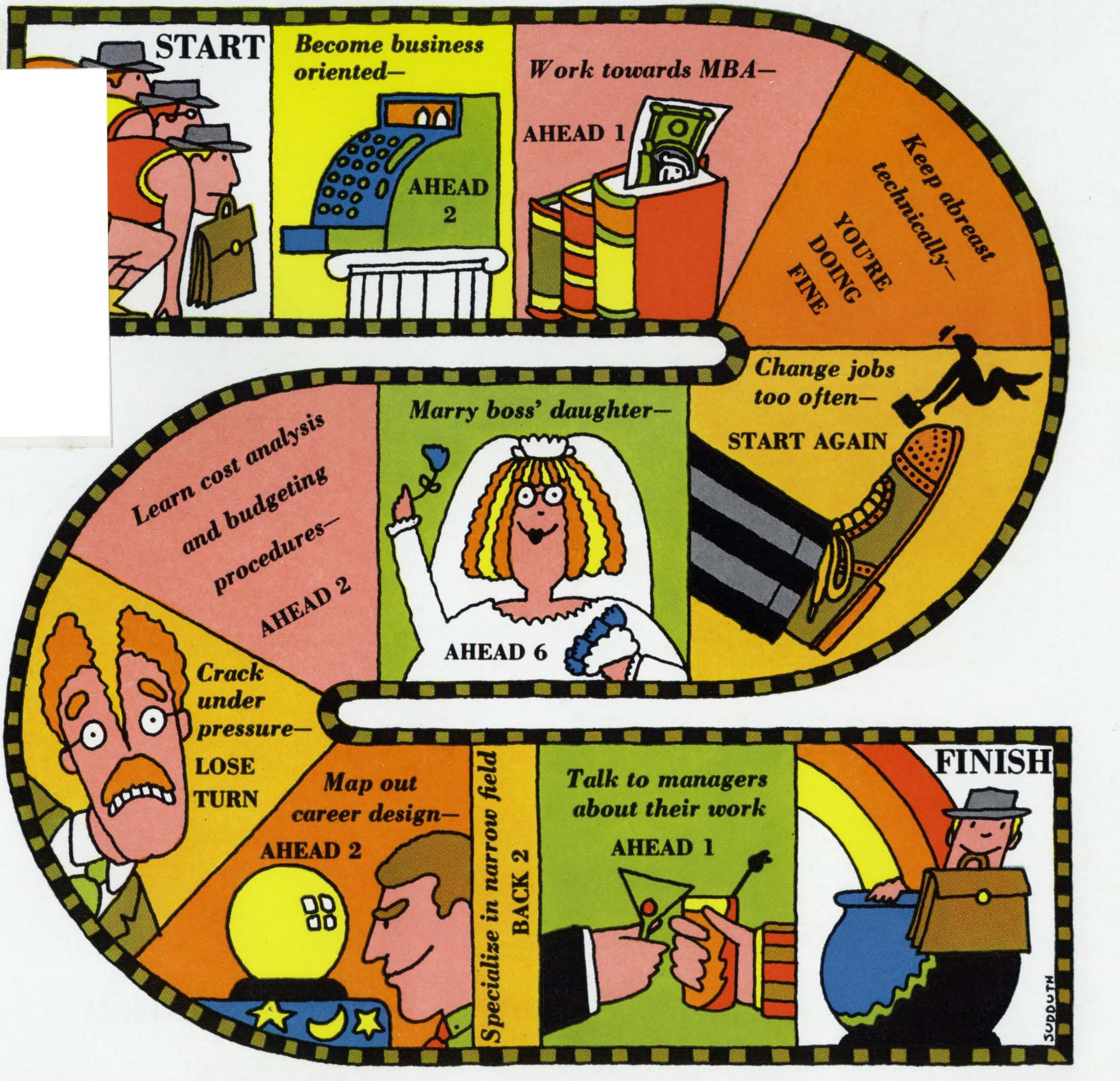
Electronic Design

VOL. 15 NO. 21

FOR ENGINEERS AND ENGINEERING MANAGERS

OCT. 11, 1967

Move to the head of your field by going into management. Top engineering managers cite these guides for the "Chief Engineer Game": map out a career design, learn management techniques, keep technically current, become business-oriented and diversify your experience. For the views of chief engineers, see page 86.



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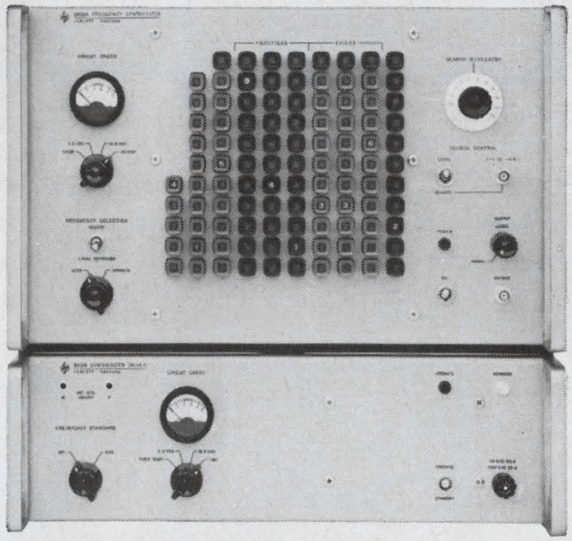

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2490

ON READER-SERVICE CARD CIRCLE 3

VOL. 15 NO.

Electronic Design 21

FOR ENGINEERS AND ENGINEERING MANAGERS

OCT. 11, 1967

NEWS

TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y. 10022. James S. Mulholland, Jr., President. Controlled-circulation postage paid at Chicago, Ill., and New York N. Y. Application to mail at controlled postage rates pending at St. Louis, Mo. 63,304 copies this issue.

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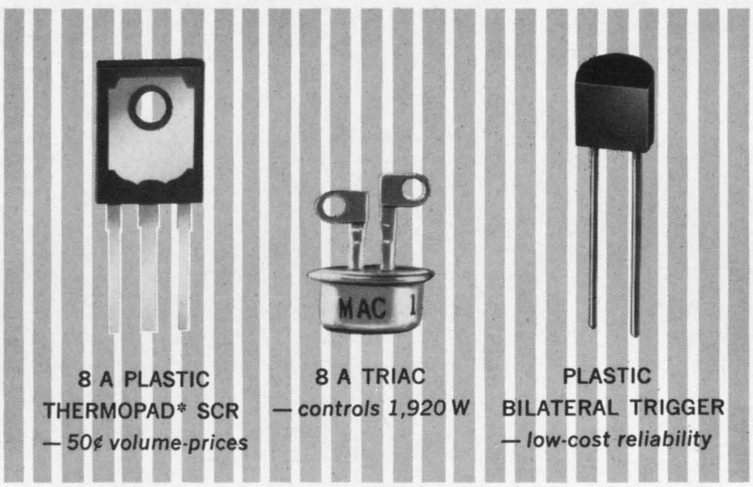

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ON READER-SERVICE CARD CIRCLE 5

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Now! Maximum Reliability in the Smallest Size Available

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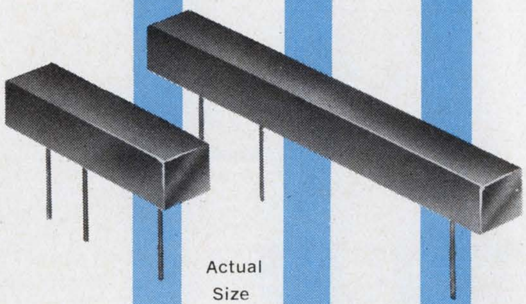
Units listed are available from stock.

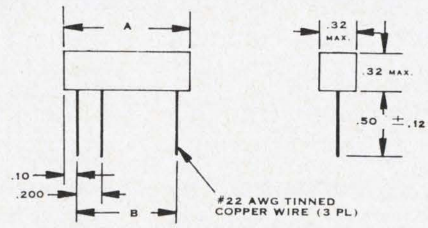


Actual Size

Specifications

- **Operating Temperature:** $-55°C$ to $+125°C$
- **Temperature Coefficient:** 100 ppm/°C
- **Attenuation:** 0.5 db max.
- **Distortion (typical):** ±10%; with an input rise time of 20% of specified rise time or 1 nsec. whichever is greater
- **Dielectric Strength:** 100 VDC

IMPEDANCE 100Ω ±10%				IMPEDANCE 200Ω ±10%				IMPEDANCE 500Ω ±10%			
MODEL NO.	DELAY nsec. ±5%	RISE TIME nsec. MAX.	CASE	MODEL NO.	DELAY nsec. ±5%	RISE TIME nsec. MAX.	CASE	MODEL NO.	DELAY nsec. ±5%	RISE TIME nsec. MAX.	CASE
SMA10	10	2.5	1	SMB10	10	2.5	1	SMC100	100	30	1
SMA20	20	6.0	1	SMB20	20	6	1	SMC150	150	45	1
SMA30	30	8.5	1	SMB30	30	8.5	1	SMC200	200	60	1
SMA40	40	12	1	SMB40	40	12	1	SMC300	300	80	1
SMA50	50	15	1	SMB50	50	15	1	SMC400	400	55	2
SMA60	60	12	2	SMB60	60	12	2	SMC500	500	70	2
SMA80	80	16	2	SMB80	80	16	2	SMC600	600	80	2
SMA100	100	20	2	SMB100	100	20	2	SMC1200	1200	250	2



CASE	A	B
1	1.00	0.800
2	2.00	1.800

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ON READER-SERVICE CARD CIRCLE 7

NEW DVM

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hp 3460B Integrating/Potentiometric Voltmeter Has High Accuracy... >$10^{10}\,\Omega$ Input Resistance... Systems Compatibility

The new hp 3460B Digital Voltmeter is a dual-technique instrument that combines the best features of an integrating voltmeter with those of a potentiometric voltmeter—to give an accuracy of 0.004% of reading, superimposed noise immunity of integrating DVM's *and* a high common mode rejection of 160 dB at dc.

You get up to 15 readings per second with five full digits and 20% overranging indicated by a sixth digit. Polarity selection is automatic. The 3460B has 10 μV sensitivity. Four ranges are selectable by pushbuttons on the front panel, or, range selection can be automatic or remote.

Floating and guarded input connectors are on both the front and back of the instrument. Input resistance is $>10^{10}\,\Omega$ at balance on 1 V and 10 V ranges (minimum 10 MΩ), and a constant 10 MΩ on 100 V and 1000 V ranges.

Programmability.—hp 3460B is designed for fully automatic operation in a digital data acquisition system. A four-line BCD output (1-2-4-8) on the back of the instrument contains 6 digits of data, polarity, decimal location and overload information. Voltage range and two integration periods can be selected by external circuit closure to ground.

Get the full story on the new dual-technique hp 3460B Digital Voltmeter from your nearest hp field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva. Price: hp Model 3460B, \$3600.00.

097/13

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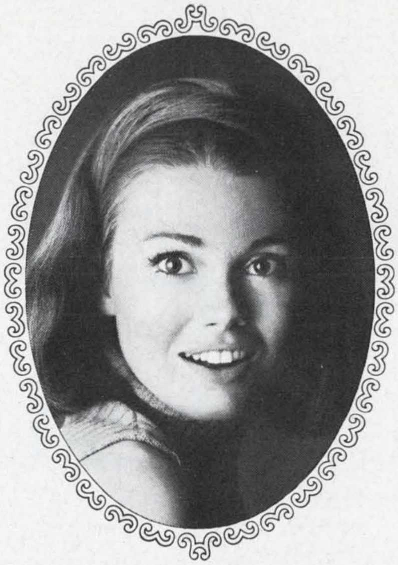
ON READER-SERVICE CARD CIRCLE 6



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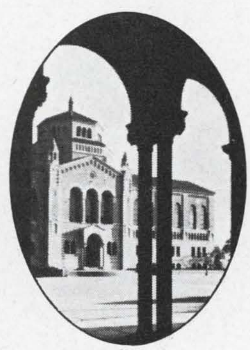

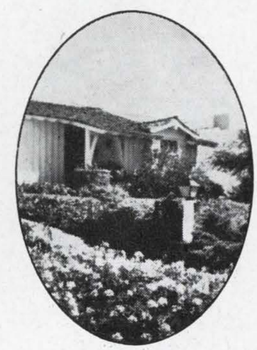

The climate. Often it's compared with the Riviera's. In truth, Southern California's is better. Dryer in summer: no mosquitos, little mugginess. Balmy in winter: seven hours of sunshine a day. You'll *save* on galoshes!

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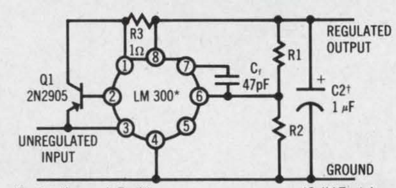
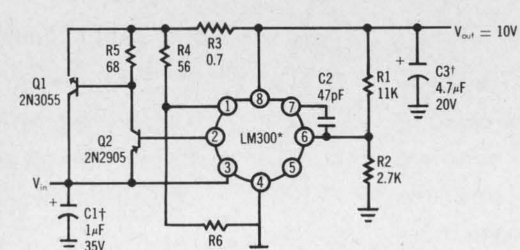


*Basing diagram is Top View †Solid Tantalum

2A Regulator with Foldback Current Limiting



*Basing diagram is Top View †Solid tantalum.

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It's probably the biggest bargain you'll find in this magazine.

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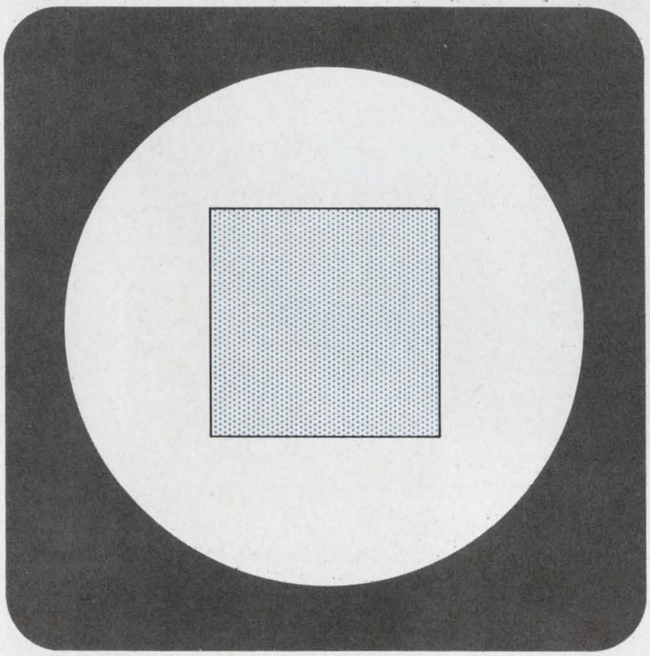
ON READER-SERVICE CARD CIRCLE 9

News

New low-cost IC testers in the $500 to $5000 range have reduced the cost of testing integrated circuits. In addition, IC testing services are on the increase. Page 17



A 'whiskered' cold-cathode in a CRT produces high current densities at low power. Page 36

Army manpack radar was among combat devices shown at a military fair. Page 24

Also in this section:

Defense Dept. rules out standards for IC types

The Defense Dept., in a move to give design engineers more latitude in selecting integrated circuits for military systems, has decided not to standardize the IC types that can be used at this time.

Col. John W. Elder, deputy director of the Technical Data and Standardization Policy Directorate, says that premature employment of piecemeal standardization would lead to undesirable constraints on the design of each succeeding system. Because of the increased reliability of ICs, Colonel Elder says, the Defense Dept. believes that the lifetime of devices will be relatively long and that replacement parts will be relatively few, thus posing little threat to logistics needs. Another factor is the dynamic state of IC design, particularly with the move toward large scale integration.

There has been considerable activity, however, on the part of the Defense Dept. and NASA to speed standardization of definitions, common test methods, packaging and recommended applications. A five-part program, started in July, includes:

(1) Terms and definitions released to industry as MIL-STD 1313.

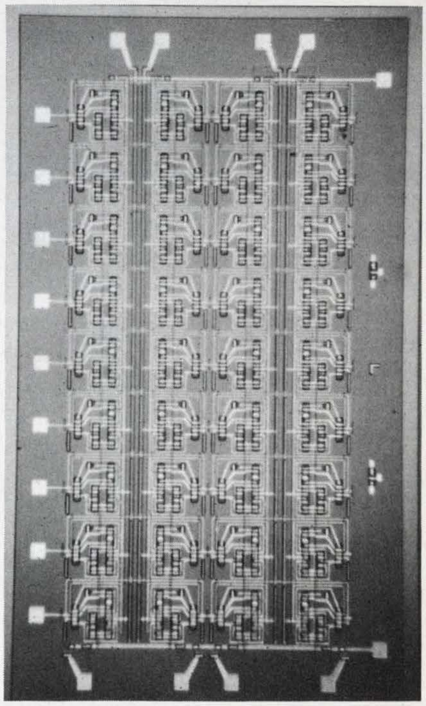
(2) Test methods and procedures, including environmental as well as physical and electric tests.

(3) Parameters to be controlled for circuit characterization—for selection of digital ICs.

(4) General application guidance, sign engineers.

(5) Packaging techniques, to cover requirements and quality assurance for packaging, shielding and marking of IC containers.

MIL-STD-1313 was released in early August, and the remaining four parts of this standardization program are expected to be put into effect in the next six months.



LSI is coming—here's a 36-bit complementary-MOS memory from RCA.

Navy acts to automate its avionics testing

The Navy has briefed industry on its avionics test system called VAST, to clarify its notice in May that it expects all future avionics to be compatible with that computor system.

Under the sponsorship of the Naval Air Systems Command and the Electronics Industries Association, one-day briefings were held at four cities around the country. The Navy plans to install VAST (Versatile Avionic Shop Test System) on its aircraft carriers in 1970.

A navy spokesman told industry that the automatic testing was needed to replace the profusion of special test equipment now required to support airborn electronics. He reported that about 85 per cent of the Navy's avionic test equipment is now custom-made for specific applications, thereby creating "serious maintenance problems for the Navy." He reported that 20 years ago only about 15 per cent of the test equipment in use then was in this category.

The Navy spent more than $165 million on special support equipment in the last fiscal year.

Other factors listed by the Navy for encouraging adoption of VAST included these:

- A shortage of skilled technicians to man the avionics shops ashore and afloat.
- A shortage of space, particularly on aircraft carriers, to house the equipment.

The VAST concept is the result of more than three years of study by PRD Electronics, Inc., of Westbury, N. Y. A Univac 1218 computer performs the logic and other procedures usually done by trained technicians. As many as three VAST test stations can be time-shared with a single computer.

The Navy says that the family of functional building blocks that was developed will permit it to test and isolate faults in up to 85 per cent of its existing and projected carrier-based avionics.

Air Force stressing electronics for today

Electronic warfare programs are running into budget obstacles in the Pentagon for two major reasons:

- The programs are emphasizing far-out research rather than production capabilities.
- There is a lack of good "system effectiveness" measures to evaluate these systems.

These are the trouble areas cited by Lt. Gen. Jack J. Catton, Air Force Deputy Chief of Staff for Programs and Resources. He has urged the electronics industry to improve its competence in these two areas.

In citing the importance of electronic warfare, General Catton said in a Washington address to electronic specialists that Russian-built surface-to-air missiles (SAMs) had not been nearly as effective as the North Vietnamese had hoped they would be. He reported that American electronic systems for avoidance of both SAMs and radar-di-

News Scope CONTINUED

rected antiaircraft fire have led to steadily decreasing aircraft loss ratios. Despite the public impression of the war, the general said, ". . . not everybody is crawling around the jungle in black pajamas; we are engaged in a contest with an intelligent enemy who possesses extremely sophisticated and complicated electronic equipment and who knows how to exploit it to the maximum."

The electronic systems now being used in American aircraft were not available at the beginning of the conflict, he noted. In fact, he said, not one tactical aircraft now operating in Southeast Asia was designed with sufficient attention to electronic warfare systems. The F-111, soon to be operational, is the first such plane to have these provisions in its basic design.

In calling for the electronics industry to direct more attention to immediate production, General Catton said: ". . . too large a segment of the electronic industry is preoccupied with solving the problems of tomorrow rather than the problems of today."

To compete for funds in the Pentagon, the general commented, proposals for electronic warfare systems must be more firmly based on cost-effectiveness factors. Some standard measures are needed, he said, to permit comparisons of electronic warfare systems with other types of systems when the budgets are drawn. He suggested "penetrability" of an aircraft to its target might be one such measure.

The fall meeting of the Air Force Scientific Advisory Board will be devoted completely to electronic warfare.

New 'bird,' Pacific II, hovers over Hawaii

Pacific II, a new communications satellite, has joined an ailing Pacific I in synchronous equatorial orbit. The new "bird" is expected to be on station approximately over Hawaii and in full operation by mid-October.

One of the four traveling-wave tubes in the earlier satellite had failed, and the system was being used to full capacity. Although the tube that failed was on stand-by, another failure would have reduced service. Thus the new satellite was needed, according to the Communications Satellite Corp., in order to ensure uninterrupted operations.

If all goes as planned, four satellites, two over the Atlantic and two over the Pacific, will provide commercial service. Comsat Corp. contracts for the satellites under the 58-nation Intelsat consortium. NASA provides launching facilities.

The new satellite includes two redundant linear repeaters with 125-MHz bandwidth and four 6-watt TWTs. This provides 40 two-way voice channels. An omnidirectional biconical horn array radiates 15 watts of transmitted power,

Pacific II was launched Sept. 27 from Cape Kennedy, Fla.

More electronics sought for air safety

Congressman Richard L. Ottinger (D-N. Y.) has introduced new legislation to modify the Federal Aviation Act of 1958, which deals with air traffic rules. Essentially, he proposes a new subsection for the act to promote safety in commercial aviation (see "CAS: Aid to traffic safety in crowded skies, ED 10, May 10, 1967, pp. 17-23).

He has called on the FAA to consider strengthening flight rules in eight major categories. He has also urged the agency to install available advanced electronic traffic control equipment and to start developing and testing new types.

Many of the innovations pressed by the congressman are based on equipment and systems already proved by the military. Chief among his suggestions are:

3-D radars—He pointed out that the Navy has successfully used 3-D radar in Vietnam for nearly two years, yet the FAA has failed even to seek operational data on such equipment. The units he referred to are manufactured by ITT Gilfillan and cost $1.5 million each. While not necessarily feasible for direct domestic use, he said, the principle of 3-D radar should be explored as a possible alternative to the alphanumeric systems now in use.

Downed aircraft locators—The FAA, he declared, should develop a signaling device that would be activated immediately and automatically as soon as an aircraft crashes, to pinpoint the site of the disaster for ground and air search parties.

Airborne recorders—Testing of an airborne recording system that would keep a constant check on both pilot and aircraft performance should be accelerated. He cited the system now being tested by American Airlines as the sort of equipment needed.

Secondary radars and ILS—Back-up radars must be installed at each of the 23 principal U.S. airports, he said, and instrument landing systems should be installed at every airport handling scheduled airline services.

Airborne transponders—All regular aircraft should be required by the FAA to carry on-board transponders capable of automatically reporting the aircraft's identity and altitude.

Collision avoidance system—The development of an effective low-cost anticollision system for general aviation should be given top priority by the FAA. The danger of midair crashes will continue to be high until all aircraft are equipped with such devices, he said. The cost of developing such a system could be borne by the commercial airlines, he borne by the commercial airlines, the Congressman added.

Seamans to quit NASA

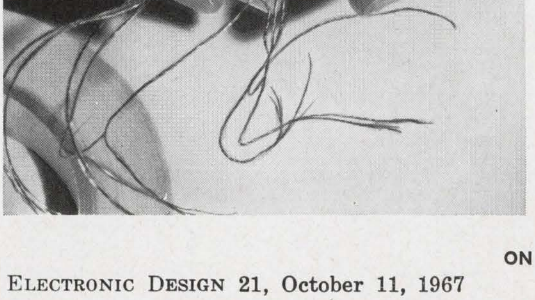
Dr. Robert C. Seamans, Jr., will leave his post as deputy administrator of NASA on Jan. 1. The number-two man in the National Space Agency, he ranks immediately below its head, James E. Webb.

Dr. Seamans has recently been involved in tangles with Congress over cuts in the NASA budget. He has expressed concern that the manned flight to the Moon may now be delayed to the early Seventies.

He said that he has no definite plans, but "I have been thinking for a period of time of leaving and going back to industry or to a university."

Before joining NASA in 1960, he was chief engineer for RCA's Missiles and Space div. in Burlington, Mass.

When it comes to electrical tapes, Mystik is king!



No doubt about it, Mystik leads the field in special-purpose tapes. Our extensive line of top quality products are perfect for hundreds of applications ranging from conventional industrial uses to the more sophisticated demands of the space age.

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ON READER-SERVICE CARD CIRCLE 12

Designers' IC testing costs head downward

Testers are offered at $495, but user can still pay $60,000 to $100,000 for an automatic system

Ron Gechman
West Coast Editor

"How can I test the integrated circuits I buy, and do it inexpensively, before assembling them in my equipment?"

Until a year ago this question was asked often by the small users of ICs who could not afford to buy the high-priced automatic testers available then.

Today users like these have a number of low-priced testers to choose from, and more are on the way. Their question now is: "What tester should I buy?"

Tester prices, previously at $60,000 or more, have dropped to $495 and up. You can still spend $60,000 or even $100,000 if you want a costly computer-operated automatic system. But a wide range of testers is available, depending on:

- How much information is needed about an IC.
- How automatic you want the testing to be.
- How many integrated-circuit devices must be tested.
- How much documentation is needed.

In addition, competition for IC-tester manufacturers may come soon from a new source. Testing service organizations, equipped with large, automatic computer-controlled testers, are beginning to operate. They are capable of running tests on small quantities of ICs at a relatively nominal cost, thus eliminating the need for the small IC user to purchase capital equipment.

$40-million market seen

Many tester manufacturers predict that the present IC test-instrument market of around $20 million a year should reach $40 million to $50 million by 1970. With the possibility of widespread use of ICs for applications in the home and in automobiles, some manufacturers feel that even these figures may be conservative.

Compact design of Beckman Instrument's analog-reading IC tester is evident in these units. They are said to be the least expensive on the market.

Tester manufacturers generally agree on where their market is and the people who need testers. Richard Barr, sales manager for one manufacturer, the Redcor Corp. of Canoga Park, Calif., sums up the categories of users this way:

- Semiconductor manufacturers that have produced small lots of ICs for a special purpose. Programing their automatic testers for testing these devices would be too costly and more time-consuming than using a small manual or semi-automatic tester.
- Small-production users, who may use one or more testers for receiving inspection, production testing and quality assurance.

Evaluation engineers in both large and small companies, for evaluating new devices and circuits and for qualifying a manufacturer's IC.

- Colleges and universities, for laboratory and classroom work.

Dynamic testing pressed

One of the more recent changes in testing philosophy is the move toward dynamic testing—testing under conditions that the IC will encounter when operating in its intended circuit. If an IC user is interested only in determining if a device is good or bad, such as in receiving-inspection functions, dc testing may be sufficient. However, a detailed evaluation of the device may be necessary to determine its suitability in a new circuit design.

Testers with a price tag of around $5000 seem to be the most popular on the market, with less sophisticated testers selling for $2000 and less.

The popular-priced testers include these:

- Beckman Instruments' Model 999, probably the least expensive. It sells for $495, and it tests the entire IC family for such parameters as input threshold levels, output current (both high and low levels) and short-circuit output currents.
- Birtcher Corp.'s Model 800. It includes the basic modules for dc

(IC tester, ***continued*****)**

Low-priced integrated circuit testers

Manufacturer	Model	Price	Readout	Current Range Measuring	Voltage Range Measuring	Forcing Voltage	Forcing Current	Program Technique
Aerotronic Assoc., Inc. Contoocook, N.H.	1061	$5900	Meter, provision for ext. DVM or oscilloscope	0 to 1 A	0 to 25 V	0 to 10 V	0 to 1 A	Thumbwheel switches
Beckman Instruments Inc. Richmond, Calif.	999	$495	Meter, provision for ext. DVM or oscilloscope	0 to 100 mA	0 to 10 V	0 to 10 V	0 to 100 mA	Slide and decade switches
Birtcher Corp. Monterey Park, Calif.	800	$2200	Meter, provision for ext. DVM or oscilloscope	0 to 100 mA	0 to 100 V	0 to 100 V	0 to 100 mA	Slide switches and pushbuttons
Computer Test Corp. Cherry Hill, N.J.	MICA-150	$11,200	DVM, meter optional	0 to 1000 mA	0 to 1000 V	0 to 100 V	0 to 100 mA	Slide switches
Continental Device Corp. Hawthorne, Calif.	9545	$4500	Go/No-go, provision for ext. DVM and printer	0 to 100 mA	0 to 20 V	0 to 20 V	0 to 75 mA	Plug-in cards
Integrated Systems Corp. Stowe, Vt.	1100	$750	Meter, provision for ext. DVM or oscilloscope	Presently not measured	0 to 30 V	0 to 28 V	0 to 200 mA	Slide switches
Microdyne Instruments Inc. Waltham, Mass.	710	$995	Meter, DVM and printer optional	0 to 100 mA	0 to 50 V	0 to 25 V	0 to 100 mA	Slide switches
Monitor Systems Inc. Ft. Washington, Pa.	851	$1920	Oscilloscope	–	–	0 to 7 V	0 to 35 mA	Prewired program
Optimized Devices, Inc. Pleasantville, N.Y.	IC 101	$1600	Meter, provision for ext. DVM	0 to 100 mA	0 to 100 V	0 to 100 V	0 to 100 mA	Slide switches
Redcor Corp. Canoga Park, Calif.	990	$4950	Meter, provision for ext. meter or oscilloscope	0 to 1 A	0 to 100 V	0 to 100 V	0 to 100 mA	Thumbwheel and pushbutton switches
RFS Engineering Co. Philadelphia, Pa.	1800	To be announced (Under $10,000)	DVM	0 to 100 mA	0 to 100 V	0 to 100 V	0 to 100 mA	Slide switches, automatic programed tape optional
Signetics Corp. Sunnyvale, Calif.	1100	$4995	Go/No-go	–	–	0 to 5.5 V, jacks for ext. 10 V supply	0 to 20 mA	Plug-in cards
Teradyne, Inc. Boston, Mass.	J133	$4850	Go/No-go	–	–	0 to 8 V	0 to 50 mA	Plug-in cards

Terminals	Dynamic Testing Capability	Sampling Oscilloscope	Pulse Generator	Tester Operation	Construction	Input Power	Weight	Size	Manufacturer
To 20 pins	No	No	No	Manual, programmer available for semi-automatic operation	Modular	115 V ac, 60 Hz, 80 W	90 lbs	W 21 in. H 22 in. D 23 in.	**Aerotronic Assoc., Inc.** Contoocook, N.H.
To 16 pins	No	No	No	Manual	Hardwired	115/230 V ac, 50-60 Hz, 10 W	10 lbs	W 16.50 in. H 7 in. D 12.25 in.	**Beckman Instruments Inc.** Richmond, Calif.
To 16 pins	Yes	Provision for ext. connection	Plug-in module	Manual	Modular	115/230 V ac, 50-60 Hz	65 lbs	W 19.50 in. H 25 in. D 13 in.	**Birtcher Corp.** Monterey Park, Calif.
To 40 pins	Yes	Provision for ext. connection	Plug-in module	Semi-automatic	Modular	105-125 V ac, 50-60 Hz	–	W 23.50 in. H 31 in. D 32 in.	**Computer Test Corp.** Cherry Hill, N.J.
To 20 pins	Yes	Provision for ext. connection	Provision for ext. connection	Automatic and manual	Hardwired	115/208 V ac, 50-60 Hz, 300 W	80 lbs	W 17 in. H 10.50 in. D 22 in.	**Continental Device Corp.** Hawthorne, Calif.
To 20 pins	Yes	Provision for ext. connection	Provision for ext. connection	Manual	Hardwired	115 V ac, 60 Hz, 85 W	14 lbs	W 14 in. H 9 in. D 8 in.	**Integrated Systems Corp.** Stowe, Vt.
To 16 pins	Yes	Provision for ext. connection	Built-in	Semi-automatic	Hardwired	115 V ac, 50-60 Hz, 10 W	–	W 12 in. H 10.50 in. D 15.50 in.	**Microdyne Instruments Inc.** Waltham, Mass.
To 16 pins	Yes	No	Built-in	Manual	Hardwired	115 V ac, 47-63 Hz, 50 W	27 lbs	W 17.25 in. H 7 in. D 11.75 in.	**Monitor Systems Inc.** Ft. Washington, Pa.
To 16 pins	Yes	Provision for ext. connection	Provision for ext. connection	Manual	Modular	115 V ac, 50-60 Hz, 25 W	30 lbs	W 23 in. H 10.50 in. D 14 in.	**Optimized Devices, Inc.** Pleasantville, N.Y.
To 16 pins	Yes	Provision for ext. connection	Plug-in module	Manual	Modular	110/220 V ac, 50-60 Hz	82 lbs	W 21.25 in. H 24.50 in. D 19.25 in.	**Redcor Corp.** Canoga Park, Calif.
To 16 pins	Yes	Provision for ext. connection	Plug-in module	Manual, automatic with optional programmer	Modular	115/230 V ac, 50-60 Hz	70 lbs	W 22 in. H 20 in. D 20 in.	**RFS Engineering Co.** Philadelphia, Pa.
To 14 pins	No	No	No	Semi-automatic	Hardwired	105-130 V ac, 50-60 Hz, 100 W	22 lbs	W 17 in. H 9 in. D 13 in.	**Signetics Corp.** Sunnyvale, Calif.
To 16 pins	No	No	No	Automatic	Hardwired	105-130 V ac, 50-60 Hz, 45 W	32 lbs	W 19 in. H 5.50 in. D 18 in.	**Teradyne, Inc.** Boston, Mass.

(**IC tester,** *continued*)

testing, as well as modules for testing linear ICs and generating pulse parameters for testing digital ICs. A built-in analog meter monitors each power supply or any device leads selected.

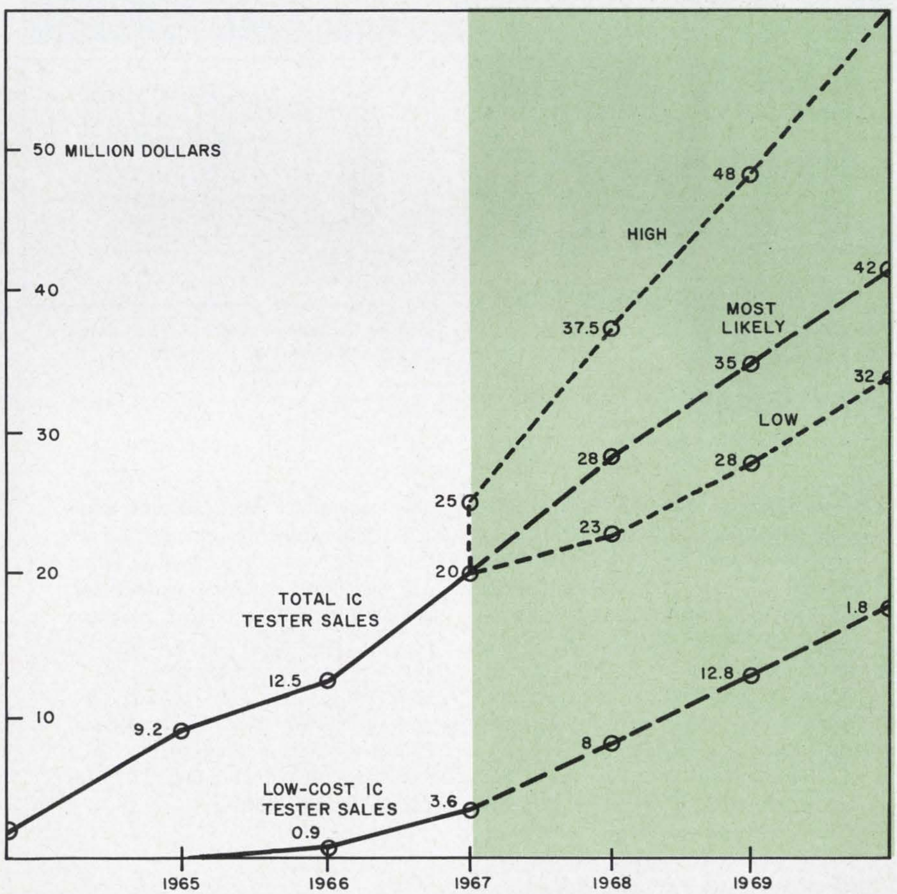
■ Computer Test Corp.'s MICA-150. It is capable of a wide variety of pre-programing test combinations, ranging from a single test on a 40-pin device to as many as 20 different tests on a 2-pin device. All test conditions are set up on two independent crossbar programing switches, which connect any of up to eight different function generators and a built-in DVM to the desired pins of the device under test. A pushbutton keyboard advances the test from pin to pin and program to program without resetting any switches.

■ Redcor Corp.'s Model 1900, which can perform dc, ac, linear, dynamic and functional tests on all currently available monolithic ICs. Programing is achieved with a digit switch register that selects the matrix connections. Testing is performed by sequentially depressing a series of programmable pushbuttons.

■ Signetics Corp.'s Model 1100. It subjects all devices to a series of six functional tests: continuity, orientation, power dissipation, functional, noise immunity and high-frequency toggle rate. Test results are displayed on go/no-go lights. A plug-in program board automatically programs the tester for the device to be tested.

■ Teradyne Corp.'s Model J133, automatically programed by inserting two plug-in cards in the front panel. One card is for the IC family being tested and the other for the particular device under test. The tester compares the results of the device under test with a similar device installed on the program board. Test results are indicated by a group of go/no-go lights on the front panel.

For the very-high-speed, computer-controlled systems prices start at about $60,000 and climb above



Annual IC tester sales of $20 million are expected to rise to about $40 million by 1970. Surveys see low-cost tester sales increasing five-fold in three years. The above data were compiled by Gordon L. Ness Associates, Los Altos, Calif.

(**IC tester,** *continued*)

$100,000. Fairchild Instrumentation holds about 80 per cent of the high-priced equipment market with its Series 4000 and 5000 IC test systems. Competitors include Texas Instruments' Model 861, AAI Pacific Div.'s Series 1000 and, to some extent, Teradyne Corp.'s Model J259.

Testing companies forging ahead

Typical of the companies that will test ICs for you is Fairchild Instrumentation's Los Angeles Test Facility, which began operating last June. The company uses a Fairchild 4000M test system to provide high-speed testing of dc and switching-speed parameters.

Capabilities include complete environmental testing and automatic recording of devices tested to a customer's specification. The cost of testing is based on the customer's requirements, test complexity and volume of testing. A typical charge to test a device on a go/no-go basis, at ambient temperature with about 34 dc tests, is 17 cents a device in quantities of 500 to 5000, plus a setup charge of $40.

Other manufacturers of IC test equipment are considering establishing service organizations for testing. Raymond Wells, vice presi-

Modular design of Birtcher Corp. tester can be upgraded by replacing the blank panel with a decade load module, for adding RC networks to the device under test, and a pulse generator, for measuring pulse parameters of digital logic circuits.

dent of the AAI Pacific Div. in Northridge, Calif., says his company is establishing a testing service using its Series 1000 as the basic test system. AAI expects to be in operation within a few months. Continental Testing Laboratories, Inc., at Orlando, Fla., is using Fairchild Series 4000 test equipment to provide testing service.

Integrated-circuit manufacturers have spent considerable sums to advertise the fact that they test their devices thoroughly before shipment, and often a small company just beginning to use ICs feels it is unnecessary to conduct further tests. However, even at the high testing speeds that the device manufacturers employ, only a partial profile of the device can be made. Testing costs would mount considerably otherwise.

The manufacturer of instrumentation equipment who designs with ICs must examine the IC himself in greater detail to determine all its limitations as they apply to his intended use.

Failures are expensive

Dugald Roy, product marketing manager for Texas Instruments' Apparatus Div. in Houston, says that a serious problem facing the IC user is to remove those devices from production that have failure characteristics before time is invested in mounting a bad device on a printed-circuit board. The cost for removing a defective IC from a board ranges from $15 to $100, with $30 the average price, according to Donald Ristine, test facility engineer for Fairchild Instrumentation in Los Angeles. It's cheaper to test a device before it is installed.

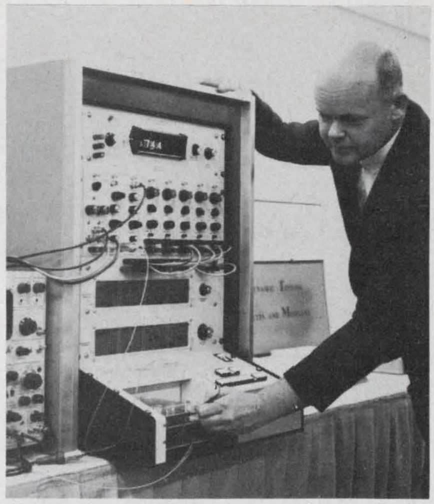
Some failure modes develop with time and cannot be determined at the time of the seller's final test of a device. Roy points to these possible failure modes:

- Cracks in the substrate caused by voiding or lead bonding that propagate with time.
- Wire embrittlement caused by overheating during bonding.
- Hot spots caused by diffusion spikes that stem from crystal faults.
- Thin spots in aluminum interconnects that fail under load.
- Shock-inflicted damage during shipment.

But the fact that a device has passed its static tests does not necessarily mean that it is suitable under dynamic conditions, Roy says. Tolerances in the manufacturing process, while improving, still cause variation from device to device. Even a slight variation of device geometry can cause serious degradation in the operation of a device. This, plus two other factors—cross talk and bandwidth degradation due to parasitic components and device geometry—create a need for dynamic testing, according to Roy.

The equipment to perform dynamic testing usually includes a pulse generator, sampling oscilloscope, high-frequency test fixture and a switching time converter. This equipment rapidly increases the cost of test equipment. Some of the lower-priced equipment can perform dynamic testing or have provisions for easily connecting the necessary equipment.

Most manufacturers report that technology has not been their major problem in designing testers. The problem has been to construct a machine with a minimum of operator set-up time. Daniel Marshall, product-line manager for Beckman Instruments, Inc., in Richmond, Calif., says: "Our biggest problem was to design a system so that an operator with a basic familiarity with ICs could run it without constantly consulting a manual."



Dynamic testing is performed by Computer Test Corp. tester by connecting a sampling oscilloscope to an internal pulse generator.

As for future prices, some companies feel that the cost gaps between the different categories of testers may become wider; others disagree. Irwin Roth, manager of instrumentation at the Signetics Corp. in Sunnyvale, Calif., believes that IC tester prices should decrease as more of any particular type are manufactured. He says, for example, that the price of Signetics tester will remain at $4995 for about the next six months, but will decrease thereafter. ■ ■

Fluidic tester developed for weapon circuitry

Electrical circuits in nuclear weapons may soon be checked automatically with a fluidic tester developed at Sandia Laboratories, Albuquerque, N. M.

The tester, according to Sandia scientists, would make greater use of automation than conventional testers, yet still comply with safety regulations limiting the use of electric current. Heretofore, automatic equipment has required larger power sources than Sandia standards permitted.

The fluidic tester operates as follows:

A perforated tape with programed instructions is threaded into the sensing head of a reader. The instructions are "read" by the action of air passing through the code holes in the tape. The holes are arranged in blocks of 320 and are read simultaneously.

The perforations in the tape allow the air to flow into an outlet in the bottom of the head, then into the 320 plastic tubes, one for each hole.

The air flow in each line sets up the selected metering circuit by flexing a leather diaphragm that pushes rods, linking the test circuit to conductors for the desired positive or negative polarity. The tester checks the circuit and tells the operator to record the test results. ■ ■

Army unveils its combat electronics at 'fair'

Suppliers view mobile radar and other equipment suited for surveillance along Vietnam's 'wall'

Neil Sclater
East Coast Editor

A cigarette-pack-sized electronic device designed to warn of sneak infantry attacks . . . a manpack radar that locates vehicles 10,000 yards away . . . a mobile radar with a computer that pinpoints enemy mortar and rocket emplacements.

These were a few of the 150 items on display at Fort Monmouth, N. J., as the Army Electronics Command held a Procurement Fair for more than 6000 suppliers in the United States and Canada. Communications, surveillance and meteorological equipment was shown. Conspicuously absent were such novelties as lasers and all-solid-state field radars.

The fair, designed to induce more manufacturers to participate in Army procurement, stirred added interest among observers who were seeking clues to what the Defense Dept. might use in the "electronic wall" to be built just south of the de-militarized zone in Vietnam.

The pocket-sized intrusion detector, intended to fend off sneak attacks by an enemy at night or in thick jungles, is essentially a combination buzzer and flashlight, activated by a break in a hair-thin loop of wire. The AN/GSS-9, as the tripwire device is called, is probably the least complex solid-state circuit now being procured by the Army.

A flick of a switch can make the alarm either a light or a buzzer. The small, olive-drab, waterproof plastic box contains a standard 1-1/2-V cell and a replaceable plug-in cartridge with two miles of No. 44 wire. According to the Army, broken strands can be fused together with a match.

False alarms expected

One sergeant at the fair, a veteran of Vietnam, was asked about the possibility of false alarms. He said he would prefer to crawl out at night to mend a circuit broken by wind or animals than to be unaware of approaching Viet Cong. The circuit may find use in the anti-infiltration barrier proposed in Vietnam.

The Army has been working for years to develop effective manpack combat surveillance radars, but they have gone into the field only recently. The inventory lists three models. All use noncoherent Doppler pulses to furnish aural intruder detection signals. They are intended to detect the movements of humans or vehicles in combat zones, primarily by means of an audio tone related to the radial velocity of the target.

All models have headphones that plug into main frame jacks and small telescopes for visual alignment of the antenna. Batteries are used for primary power but some have adapters for use with a vehicle power supply.

One model, the AN/PPS-4, has an effective range of about 1500 yards against personnel and 6000 yards against vehicles. The newer, lighter and more compact PPS-6 has a comparable range for personnel but its range on vehicles is only 3000 yards. The Army favors the heavier, more versatile PPS-5, because, in addition to producing an audio doppler beat note, it has a video chassis attachment with "A" and "B" scopes for visual target indication. The set's range is better than 5000 yards when people are the targets and 10,000 yards for vehicles.

Developed since 1955

The PPS-4 was first built by the Sperry Gyroscope Div. of Sperry Rand Corp. of Great Neck, N. Y., in 1955. The covered antenna produces a narrow pencil beam. More than 800 units were made by Sperry before production was discontinued. They are now on duty in Vietnam combat zones and are used for training in the United States.

The self-contained PPS-6, designed by the Army but favored by the Marine Corps, weighs 35 pounds. It employs solid-state circuitry but has a magnetron as a transmitter tube. It is tunable through the X-band region of 9.0 to 9.5 GHz. Its antenna also forms a narrow pencil beam. The Radio Receptor Div. of the General Instrument Corp., Hicksville, N. Y., is the builder of the system.

The PPS-5, a Ku-band system, weighs 95 pounds with all attachments: power supply, headphone,

Infantry troops use the AN/PPS-5 to detect the approaching enemy. The soldier in the center position is viewing target movement on a dual CRT attachment, but headphones can also be used to hear Doppler tone changes.

(**Army 'fair',** *continued*)

tripod, antenna and video chassis. It uses a magnetron operating in the 16-to-16.5-GHz region as its power tube. The antenna, a paraboloidal segment, produces a narrow fan-shaped beam. The builder is the Airborne Instrument Laboratory, a division of Cutler-Hammer, Deer Park, N. Y.

Manpack radars are expected to play a key role in routine patrolling of the Vietnam barrier.

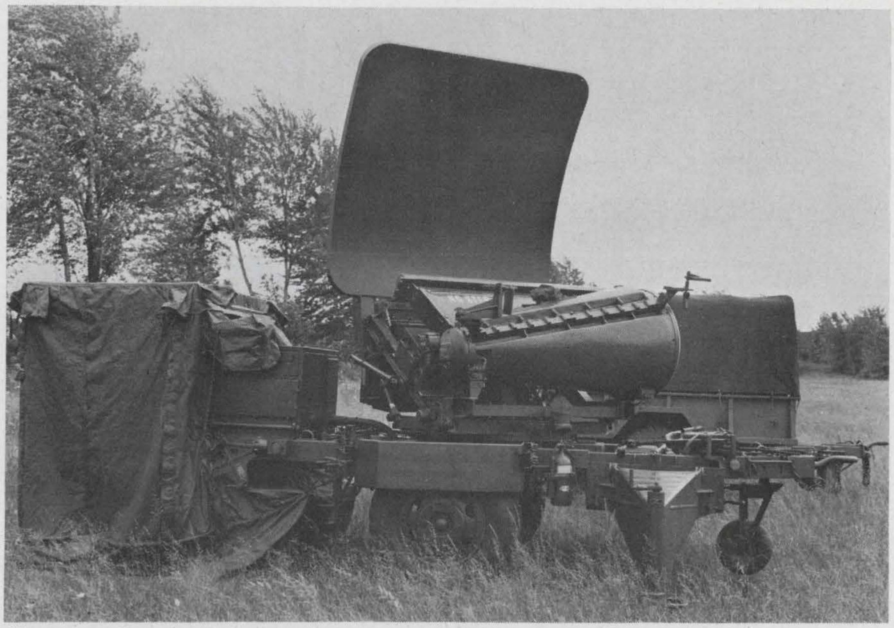
Radar pinpoints enemy mortars

Army personnel report excellent results in Vietnam from a radar mortar locator that was originally procured more than 10 years ago. An outgrowth of a model intended to locate North Korean mortars in a war with relatively stable front lines, the AN/MPQ-4 has nevertheless been remarkably successful in ferreting out Viet Cong mortar and rocket sites. The Army is buying more improved versions.

At first glance the MPQ-4 hardly looks like an ideal piece of equipment for war where jungles abound and the enemy is likely to be anywhere. Trailer-mounted, it is heavy and has a complex, rotating mechanical antenna feed, all-vacuum-tube circuitry and an electromechanical computer. And it has an antenna reflector that is more than 10 feet high. As if these were not bad enough, the system needs a large, heavy power-supply and can scan only a 25° sector at one time.

But when emplaced in critical areas where the general direction of the enemy is known, the set has proved to be invaluable. While it was designed to pick out mortars, field troops have found it extremely effective against rocket sites, too,—even those more than five miles from the radar.

The prime contractor of the MPQ-4, General Electric's Heavy Military Electronics Dept. at Syracuse, N. Y., has received orders for additional units. Company spokesmen say that kits will be furnished to improve the present equipment, but the circuitry will be essentially unchanged from that of 10 years ago. The Army wants to hold all changes to a minimum for technical and logistical reasons.



Mortar-and-rocket-locating radar, AN/MPQ-4, which has been around for 10 years, is proving itself against the Viet Cong. General Electric is building additional systems, but the Army still seeks an omnidirectional mortar locator.

The MPQ-4 transmits 16-GHz pulsed power in the form of two pencil beams having a vertical separation of 2°. A dual-beam Foster scanner feed system, rotating at 1000 rpm, emits radiation in successive half revolutions, thus producing alternate upper and lower fan-shaped sweeps. The rotor is calibrated so that the azimith of any target within the 25° scan is determined. A shell or rocket passing through the scan patterns gives two echo blips on the "B" scope range and azimuth display.

Two electronic cursors can be moved to intersect successively at the two target blips. The built-in analog computer receives range and azimuth data on the two points in the trajectory. The computer is then able to extrapolate the trajectory to ground level and thus locate the launcher. Accuracy is said to be 50 yards.

In Vietnam, the Army is using the MPQ-4 in conjunction with helicopter observers. The copters, hovering over enemy positions at night, pick up indications of a concealed enemy gun emplacement with infrared-detection equipment. The flight crew then calls for support from the radar, which is directed toward the suspected area. A helicopter crewman then tosses out a sand-filled soda can, which falls through the rf beam patterns. The radar's computer quickly determines the exact geographical coordinates, and artillery begins dropping shells on the Viet Cong emplacement.

The Army would like to have a weapon-locating system with all of the qualities of the MPQ-4 but able to scan through 360°.

The Army Electronics Command has held a design competition for an omnidirectional mortar locator. A contract has been awarded to ITT Gilfillan, Inc., Los Angeles, for a frequency scanned system. It will use four separate panel reflectors, each covering about 90°. Gilfillan expects to deliver the development model, AN/TPQ-28, to the Army next year.

Industry observers say that this procurement is so important to the Army that it is narrowing the time gap between approval of a development model and production to about a year instead of the more usual two to three years.

In addition to the omnidirectional problem, an effective replacement for the MPQ-4 would have to do a better job of handling signal attenuation due to rain. The present equipment uses a circular polarizer consisting of conductive strips embedded in a fiberglass cover. It is positioned over the feed slots on the antenna. General Electric engineers admit that the ability of the set to pick out targets in a driving rain is marginal, but fortunately rain also makes it difficult for the Viet Cong to fire mortars. ■ ■

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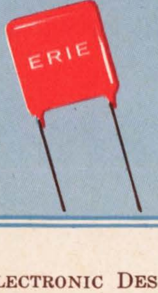

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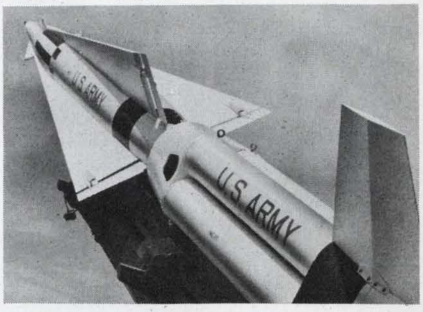


Washington Report

CHARLES D. LAFOND
WASHINGTON BUREAU

Sea-based missile defense sought

Defense Secretary Robert S. McNamara's announcement of approval for a thin-defense antiballistic missile system set off a round of oratorical applause that lasted several days in both houses of Congress. Dissenters remained very quiet.

One missile-hawk, Rep. Clinton P. Anderson (D-N.M.), proposed an early expansion of the Nike-X system with a sea-based antiballistic interception capability. He likened the Spartan-Sprint terminal-phase defense system to "the gladiator's helmet and breast plate." The United States scientific establishment "now offers us a shield or net," he said in referring to the sea-launched interception potential.

Hughes Aircraft of Redondo Beach, Calif., has been awarded a six-month, $720,000 contract to study the sea concept, code-named SABMIS. Lockheed Missiles and Space in Sunnyvale, Calif., will do subcontracting work on the project. The system probably—but not necessarily—would employ Spartan missiles together with the electronic support components of Nike-X. It would be carried aboard surface ships. It would complement the ground-based Nike-X elements but would intercept ballistic missiles during the phase of flight prior to separation of multiple warheads or decoys. The cost of the system has been estimated optimistically by the Navy at about $2 billion. It should be noted, however, that even if feasibility studies prove out, the earliest that the program definition phase could be initiated would be 1969, and if all went well, operational elements would not be available before 1975.

Electronics raising bombing accuracy

To assure pinpoint bombing and strafing accuracy for the close support of troops in Vietnam, greater emphasis is being placed on electronics development—not only for on-board systems but for air and ground fire-support techniques. During the annual Air Force Association conference here, Col. A.B. Martin of the Air Force's Límited Warfare Office, disclosed that both F-4 and F-105 fighter-bombers have had their bombing systems modified to perform "surgical strikes." Typical new approaches for attacking obscured targets include the use of modified radar bomb-scoring systems for ground-controlled bombing. For greater accuracy in the future, Colonel Martin said, new programs employing laser technology and other terminal guidance schemes are being developed.

The bomb-scoring system technique is the reverse of the conventional use of such hardware—that is, instead of plotting the hit location based on an aircraft's position, speed, etc., at the time of ordnance release, the curve is plotted electronically from a known target to the aircraft by ground controllers, and the bomb release is directed by them. The first laser guidance system expected to see operational use, informants claim, probably will be semi-active. In this approach, a forward air controller illuminates the target from a station-keeping aircraft and the missile or guided bomb homes on the reflected echo or point of high radiation contrast.

Voyager cutbacks assailed in Senate

Expressing his concern over further reductions in NASA's appropriation for fiscal 1968, Sen. Thomas H. Kuchel (R-Calif.) has denounced the total elimination of funds for Project Voyager and advanced missions and a 50 per cent cutback of funds for Nerva, the nuclear rocket engine. Kuchel cited a recent report from the President's Science Advisory Committee that strongly urged a high national priority for planetary exploration in the post-Apollo period (1975-1980). The deletion of Voyager, the Senator told his colleagues in a Senate speech, "may well mean a halt to the U.S. planetary program after Mariner Mars 1969, and thus abdication of the program to the

Washington Report CONTINUED

Russians, who have launched 18 planetary missions to our five."

Britain joins Mallard program

Reversing its earlier position, Great Britain has expressed its desire to join the United States, Canada and Australia in developing an advanced automatic military field communication system. To be constructed under what is called the Mallard program, the system would provide high-speed, versatile digital communications (voice, telegraph, data and facsimile) with automatic switching from the field army headquarters level down to battalion. It also would include supporting air and naval elements. Research and development costs alone for Project Mallard are estimated by the Dept. of Defense at $126 million, and the total system costs are expected to reach $1 billion to 1.5 billion over an eight-year period.

The British had held out for specific allocations of contracts by the participating nations, while the United States, which will bear the largest share of costs, pressed for open competition. Apparently a compromise was reached, in which an open competition will be held for Mallard design contracts but with the stipulation that two U.S. and one British contractor be selected. Initial contracts are expected to be on the order of $20 million each.

In the final production phase, according to project headquarters officials at the Army Electronics Command, Fort Monmouth, N. J., major subsystems will be contracted individually. American team bids have been submitted by Communications Systems, Inc.; Hughes, ITT, Philco-Ford, RCA, Raytheon and Sylvania.

Rise in contractor benefits proposed

A new clause to raise the war-zone benefits for contractor personnel has been proposed for future U.S. defense contracts by the Armed Services Procurement Regulations Committee. The present Defense Base Act states: ". . . the cost of such war-risk insurance shall not be reimbursable under a cost type contract or a proper element of cost for consideration in negotiating a fixed-price contract."

The armed services committee clause would raise disability payments from $70 to $150 a week, funeral-cost payments from $400 to $1000, and the maximum injury compensation from $24,000 to $50,000. It also would raise the maximum average weekly wage limit used for computing death benefits from $104 to $224. Industry comments, sought by the committee chairman, Col. Reagan A. Scurlock, should be submitted by Oct. 23.

IC sales climb 56% in six months

Integrated-circuit sales for the first-half of the year totaled $104 million, an increase of $38 million, or 56.6%, over the same six months of last year, according to the Electronic Industries Assoc. Despite a steady decline in unit prices, the association says, factory sales jumped from roughly 12,000 units in 1966 to over 27,000 units this year, for a 128% gain.

Electronics: weighty in the budget pie

Ever wonder where your taxes go? Well, excluding interest payments on the national debt, the Air Force Systems Command takes the largest piece of the pie. And from 40 to 45 per cent of its expenditures were for electronics or associated R&D. According to Air Force figures, 6% of the total Federal budget for fiscal 1966 went to the Systems Command for research, development, tests, evaluation and production. This turns out to be about one-third the entire Air Force appropriation for that year.

