of rotary switches are given in a new 24-page technical catalog. Information is also provided on proper switch selection, pre-wired terminal boards, multiple-deck units and military and high-reliability types. These precision switches are suitable for use in computers, telemetering systems, test equipment, instruments, programing and automatic checkout equipment. Aerovox Corp.

CIRCLE NO. 408

Logic ICs

A handy two-color pocket-sized brochure contains information on monolithic TTL integrated circuits that are members of the SULH I and SUHL II families. Logic diagrams, descriptions and type numbers are given, indexed according to family and function. In addition, the folder has typical electrical characteristics for each circuit and shows available package dimensions. Sylvania Electric Products Inc.

CIRCLE NO. 409

Drum memories

All essential facts about a standard line of drum memories, which cover a storage range of 0.56 to 71.6 megabits, are shown in a new six-page folder. Also provided is a design summary, basic specifications of four models, dimensioned photographs, and digital interface lines. Vermont Research Corp.

CIRCLE NO. 410

Subminiature lamps

Complete specifications, configurations and characteristic curves are contained in a two-page brochure on subminiature lamps. Also shown are filament outline drawings and indicator lamp specifications. Inter-Market Inc.

CIRCLE NO. 411

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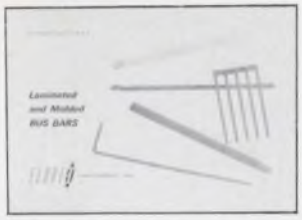

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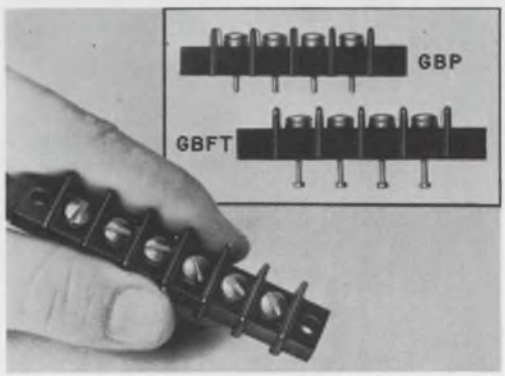

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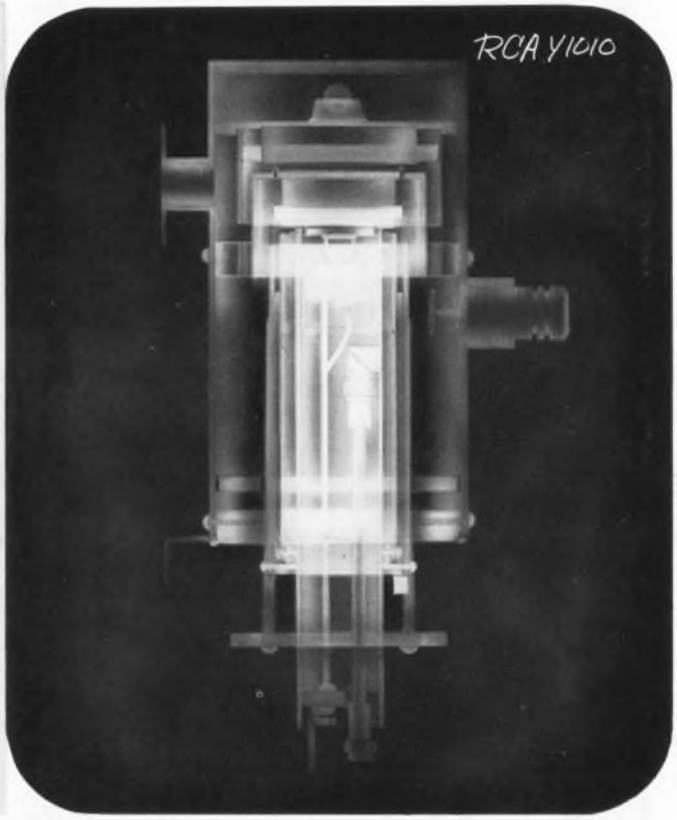

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Y1051	8227	450	pulse	500
Y1052	8227	400	pulse	350
Y1054A	7651	5,500	pulse	150
Y1059	7214	12,500	pulse	150
Y1070	7651	6,500	pulse	200
Y1086	7651	375	pulse	200

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