FCC moving to new headquarters

The Federal Communications Commission has begun moving to new Washington quarters in a new building at 919 M St., N.W. For 33 years the agency has occupied offices in the Post Office Department's headquarters building at 12th St. and Pennsylvania Ave., N.W. The new FCC headquarters, occupying some 205,000 square feet in the eight-story building, will house all FCC facilities, except the laboratory in Laurel, Md., a license-processing office in Gettysburg, Pa., and 24 field offices and 18 monitoring stations in the country. The move which began Oct. 1, will be completed over a five-to-six week period.

ON READER-SERVICE CARD CIRCLE 22

Thin beam doubles CRT resolution

A new cathode gun that produces a very narrow or, "laminar," beam of electrons is reported to double the resoluton of CRTs.

The development is being incorporated in a new series of cathode-ray tubes to be manufactured by the English Electric Valve Co. of Chelmsford, England.

In the new tube, the cathode and focusing assembly produce an electron beam with no crossover, and thus only a narrow divergence. The resulting laminar beam has a uniform electron density across the beam, instead of the normally Gaussian, or bell-shaped distribution.

The even density of the laminar beam produces a spot with uniform brightness and a very sharp edge. In addition the narrowness of the beam at the deflection point results in much reduced deflection defocusing. The spot size may be varied also without defocusing.

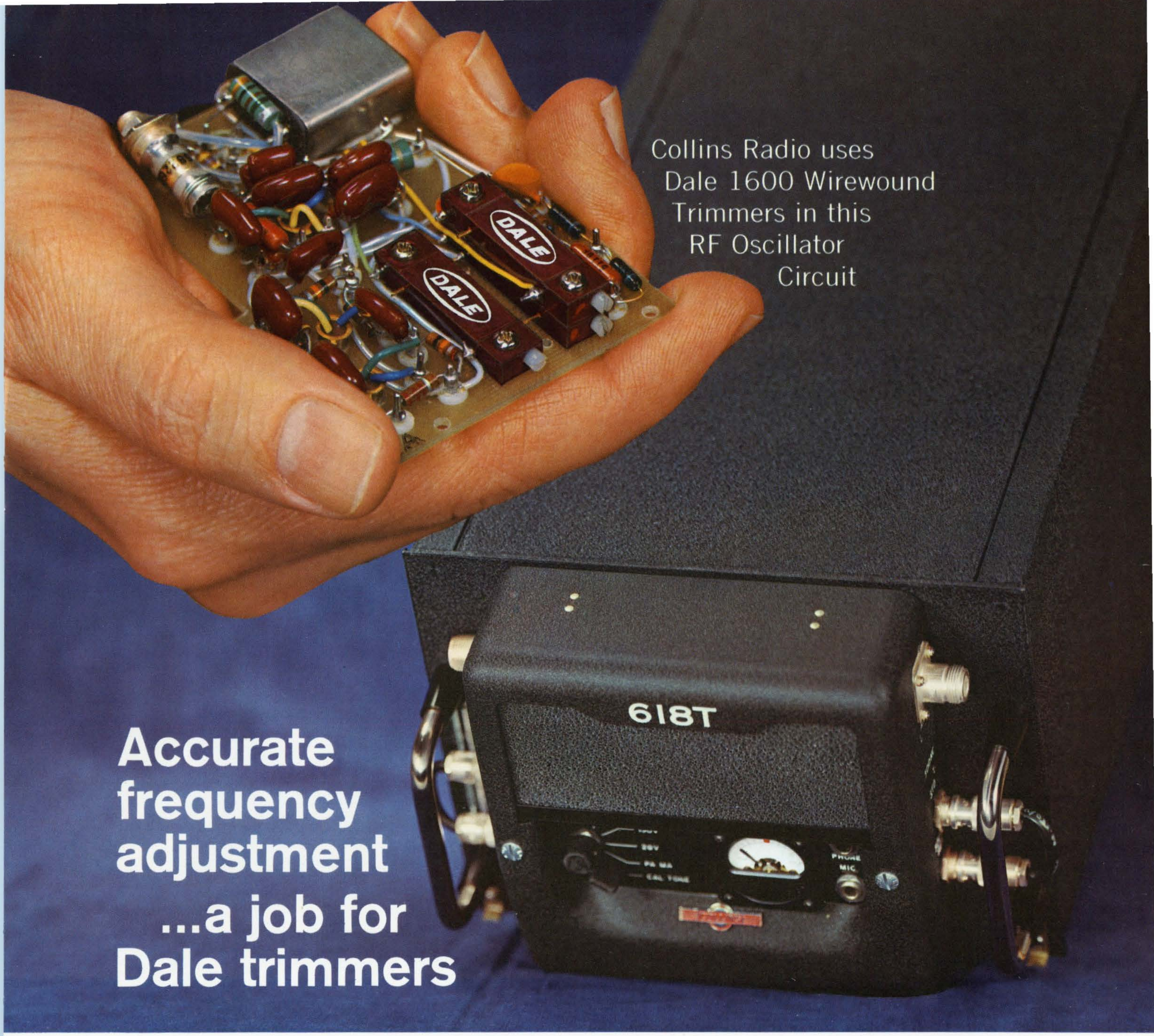
Roger Thompson, English Electric's manager of display tubes, asserts that these advantages give the laminar beam tube a 2:1 improvement in resolution.

Thompson also notes that the narrowly divergent beam requires a weaker focusing field, enabling the manufacturer to use a metal spiral mounted on the inside of the neck of the tube. This precludes the possibility of breakdown between high-voltage-focusing electrodes—an important consideration in transistorized equipment.

The cost of the new tube is expected to be approximately 30% higher than that of a conventional tube.

Gettering, the removal of residual gases from the tube, is less effective with the new design. A smaller gettering area—the result of placing the getter behind the cathode gun—means that the tubes have to be vacuum pumped for a longer time. Work is in progress to place the getter in front of the focusing spiral, to enlarge the sputtering area and thus reduce the pumping time, Thompson reports.

After two years of development work, English Electric expects to begin delivery of CRTs with laminar beams in November. ■ ■



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Carrier control is key to solid-state future

The control and precise location of ionizable atoms or dopants in host semiconductor materials is the next major step in the advance of solid-state technology, according to a Cornell University physicist.

Prof. Robert Sproull, a vice president of the university, told a recent conference at the Ithaca, N. Y., campus: "We are approaching a whole new era of sophistication in the doping of solids." He added that in future not only would the concentration and types of dopants be known, but it would also be possible to specify their exact location in the crystal.

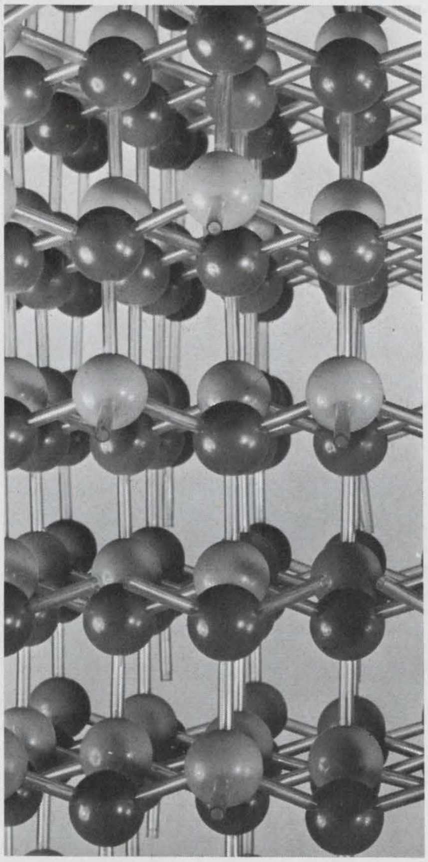
Professor Sproull, speaking at the recent High-Frequency Generation and Amplification Conference, said there were many promising approaches in solid-state physics that could be expected to yield new, exciting devices. He listed some of these as:

- Superconductivity phenomena based on the use of semiconductors containing various iron ions.
- Channeling techniques in which heavy ions are made to oscillate between the crystal planes.
- Ion implantation in which the surface of the solid is bombarded selectively with ions at specified energies.
- Geometrical control of impurities in solids in which known impurities are placed at specific dislocation boundaries or lattice discontinuities within the solids.

Professor Sproull predicted that within twenty years it would be possible to specify impurity concentration of less than ten parts per million in crystals. He said that this would open the door to future developments equal to those which have already been made with relatively impure materials within the past few years.

We are a long way from "scratching the ceiling" on fundamental limitations in solid-state physics, the professor said. As an example of how great a gap there is between the present state of advancement and fundamental limits, he cited information storage.

At present, he said, it takes about 10^{-8} cubic meters to store one bit of information. Now memory devices such as thin films are progressing toward the goal of 10^{-15} cubic meters to store one bit. But the fundamental limit is the space occupied by one active atom: 10^{-29} cubic meters, he explained. So, too, switching power is still a long way from its theoretical limit, he added.



Precise control of dopants is the next step for solid-state lattices.

Professor Sproull referred to a widespread notion that "science is running out of steam" and that future effort was not likely to come up with such interesting devices as Gunn oscillators and solid-state lasers. He also noted a tendency to reject concepts if they were not immediately applicable to a practical device.

He disagreed with such views. Based on the accomplishments of the past 20 years, he forecast that many undreamt-of devices will come out of future research if it continues at its present pace. ■ ■

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Whiskered cathodes are cool emitters

Cornell study shows semiconductors may replace conventional barium oxides in CRT electron guns

Neil Sclater
East Coast Editor

A new cold cathode with hundreds of microscopic "whiskers" on its emitting surface may be used in electron guns for cathode-ray tubes and other electronic display devices. The cathode, which requires no external heating, produces high current densities that are competitive with conventional barium oxide emitters. Moreover the new emitter uses less power.

The high electron emitting quality of certain semiconductors with the whiskered surfaces was discovered by two Cornell University scientists: Dr. Takao Utsumi and Prof. G. Conrad Dalman, both of the School of Electrical Engineering, Ithaca, N. Y.

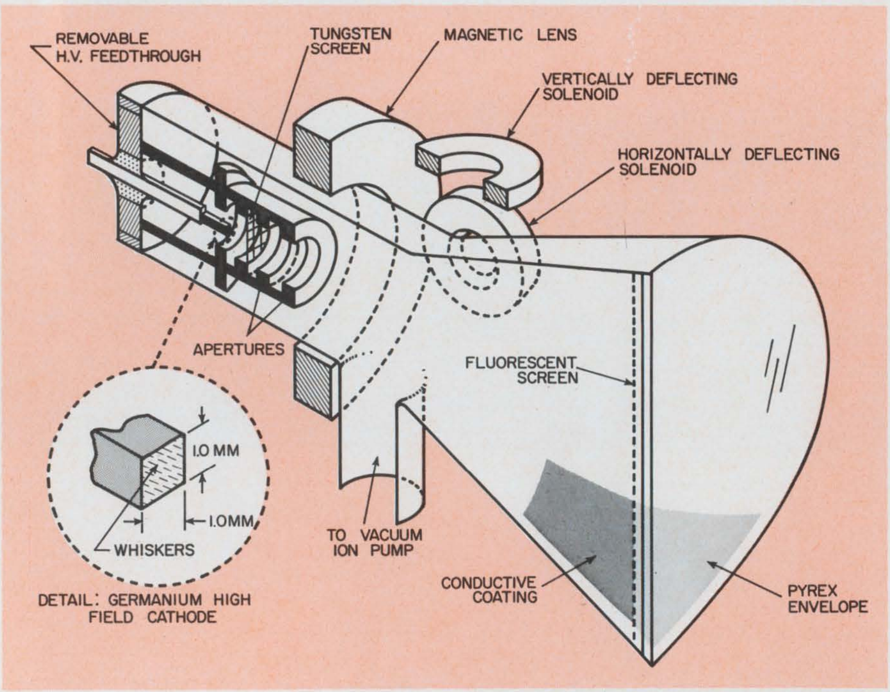
The micron-sized projections act as individual electron stream sources, Dr. Dalman explains. So effective are they at emitting electrons when set in parallel plane diodes with appropriate voltages that no external heat energy is required, he says.

Generated initially by a voltage breakdown process, the whiskers, according to the researchers, apparently go through a continuous death and regrowth cycle. Electron densities of greater than 1 ampere per square centimeter have been obtained from both silicon and germanium samples, with emitting surfaces of only 1 square millimeter.

To demonstrate the feasibility of the cathode, Dr. Dalman and Dr. Utsumi constructed a laboratory cathode-ray tube (see illustration). The cathodes used were typically bars of n-type germanium with a 1-square-millimeter cross section, 15 millimeters long. The material, with a resistivity of 2 ohm-cm at room temperature, was machined, polished and then chemically etched.

The emitting whiskers were produced initially by a voltage breakdown process. However, Dr. Dalman indicates that other successful growth methods have been demonstrated.

In the successive breakdown process, the raw cathodes were mounted in a test diode within a high-vacuum bell jar. Controlled low energy arc discharges were produced between the cathode and a removable tungsten anode. The electrostatic forces apparently caused the semiconductor growth. The process was repeated until the researchers grew what they considered a satisfactory number of whiskers.



High field cathode in demonstration cathode-ray tube needs no heater. Cornell University device gives 1 A/cm^2 electron emission density from novel whiskered cathode in the parallel plane diode structure.

Growing the whiskers

Dr. Utsumi and Dr. Dalman were able to measure the current produced by the cathode after each breakdown and were able to view the emission patterns, by inserting a fluorescent screen in place of the movable tungsten anode.

As a result of beam-spreading measurements, the researchers were able to estimate the approximate whisker height and thickness on a satisfactory sample. Each whisker was found to be about 0.2 micron in diameter and about 2 microns high. With a distribution of about 50,000 per square centimeter, the quantity was found to be relatively sparse on a one-square-millimeter surface. The spacing between whiskers is roughly comparable to one paper clip standing alone on a desk top. Electron microscope observations tended to confirm the estimates.

The Cornell scientists mounted the processed cathode in the experimental cathode-ray tube (see illustration). The electron gun consisted of the cathode, an accelerating grid mesh, and a pair of apertures to define the beam. This assembly was mounted on a removable feedthrough assembly.

The demonstration gun, which was never removed from the vacuum pump, was used to produce Lissajous figures. A simple magnetic

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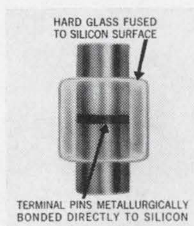

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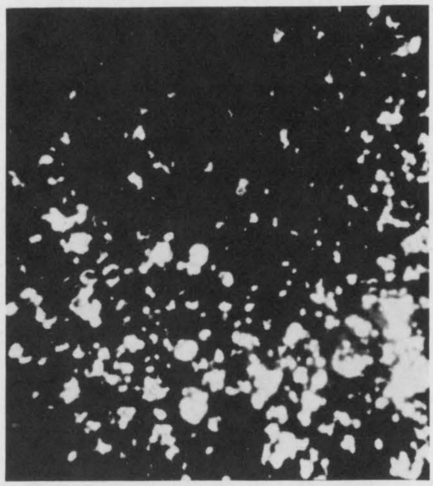
(**cold cathode,** *continued*)

lens focused the electron beam on the fluorescent screen, and two external solenoids were used to deflect the beam.

Although they see possible applications in display tubes, cold cathode vacuum tubes and radiation resistant electron devices, the researchers do not believe that the concept, in its present state of development, is adaptable to low noise tubes.

The cathode work was supported by the U.S. Air Force Rome Air Development Center. ■ ■



Electron-emission patterns from the whiskered cold cathode, as seen on a microphotograph.

'Detective' computer matches bullets to guns

Gun crimes of the future may be solved with digital computer techniques. With a new system called BALID (for Ballistics Identification), developers at Computer Technology, Inc., say that markings on a recovered bullet can be scanned and compared automatically with pre-stored data to establish the origin and possibly the ultimate ownership of a weapon.

The technique employs three different computer programs and electromechanical scanning, according to Bernard Scott, developer of the system and research director at Computer Technology. A Digital Equipment Corp. model PDP-85 scientific computer and a Talysurf 4 surface analyzer have been used in laboratory demonstrations. The latter produces analog tracings that are then converted to digital form for entry into the computer.

Bullet markings are stored

One program is employed to accept scanner outputs and produce an index reference of the ballistic markings of a bullet from each particular weapon. The second stores these data approximately on magnetic tape. The third program is used to match the characteristics of a "search" bullet against the stored information and to find and identify the most probable match, if one exists in the data bank.

The Talysurf 4, manufactured in England by the Rank Taylor Hobson Div. of the Rank Organization, uses a standard 0.0001-inch-diameter stylus to obtain surface tracings of the lands and grooves of a bullet. A solid-state scanner, it provides horizontal amplification of up to 500 times and vertical amplification of up to 100,000 times. The pick-up arm has a bearing force of 0.1 gram and traces at a rate of 0.002 inch per second. A typical six-land bullet can be scanned completely in 10 minutes, Computer Technology says. Repeatability of the pengraph used is 99%, the company reports, providing an accurate graphic representation of surface characteristics.

During the scanning process, the resultant analog signal is sampled 20 times a second, and these data are converted to 10-bit ordinates for entry into the digital computer. The data are then processed for storage as surface indices suitable for conventional comparison techniques. Coarse-mesh logic is used for recognition—that is, a reasonable distortion range is permitted before it loses the capability for recognition.

The BALID system was described by its developer at the recent 1967 Conference of the Association for Computing Machinery in Washington. ■ ■

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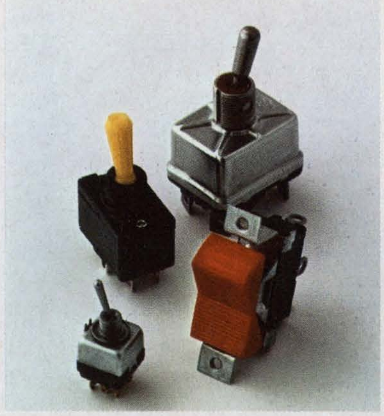

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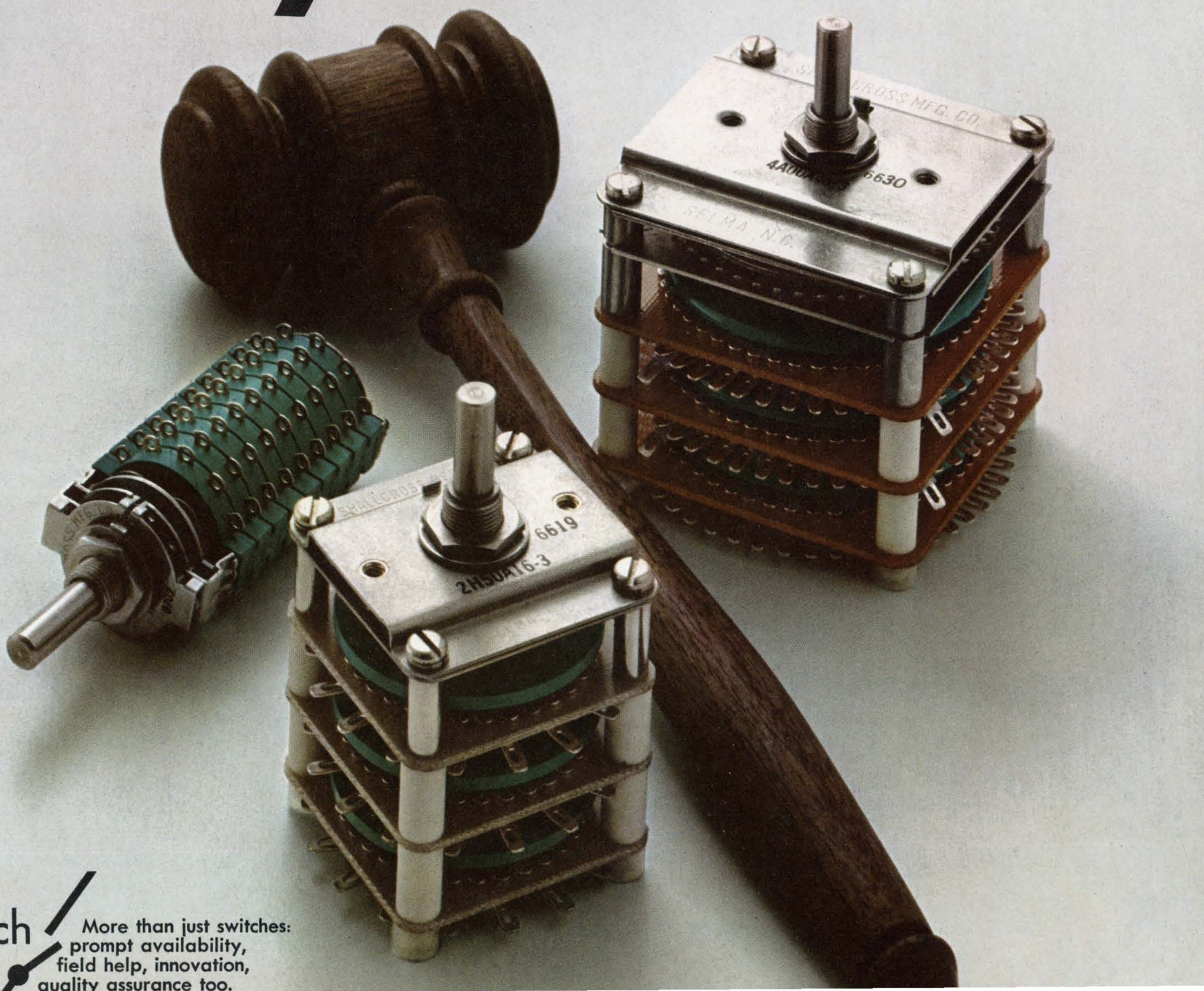

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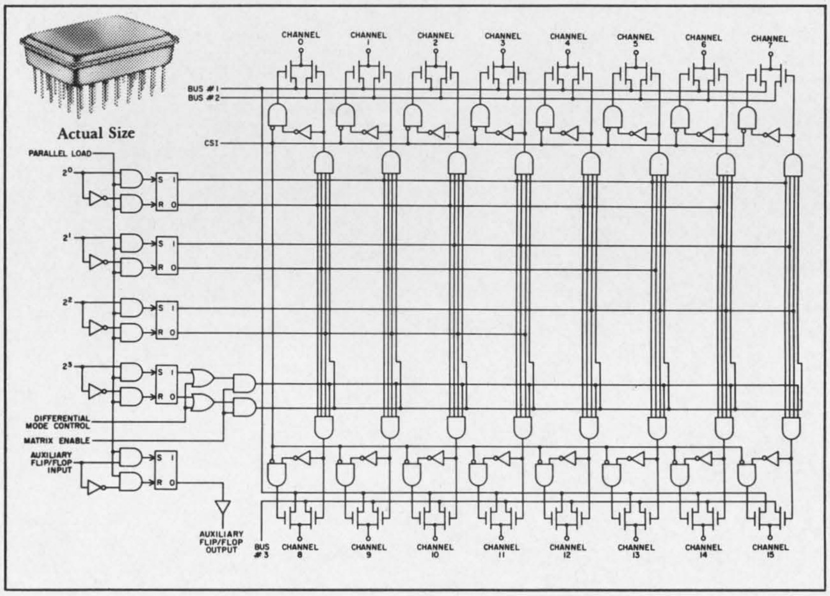

General Instrument's MEM 5015 is the newest complex integrated circuit available in the rapidly expanding line of MTOS firsts. It is a monolithic MTOS Large Scale Integrated Circuit containing 223 P-channel enhancement mode transistors on a chip 77 x 74 mils operating as a 16 channel randomly addressable multiplexer. The unit consists of four address holding flip-flops, a "four-in/sixteen-out" decoding matrix, 16 single-pole-double-throw switches, and some auxiliary logic for increased versatility. A Current Shunt Inhibit control line permits the selection of Current Mode or Voltage Mode multiplexing, while the Differential Control allows the switches to operate as eight ganged pairs. A Matrix Enable line allows multiple MEM 5015s to be connected to form larger multiplexing arrays.

The MEM 5015 is in a 40 lead hermetically sealed in-line package which can be soldered to a printed circuit board or used with a 40 pin socket. They're available off-the-shelf from your authorized General Instrument Distributor. In Europe, contact General Instrument Europe, Via Turati 28, Milano, Italy. Write for complete data.

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Letters

Corona detection method criticized as retrograde

Sir:

Your May 24, 1967, issue has an Idea for Design, "Pocket radio detects corona or insulation breakdown" [ED 11, p. 114]. When I read this, I felt that the industry had taken a giant step backward, at least 15 years.

It has been shown in the literature that the proposed radio detection method will in fact detect corona, but it can be extremely insensitive and in this case uncalibrated. This could be compared to making a voltage measurement with a voltmeter without a scale and without knowing what its full-scale deflection is. The only thing you know is that you have an indication.

It has further been shown that this type of detection produces an integrated evaluation, in that there are two conditions that could produce the same result:

- Corona in one site producing large-amplitude signals which could be quite damaging.
- Corona in several sites producing small-amplitude signals which could be quite harmless.

The idea of inserting an antenna into a case which has high voltage contained in it could be extremely hazardous.

I hope I have not appeared too critical, but I felt it necessary to express my views on this approach to corona-testing.

C. J. Saile
Development Engineer
Engineering Dept.
James G. Biddle Co.
Plymouth Meeting, Pa.

The author replies

Sir:

It would seem appropriate to point out that all test laboratories are not equipped with specialized corona test sets. Under these circumstances simple checks by the method I have described may be used initially to determine if more complex testing is required. Moreover, certain kinds of go/no-go testing may be completely performed in the manner described. The key feature of the method lies in the novel use of a pocket radio as a simple test set.

In the case of any high-voltage testing, it must be expected that appropriate caution would be exercised at all times. Doing otherwise would be analogous to operating an ac-dc radio while taking a bath.

Kenneth G. Holmes
Chief Engineer
Magnetic Circuit Elements, Inc.
Montrose, Calif.

Human-factors report defended by authors

Sir:

As the authors of the human-factors study cited in your "Washington Report" in ELECTRONIC DESIGN for July 19, 1967 [ED 15, p. 30], we take exception to the way in which the article was slanted. The casual reader might infer from your story that:

- It is worthless to provide human-factors data to engineers because those data are less than perfect.
- Design engineers have been unjustly accused (perhaps by human-factors engineers) of ignoring the data "handed to them at great expense by the military establishment."

Neither conclusion is justified.

The research study performed was part of a continuing effort by the Office of Naval Research to improve the manner in which human-factors data are disseminated to engineers. Among other things, the study pointed out that design engineers do ignore human-factors data and that their designs are much less effective than they would be if they used such data. One of the major problems in communicating with design engineers is their unwillingness to consider concepts and data from outside their own disciplines. This is why it is so necessary for such specialties as reliability, maintainability, systems engineering, value engineering, etc., as well as

(continued on p. 46)

ON READER-SERVICE CARD CIRCLE 34

WAVETEK uses Allen-Bradley Type F variable resistors exclusively because of their

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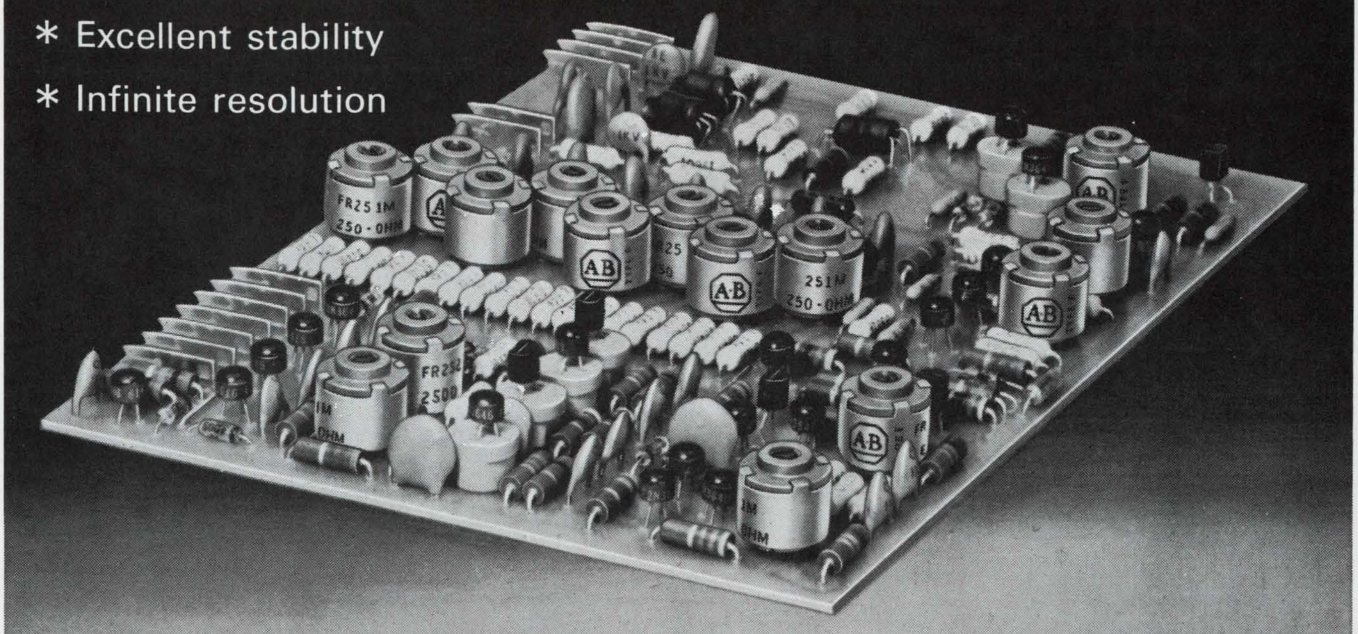
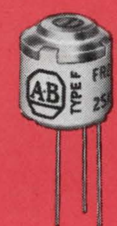
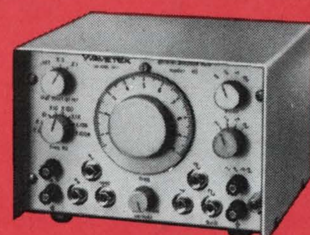


One of the 5-inch by 6½-inch Wavetek printed circuit cards, showing 15 of the 25 Allen-Bradley Type F hot molded variable resistors and numerous hot molded fixed resistors used in the Model 111 VCG function generator.



Type F variable resistor with pin type terminals for mounting directly on printed wiring boards. Rated ¼ watt at 70°C. Total resistance values from 100 ohms to 5 megohms. Actual Size



Wavetek Model 111 VCG generates sine, square, triangle, and ramp waves from 0.0015 Hz to 1 MHz, and offers precision control of the frequency of the waveforms by external voltage.

The precision waveforms generated by Wavetek's Model 111 VCG place exacting demands on the large number of variable resistors used to set amplitudes to very precise values and assure symmetry of all functions. They must provide velvet smooth control, and quiet operation. And since this is a Wavetek adjustment, it is essential that the variable resistors, once adjusted, will stay "put".

Allen-Bradley Type F variable resistors satisfy all of these requirements, because they have the same solid hot molded resistance track as the famous Type J and Type G variable resistors. There's velvet smooth control at all times—never the problem of discrete steps common to all wire-wound units. And since Type F variable resistors are essentially noninductive and have low distributed capacitance, they can be used at high frequencies where wire-wound controls are useless.

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For more details on the complete line of Allen-Bradley quality electronic components, please write for Publication 6024. Allen-Bradley Co., 1344 South Second Street, Milwaukee, Wis. 53204. In Canada: Allen-Bradley Canada Limited. Export Office: 630 Third Avenue, New York, N.Y., U.S.A. 10017

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(continued from p. 42)

for human factors, to improve the nature of their dialogue with the engineer.

The study was certainly not designed to demonstrate, as your story subtly implies, that human-factors data and the human factors discipline itself are unimportant and unnecessary for better design. Quite the contrary. With 20 years of human-factors experience behind us, we are astounded by the gross errors produced by engineers who "ignore human-factors data." We are even more dismayed when we contemplate what design would be like today if the human-factors discipline did not exist.

While it is unlikely that a single study would "jolt" the Pentagon into reversing its "unending battle to coordinate engineering design with human-factors studies," it is unfortunate that reputable engineering journals such as ELECTRONIC DESIGN misinterpret the effort which the human-factors discipline is making to improve the quality of its services to the enginering profession.

The study that we performed demonstrated that there is still a hard core of indifference and hostility to human factors which permeates "old-line" engineers. Apparently your story demonstrated that indifference and hostility also exist among engineering reporters.

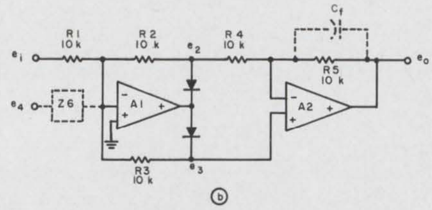
D. Meiser
Technical Director
Human Factors Programs
The Bunker-Ramo Corp.
Canoga Park, Calif.

Modification urged for 'ideal rectifier'

Sir:

The "ideal rectifier" of Fig. b, ["Ideas for Design" section, ED 13] June 21, 1967, p. 96, is a fine idea except for one easily remedied shortcoming. It amplifies negative inputs by −1.5 and positive inputs by +1.0. This unequal rectification can be remedied by making $R3 =$ 2/3 the value of the other resistors.

The reason for this unequal amplification is that positive inputs



Full-wave rectifier amplifies unequally unless R3 is made equal to two-thirds the value of the other resistors.

are multiplied by $(R2/R1)(R5/R4) = 1.0$, while negative inputs are multiplied by $[R3/R1]\,[(R2 + R4 + R5)/(R2 + R4)] = 1.5$. The latter holds because the e_2 diode cuts off for negative input and the junction of $R1$ and $R2$ is a virtual ground. Thus the summing resistor for $A2$ is $(R2 + R4)$, giving a gain from the $A2$ positive input terminal of $[(R5 + R2 + R4/(R2 + R4)] = 1.5$.

If we change $R3$ to 2/3 the value of the other resistors, we get a gain for negative signals of 2/3 from the e_1 input to the positive input of $A2$. This gives an over-all gain of 1.0 when multiplied by the 1.5 gain calculated above.

Nathan O. Sokal
President
Design Automation, Inc.
Lexington, Mass.

Myron S. Wolf
Design Engineer
Missile Systems Div.
Raytheon Co.
Bedford, Mass.

Accuracy is our policy

In "Y-parameters simplify mixer design," ED 7, April 1, 1967, pp. 68-74, author Ernest Klein has made the following corrections:

On p. 71, column 2:

$1/y_{11e}{}^* = (160\ \Omega\| -50.5\ \text{pF})$,

not $y_{11e}{}^* = \ldots$ as printed.

$1/y_{22e}{}^* = (3.7\ \text{k}\Omega\|\ 9.0\ \text{pF})$,

not $1/y_{22e}{}^* = (37\ \text{k}\Omega\| -9.0\ \text{pF})$ as printed.

On p. 72, column 1:

$$L_p \approx L_s = 43.5\ \mu\text{H},$$

not 54.5 μH as printed.

On p. 72, column 2:

The required inductance for resonance at 30 MHz is $L = 0.3\ \mu$H (not 0.6 μH as printed). The reason for this is that the capacitance at this point is C_p plus the capacitance of the transistor, or 49.5 pF + 50.5 pF = 100 pF. Therefore, for resonance, $L = 0.3\ \mu$H.

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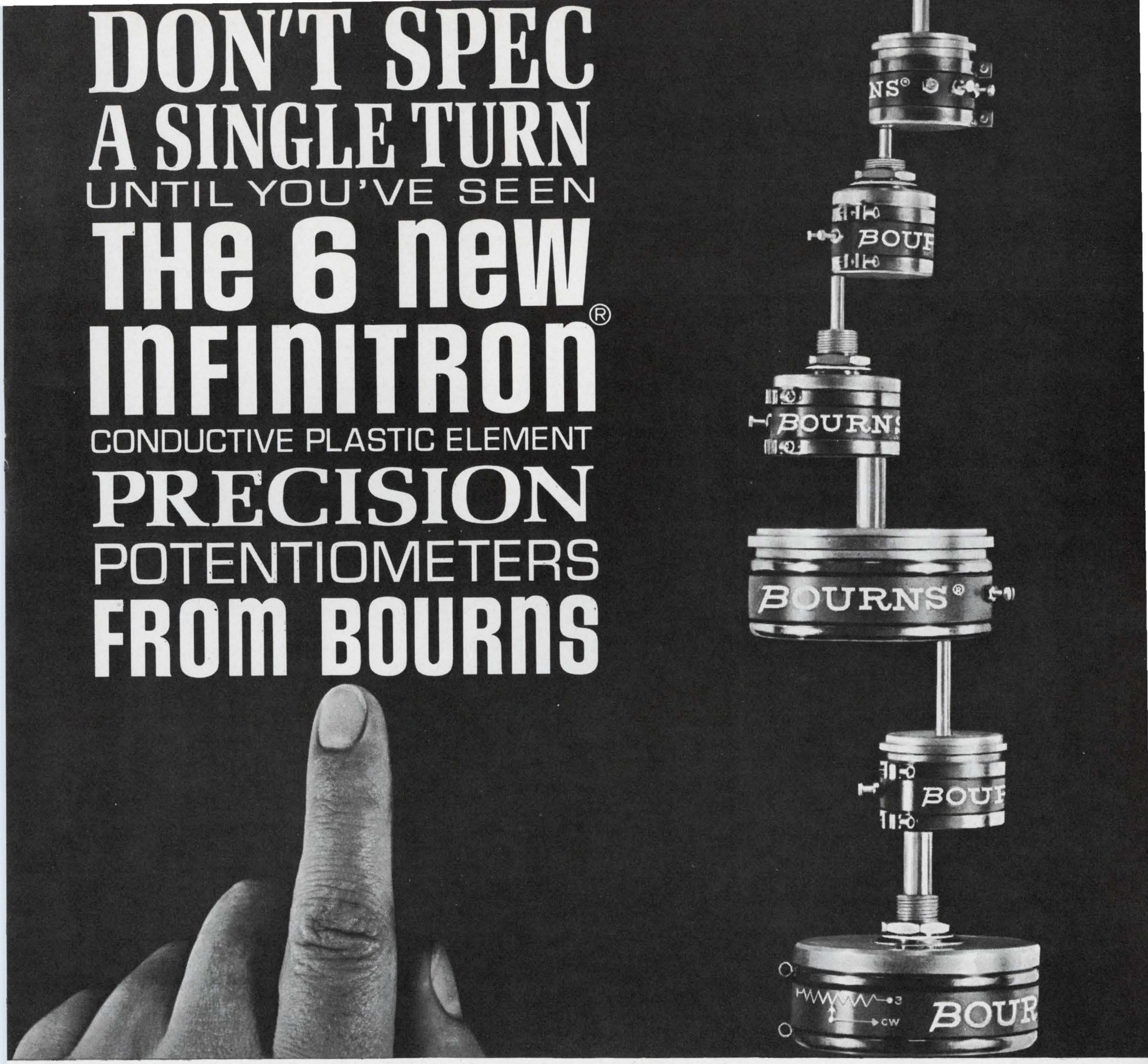

The new Bourns units are available in 7/8", 1 1/16" and 2" diameters with either bushing or servo-mount lids. Standard linearity is 0.5% with special linearities on request. Rotational life of the new conductive plastic units is 50,000,000 shaft revolutions and temperature range is —55°C to +125°C. All have outstanding resistance to humidity and exceed the moisture resistant requirement of MIL-R-39023. Most are available in ranges of 100 to 1,000,000 ohms. All models are manufactured to the stringent quality specifications you have come to expect from a Bourns product line. As with all products manufactured by Bourns, every single INFINITRON unit is guaranteed by the Bourns Reliability Assurance Program, which includes individual inspection to published electrical and physical characteristics. Standard units are ready to ship off-the-shelf to fit your production or engineering requirements. . . special resistance values, taps, electrical angles and mechanical stops are available upon request.

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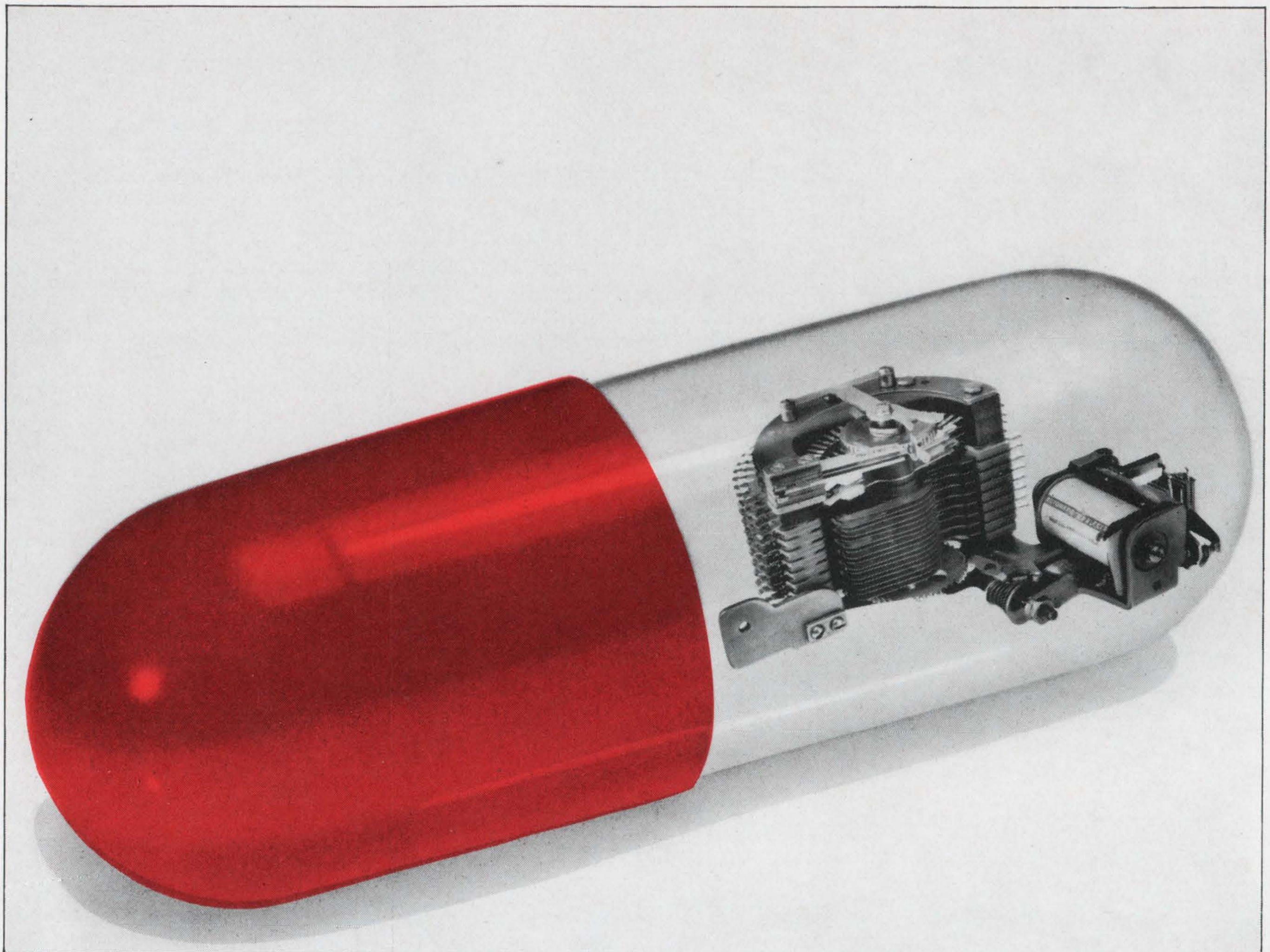

Remedy for nightmares: AE's Type 45NC stepping switch with "shorting" levels.

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This switch has normally closed ("shorting") levels. It's designed so that pairs of contacts *open* successively when the rotor is stepped.

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It's ideal for self-interrupted hunting, and you don't need auxiliary relays.

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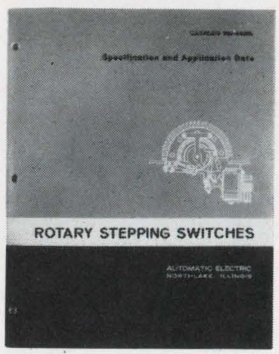
Contacts are gold-plated phosphor bronze. Contact resistance: a maximum of 50 to 100 milliohms, measured at 6 volts 100 milliamperes.

When you specify AE rotary stepping switches, you get the benefit of our continuous research—in design, in metals and insulating materials. All this plus *positive positioning* — a unique AE design feature that locks the rotor and makes overthrow impossible.

Find out more about AE rotary stepping switches—an economical, rugged and reliable way to simplify switching circuits. There's a lot of helpful application information in our new reference circular 1698-L. To get your copy, just ask your AE representative. Or write to the Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.



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EDITORIAL

Is there room at the top for you?

Yes . . . and there's recognition and a high salary if you make it.

Fine, you say. But how does today's design engineer become tomorrow's chief engineer? You can take the first step by checking a survey ELECTRONIC DESIGN recently completed among chief engineers and engineering managers in the country (see p. 86 for details).

Here's what managers advise aspiring managers to do:

- Become business oriented. Practice cost analysis and budgeting, learn corporate finance procedures, and become keenly aware of profit and loss factors.
- Develop a sensitivity for human relations. Learn and apply the psychology of dealing with people, so they will work better with you and other members of your engineering team.
- Keep technically current. Be informed of the latest advances in your field. Also diversify your interests, so you become knowledgeable in allied fields.

Many of you may feel that some of this advice is not startling. You're already keeping abreast of technology, aren't you? Otherwise you wouldn't be reading this publication. But are you actively pursuing the other areas of career development?

Don't kid yourself that you can't find the time. If you want to move into management, you must learn to manage yourself first. Make the time. Evaluate your daily schedule carefully and eliminate some less important activity.

It's possible, though, that you can't set aside enough time to attend 12-week sessions at a university. ELECTRONIC DESIGN's management and careers editor, Howard Ravis, will assist you. He has been conferring with the American Management Association, the Industrial Educational Institute and other leading management organizations and, through their assistance, will bring you outstanding management guidance. Follow the management section of the magazine in coming issues and start your move to the top.

You'll get straight talk from the leading management consultants, concise and detailed counseling on all phases of your career development, and carefully planned tests, when applicable, to permit you to check your progress.

Here's to your future!

HOWARD BIERMAN

variable viewing time 5 cm/μs stored writing speed

split-screen displays

all in the Tektronix Type 549 Storage Oscilloscope

Waveform display showing train of pulses. Upper screen in the stored mode shows three pulses with falltime of the pulse trailing edge showing system deficiency. Lower screen in conventional display mode shows the same pulse train with corrections applied to provide a well formed pulse shape. Pulse width shown is 8 μs with risetime of 0.1 μs. Vertical deflection factor is 0.5 volts/cm. Horizontal deflection factor is 10 μs/cm. Repetitive sweep used for both displays.

The Type 549 allows up to one hour of continuous visual storage, giving you ample time in most applications to measure and analyze stored waveforms. Stored displays can be erased in less than one-quarter of a second.

Split-screen displays

Unique with Tektronix storage oscilloscopes, split-screen displays bring you many advantages in waveform-comparison applications. You can use either half of the 6 cm by 10 cm display area for stored displays, the other half for nonstored displays, with independent control of each half. You can also use the entire screen for either type of display.

Variable viewing time

Variable viewing time — an outstanding feature of the Type 549 — allows you to automatically store displays, view them for a selected time, then automatically erase them on either or both halves of the screen. Two modes of operation are possible. In the After-Sweep Automatic Erase Mode, the selectable viewing time of 0.5 s to 5 s begins at the end of each complete sweep. After the viewing time, the display is automatically erased and the cycle begins again when the next sweep is triggered by a signal.

In the Periodic Automatic Erase Mode, the sequence of storing, viewing time and erasure is continuous and independent of the sweep or signal. In this mode, the viewing time can also be varied from 0.5 s to 5 s.

There is no degradation of stored traces during the selected viewing time, in either mode, and you can retain or erase displays manually whenever desired.

Bistable storage advantages

With bistable storage oscilloscopes, such as the Type 564 and Type 549, the contrast ratio and brightness of stored displays are constant and independent of the viewing time, writing and sweep speeds, or signal repetition rates. This also simplifies waveform photography. Once initial camera settings are made for photographs of one stored display, no further adjustments are needed for photographs of subsequent stored displays.

Tektronix bistable storage cathode ray tubes are not inherently susceptible to burn-damage and require only the ordinary precautions taken in operating conventional oscilloscopes.

Plug-in unit adaptability

Vertical deflection characteristics of the Type 549 are extremely flexible through use of any of the Tektronix letter- or 1-series plug-in units. These include multi-trace, differential, sampling, and spectrum analyzer units. Depending upon the plug-in being used, bandwidth of nonstored displays extends from DC to 30 MHz.

Among other features of the Type 549 are 5 cm/μs stored writing speed, calibrated sweep delay from 1 μs to 10 s, sweep speeds to 20 ns/cm, amplitude calibrator from 0.2 mV to 100 V and a locate zone for easy positioning of stored traces.

Type 549, without plug-in units $2475

Type 1A1 Dual-Trace Plug-In Unit . . . . $ 625

DC to 30 MHz at 50 mV/cm; DC to 23 MHz at 5 mV/cm.
2 Hz to 14 MHz at 500 μV/cm, single-channel.

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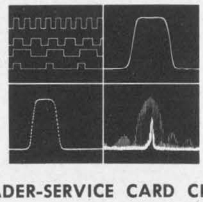
For a demonstration, contact your nearby Tektronix field engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

TEKTRONIX®

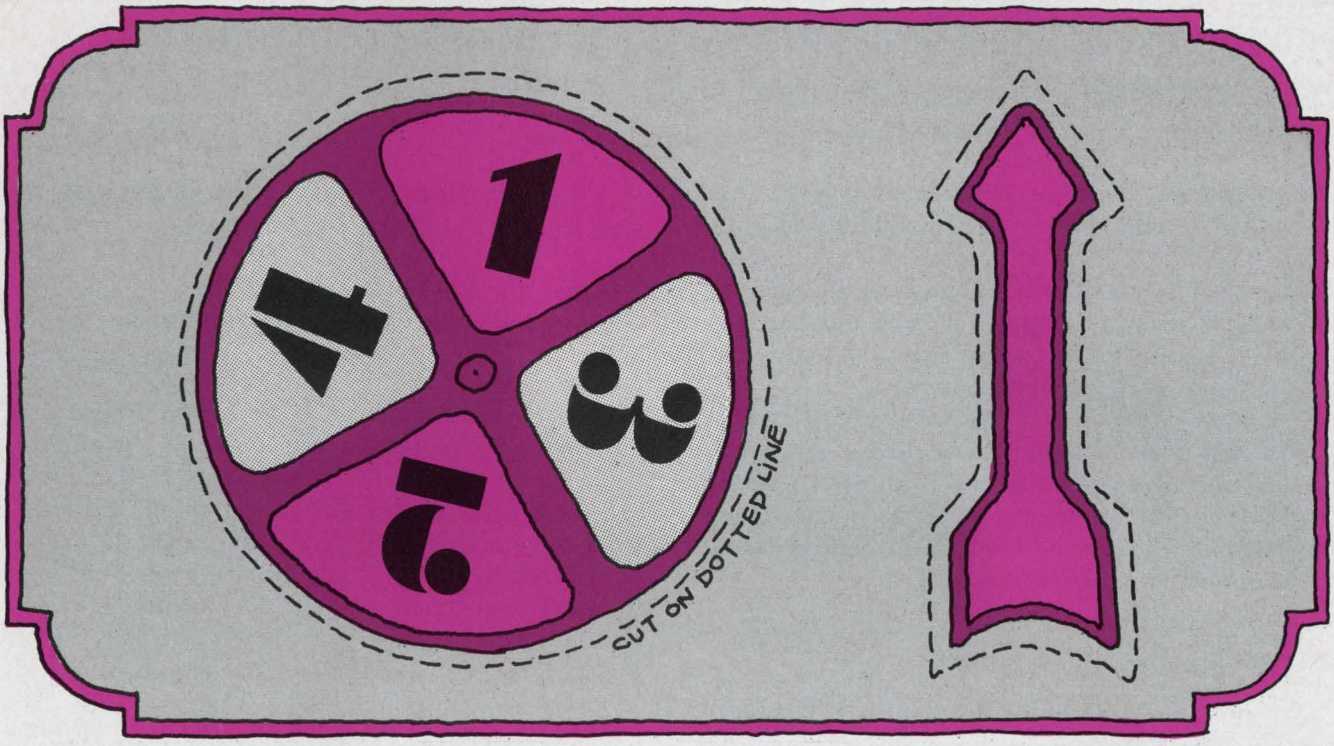
Multi-trace, differential, sampling and spectrum analysis



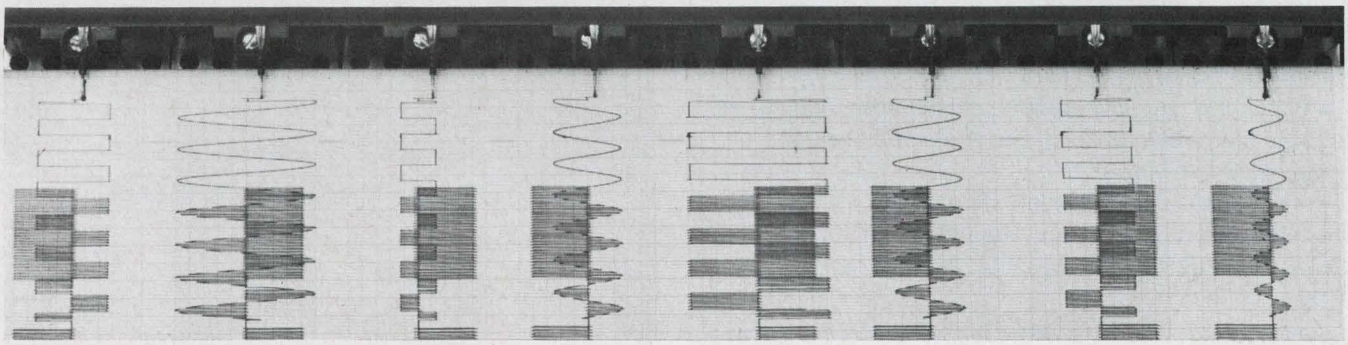
. . . in all Tektronix 530-540-550-series plug-in oscilloscopes

ON READER-SERVICE CARD CIRCLE 39

Technology



Playing the "Chief Engineer Game" is more than just idle fun. You can win the game by developing the proper skills, and not by spinning the wheel of chance. Page 86



A good trace depends on the paper as well as the recorder. A knowledge of the paper and recording process can help you use your equipment to its best advantage. Page 72

Also in this section:

Build complementary-symmetry amplifiers

with the aid of a few straightforward equations to compute the component values and circuit parameters.

The major advantage of complementary symmetry is that the output transformer is eliminated. Each output transistor, therefore, instead of seeing a maximum collector-emitter voltage equal to twice the supply voltage, sees a maximum of only one-half the supply voltage. This moreover leads to lower cost without deterioration in performance.

A rigorous analysis of complementary-symmetry amplifiers is difficult because the transfer characteristics of transistors are nonlinear. However, a set of simple design equations yielding component values which require little or no adjustment can be developed and used for practical design.

The basis for analysis formulated

The equations are derived by analyzing the quiescent condition as well as circuit conditions when the output transistors are conducting peak current. They interrelate pertinent circuit parameters, so that selecting values for most circuit parameters—such as output power required and load resistance required—enables the remaining circuit parameters or component values to be obtained. The major assumptions made are these:

- Clipping by the output transistors occurs as soon as the collector-base junction of either one becomes forward-biased.
- When one of the output transistors is conducting peak collector current, the other output transistor is conducting a negligible amount of collector current.

A basic configuration for complementary-symmetry amplifiers is shown in Fig. 1. Other configurations are simply variations of this one, and design equations for them may be derived by means of the same approach used in analyzing this circuit.

In Fig. 1 there are three conditions to be considered:

1. *Q1* is conducting peak current, and *Q2* is cut off.
2. *Q2* is conducting peak current, and *Q1* is cut off.
3. The quiescent condition—both *Q1* and *Q2* are conducting.

Prabodh Shah, Applications Engineer, General Instrument Corp., Woonstocket, R.I.

If P_o is the effective output power to the load, the peak current and voltage for the load are:

$$I_{L(max)} = (2P_0/R_L)^{1/2};$$

$$V_{L(max)} = (2P_0 R_L)^{1/2}.$$

In the following discussion of conditions 1 and 2, all values of voltage and current are peak instantaneous values.

Consider condition 1 when *Q1* is conducting peak current and *Q2* is cut off. It is assumed that the collector current of *Q3*, I_{C3}, is negligible. Capacitor *C2* acts as a power supply for *Q1*. To obtain the maximum voltage swing across R_L, Capacitor *C2* should be charged to 12 V_{CC}. It should also be large enough to supply enough power for the low-frequency response without increase in distortion. The circuit for this condition reduces to that shown in Fig. 2.

The maximum base current available is:

$$I_{B1(max)} = (V_{CC}/2 - V_{BE1})R1,$$

and since P_o is the output power required, the *Q1* collector current is:

$$I_{C1(max)} = (2P_o/R_L)^{1/2}.$$

The acceptable minimum gain is therefore:

$$h_{FE1(min)} = \left[R1/(V_{CC}/2 - V_{BE1}) \right] \left[(R_L/2P_o)^{1/2} \right].$$

Thus:

$$R1 \leqq (h_{FE1(min)}/2)(V_{CC} - 2V_{BE1})(2P_o/R_L)^{1/2}. \quad (1)$$

Glossary of symbols

$I_{L(max)}$	peak load current
$V_{L(max)}$	peak load voltage
P_o	effective output power
I_c	collector current
V_{BE}	base-to-emitter voltage
$I_{B(max)}$	peak base current
R_L	load resistance
T_J	junction temperature
h_{FE}	forward current transfer ratio
i_e	emitter current
V_{CEA}	collector-to-emitter voltage
P_{ca}	maxim'ım power dissipation
V_{cc}	supply voltage
θ	emitter current phase angle

It is assumed that clipping due to saturation occurs as soon as the collector-base junction becomes forward-biased. Therefore the requirement that $V_{CB1} \geqq 0$ at peak load current will ensure unclipped operation. The higher the gain of the transistor, the greater the drop across R_L for a given base current and hence for a given drop across *R1*. The next concern, then, is maximum acceptable gain.

$$V_{CB1} = I_{B1(\max)} R1 - I_{C1(\max)} R_L \geqq 0\,;$$
$$R1 \geqq h_{FE1(\max)} R_L, \qquad (2)$$

where $I_{B1(\max)}$ is the instantaneous peak base current at these conditions. Although the gain limits obtained from the above equations apply to *Q1*, they also apply to *Q2* with some matching requirement to minimize distortion.

Now consider the case when *Q2* is conducting peak current and *Q1* is cut off. The circuit for this condition is shown in Fig. 3.

The capacitor *C2* may be thought of here as a $V_{CC}/2$ power supply (ac short). To guarantee that *Q2* will not clip, it is necessary for *Q3* not to clip. This is ensured by requiring that $V_{CB3} \geqq 0$ or $V_{CE3} \geqq V_{BE3}$.

$$V_{CE3} = V_{CC}/2 - V_{L(\max)} - V_{EB2} \geqq V_{BE3}$$
$$\therefore V_{CC} \geqq 2\left[V_{BE3} + V_{EB2} + (2P_o R_L)^{1/2}\right].$$

On the assumption that $V_{BE3} \approx V_{EB2}$,

$$V_{CC} \geqq 2\left[2V_{EB2} + (2P_o R_L)^{1/2}\right]. \qquad (3)$$

If Eqs. 1, 2 and 3 are satisfied, the output is limited by the driver transistor, *Q3*, alone—that is, the driver will saturate before *Q2*, since *Q2* is operating as an emitter follower. As in the preceding development, it has been assumed that clipping begins as soon as the collector-base junction becomes forward-biased, and not before. If the saturation characteristics of the transistors are good ($V_{CE(sat)} < V_{BE(sat)}$), then there is a small built-in safety factor in Eqs. 1, 2 and 3. If the saturation characteristics are poor ($V_{CE(sat)} > V_{BE(sat)}$), then clipping will begin before V_{CB} becomes forward-biased or when V_{CB} is still reverse-biased. The design equations must then be modified accordingly.

Consider now condition 3, the quiescent condition. Transistors *Q1* and *Q2* should be slightly forward-biased to eliminate crossover distortion. Because the voltage across *R2* is the sum of V_{BE1} and V_{EB2}, V_{R2} is known if the V_{BE} of the two devices is known.

The capacitor voltage is:

$$V_{CC}/2 = I_{R1} R1 + V_{BE1}$$
$$\therefore I_{R1} = (V_{CC} - 2V_{BE1})/2\,R1 = I_{C3} \qquad (4)$$

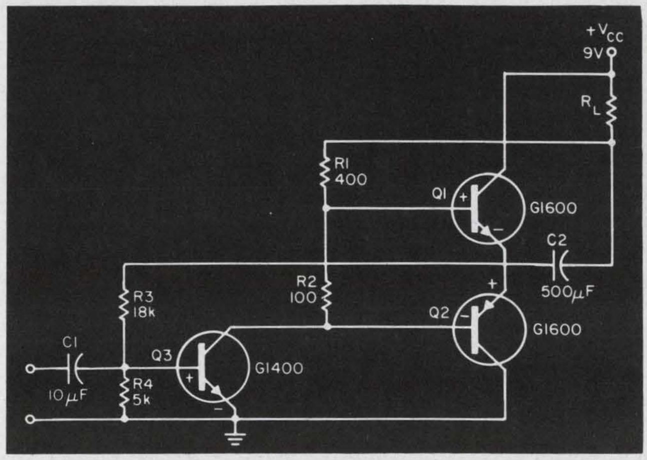
$\therefore$ *Q3* should be biased at I_{C3} (Eq. 4) and:

$$V_{CE3} = V_{CC}/2 - V_{EB2}. \qquad (4a)$$

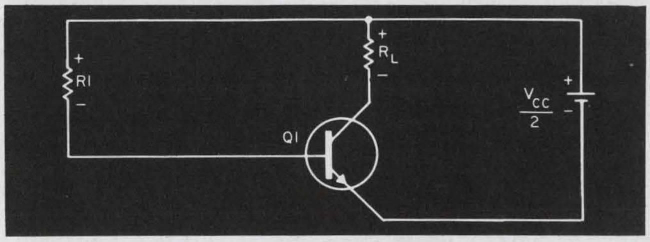
In Eqs. 1, 3, 4 and 4a, the value of base-emitter voltage used should be that at the highest operating junction temperature.

Consider additional requirements

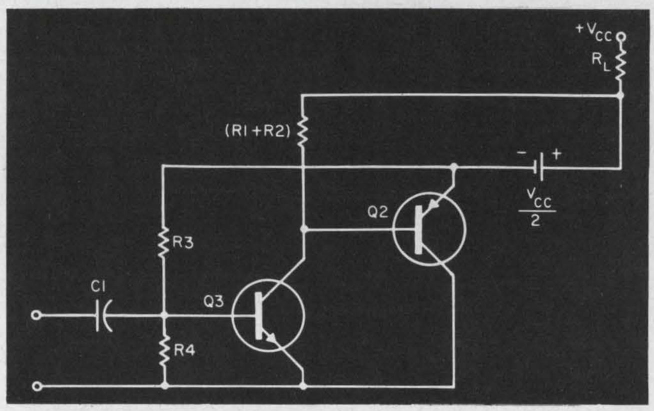
Resistor *R3* determines how much ac and dc negative feedback is present (see Fig. 1). If, through the reduction of *R3*, enough negative feedback is used,



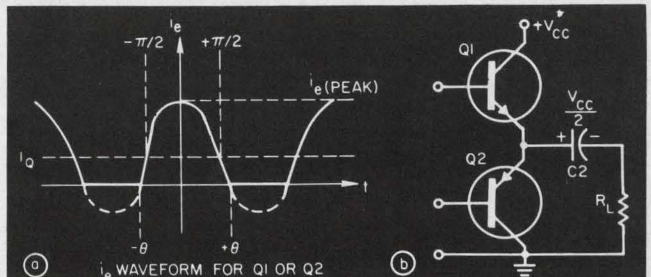
1. **Generalized complementary-symmetry amplifier** schematic includes three transistors. In this case Q1 and Q3 are a matched complementary pair of silicon epoxy transistors (GI 600) and Q3, the driver, is an epoxy GI 400. Note that each output transistor sees only a maximum of one-half the supply voltage. All values are computed in the design example.



2. **When Q1 is conducting peak current** and Q2 is cut off the circuit of Fig. 1 is reduced to this.



3. **Equivalent amplifier circuit** of Fig. 1 when Q2 is conducting peak current and Q1 is cut off.



4. **Transistor power dissipation** is computed by means of an equivalent circuit (b) and its current wave (a).

it is possible to use output transistors that are not matched for gain or V_{BE}. The selection of *R3* and *R4* is primarily influenced by the input impedance and feedback desired, and the gain of *Q3*.

Distortion at low frequencies is seriously affected by capacitor *C2*. The value of *C2* is determined empirically on the basis of the tolerable distortion at the lowest frequency of interest and the lower cut off frequency desired.

The other major consideration is power dissipation of the output transistors.

Calculate power dissipation

To derive the expression for power dissipation in *Q1* or *Q2*, it is assumed that collector current is equal to emitter current and that $\pi/2-\theta$ (see Fig. 4a) is extremely small—in other words, that $i_{e(peak)} \gg I_Q$.

Now $i_c = I_{C(max)} \cos\theta$ and $v_{ce} = V_{CC}/2 - I_{C(max)} R_L \cos\theta$, so that:

$$P_c = (V_{CC} I_Q/4) + 1/\pi \int_0^{\pi/2} (i_c v_{ce}) d\theta$$

$$= (v_{CC} I_Q/4) + 1/\pi \int_0^{\pi/2} \left[I_{C(max)} \cos\theta (v_{CC}/2 - I_{C(max)} R_L \cos\theta) \right] d\theta$$

$$= (V_{CC} I_Q/4) + 1/\pi \left[(V_{CC} I_{C(max)}/2) - (I_{C(max)}^2 \pi R_L/4) \right].$$

Maximum power dissipation, $P_{c(max)}$, occurs not at maximum load (output) power, but at $I_{C(max)} = V_{CC}/\pi R_L$:

$$P_{c(max)} = (1/4\pi^2)(V_{CC}^2/R_L) + (V_{CC} I_Q/4).$$

The second term is of negligible magnitude in relation to the first, so one can write:

$$P_{c(max)} \approx V_{CC}^2/4\pi^2 R_L. \qquad (5)$$

The above expression for the maximum power dissipation does not take into account the heat sinking of the transistor. It is well known that more power can be obtained from a given device with the use of a properly designed heat sink.

Formulating the design procedure

Now that the major design equations needed to calculate all the component values for a complementary amplifier have been derived, a detailed design procedure can be formed.

For convenience, the design equations are repeated below:

$R1 \leq (h_{FE(min)}/2)(V_{CC} - 2V_{BE1})(R_L/2P_o)^{1/2}$. (1)

$R1 \geq h_{FE(max)} R_L$. (2)

$V_{CC} \geq 2\left[2V_{EB2} + (2P_o R_L)^{1/2}\right]$. (3)

Bias point of *Q3*:

$I_{C3} = (V_{CC} - 2V_{BE1-})/2R1$, (4)

$V_{CE3} = V_{CC}/2 - V_{EB2}$. (4a)

$P_{c(max)} = V_{CC}^2/4\pi^2 R_L$. (5)

The design procedure is as follows:

- Select P_o and R_L.
- From Eq. 3, calculate the minimum value of V_{CC} and select a value of V_{CC}.
- From Eq. 5, calculate the power dissipation of the transistor.
- Select a transistor, and from Eqs. 1 and 2 calculate $R1_{(max)}$ and $R1_{(min)}$ respectively, and select *R1*.
- Calculate the bias point of *Q3* from Eq. 4.

This is merely a suggested design procedure, and one can just as well start with a device.

GI 600 and GI 400 parameters

Specification for General Instrument Type GI 600, a matched complementary pair of silicon epoxy transistors:

$V_{CBO} > 25$ V@$I_C = 10\ \mu$A
$V_{CEO} > 25$ V@$I_C = 10$ mA*
$V_{EBO} > 3$ V@$I_E = 10\ \mu$A
$h_{FE} > 50$@$V_{CE} = 5$ V, $I_C = 5$ mA
$I_{CBO} < 10$ nA@$V_{CB} = 10$ V
$I_{EBO} < 10$ nA@$V_{OB} = 2$ V
h_{FE} groups @$V_{CE} = 1$ V, $I_C = 250$ mA*
a. 30 - 35
b. 35 - 40
V_{BE} 0.75-1.05 V@$I_C = 250$ mA, $V_{CE} = 1$ V.*

Specifications for General Instrument Type GI 400, an npn silicon epoxy transistor:

$V_{CEO} > 25$ V@$I_C = 10$ mA*
$V_{CBO} > 50$ V@$I_E = 10\ \mu$A
$V_{EBO} > 5$ V@$I_E = 10\ \mu$A
$I_{CBO} < 50$ nA@$V_{CB} = 40$ V
$I_{EBO} < 50$ nA@$V_{OB} = 3$ V
h_{FE}75 - 150@$V_{CE} = 4$ V, $I_C = 10$ mA

* Pulse width = 300 μs, duty cycle $\leq 2\%$.

Design an amplifier

Consider, for example, the design of an amplifier like that in Fig. 1, using General Instrument transistors GI 600 and GI 400 (for specifications for these types, see box). The GI 600 is a mtached complementary pair of silicon epoxy transistors especially suited to low-cost, low power complementary-symmetry amplifiers, because of their excellent gain and saturation characteristics. The GI 600 is used for *Q1* and *Q2*, and GI 400 is used for *Q3*.

Suppose an output power of 300 mW is required and it is desired to limit maximum power dissipation to 210 mW. For a 4-ohm load, this requires a peak collector current of 387 mA, and for a 16-ohm load, a peak collector current of 194 mA is required. For GI 600, when $I_C = 250$ mA, $V_{CE} = 1$ V and $T_J = 25°$ C, the V_{BE} is typically 0.9 V. Since the V_{BE} of silicon transistors decreases at approximately 2 mV/°C, a value of $V_{BE} = 0.75$ V at $V_{CE} = 1$ V and $T_J = 100$ °C (maximum anticipated operating temperature) may be used as an approximation in the I_C = 195-to-390-mA current range.

From Eq. 5:

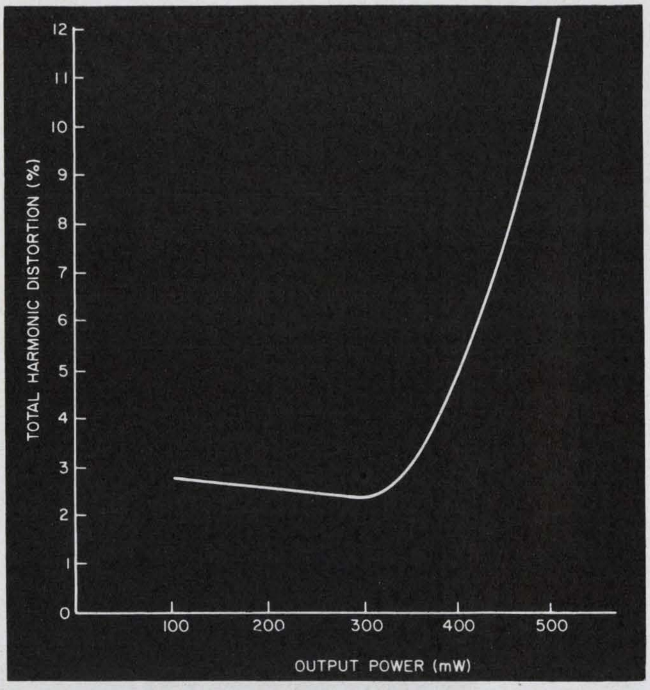
$(1/4\pi^2)(V_{CC}^2/R_L) \leq 0.21$;

$\therefore V_{CC}^2 \leq 8.3 R_L$. (6)

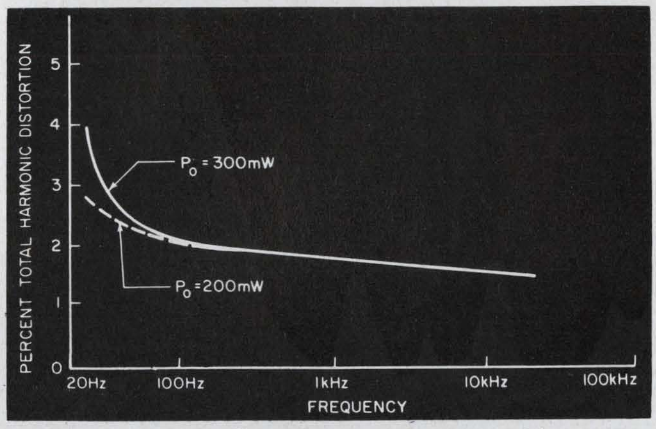
From Eq. 3:

$V_{CC} \geq 2\left[1.5 + (0.6 R_L)^{1/2}\right]$.

If $R_L = 10\ \Omega$, then:



5. **Total harmonic distortion at 1 kHz** is less than 3% over the design power output range (300 mW). The gain of the amplifier under these conditions is 44 dB and the input impedance is 3 kΩ.



6. **Total harmonic distortion** as a function of frequency for two values of output power is under 4% at 25 kHz and 300 mW.

$V_{CC} \geqq 7.9$ V.

And from Eq. 6:

$V_{CC} \leqq 9.1$ V.

Therefore let $V_{CC} = 9$ V and $R_L = 10$ Ω,

$\therefore I_{C(max)} = 245$ mA.

The same high-temperature value for V_{BE1} (0.75 V) yields from Eq. 1:

$R1_{(max)} = 15.3\, h_{FE(min)}$.

From Eq. 2:

$R1_{(min)} = 10\, h_{FE(max)}$.

For GI 600, at $I_C = 250$ mA and $V_{CE} = 1$ V:

$h_{FE} = 30$ to 40.

$\therefore R1_{(max)} = 460$ Ω.

$R1_{(min)} = 400$ Ω.

Therefore let $R1 = 400$ Ω.

From Eq. 4:

$I_{C3} = 9.6$ mA,

$V_{CE3} = V_{CC}/2 - V_{EB2}$.

For $Q1$ and $Q2$ at $T_J = 100°$ C, the V_{BE} at $I_C = 10$ mA and $V_{CE} = 5$ V is typically 0.5 V.

Therefore:

$$V_{CE3} = 4.0 \text{ V}.$$

Since I_{B1} for the quiescent condition is negligible in comparison with the I_{C3} of 9.6 mA, it may be assumed that the current in $R2(I_{R2}) \approx 9.6$ mA. The V_{BE} of $Q1$ and $Q2$ is typically 0.5 V at $I_C = 10$ mA, $V_{CE} = 5$ V and $T_J = 100$ °C.

Therefore:

$R2 = 2V_{BE}/9.6(10^{-3}) \approx 100$ Ω.

Therefore let $R2 = 100$ Ω.

The GI 400 has a typical gain of 100 at $I_C = 10$ mA and $V_{CE} = 4$ V, and it has a typical V_{BE} of 0.65 V under the same conditions. Therefore:

$$I_{B3} = 100\ \mu\text{A}.$$

Let $R4 = 5$ kΩ.

$I_{R4} = 0.65/5\text{K}\ \Omega = 130\ \mu$A.

$I_{R3} = 230\ \mu$A.

$R3 = (V_{EC2} - V_{BE3})/I_{R3}$

$\simeq (4.5 - 0.65)/230)10^{-6}) = 16.7$ kΩ.

Therefore let $R3 = 18$ kΩ.

The component values thus become:

$R1 = 400$ Ω.
$R2 = 100$ Ω.
$R3 = 18$ kΩ.
$R4 = 5$ kΩ.
$V_{CC} = 9$ V.
$C1 = 10\ \mu$F (selected experimentally).
$C2 = 500\ \mu$F (selected experimentally).

An amplifier that incorporated these values was built and found to have the following characteristics:

At zero output power, supply current = 9 mA.

At 300-mW output, supply current = 90 mA.

The lower half-power frequency is 25 Hz, and the upper half-power frequency is in excess of 600 kHz.

At 25 Hz and 300 mW output, the total harmonic distortion (THD) = 4%.

At 25 Hz and 200 mW output, THD is less than 3%.

At 1 kHz and an output power of 300 mW, the amplifier has a power gain of 44 dB, and the input impedance is approximately 3 kΩ.

Figure 5 shows THD vs output power at 1 kHz.

Figure 6 shows THD vs frequency.

Other circuit parameters are as follows:

Parameter	Design objective	Measured
V_{CE1}(dc)	4.5 V	4 V
V_{CE2}(dc)	4.5 V	5 V
V_{CE3}(dc)	4.0 V	4.5 V
V_{R2}(dc)	1 V	0.9 V
Quiescent supply current (mA dc)	10.0 mA	9.0 mA

It may be observed that the measured and the desired values are in good agreement. Thus one can conclude that the simplifying assumptions made in the beginning of this analysis do not appreciably affect the accuracy of the results and that the equations actually describe the performance. ■ ■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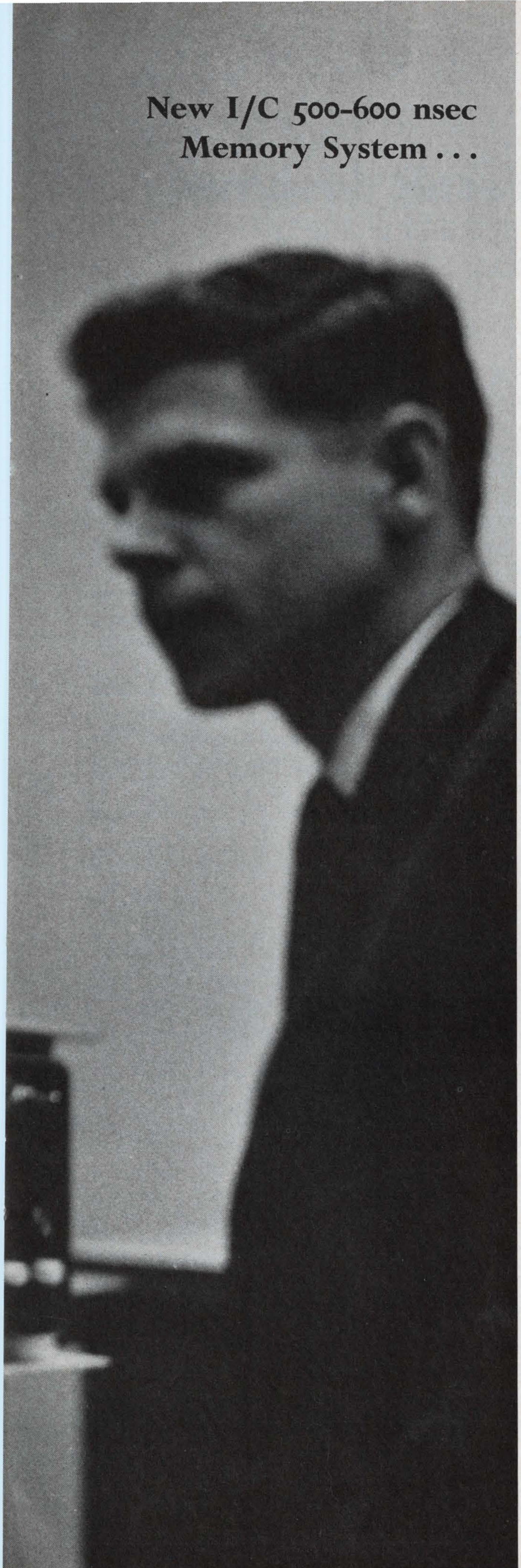
DR
ICM-500 I/C CORE MEMORY



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3C COMPUTER CONTROL DIVISION

ON READER-SERVICE CARD CIRCLE 40

Computer talks to the circuit designer

in his own language. Designs are evaluated and changes made immediately by simple conversation.

A major drawback of computer-aided circuit design programs has been the designer's lack of contact with the solution process. He sends his problem to a typical batch-processing computer facility and some time later gets results back. This means that he has no equivalent of laboratory breadboarding, because no changes can be made while the program is in progress. The delays that this can lead to may well dissuade him from using these programs.

Now there is a program that gets around the problem. It allows the engineer to "chat" with the computer as it works toward a solution. The CIRCuit design analysis program gives the engineer real-time conversational control of the input and output of the program and enables him to control parameter variation, without having to run the program again. Offline working—that is, where the designer is not involved with the actual computer operation—is also possible for routine analysis where on-line facilities are unnecessary.

Additional features of CIRC are:

- The conversational language is easy to learn, and requires no previous programing knowledge.
- It may be used for discrete or integrated circuits with up to approximately 50 nodes.
- It provides nonlinear models to simulate accurately diodes and transistors.
- It is implemented on small-to-medium scale computers, (see box on CIRC availability).
- The necessary circuit equations are normally written by CIRC but the equations can be supplemented or modified if required.

CIRC at work

An example will demonstrate how CIRC analyzes a simple circuit (Fig. 1a). In this instance CIRC derives nominal results with the nominal-analysis section of the program. The program could equally well derive worst-case results or permit parameter variations through the user-control (UC) feature. User control will be discussed further on and worst-case analysis will be the subject of a later article.

Richard McNair, Staff Engineer, Scientific Data Systems, Inc., Santa Monica, Calif.

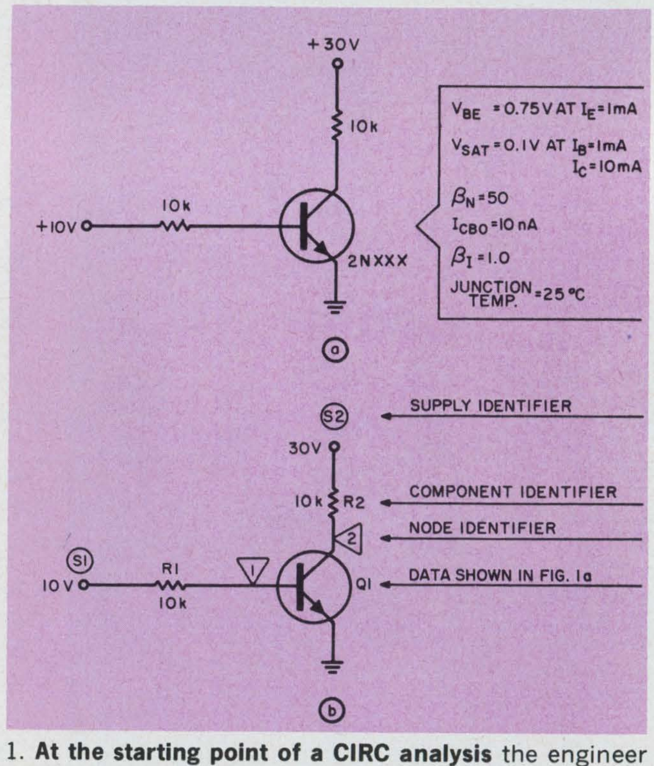
Since CIRC proceeds in question-and-answer fashion, the analysis of Fig. 1a can be considered step by step together with the printouts on the opposite page (Figs. 2 and 3).

Step 1: The engineer numbers all nodes, supplies, and components. This produces a diagram labeled as in Fig. 1b. No transistor equivalent circuit is necessary for this program.

Step 2: Once CIRC has been loaded into the computer and set to run, the computer's input-output typewriter will print out the questions for the engineer to answer (Fig. 2).

Step 3: The engineer next specifies the connections for each element as the computer asks the questions (Fig. 3). Each of the questions in Step 3 is followed by a further question. These yield the data for Step 4.

Step 4: The engineer describes the component



1. **At the starting point of a CIRC analysis** the engineer takes his circuit design (a) and numbers each element and node (b). This simple example has two nodes but CIRC can handle fifty.

Step 2 begins with a CIRC question.
Engineer's answer.

```
NUMBER OF NODES
2,

NUMBER OF VOLTAGE SUPPLIES
2,

ARE SPECIAL EQS USED
NO
```

Resistors. Voltage Resistance Sources, Current Sources, Diodes, Transistors.

```
SPECIFY THE QUANTITY OF THE FOLLOWING CIRC STND ELEMENTS THAT ARE USED,
RES.,VRS ,CUR ,DIO ,TRAN,
2,Ø,Ø,Ø,1,

VOLTAGE SUPPLIES
SPECIFY THE FOLLOWING,
NOM VAL,MIN INFO,MAX INFO, (FOR ALL PARAMETERS INDICATED)
```

Only nominal values are given since only a nominal analysis is required.

```
SUP   1 = PARAMETER NUMBER   1
1Ø.,
SUP   2 = PARAMETER NUMBER   2
3Ø.,

JUNCTION TEMPERATURE  (DEG. CENT.)
SPECIFY THE FOLLOWING,
NOM VAL,MIN INFO,MAX INFO, (FOR ALL PARAMETERS INDICATED)

TEMP  1 = PARAMETER NUMBER   3
25.,
```

2. **Description of circuit is given to computer** by a question and answer process.

Step 3.

```
RESISTORS

SPECIFY THE FOLLOWING,
TERM 1 INFO,TERM 2 INFO,
NOM VAL,MIN INFO,MAX INFO,  (FOR ALL PARAMETERS INDICATED)
```

Resistance 1 is connected between S1 and N1, and has a value of 10 kilohms (Step 4).

```
RES.  1
S1,N1,
RES.  1 = PARAMETER NUMBER   4
1ØØØØ.,

RES.  2
S2,N2,
RES.  2 = PARAMETER NUMBER   5
1Ø.E3,

TRANSISTORS

SPECIFY THE FOLLOWING,
BASE INFO,COLL. INFO,EMIT. INFO,COPY DATA INFO,P IF PNP,
NOM VAL,MIN INFO,MAX INFO,  (FOR ALL PARAMETERS INDICATED)
```

Transistor 1 base, collector and emitter connections.

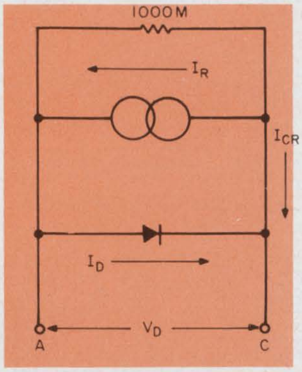
```
TRAN  1
N1,N2,GØ,
```

Transistor 1 parameters specified (nominal values only).

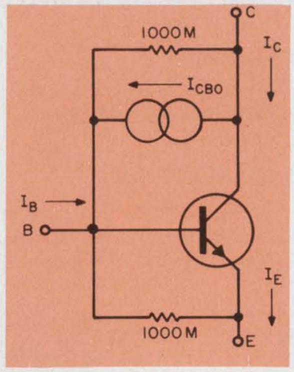
```
IC-S  1 = PARAMETER NUMBER  11
.Ø1Ø,
IB-S  1 = PARAMETER NUMBER  12
.ØØ1,
IE-A  1 = PARAMETER NUMBER  13
.ØØ1,
VBE   1 = PARAMETER NUMBER   6
.75,
VSAT  1 = PARAMETER NUMBER   7
.1,
BN    1 = PARAMETER NUMBER   8
5Ø.,
BI    1 = PARAMETER NUMBER   9
1.,
ICBO  1 = PARAMETER NUMBER  1Ø
1Ø.E-9,

NOMINAL SOLUTIONS     14
```

	V	VALUE	V	VALUE	V	VALUE	V	VALUE
Nominal solutions are printed out in the same order as the specify statement of Fig. 2.	1	.79ØØØ25E ØØ	2	.7473989E-Ø1				
	D	**VALUE**	**D**	**VALUE**	**D**	**VALUE**	**D**	**VALUE**
Resistor 1.	1	.92Ø9997E-Ø3 (I)	2	.84824Ø5E-Ø2 (P)				
Resistor 2.	3	.2992526E-Ø2 (I)	4	.8955212E-Ø1 (P)				
	5	.92Ø9997E-Ø3 (I_B)	6	.2992536E-Ø2 (I_C)	7	.3913526E-Ø2 (I_E)	8	.9512539E-Ø3 (P)
Transistor 1.	9	.79ØØØ25E ØØ (V_{BE})	1Ø	.7152626E ØØ (V_{BC})	11	.7473989E-Ø1 (V_{CE})	12	.3249226E Ø1 (I_C/I_B)

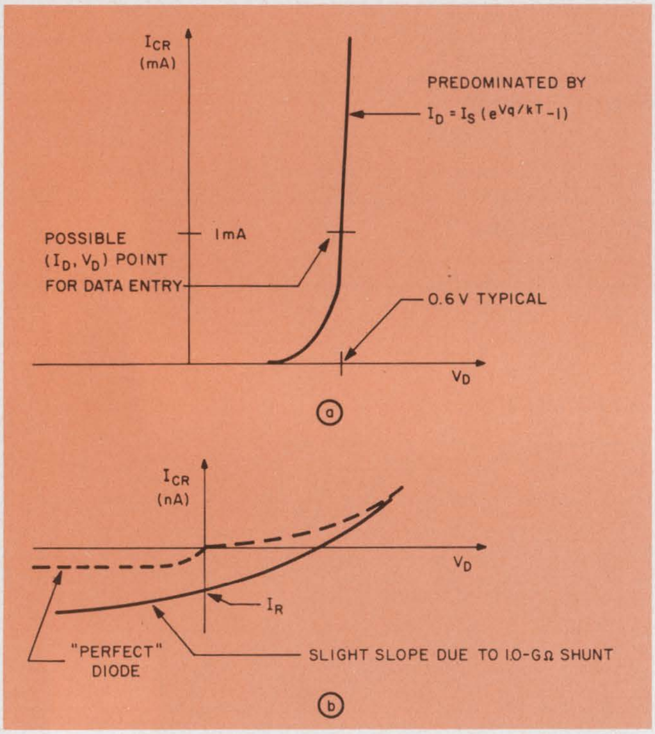
3. **Connection and component data are requested** by CIRC. Then CIRC outputs the solutions requested.



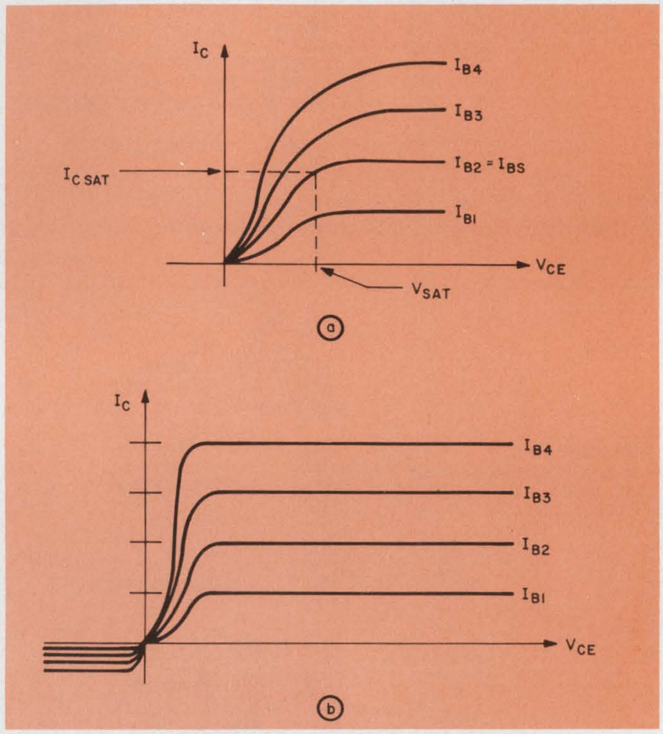
4. **Simple models are used by CIRC.** The diode model has three parameters and is easily specified from the manufacturer,s data. The shunt resistor is needed for CIRC mechanization.



6. **The eight-parameter transistor model** is described by considering the transistor as two diode junctions. Npn is shown; for pnp the direction of the currents is reversed.



5. **Nonlinear characteristic of model** (a) compares well with actual diode. Reverse bias line (b) has slight slope due to the shunt resistor required by the program.



7. **CIRC locates model** in the appropriate part of the characteristics. Load line shows operation in active or saturation region according to base current level.

specifications or performance characteristics. CIRC simultaneously assigns a parameter number to each element or variable. These numbers are used as identifiers in the CIRC parameter-variation section.

When the last transistor parameter, I_{CBO}, has been entered, CIRC analyzes the circuit and prints out the nominal results (Fig. 3) for two classes of circuit variables—node voltages and dependent variables (see Table 1). The term dependent variable is used to describe all the circuit variables, such as element currents, power dissipations and voltage drops, which are dependent on the node voltages and the element parameters.

For initial input and routine circuit analysis, however, this conversational mode may be too time-consuming. Then the questions may be anticipated and the answers punched on card or tape to be fed into the computer with CIRC in the same way as programs are run in a batch-processing operation. In this case a line printer output could show both the questions and the answers.

CIRC models are specified simply

If an engineer intends to use a circuit design program, it is important for him to have some insight into the nature of the program's network elements, particularly nonlinear models. At present, CIRC contains five types of network element: resistor (RES), voltage-resistor source (VRS), current source (CUR), diode model (DIO) and transistor model (TRAN).

The mathematical representations of the first three elements are based on Ohm's law. The latter two are based on the basic Ebers-Moll model.[1,2]

The diode model implements the diode equation:[3]

$$I_D = I_S \left[\exp\ (V_D q/kT) - 1\right],$$

where V_D is the voltage across the diode for current I_D, q is the electron charge, k is Boltzmann's constant, T is the junction absolute temperature in degrees Kelvin, and I_S is the saturation current.

The model itself consists of three parts—a perfect diode, a reverse or leakage current source, and a high-impedance shunt (Fig. 4). The shunt impedance is required for CIRC mechanization purposes and is normally unimportant since its value is 10^9 ohms. The diode-element routine calculates I_S as a function of the input pair (I_D, V_D), the parameter T, and the constants q and k. This calculation is a simple curve-fitting process that makes the diode fit the point I_D, V_D exactly, while maintaining a close fit for all the other diode operating points, since the model is based on the nonlinear diode equation. I_R, the reverse current, simulates diode leakage, which is normally much larger than the saturation current of the perfect diode. Saturation currents are typically 10^{-12} amps and leakage currents 10^{-9} amps and larger. The electrical characteristics of the diode element (Fig. 5) show that it possesses the nonlinear features of an actual diode.

Since the diode model uses data normally specified by diode manufacturers, it is entitled the SPEC model. The SPEC model does not, however, possess all possible diode device characteristics. Those lacking are:

- The bulk resistance (this may be added by use of a resistor element).
- The voltage breakdown with reverse bias.
- The voltage dependence of I_R.
- The diode slope factor, M, as used in the modified form of the diode equation:

$$I = I_S \left[\exp\left(Vq/kTM\right) - 1 \right] .$$

The slope factor is significant for some devices, particularly integrated-circuit designs, and will be described in a later article.

Eight parameters describe transistor model

Like the diode, the transistor model is a basic Ebers-Moll model.[4,5] The model parameters are:

$I_{C(sat)}$	the collector current at saturation.
$I_{B(sat)}$	the base current at saturation.
$I_{E(act)}$	an emitter current in the active state.
V_{BE}	the base-to-emitter voltage at $I_{E(act)}$
V_{SAT}	the collector voltage at $I_{C(sat)}$ and $I_{B(act)}$
β_N	the normal-mode (common-emitter) current gain.
β_I	the inverted-mode current gain (emitter and collector interchanged).
I_{CBO}	the collector-to-base leakage current with the emitter open.

The transistor model (Fig. 6) consists of the current gains β_N and β_1, and a pair of diode elements comprising the base-emitter and base-collector junctions. The base-emitter junction is described at one point ($I_{E(act)}$, V_{BE}) on the nonlinear junction characteristic. The base-collector junction is specified by the collector current, $I_{C(sat)}$, and the base current, $I_{B(sat)}$, at which saturation voltage V_{SAT} is measured. A separate parameter, $_{CBO}$, is used for the base-collector leakage, since this current is normally much larger than for an ideal junction.

The transistor model, like the diode model, is set up with the data normally cited for a transistor, so it, too, is called the SPEC model. Likewise, certain features are omitted:

- Bulk resistances; where known, these may be added with resistor elements. Since normally there is no collector bulk resistor, saturation conditions are set up with ideal transistor characteristics. This may result in a different dynamic saturation impedance. For high-power devices it may be desirable to use a separate resistor element in the collector path.
- There is no breakdown voltage, very little reverse feedback of voltage, and very little voltage effect on I_{CBO}.
- Neither junction has a slope factor. Another CIRC model does include slope factors and will be discussed in a later article.
- The model has a linear current gain, β_N, as shown in Fig. 7 by the fact that equal base current

Description and availability

A FORTRAN II-based program, CIRC operates on any SDS-900-Series computer that has a minimum of 16,384 words of memory and a typewriter and paper-tape equipment. The program contains 29 FORTRAN and 17 SYMBOL machine-language sections.

At the present time, the dc analysis section of CIRC is available to "installation members" of the SDS User's Group. It is released in the form of a magnetic tape that contains both object versions ready for execution by the computer, and the major portion of CIRC in the card image of its original, source language form. CIRC is copyrighted by SDS. Non-SDS users interested in CIRC should contact Richard McNair, Scientific Data Systems, Inc., 1649 Seventeenth St., Santa Monica, Calif. 90404.

Table 1. Dependent variable outputs

Element	Output quantities
RESistor	Current and power
Voltage-Resistor-Source	Current and power
CURrent-source	Power
DIOde	Current, power dissipation and voltage drop
TRANsistor	Base, collector and emitter currents, power dissipation, forward base-emitter and base-collector voltage drops and circuits gain, I_C/I_B.

```
                             After CIRC produces a set of nominal solutions as in Fig. 3. the program
                             invokes user control by printing

                                PROVIDE CONTROL MESSAGES

                             CPPR

                                SPECIFY THE FOLLOWING.

                                PAR. NO. (Ø TO COMPLETE ENTRIES),CONTROL (Ø=SPECIFY. 1=NOM.,2=MIN. 3=MAX),
                                PAR. VALUE,

Supply S1 is 60 V.           1,
                             6Ø.,
                                      PAR. NO.   1 =   6ØØØØØØØE Ø2

Supply S2 is 35 V.           2,
                             35.,
                                      PAR. NO.   2 =   35ØØØØØØE Ø2

Error (deleted).             5,~~III~~

Resistor R1 is 1 MΩ.         4,
                             1.E6,
                                      PAR. NO.   4 =  .1ØØØØØØØE Ø7

Carriage return provides
implied zero to close list.
                                PROVIDE CONTROL MESSAGES

UC is relinquished.          EXIT

Nominal solutions.              TEMP.RY SOLUTIONS      12

                                V    VALUE             V    VALUE            V    VALUE            V    VALUE

Node voltages.                  1   .7784164E ØØ       2   .538215ØE Ø1

                                D    VALUE             D    VALUE            D    VALUE            D    VALUE

Resistor 1.                     1   .5922158E-Ø4       2   .35Ø7196E-Ø2
Resistor 2.                     3   .2961785E-Ø2       4   .8772171E-Ø1

                                5   .5922158E-Ø4 (I_B)    6   .2961795E-Ø2   7   .3Ø21ØØ7E-Ø2   8   .1598692E-Ø1
Transistor 1.                   9   .7784164E ØØ (V_BE)  1Ø  -.46Ø3733E Ø1  11   .538215ØE Ø1  12   .5ØØ12Ø9E Ø2

UC is invoked.                  PROVIDE CONTROL MESSAGES

                             CPPR

                                SPECIFY THE FOLLOWING.

                                PAR. NO. (Ø TO COMPLETE ENTRIES),CONTROL (Ø=SPECIFY. 1=NOM.,2=MIN. 3=MAX),
                                PAR. VALUE,

Revised S1.                  1,
                             6Ø.778
                                      PAR. NO.   1 =  .6Ø778ØØØE Ø2

                                PROVIDE CONTROL MESSAGES

                             EXIT

                                TEMP.RY SOLUTIONS      4

                                V    VALUE             V    VALUE            V    VALUE            V    VALUE

                                1   .7787515E ØØ       2   .4993516E Ø1

                                D    VALUE             D    VALUE            D    VALUE            D    VALUE

Base current now 59.999 μA.     1   .5999925E-Ø4       2   .359991ØE-Ø2
                                3   .3ØØØ648E-Ø2       4   .9ØØ3891E-Ø1

                                5   .5999925E-Ø4 (I_B)    6   .3ØØØ658E-Ø2   7   .3Ø6Ø648E-Ø2   8   .15Ø3Ø56E-Ø1
                                9   .7787515E ØØ (V_BE)  1Ø  -.4214764E Ø1  11   .4993516E Ø1  12   .5ØØ116ØE Ø2
```

8. **Breadboard capability** of parameter variation is provided by the user-control feature. Here it is used to fix the base current at 60 μA for a saturation performance check of the transistor model of CIRC itself.

Table 2. Saturation study results

$R_1=1M$; $R_2=10K$; $S_1=60.778$				
S_2 (V)	I_C (mA)	V_{CE} (V)	V_{BC} (V)	I_C/I_B
35.	3.00	5.382	-4.60	50.00
32.	3.00	1.99	-1.22	50.00
30.	2.97	0.254	0.525	49.57
25.	2.48	0.172	0.602	41.37
15.	1.49	0.132	0.629	24.77
5.	0.49	0.095	0.642	8.17

steps produce equal changes in collector current.

The 1000-megohm shunts are included for CIRC mechanization purposes but their effect on the model should normally be negligible.

Engineer controls CIRC

For a circuit analysis program such as CIRC to give significant aid with design, it must perform more than just nominal circuit analyses. It must also enable the designer to experiment with the proposed design much as he can with a breadboard. CIRC provides this ability through a facility called user control (UC). For example, user control can allow element values to be temporarily or permanently changed; elements may be removed from or added to the circuit; a transistor may be converted from one device type to another by appropriate parameter changes. Other UC features enable the designer to control the progress of the program. In particular they allow him to control the peripheral output equipment, the nature and volume of CIRC labor and output, and the type of operations the program performs.

The user control feature is made available at set points in the program. For example, it is available after nominal solutions are completed and printed out, provided that certain switches are set on the computer operating console. At these points CIRC types the message:

PROVIDE CONTROL MESSAGE

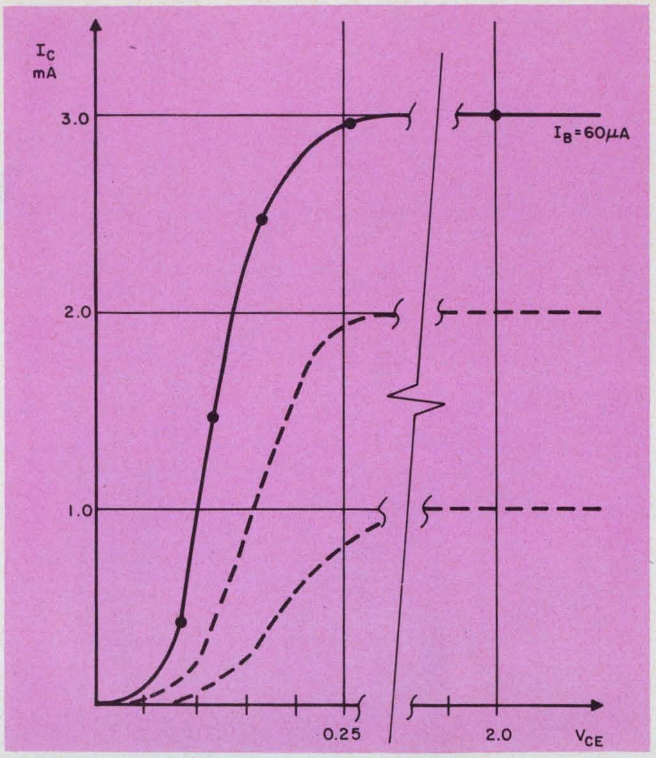
and then looks for a control message.

The control messages are four-letter mnemonics that direct CIRC to some specific action. For example, POTY means that the Printed Output is to be provided with the TYpewriter. Forty control messages are available.

CIRC looks at itself

To illustrate user control, one of the most significant of these messages, the parameter-change control, will be used to study the nonlinear characteristics of the transistor element in the circuit of Fig. 1a. The control message to be used is CPPR, Change the Present value of the PaRameter.

For this example, the saturation performance of the transistor model will be examined by generating one of the collector characteristic (common-emitter)



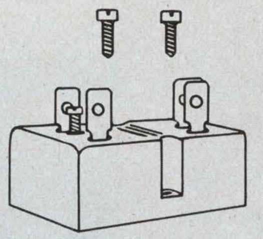
9. **User control enables parameter changes** to be made—in this case, in collector supply voltage—to obtain model characteristics for the CIRC transistor so that its performance may automatically be checked.

curves. This is done by forcing the base current to be constant and generating data to plot collector current (I_C) versus the collector-to-emitter voltage, (V_{CE}). The easiest way to do this is to use a CIRC current element to keep this base current constant, but in this case a large base resistor will be used so that the configuration of Fig. 1 can be referred to. The base current is forced to approximately 60 μA by setting the input supply, *S1*, to 60 volts with an input resistance, *R1*, of 1 megohm. V_{CE} can be varied by changing the collector supply voltage, *S2*. Part of the resultant conversation between the user and CIRC is shown in Fig. 8.

After the first analysis the base current is 59.2 μA instead of 60 μA, so drive source *S1* is increased to 60.778 volts. This gives a base current of 59.9992 μA. A complete examination of saturation performance is carried out in this manner by changing the collector supply voltage, *S2*. The results show the saturation of the transistor element (Fig. 9). ■ ■

References:

1. Nathan O. Sokal *et al.*, "Use a good switching transistor model," ELECTRONIC DESIGN, XV, No. 12 (June 7, 1967), 54-59.
2. C.T. Kleiner, E.D. Johnson, W.D. Ashcraft, "A general purpose system of digital computer codes for linear/nonlinear network and systems analysis," *I.E.E.E. Conv. Record,* XV, Part 5 (March 1967), 136-148.
3. Sokal *et al.*, "Diode model is analyzed by computer," *ibid.*, No. 14 (July 5, 1967), 80-83.
4. ———, "Assign the proper numerical values," *ibid.*, No. 13 (June 21, 1967), 60-66
5. ———, "Use a good switching transistor model," *loc. cit.*



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Which delay line is best to simulate very fast targets for Doppler radars? The choice narrows down to two groups but there is no clear-cut boundary.

The simulation of aircraft, missiles and other very rapidly moving targets is essential to the testing and production of radar systems. There are two types of black box that can do the job, each with its own peculiarities. In order to make the best choice, the designer should have a good grasp of the devices' basic designs, their present performances and future potentials.

The classic conflict: solid-state or tube

The two types of device are solid-state delay lines and electron-beam delay lines operating at microwave frequencies. (The concern here is only with delay lines that can simulate both the range and velocity characteristics of rapidly-moving targets. There are other approaches that combine transmission lines and variable-delay devices, but they work well only when range information alone is sought. These systems have either fixed or slowly variable delays, which make it very difficult to simulate the Doppler shift of fast targets.)

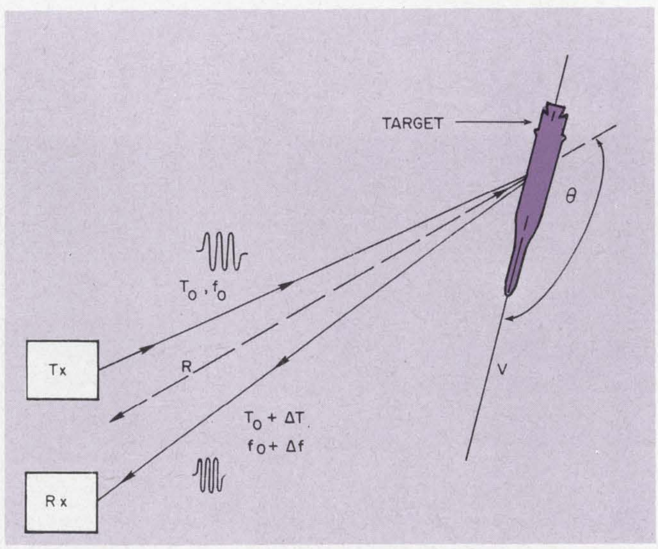
In general, solid-state delay lines provide large ranges of delay but are lossy. Electron-beam lines—in particular, traveling-wave types—offer wide bandwidths and less insertion loss, but also less delay.

The solid-state approach is designed around a semiconductor material (yttrium iron garnet, for example) with a transducer attached to each end. The incoming signal is converted into some other wave—acoustical, shear, magnetoelastic, etc.—by the first transducer. The propagation in the material introduces the delay. The wave is then coverted back into a signal by the other transducer. There is some variation in the actual systems. The delay, for instance, may be doubled if the wave is bounced back and travels twice the length of the material.

In electron-beam lines, the delay is introduced by a strategically-placed electrode, which is at a potential that may be varied externally, to control the speed of the electron beam in a vacuum tube.

Jack Lucken, Senior Engineer, Microwave Associates, Inc., Burlington, Mass.

Testing an O-type delay line, Jack Lucken adjusts the bias voltage on the electrode that controls the delay.



1. **A Doppler radar tracks** a moving target. The rate of change in the delay of the received signal depends on the target's velocity. To simulate a target traveling at a velocity of 10,000 mi/h, the delay should change at a rate of 1.5×10^{-5} seconds/second.

The beam is generated by the incoming signal.

What are the typical specs?

For an idea of the performance required of these variable delay lines, consider a typical case. The reproduction method of both range and velocity characteristics is shown in Fig. 1. A pulse of energy with carrier frequency f_0 is transmitted at time T_0, is reflected from the moving target and reaches the receiver at time $T_0+\Delta T$ with a Doppler-shifted frequency of $f_0+\Delta f$. If c is the velocity of light and R is the range, the change of frequency with velocity may be calculated:

$$\Delta T = 2R/c, \qquad (1)$$

$$d/dT(\Delta T) = (V/c)\cos\theta, \qquad (2)$$

and:

$$\Delta f/f_0 \approx -(V/c)\cos\theta. \qquad (3)$$

From these relations, the rate of change of the delay can be found for a given closing velocity. Assume a closing velocity of, say, 10,000 mi/h where $\theta=180°$:

$$-(\Delta f/f_0) = d/dT(\Delta T) \approx 1.5\times10^{-5}.$$

Hence, if $f_0=10$ GHz, then $\Delta f=+0.15$ MHz, and the rate of change of delay needed to simulate this effect is:

$$d/dT(\Delta T) = -1.5\times10^{-5} \text{ seconds per second.}$$

The block diagrams of some typical delay systems are shown in Fig. 2. Electronically variable delay lines can achieve such calculated delay rates. They have the advantage over fixed delay lines that a variable attenuator can be ganged to the delay line in many instances, allowing a reduction in pulse with the range under simulation.

The most promising approaches to electronically variable delay lines that are under investigation at present are:

- Solid-state delay lines—devices using magnetostatic and spin waves.
- Electron-beam delay lines—using either crossed-field or O-type beams.

Solid-state types offer large delay variations

The most practical solid-state microwave variable delay line to date uses magnetoelastic and spin wave[1,2] in a ferrite material—typically yttrium iron garnet (YIG). Large variations of delay are obtainable—on the order of tens of microseconds. The main assets of this type of delay line are:

- Large variation of delay time. Typical variations are about 3 μs, and some measurements were reported up to 20 μs.
- Small size and power requirement. The maximum dimentions of the YIG crystal itself are typically about 1 cm. The only power requirements are for trimming the magnetic field, if the main field is obtained with a permanent magnet. In a parametrically pumped delay line (Fig. 3), a suitable oscillator is required, together with its own power supplies.

The major drawbacks of these delay lines are:

- High insertion loss at room temperature—typically 70 dB for a 2-μs delay line in X band.
- Narrow bandwidth—approximately 2 to 3%.
- Pulse distortion on short pulses because of the bandwidth limitation. At 3 GHz, for example, a bandwidth of 3% results in a rise time of greater than 6 ns.
- Large delay sensitivity to small changes in the magnetic field. This means that a high degree of homogeneity of the magnetic field is necessary for minimum pulse distortion. The minimum rate of change of delay of magnetoelastic waves with magnetic field is about 25 ns/Oe[3] and increases rapidly at the maximum delay.
- Rapid changes in delay are limited by how rapidly the magnetic field can be varied.

The uniformity of the magnetic field used with solid-state delay lines depends on the proper design of the magnet gap and the use of the region in the gap in which the magnetic field maintains the required degree of uniformity. Temperature control is important, to maintain time stability and repeatability of delay.

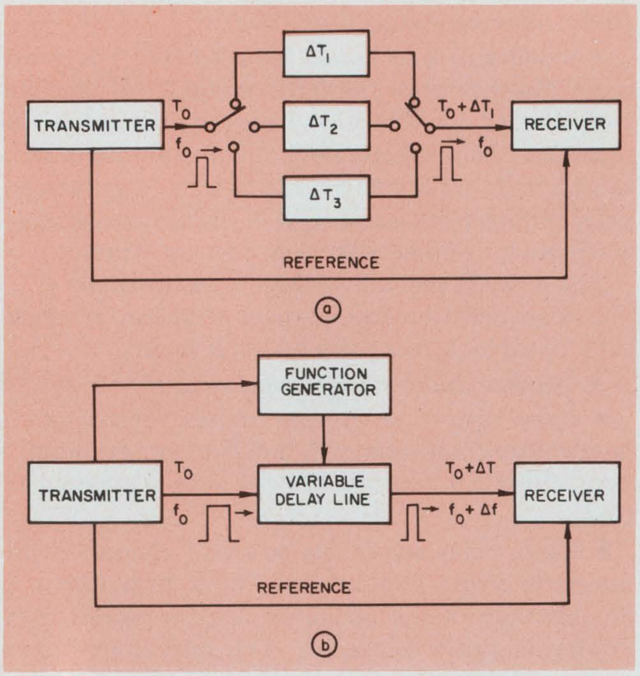
Variation of magnetic field is best achieved by a combination of a permanent magnet and a small adjusting coil, which can also be used to compensate the field for time variations. The maximum frequency at which the field can be swept without excessive losses is determined by the resistance and inductance of the modulating coil, within a range of $\pm$ 100 kHz. The coil should have an inductance as low as 100 mH and a capacitance as low as 100 pF.

The high insertion loss of solid-state delay lines has been overcome in some devices by applying the parametric amplification principle.[4] However, the need for large rf pump powers (typically greater than 20 watts at S band) and the narrower bandwidth of this form of interaction are difficulties that have not yet been solved satisfactorily.

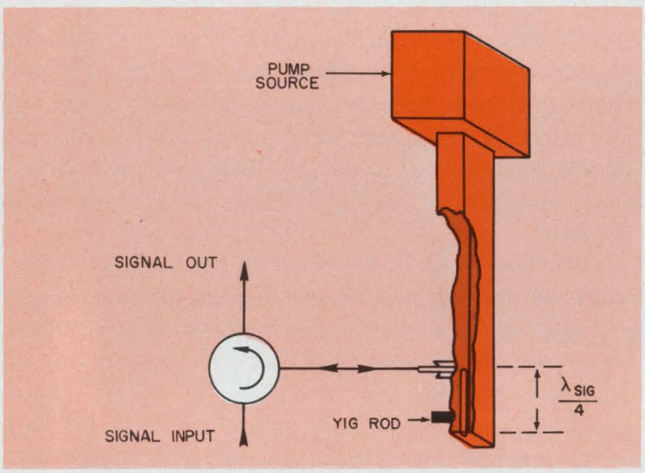
Electron-beam types have low insertion loss

Crossed-field delay lines[5,6] offer a lower insertion loss at comparable delay values than solid-state ones. For example, the loss of an Sband crossed-field delay lines was measured at 60 dB at a 3-μs delay.[7] This major advantage, however, has to be set against their shortcomings:

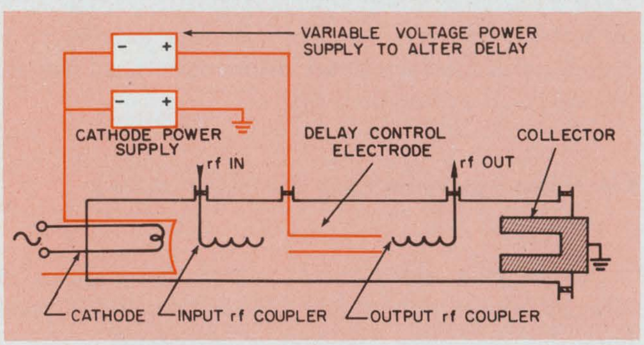
- Like solid-state delay lines, they have limited



2. **Simulators of moving targets** may use several fixed delay devices (a) or a variable delay line (b) controlled by a function generator.



3. **Parametrically pumped solid-state delay line** needs large rf pump powers: typically greater than 20 watts in S band. They offer large variations in delay times: up to 20 μs was reported.



4. **Traveling-wave delay lines** are basically modified TWTs. As a delay line, the TWT circuit is severed and has a drift space that changes the beam velocity. The delay depends on the potential and the length of the drift region in the tube.

bandwidth (a few per cent). This limitation is inherent in the principle of operation, owing to the dispersive nature of the waves carrying the rf signal.

- Since the time delay depends on the value of applied magnetic field, it is sensitive to field inhomogeneities, which cause pulse distortion.

Traveling-wave delay lines (O-type lines) completely eliminate bandwidth limitations. They are basically modified TWTs. The difference is that in the delay line the circuit is severed and has in the partition a drift space of variable potential, which causes a corresponding variation of beam velocity. The delay depends only on the length and potential of this region. A long drift space or a low potential causes a long delay and vice versa. The drift tube is supported inside the tube shell and is varied in potential by means of a lead taken through a coaxial pin seal (Fig. 4).

The advantages of this construction are fourfold:

- Because of their similarity to traveling-wave tubes, these delay lines are capable of very broad bandwidths—greater than an octave.
- The magnetic fields are used solely for beam-focusing and are not involved in determining the delay time. These qualities, together with the broad, instantaneous bandwidth, make the tube suitable for use with very short pulses and, allow simultaneous multiple signal-handling at frequency separations up to the full bandwidth of the tube. (Within the specified instantaneous bandwidth, the delay line needs no adjustments, and all frequencies have the same delay and suffer the same insertion loss.)
- Minimum delays on the order of 10 to 20 nanoseconds can be achieved.
- These delay lines are simpler than the crossed-field devices and so are more reliable and less expensive.

The major disadvantage of traveling-wave delay lines is that variable delays are presently limited to several tenths of a microsecond.

Measurements on traveling-wave delay lines have shown that bandwidths of about 2.5 octaves are obtainable with a gain variation of ± 2 dB in a type MA 2018 tube built for the 500−1500-MHz band (Fig. 5).

Particularly noteworthy is the rapidity with which the delay can be varied with these tubes. The delay-controlling electrode has a capacitance to ground of some 100 pF. Because of this low capacitance, the electrode potential can be swept through its full range in about 10 μs. This is a sweep rate on the order of 10^{-2}seconds/second, or approximately 10^7 ft/s. Furthermore, since the delay value is controlled by a dc potential, it is very easy to govern the shape of the output pulse by applying suitable waveforms to the control electrode.

The major objective of development work is to push the delay of traveling-wave lines to one microsecond and beyond.

Bearing the properties of these different delay lines in mind the systems engineer should have little difficulty in selecting the one best suited to his purposes.

Typical applications guide proper selection

The commonest applications of microwave delay lines are in crosscorrelators, autocorrelators, in pulse synthesis and in electronic-countermeasure: (ECM) systems.

In crosscorrelators (Fig. 6a), one of the signals is passed through a fixed delay line (which may have zero delay in some cases) and the other through a variable delay line. The signals are then combined and their product examined as a function of the variable delay, to determine the degree of correlation. Autocorrelators (Fig. 6b) perform the same function by comparing a signal with itself at different points in the wave train. In both cases, the product of the amplitudes will peak at certain values of delay if the signals are correlated with each other.

In general, cross- and autocorrelators require broad bandwidth but do not need a long delay capability. Thus electron-beam variable delay lines lend themselves to these applications.

In pulse synthesis applications (Fig. 7), the delay is varied in a preset fashion to produce a frequency shift and change in the pulse length. This can be combined, if necessary, with an electronically variable attenuator to alter the height of the pulse in conjunction with its frequency. The large delay variations in solid-state lines makes them suitable in these applications.

ECM applications involve detecting pulses from an enemy radar and retransmitting them with altered delays with the idea of confusing the hostile system.

In these applications, long variable delays are desirable. However, broad bandwidth and low dispersion are also required, so that the use of an electron-beam variable delay line in combination with a switched, fixed delay, or two variable delay lines in cascade, probably offers the best performance. ■ ■

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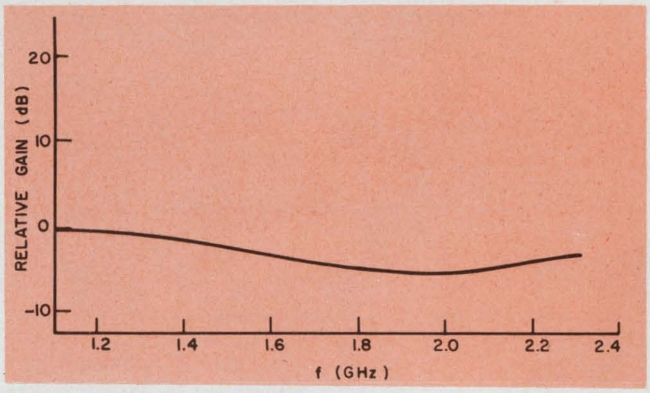
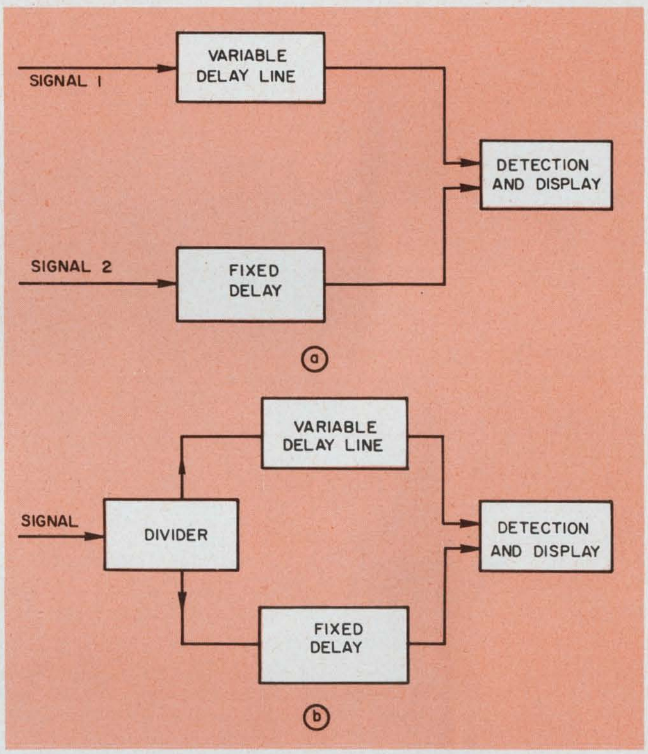
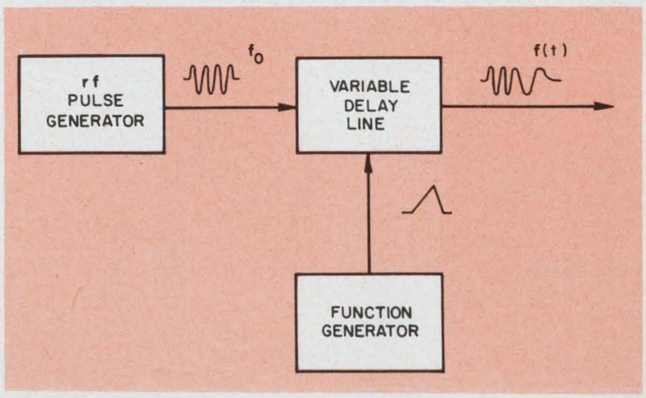


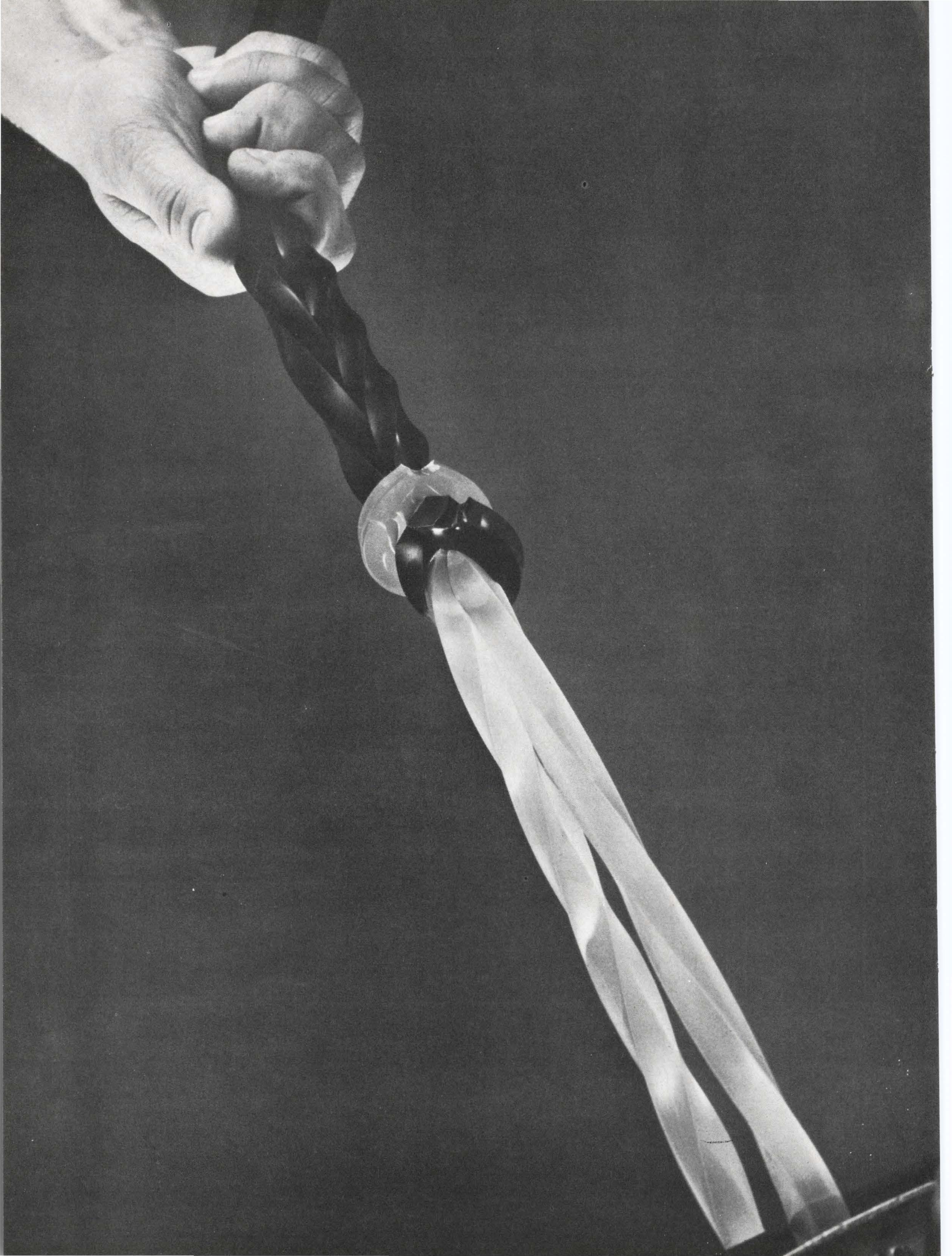
5. **Typical test result for an O-type delay line** shows its wide band (about 2.5 octaves). The tube is a type MA 2018 of Microwave Associates, Inc.



6. **Typical applications** of variable delay lines occur in crosscorrelators (a) and autocorrelators (b). There the major requirement is wide bandwidth.



7. **In pulse synthesis** the delay line produces a frequency shift and changes the pulse's length. A large variable delay is essential in these systems.



The paper is as mighty as the pen

in taking a good trace. Know your papers and you'll avoid pitfalls in data recording.

A few years ago, all that was needed to record information was a pencil and a couple of pages in an engineer's laboratory notebook. Today, however, it may take hundreds of feet of recording paper to nail down all the details of a design test, thousands of feet of analog channels to preserve all the information from a test run of a new engine, or literally miles of multichannel recording charts to present all the data on a single satellite shot. This makes it important for the engineer to know the advantages and limitations of his recording paper if he is to make the best possible use of his equipment.

There are six basic kinds of recording paper in common use today for data recording:

- Ink-process, of fluid-process.
- Thermal-process.
- Pressure-process
- Ultraviolet-process.
- Electric-process.
- Pressure-process.

Each of these recording papers has its own pros and cons and peculiarities.

Paper depends on recorder

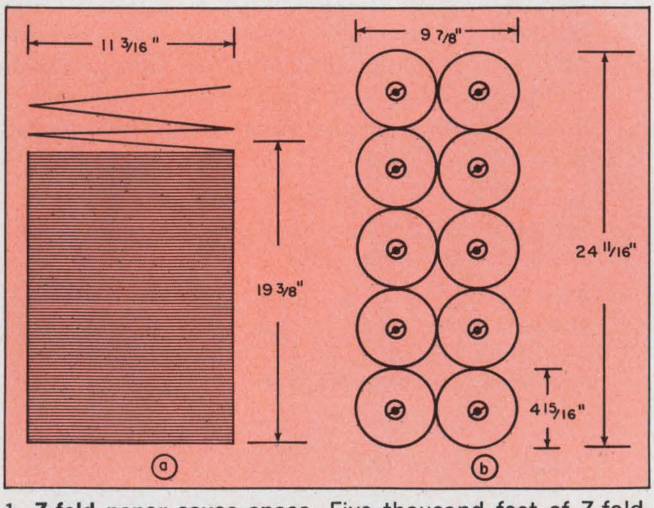
Any recorder or recording system generally functions only with the particular recording paper selected for it by the manufacturer. Since the recording elements, chart drive system, and recording paper are designed together for optimum operation, the user cannot expect equivalent results with other chart papers. The user, however, does have some choice in the way the paper is stored. Some recorders provide for rolls of recording paper, some are designed for Z-fold packs of recording paper; others allow use of either type. The familiar roll-feed is somewhat less expensive than Z-fold paper, but either needs to be unrolled manually or requires a chart-viewing assembly whenever the user wishes to look at any portion of the recording. Z-fold charts, on the other hand, permit immediate access to any part of the recording, and, unlike rolls, occupy a full 100 per cent of their storage space (Fig. 1).

Hector French, Manager, Training Publications, Hewlett-Packard, Sanborn Div., Waltham, Mass.

Ink and fluid processes in greatest use

Ink or fluid-process recording papers operate by depositing a film of ink or dye on the surface of the recording chart as it moves beneath the recording pen. Low-speed recorders, such as those used in industry to monitor a full working shift or 24-hour day, are often circular, with the time axis represented by the angular displacement of the chart. Higher-speed recorders generally use a strip chart, where the time axis runs along the length of the chart. The smooth paper surface provides a permanent, quick-drying, smudge-free recorded line.

Temperature and humidity will have little effect on the recording process except in extreme cases. They can, however, affect the dimensional stability of the recording and this can introduce error when measuring long time intervals. Such time-axis errors, whether caused by dimensional change or by changes in chart drive speed, may be overcome by registering a series of timing "pips" along the data strip. These pips are derived from a precise time source. Checking the pips against the printed grid will reveal any inaccuracies in the



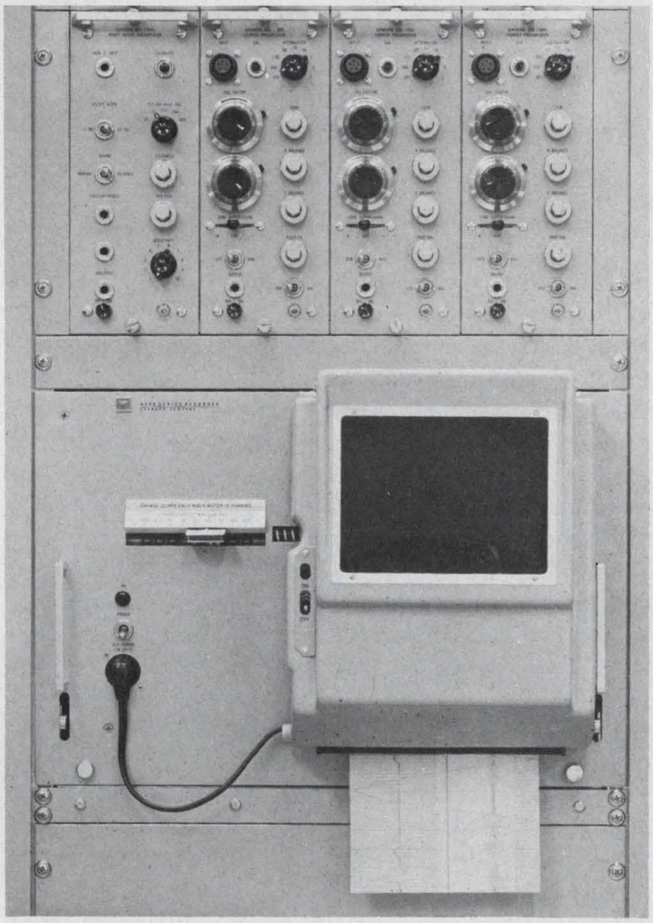
1. **Z-fold paper saves space.** Five thousand feet of Z-fold (a) stand 19-3/8-inches tall; a comparable amount of roll-fed paper (b) takes over 40% more space. Z-fold records are easily accessable; roll-fed is unraveled foot by foot.

grid lines with respect to time.

Amplitude-axis errors caused by dimensional change will not usually be great enough to cause appreciable error. In the unlikely case that dimensional change occurs between setup and recording, the dimensional change may appear as a borderline shift in the zero position of one or more channels in the recording charts. This can be detected by recording a short section of zero-input signal immediately before and after the actual data, to provide a true zero reference. This procedure, however, is reliable only when using drift-free amplifiers with a servo-feedback recorder. With other recorders, the error may be detected only by actual measurement of chart width with a metal rule.

In some cases, different weights of recording chart paper are available. Selection of the best weight depends largely on the intended use. A heavier stock is more rugged, but thinner stock allows a longer recording time with one roll or pack of paper, and requires less storage space per thousand feet of recording. Color, contrast, and density of the grid lines are considerations if good-quality reproduction on a copier is desired.

The handling properties of ink-process recording papers have also to be borne in mind. If the recording has to pass through many hands before it reaches its final destination, its resistance to scratches, pressure, finger marks, wrinkling, moisture and mounting adhesives should be checked beforehand.



2. **Photographic-paper processing can be sped up** with a rapid-developing adapter. Such recordings exhibit very high contrasts and lend themselves well to duplication by any standard method.

Thermal papers are prone to scratching

Thermal-process recording chart paper is a sandwich of base stock, a black coating on this base, and a plastic coating which conceals the black. Heating the surface with a concentrated, well-defined heat source, such as a hot-wire recording stylus, will melt the plastic coating at the point of contact to reveal the black coating beneath. The recording may be made in either of two ways: by wiping the hot-wire recording stylus across the chart paper in accordance with the signal, while the paper is moving over a knife-edge writing surface; or by moving a hot-tip recording pen across the chart paper, while the paper is moving over a flat writing surface. In a good thermal recording paper, the plastic coating is resistant to pressure and moisture, and will respond only to the application of heat. Modern thermal papers are more scratch-resistant than earlier types, but repeated, careless handling may scrape the plastic coating.

The quality of the recorded line, as well as the frequency and transient response of the recording, depend on stylus temperature and pressure. For best results, stylus pressure should be kept constant at the value specified by the manufacturer, and stylus temperature should be adjusted for optimum recording quality. Many modern recorders use a regulated stylus heat, which not only requires no adjustment, but is also automatically varied in accordance with chart speed.

Grid lines are printed on the plastic surface of the chart. Any dimensional changes can be treated in the same way as those of the ink-process papers. Thermal papers, however, will tolerate a wider range of ambient temperature and humidities than ink-process papers.

Options are sometimes available for the weight of the recording paper. Some manufacturers offer a translucent paper, which is designed for immediate reproduction on an ammonia-process duplicator. This translucent paper is not of sandwich construction. It is semitransparent over its entire surface to the ultraviolet illumination of the ammonia-process duplicator, except for the almost completely opaque printed grid lines and for the almost completely transparent recorded line made by the hot-wire stylus. This produces a duplicate which appears as a white recording and a dark blue grid against a light blue background. Some users prefer an office-type duplicator to copy the standard thermal-process recording papers. This will give satisfactory reproductions if the original has clear, sharp grid lines. Any duplicator may be used except those which work by heat.

Photographic papers take a little time

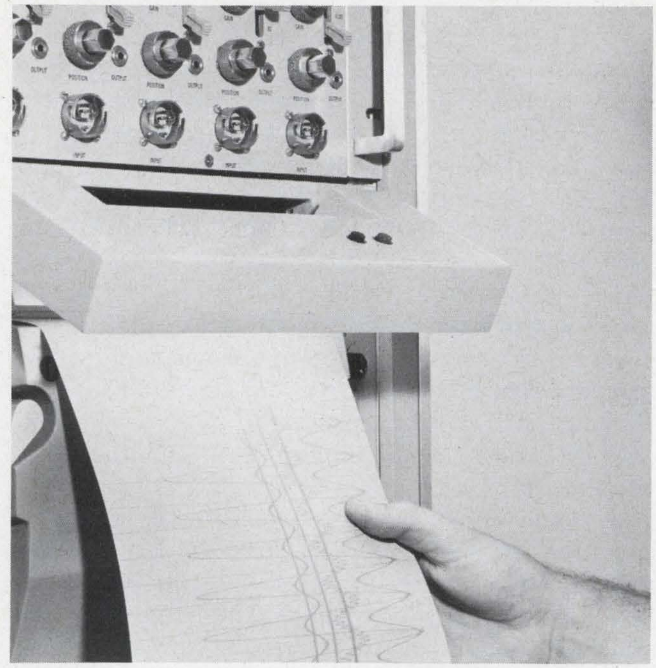
Photographic papers are made from a sturdy, moisture-resistant base covered with a light-sensitive coating. A fine beam of light, reflected from a moving galvanometer mirror onto the moving paper, produces a latent image on the chart paper, which is then developed by standard photographic chemical processing. Photographic papers are often used for recording high-frequency data, since the only moving part in the process, other than the chart drive, is a tiny galvanometer with a high natural frequency. The moment arm is replaced by the beam of light from galvanometer to paper. This does not restrict deflection velocities at the paper, so long as sufficient light energy is available per unit of chart paper area at the higher speeds of beam spot motion. With photographic papers, the recording is not immediately visible. This minor fault may be almost completely overcome, however, by using one of the rapid-developing adapters (Fig. 2) offered by many units.

Humidity is not a limitation, but the processing is somewhat dependent on the temperature of the processing solutions. This limitation is normally controlled by the manufacturer's selection of papers and his recommendations for processing solutions and methods. Since the grid lines are impressed on the recording photographically along with the data, dimensional change may be overcome by using the grid lines themselves as the definitive references of time and amplitude. Different weights of photographic recording paper are available. The best weight depends on the intended use; this can be found by experiment. Most photographic papers have excellent resistance to scratches, pressure marking and mounting adhesive, so handling need cause no worry.

Photographic-process recordings usually have a higher contrast than those made by any other process. As a result, they are ideal for display purposes and reproduce excellently with a standard office duplicator.

Watch the clock when exposing ultraviolets

Ultraviolet-process recording papers are much the same as photographic papers, but have a special photographic coating that makes high-speed direct writing possible. The coating records a latent image by exposure to a strong beam of ultraviolet light. This is developed and made visible by brief exposure to a fluorescent light of lower energy concentration at the surface of the paper (Fig. 3). This eliminates the liquid chemical development required with standard photographic papers. However, there is still a time lag between the instant of recording and the first view of the recorded data. This is a minor detail in view of the convenience and high recording speed which this class of paper can provide.



3. **Ultraviolet paper requires fluorescent post-exposure** to bring out the latent image. Care must be taken during development, since overexposure will render records totally useless.

The recording may be made by reflecting a beam of ultraviolet light from a galvanometer mirror, as in photographic recording, or by using an electron-beam–fiber-optic combination to bring the illumination right to the paper surface.

Humidity and temperature have little effect on the recording process, although they can affect the dimensions of the stock. Since the grid lines are recorded on the chart along with the data, the grid lines themselves are the reference for time and amplitude.

Ultraviolet recording presents neither the knife-sharp definition nor the extreme black-and-white contrast which are characteristic of standard photographic papers. As a result, the recordings will not reproduce so cleanly on an office duplicator. The recording is less permanent, since the development process will continue until the recording is useless, if the paper is allowed to remain exposed to light. The recording can, however, be made permanent by photographic development and fixing, as though it were a standard photographic paper.

Electric process can interfere with test rig

Electric-process recording chart papers respond to the passage of an electric current. Three types

Pros and cons of different papers

Ink-process papers are rarely affected by temperature and humidity, only occasionally troubled at extreme values; with good quality contrast and density of grid, they reproduce well by any standard copying process.

Thermal-process papers resist pressure and a wide range of ambient temperatures, humidities and moisture; they respond only to application of stylus heat. Care is necessary to avoid scratching the plastic coating of the paper. Duplication can be accomplished with any duplicator except a thermal process.

Photographic-process papers take time to develop; a rapid-developing adapter can speed the process. Little care is needed in handling, as resistance to scratches, pressure, marking and moisture is excellent. The printed trace exhibits a higher contrast than any other process, so reproduction can be made with any duplicator.

Ultraviolet-process papers need a fluorescent post exposure; too long an exposure will render the trace useless. Photographic fixing can make the record permanent. Contrast and definition are less sharp than photographic papers; reproductions on an office duplicator are usually unsatisfactory.

Electric-process papers can create objectionable fumes. In addition, high voltages can be dangerous to the operator and can interfere with nearby circuitry. Duplication is good by any standard method. A low-voltage method reduces the chance of interference and allows greater operator safety.

Pressure-process papers are extremely susceptible to unintentional damage through handling. It is wise to duplicate, by any standard method, those important portions of the trace and use the duplicate as a reference.

are in common use: high-voltage papers which record from a current passing through the entire thickness of the chart paper; low-voltage papers which record from a current passing through the entire thickness; and low-voltage papers where a current passes through a current-sensitive surface layer of the paper.

The high-voltage, whole-thickness papers operate on the basis of a physical change at the paper surface. The necessary high voltages can be dangerous to the operator and could interfere with nearby circuitry. With some of the papers, the process releases objectionable fumes.

The low-voltage, whole-thickness papers operate on the basis of an electrolytic action, which transfers metallic ions from the recording electrode, to produce a visible indication on the chart. These papers must be damp for this electrolytic action to take place.

Papers which pass a current through a sensitive coating are of sandwich construction, built with a paper base and a current-sensitive surface, separated by a conducting foil such as aluminum. Passage of current from a stylus in contact with the sensitive surface through this surface layer to the foil results in a permanent change at that point on the chart. This appears as a recorded trace as the chart paper moves past the recording pen. This low-voltage method is safer for the operator and reduces the likelihood of interference. No objectionable fumes are emitted.

Recording speed is limited with these papers by the same mechanical considerations that are found with the ink-based and thermal-based processes—a mechanical element must move across the chart to make the actual recording. The grid lines are printed on the stock as with ink-process and thermal-process charts. Normal office duplicators may be used to make satisfactory copies of electric-process recordings.

Pressure papers need careful handling

In the carbon-transfer pressure process, two separate paper stocks are used: one is the chart paper, with printed grids, and the other is a carbon stock which is discarded after use. The two papers pass beneath the pressure recording pens together, so that pressure on the back of the carbon stock will transfer an image of the data onto the recording paper. In the paper encapsulation process, the surface of the recording paper is coated with microscopic granules of ink or dye, each in a protective coating. Pressure against the paper surface will break these capsules at the point of contact and so release the ink or dye and produce an image on the paper. Characteristics of this paper are similar to those of fluid and thermal-process papers, especially with regard to dimensional changes. Pressure recordings made from encapsulation papers are more susceptible to damage from handling than those of other processes. For this reason, it is often helpful to make a duplicate of the important segments of these recordings, then use the duplicate as a reference, to keep the original from damage. The copy may be made photographically or with an office-type duplicating machine. ■ ■

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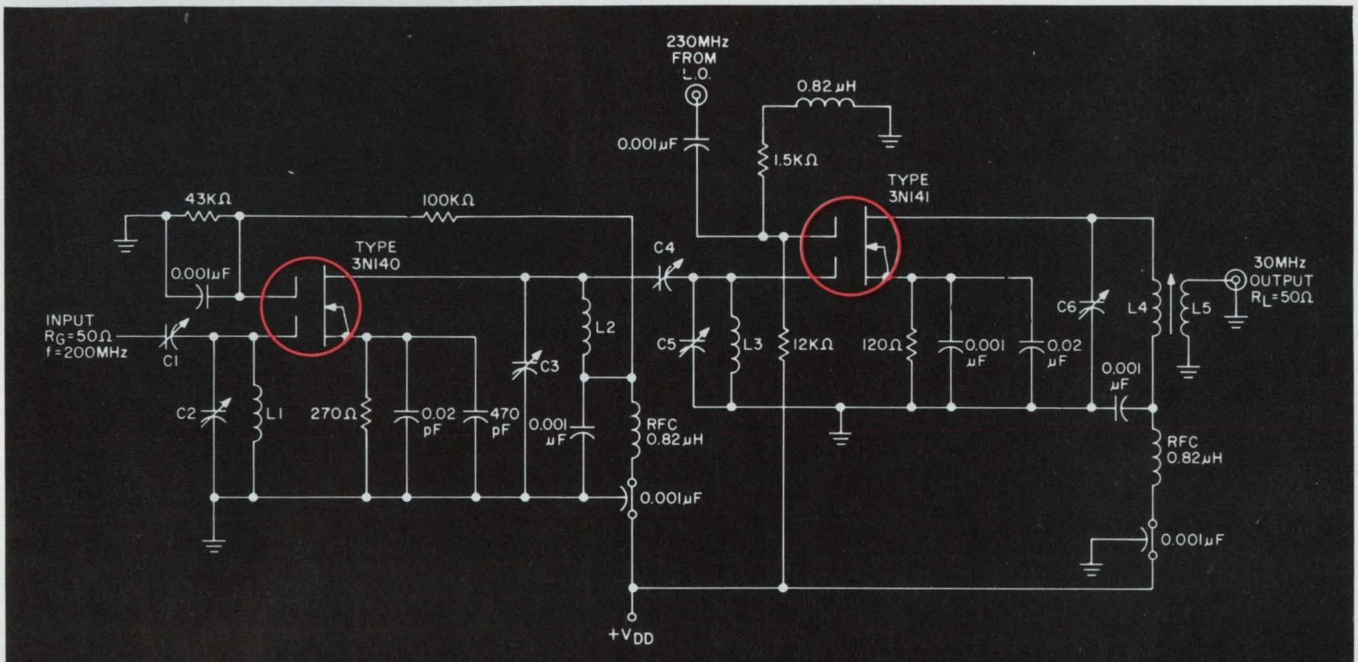

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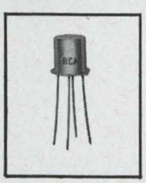

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ON READER-SERVICE CARD CIRCLE 42

Put the varactor's inductance to use

instead of looking upon it as a nuisance. Its effects on frequency range and losses can be overcome.

The effect of varactor inductance is one of the most troublesome aspects of the design of varactor-tuned circuits above 50 MHz. It degrades the diode's Q, and limits the frequency. These effects can be largely overcome, but to do so, many factors must be taken into consideration.

The recent availability of very high-Q voltage-variable capacitors[1] has made possible extensive application of these diodes in both the vhf and uhf ranges. As many designers have doubtless learned, however, merely having a high Q is not enough to ensure satisfactory performance.

Package adds inductance

The tuning diode, also known as varactor or voltage-variable capacitor, is a reverse-biased pn junction. In itself this junction has negligible inductance—its equivalent circuit at higher frequencies is solely the voltage-dependent junction capacitance, C_J, with a series resistance, R_s. The housing that protects the circuit contacts, however, gives rise to both an internal series lead inductance, L_s, and a shunting case capacity, C_c. The lead, in the form of a strap, wire, whisker or spring from the junction to the package contact, contributes most of this inductance. Inductance is also added by lead connections (Fig. 1).

The internal lead inductance is a function of the package and its internal structure. For tuning diodes housed in a DO-7 glass package (Fig. 2a), the inductance is approximately 3 nH; in a ceramic pill (Fig. 2b), it is about 0.5 nH.

The inductance of nonmagnetic round leads in the external circuit can be estimated from:

$$L(\mu\mathrm{H}) = 0.00508\, l[2.303 \log_{10}(4l/d) - 1 + \mu\delta], \quad (1)$$

where:

l = length (inches),
d = diameter (inches),
μ = permeability (1 for nonmagnetic material),
δ = skin effect factor.[2]

At low frequencies a 0.020-in.-diameter wire has an inductance of 26.8 nH/in., for example. The skin effect decreases inductance by about 6% at frequencies above about 100 MHz.

Most tuned circuits use parallel resonant tanks either in lumped or distributed form, and these are the circuits most sensitive to varactor inductance. Therefore it is desirable to use a series resonant circuit whenever the frequency approaches one-fourth the diode's self-resonant frequency. The diode's inductance can be made to appear either in series or in parallel with the tuning circuit. In a parallel configuration, it can be shown that it degrades the frequency range; in a series mode, it raises the operating frequency.

Inductance detunes parallel resonant tanks

Consider a varactor in a lumped tank circuit where the diode is in parallel with the tuning elements. The inductance of the diode's lead, L_s, is neglected in the equivalent circuit of Fig. 3a; it is included in Fig. 3b. In both figures, g_c denotes the loss of the external circuit, and g_g and g_L represent the source and the load, respectively.

Calculation of the insertion loss involves two assumptions: that the diode $Q > 5(\omega C_J R_s) \geq 5$ at the operating frequency, and that the source and load conductances are equal, $g_g = g_L$.

If inductance is not taken into account, the insertion loss at resonance is:

$$\begin{aligned} I_L &= P_{available}/P_{out} \\ &= \{1 + [(g_c + \omega^2 C_J{}^2 R_s)/2g_g]\}^2. \end{aligned} \quad (2)$$

The term $\omega^2 C_J{}^2 R_s$ is merely the equivalent parallel conductance of the varactor. Equation 2 can be simplified to:

$$I_L = \{1 + [(1/Q_c + 1/Q_D)/(1/Q_{ext})]\}^2, \quad (3)$$

where Q_c is the Q of the coil, Q_D is the Q of the varactor, and Q_{ext} depends on the external circuit and is equal to $\omega C_J/2g_g$.

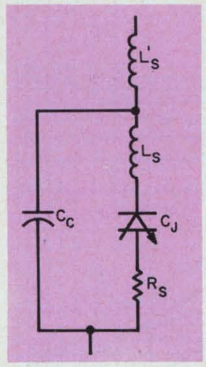
The bandwidth is determined by the loaded Q, Q_L, which can be calculated from the circuit Qs:

$$1/Q_L = 1/Q_{ext} + 1Q_c + 1/Q_D. \quad (4)$$

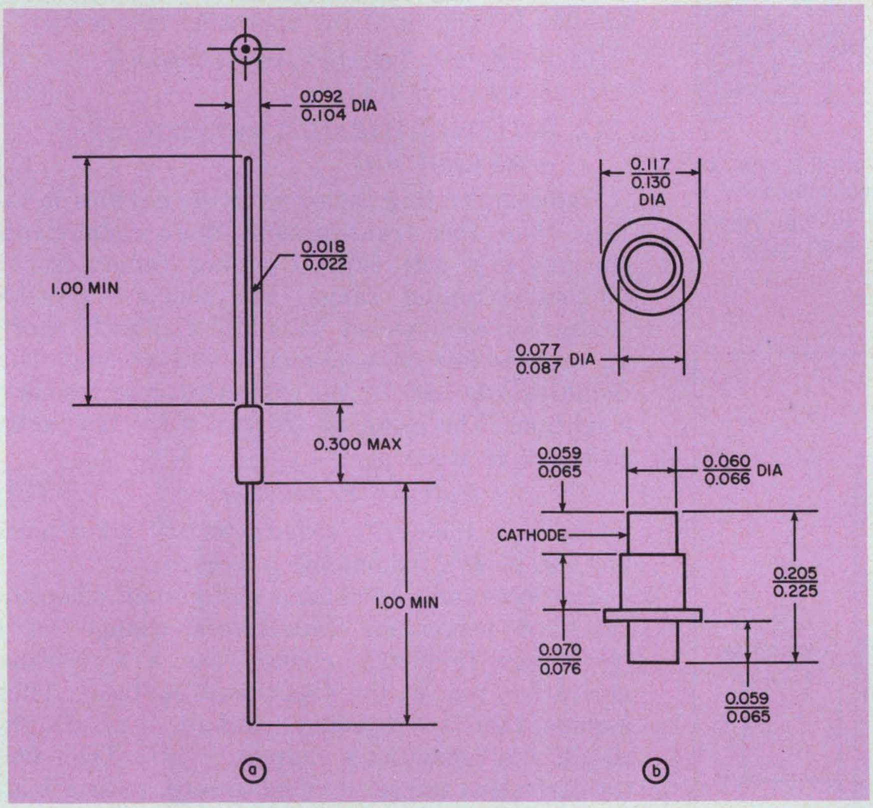
The diode's inductance modifies the loss:

$$I_L = \left[1 + \left(g_c + \frac{\omega^2 C_J^2 R_s}{(1 - \omega^2 L_S C_J)^2 + \omega^2 C_T^2 R_s^2}\right) \Big/ 2g_g\right]^2, \quad (5)$$

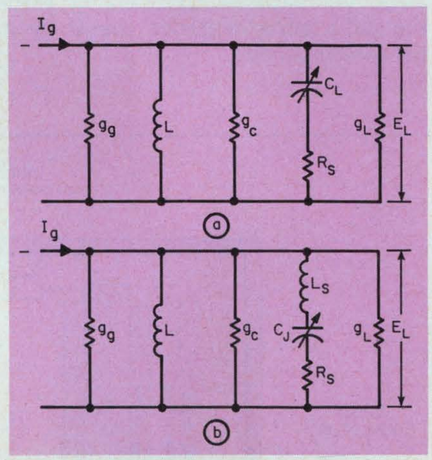
Gerald Schaffner, Applications Engineer, Motorola Semiconductor Products, Inc., Phoenix, Ariz.



1. **Equivalent circuit of a mounted tuning diode** includes the inductance of leads to the tuning diode L_s', the case capacity C_c which is approximately 0.3 pF, the internal lead inductance L_s, and the pn junction parameters, C_J and R_s.



2. **Two widely used package types** are the DO-7 (a) and the pill with prongs (b). The DO-7 package inductance is about 3 nH, while the ceramic pill's is about 0.5 nH. The dimensions are in mils.



3. **Equivalent circuit of parallel resonant tank circuit** may omit the varactor's inductance (a). Its inclusion (b) leads to a more accurate analysis.

which can be more simply written as:

$$I_L = [1 + (1/Q_c + 1/Q_D')/(1/Q_{ext})]^2, \qquad (6)$$

where Q_D' is the diode Q modified by the inductance:

$$1/Q_D' = (1/Q_D)/[(1 - \omega^2 L_S C)^2 + 1/Q_D^2]$$
$$= (1/Q_D)/\{[1 - (f/f_{sr})^2]^2 + 1/Q_D^2\}, \qquad (7)$$

where f_{sr} is the self-resonant frequency of the varactor:

$$f_{sr} = 1/2\pi(L_S C_J)^{1/2}, \qquad (8)$$

and $f = \omega/2\pi$, the frequency at which Q is calculated.

If the operating frequency is 0.223 f_{sr}, for example, the diode Q has been degraded by 10 per cent by its inductance: $Q_D' = 0.9\ Q_D$. In general, tuning diodes in parallel resonant circuits should not be used at frequencies higher than 0.223 f_{sr} because of the excessive Q degradation. This limit is shown in Fig. 4 for both DO-7 glass and ceramic-pill diodes.

When the diode is placed in a cavity, the limitations are essentially the same as those developed for a lumped circuit.

Cavity parameters are modified

Consider a typical case of a varactor tuning a foreshortened quarter-wave coaxial cavity,[3,4,5,6] as in Fig. 5.

The resonant frequency of this system without the diode's inductance is found from:

$$1/(2\pi f C_J) = Z_0 \tan(2\pi f\, l/v_c), \qquad (9)$$

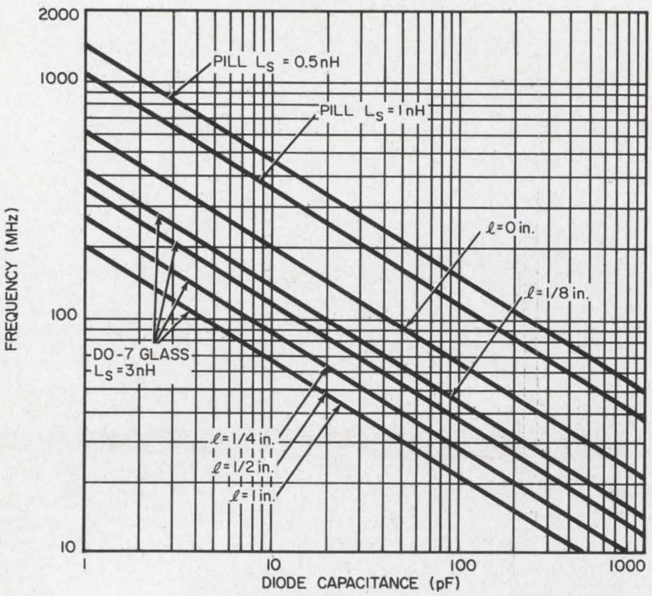
where:

Z_0 = characteristic impedance of the shorted coaxial line,

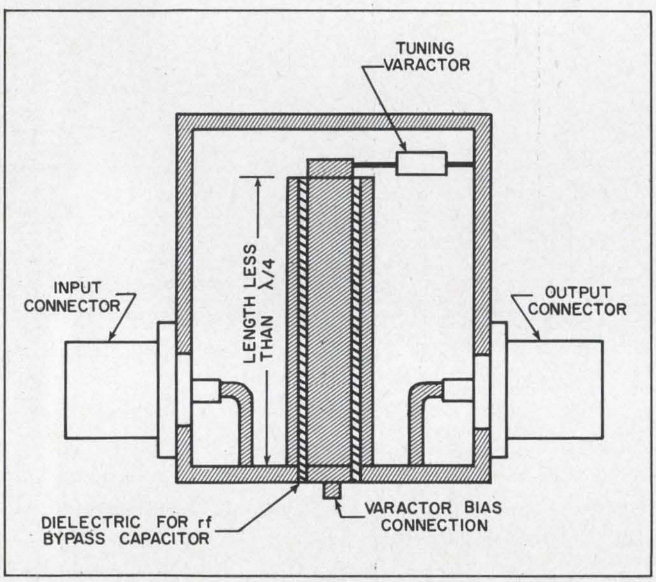
l = length of the coaxial line,

v_c = velocity of light = 3×10^{10} cm/s.

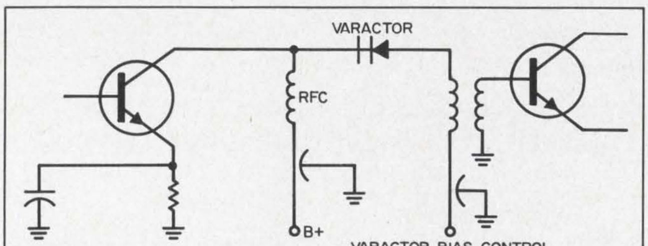
The effect that inductance has on cavity response is identical to that it has on the lumped circuit, provided that the following two points are remembered.



4. **The diode's frequency limits** depend on the type of package and lead length. The limit is determined by a 10% decrease of Q_A. Parallel resonant tuning, where the inductance degrades the Q by more than 10%, is not recommended.



5. **In a varactor-tuned coaxial cavity,** the cavity length should be less than $\lambda/4$, so that the cavity impedance is inductive at the varactor terminals. The diode's capacitance resonates with the inductance at the mean frequency.



6. **Series resonant tuning** permits the varactor inductance to be added to tank circuit inductance, thereby raising the possible operation frequency.

■ The equivalent circuit of the cavity is identical to that of a lumped tank if the point of reference is the varactor itself. Conductances g_g and g_L must then be transformed to the impedance level of the varactor. Conductance g_c represents the cavity loss looking out from the varactor terminals and can usually be neglected in a well-constructed cavity.

■ The shorted transmission line can be represented by an inductance in parallel with a capacitance over a fairly broad frequency range.

These equivalences may be derived by equating the magnitude and phase of the admittances of the shorted transmission line and the equivalent parallel LC circuit at the operating frequency:

$$L_{eq} = [Z_0/\pi f]/[(2\pi fl/v_c)\csc^2(2\pi fl/v_c) + \cot(2\pi fl/v_c)]; \qquad (10)$$

$$C_{eq} = [1/4\pi f Z_0][(2\pi fl/v_c)\csc^2(2\pi fl/v_c) - \cot(2\pi fl/v_c)]. \qquad (11)$$

One complicating factor with the cavities is the fact that the transmission line's admittance changes over the desired tuning range. For a maximum tuning range, the shortest possible cavity is recommended. This also applies to shorted cavities less than a quarter-wave long. This point is made clear by the examination of resonant conditions. The resonant frequency for the cavity in Fig. 5 is given by:

$$2\pi f C_J = Y_0 \cot(2\pi fl/v_c), \qquad (12)$$

where Y_0 is the cavity's characteristic admittance and the diode's inductance is ignored.

The best tuning conditions will prevail when the curve of percentage capacitance change vs a percentage frequency change has a zero slope derivative; that is, the dependence is linear. Thus assume that a frequency change, $+\Delta f$, is the result of a capacitance change, $-\Delta C_J$. Then find the derivative and set it equal to zero, to arrive at:

$$2\pi f C_J(1+\Delta f/f)(1-\Delta C_J/C_J) = Y_0 \cot[2\pi fl(1+\Delta f/f)/v_c]. \qquad (13)$$

If Eq. 12 is subtracted from Eq. 13 and higher-order differentials are neglected, the result is:

$$\Delta C_J/C_J = (\Delta f/f)[1 + (4\pi fl/v_c)/\sin(4\pi fl/v_c)]. \qquad (14)$$

A change of C_J will best approach linearity with a change of f when the bracketed expression is minimum, or when $\tan(4\pi fl/v_c) = 4\pi fl/v_c$, which occurs when $l = 0$. Hence, for maximum tuning range, the minimum cavity length should be used.

Series resonant circuits alleviate some problems

The frequency limitations of parallel resonant circuits (Fig. 4) can be partially overcome by exploiting the inductance in lumped series resonant circuits, where the diode inductance adds directly to circuit inductance.

A single-tuned, resonant lumped circuit for tuning and coupling transistor circuits is shown in Fig. 6. Here the varactor bias is between the collector supply voltage and a lower-value control voltage.

In a double-tuned series resonant circuit (Fig. 7a), the varactor inductances again merely add to the circuit inductances so that performance is not degraded. Coupling capacitor C_m can be replaced by a varactor to provide wider tuning range. Its equivalent circuit (Fig. 7b) is useful for determining the necessary design equations.

For minimum insertion loss and a single-peaked response, the ratio of the capacitances should be:

$$C_m/C_A = 1.4(f_0/BW) - 1, \qquad (15)$$

where:

C_m = coupling capacitor,
C_A = series capacitor,
f_0 = center frequency,
BW = 3-dB bandwidth.

For lowest midband insertion loss, I_{L_0}, critical coupling should be achieved. The condition is:

$$I_{L_0} = [(1+Q/Q_u)^2+1]^2/4, \qquad (16)$$

where $Q \approx 1+C_m/C_A$. The loaded Q of each circuit is much less than Q_u, its unloaded Q, which is:

$$1/Q_u = (1/Q_c) + C_m/[(C_A+C_m)Q_A] + C_A/[(C_A+C_m)Q_m], \qquad (17)$$

where Q_A is the Q of the series capacitor or varactor, and Q_m is the Q of the coupling capacitor or varactor.

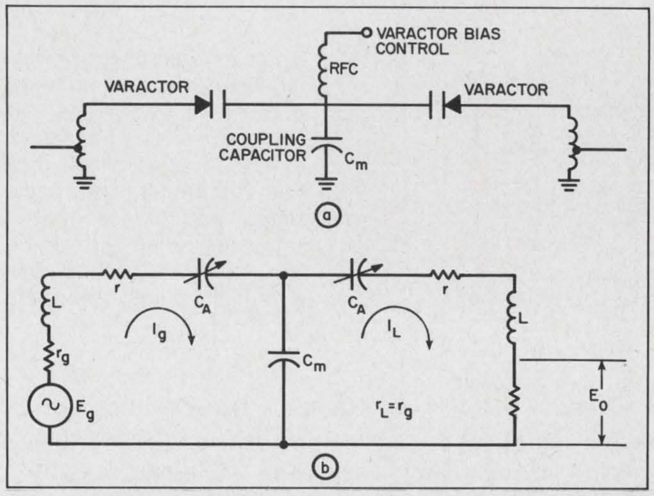
To illustrate the use of these equations, assume that a circuit is needed with a 10% bandwidth. Then $C_m/C_A = 1.4\ (10) - 1 = 13$. The selection of a specific C_A depends on frequency and available varactors. Varactors with smaller capacitances have higher Qs, however. Larger inductances would then be required and these, in turn, would probably have lower Qs and so degrade the over-all figure. At 400 MHz, for example, for a C_A of 2 pF, a reasonable Q_A to expect is about 100. A coil with a Q of about 200 is easy to obtain. Then $Q_u = 64$ and:

$I_{L_0} = [(1+14/16)^2+1]^2/4 = 1.57$, or about 2 dB.

In the coupling capacitor of Fig. 7b, inductance problems can still occur, especially if a varactor is used. Though the Q of the coupling capacitor is less critical than that of the series capacitor, care should be taken that the operating frequency is well below the coupling capacitor series resonant frequency. If this is impossible, an inductance can be placed in series with the coupling varactor to give a net inductive reactance (tunable by the varactor) as the coupling impedance.

Diode is put in series with the line of the cavity

The frequency limitations of distributed resonators can be bypassed in much the same manner as those of lumped circuits. The varactor inductance is made part of the cavity by placing the diode in series with the transmission line. A varactor, with



7. **The varactor inductance adds to circuit inductance,** hence response of circuit is not degraded. The coupling capacitor, C_c, can be replaced by a varactor for wider tuning range (a). In its equivalent circuit (b), it is assumed that the circuit coupling is adjusted for $r_L = r_g$, and is otherwise symmetrical.

junction capacity C_J and lead inductance L_S, tunes a line that is loaded by capacity C_T, as shown in Fig. 8. Making L_S and C_J resonant, C_T large (hence, line length small), and Z_0 small enables a wide tuning range to be achieved.

The philosophy of this series-tuned cavity design is to keep the equivalent fixed capacity that appears in series with the varactor as large as possible. This allows the voltage-variable junction capacitor to control the resonant frequency to the greatest extent. The largest tuning range is obtained when the equivalent capacitance of the transmission line in series with C_J is maximum. A few equations will prove this. A capacitively loaded line has an impedance:

$$Z = j2\pi f L_{eq} - j/(2\pi f C_{eq}) = j[(Z_0^2 2\pi f C_T \tan\theta - Z_0)/(Z_0^2 \pi f C_T + \tan\theta)], \qquad (18)$$

where:

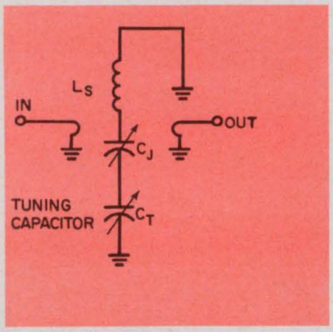
C_T = tuning capacitance,
Z_0 = line's characteristic impedance,
θ = line's electrical length = $2\pi f l/v_c$,
L_{eq} = line's equivalent series inductance,
C_{eq} = line's equivalent series capacitance.

Differentiating Eq. 18, multiplying it by $2\pi f$ and subtracting the result from Eq. 18 yield:

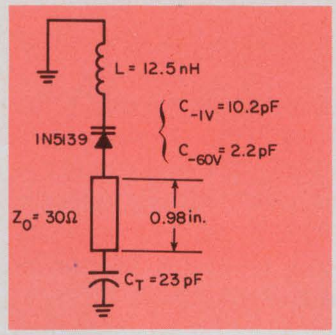
$$\frac{2}{2\pi f C_{eq}} = \frac{Z_0 + Z_0^2\, 2\pi f C_T\, \theta \sec^2\theta}{Z_0^2\, \pi f C_T + \tan\theta} - \frac{(Z_0\, 2\pi C_T + \theta\sec^2\theta)\,(Z_0^2\, 2\pi f C_T \tan\theta - Z_0)}{(Z_0\, 2\pi f C_T + \tan\theta)^2}. \qquad (19)$$

The maximum capacity occurs when the line appears as a short circuit, in which case $1 = Z_0 2\pi f C_T \tan\theta$. Then Eq. 19 can be simplified to:

$$C_{oq} = (2/\omega Z_0)\ (\cot\theta + \tan\theta)/(1 + \theta\cot\theta\sec^2\theta) = (2/\omega Z_0)/(\theta + \sin\theta\cos\theta). \qquad (20)$$



8. **In a varactor-tuned cavity,** where the diode may be in series with the line, the cavity consists of a capacity-loaded open-circuit line. The varactor and its associated inductance terminates the other end of the line. Inductive input and output couplings are used.



9. **Equivalent circuit of a varactor-tuned cavity** covering from 470 MHz to 890 MHz uses the values calculated in the text. The given values for C_T, Z_0 and L, and a Smith chart permit calculation of the 1N5139 capacity values: C_{max} = 11.1 pF and C_{min} = 2.35 pF.

Equation 20 is maximum when both Z_0 and θ are as small as possible. In other words, for maximum tuning range, the end turning capacitor should be large, Z_0 should be small, and the varactor should be resonated by the inductance to ground at the design center frequency.

Design can be completed in seven steps

A design procedure encompassing these considerations can be synthesized in seven steps. A numerical example accompanies the procedure, the results of which have been experimentally verified.

1. For the desired tuning range, f_{max}/f_{min}, select a varactor with the highest possible Q, where $C_{max}/C_{min} > (f_{max}/f_{min})^2$.

To tune, for instance, from 470 MHz to 890 MHz, $f_{max}/f_{min} = 1.89$, or $C_{max}/C_{min} > 3.58$. For the 1N5139, $C_{-1V} = 10.2$ pF and $C_{-60V} = 2.2$ pF; hence, $C_{-1V}/C_{-60V} = 4.64$.

2. Find the mean frequency, $f_m = (f_{max}f_{min})^{1/2}$. Then pick a lead length of the varactor so that it will resonate with the junction capacitance at f_m.

For the 1N5139, for instance, the mean capacitance between C_{-1V} and C_{-60V} is 4.8 pF at 10 volts' applied bias. To resonate 4.8 pF at the mean frequency of 650 MHz requires $L = 12.5$ nH. With 27 nH/in. for lead inductance and a 3-nH internal varactor inductance, the required lead length is 0.35 inch.

3. Select a low characteristic impedance, Z_0, for the transmission-line portion of the cavity; between 20 Ω and 40 Ω is reasonable.

Select Z_0 to be 30 Ω, for example. For a coaxial line where OD = 1 inch and ID = 0.6 inch, Z_0 = 30 Ω.

4. Calculate the minimum allowable equivalent transmission-line capacity, C_{eq}, which is in series with the capacity of the varactor, according to:

$$[(C_{min} + C_{eq}) / (C_{max}+C_{eq})] \, C_{max}/ C_{min}= (f_{max}/f_{min})^2. \quad (21)$$

Equation 21 is derived from:

$$f_{min} = 1/[L\, C_{max}\, C_{eq}/(C_{max}+C_{eq})]^{1/2}$$
$$f_{max} = 1/[L\, C_{min}\, C_{eq}/(C_{min}+C_{eq})]^{1/2},$$

which express cavity resonance at the tuning diode's limit frequencies.

For the example, where $(f_{max}/f_{min})^2 = (890/470)^2 = 3.58$, $C_{max} = C_{-1V} = 10.2$ pF and $C_{min} = C_{-60V} = 2.2$ pF, then $C_{eq} = 24.5$ pF.

5. Calculate the transmission line's electrical length, θ, at the mean frequency, from the transcendental equation, Eq. 20:

$$\theta + \sin\theta \cos\theta = 2/(\omega\, C_{eq}\, Z_0).$$

Since θ is normally fairly small, a first-order approximation is acceptable. This yields:

$$\theta \approx 1/(\omega\, C_{eq}\, Z_0).$$

The correct θ is usually slightly larger than the trial θ, but a precise calculation of θ is generally unnecessary.

For the example, where $Z_0 = 30$ Ω, $\omega = 2\pi 650 \times 10^6$, $C_{eq} = 24.5 \times 10^{-12}$, θ is calculated to be 0.34 rad.

6. From θ calculate the transmission-line length, $l = \theta\lambda/2\pi$, where λ is the mean frequency wavelength.

Thus, $l = 0.34/2\pi \times 18.2 = 0.98$ in.

7. Calculate the loading capacity, C_T, from $1 = Z_0\, 2\pi f C_T \tan\theta$, for maximum tuning range, where f is the mean frequency.

Thus, $1 = 30 \times 2\pi 650 \times 10^6 \times C_T \times \tan 19.6$; hence $C_T = 23$ pF.

An equivalent circuit of the varactor-tuned cavity for 470 to 890 MHz is shown in Fig. 9.

An exact check of the tuning range was made using transmission-line theory and a Smith chart for the two extreme frequencies, 470 and 890 MHz. At 890 MHz, the junction capacitance needed to tune the cavity was calculated to be 2.35 pF, and at 470 MHz, to be 11.1 pF. These were close enough to the values of $C_{-1V} = 10.2$ pF and $C_{-60V} = 2.2$ pF to permit the design to stand. ■ ■

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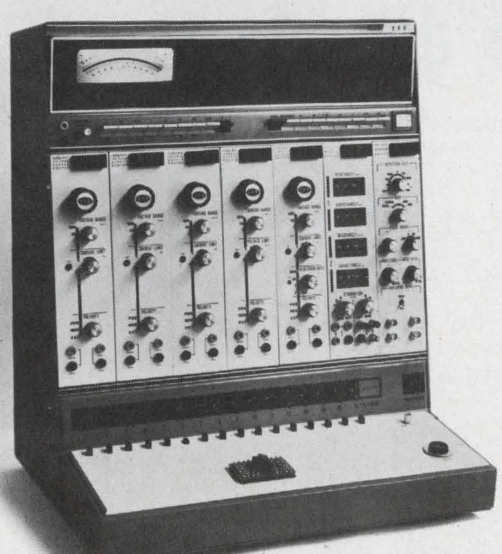

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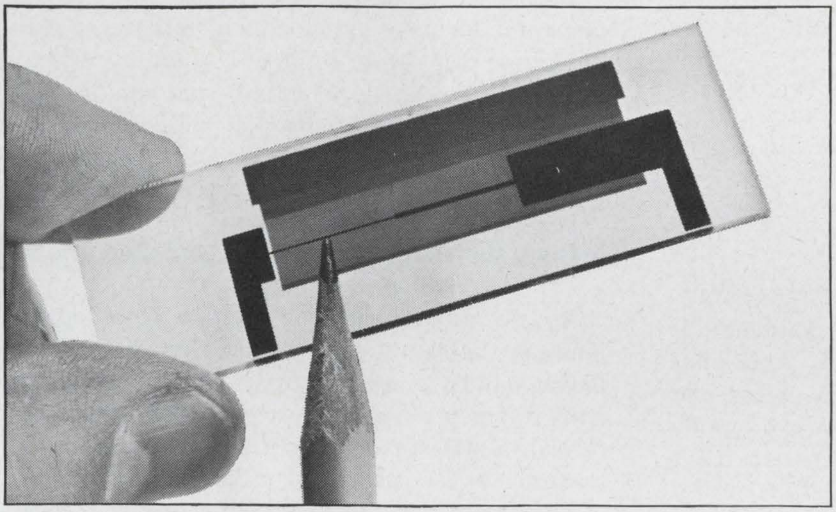
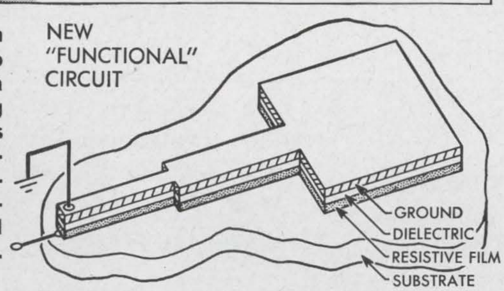
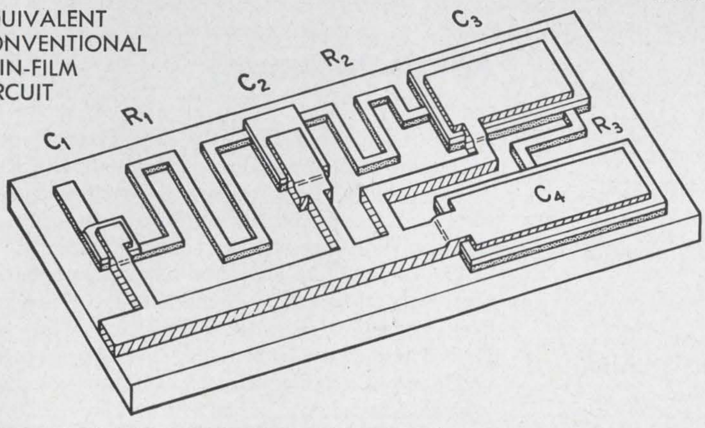
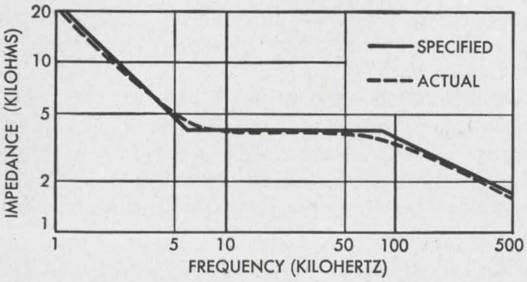
"Functional" Tantalum Integrated Circuits



The new "functional" thin-film circuit, shown in the above photo and in the drawing, right, is a two-terminal network consisting of thin films deposited on a glass substrate. For equivalent electrical performance, a conventional thin-film circuit would require at least three resistors and four capacitors (drawing, below).







Wyndrum formulated a class of equations which relate frequency response to the geometry of the thin-film pattern. The curves, left, show the specified and actual performance of such a circuit.

As electronic systems have grown in size and complexity, tantalum integrated circuits have reduced costs while increasing reliability and performance. To obtain even further integration of circuit functions, however, engineers at Bell Telephone Laboratories have used tantalum technology to build single thin-film components equivalent to networks of thin-film resistors and capacitors.

This new single, "functional" component (left) is basically a film capacitor with one electrode of resistive tantalum and a second electrode of conductive gold, separated by a dielectric layer of tantalum pentoxide. The component is made by depositing a thin film of tantalum onto a glass substrate, converting a portion of this layer to the insulating oxide, and then depositing the conductive gold electrode onto the oxide. In this arrangement, resistance and capacitance are distributed throughout the structure rather than among discrete electrical components. In addition to providing reliability and economy, this approach also offers the advantages of simpler fabrication and fewer electrical parasitics.

As an important contribution to the design of such structures, Bell Laboratories engineer Ralph W. Wyndrum, Jr., showed that it was possible to convert circuit performance specifications directly to tantalum thin-film patterns. Furthermore, he showed how appropriate geometries and film compositions could yield a wide range of impedance and transfer functions.

Wyndrum developed this synthesis technique while doing graduate work at New York University. He has advanced this technique further at Bell Laboratories, where tantalum integrated circuits were first created some ten years ago.

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Here is how the picture emerged in questions and answers:

Why is there no pat formula for becoming a chief engineer?

No two chief engineers' jobs are the same. No two engineering departments are the same. No two companies are the same. Ask a manager, "How much of your work is nonengineering?" and you'll get answers ranging from "95 per cent nonengineering" to "I do more engineering now than I ever did before."

Or, as one respondent said: "Once you decide that you want to move up in management, you have to determine the type of organization in which you would like to manage. Find out what you'll be getting into before you make the move. Look around, ask questions--in your own company and elsewhere."

Is there such a thing as a typical chief engineer?

No. As already stated, no two chief engineers' jobs are the same--even within the same company. If you want a picture of the hypothetical "average" chief engineer, the ELECTRONIC DESIGN survey can furnish a statistical picture. But you are cautioned to treat it as statistical and subject to variation.

The average chief engineer, according to the survey:

- *Was an engineer for 15 years before becoming chief engineer.* For seven of those years, he was in lower management positions, such as supervisor, project manager and department head (see Fig. 1).
- *Held between two and three management jobs before his present one.*

Howard S. Ravis,
Management and Careers Editor

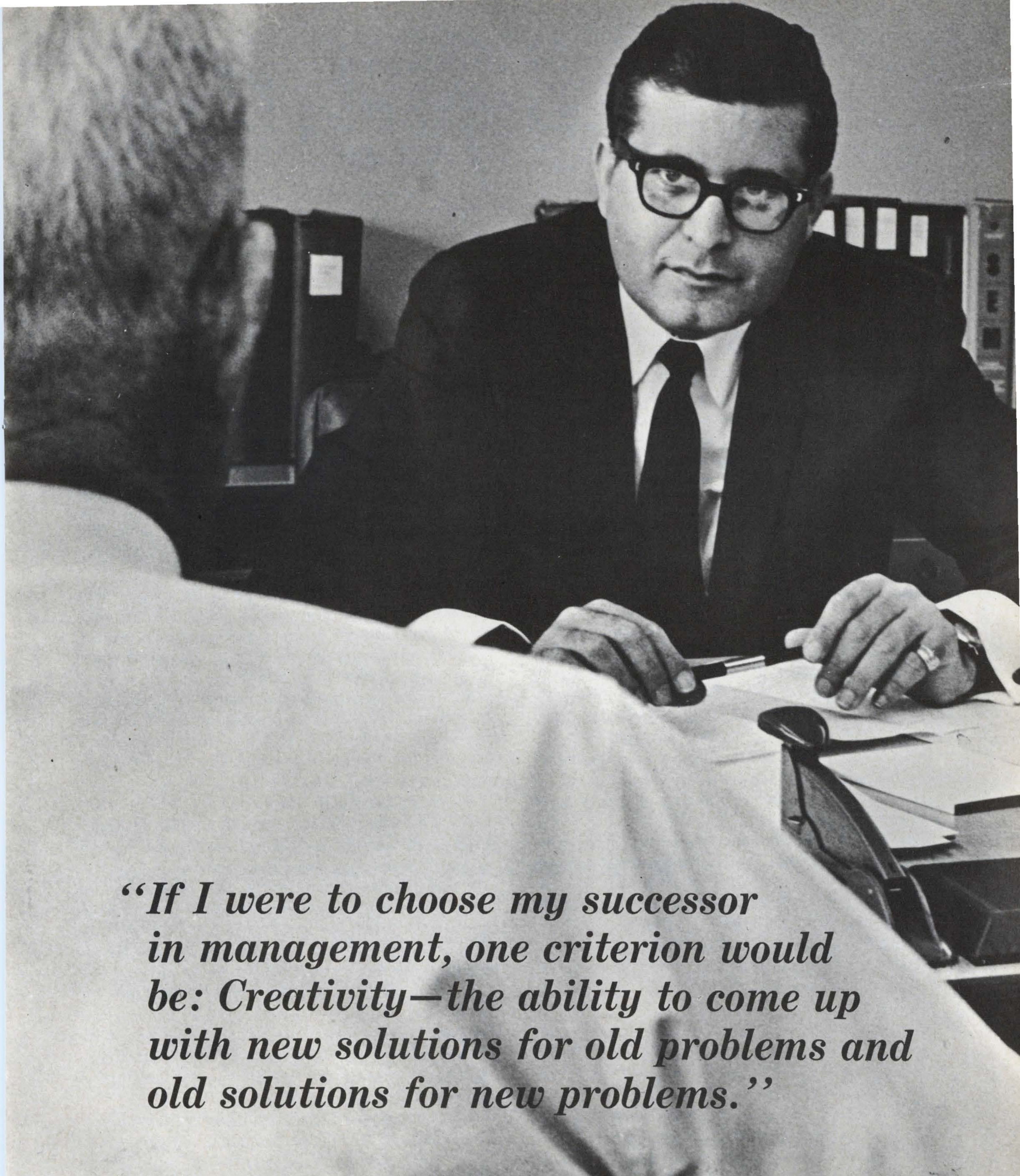
About the survey

The editors of ELECTRONIC DESIGN questioned engineering managers throughout the nation in person and on the telephone. Great effort was made to obtain diversified distribution in geography, company size and type of electronics company.

The term "chief engineer" is used in a broad context. It connotes the top engineering manager of the firm or division, regardless of his title. Thus we interviewed men with such titles as chief engineer, vice president of engineering and engineering manager.

Each was asked a series of questions pertaining to his position, as well as his views on engineers and engineering in general. The results are the basis of this article.

A second article, appearing in the Oct. 25 issue, will take this approach one step farther: How can engineering schools, engineering societies and engineering companies help engineers become successful managers? The chief engineers will pinpoint the present failings.



Stanley Schneider, Engineering Manager, Helipot Div., Beckman Instruments, Inc., Fullerton, Calif.

■ *Worked for four companies,* including his present one (Fig 2).

■ *Makes 38.7 per cent more in his present position than he would be making if he had not moved into management* (Fig. 4). Those interviewed were asked to cite a percentage based on the top salary of a non-management engineer in the company. (A recent salary survey conducted by the Engineering Manpower Commission of the Engineers Joint Council generally corroborates these findings. (See Fig. 3)

■ *Spends half his time in nonengineering work,* administrative, personnel, etc. (Fig. 5). Time spent supervising engineering projects was considered engineering work for survey purposes.

■ *Supervises 70 technical employees.* The survey clearly demonstrated that there was absolutely no correlation between the number of years a man was in engineering before becoming chief engineer and the number of technical people he was now supervising or the size of his company. One chief engineer was in the field of 36 years before moving into his present post. He now supervises 45 technical people. Another became chief engineer after only 14 years, and he is in charge of 125 technical employees.

What training or experience do they wish they had more of before moving into management?

There's no doubt how they feel about this. Four of every five--79.3 per cent--cite business management in general as essential to management, especially finance. And, further, this 79.3 per cent represents every manager who responded to the question. The other 20.7 per cent did not answer the question.

Only 7 per cent listed additional engineering or other technological training as needful. And all of these also listed business management experience as well.

Here are the most frequent responses (many gave multiple answers; thus the percentage total exceeds 100):

Business management (Specific areas mentioned most often were supervision, manufacturing, contract law, patent law and labor relations).	79.3%
Psychology or human relations	10.3%
Engineering or technological	6.9%
Liberal arts	5.0%
No response	20.7%

Many respondents placed strong emphasis on budgeting and cost accounting training:

" I sure wish I had much more business administration, especially finance and accounting, so I could read and understand these reports I get."

"More financial training definitely would have helped. I was lost when it came to budgeting. It took me a while before I could combat the accounting department."

Another response was this: "Although practical experience is still the best experience, a thorough knowledge of accepted practices usually taught in college would have been a great help."

If there is one answer to why four-fifths of all engineering managers in the survey felt they did not have sufficient business and finance training, it may be reflected in this answer: "I wish I had taken more management courses in college. I never took any, because at age 22 I never expected to be a manager. I only wanted to become an engineer."

What are the engineer's biggest adjustments in moving into management?

You must develop the management viewpoint. You must make significant adjustments along these lines:

■ *Moving out of total engineering environment.* As already pointed out, the chief engineers polled spent half of their time on the average in nonengineering work. The engineer in moving into management gets away from the drawing board--if not entirely, at least in good part. At the same time, however, chief engineers are unanimous in believing that the other rewards--both professional and economic--more than make up for the decrease in creative engineering work.

■ *Broader responsibilities.* In moving away from the drawing board, you are no longer just an engineer responsible for yourself and your own project. You are responsible for the work of many others. If they bungle, you are held at fault.

■ *Greater pressures and demands.* You will have more people and projects making demands on your time. You will find you have less time for personal matters. But keep in mind that you are being paid more as a manager. More is expected of you.

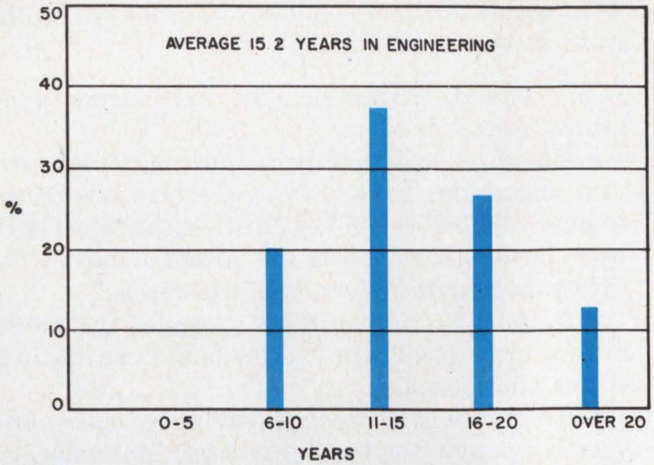
■ *Dealing more with people instead of things.* You will have to learn how to handle people, supervise them, work with them. You will have to get to know people, how they act, react and interact.

■ *Self-discipline.* No longer can you afford to spend a disproportionate amount of time on things that you are interested in. You will have to allow time not only for your own work but also find time for the people who work for you when they need you.

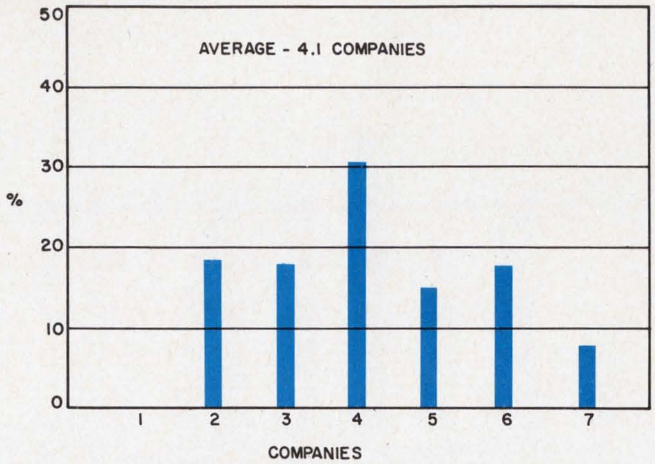
■ *Communication with other departments.* As part of management, you will have to deal with your counterparts in other departments. Most engineers have no comparable experience before moving into management. Many engineers are scarcely aware other departments exist.

■ *Moving into the world of business and finance.* You must acquire the profitmaking incentive. You must learn that the company was established to make money. Many nonmanagement engineers refuse to accept this premise.

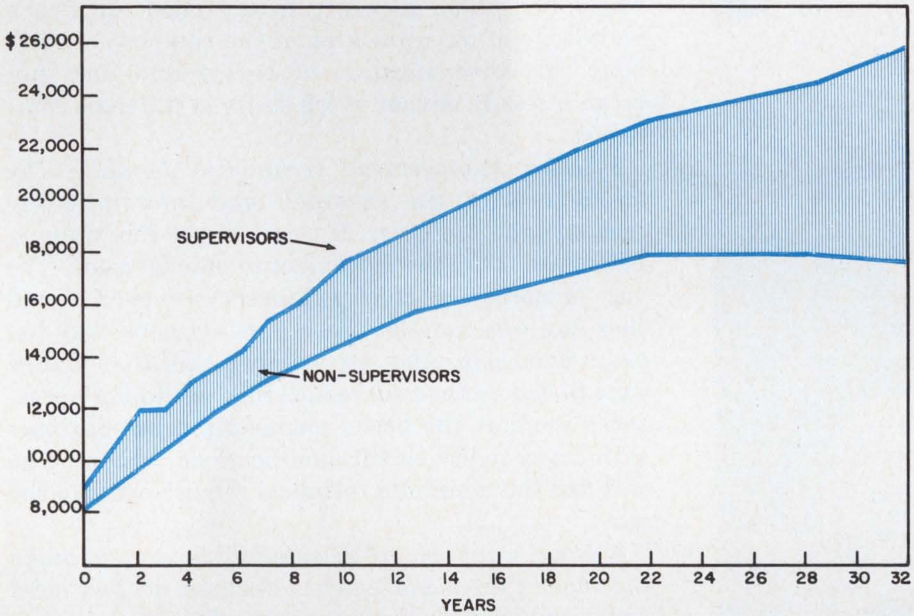
■ *Trying to remain technically current.* Paradoxically you will find yourself with less time but more need to keep up with the broader technological area into which you are moving.



1. **The chief engineers surveyed were in the engineering** field an average of slightly more than 15 years before reaching their current top management positions. This graph shows the breakdown in five-year groupings.

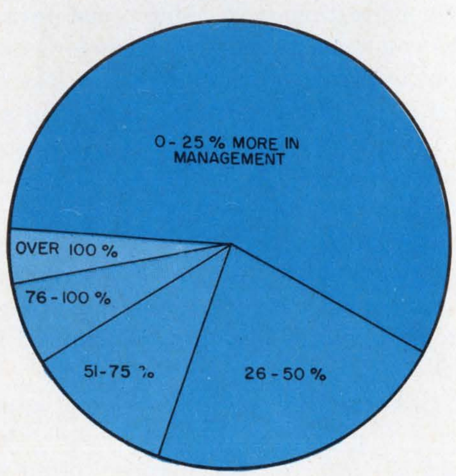


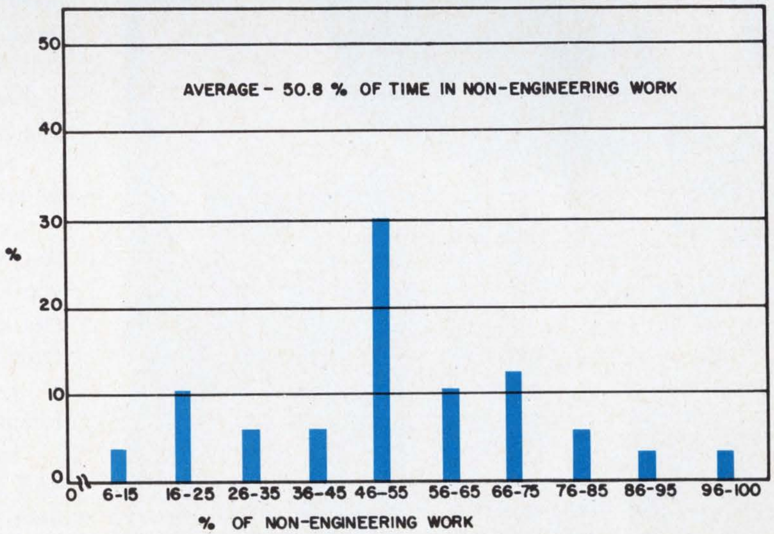
2. **In his rise to top management,** the chief engineer worked for an average of four companies. Above a third of the respondees cited this total, with answers ranging from two to seven companies.



3. **This graph shows the results** of a recent salary survey conducted by the Engineering Manpower Commission of the Engineers Joint Council. It represents the top decile in salaries of engineers and engineering supervisors, and in general, it concurs with the ELECTRONIC DESIGN survey. Note that the salary differential continues to widen each year.

4. **While the chief engineers** estimated an average salary differential of 38.7% over what they would be making if they did not move into management, more than half placed the differential at 25% or less. Responses ranged from 0 to a whopping 200%. (See Fig. 3.)





5. **When asked how much time** the chief engineer spends in non-engineering work, the responses followed an organized pattern. It was one of the few instances in the survey where there was such a pattern—where the mathematical average and the mean coincided. Both were 50%.

"The way to reach the top is, pure and simply, to work hard. Keep as broad horizons as possible. Keep abreast of technology in as many areas as possible."

Werner Brack (left) Chief Engineer, Communication Associates, Inc., New Hyde Park, N.Y.

What advice do chief engineers have for easing the transition to management?

While no two managers gave the same answer, a few general themes do recur:

- *Obtain a broad company outlook.* Think past your engineering work. Learn what the rest of the company is all about. A key criticism that chief engineers have of engineers is the latter's tendency "to isolate themselves in their own little worlds."
- *Become business oriented.* Acquire the profit-making incentive. Learn to think both as an engineer and as a businessman.
- *Keep pace with developments in your own and your company's areas of technology.* Maintain also a broad view of the engineering world.
- *Diversify your engineering background.* Usually this is preferred to specialization when managers are chosen. However, there are occasional exceptions, where the prime requisite is the chief engineer's knowledge of a narrow area of the company's work. Note that diversification of background does not mean a steady stream of job shifts to different companies.
- *Learn management techniques formally (by taking courses, for example) and informally (by reading and observing).* If possible, get this training before you make the movement to management. The vast majority of chief engineers surveyed found they had less time for these pursuits once they became managers. And the majority said that if they were to choose their successor, they would not necessarily promote the better engineer but the engineer with better management qualifications, assuming he satisfied the minimum technical requirements of the job.
- *Know what you are getting into before you make the move into management.* Because no two chief engineers' jobs are the same, one may involve engineering work 95 per cent of the time and another--perhaps even in the same company--engineering only 5 per cent of the time.

Here is other advice from chief engineers for paving the way to management:

"After you get that PhD in engineering, go after a Master in Business Administration."

"A good education--and I don't just mean those four years you spent getting the bachelor's degree--is vital. Continue your education. Never lose track of the status of the field. If you do, the results can be tragic."

"Learn what it means to run a business, what a business is all about."

"Have a good idea of your talents, capabilities and weaknesses. A good engineer who enjoys engineering sometimes gets shoved into management, and it proves to be the last thing he's suited for, and he hates it."

"First, pass the threshold of technical capability, then tackle management. In other words, don't try to advance too fast. Young engineers often want to move into management before they are qualified and before they know what it's all about."

What happens to the engineer who refuses to move into engineering management?

There is a general tendency among chief engineers to hedge on this. Many answered that nothing would happen to such engineers professionally, but then they offered qualifying statements that tended to contradict the initial responses. Nearly 100 per cent of those surveyed concurred on one obvious point, however: the nonmanagement engineer would not do as well financially.

Many engineering concerns have no place for the creative engineer to advance to once he has reached a certain plateau, unless he wants to move into management. Some chief engineers surveyed admitted that they would "take a dim view" of the man who declined to move into management.

"There would be a tendency for his stature to be reduced," one put it. "It shows that perhaps he wasn't aggressive and didn't want to get ahead."

Another: "In a small company, if the man is qualified and didn't take the job, he'd find himself in an awkward position."

But, this situation seems to be changing slowly. Some chief engineers admit that their companies found it necessary to reshape their thinking, because they were losing good engineers.

One chief engineer summed up the problem this way: "The company I worked for before would have been very averse to any engineer who did not want to move into management. Its very structure is such that they don't have anything above development engineer, unless you move into management. It was a source of great frustration, and many engineers left because of it. The company sometimes took a good engineer and made him into a manager, and this failed miserably, both from the engineer's and the company's points of view."

More and more, however, top company management around the country is recognizing the need to reshape its thinking on the nonmanagement engineer. Not all engineers have what it takes to be a manager, yet these men can be of great value in nonmanagement engineering posts.

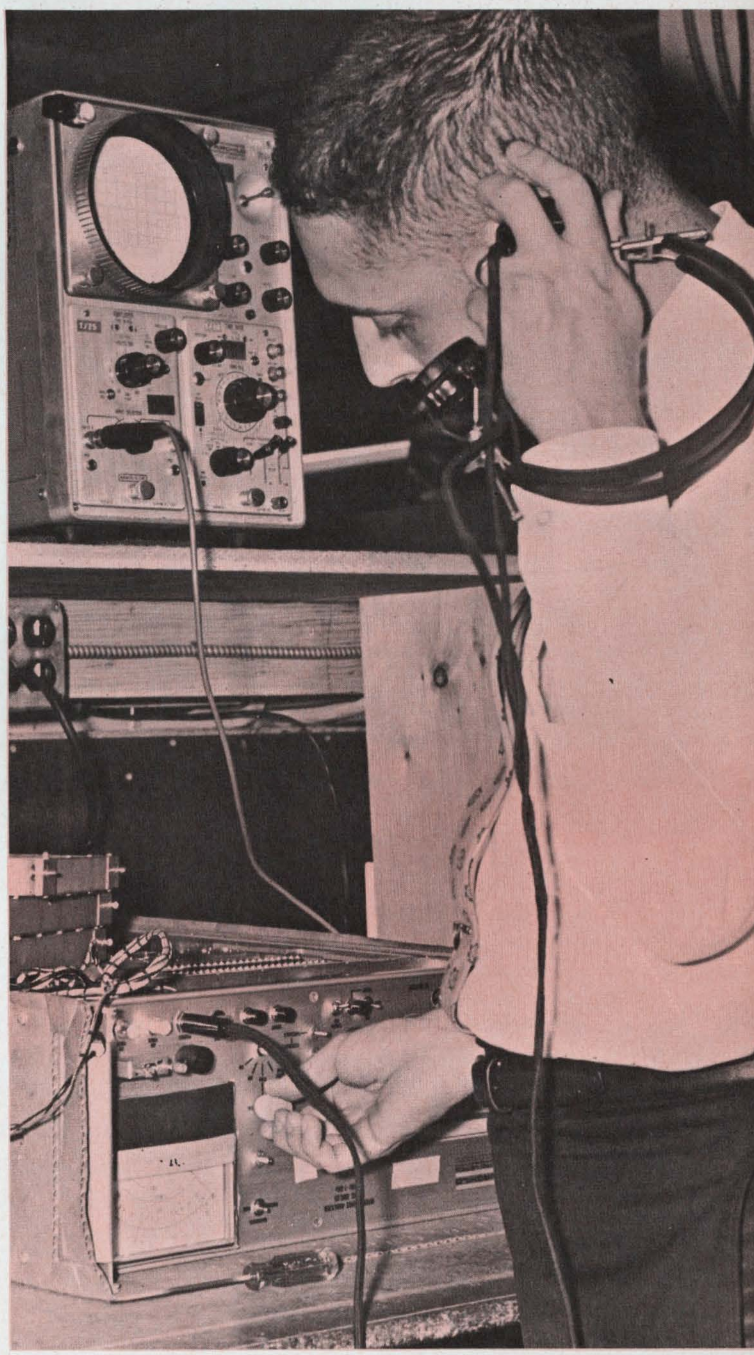
More and more companies are adopting this policy expressed by one chief engineer:

"Our firm realizes that not every man makes a good supervisor. We are making every effort to keep good engineers by establishing pay grades and job classifications for engineers desiring to remain purely in technical areas."

But if the rewards of management are what you are after, there is this advice from a corporate director of research and development:

"There's no problem getting to the top once you're in management. The real problem is getting through the crowd at the bottom." ■ ■

"A good engineering manager must be prepared to make decisions and then stick by them. And he must realize that there will be times when he'll make the wrong decision."



David E. Smoler, Chief Electronic Engineer, Fairchild ElectroMetrics Corp., Amsterdam, N.Y.

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Dates	to	to	to
Title			
Specialty			

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City, State			
Dates	to	to	to

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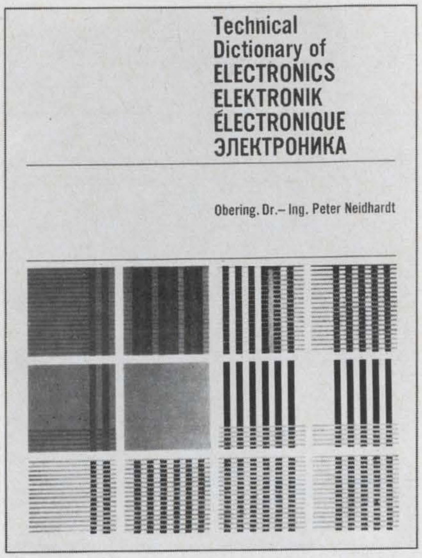
ELECTRONIC DESIGN
850 Third Avenue
New York, New York 10022

Book Reviews



Electronics Dictionary

Technical Dictionary of Electronics, Peter Neidhardt (Pergamon Press, New York), 1660 pp. $38.50.

While the author and publishers are to be commended for their ambition in publishing a comprehensive, four-language (English, Russian, German, French) technical dictionary, its value, at least in the case of the Russian-English, English-Russian section is, at best, questionable.

Even a very brief review of these sections reveals many gross inaccuracies that tend to make the book practically useless except to those who can spot such errors (but such readers do not need the dictionary). For example, on page 1306, entry N 320 in Russian (I transliterate) reads "gorelka." This means not "nozzle" as stated, but "burner." A nozzle in Russian (when it is a nozzle of, say, an oil burner, would be called "forsunka").

There are many other errors too numerous to list. The point is, that in technical translation, even minor inaccuracies in jargon can totally nullify the value of an article.

While a multilingual dictionary would be of value, this one falls short of the mark.

Peter N. Budzilovich

CIRCLE ON. 250

Semiconductor devices

Physics and Technology of Semiconductor Devices, A. S. Grove (John Wiley & Sons, New York), 366 pp. $12.95.

This treatment of semiconductor-device physics focuses on modern planar silicon devices which form the basis of integrated circuits. Important physical principles are brought to the fore by simple physical models and illustrated by experimental measurements. The first part of the text is a quantitative treatment of those processes of solid-state technology that determine the electrical characteristics of semiconductor devices. The second part deals with semiconductors and semiconductor devices. The third part covers surface effects and surface-controlled devices.

CIRCLE NO. 251

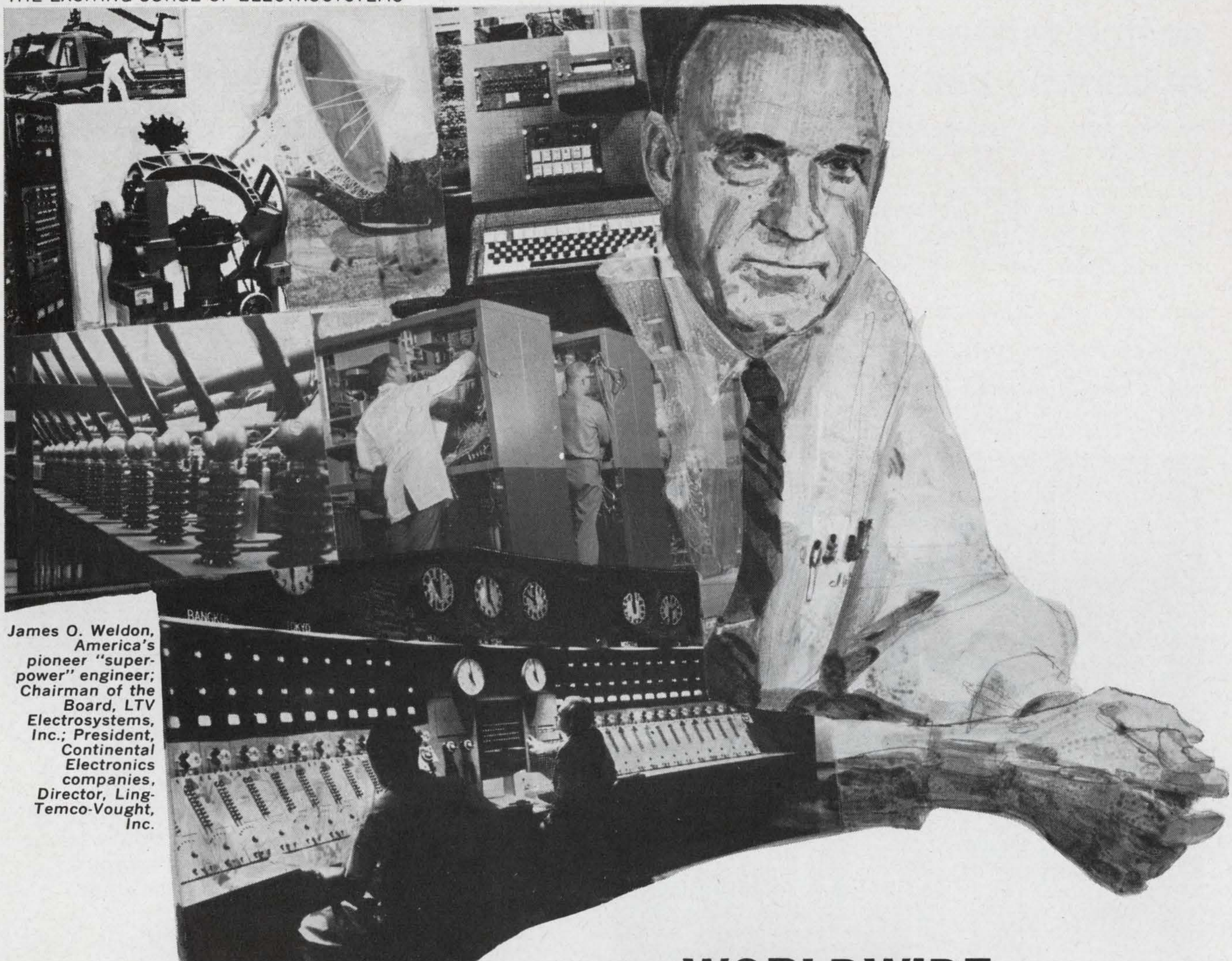
Communications engineering

Communication System Engineering Handbook, Donald H. Hamsher, ed. (McGraw-Hill Book Co., New York), 970 pp. $28.50.

This digest of communications system engineering ranges from the preliminary analysis of system requirements to the installation of wires and cables. Designed to help the specialist in one field relate his expertise to associated fields, the book covers principles, customary practices and variations, and standards. The book begins with information needed prior to system design, goes through the development of the communication system plan, and the variety of transmission and switching components of the system, to the essential auxiliary and supplementary topics of power, facility layout, operation, and costing. Particular consideration is given to data transmission, closed-circuit television, potential address systems, and radio frequency assignment procedures.

CIRCLE NO. 252

THE EXCITING SURGE OF ELECTROSYSTEMS



James O. Weldon, America's pioneer "super-power" engineer; Chairman of the Board, LTV Electrosystems, Inc.; President, Continental Electronics companies, Director, Ling-Temco-Vought, Inc.

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ON CAREER-INQUIRY FORM CIRCLE 903

'Slip-stick' manual

The Slide Rule: A Complete Manual, Alfred L. Slater (Holt, Rinehart and Winston, Inc., New York), 291 pp. $5.50.

This manual is a prime source for skill in manipulating the slide rule's scales. The basic mathematical scales (C, D, CI, CF, DF, CIF, R, Sq, $\sqrt{\ }$, A, B, & K) are clearly explained. A little elementary algebra will suffice for these chapters. Trigonometry that would be needed is shown on the slide rule itself. The trigonometric scales (S, St, & T), the logarithmic scale (L), and the log-log scales (LL) are discussed in separate chapters.

Numerical examples aid understanding; exercises are included in each chapter; correct answers are supplied for each exercise.

The base-10 LL scales, the hyperbolic scales (Sh, Th), and exponential scales (Ln) are briefly discussed in the appendix.

The college student or twelfth-year mathematics student will find this book valuable, but for further, more esoteric "slip-stick" handling, the reader will have to go to other sources of information.

William Alvarez

Electronic sensors

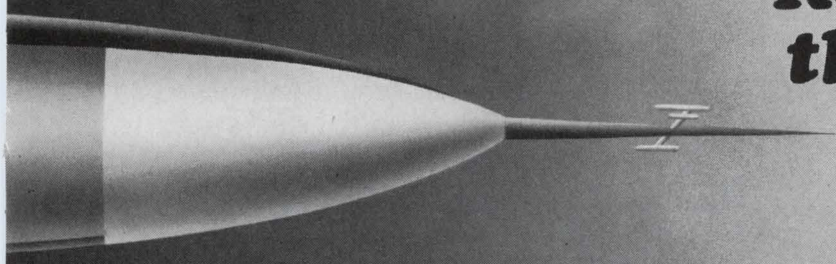
Electronic Sensing Devices, A. F. Giles, (CRC Press, A Div. of Chemical Rubber Company, Cleveland), 158 pp. $13.50.

The application of physical- and chemical-electronic effects to the solution of industrial problems is reviewed, with chapters on solids, liquids and gases and on capacitance and magnetic induction effects. Applications covered range from polarography to digital-positioning systems. The book assumes some knowledge of electronics but the treatment is non-mathematical.

CIRCLE NO. 253

As a further service to our readers, ELECTRONIC DESIGN is now including a Reader's Service number with book reviews. Publishing companies have agreed to supply information about their books to interested readers.

AGE engineering is the art of anticipation



Keeping ahead of this one requires a special sophistication

The F-111 places heavy demands on the foresight of an AGE engineer. This—the most advanced combat aircraft in the U.S. arsenal—has already been extended to several versions. Ground- and carrier-based fighters. Attack bomber. Reconnaissance craft. Our AGE engineers, who pioneered and developed AGE for the original F-111, are now committed to a still more challenging task: developing equipment to test all aircraft configurations—present and future—so that as new avionics systems and aircraft missions are defined, the additional test needs can be met without major redesign. Necessarily, the equipment will require an expanded depth of testing capability, combined with a high degree of compactness and rugged construction for deployment and usage in all areas of the world.

The magnitude of the systems and design problems to be encountered really comes into focus when you consider the complexity of Aerospace Ground Equipment: it's a highly-automated test and fault-location system which includes a video station, radar/receiver/transmitter modulator station, indicator/controls station, central air data computer station, radar servo and indicator station, computer station, penetration aids station, attitude and rate station, UHF communications station, HF communications station, TACAN station, HF communications flight-line tester, IR station, UHF guidance station and digital station—each sophisticated enough to test state-of-the-art equipment.

And this is only one of the programs our AGE laboratory is "writing the book" on. Other programs include internal and external checkout systems for missiles such as Atlas, Nike-Zeus and Polaris . . . flight-line and depot systems for terrain-following radar . . . SSB equipment . . . automated vehicular trouble-shooting systems, and many more.

Obviously, if any of these areas dovetails with your interests, we have a lot to talk about. (You'll quickly see why so many engineers like the growth atmosphere of the Electronics Division.)

If you'd prefer to move in another direction, send us your resume anyway. We have rapidly expanding study and development programs going in ASW, radio communications, data equipment, navigational aids, tracking equipment and countermeasures. Opportunities are wide open. Direct your resume, in confidence to, Mr. J.P.O'Reilly, Dept. 131.

GENERAL DYNAMICS

Electronics Division

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Level detector has independently adjustable hysteresis and trip point

This regenerative level detector (see figure) has several advantages over a conventional Schmitt trigger; its trip point and hysteresis are independently adjustable, it has good temperature stability obtained by using a differential comparator circuit and a low-temperature-coefficient Zener diode, and the full supply voltage is available in the on state.

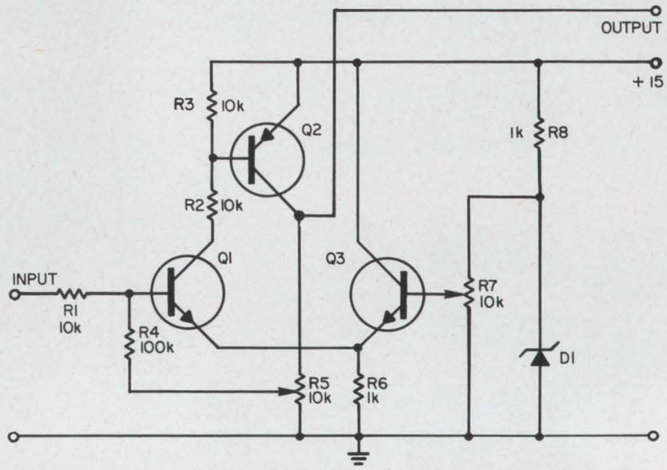
Q1 and *Q3* form a differential comparator. The reference level is fixed by Zener diode *D1*, adjusted to the desired value by means of *R7*, and applied to the base of *Q3*. The input signal is applied to the base of *Q1* through *R1*.

When the input signal exceeds the reference, *Q1* starts conducting and *Q3* cuts off. Then *Q2* is turned on by a negative swing of the *Q1* tapped collector load and its collector voltage rises to near the positive supply value. The regenerative effect takes place through *R4*, which is tied to the sliding contact of potentiometer *R5*, and results in fast switch on. *R5* is the *Q2* collector load. When the input signal decreases below the reference value, the reverse process takes place and *Q2* switches off.

Varying the loop gain by means of *R5* allows the hysteresis to be adjusted from few millivolts to one volt without altering the trip level.

Varying the reference level by means of *R7* allows the trip point to be adjusted from 0.7 volt to 5 volts without affecting hysteresis.

Temperature-stable reference is achieved by using the Zener diode within a 5.6-volt range, because its temperature coefficient is very low.



Trip point and hysteresis can be independently adjusted by varying R5 and R7, respectively. See text for suitable transistors and diodes.

Tests carried out with a 15-volt supply voltage showed that varying it from 10 to 20 volts had negligible effect on trip level and hysteresis.

Suitable semiconductors are the following: for *Q1* and *Q3*: 2N1711, 2N2219, 2N2222, 2N3904 or equivalent types; for *Q2*: 2N2905, 2N2907, 2N3906, or equivalent types; and for *D1*: 1N708

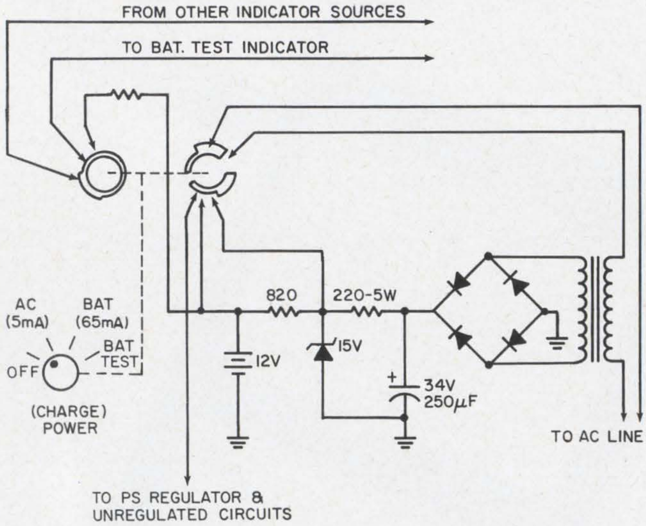
Robert Billon, Design Engineer, Meylan, France.

VOTE FOR 110

Fail-safe unit operates from NiCad batteries or ac line

The circuit (see figure) used in a 12-volt NiCad battery or an ac-operated unit simplifies front-panel switching and protects against battery failure. In addition, the battery-charging circuit provides the power supply for ac operation.

Objections to battery-operated equipment have been that failure of the battery makes the unit unusable unless complicated and confusing switching is incorporated. This switching scheme has three stable positions—off, ac or battery operation—and one momentary position—battery test. In ac operation, a low ripple dc voltage of about 15 volts powers the unit and charges the



Battery-charging circuit doubles as the power supply to operate the unit either from ac or a battery.

battery at a trickle current of 5 mA. Shorting or opening the battery causes no failures. In battery operation the trickle-charge 820-Ω resistor is shorted out and the 12-V dc from the battery powers the unit. For fast battery-charging, the power cord is plugged in when the unit is in battery operation. The Zener diode prevents overcharging by limiting the battery voltage to 15 volts. If the battery shorts, the unit will still function in ac mode. If the battery opens, the Zener will protect the circuitry in the unit from overvoltage. The battery test position checks the battery while the ac power is removed, but the loading of the unit is on the battery.

John Collins, Chief Engineer, and William Whitaker, Engineer, Rycom Instruments, Inc., Raytown, Mo.

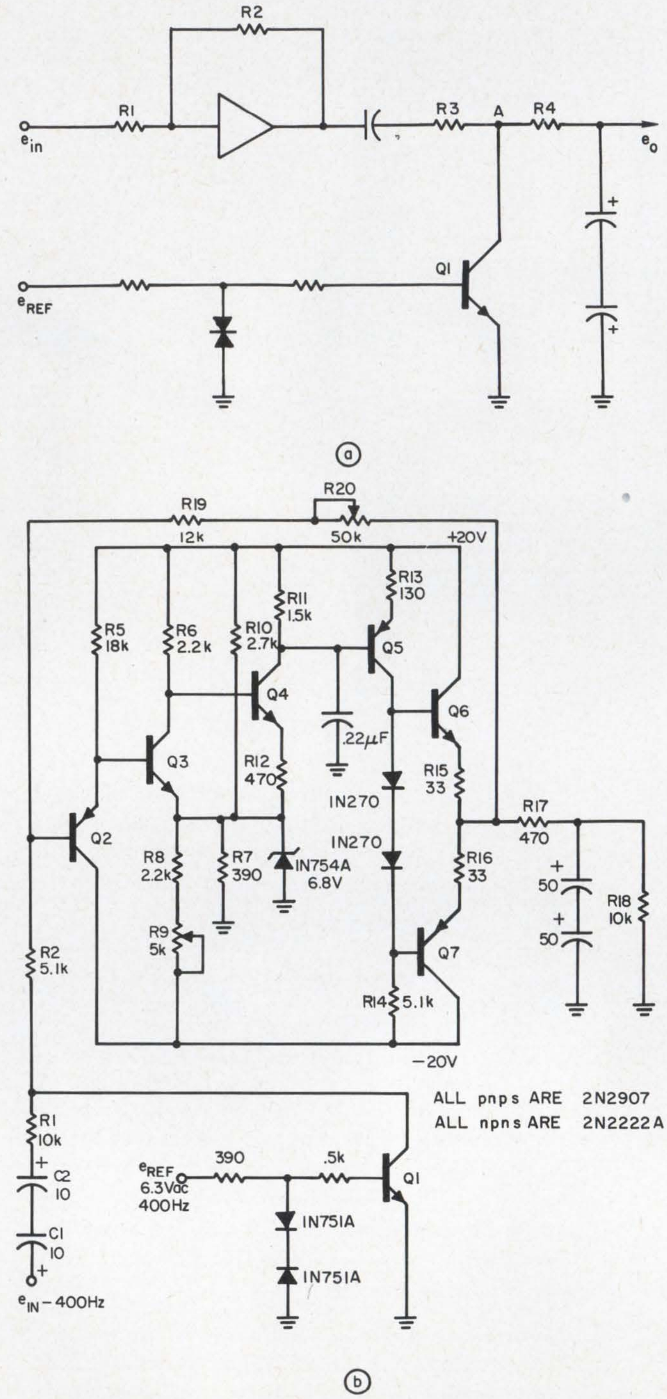
VOTE FOR 111

Linear demodulator combines high output and phase sensitivity

The circuit in Fig. 1a is a standard connection for a phase-sensitive demodulator. The output is limited by the transistor's V_{BEO}; when point A exceeds V_{BEO}, there is distortion. When e_{IN} is in phase with e_{REF}, reducing $R3$ to 1 kΩ will forward-bias the collector diode and $Q1$ will lose its transistor action. Both half cycles will then pass through and yield an erroneous dc output.

For a high transfer function, the transistor grounding network is located at the input, as shown in Fig. 1b.

Transistor $Q1$ grounds the positive half cycle of



1. **Standard phase-sensitive demodulator** (a) is implemented as shown in (b). The dc output is positive when e_{IN} is in phase with e_{REF} and negative when e_{IN} is out of phase with e_{REF}.

the input signal, when e_{IN} is in phase with e_{REF}, to produce a positive dc output. Similarly the output is negative when e_{IN} is out of phase with e_{REF}.

The output is linear when:

$$e_{IN\ (peak)}\ R2/(R1 + R2) < V_Z + 0.7$$

or:

$$e_{IN\ (peak)} < (V_Z + 0.7)\ (R1 + R2)/R2,$$

where V_Z, the Zener voltage, is less than the V_{BEO} of $Q1$.

ON READER-SERVICE CARD CIRCLE 47

The input-output transfer function is:

$E_{O\ (dc)}/E_{IN\ (rms)}$

$= [(R19 + R20)/(R1 + R2)]\ [R18/(R17 + R18)]\ [(1.41)\ (0.636)/2].$

The maximum dc output is 5.5 volts. *R9* sets the dc output to zero with $e_{IN} = 0$ after *R20* has been adjusted.

Nelson Nekomoto, Designer, Tasker Instruments Corp., Van Nuys, Calif.

VOTE FOR 112

A 2-kV 0.1-A switch uses mesa transistors

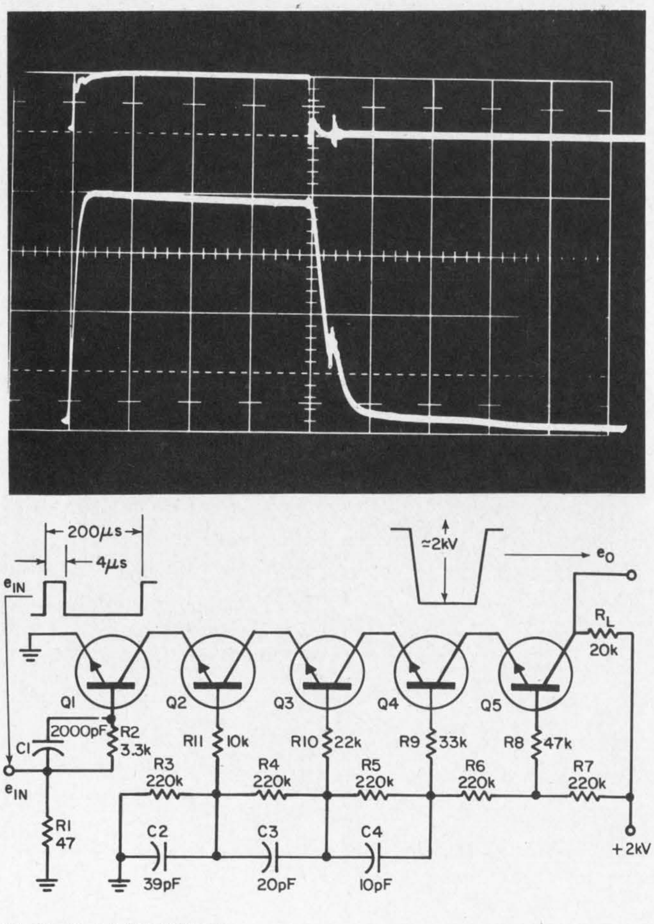
The use of mesa transitors in the avalanche mode to obtain short-rise-time, high-speed switching has long been known. It is also possible to operate high-voltage mesas in series to obtain an economical high-voltage switch, as illustrated in the accompanying figure. A 5-volt pulse is used to turn on *Q1*. This permits *Q2* through *Q5* to operate. *R3* through *R7* force equal sharing of supply voltage on a dc basis. Capacitors *C2* through *C4* prevent excessive voltage surges during turn-on. *R8* through *R11* prevent excessive base drive and also offer some V_{BE} compensation.

Transistor leakage current is in the microampere region. Therefore, if the entire circuit is operated as a series element, the off resistance is essentially that of $R3+R4+R5+R6+R7$, which is more than 1 megohm. The oscilloscope photograph shows a 5-volt, 4-μs input pulse and the output pulse (shown inverted for comparison). The drop across the transistor after avalanche is negligible. $t_d+t_r \simeq 0.4\ \mu$s and $t_s+t_f \simeq 0.4\ \mu$s. In this case the duty cycle is 2%. The storage and fall time can be reduced by returning the bases to a slightly negative (2-4 volts) supply.

An inductive load will require diode-clamping.

Saul A. Ritterman, Assistant Professor, Bronx Community College, New York.

VOTE FOR 113

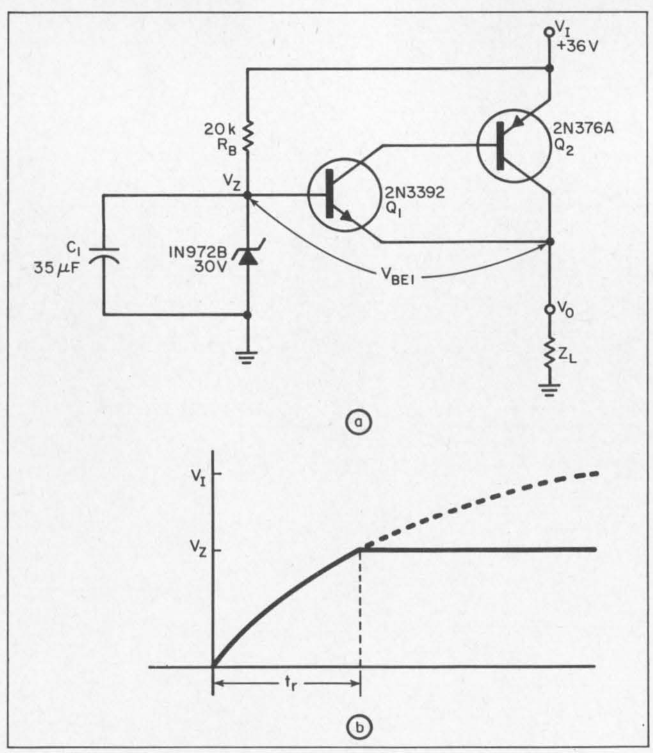


2-kV pulses are obtained by applying a pulse of 5 volts to the base of Q1. Input (upper) and output (lower) traces show the circuit action.

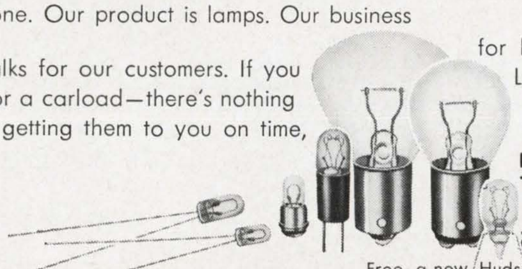
Voltage regulator has built-in delay time

This high-gain voltage regulator with only two transistors (see schematic) has characteristics superior to those of the commonly used compound emitter-follower type.

The circuit was used in a 30-watt stereo amplifier which required not only a well regulated supply, but also an output voltage that would rise



Slow build-up of output voltage is obtained (a). The delay time is about 2 seconds (b).



slowly from zero volts when the system was first turned on. This slow application of power (approximately 2 seconds) to the power amplifiers allowed the 2000-μF output capacitors to charge without causing excessive collector current in the output transistors.

Typical regulator output impedance is 0.1Ω.

Output voltage is expressed by:

$$V_o = V_z - V_{BE1}.$$

Output voltage rise time is:

$$T_r = - R_B C_1 \ln (1 - V_z/V_I).$$

Some digital and other systems require a preset turn-on sequence for their several power supplies. By fixing appropriate $R_B C_1$ values, the circuit's output rise time can be set to provide this sequence or delay.

Using this circuit for the system's power supplies would simplify the task of providing several well-regulated voltages with delayed or slow rising outputs where required.

George R. Skoblin, Kearfott-San Marcos Div., General Precision, Inc., San Marcos, Calif.

VOTE FOR 114

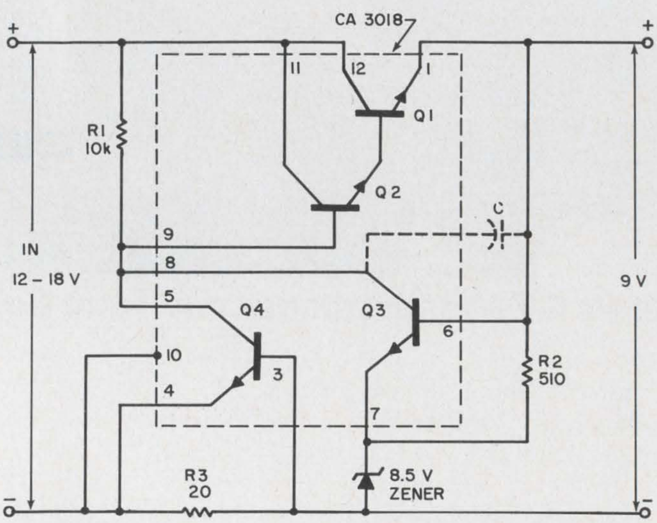
Integrated circuit is key to foolproof voltage regulator

A tiny and inexpensive voltage regulator (see figure) can be built with a CA 3018. In this fairly conventional circuit, the fourth available transistor in the IC and one resistor form a safety circuit, so that the IC cannot be damaged by overloading or short-circuiting the output.

When current flow is too high, the voltage drop across *R3* becomes large enough to open *Q4* so that it can limit the current through *Q1-Q2*. If the value of *R3* is about 20 ohms, the maximum current is limited to a little less than 30 mA. At lower currents, *Q4* will stay closed and the circuit will act as a normal voltage regulator. To avoid high-frequency oscillations, a small capacitor (about 1000 pF or so) may be necessary.

Eckart Schmitzer, Development Engineer, Nuremberg, West Germany.

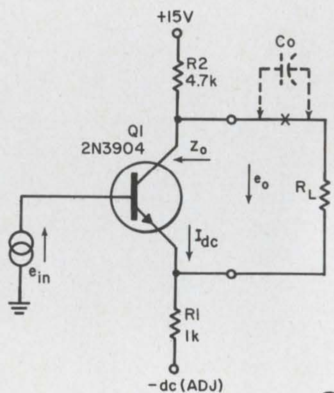
VOTE FOR 115



Overload and short-circuit protection is obtained in a simple voltage regulator by using Q4 and R_3 to limit the output current to just under 30 mA.

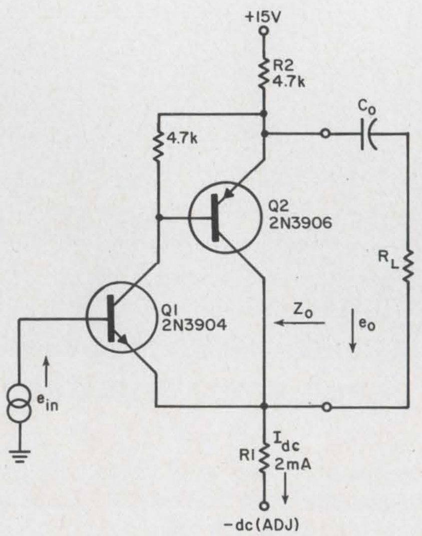
Output impedance is cut in a transistor amplifier

The output impedance of a transistor amplifier can be substantially reduced by connecting load R_L from the collector of Q_1 to an unbypassed emitter resistor, R_1, as shown in Fig. 1a. Coupling capacitor C_o is optional. This is a form of positive current feedback which reduces the output impedance seen by the load. For moderate ratios of $R_2 <$



I_{dc}	GAIN, e_o/e_{in}		Z_o (OHMS)	
	CALC.	MEAS.	CALC.	MEAS.
1mA	5.7	5.7	170	190
3mA	5.7	5.7	57	64

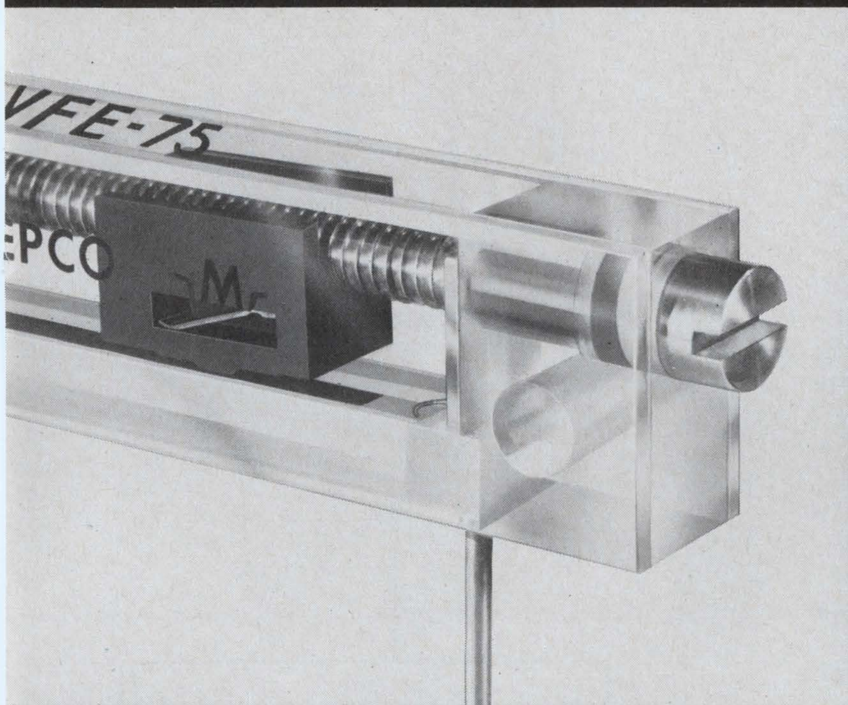
(a)

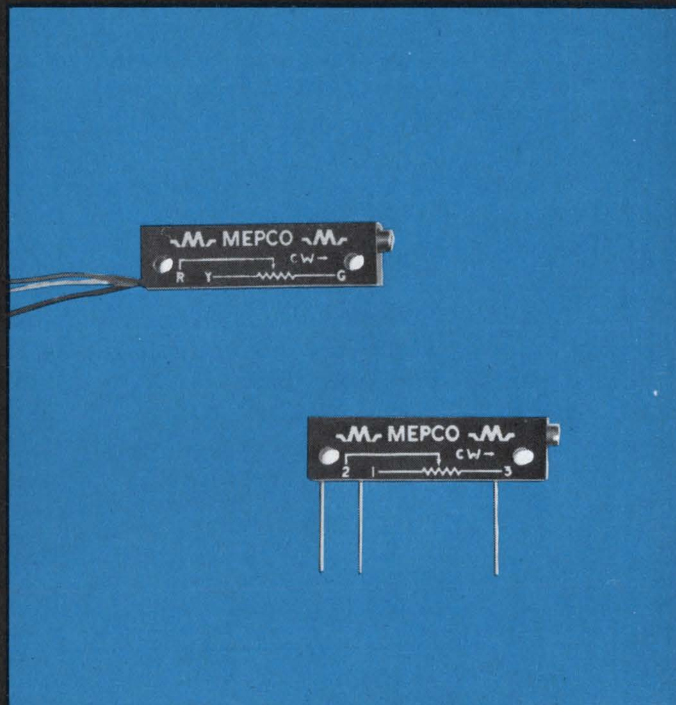


R1	GAIN = e_o/e_{in}	Z_o(OHMS)
1k	5.7	9
4.7k	2.0	4.5

(b)

1. **Low output impedance** is obtained in circuit (a) when R_L is connected across the transistor. Note effect of operating current I_{dc} on the Z_o. Two-transistor version (b) has much lower Z_o. Note the effect of gain.




MEPCO
CW–
R Y G
MEPCO
CW–
2 1 3

10 R_1, the voltage gain is:

$$G = e_o/e_{in} = 1 + R_2/R_1, \qquad (1)$$

and output impedance is:

$$Z_o = (1 + R_2/R_1)R_e, \qquad (2)$$

where $R_e = 30/I_{dc}$ (mA) in parallel with R_1.

R_e is recognized as the output impedance of the transistor connected as an emitter follower ($R_2 = 0$). The collector dc operating voltage and gain are practically independent of R_L (C = short circuit). Collector Q-point is calculated easily by assuming $R_L = \infty$. Connecting R_L changes the collector voltage only by the small amount given by $\Delta E_o = \Delta I_o Z_o$, where Z_o is given by Eq. 2. The collector-emitter junction looks like a constant voltage source to load R_L. A disadvantage of this circuit is that both ends of load R_L must be off ground.

Figure 1b shows a higher-gain version of the circuit. Performance figures for both circuits are tabulated in the figures.

Allan G. Lloyd, Project Engineer, Avion Electronics, Inc., Paramus, N. J.

VOTE FOR 116

Transformerless chopper circuit built with a differential amplifier

Standard chopper circuits use transformers. These, in certain applications, may be undesirable. Moreover, circuits with transformers are hard to adapt to integrated-circuit design.

A method for eliminating the transformers is illustrated in Fig. 1a. The circuit comprises a differential amplifier, *Q1* and *Q2*, with a constant-current source, *Q3*, which offers good temperature and drift stabilization in the input stage. The operation of the circuit, however, is best explained with the aid of Fig. 1b.

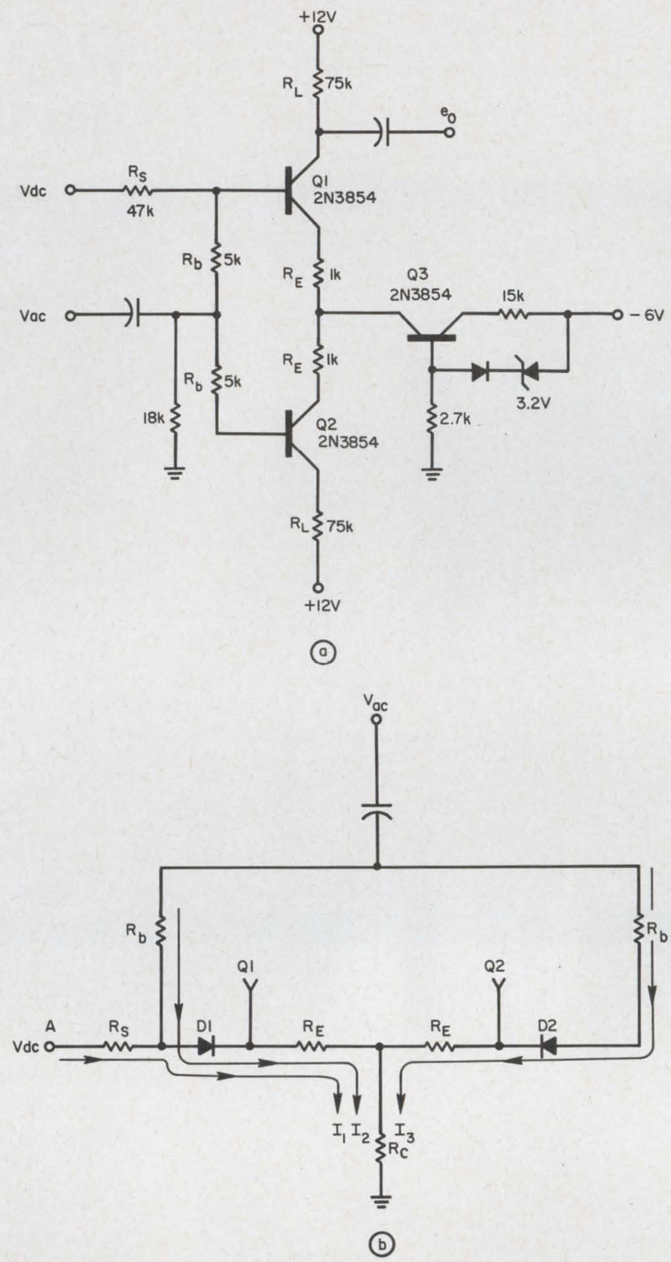
D_1 and D_2 are the base diodes of the differential input, with R_c acting as the equivalent resistance of the constant-current source. Since the output of the differential amplifier is proportional to the difference of the base diode currents of the input transistors,

$$e_o = K(I_1 + I_2 - I_3).$$

With $V_{dc} = 0$, the differential amplifier is balanced so that:

$$I_1 + I_2 = I_3,$$

an adjustment that is made only once with point A grounded. This produces a zero or reference output from the unit. When V_{dc} differs from zero, then the balanced state of the device is disrupted by the offset of the diode currents. By capacitive coupling out the output, the dc offset is removed so only the resultant ac offset current is transmitted.



1. **Transformerless chopper (a)** uses a differential amplifier (Q1, Q2) and a constant-current source (Q3). The circuit action is explained in (b).

Conversion of very low dc signals can best be obtained by operating the differential amplifier at low (≈ 10 microamperes) currents.

Anthony C. Caggiano, Scientific and Technical Advisor, Ridge, N. Y.

VOTE FOR 117

Use single printed circuit for several logic card types

In designing digital circuit cards, it is desirable to build general-purpose cards which can be used in many places in the same system. One logic card

may thus contain several groups of 2-input AND gates, another card may contain flip-flop storage registers, and so forth.

The number of integrated-circuit (IC) components that can be placed on such a general-purpose type of board is usually pin limited—that is, there is space for additional components but pins are not available to provide the necessary input and output signals to the ICs. Normally each different type of logic card is built on a different circuit board.

In this proposed packaging scheme, printed circuitry for extra ICs used in building other logic-card types is placed on the available left-over board space, and the pins are shared among these "extra" ICs. This results in a single printed-circuit board which can be used for several different types of logic cards.

During the assembly process, the particular ICs inserted into the printed-circuit board determine the type of logic card that will be produced. The advantages of this are to reduce the number of types of circuit board thus cutting over-all board-design and -drafting time, to lower the costs per board, and to shrink the spare parts inventory. This packaging technique is best illustrated by the following example.

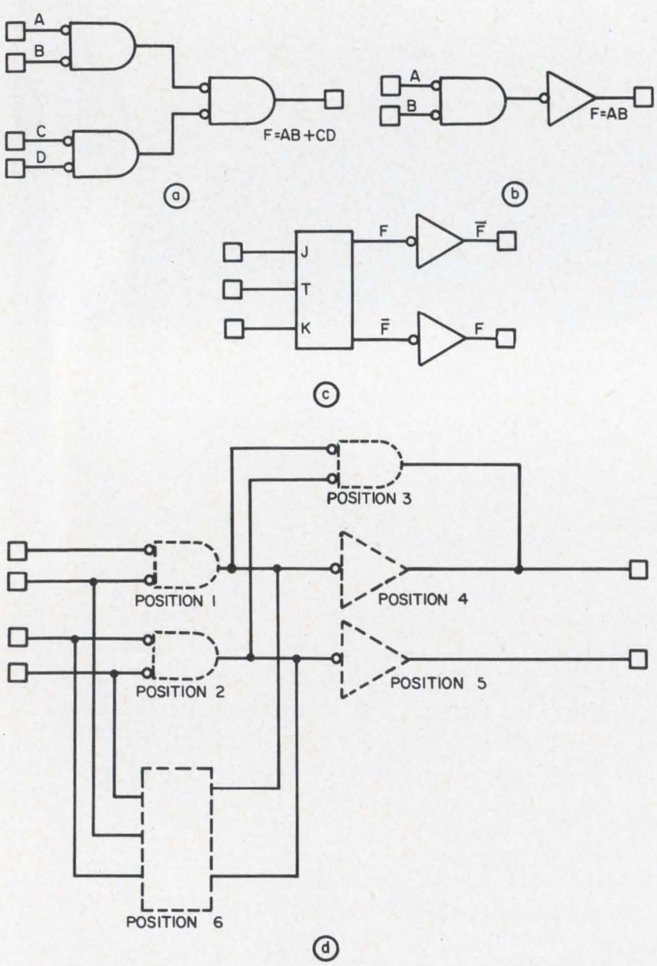
Figure 1a represents one of a group of 2-input AND/OR gates that have an output $F=AB+CD$; Fig. 1b shows one of a group of 2-input AND gates with an output $F=AB$, Fig. 1c is one of a group of flip-flops containing buffered outputs; and Fig. 1d is the schematic for the circuit board which can be used to build any of the foregoing three logic functions. In these schematics all gates are NAND gates. From Fig. 1d it can be seen that:

- If the ICs are not inserted into positions 4, 5 and 6 during assembly, then the logic-card is of the type in Fig. 1a.
- If the components are left out of positions 3 and 6, the logic card is of the type in Fig. 1b.
- If the components are left out of positions 1, 2 and 3, the card is as in Fig. 1c.

The pins and ICs are so arranged that it is impossible for different signals from the various logic-card types to interfere with one another. The outputs from the flip-flop in Fig. 1d, for example, enter the inverter buffers located at positions 4 and 5. If the card is not used as a flip-flop card, however, then the IC in position 6 will be absent and the lines from the flip-flop outputs to the buffers will be left open. The buffers can therefore receive their inputs from the conponents in positions 1 and 2. Also note that some of the IC components are common to both logic functions that are to share a printed-circuit board, very little extra board space is necessary to mechanize these extra functions. For example, in Fig. 1d the components in positions 1 and 2 comprise both the functions in Figs. 1a and 1b.

Norton Markin, Senior Engineer, Bendix Corp., North Hollywood, Calif.

VOTE FOR 118



1. **One printed-circuit board** (d) can be used for three logic functions (a, b, c) by placing ICs in proper positions. Function (a) is obtained by leaving positions 4, 5 and 6 empty; (b) by leaving positions 3 and 6 empty; (c) by leaving 1, 2 and 3 empty.

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Carlos A. Riveros, Systems Development Div., International Business Machines Corp., San Jose, Calif. His Idea, "Composite amplifier has improved dc bias stability," has been voted the $50 Most Valuable of Issue Award.

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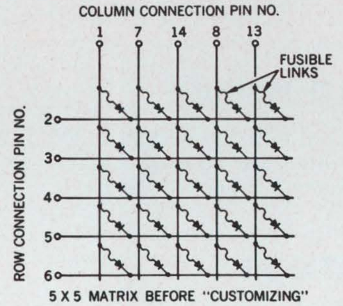

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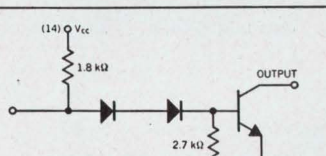

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6 x 8	**RM-30** RM-130	**RM-31** RM-131	**RM-34** RM-134
8 x 5	**RM-80** RM-180	**RM-81** RM-181	**RM-84** RM-184
8 x 6	**RM-40** RM-140	**RM-41** RM-141	**RM-44** RM-144
4 x 10	**RM-90** RM-190	**RM-91** RM-191	**RM-93** RM-193

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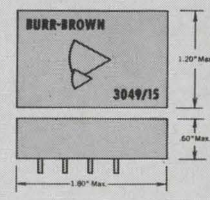

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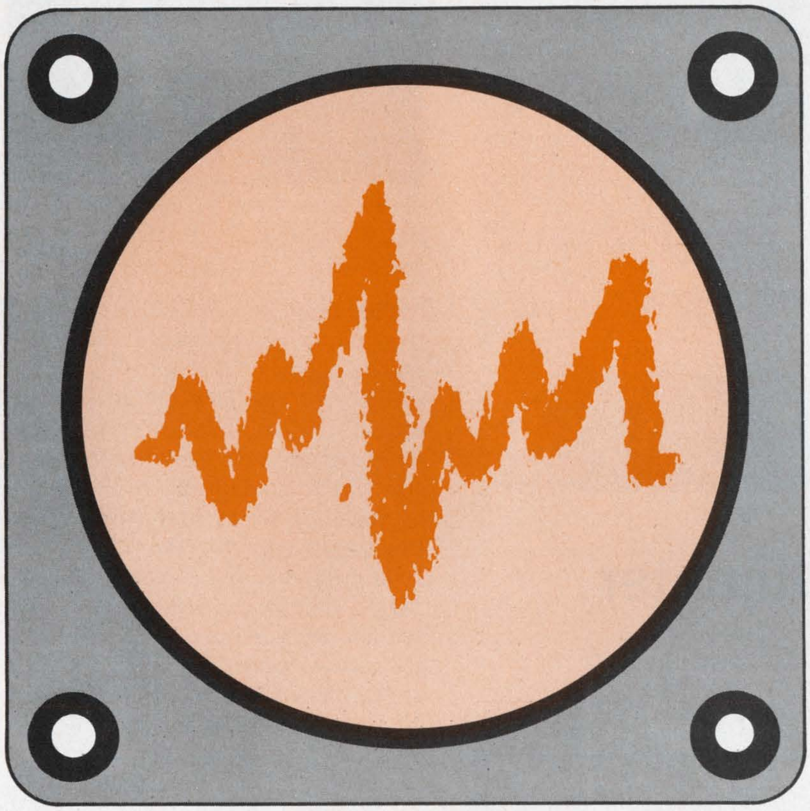
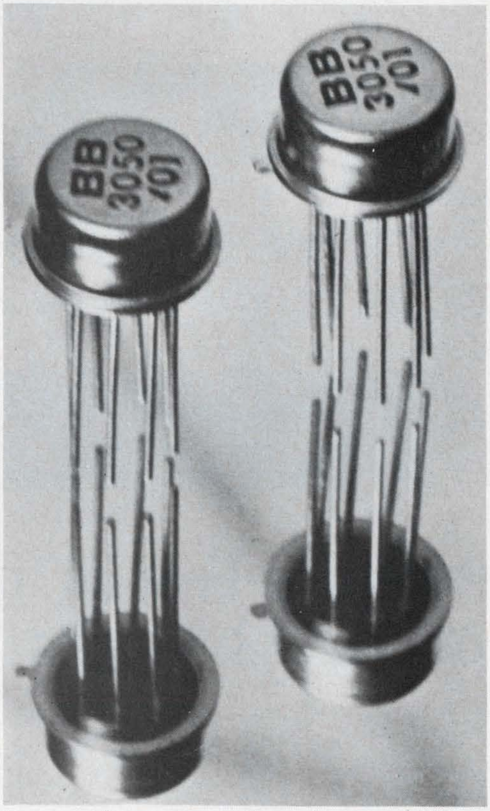
ON READER-SERVICE CARD CIRCLE 106 FOR AMPLIFIERS AND 107 FOR MODULES

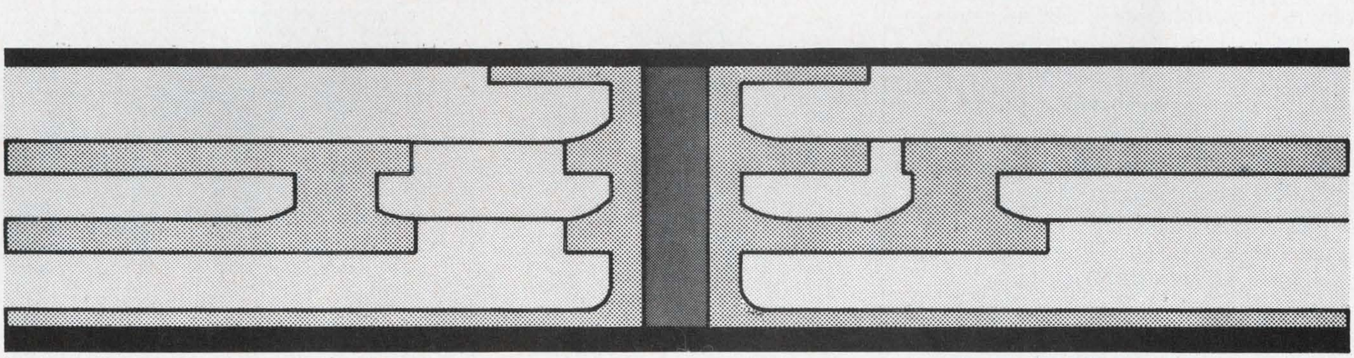
Products



Now is the time for all test equipment to come to the aid of the engineer. Test equipment section. Page 114



Low-noise operational amplifiers will overcome shorting. Page 138



A wiring board in multilayer form uses a solid post technique that will allow dual-in-line ICs to be surface mounted. Holes may also be drilled through the posts. Page 148

Also in this section:

Triac hits 200-A operation using epitaxial process. Page 140

A camera-port microscope-laser exhibits 100% reflection. Page 146

Encapsulated power supply gives 20,000 V out on 28 V in. Page 158

Design Aids, Page 170 . . . Application Notes, Page 172 . . . New Literature, Page 174

Portable French multimeter offers 23 ranges

Honeywell, Test Instruments Div., 4800 E. Dry Creek Rd., Denver, Colo. Phone: (303) 771-4700. Price: $525.

The Digitest, a three-digit multimeter built in France and distributed by Honeywell, can measure 23 different ranges, including voltage, resistance and current. It is said to provide accuracies of ±0.5 per cent for dc voltages and ±1 per cent for ac. The instrument can be operated from a standard line outlet or by a rechargeable nickel cadmium battery. Other capabilities are shown in the following table.

Function	Range	Accuracy
Ohmmeter	100 Ω	1% ± 1 digit
	1000 Ω	
	10 kΩ	
	100 kΩ	
	1000 kΩ	
dc Voltmeter	1000 V	0.5% ± 1 digit
	100 V	
	10 V	
	1000 mV	
	100 mV	
ac Voltmeter	300 mV	1% ± 1 digit
	3 V	
	30 V	
	300 V	

A new French import shows a thing or two, like a sloping profile, 23 ranges and an overload light.

The digitest is manufactured by Schneider Radio Television, S. A., Professional Electronics Div., Ivry-Seine, France. Under the distribution agreement, Schneider is supplying Honeywell's Test Instruments Div. with the multimeter for exclusive distribution throughout the United States, Mexico, Canada, and Central and South America.

CIRCLE NO. 254

Thermocouple controls in gauge form

Veeco Instruments, Inc., Terminal Dr., Plainview, N. Y. Phone: (516) 681-8300.

The TG-7 and TG-27 supplement the line of gauge controls and will replace models TG 6 and TG 20 respectively. The new gauge controls utilize the solid-state design and construction, and modular 1/4 rack size which is adaptable to bench use by the addition of four rubber feet. Pressure range for the TG 7 is 1-1000 millitorr, and 0-20 torr for the TG-27. The units are recommended for use with matched-V thermocouple gauge tubes DV IM and DV 4AM. Dimensions of both units are 5-3/16 x 4-5/32 x 11 in. and each weighs 6-3/4 lb.

CIRCLE NO. 255

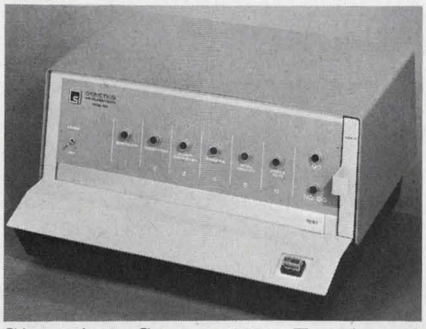
Half-rack counter spans 5 Hz to 12.5 MHz

Monsanto Electronics Technical Center, 620 Passaic Ave., West Caldwell, Mo. Phone: (314) 694-2889. P&A: $575; stock.

The instrument provides capabilities which include measurement of average frequency from 5 Hz to 12.5 MHz, and its frequency ratio is from 1 to 10^6. The unit embodies a crystal-controlled clock having an aging rate of better than 5 parts in 10^7 per day after 72 hour warm-up, and has a basic sensitivity of 50 mV, rms. The final decade carry-pulse is available at a rear panel connection, permitting cascading of slave units to extend range and/or resolution in multiples of 5 digits.

CIRCLE NO. 256

IC test set has 6 levels



Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. Phone: (408) 739-7700. P&A: $4995; 10 wks.

With the appropriate device-test head installed, the unit can test any of the present standard integrated-circuit-package configurations 14 or 16 lead dual in-line, 10 or 14 lead flat pack, and ten lead TO-5. All devices are subjected to a series of six consecutive tests which dynamically check the performance of the device under realistic applications-simulated conditions. The tests include continuity, orientation, power dissipation, a functional test, noise immunity and a toggle-rate test.

CIRCLE NO. 257

Measure switching times from ns to μs

B-Line Electronics Corp., 4 Music Hall Ave., Waltham, Mass. Phone: (617) 899-3880. Price: $835.

Extremely useful for the measurement of stored charge, this unit gives an accurate measurement of the switching time of semiconductor diode devices. With its stored charge range of 100 nC and forward current bias levels to 50 mA, it possesses large applications for the measurement of the switching time of so-called fast rectifiers, slow germanium gold-bonded diodes and PIN diodes, from 20 ns up to μs region.

CIRCLE NO. 258

Tester analyzes 40-IC pins, with option for dynamic scope

Computer Test Corp., 3 Computer Dr., Cherry Hill, N. J. Phone: (609) 424-2400. Price: $11,200 to $17,500.

A semi-automatic bench tester has been developed for dc-analysis of integrated circuits that have up to 40 pins. Dynamic testing with an auxiliary sampling scope is also available as an option.

The tester, designated MICA-150 by the Computer Test Corp. of Cherry Hill, N. J., can be used for incoming inspection, small-run production, and laboratory and failure analysis. The analyzer can be sequenced from pin to pin of the device under test by application of a pre-programed series of precision voltages that simulate typical or worst-case operating conditions. Test results are indicated on a direct digital readout.

All test conditions are set up on two independent 11-by-40 cross-bar programing switches that connect any of up to eight function generators and a built-in digital voltmeter to the pins of the device under test.

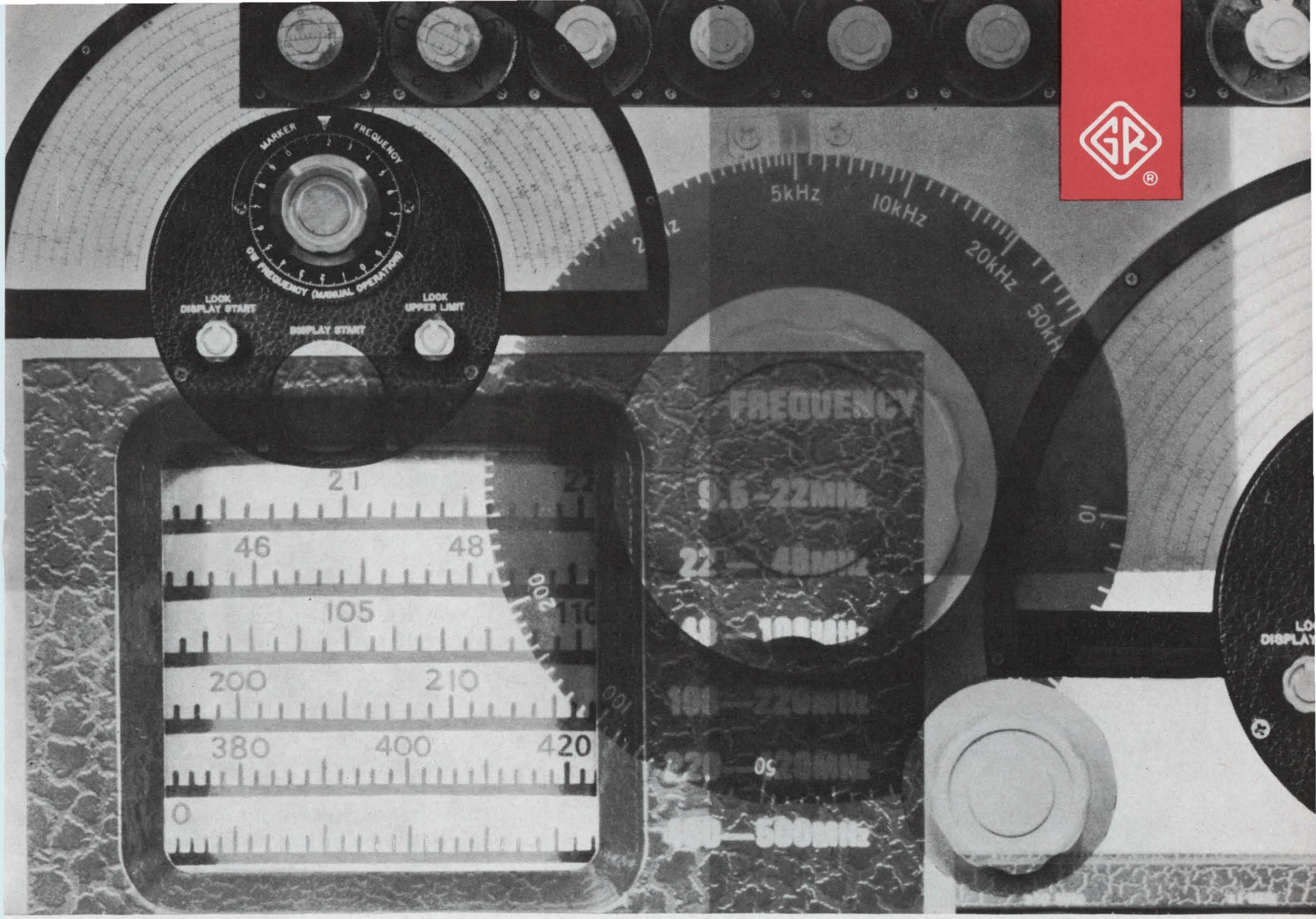
Dc analysis of ICs with up to 40 pins can be handled by this tester. Dynamic testing with a sampling scope is available as an option.

The flexibility provided by the crossbar matrices permits a wide variety of test combinations. For example, a two-terminal device can be checked with as many as 20 different tests; a 10-pin circuit with four different programs; in which function generators are transposed as desired; or a two-pin device with Kelvin connections with up to 10 test programs.

It is possible to have the digital meter measure current on one pin of the device and voltage on another; the operator can change the polarity of the meter leads, as necessary. Once the program has been established, the test can be sequenced quickly by a numbered pushbutton keyboard arranged in a 10-by-4 matrix. The number of the pushbutton that is despressed determines the pin at which the test is to be made. The operator initiates the test by depressing a finger bar that applies power to the device under test. The readout indication is delayed by a "soak time" control, to provide a period for thermal stabilization of the device prior to measurement. This control makes it possible to detect marginal device operation. A position on this control allows the operator to vary the output of the function generators while observing device reaction for further analysis of marginal circuit operation. Upon completion of the measurement, the power is automatically removed. The memory readout of the digital voltage/current meter continues to display the measurement until the data are replaced by new information in the test sequence.

Universal test adapters are designed to speed testing and reduce adapter inventory by accepting all devices of the same package configuration and the appropriate number of pins, regardless of manufacturer or circuit type. Adapters are available for ICs.

CIRCLE NO. 259



Dial GR for Sine-Wave Signals

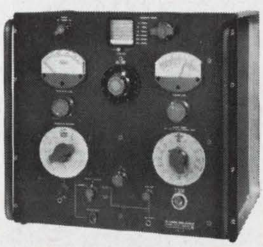
Over 100 different models of GR oscillators, signal generators, and synthesizers are listed in our catalog. These sine-wave signal sources provide a wide choice of frequencies, power outputs, and modulation and sweeping capabilities. For instance:

Included among the oscillators are our four new "sync-able" oscillators, each a small (8 x 6 x 8 in.), self-contained unit with a sync jack for phase-locking to an external signal. These oscillators offer a wide choice of performance: fixed frequencies (to 10 kHz) or continuous tuning (to 2 MHz), up to 1-watt output, as much as 0.001% short-term frequency stability, and distortion as low as 0.05% or less.

If you need a high-resolution signal source with a wide choice of operating features, you can satisfy your need with one of the 80 versions of our frequency synthesizers. Their modular construction makes it possible to order any of the four basic models with from three to seven manual step-decade modules, programmable modules, and with or without a continuously adjustable decade module that provides additional resolution and sweep capability. Upper frequency limits of the four basic models are 100 kHz, 1 MHz, 12 MHz, and 70 MHz with maximum possible resolutions of 0.0001, 0.001, 0.01, and 0.1 Hz, respectively.

The newest addition to our ensemble of sine-wave sources is the 1026 Standard-Signal Generator. This unique instrument puts out *½ watt* into 50 Ω (10 V behind 50 Ω, 5 V when modulated), has excellent output leveling, and has true single-dial tuning over its entire 9.5- to 500-MHz frequency range. The ease of operation and outstanding performance of the 1026 in the most critical applications must be experienced to be appreciated. Request a demonstration and see for yourself.

Prices for GR sine-wave signal sources range from $225 for a "sync-able" audio oscillator with 11 fixed frequencies to $7515 for a full-complement, 70-MHz frequency synthesizer. For complete information, write General Radio Company, W. Concord, Massachusetts 01781; telephone (617) 369-4400; TWX (710) 347-1051. Sales Engineering Offices are located in major cities throughout the United States and Canada.



Type 1026 Standard-Signal Generator, $6500 in U.S.A.

GENERAL RADIO

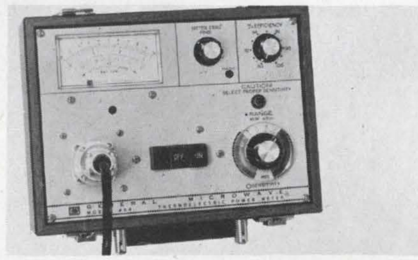
Power-factor meter covers 50 to 2500 Hz

Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, N. J. Phone: (201) 243-4700.

This instrument is designed to measure and indicate power factor over an input frequency range of 50 to 2500 Hz. It will maintain its accuracy rating of ±1% of total span with sine-wave inputs of 120 V and currents ranging from 1 to 5 A. Using a transistorized squaring amplifier, the model 83 operates on the zero crossing points of current and voltage waveforms to produce dc outputs linearly dependent upon the phase angles between parameters.

CIRCLE NO. 260

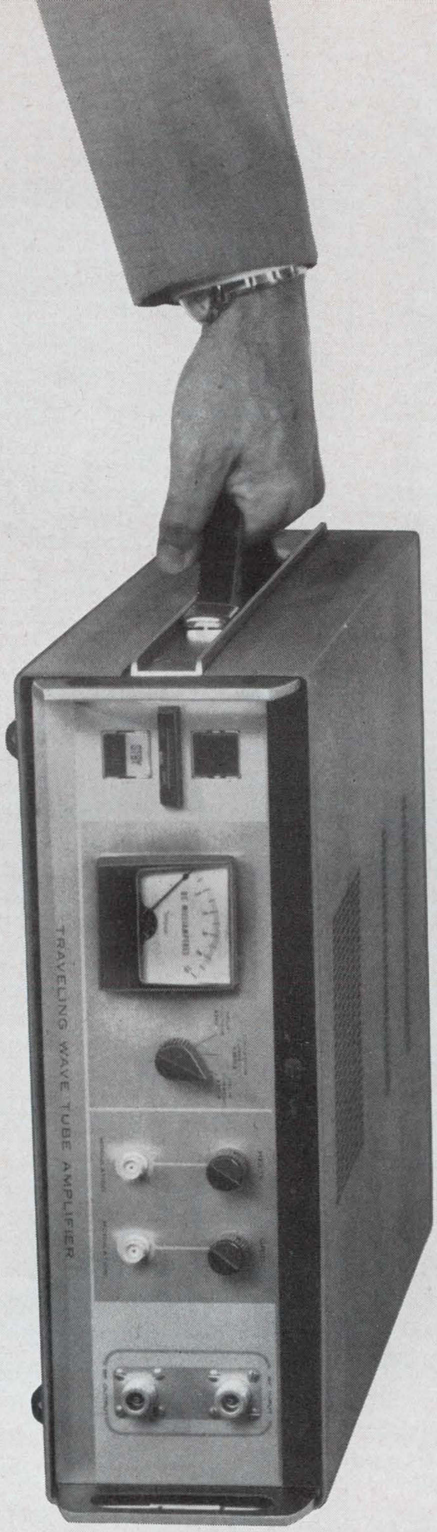
Microwave power weighed on 8 scales



General Microwave Corp., 155 Marine St., Farmingdale, N. Y. Phone: (516) 694-3600. Price: $350.

Designed for field and laboratory applications requiring portable instrument, the unit is solid-state and battery-operated, and is housed in a walnut-grained instrument case with hinged cover and handle. Power measurements can be made from −25 to +20 dBm. Eight scales are provided and its accuracy is ±3% full scale over the temperature range from 0 to +50°C; or ±4% from −25 to +75°C. The model 464 will operate with all coaxial and waveguide models in the TFT power head series, which ranges in frequency from 10 MHz to 40 GHz.

CIRCLE NO. 261



A brief case for TWT Amplifiers

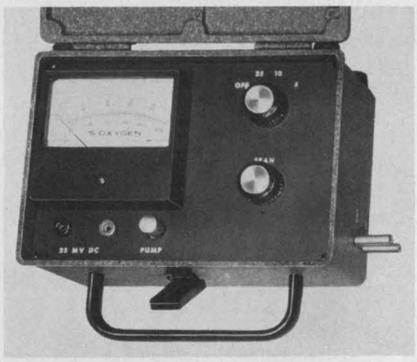
Frequency range from 0.5 through 12.4 GHz. Power outputs up to 10 watts. Front panel connection for grid **and** helix modulation, and best of all . . . our own built-in Traveling Wave Tubes. For more details, write Microwave Associates today, leaders in TWT's and TWT Amplifiers since 1951.

MICROWAVE ASSOCIATES

Burlington, Massachusetts

Offices: Burlington, Mass.; 9911 Inglewood Ave., Inglewood, Cal.; Subsidiaries: Microwave Associates (West) Inc., Sunnyvale, Cal. Microwave Associates, Ltd., Luton, Beds, England.

O_2 analyzer unaffected by organic gas



The Hays Corp., Michigan City, Ind. Phone: (219) 872-5561. Price: $400.

Accurate oxygen analyzation is unaffected by organic gases such as methane, ethane, propane, butane, ethylene and propulene. No power is required, as the cell generates its own output. It is suitable for hazardous areas with no modification. This small, hand-held, membrane-type oxygen analyzer fills the need of boiler men, plant operators, health and safety inspectors and many others with a need for a quick portable means of measuring oxygen in gas streams.

CIRCLE NO. 262

Multirange meter senses 100,000 V per Ω

Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, N. J. Phone: (201) 243-4700.

The model 401 is a new design featuring an optical pointer system for sensitivity gain and freedrom from parallax problems. Provided with flat scale presentation it has the reading ease of a single-range instrument. The shrouded case reduces external light and swivels to the desired reading position.

CIRCLE NO.263

Detect light at 0.2 lm/ft²

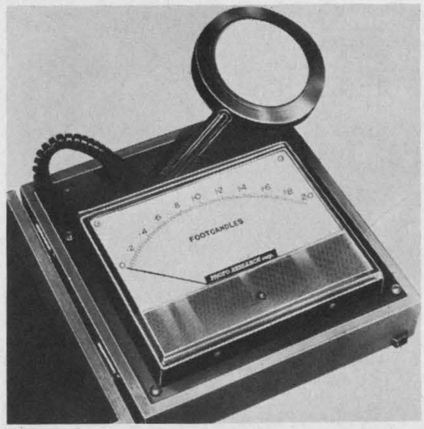


Photo Research, 837 N. Cahuenga Blvd., Hollywood, Calif. Phone: (213) 462-6673. Price: $250-$300.

Extremely sensitive, this is an accurate instrument for laboratory or field use. It features a taut-band meter, a 7-in. mirror scale and full-scale reading of 2 lm/ft². The sensitivity range may be extended as needed by the use of attenuators supplied with the meter. The light sensor is a selenium photocell with a sensitive area of 9 sq in. The combination of this photocell and the meter dial assure accurate reading at light levels as low as 0.2 lm/ft².

CIRCLE NO. 264

Calibrator receiver spans 10 mHz to 40 GHz

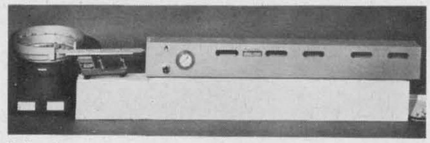
Narda Microwave Corp., Plainview, N. Y. Phone: (516) 433-9000. P&A: $2,475; stock.

The model 61A1A allows calibration of gain or loss characteristics accurately over 100 dB dynamic range in a single step, independent of operating frequency. Modified square-wave phase-shift control provides signal switching 0 to 75 V with 0° or 1800° phase. Measurements over ranges from 10 mHz to 40 GHz, can be made to calibrate components, signal generators and other microwave devices. Precision and resolution is 0.02 dB. The unit may also be used as a conventional lin-log receiver. For antenna pattern measurements, a 60-dB log scale and recorder output are provided. In conventional linear operation, the unit can be used as a microwave detector.

CIRCLE NO. 265

TEST EQUIPMENT

Transistor shock tester is air-operated



Mechanization Associates, 2622 Frontage Rd., Mountain View, Calif. Phone: (415) 967-4262. Price: $285 to $1885.

A transistor, IC or similar device is inserted into the venturi section of a long tube. It is drawn in by air jets and then accelerated down the tube by the expanding air stream. After leaving the tube it impacts against a hinged striker plate and drops into a tray. The acceleration down the tube is determined by the air pressure. By varying the air pressure, the striker plate mass and/or resilience, the device can be made to undergo various peak shock loadings and durations.

CIRCLE NO. 266

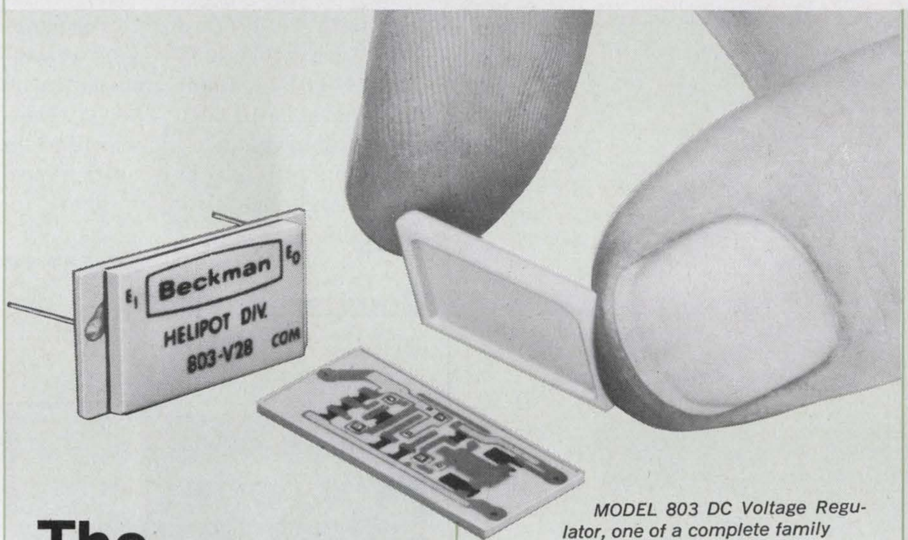
Tangential sensitivity measured on X-Y plot

Emerson Electric, 24003 Ventura Blvd., Calabasas, Calif. Phone: (213) 347-5446.

The ET-24 automatically measures and records noise output, tangential sensitivity and detected pulse height of a microwave video detector, sweeping across an entire octave. A permanent X-Y recorder plot of tangential sensitivity and video output versus frequency is provided plus a record of the white noise level in a 10-MHz bandwidth. A quick disconnect coaxial holder, and an automatic chart advance for the recorder permits 500 units to be tested in one day. The unit is available in coax through X-band.

CIRCLE NO. 267

±0.05% regulation is only one of twelve outstanding specs in Helipot's exclusive new microcircuit dc voltage regulator series.



MODEL 803 DC Voltage Regulator, one of a complete family of six miniature, hybrid cermet thick film units with outputs from 3 to 32 volts.

The applications:

Helipot Series 800 DC Voltage Regulators are physically compatible with dual in-line and flat pack integrated circuits. This permits system use of unregulated power with precise regulation at the point of use. In addition to the 1,000:1 ripple rejection capability, these units provide excellent circuit decoupling and protection from transients and sudden power surges.

	Application		
	Digital Circuits 3 to 9 Volts	**Analog Circuits 9 to 21 Volts**	**Airborne and General Purpose Circuits 20 to 32 Volts**
Fixed Output	**Model 805** Reader Service No. 241	**Model 801** Reader Service No. 242	**Model 803** Reader Service No. 243
Adjustable Output	**Model 806** Reader Service No. 244	**Model 802** Reader Service No. 245	**Model 804** Reader Service No. 246

The other eleven:

- short circuit proof models
- small size–0.5 sq. in.
- low profile–0.170"
- up to 5 amps load current
- output range–3 to 32 volts
- fixed and adjustable outputs
- fully sealed
- hybrid cermet construction
- operating temperature range: –55°C to +125°C
- 60 db ripple rejection
- mil spec tested

The price:

- $30.00–fixed output models
- $35.00–adjustable output models

(prices are 1-9 quantity, delivery from factory stock)

Ask your local Helipot sales representative for information or circle the appropriate number on the reader service card.

Beckman®

INSTRUMENTS, INC.
HELIPOT DIVISION
FULLERTON, CALIFORNIA • 92634

INTERNATIONAL SUBSIDIARIES: GENEVA; MUNICH; GLENROTHES, SCOTLAND; TOKYO; PARIS; CAPETOWN; LONDON; MEXICO CITY

ON READER-SERVICE CARD CIRCLE 241-246

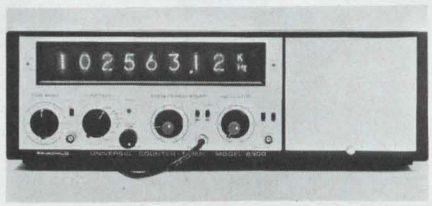
Ni-Cad batteries in portable multimeter

California Instruments Corp., 3511 Midway Dr., San Diego, Calif. Phone: (714) 224-3241.

Multimeter performance of three ranges of dc V, three of ac V and five of resistance are offered. Performance characteristics of the model 8000B includes 4-digit readout, with 10% 5th-digit over-ranging. Accuracy is 0.05% and resolution is 0.01%. Input impedance on all ranges is 10 MΩ. The batteries are rechargeable nickel-cadmium and supply up to 6 to 8 hours of use in normal operation without recharging.

CIRCLE NO. 268

Counter-timer out to 8 digits

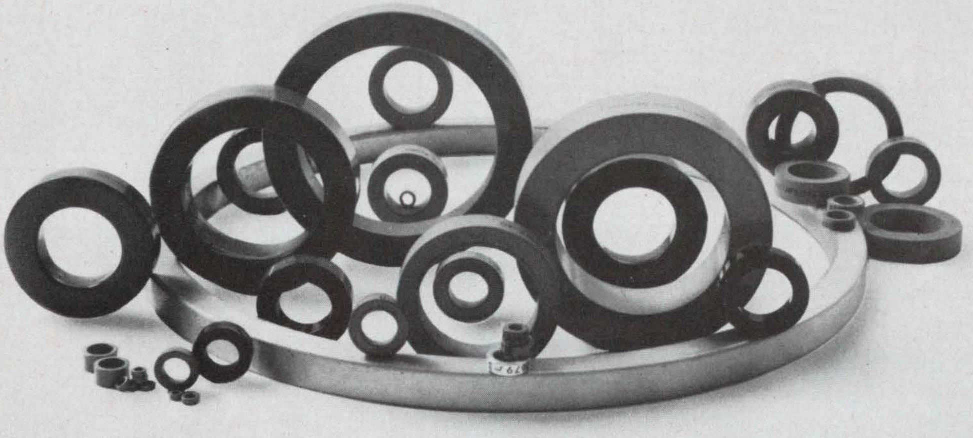


Fairchild Instrumentation, 475 Ellis St., Mountain View, Calif. Phone: (415) 962-2011. Price: $2495.

The model 8300 is an eight-digit instrument with 10-ns resolution, high input impedance and ac or dc input coupling. By adding a plug-in module, the instrument's frequency range may be extended to 500 MHz. The unit makes frequency, multiple period average, frequency ratio, time interval and totalizing measurements. Time base stability is attained with a proportionally controlled oven for the quartz crystal. A variety of options makes it possible to interface the unit with other instruments and systems.

CIRCLE NO. 269

you get a choice,



not a challenge

Most complete line of high quality tape wound cores available from any manufacturer

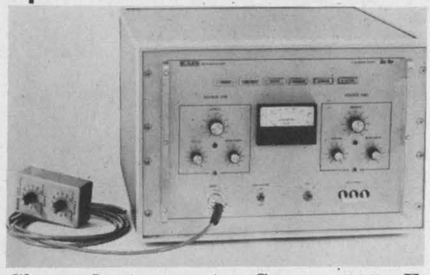
Magnetics' selection of tape wound cores encompasses eight material types, in a range of sizes from 0.050″ to 12″ inside diameter. For frequencies from DC through 500 kc, materials are produced in thicknesses ranging from ⅛ mil through 14 mils. All core sizes are available boxed in phenolic or plastic, aluminum or GVB- coated aluminum. Magnesil®, less sensitive to external stresses, is also available unboxed or epoxy encapsulated.

In addition to offering this broad range of tape wound cores, Magnetics has improved its production of raw materials, using the most advanced testing devices to control quality in metals, winding, annealing, potting compounds, boxing processes and the application of encapsulating materials. This across-the-board control assures you of getting what you pay for in performance.

If you have an application for tape wound cores, why settle for an approximation of your specifications? With Magnetics, you don't have to "make do"—you get a choice, not a challenge. For further information on our complete line of tape wound cores, write for Catalog TWC-300, Magnetics Inc., Butler, Pennsylvania 16001

MAGNETICS inc.®

Electron beam supply operates in 3 modes



Sloan Instruments Corp., 535 E. Montecito St., Santa Barbara, Calif. Phone: (805) 963-4431.

An electron-beam power supply for either manual or automatic control has a constant-voltage, variable-emission type with a gun-filament source and two-gun magnet supply. It provides 10,000-V dc at 0.6 A. In addition to beam-position-control a variable beam-sweep function allows evaporation from a large area without defocusing beam. A second emission control module may be added for simultaneous two-gun operation. A hand-held remote control permits manual emission and beam positioning from up to 8 feet from supply. All controls and indicator lights are front panel mounted. Operator safety is assured through three interlocks. Forced-air cooling and electronic overload protection offer reliability.

CIRCLE NO. 270

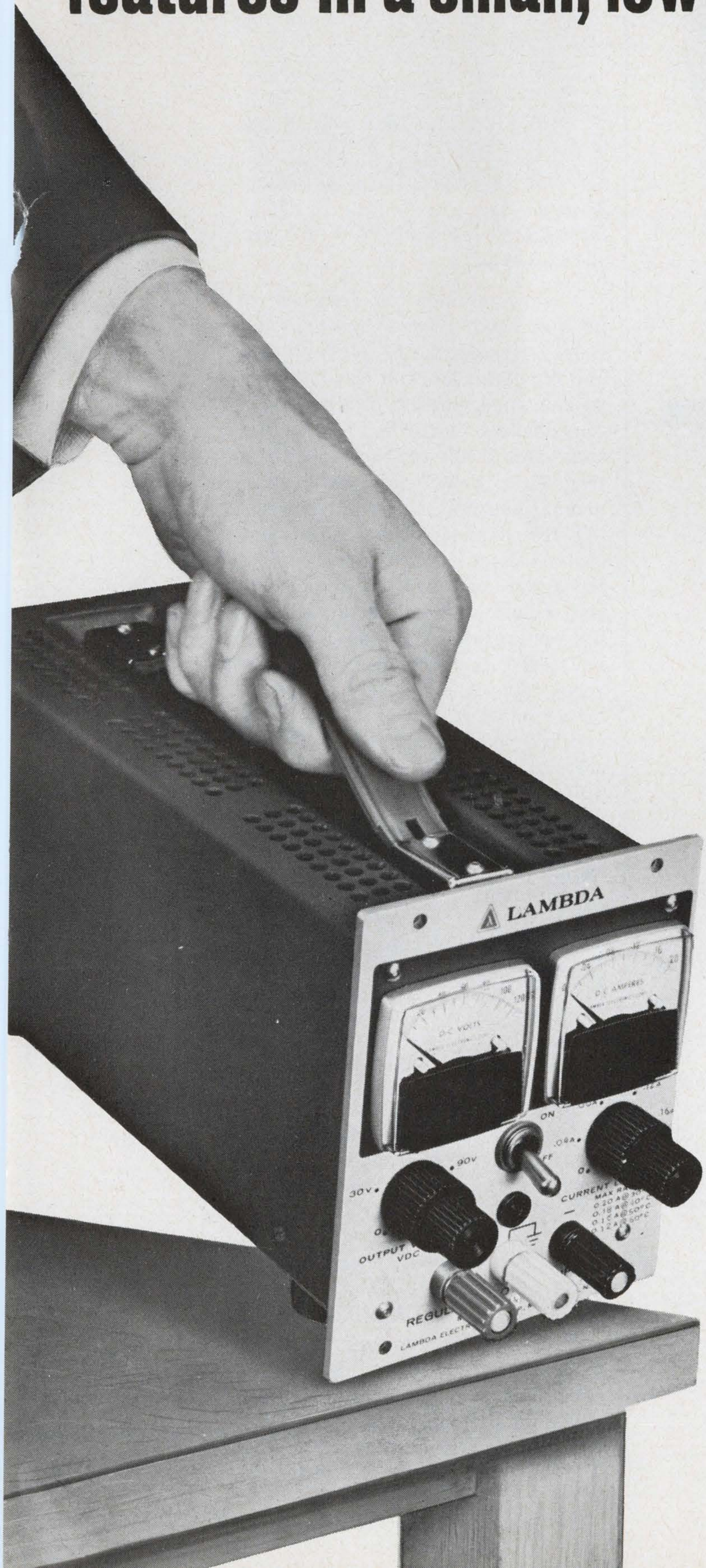
Wide chart recorder responds in 0.5 s

Honeywell, Inc., Ft. Washington, Pa. Phone: (215) 643-1300. P&A: $900 to $2300; 10 to 12 weeks.

The Electronik-194 recorder, has a 10-inch calibrated chart. The instrument is available in one-and two-pen, multi- and single-range models for bench use or relay rack and panel mounting. It is expected to find application in areas involving analysis, precision production-line testing, and monitoring of automotive, aircraft and rocket test-stand data. The instrument measures dc signals over a range of 100 μV to 100 V. It is for use in conjunction with low-impedance (up to 25,000 Ω) sensing devices, high-impedance bridge circuits, and high-level dc signals.

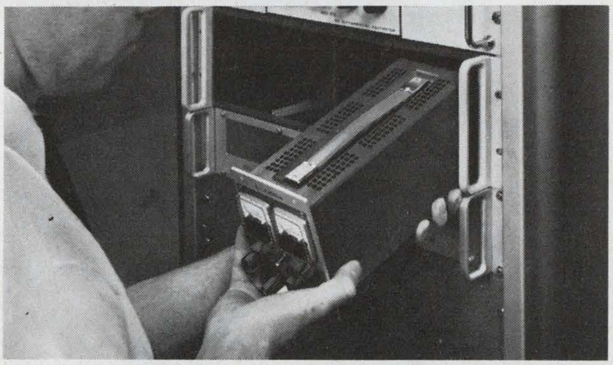
CIRCLE NO. 271

Only new Lambda LP Series lab power supplies provide all these big system features in a small, low-cost package.



Starting at only $114.

- High power output—up to 28 watts.
- Wide voltage range versatility—0-10 VDC up to 0-250 VDC.
- Bench or rack use—without adapters.
- Unusually wide automatic current limiting—from 1% (or 5 MA) to 105% of rated output current.
- Two meters for voltage and current.
- Both coarse and fine adjustment of voltage and current.
- Over-temperature protection by thermal relay—prevents overheating.
- Convection cooled—no blower failures.



You can mount up to 4 units in a standard LRA-1 or LRA-2 rack adapter.

Other features

- Regulation (line or load): .01% + 1 MV.
- Ripple: 500 μV RMS. 1.5 MV p-p
- Temperature coefficient: .015% + .5 MV/°C.
- CV/CC with automatic crossover.
- A-C input: 105-132 VAC 45-440 Hz (ratings based on 57-63 Hz operation).
- All Lambda power supplies are guaranteed for 5 years.

Select from six models

Model	Voltage Range	MAX. CURRENT AT AMBIENT OF:				Price[1]
		30°C	40°C	50°C	60°C	
LP 410	0-10 VDC*	2A	1.8A	1.6A	1.4A	$129
LP 411	0-20 VDC*	1.2A	1.1A	1.0A	0.8A	119
LP 412	0-40 VDC*	0.70A	0.65A	0.60A	0.50A	114
LP 413	0-60 VDC*	0.45A	0.41A	0.37A	0.33A	129
LP 414	0-120 VDC	0.20A	0.18A	0.16A	0.12A	149
LP 415	0-250 VDC	80MA	72MA	65MA	60MA	164

*Overvoltage Protection available as an accessory—$40.00 each.
[1] Prices are for non-metered models. For metered models, add suffix (FM) and add $10.00 to price.

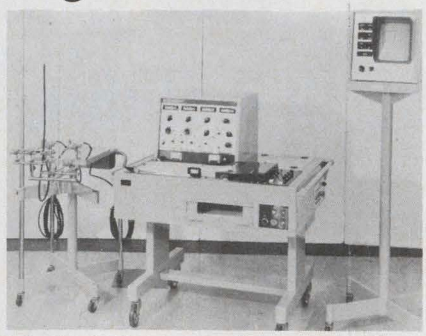
SEND FOR COMPLETE LAMBDA CATALOGUE

LAMBDA ELECTRONICS CORP.
515 BROAD HOLLOW ROAD • MELVILLE, L.I., NEW YORK 11746 • (516) 694-4200
A Veeco SUBSIDIARY

VEECO HIGH VACUUM EQUIPMENT/LAMBDA POWER SUPPLIES

TEST EQUIPMENT

Broad spectrum surgical monitor



Medical Systems Corp., 43 Plymouth Rd., Great Neck, N. Y. Phone: (516) 488-4848.

A surgical monitor designed to monitor and record arterial and venal pressure, EEG, ECG, EMG, and phonocardiograph consists of a four-channel viewing oscilloscope, a four-channel recorder (including time and event markers), and a transducer holder and calibration mount. The unit is used in operating rooms and catheter treatment centers. Modular in design, the unit has several optional plug-in accessories including transducers to measure respiration curve, galvanic skin resistance, and photoelectric plethysmogram. Another feature is remote control operation, allowing the oscilloscope to be viewed in the operating room while the recording unit can be maintained at a different location. The recorder can also be operated remotely by a foot switch.

CIRCLE NO. 272

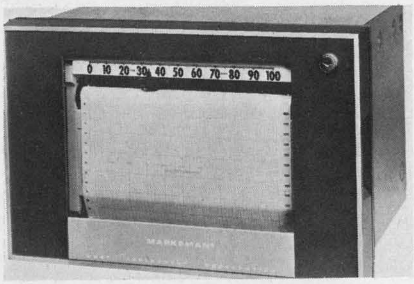
Micrologic circuits checked with IC tester

Microdyne Instruments, Inc., Waltham Engineering Center, 225 Crescent St., Waltham, Mass. Phone: (617) 893-8210.

Designed as a low-cost analyzer, it is capable of testing most dc parameters of micrologic circuits. Portable, the model 701 is self contained, with all necessary power supplies, electronic current/voltage meter, output indicators and pulse generator. Testing can be achieved utilizing the pre-programed patch plug. Four tests can be operated in series to provide 16 tests in a single sequence. 15 seconds per unit is required for functional testing.

CIRCLE NO. 273

Strip chart recorder plots 24 points



West Instrument Corp., 3860 N. River Rd., Schiller, Pk., Ill. Phone: (312) 678-6400.

Up to 24 points can be recorded with this potentiometric recorder. The unit uses solid-state electronics including the photochopper. Printed circuit plug-in cards for zero position, span and function (suppression) on mV ranges provides flexibility. The three separate cards plug into an amplifier socket. For thermocouple reading, the cards are replaced by a single temperature card with a complete choice of ranges. Accuracy of readings is $\pm 0.25\%$ of full scale or ± 5 μV. Three types of graphic displays are possible. Through a mechanical adjustment, an operator can select graphic presentation of dots only, dots with input number next to every twenty-fifth dot or dots with input number next to every dot.

CIRCLE NO. 274

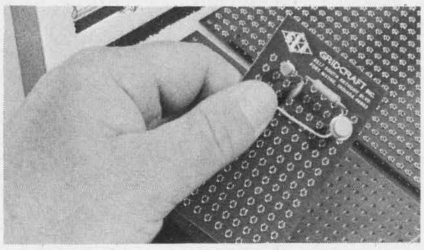
In-line voltage calibrator to 1111.110 V in 3 ranges

Cohu Electronics, Inc., Box 623, San Diego, Calif. Phone: (714) 277-6700. P&A: $995; stock.

The model 324 A features an in-line readout, a voltage range from 0 to 1111.110 in three ranges of 10 V, 100 V and 1000 V and a stability of 30 RPM for 24 hours and 50 ppm for 30 days. Output-voltage dials control make-before-break switches and permits the output voltage to be varied in steps as small as 10 μV. Output current capability is 25 mA at any voltage setting.

CIRCLE NO. 275

Circuit board simplifies design



Grid Craft, Inc., 2217 S. Anthony Blvd., Fort Wayne, Ind. Phone: (210) 744-4314. Price: $25.

Complete with multigrip terminals installed in all holes, this patchboard simplifies prototype circuit development on closely spaced grids which can later be translated into equivalent printed circuits for production runs. Offered is a packaged selection of the board, including four units 3 x 6 in. in size (a fifth board of the same size is provided with the holes but without installed terminals); three 6 x 1/2 in. strips for joining adjacent cards without losing grid spacing; and one submodule card. The larger boards have 402 terminals.

CIRCLE NO. 276

Dc power supply to 15,000 V

Spellman High Voltage Co., Inc., 1930 Adee Ave., Bronx, N. Y. Phone: (212) 547-0306.

This unit features solid-state design with an adjustable output from 100 to 15,000-V dc. Polarity is reversible. It is short-circuit proof and upon removal of the short circuit, the unit will return immediately to normal operation. The unit has a maximum current capability of 2 mA. The power supply with carrying handle is 10-1/4 x 8-1/2 x 8 in. and weighs 12 lb.

CIRCLE NO. 277

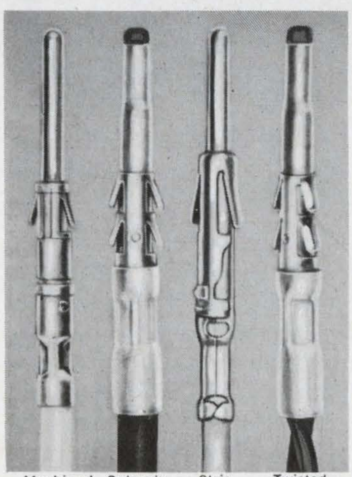
1.34×10^5 COMBINATIONS

(ONE OF THEM HAS GOT TO WORK FOR YOU.)

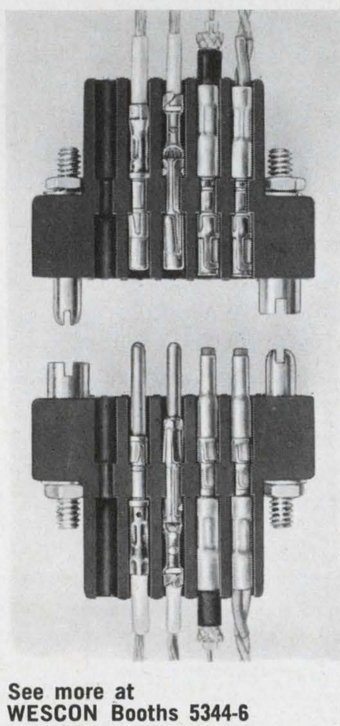
When we say our Trim Trio has enormous application potential, we're not kidding. The combination of numbers surprised us too. For any of our three types of contacts—sub-min coax, machined or continuous formed strip—will work in any of nine connector blocks (14 to 152 positions). In any combination.

And if you wanted to count wire sizes, or figure the twisted pairs our sub-min coax can accommodate, or leave some contact holes open, the possibilities would truly be endless. Probably most of them haven't been used yet. Surely some of them will solve your problems.

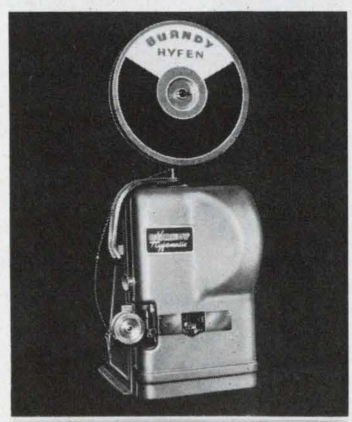
And Burndy can make your installation problems easier, too. Whether you crimp one at a time on a hand tool or 3,000 per hour with a Hyfematic™ you can count on built-in quality control, save time and money. For the full story and details on the combination that will work for you—from breadboard to production—write for our Bulletin MS67.



Machined Sub-min Coax Strip Hyfen Twisted Pair



See more at WESCON Booths 5344-6



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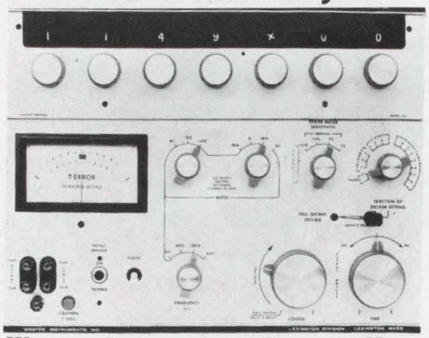
TEST EQUIPMENT

Instrument calibrator with 0.2% accuracy



Weston Instruments, Inc., 17 Hartwell Ave., Lexington, Mass. Phone: (617) 861-9000.

This calibrator provides a means of calibrating meters both portable and panel mounted. The operation is accomplished by using a fractional scale-divider which enables calibration throughout a meter range without resetting full-scale values or amplitude controls. Operator calculations are eliminated when determining per cent accuracy at fractional scale points, since the results are always displayed in terms of full scale. Ac and dc voltages to 1100 V, currents to 11 A and resistance to 11 MΩ are provided with 6-digit resolution. Accuracy is specified at 0.1% of reading for dc voltages, and 0.2% for most other functions.

CIRCLE NO. 278

Frequency meter to 500 MHz

Fairchild Instrumentation, 475 Ellis St., Mountain View, Calif. Phone (415) 962-2011. Price: $1695.

Featuring direct frequency measurement and seven-digit resolution, this light, compact instrument is designed to meet the needs of the communications industry as well as other industrial and laboratory applications. The 8229 requires no tuning adjustments for direct reading across the entire range of 10 Hz to 500 MHz.

CIRCLE NO. 279

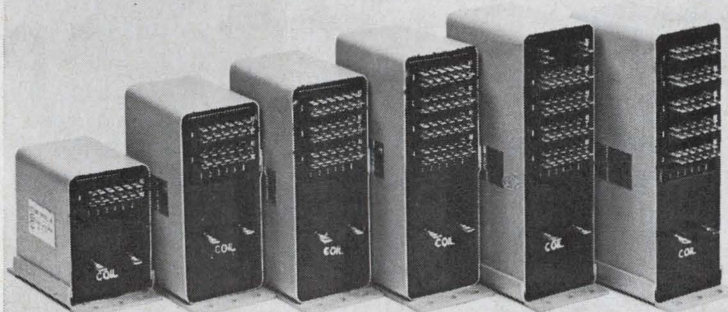
Sealed hi-density switching

from 12 PDT to 144 PDT . . . with MIL-R-5757 protection against

humidity
sand
dust
moisture
splash
explosion
corrosion . . .

. . . and withstands shock and vibration too! How? **Tried T-Bars® lately?**

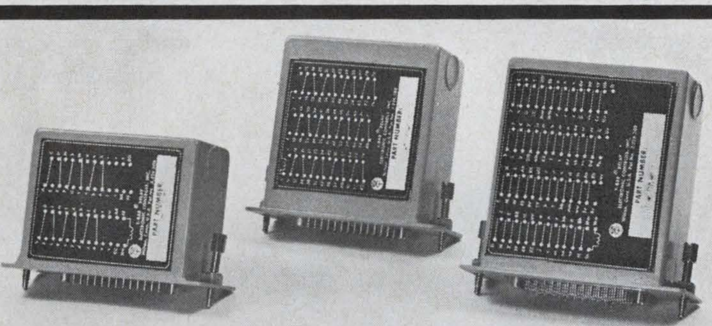
ENVIRONMENTALLY SEALED
T-BAR SERIES 831
RELAYS



12P, ST or DT 24P, ST or DT 36P, ST or DT 48P, ST or DT 52P, ST or DT 60PST

All contacts epoxy sealed in backfilled metal enclosure for ground support and shipboard applications or other demanding environments. Pulse operated magnetic latching available. Simple crimp snap-in contacts fit into single block connectors for easy wiring.

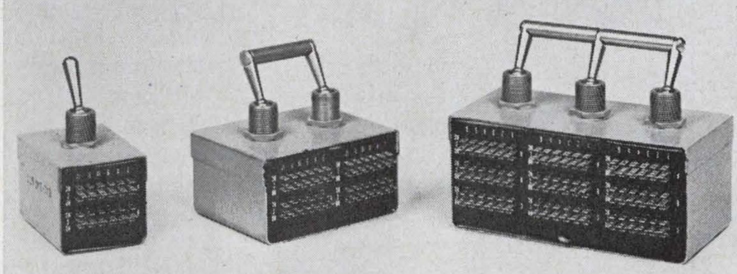
HERMETICALLY SEALED
T-BAR SERIES 808
RELAYS



12PDT or 24PST 24PDT or 36PST 34PDT or 48PST

Hermetically sealed glass and metal-to-metal enclosures backfilled for ground support and selected airborne applications. Mates with MS connectors. Pulse operated magnetic latching available.

ENVIRONMENTALLY SEALED
T-BAR SERIES 832
SWITCHES



12P, 24P, 36P, ST or DT 48P, 60P, 72P, ST or DT 84P, 96P, 108P, 144P, ST or DT

Toggle switches with contacts epoxy sealed in backfilled metal enclosures. Lever operates through diaphragm. Dust boot supplied to exclude salt and sand from mechanical actuator. Simple crimp snap-in contacts fit into single block connectors for easy wiring.

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ON READER-SERVICE CARD CIRCLE 70

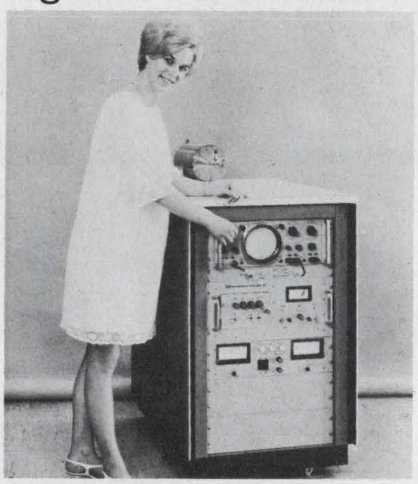
Reference junction for monitoring temperature

Scientific Engineering & Mfg. Co., Inc., 11505 Vanowen St., North Hollywood, Calif. Phone: (213) 982-1400.

This unit features multiple inputs so that various thermocouple materials may be utilized in each channel. The reference-junction temperature is adjustable by means of an external, ten-turn potentiometer. A well is provided to allow insertion of a probe to monitor the equalizing block temperature. The proportional, solid-state, temperature controller used to maintain the constant reference temperature, has a very high degree of accuracy and stability.

CIRCLE NO. 280

Mass spectrometer registers 1 to 250 amu

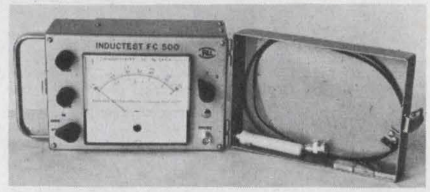


EAI, Scientific Instruments, 4151 Middlefield Rd., Palo Alto, Calif. Phone: (415) 321-7801. Price: $13,-850.

A laboratory mass spectrometer features linear mass resolution from 1 to 250 amu. The QUAD 160 can sweep the mass range from 10 to 250 amu, (optional 1-150 amu) or any portion of this range, in 100 ms to 10 minutes. Manual control also permits continuous monitoring of a single peak. The sensitivity of the unit assures a detectability of less than 1 ng. Other features of the system include emission regulation, variable automatic or manual mass scan, and a mass marker/emission meter. Resolution is better than unity, using a 10% valley definition.

CIRCLE NO. 281

Conductivity meter ranges from 0.5 to 103%



Uresco, 12412 Benedict Ave., Downey, Calif. Phone: (213) 923-3278.

Eddy current instrument, model FC-500, permits direct reading of electrical conductivity values in per cent covering the entire range of metals with conductivities from 0.5% to 103%. It is possible to measure conductivity of thin gauge aluminum (below 0.020 in.) as well as titanium and other low-conductivity alloys with one instrument. In addition, other scales make it possible to read directly nonconductive coating thickness. Because a direct relationship exists between electrical conductivity and many other material properties and characteristics it is possible with the FC-500 to indirectly determine mechanical properties for many metals in structures. An accessory gate and alarm system permits automatic scanning.

CIRCLE NO. 282

Frequency counter ranges to 200 kHz

Anadex Instruments, Inc., 7833 Haskell Ave., Van Nuys, Calif. Phone: (213) 782-9527.

Called the model-CF-503C frequency counter, it is used for measuring frequency or totalizing the number of input cycles or events. Maximum input sensitivity is 10-mV rms for frequencies from 3 Hz to 200 kHz, which permits direct operation from low-level sine-wave signals. The unit can be used with turbine flowmeters, tachometers, oscillators, and other frequency-generating devices. Gates times of 0.1, 0.6, 1, 6 and 10 seconds are derived from a 60 Hz line frequency. Variable display time is from 0.2 seconds to 6 seconds and hold. Plug-in transistors in the circuit boards offer simplified trouble shooting and maintenance. The counter measures 9 x 6 x 13 in. and four, five or six-decade models are available.

CIRCLE NO. 283

RCA's popular "Under $1" sensitive-gate Triacs are now immediately available in mass production quantities... and what a combination of low-cost and exceptional performance!

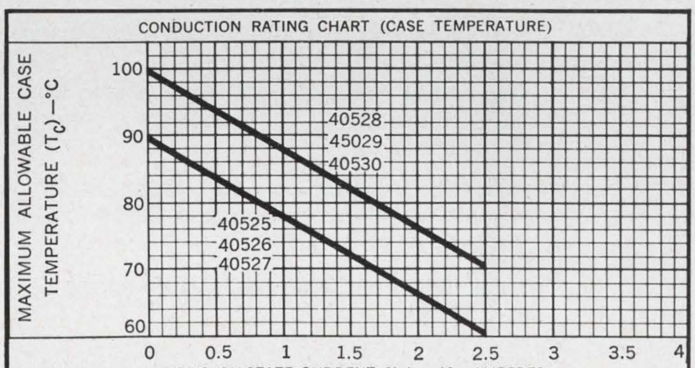
Over a year in the field has demonstrated the unmatched advantages of RCA sensitive-gate Triacs for ac phase control, load switching, and solid-state replacement for relays. And now we're ready for mass production orders. Just check these circuit benefits:

High gate sensitivity—10 mA max. gate current is many times more sensitive than conventional Triacs... and types as low as 3 mA are also available for designs where critical heat-sinking is not an important consideration.

Low current—2.5A (rms) is ideal for many 110V or 220V appliances and motors... plus surge current protection to 25A.

Convenient size—popular TO-5 package combines the advantages of a compact, hermetically sealed metal case with the Triac's inherent ability to perform the full-wave functions of 2 SCR's.

Your RCA Field Representative can give you complete information on RCA's six different versions of sensitive-gate Triacs, including price and delivery. For additional technical data, write RCA Commercial Engineering, Section RG10-2, Harrison, N.J. 07029. See your RCA Distributor for his price and delivery.



I_T(rms)	I_{GT}	Low Voltage (V_{DRM}=100V)	120V Line (V_{DRM}=200V)	240V Line (V_{DRM}=400V)
2.5A	3 mA Max	40525 (0.95*)	40526 (0.98*)	40527 (1.40*)
	10 mA Max	40528 (0.95*)	40529 (0.98*)	40530 (1.40*)

*Prices in quantities of 1,000 and up

RCA Electronic Components and Devices

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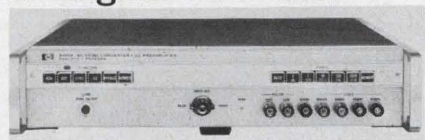
ON READER-SERVICE CARD CIRCLE 248

Sensitive ac/Ω converter for digital voltmeter



Hewlett Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $2075; 30 day.

The instrument converts ac voltage or resistance to a proportional dc voltage for measurement by the digital voltmeter. It thus enables the digital voltmeter to work with dc, ac, and resistive transducers, as well as to make a wide variety of other measurements. It is designed to be used with the model 3460 B digital voltmeter. The converter-preamp produces a dc output proportional to the average value of sine wave inputs over a 50 Hz-100 kHz frequency range. Four voltage ranges are provided from 1 V full scale to 1000 V full scale, and the instrument makes measurements accurately up. Resistance measurements are made in five ranges, from 1000 to 10 MΩ with 20% overranging on all ranges. The unit also functions as a dc preamplifier. The input impedance, on the 0.1-, 1-, and 10-V ranges, is greater than $10^{10}\Omega$ making possible measurements on devices of high source resistance, such as standard cells, with negligible loading error.

CIRCLE NO. 284

CO analyzer sounds the alarm

Mine Safety Appliances Co., Pittsburgh, Pa. Phone: (412) 241-5900

A carbon monoxide analyzer-alarm uses a catalytic oxidation principle for the analysis of carbon monoxide features solid-state circuitry. The model 701 can give visible as well as audible warnings when carbon monoxide in the atmosphere reaches a predetermined point. It can be set to give an alarm for concentrations in the range of 0 to 500 parts per million. A small pump draws a continuous sample through a cell which has active and inactive chemical surrounding two thermistors, which are part of a bridge circuit.

CIRCLE NO. 285

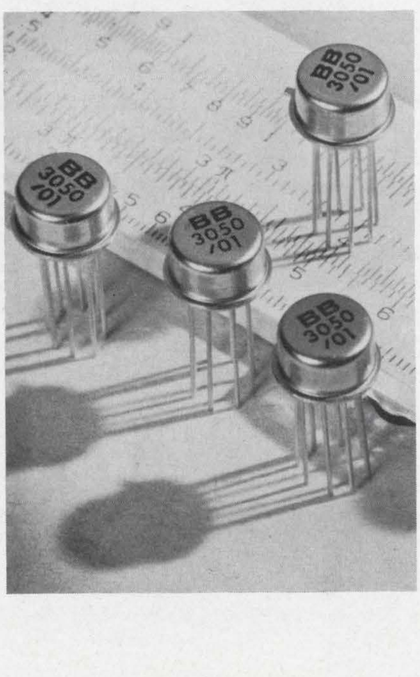
Shorting can't harm operational amplifiers

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. Phone: (602) 294-1431. Price: $8 to $45 in 100 lots.

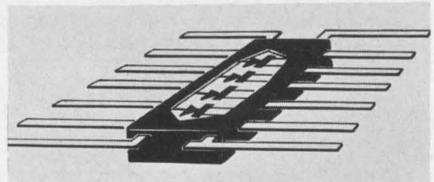
Eight models of integrated-circuit operational amplifiers can be shorted indefinitely to ground without damage, and the input is protected up to the supply voltage. Unity gain stability is assured with any capacitive loading without changing phase compensation or adding a decoupling resistor.

Specifications for the models include selection of input voltage offset drifts from $\pm 5\ \mu V/°C$ to $\pm 30\ \mu V/°C$ maximum, and of maximum offset current drifts from ± 0.2 to ± 0.4 nA/°C. These specifications apply over the full -55 to $+125$°C for the four military temperature range units and from -25 to $+95$°C for commercial amplifiers. The voltage gain is typically 100 dB for all units, and the open loop gains range between 93 and 100 dB. Rated output voltage is ± 10 V on all units. The output current is ± 10 mA for the wide temperature units and ± 5 mA for the commercial amplifiers. Two low-noise units are offered with 3-μV peak and 0.15-nA peak input noise. All units are supplied in a standard TO-99 can (low-profile TO-5). Supply voltages from ± 9 V to ± 18 V may be used.

CIRCLE NO. 286



Four-junction FETs in a flat pack



Siliconix Inc., 1140 W. Evelyn Ave., Sunnyvale, Calif. Phone: (408) 245-1000. P&A: From $20 to $34.80 per 100; stock.

Eight new 4-channel junction FET switches, the G125F-132F, are packaged four to a TO-84 and are designed primarily for switching applications; however they are also useful in amplifiers, voltage-controlled-resistors, and constant-current applications. Maximum pinch-off voltages are 5 and 10 V; maximum ON resistances are 500, 250, 90 and 45 Ω.

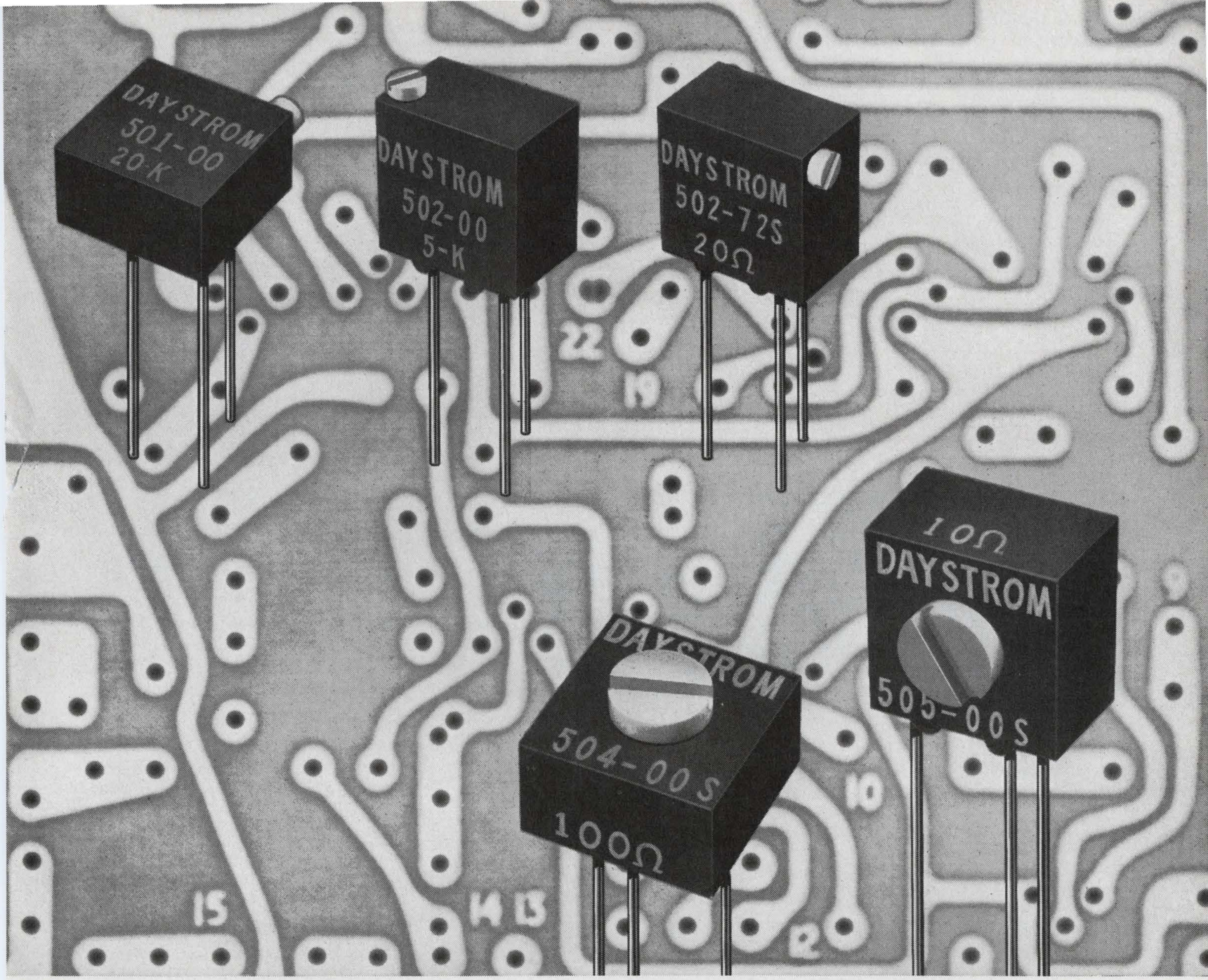
CIRCLE NO. 287

Dc regulators handle 1/2 A

Helipot Div., of Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 871-4848. P&A: $35; stock.

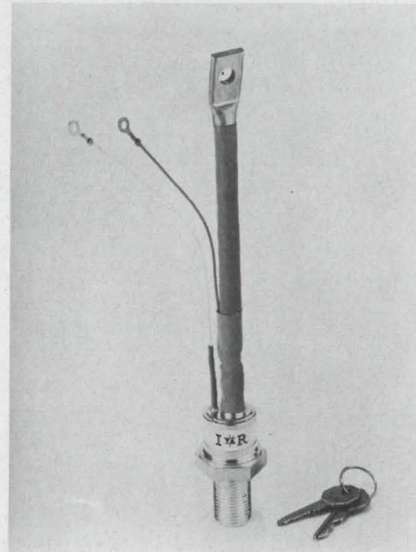
Beckman's model 802 and 804 cermet dc regulators are short-circuit proof and externally adjustable from 9 to 21 V and 20 to 32 V respectively. Both provide output regulation of $\pm 0.05\%$ for line as well as load variations. Units have a load current handling capability of 1/2 A, which can be increased to 5 A with the addition of an external power transistor. Power rating of 1.8 W at 25°C can be increased to 5 W by mounting the unit on a 3 x 3 x 0.125-inch aluminum plate. Operating temperature range is -55°C to 125°C.

CIRCLE NO. 288


DAYSTROM
501-00
20-K
DAYSTROM
502-00
5-K
DAYSTROM
502-72S
20Ω
10Ω
DAYSTROM
505-00S
DAYSTROM
504-00S
100Ω

SEMICONDUCTORS

Epitaxial Triac reaches 200 A



International Rectifier, 9220 Sunset Blvd., Los Angeles. Phone: (213) 678-6281. P&A: $216-$680 ea., samples 10-99.

The "logic" capability allows the selection of the direction the current flows as a function of the gate signal. This power logic-triac offers current rating up to 200 A and rms and peak voltage ratings as high as 1000 V. The 220 kW power handling capacity of the device is twenty times that of comparable electronic range devices now on the market. Applications for these devices are in industrial controls, temperature regulators, motor controls and overload protection, emergency lighting systems, and welding equipment, as well as in inverters and dc-ac converters. In these and other applications where the logic-triac can replace two SCRs connected in antiparallel and in some cases actually accomplish part of the control function within the device itself, the advantages are: a reduction in the number of heat sinks required, the necessity of only one control gate instead of two, a reduction in the complexity of the gating circuits, and self protection against damage by high voltage transients.

Other important features include a transient voltage rating in both directions exceeding the operating voltage rating as well as a guaranteed dv/dt and di/dt rating on all devices.

CIRCLE NO. 289

RG

Metal Glaze resistors offer .02% reliability and low cost

IRC Metal Glaze resistors now offer you a combination of proved reliability and economy that just can't be matched. You can upgrade your circuit designs and still keep the lid on costs.

- RELIABILITY PROVEN DESIGN. A design so conservatively rated that even at *twice rated load,* performance still far exceeds applicable MIL requirements.
- RELIABILITY PROVEN BY TESTS. After more than 4 million unit hours of testing, estimated maximum failure rate is .02%/1000 hours, full load @ 70°C, at 60% confidence. Failure is defined as Δ R > ± 4%.
- RELIABILITY PROVEN IN USE. Millions used in a wide range of applications. No in-circuit failure—*catastrophic or otherwise*—has ever been reported.

Metal Glaze resistors offer other benefits, too: indestructible thick-film resistance element, plated-on copper end cap, high-temperature soldered termination and a smooth, tough molded body that resists solvents, corrosion, and mechanical abuse.

For top resistor performance without any cost penalty, specify IRC Type RG. Write for data, prices, and sample. IRC, Inc., 401 N. Broad St., Phila., Pa. 19108.

CAPSULE SPECIFICATION

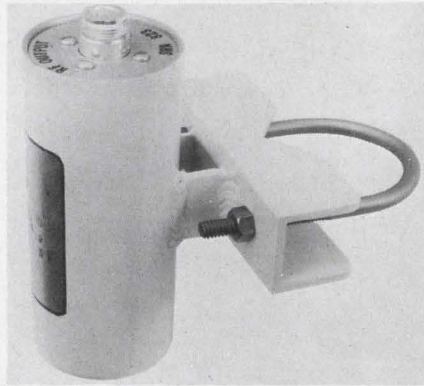
WATTAGE:	¼ W @ 70°C	½ W @ 70°C
RESISTANCE:	51Ω thru 150K	10Ω thru 470K
TOLERANCES:	± 2%, ± 5%	± 2%, ± 5%
TEMP. COEF.	± 200ppm/°C	± 200ppm/°C
IRC TYPE:	RG07	RG20

IRC

ON READER-SERVICE CARD CIRCLE 81

SEMICONDUCTORS

FET preamplifier for antenna mounting



Smyth Research Associates, 3555 Aero Court, San Diego, Calif. Phone: (714) 277-0543.

The SRA-823 preamplifier is a solid-state unit designed for mounting near the antenna feed. The unit is powered by 12-V-dc feed through the transmission-line center conductor. Installation of the preamplifier near the antenna feed eliminates the transmission line as a contributor to system degradation, reducing the system noise figure to very nearly the noise figure of the preamplifier alone. The intermodulation response of this unit provides a wide dynamic range when used in areas of heavy interference. Typical noise figures range from 2.2 dB at 150 MHz to 4 dB at 500 MHz. Nominal gain is 20 dB.

CIRCLE NO. 290

Miniature reed relay has transistor drive

Wheelock Signals, Inc., Long Branch, N. J. Phone: (201) 222-6880.

This design offers high packaging densities, since the reed relay with the transistor driving stage occupies 0.05 cubic in. Typically, 40 two-pole 442SS relays with their built-in driver stages, can be mounted on a 4-1/2 by 5-1/2 in. PC board. Contact for the 442SS series is rated at 7 W. They are available in 1 to 4 pole models.

CIRCLE NO. 291

Attacking industrial counting on all fronts takes unusual counter-intelligence.

We've attacked it with two complete lines of integrated-circuit counting instruments that will take any man's measure.

The new 6200 Series for up to 200 kHz counting. Closed-box design. No cooling fan needed. Drip-tight. Dustproof. Able to stand severe work environments. Compatible with a wide range of input transducers. Available with 1-2-4-8 binary data output for direct feed into printers or tape punchers.

And the unique expandable 6300 Series for low-cost frequency-and-time measuring. Dual sets of plug-in modules tailor your cost to your desired function and frequency. You buy for today's need, expand capability for tomorrow's. 6-7- or 8-digit display with optional 9th.

Any way you figure it, EiD's up front in counter-intelligence.

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EiD more than measures up.

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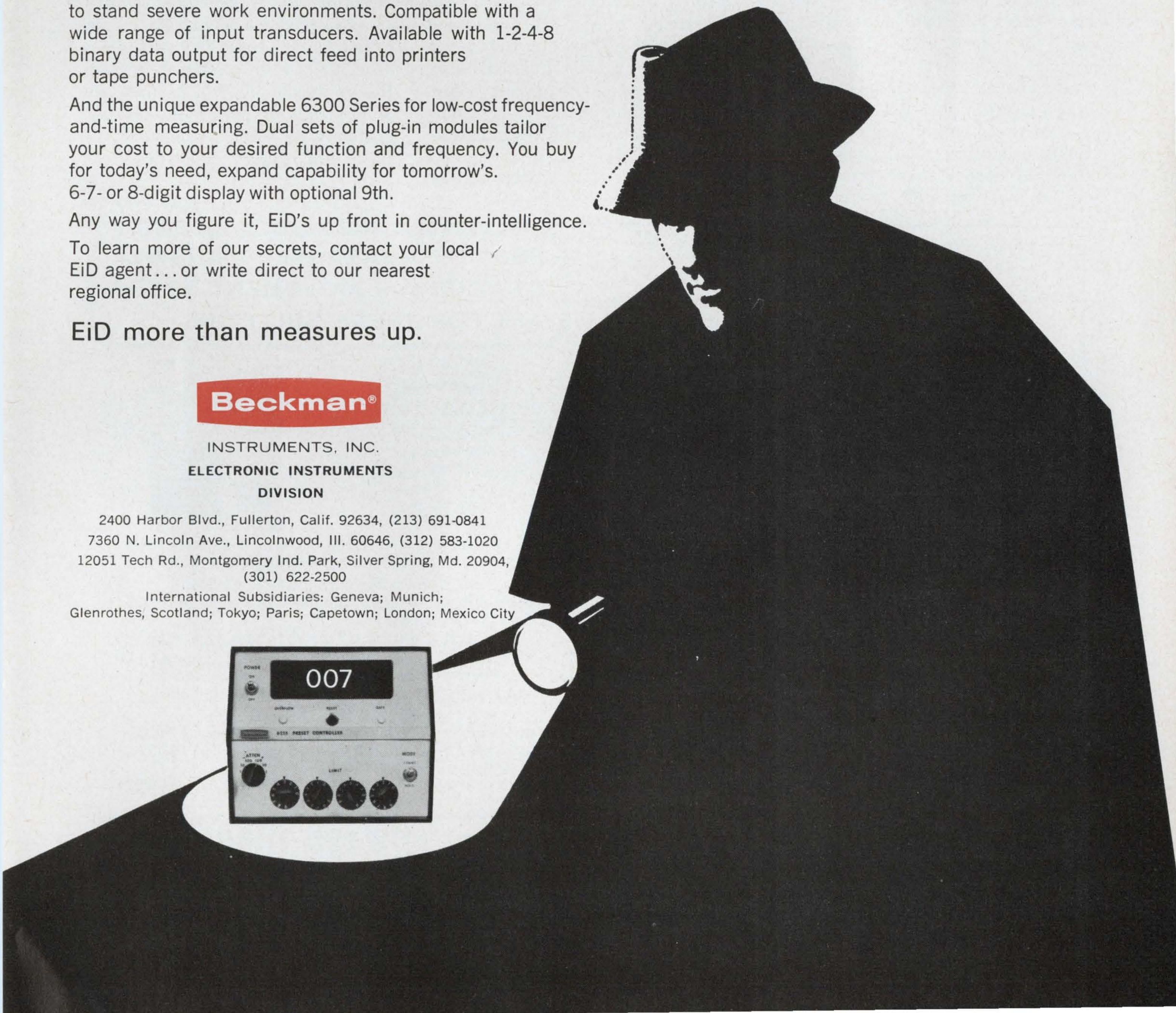
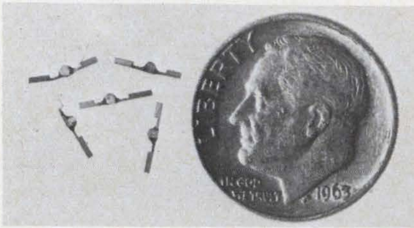


Pellet-diode under one cover

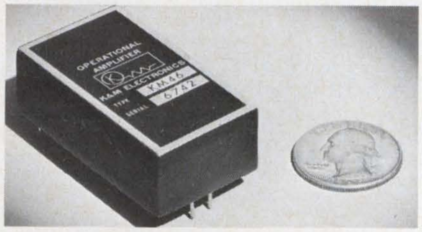


Microsemiconductor Corp. 11250 Playa Court, Culver City, Calif. Phone: (213) 391-8271. Price: 79¢/100 up.

These micro-silicon devices are suited for thin/thick film and printed circuit-board insertion. The units are whiskerless, hermetically sealed and occupy approximately 1/50 of the volume of standard DO-7 packages. Users have options of either a pellet or microdiode in the same package. Pellet and microdiode mechanical sizes are 0.035 in. in diameter x 0.020 in. in height with 0.004 x 0.20 in in. kovar leads. MIL-S-19500 reliability requirements are standard. Device specifications of 4 pF and 4 ns are used.

CIRCLE NO. 292

FET amplifiers are battery operated

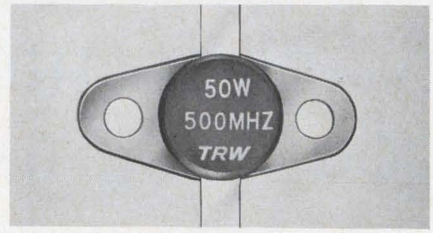


K & M Electronics Corp., 102 Hobart St., Hackensack, N. J. Phone: (201) 343-4518. PA: $55 ea.; stock.

FET operational amplifiers with current drains of less than 1 mA have been designed for applications that require battery power as well as high input impedance (10^{12} Ω), negligible current offset (10 pA), extremely low offset voltage (from 1 μV/°C) and large slewing rate. They are suited for integrators; sample and hold circuitry; isolation amplifiers; low-noise, high-impedance ac amplifiers; and general instrumentation amplifiers.

CIRCLE NO. 293

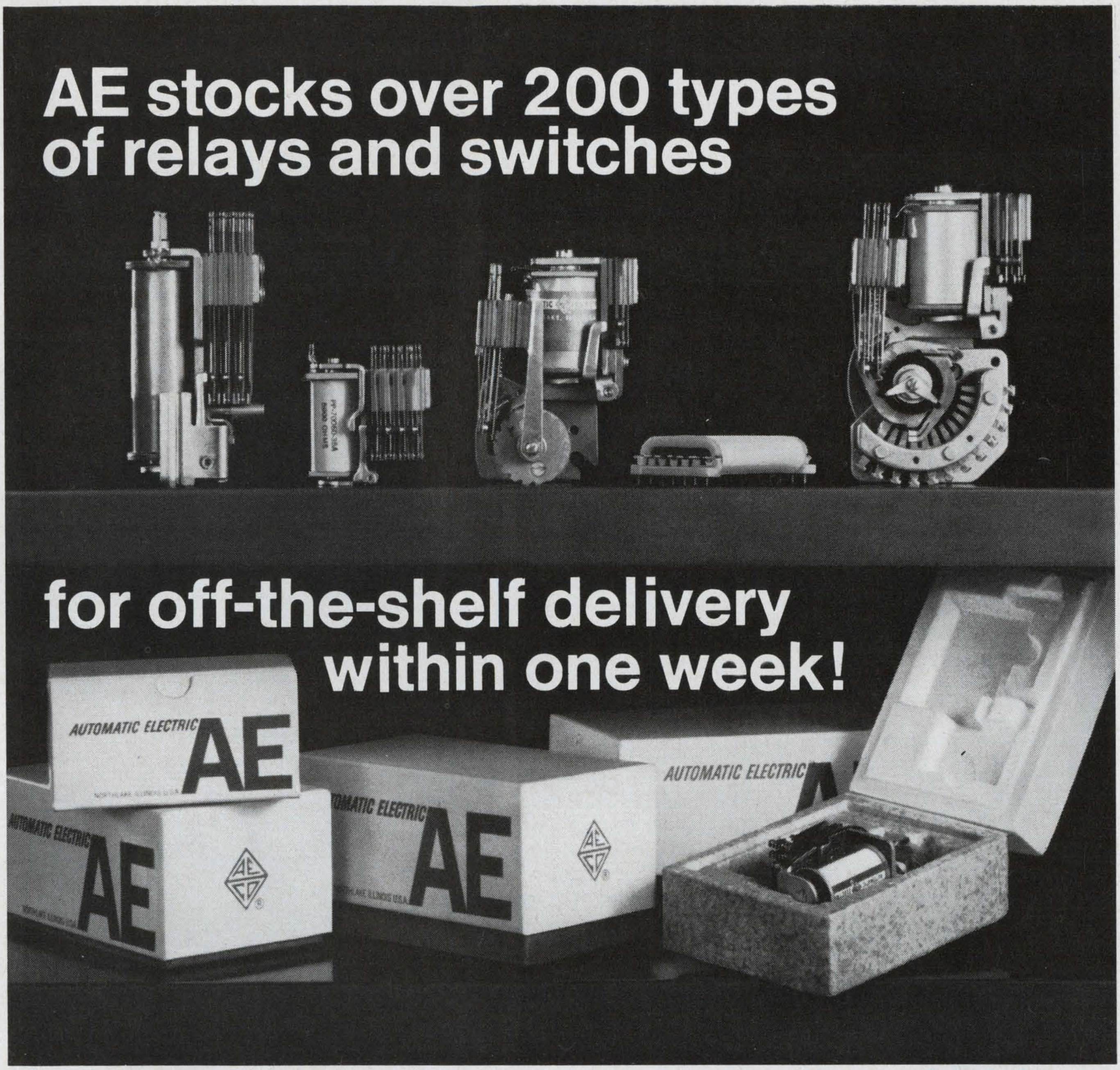
Transistors show 50 V at 500 MHz



TRW Inc., 1100 Glendon Ave., Los Angeles. Phone: (213) 477-6061. P&A: $71 to $142 eg; one month.

This high-power communications transistor is capable of producing 50-V-rf output at 500 MHz from a 28-V source. Designated as the type 2N5178, this device employs a patented interdigitated cellular construction in a grounded emitter stripline package comparable in size to the TO-37. A 25-W version, type 2N5177, is also available. In addition to its application as final amplifiers in high-power uhf military transmitters, the transistors are suited for use in radar-pulse circuits.

CIRCLE NO. 294



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This program keeps growing. Now, we stock over 200 kinds of relays, switches, and accessories. In large enough quantities to fill your normal prototype requirements within 7 days.

That means fast delivery on many of the most popular types from AE's broad line. EIN (integral socket) relays with power contacts; mercury-wetted-contact relays; PC Correeds; rotary stepping switches with gold levels for dry- and low-level circuits; ERM (magnetic latching) relays; Class E relays with four different wire termination methods; and many more.

Send for a free copy of Circular 1053, our newest "Stock Letter." It's the latest listing of items you can get quickly. Just write to the Director, Relay Control Equipment Sales, Automatic Electric, Northlake, Illinois 60164.

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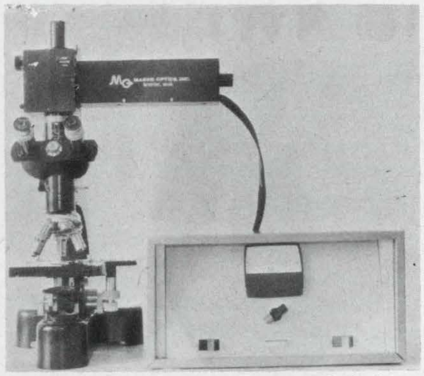
ON READER-SERVICE CARD CIRCLE 86

Microscope laser with 100% reflection



Maser Optics, Inc., 89 Brighton Ave., Boston, Mass. Phone: (617) 254-7880.

The model M-L microscope laser is designed to fit most microscopes adapted to photo-micrography. This unit fits into the camera port, yet allows the camera to be fitted into the new port directly over it so as not to lose the ability to photograph through the unit. It utilizes a dichroic mirror that will transmit all wave-lengths excepting 6943Å which are reflected 100%. It also utilizes the microscope objective for focusing the laser beam on a small spot, in order to increase laser-energy density. Because light coming from a point on a focused image is nearly parallel in the microscope tube, the laser beam works in reverse and its image plane will very nearly coincide with the object plane. The energy density on target of 1-micron hole coming through a 0.004 in. hole and a 60-x lens is in the order of 10,000 joules per sq. centimeter.

CIRCLE NO. 295

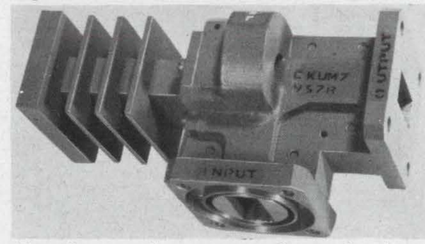
Beacon transmitter on 6 to 6.3 GHz

Microwave Associates, Burlington, Mass. Phone: (617) 272-3000.

This all solid-state, fixed, tuned, C-band rf generator is crystal controlled, providing frequency stability in extreme environmental conditions up to an altitude of 70,000 feet. It operates within the 6 to 6.3 GHz frequency range with a minimum power output of 1 W. The transmitter has been designed for high-performance aircraft and ground-based beacon applications.

CIRCLE NO. 296

Junction circulator spans 16.6 to 17.1 GHz

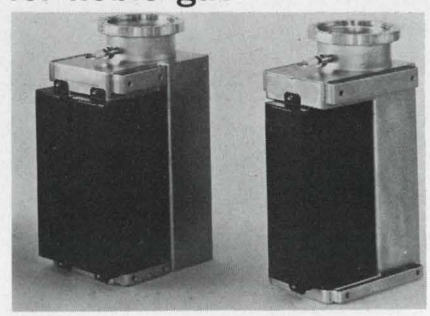


Raytheon Co., 130 Second Ave., Waltham, Mass. Phone: (617) 646-7648.

This waveguide-junction circulator is designed to operate at a peak power of 50 kW and at a frequency of 16.6 to 17.1 GHz. Designed model CKuM7, the high-power circulator will operate at an average power of 50 W. The unit weighs 5 oz and achieves a minimum isolation of 12 dB and a maximum insertion loss of 0.4 dB. Maximum VSWR is 1.20. Cooling is not required.

CIRCLE NO. 297

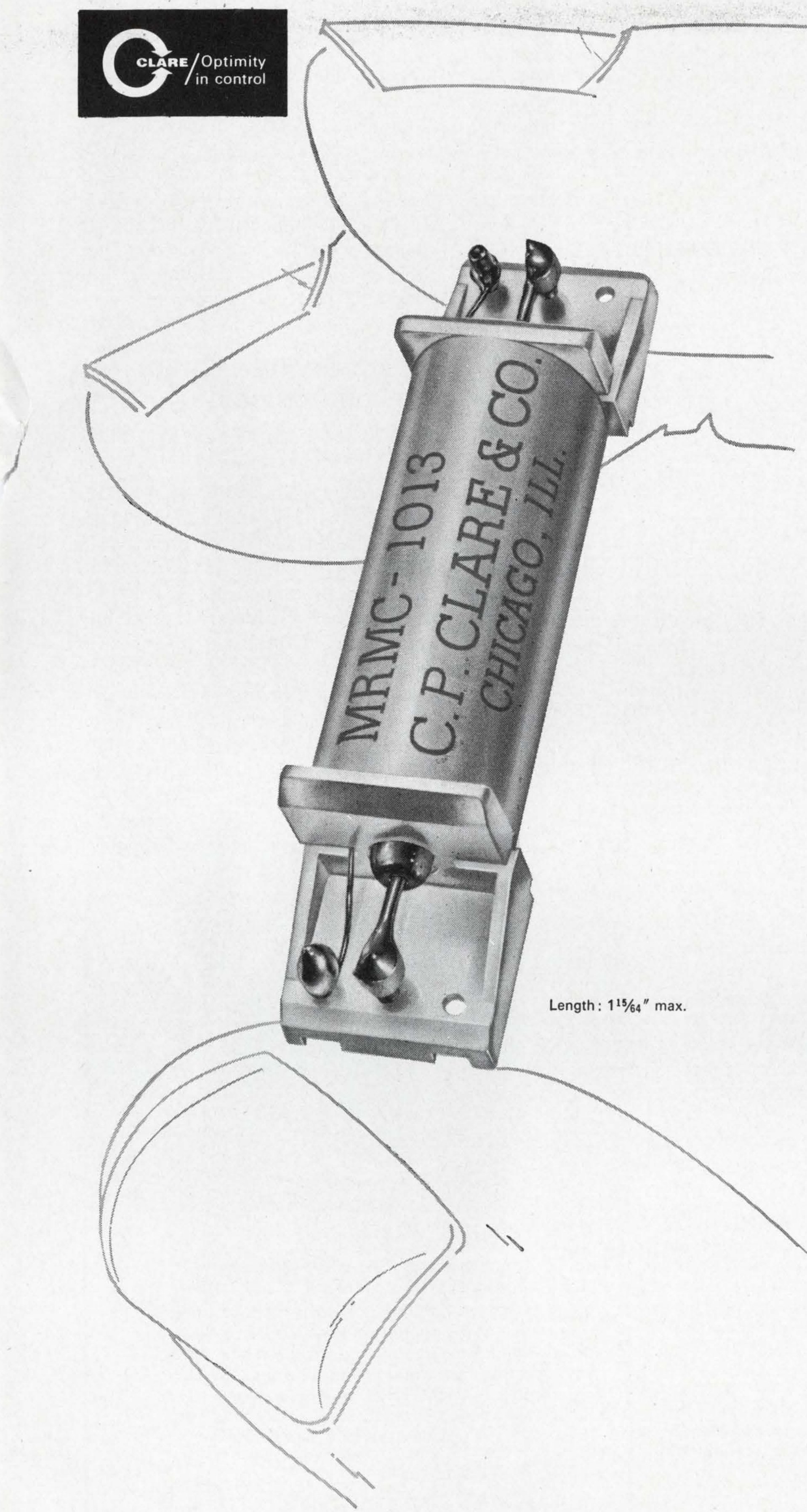
Varian pumps for noble gas



Varian, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

These pumps have elements that handle noble as well as active gases with speed and stability. Even with pure argon, the pumps ensure complete pumping stability below $1x10^{-5}$ Torr. These units come in three sizes, 140, 270, and 500 liter per second. They pump argon at 21%, and helium at 30%, of their respective speeds for air. An oil-free device, it functions electronically, chiefly on the principles of gettering of active gases by titanium sputtering, and permanent pumping of noble gases by ion burial on the pump wall. The units are for use with large space-simulation chambers, mass spectrometers, and physics experiments involving noble gases.

CIRCLE NO. 298



Length: $1\frac{15}{64}$" max.

try this for size...

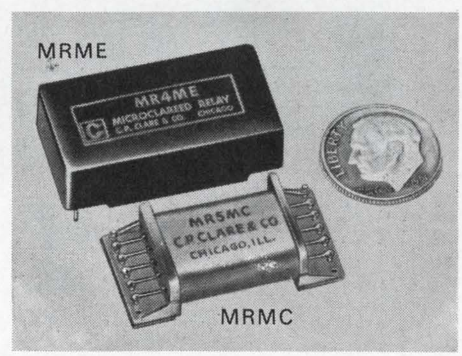
there's no doubt about performance!

Sized right for high density pcb switching—as small as .145 cu. in.—the MicroClareed MR Relay adds a new dimension to Clare Sealed Contact Reed Relay capabilities. Design around 1 to 5 contacts in epoxy sealed and open coil modules—take advantage of all of the inherent reliability and performance achievements of CLAREED Relays in only 1/5th the size.

Super-clean in construction, the 100% operation-tested, glass-encapsulated contacts never need maintenance or adjustment. Fast . . . with switching speeds in the low millisecond range. On the job, insensitivity to electrical transients . . . and complete input/output isolation . . . provide high reliability with maximum circuit simplicity.

For complete design information, circle reader service number—or ask Clare for Data Sheet 961 . . . Write Group 10A9.

C. P. Clare & Co., Chicago, Illinois 60645



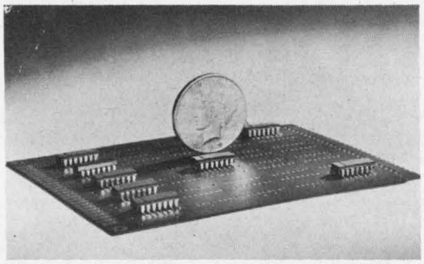
- Inherent reliability with no maintenance (Contacts sealed in glass)
- Switching times 0.5 to 2 ms
- Insensitive to transient electrical / electronic noises
- Contact load versatility—low level to 10 va
- Life:
  .125 amp., 28 v: 10 x 10^6 operations
  low level: 100 x 10^6 operations
- 1 to 5 contacts per module—open coil or molded epoxy modules

MICROCLAREED SEALED-CONTACT REED RELAYS

for industrial control, data logging and instrumentation, communication switching, ground control, checkout systems

ON READER-SERVICE CARD CIRCLE 88

Wiring board in multilayer form

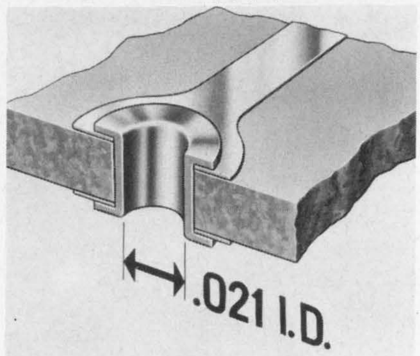


Intellux, Inc., 26 Coromar Dr., Santa Barbara Industrial Pk, Goleta, Calif. Phone: (805) 968-3541. Price: $1 per sq. in.

Multilayer printed wiring boards are designed for high volume printed wiring-board applications requiring speed, economy and quality in manufacturing, processing and repair. This solid post technique allows dual in-line ICs to be automatically positioned and surface mounted to pads on the top surface of the board. Holes may be drilled through the solid posts where automatic insertions of modules is required. Engineered for applications in which there would be a requirement for a ground layer, voltage layer and two signal layers. Inexpensive production techniques recommended by the manufacturer include the use of programed or hot gas soldering methods allowing module leads to be attached to the surface pads.

CIRCLE NO. 299

Board connectors of annealed copper



Mark Eyelet & Stamping Inc., 63 Wakelee Rd., Wolcott, Conn. Phone: (203) 756-8847.

Flat flange eyelets with consistent diameters and graduating lengths are suitable for various thicknesses of printed circuit boards. Tolerances are held on the 0.03-in. barrel OD and 0.021-in. barrel ID while increasing lengths from 0.048 to 0.165 in. under the flange. They have a standard 0.046-in. flange diameter which can be spaced on 100-mil centers for IC packages. These eyelets are manufactured from oxygen-free, high-conductivity copper to federal specification QQ-C-576. They can be supplied with any of the standard plating finishes.

CIRCLE NO. 311

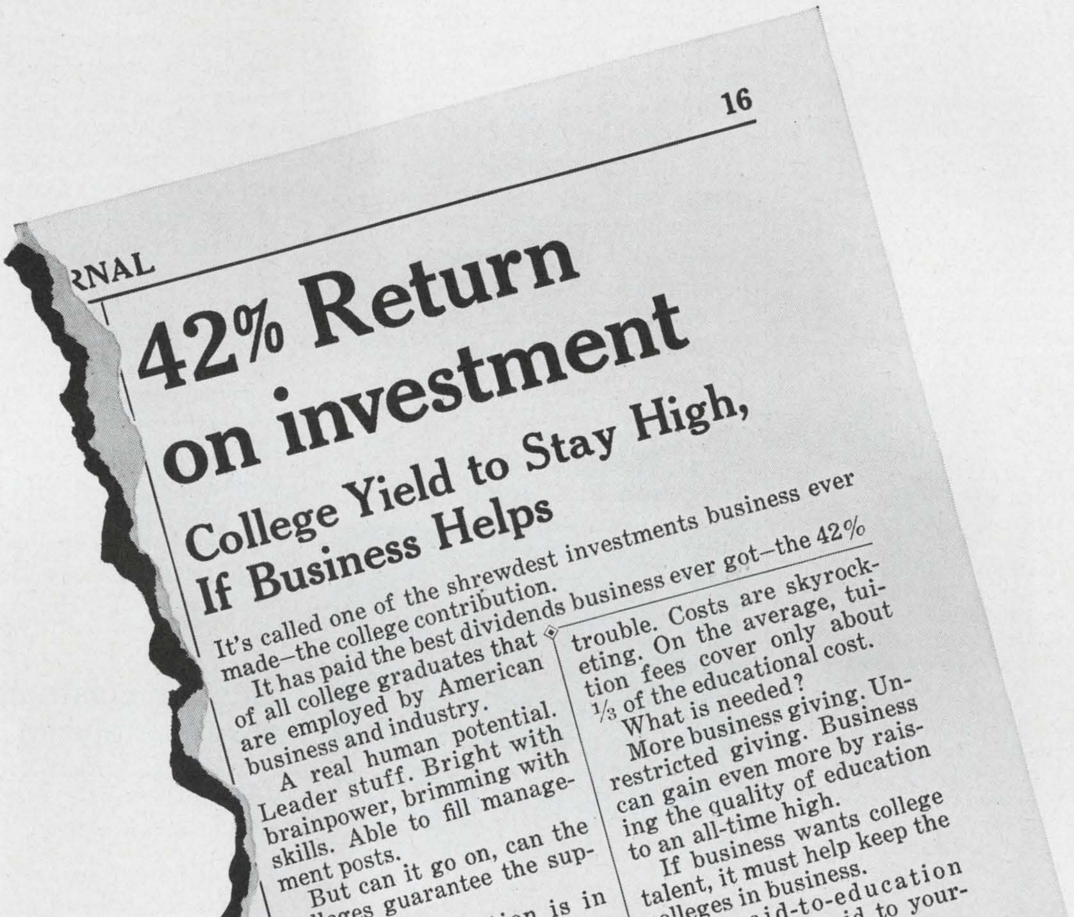
Quick-drying cement for joining vinyl

Quelcor, Box 33, Media, Pa. Phone: (215) 544-7710.

Designed specifically for vinyl-to-vinyl cementing applications Quelseal provides high shear lap strength and dries in minutes to provide a permanent liquid and air-tight joint. Formulated especially for aerosol dispensing, it comes in 16-oz spray cans. It is clear; where color is required for color coding or marking or where metal brackets, clamps, hardware are to be coated, use the self-adhering vinyl.

CIRCLE NO. 312

Blue chip.



16

RNAL

42% Return on investment

College Yield to Stay High, If Business Helps

It's called one of the shrewdest investments business ever made—the college contribution.

It has paid the best dividends business ever got—the 42% of all college graduates that are employed by American business and industry.

A real human potential. Leader stuff. Bright with brainpower, brimming with skills. Able to fill management posts.

But can it go on, can the colleges guarantee the supply?

Higher education is in trouble. Costs are skyrocketing. On the average, tuition fees cover only about $1/3$ of the educational cost.

What is needed?

More business giving. Unrestricted giving. Business can gain even more by raising the quality of education to an all-time high.

If business wants college talent, it must help keep the colleges in business.

Your aid-to-education program is an aid to yourself.

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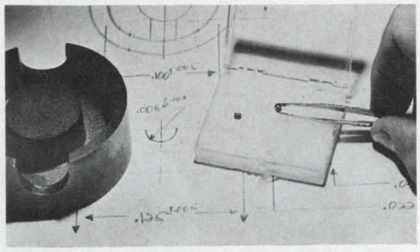
Write for: **"THE RATIONALE OF CORPORATE GIVING,"** Box 36, Times Square Station, New York, N. Y. 10036.

MATERIALS

Cup core for IC's



Indiana General Corp., Keasbey, N. J. Phone: (201) 826-5100.

Offered is a cup core with an OD of 0.125 in. ground to a 0.035 in. thickness. Main applications are in portable and vehicular communications equipment where size reduction is a prime concern. Its small size allows it to be used in ICs of frequency synthesizers and i-f sections such as radio frequency chokes and transformers. The core material is ferrite because of its good frequency response in the 10 to 65 MHz range and its flat temperature coefficient range is from −55 to +125°C.

CIRCLE NO. 313

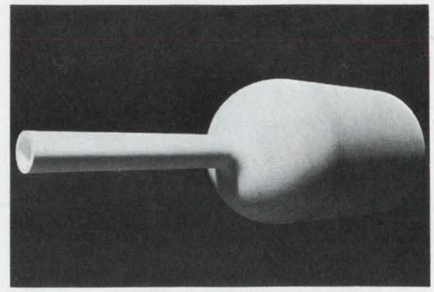
Impregnant resin has low viscosity

Emerson & Cuming, Inc., Canton, Mass. Phone: (617) 828-3300. P&A: 90¢ to $1.00 per lb.

Stycast 3050 T is a low viscosity resin system, which is useful for impregnation and encapsulation in one operation. Thus, coils, transformers, motor windings, etc. can be cast in resin without a previous impregnation and cure. Because of low viscosity in many applications, void free castings can be obtained without the use of vacuum processing. The resin may be cured at room temperature with catalyst 9 or at an elevated temperature with catalyst 11.

CIRCLE NO. 314

High-purity mullite solves laser problem



McDaniel Refractory Porcelain Co., Dept. S., Beaver Falls, Pa. Phone: (412) 843-8300.

High temperatures to 2600°F are needed to melt the high-barium crown glass used in the rods. Before PMV 31, crucibles failed under thermal stress or contaminated the glass with stones and trace impurities of iron. Minute stones in laser rods may cause explosions when the rods are energized, and trace impurities of iron can impair the transmitting capabilities of the rod. These problems are eliminated through use of PMV 31. While this substance is now being used exclusively for crucibles and rods for laser-glass production, its high purity, together with its thermal shock resistance offer applications when these properties are the critical requirements.

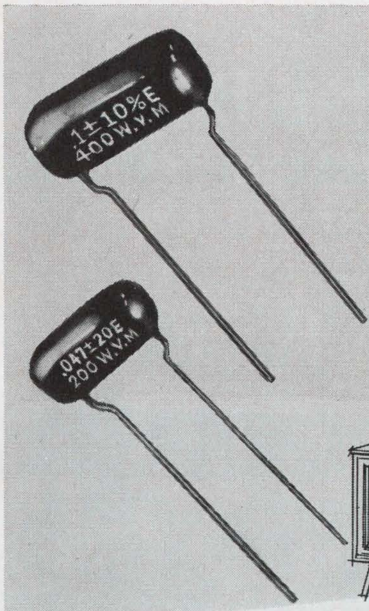
CIRCLE NO. 315

Silicone elastomer is self-catalyzed

Transene Co., Inc., Route 1, Rowley, Mass. Phone: (617) 948-2501. P&A: $4. up; stock.

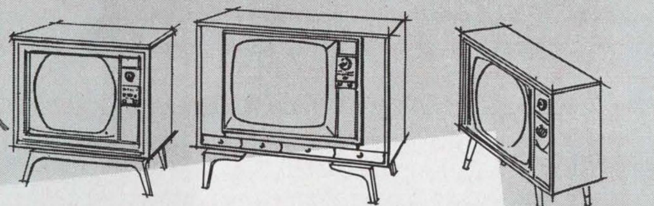
A self-catalyzed silicone elastomer can be used as a protective coating and encapsulant for semiconductor devices and for potting sensitive electronic components. It is designed to stabilize semiconductor surfaces and p-n junctions. Available in a pre-polymerized state, ready for application, it cures by heating without the addition of a catalyst. The cured product is a white, resilient, dielectric material that is heat stable and waterproof. Cured SSE exhibits flexibility at −75°C. Heat resistant up to 300°C, it has a bulk resistivity of $5 \times 10^{14}\Omega$ and a dielectric strength of 550 V/mil.

CIRCLE NO. 316



Proof Positive of High Reliability of EL-MENCO **MYLAR-PAPER DIPPED* Capacitors

OVER 330,000,000 OF THESE HIGH QUALITY UNITS USED IN TV SETS SINCE 1959!



The number of EL-MENCO capacitors in TV sets is truly amazing. This figure of 330,000,000 represents more than the total population of the following countries:

United States and Possessions
United Kingdom and Canada
Argentina Belgium
Denmark Ecuador Chile

299,813,929 people (1960 Census)

Even with this tremendous mass production the quality of EL-MENCO capacitors has not suffered. Here's a fine tribute of the high reliability of EL-MENCO capacitors from a leading TV manufacturer:

"... I am certain that you are aware of the enthusiasm our Engineering and Quality people have displayed for this unit, for to us it represents the virtual elimination of capacitor field problems in the future ..."

Write dept. AE for descriptive bulletin #MPD

Imagine! Over 330 million EL-MENCO Mylar Paper Dipped Capacitors have been used in black and white and in color TV sets since 1959! These capacitors of the highest quality and reliability help bring programs to millions of people who have invested in TV sets ... and 330 million is just a drop in the bucket! For the demand for EL-MENCO capacitors still far exceeds the supply!*

El-Menco Capacitors

DIPPED MICA
MOLDED MICA
SILVERED MICA FILMS
MICA TRIMMERS & PADDERS
MYLAR PAPER DIPPED*
PAPER DIPPED
MYLAR DIPPED*
TUBULAR PAPER

*Registered Trade Mark of DuPont Co.

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WILLIMANTIC, CONNECTICUT

Exclusive Supplier to Jobbers and Distributors in the U. S. and Canada
ARCO ELECTRONICS, INC., COMMUNITY DRIVE, GREAT NECK, L. I. NEW YORK

West Coast Manufacturers Contact:
COLLINS & HYDE CO., 1020 CORPORATION WAY, PALO ALTO, CALIFORNIA
5380 WHITTIER BOULEVARD, LOS ANGELES, CALIFORNIA

ON READER-SERVICE CARD CIRCLE 93

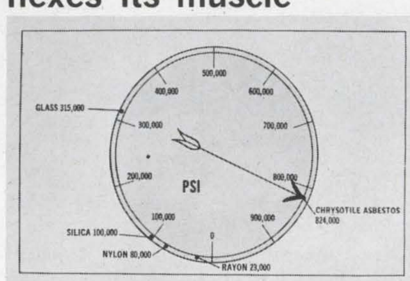
High temperature paints work to 4400°F

Industrial Infra-Red, Inc., 157 Dayton Way, Sharon, Pa. Phone: (412) 342-8457.

These paints produce an extremely hard, abrasion-resistant surface of very low porosity. All paints are water base and are spray-applied like regular paints with the same basic metal preparation normally required. Designed for use on a variety of substrates, they find their use on almost any application, from low-temperature corrosion to high-temperature oxidation protection. They have a maximum temperature range from 2000°F on metals to 4400°F on refractory linings. The natural high emissivity of these paints produces significant fuel savings and dust elimination, when used on refractory linings as in boilers, furnaces and ovens.

CIRCLE NO. 317

Asbestos fiber flexes its muscle

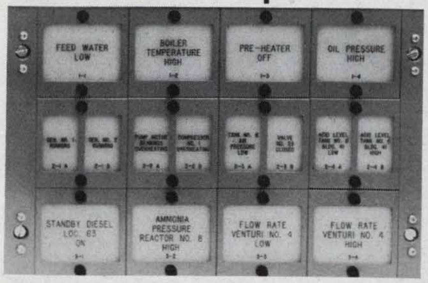


Raybestos-Manhattan, Inc., Manheim, Pa. Phone: (717) 665-2211.

Laboratory and simulated field tests show that the tensile strength of the asbestos fibers as compared to the strength of such other fibers as glass, silica, nylon and rayon, is far superior. Its strength is at least twice that of glass and almost eight times that of nylon. Reinforced asbestos provides low thermal conductivity and diffusity, uniform ablation, excellent dimensional stability and high resistance to thermal shock. The fineness of the asbestos fibers also permits a dense structure with maximum surface area for resin adhesion. Pyrotex is a composite material, available as asbestos-reinforced felts, tapes, mats and molding compounds.

CIRCLE NO. 318

Solid-state alarms offer custom options

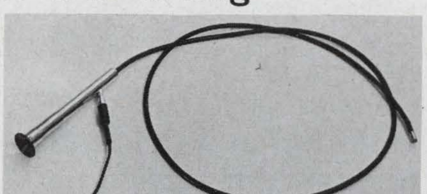


Deltron, Inc., Wissahickon Ave., North Wales, Pa. Phone: (215) 699-9261. Price: $40 per point.

Alarms featuring ICs and silicon-controlled rectifiers offer solid-state reliability. All sequences including first out and ringback types are available and all units provide transformer-isolated alarm contact and lamp circuits for protection against shock. Inputs are diode-protected and filtered against transients and surges. Contact options are easily changed by a linkage system eliminating slide switches.

CIRCLE NO. 319

Optical Fiberscope to 12.5 ft long

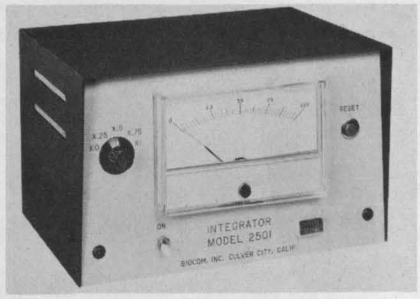


American Optical Co., Southbridge, Mass. Phone: (617) 764-3211.

Areas into which entry is only possible through extremely small openings can be inspected with the optical FS-21 Fiberscope. This flexible unit is specially designed for remote viewing of locations inaccessible to either large or rigid devices. The unit can pass through openings of 1/4 in. and relay visual information. The scope is made in lengths up to 12-1/2 feet, and can negotiate narrow passages with a band radius of as little as 3/4 in. In a unit as small as the FS-21, there are more than 40,000 individual fiber-optics elements. As a result, the device has a resolving capability of 45 lines per mm. A small lamp supplies light to the halo.

CIRCLE NO. 320

Integrator converts biological data



Biocom Inc., 5883 Blackwelder St., Culver City, Calif. Phone: (213) 839-2581. P&A: $450; 30 days.

The model-2501 integrator is used to reduce physiological and biological data which is not readily handled in its raw form. It may be used to yield volume from a respiratory flow meter, fluid-dynamics studies, physiological studies (patient activity, voice studies of intensity of amount of speech, etc.). This instrument does this continuously, automatically and accurately. It may be tied into any existing recorder or data-acquisition system such as Grass, Cambridge, Sanborn or Beckman. Data such as patient activity or conversation may be tape recorded in the field and brought back to the laboratory for subsequent reduction and analysis.

CIRCLE NO. 321

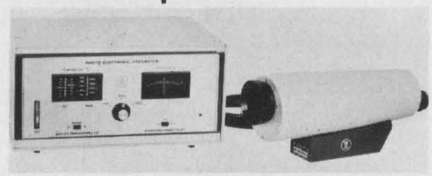
Photo sensor cycles at 40 Hz

Durant Manufacturing Co., 693 N. Cass St., Milwaukee. (414) 271-9300.

The photocell assembly consists of a pick-up control, cable pre-wired to the count input connector, and three sizes of reflectors (3-3/8 x 1-1/4 x 1/2 in). It has the capability to count light weight and fragile items as well as large bulky pieces. Typical applications are in production control, processing, packaging and assembly procedures for glass, paper and wood products. The sensor will respond to a 1/16 in. square beam of light projected onto the lens. It can be adjusted or adapted to reduce sensitivity to ambient lighting and undesired reflections. It is totally insensitive to fluorescent lighting.

CIRCLE NO. 322

Pyrometer has 5 ms response



Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. Phone: (203) 348-5381. P&A: $4950; 60 days.

A fast-responding, photoelectronic pyrometer is for direct temperature measurement of remote targets in the 700 to 3000°C range. This instrument provides non-contact measurement of "true" target temperature. Its sensitivity is 1° C at all temperatures, and reaches 0.1°C at 1000° C. Temperature readout is direct in two expanded scales—700 to 1500° C, and 1400 to 3000° C. Response time is 5 ms. The model EP-1 is capable of reducing the effect of unexpected emissivity changes that are often encountered in transient measurements by operating in either one of two selectable narrow wavelength regions. In the low range, operation is centered at 0.62 micron. The high-range wavelength region is centered at 0.37 micron. Input power is 110/220 V, 50-400 Hz and 30 W.

CIRCLE NO. 323

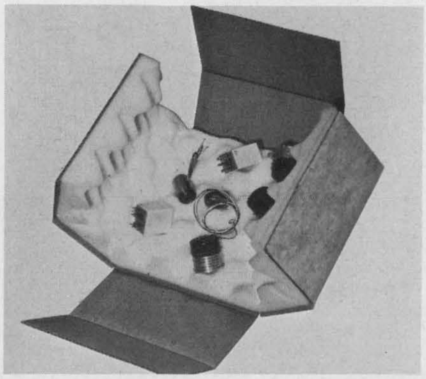
Differential amplifiers for instrumentation

Astrodata, Inc., 240 E. Palais Rd., Anaheim Calif. Phone: (714) 772-1000.

The basic amplifier is a chopperless, direct-coupled, differential unit for either single- or dual-output operation. The single-output model delivers a wideband signal of ±10 V at 100 mA for galvanometers and the dual-output model provides both the 100-mA output and ±10 V at 5 mA selectable bandwidth output for multiplexers, VCO's analog-to-digital converters, etc. Bandwidth of the dual-output model is controlled by a three-pole, linear-phase, 10-position, selectable filter. Ten fixed gain ranges from 1 to 1000 with a 2.5 times vernier are offered. Settling time to 0.02% accuracy is 150 ms; overload recovery accuracy is 0.1% in 300 ms.

CIRCLE NO. 324

Shipping container suspends parts in foam

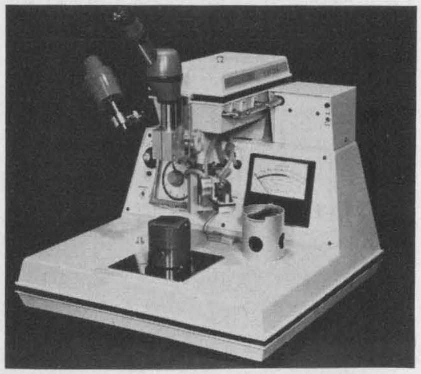


Federal Paper Co., 4200 Olson H'wy., Minneapolis. Phone: (612) 522-6644.

Fold-Pac is made of boxboard. It has corner protectors and a non-slip double bottom and is lined with urethane foam that is convuluted into cone-shaped fingers which yield and envelop items placed inside. The products are placed on the foam and the box is folded shut and then sealed with one strip of type. The packaging is available in dimensions from 3-1/2 x 3 x 2 in. to 15 x 12 x 3 in.

CIRCLE NO. 325

Die bonder handles to 400 per hour



Unitek Corp., 950 Royal Oaks Dr., Monrovia, Calif. Phone: (213) 359-8361.

Adaptable for glass, glass eutectic, and eutectic bonding, this unit is capable of handling flat packs, header mounts, and a wide variety of current specialty packages. Using automatic vacuum pickup and attach cycle, the bonder is alignable without side adjustments. Repeatable and stable placement characteristics (=0.001″ in both axes present) give numerous automatic programming possibilities. Heater cavities and pickup-arm assembly rods interchange to accept virtually all current package styles. Produced to customer specifications on lead frame, substrate, and chip characteristics, the unit measures 17 x 18 x 18 in.

CIRCLE NO. 326

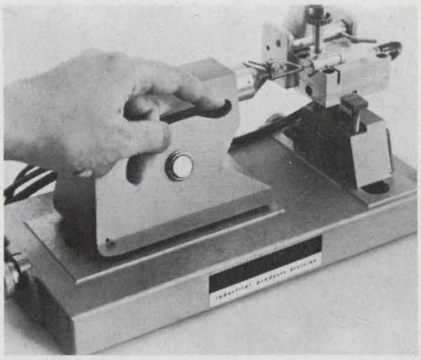
Digital blender mixes and matches

Foxboro Co., Foxboro, Mass. Phone: (617) 543-8750.

The model 99C blender is available in two configurations: to ratio one flow to the other or to ratio one flow to the total flow. Typical applications of the unit include blending heavy crude and cutter stock to produce a specified viscosity; blending gasoline of two octane values to produce an intermediate octane; feed dilution into chemical reactors; and diluting syrup in food processing. The new instrument will accept high-frequency turbine-meter inputs or low-frequency meter inputs. Equipped with memory capability, it produces a 10-50 mA signal to control the ratioed flow.

CIRCLE NO. 327

Arc-welding system fine for bench-top use



Sippican Corp., Barstow St., Mattapoisett, Mass. Phone: (617) 758-6905.

This unit, model 720, has an automatic gap-setting mechanism that permits an operator to make up to six times as many welds per minute as was possible with previous equipment. Once a weld schedule has been developed, the materials to be joined only have to be placed in the fixture and the firing switch activated. No other timing or alignment adjustments are necessary. The fixture is compatible for use with the model-520 pulse arc power supply. Many production-line accessories and special-purpose tools are available for butt welding and other modes of arc-percussion joining.

CIRCLE NO. 328

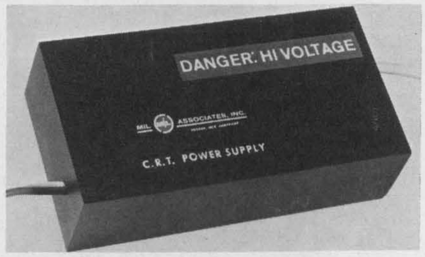
Timer/counter accepts 30,000 counts

E. W. Bliss Co., 736 Federal St., Davenport, Iowa. Phone: (319) 324-1361.

This combination timer and counter is of solid-state construction and can accept up to 30,000 counts per second. The count speed of this unit, designated the CT 101, approaches that of laboratory instruments. By flipping an integral mode switch this new instrument is easily converted from a counter to a timer. Precise intervals from 10 μ to 9.99 seconds in 10 μ increments, can then be timed. Reset time is 8 ms (max.) and accuracy is $\pm$0.01 s or 0.5%, whichever is greater. The CT 101 measures 7 x 3-1/2 x 6-1/2 in. A 3-1/2-in.-sq bezel shows on panel front and the weight is 4 lbs.

CIRCLE NO. 329

Supply 28 V in, get 20,000 out



MIL Associates, Inc., Dracut Rd., Hudson, New Hampshire. Phone: (603) 889-6671. P&A: $350 to $390; 30 days.

A complete encapsulated power supply, designed specifically for use with cathode-ray tube displays, provides up to 20,000-V-dc output with a 28-V-dc input. The 15 cubic in. power supply weighs less than 16 oz. and is supplied with insulated leads. Output ripple of all models is less than 100 V and each provides an isolated output. Packaged to meet appropriate specifications for military airborne equipment, models in the series may be operated within an ambient temperature range from 55 to +71°C.

CIRCLE NO. 330

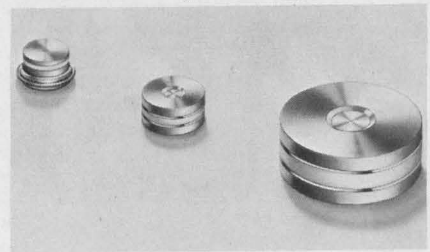
Power supply ranges to 1000 V

Arnold Magnetics Corp., Los Angeles, Calif. Phone: (213) 837-5313. P&A: $295; 3 to 8 wks.

Multiple output power supplies for digital computers, cathode-ray tubes and solid-state circuitry are available with up to six individual specified outputs. These static converters are rated up to 1000-V dc. Outputs are floating and as low as 10 pF to ground. Input is 26 - 30 V dc. Line regulation is 0.06% per V. The units meet MIL-E-5272C and the case size is 21 cu in.

CIRCLE NO. 331

Power rectifiers in button packages



Electronic Devices, Inc., 21 Gray Oaks Ave., Yonkers, N. Y. Phone: (914) 965-4400.

Three series of flexible, fast recovery silicon reactifiers in flat button form are the TR, RU and RD. They have ratings of 20, 40 and 200 A. Both the TR and RU series have 500-ns recovery times. RD units offer a 700-ns recovery time when measured from 1-A forward current to 30-V blocking. All rectifiers can be supplied singly or in stack combinations. Featuring ratings from 50 to 1000 V, the new power rectifiers are best suited for inverters, alternators, motor controls and other higher input frequency or pulse devices.

CIRCLE NO. 332

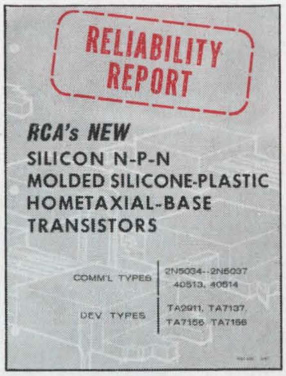
Single-turn encoder with 13-bit accuracy

Litton Industries, 9370 Santa Monica Blvd., Beverly Hills, Calif. Phone: (213) 273-7500.

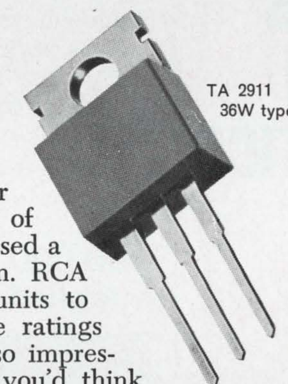
Consisting of a size 11 self-decoding pin-contact encoder and a 32:1 speed increaser this unit provides 13-bit accuracy and resolution in a single turn. During MIL tests the encoder was subjected to temperatures of 120°C together with the shock and vibration experienced in the vicinity of the exhaust of a jet aircraft.

CIRCLE NO. 333

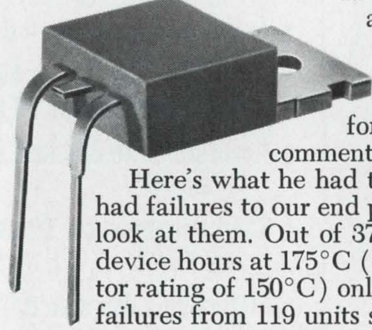
The "non-plastic" plastic transistors



So reliable you'd think they were hermetic



TA 2911
36W type for printed-circuit boards



TA 7155
36W type for TO-66 sockets

We're big enough to realize that with any plastic transistor, you're bound to have questions concerning reliability.

So...long before RCA announced this family of "Hometaxial-Base" silicon power plastic devices (10 transistors with ratings of 36W or 83W), our reliability engineers devised a most rigorous new-product testing program. RCA subjected hundreds of units to stresses beyond device ratings and the results are so impressive that, frankly, you'd think the transistors were hermetic.

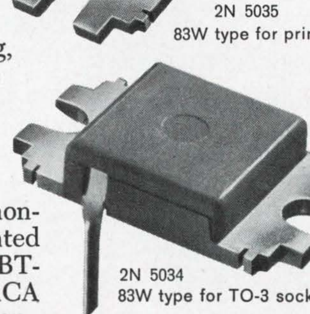
We thought it would be appropriate for you to see our reliability manager's comment on the tests to date.

Here's what he had to say: "...sure we've had failures to our end points. But take a close look at them. Out of 376 units totalling 410,000 device hours at 175°C (versus an actual transistor rating of 150°C) only 3 failed. There were 2 failures from 119 units subjected to 25 temperature cycles of –65°C to 175°C (device rating is 5 cycles of –65°C to 150°C). In all, our actual unit hours on all life tests, including storage, operating, and reverse bias, total over 1,600,000 with a failure rate of 1.7% per 1,000 hours. And if you adjust for the fact that all these tests were essentially at overstress conditions, the result is an estimated failure rate of less than 0.1% per 1,000 hours."

Why not evaluate the facts behind RCA's "non-plastic" plastic transistors yourself? We documented all of the details in a no-nonsense brochure (HBT-600A) which we'll be glad to send you. Just write RCA Commercial Engineering, Section IG10-2, Harrison, N. J. 07029, or see your local RCA representative.

RCA Electronic Components and Devices

2N 5035
83W type for printed-circuit boards



2N 5034
83W type for TO-3 sockets

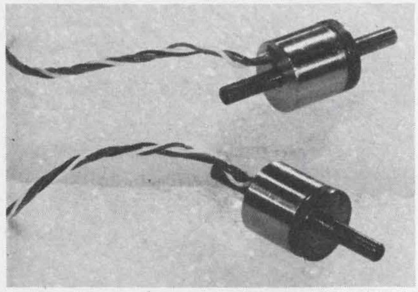
ON READER-SERVICE CARD CIRCLE 249

RCA®

The Most Trusted Name in Electronics

COMPONENTS

Differential transducer sensitive to 20 mV/V



Scientific Advances, Inc., 1400 Holly Ave., Columbus, Ohio. Phone: (614) 294-5436.

This subminiature transducer has the same volume pressure cavity on each side of the diaphragm to provide improved reciprocal performance. The transducer body is 0.290 x 0.270 in. Pressure stems are 0.063 in. OD and extend 0.188 in. from either end. This unit utilizes semiconductor-type, bonded-strain gauges in a fully active four-arm bridge and provides sensitivity up to 20 mV/V. The unit contains internal temperature compensation, available to 300°F.

CIRCLE NO. 334

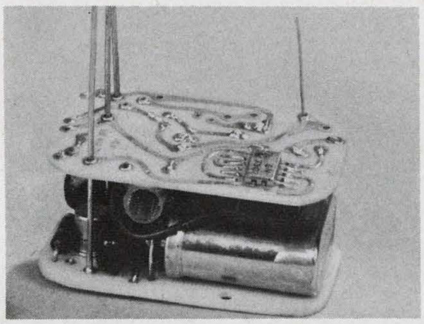
300,000 V ac supplied to 10,000 hours

Condenser Products Co., Brooksville, Fla. Phone: (904) 796-3562.

Subminiature solid-state high-voltage power supplies range from 1000 to 300,000 V ac and 1 mA to 10 mA, and have a guaranteed operating life up to 10,000 hours. They are hermetically sealed. Applications include linear accelerators, oscilloscopes, electrostatic equipment and precipitation, ground-control radar and communications equipment, display tubes and photo flash devices, spectographic analyzers and radiation counters.

CIRCLE NO. 335

Crystal oscillators perform to 50 MHz.

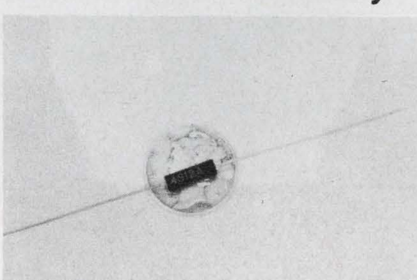


Arvin Frequency Devices, 2505 N. Salisbury, West Lafayette, Ind. Phone: 743-9639.

The solid-state TC/VCXOs are designed for communications and aerospace applications where small size, accuracy, and low-power drain are considerations. They are available for generating any frequency to 50 MHz. Units generating two or more frequencies also can be provided. The units are manufactured with pre-aged quartz crystals. Sine, pulse, and sawtooth wave forms are offered. Frequency adjustment range is 6 ppm. Aging rate is less than 1 ppm/year. Warmup time is zero. Models can be designed to accept any input voltage from ±10-to ±50-V dc. Units can be furnished to meet MIL or NASA specifications.

CIRCLE NO. 336

Wirewound resistors with ±0.01% accuracy



General Resistance, Inc., 430 Southern Blvd., Bronx, N. Y. Phone: (212) 292-1500.

These wirewound resistors feature ±0.01% accuracy and rugged construction. They include operating temperature of from −55 to +145°C, minimum resistance of 24 Ω with maximum resistance to 250 k and a stability of ±40 PPM per yr.

CIRCLE NO. 337

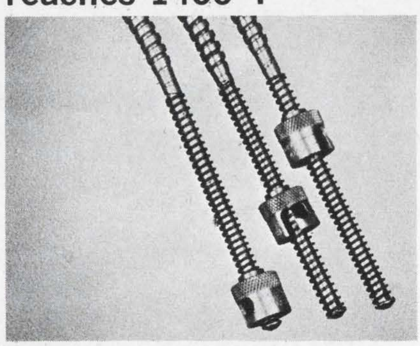
Heating tapes range to 1500°F

Hotfoil Electric Co., 242 E. Irving Park Rd., Wood Dale, Ill.

Conventional heating tapes incorporate round wires as resistor heating elements. These tapes utilize a flat foil as a resistance heating element. Improved heat-transfer efficiency enables the tapes to be used in applications up to 1500°F. They can be used to raise temperatures of objects as well as maintain temperatures. Available in various sheath materials that cover the range of temperatures and environmental conditions, in PVC (125°F), melinex (230°F), silicone rubber (400°F), refrasil (850°F) and quartz fabric (1500°F).

CIRCLE NO. 338

Adjustable thermocouple reaches 1400°F

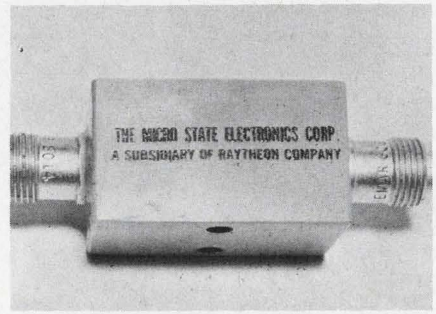


Thermo Electric, Saddle Brook, N. J. Phone: (201) 843-5800.

Spring-loaded thermocouples with locking caps are adjustable over the entire length of the probe and have a 1400°F upper temperature limit. No tools are required to adjust the cap up or down the spring. The standard locking cap can be used with previously installed mounting adapters. The most common temperature measuring applications for the adjustable cap thermocouples are: measuring plastic extruder crosshead body, die and barrel temperatures, plastic molding machine barrel temperatures, and measuring pipe wall temperature when combined with a pipe clamp adapter.

CIRCLE NO. 339

Octave band limiters limit 250 W to 100 mW



Micro State Electronics Corp., 152 Floral Ave., New Providence, N. J. Phone: (201) 464-3000.

Octave-band limiters that limit peak power of 250 W to 100 mW at 2-4 and 4-8 GHz handle an average power of up to 5 W. Insertion loss across the bands is less than 2 dB. The recovery time of the devices is 100 ns. They will operate within specifications at temperatures up to 100°C. The limiters weigh 2 oz in a package measuring 1-1/2 x 3/4 x 3/4 in. Applications include protection of tunnel diode amplifiers and mixers.

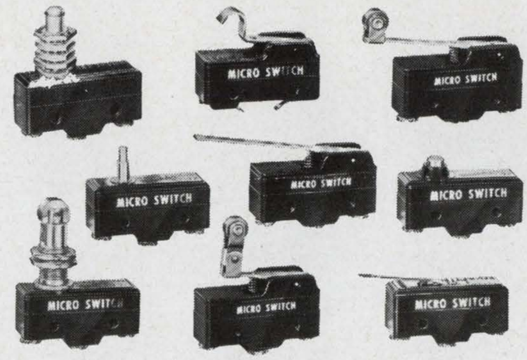
CIRCLE NO. 340

Electromagnetic clutch has 1-1/2 in. diameter

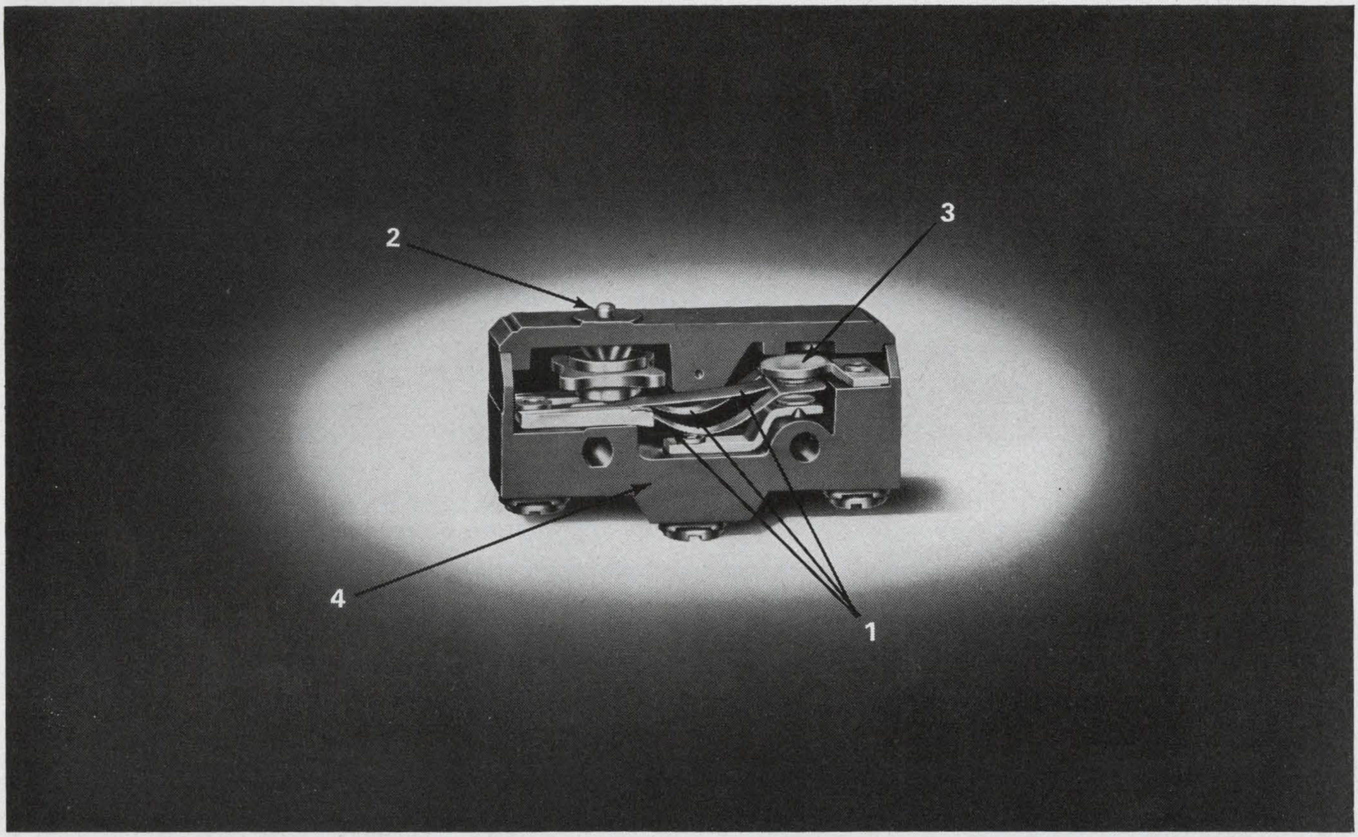
Simplatrol Products Corp., 675 Plantations St., Worcester, Mass. Phone: (617) 791-6308.

The FFC-33 is rated at 5 lb/in. with the next size 10 lb/in. and with ranges up to 600 lb/in. This clutch has a 1-1/2 in. diameter, is 1-15/32 in. long, and has a 1/4 in. bore. It is available in 24 and 90 V dc. Design features include a sine-drive diaphragm armature to accomplish this response. Typical applications include business machines, film-processing equipment and instrumentation.

CIRCLE NO. 341



Type BZ basic switches provide
a complete selection of actuators.



Two or a thousand... they're all alike

Whether you receive two or thousands of basic switches from MICRO SWITCH, you can be sure *all* are *consistent*—in sensitivity and precision operation through millions of cycles.

Reason: MICRO SWITCH has the facilities to give careful attention to the smallest details on a mass production basis. For example:

The standards set by MICRO SWITCH for the one-piece beryllium copper spring (1) are the industry's highest. Exhaustive testing assures proper alloy content, grain structure and heat treat properties. Every inch of spring material is checked for uniformity of thickness. Result: Consistent, precise repeatability, positive switching force, longest possible flexure life in *every* switch.

Plunger (2), contacts (3) and even the case (4) also conform to exclusive MICRO SWITCH standards of precision, operating sensitivity, wear life and protection.

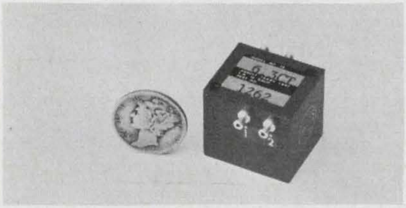
Call a Branch Office or Distributor (Yellow Pages, "Switches, Electric"). Or, write for Catalog 50.

MICRO SWITCH
FREEPORT, ILLINOIS 61032
A DIVISION OF HONEYWELL

HONEYWELL INTERNATIONAL–Sales and service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

ON READER-SERVICE CARD CIRCLE 123

Power transformer develops 2 W

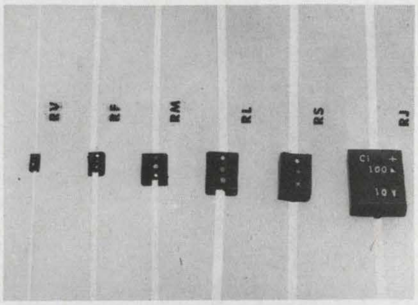


Abbott Lab., Inc., 5200 W. Jefferson Blvd., Los Angeles. Phone: (213) 731-9331. P&A: $14.40; stock.

This 400-Hz power transformer is encased in diallyl phthalate and can develop voltages of 50 to 150 V ac with a power rating of 2 W. Designated as model 2E, this unit is only slightly larger than a sugar cube and is suited for aerospace and industrial applications where small size is a prime factor. It measures 0.87 x 0.74 x 0.78 in. high. Model 2E is built to meet the specifications of MIL-T-27A and is capable of operating at a maximum of 105°C. This encapsulated and hermetically-sealed unit will also meet the requirements of MIL-E-5272C.

CIRCLE NO. 342

Tantalum capacitors carry 2 to 35 W/V dc

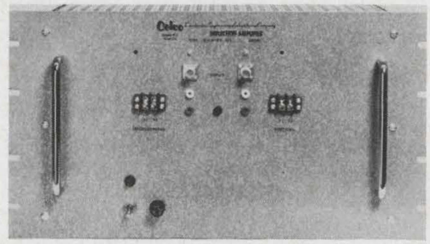


Components, Inc., Smith St., Biddeford, Me. Phone: (207) 284-5956.

Rectangular cross-section capacitors have ribbon leads and can be welded or soldered and have application for use with hybrid and monolithic ICs. The R series is available in six case sizes from 0.001 to 220 μF and 2 to 35-W/V dc. The ultraminiature RU case size handles up to 0.33 μF at 10-V dc in a 0.0035 cu in. package. The units have gold-plated kovar leads which will withstand a pull of 8 oz for 5 seconds in any direction The series is rated for operation to 125°C.

CIRCLE NO. 343

Deflection amplifier 0.1% accurate

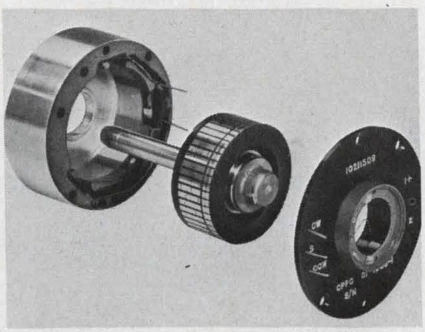


Celco, Mahwah, N. J. Phone: (201) 327-1123.

Offered are all silicon deflection drivers operating at a power input of plus and minus 20-V dc at 4, 6 or 12 A. They feature low-drift characteristics and high stability over a temperature range of 0-50°C. These units are available with regulated or unregulated power supplies and may be rack mounted. They offer direct conversion of input voltage waveforms to output current waveforms with a linearity of ±0.1%. Inputs can range from dc to pulses and complex waveforms. The unit is compatible with single-ended yokes, and has low ripple and crosstalk.

CIRCLE NO. 344

Dc torque motor withstands 230°

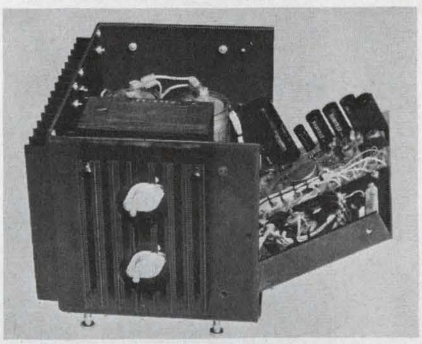


Clifton, Div. of Litton Ind., Marple at Broadway, Clifton Hts., Pa. Phone: (215) 622-1000.

This torque-pot combination can withstand internal temperatures above 230°. It has a 90-minute life test and dithers at 275 Hz about a single point over 1.2° of actual effective electrical travel.

CIRCLE NO. 345

Dc power modules for IC application

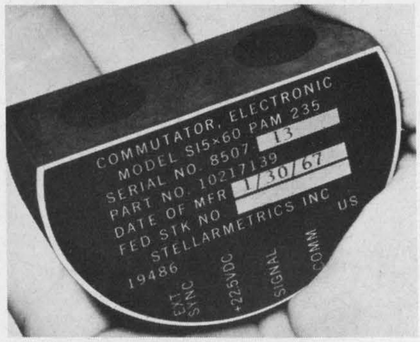


Electronic Research Associates, Inc., 67 Sand Park Rd., Cedar Grove, N. J. Phone: (201) 239-3000. P&A: $395; stock.

The units provide regulated outputs with ratings of 1 through 7-V dc and up to 40 A. All units in the series incorporate differential dc amplifiers, compensated temperature zener references, silicon rectifiers, and are fully protected with automatic recovery against short circuits. Full current and voltage ratings are applicable up to 71°C without external heat sinking or air blowers. Input for the modules is 105 to 125 V ac 50 to 400 Hz. Line regulation is 0.01% and load regulation 0.05%. Ripple is less than 800 μV rms. The temperature coefficient is better than 0.01% per degree C with an operating temperature range of −20 to +71°C.

CIRCLE NO. 346

Solid-state commutator withstands 600 G

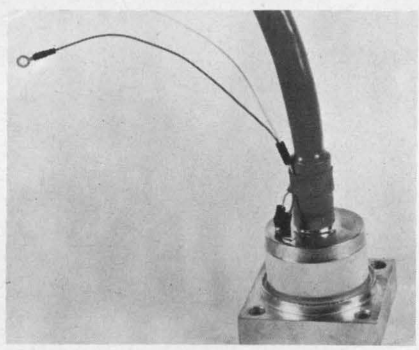


Stellarmetrics, Inc., 416 E. Cota St., Santa Barbara, Calif. Phone: (805) 963-3566. P&A: $400; 4 wks.

The model-235 commutator will withstand launching or firing shocks to 600 G. It is suitable for weapon system instrumentation. The commutators utilize FET transistors at the basis of gating. The units are single-pole 15-channel, high-level, PAM-RZ commutators. Output characteristics include a frame sync width of 2 channels, with temperature range from −40 to 70°C.

CIRCLE NO. 347

Solid-state switch surges 7000 A

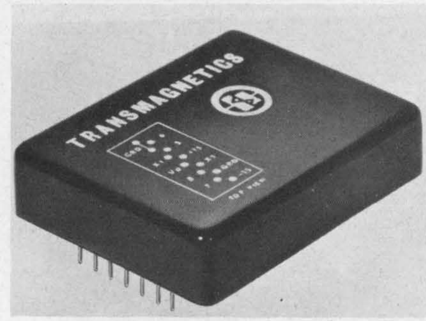


Calvert Electronics, Inc., 220 E. 23rd St., N. Y. Phone: (212) 679-1340.

The CR7K series of thyristors offers surge ratings of 7000 A and rms current from a pair in inverse parallel of 770 A. The SCR can be mounted in any position because there is no pool of mercury to worry about. The arc-volt drop and the triggering time have been brought down by a factor 20 and the power requirement of the gate is only 5-W peak. Compare this with a minimum of 2,400 W needed in a style-D ignitron.

CIRCLE NO. 348

Divider module wanders only 1%



Transmagnetics, Inc., 134-25 Northern Blvd., Flushing, N. Y. Phone: (212) 539-2570. Price: $345.

The module, model-480 CP5, provides a voltage output equal to +10X/Y, where X is −10 to +10 V into 15 KΩ and Y is always minus and less than 10 into 10 KΩ minimum. Conformity ranges from 1% full scale for Y = −10 V to 2.5% for Y = −1 V. Scale factor stability is ±1.2% over 0 to 70°C.

CIRCLE NO. 349

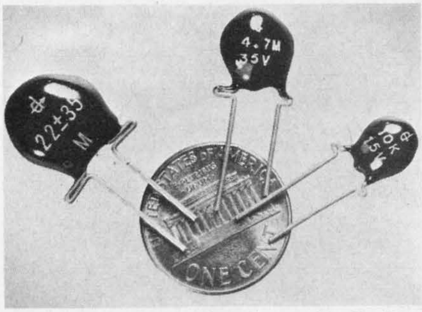
Time delay relays Rated to 60 kW

Ebert Electronics Corp., 130 Jericho Turnpike, Floral Pk, N. Y. Phone: (212) 776-1800.

Factory preset or adjustable delays on make of from 100 ms to 300 seconds are available with load ratings up to 60 kW in 1-, 2- and 3-pole models. A spst contact is all that is required to actuate the delay circuit which has the advantage of immediately resetting itself upon firing. The solid-state timing circuit and relay coil are hermetically sealed within an epoxy-filled nylon case to insure complete isolation. The operating temperature range of these units is from 10 to 65°C. Repeatability is ±2% at the stated voltages and temperature range.

CIRCLE NO. 350

Dipped caps to 150 μF

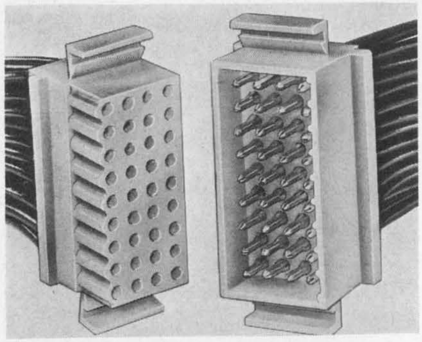


Dickson Electronics Corp., P. O. Box 1390, Scottsdale, Ariz. Phone: (602) 947-2231. Price: 32¢ to $1.65.

These dipped epoxy solid-tantalum capacitors are available in three case sizes ranging from 0.47 μF at 50 V to 150 μF at 6 V. Construction provides moisture protection without the cost of hermetic sealing. The stand-off lead functions as a stress relief during handling. It also protects the capacitor from high-temperature damage during wave-soldering operations. The units are rated to operate from −55 to +85°C without deration. All have 0.025 in. diameter leads.

CIRCLE NO. 351

Circuit connector works with 36 mates

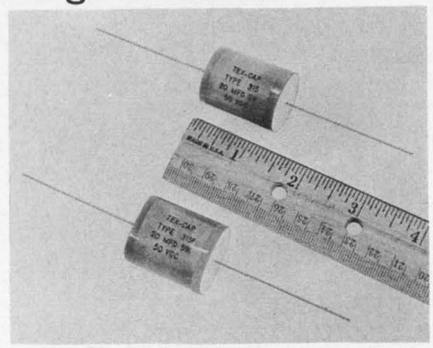


Molex Products Co., 5224 S. Katrine Ave., Downers Grove, Ill. Phone: (312) 969-4550.

Requiring no soldering, 36 circuits can be assembled in production-line fashion. The design of the nylon housing provides protection for both male and female contacts. The wire leads may be crimped by an automatic machine to the contacts and then snap-locked into the housing with perfect alignment. The nylon housings feature integrally-molded mounting ears that snap-lock into panel securely. The plugs and receptacles are available in ten colors.

CIRCLE NO. 352

Myler capacitors range to 75-V dc

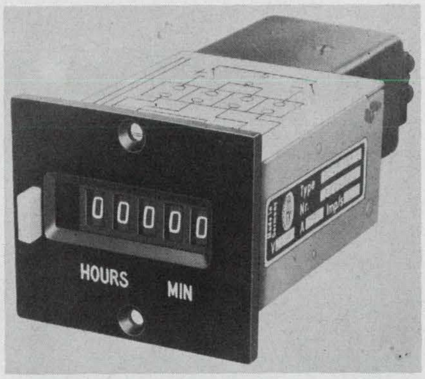


Texas Capacitor Co., Inc., 7830 Westglen Dr., Houston, Tex. Phone: (713) 782-9232.

The types 315 and 315F capacitors are available with a 75-Vdc rating, in addition to the standard 50-V. dc. Designed primarily for transistor and other low-voltage applications, these epoxy-dipped units are capable of operating within a temperature range of −55 to +85°C at rated voltage, and up to +125°C with 50% derating. Standard tolerance is ±5% with tolerances of ±10%, ±3%, ±2% and ±1% also available.

CIRCLE NO. 353

Pulsed clock adds or subtracts



Kessler Ellis Products Co., 46 Center Ave., Atlantic Highlands, N. J. Phone: (201) 291-0500.

An electrically pulsed digital clock/counter reads out in minutes and hours or seconds and minutes is now available in an add-subtract version as well as the standard totalizer. An electrical pulse generated by a microswitch, relay, or read switch operates the counter causing it to count one count per pulse. When the first two digits reach 59 the next pulse registers 1.00. Available in any ac or dc voltage the unit can be equipped with either electrical or manual reset. Electrical connection is by means of screw terminals, solder lugs, or plug-in connectors.

CIRCLE NO. 354

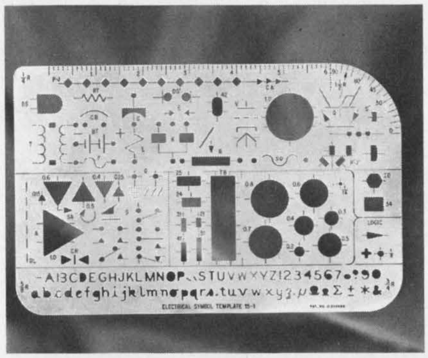
Titanium tubing strong and light

Superior Tube Co., Germantown Ave., Norristown, Pa. Phone: (215) 272-2070.

Small seamless tubing drawn from high-strength titanium alloy Ti-6A1-4V is being produced in a range of sizes up to 5/8-in. Tests indicate that stress-relieved 0.5 in. tubing has an ultimate tensile strength of 140,000 psi. High annealed strength is attained by the addition of 6% aluminum and 4% vanadium. Higher levels can be achieved by heat treatment. The alloy provides a high strength-to-weight ratio, as well as excellent resistance to corrosion and oxidation. It is stable over a temperature range of −423 to +1000°F. It also has excellent fatigue properties and fracture toughness.

CIRCLE NO. 355

Design Aids



Symbols template

Designed by electronic engineers, this template permits the drawing of graphic symbols for electronic and electrical schematic diagrams conforming in both appearance and size relationship with military specification MIL-STD-15-1A. Based on a 0.2 in. grid, it allows adequate circuit line spacing when drawings are reduced, providing adequate clarity. The letter-guide portion will facilitate placing reference designations, functional titles, nomenclature, and notes on electrical drawings. The straight edges, circles, round corners and scales on the template add to its utility. Its overall size is 8-1/4 x 5-1/4 x 0.0025 in.

Available for $3 from E. F. Thomey Co., 728 W. 10 Place, Los Angeles.

Power supplies guide

The purpose of the 8-page designer's guide is to help the system designer specify the power supply that exactly suits his needs and budget. In addition, it is intended to aid in writing specifications that are free from loopholes and bugs, thus enhancing system reliability. The cost factor is also covered, giving the designer an understanding of cost distribution, and offering suggestions for minimizing expense. The guide is divided into four sections: definitions; the checking of the specification for validity; the protecting of the power supply and its load from one another; and detail consideration of size, heat, and money. Each section is illustated with circuit and block diagrams. Trio Laboratories, Inc.

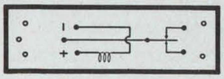
CIRCLE NO. 357

Adlake Mercury Wetted Relay — Application Data

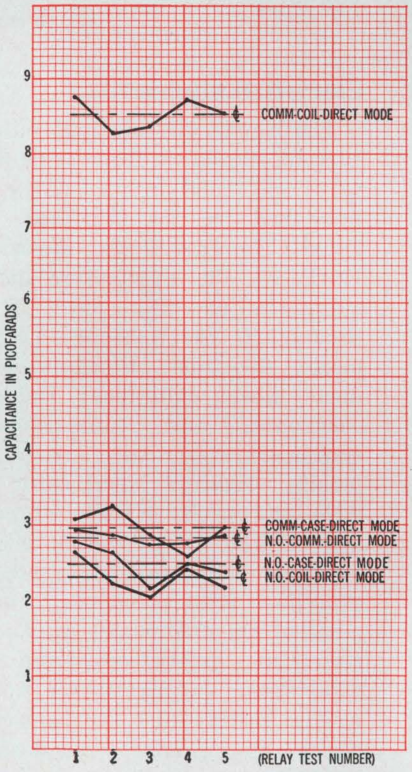
Capacitance of Adlake Mercury Wetted Contact Relays Applicable for Low Signal Applications

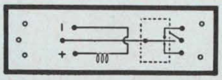
Typical Capacitance in Picofarads — Graphs illustrate typical capacitance values for Adlake AWCA-16000 series relays. Fig. I is for unshielded relays. Fig. 2: Electro-statically shielded switch brought out to a separate pin. Fig. 3: Electro-statically shielded switch with case and shield tied together at a common pin. Interelectrode capacitance across contacts of a bare switch, without external wires, is less than 1.0 picofarad.

Abbreviation COMM. stands for the Combination of the Armature and Normally Closed Contact. N.O. is the abbreviation for Normally Open Contact; whereas the symbol # is the mean average for the 5 relays. Graphs are available on other styles of Adlake Mercury Wetted Contact Relays upon request. (Please state wiring configuration.)

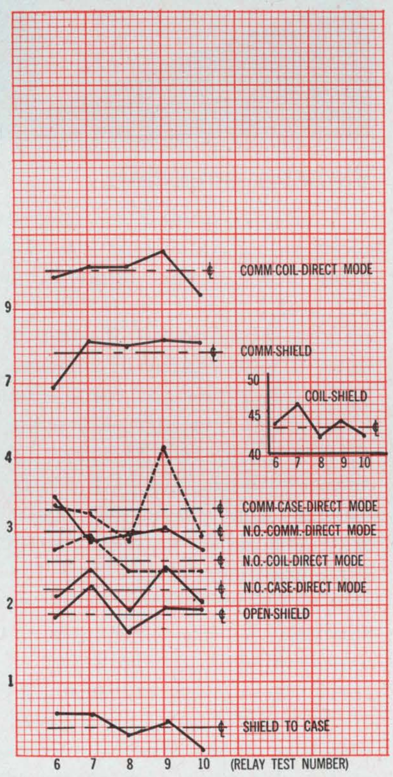


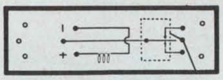
AWCA 16011-S
Fig. 1



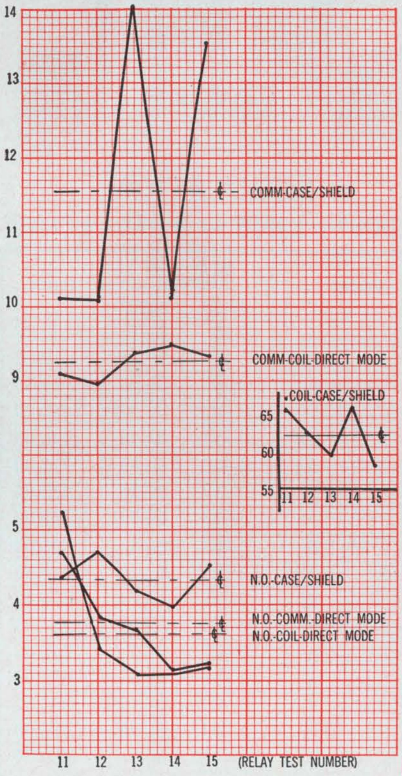


AWCA 16016
Fig. 2





AWCA 16018
Fig. 3



Data was obtained using a Boonton Electronics Corporation Capacitance Bridge, Model 75-A-S8 at 1MH$_2$

Backed by sound research and disciplined engineering, Adlake applies the industry's broadest line of mercury displacement and mercury wetted relays to the creative solution of design circuit problems. However unique or special your application, Adlake can assist you in developing it. For prompt, personal and knowledgeable attention to your relay needs, contact the one source that is the complete source in the mercury relay field. Contact Adlake today for catalog and further information.

Adlake SINCE 1857

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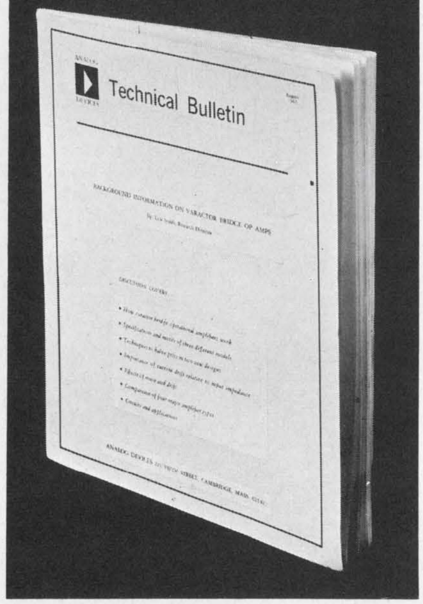
TRANSPORTATION EQUIPMENT • ARCHITECTURAL PRODUCTS • MERCURY RELAYS • DOORS AND ENTRANCES • CONTRACT MANUFACTURING

Application Notes



Varactor amplifiers

A 23-page application note uses 7 technical illustrations to discuss fundamentals and applications of varactor-bridge operational amplifiers. The first 9-1/2 pages of the note discuss varactor bridge amplifier principles and use 3 schematics to show how ultra-low noise and drift are achieved. The next 2 pages show, with the aid of a circuit diagram and numerical examples, why low drift is more important than high input impedance for amplifiers working from multi-megohm sources. Three subsequent pages are devoted to an evaluation of the influence of noise versus drift upon circuit performance, and point out how one of the other predominates under different operating circumstances. Next, a 3-page section compares chopper-stabilized, FET input, transistor differential, and varactor-bridge amplifiers, using a comprehensive set of charts to plot noise and drift errors against circuit resistance. The error curves demonstrate the varactor-bridge unit's superiority over all other types when circuit resistance exceeds about 10 MΩ. Analog Devices, Inc.

CIRCLE NO. 358

Testing

Testing is probably the last frontier of automation. This is not surprising because there is a tendency to feel that in this function, human judgment must be employed. This is true—but no more so than in many other automated processes. Human judgment is essential, but once something is programmed into the machine, it will remain thereafter. This note contains the ideas on testing for proper results. Problems and solutions are discussed. Slaughter Co.

CIRCLE NO. 359

Electrical standards

The nineteenth biennial guide to current standards for a wide variety of electrical products has been published by the National Electrical Manufacturers Association (NEMA). The publication includes standards covering most of the products in the Association's seven major divisions: Building equipment, power equipment, industrial electronics and communications equipment, electrical insulating materials, lighting equipment and wire and cable. NEMA standards are adopted in the public interest. They define a product, process or procedure with reference to one or more of the following: dimensions, tolerances, safety, operating characteristics, performance, quality, rating, testing and the service for which the product is designed. NEMA

CIRCLE NO. 360

Multiplexer modules

Applications described in the 12-page booklet include advance multiplexing, node grounding, submultiplexing, differential multiplexing, production testing, and ladder switching. Diagrams are provided as well as detailed specifications and operations data. Redcor Corp.

CIRCLE NO. 361

New Literature

Transistor brochure

A 12-page supplement features the manufacturer's line of small signal npn and pnp transistors used for military, industrial and commercial applications. It includes small signal devices recently introduced by the company. The material in the catalog deals with silicon transistors constructed by alloy, epitaxial base and planar techniques. Among the types listed are discrete transistors, choppers, differential amplifiers, darlington amplifiers and duals. Complementary npn and pnp planar transistors are also discussed. Each transistor has a summary of its primary specifications for reference. Solitron Devices, Inc.

CIRCLE NO. 362

Burr-Brown catalog

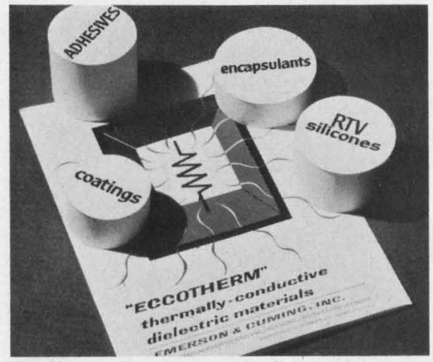
This catalog covers operational amplifiers including monolithic IC. Also function modules, including encapsulated quarter-square multipliers, sample/hold modules and active filters are described. With the product description is application information and technical specifications. Burr-Brown.

CIRCLE NO. 363

Constant-force springs

Literature describing the design and application of constant-force springs and constant-force spring motors is available. It includes basic design principles and formulas developed. Associated Spring Corp.

CIRCLE NO. 364



Dielectric materials

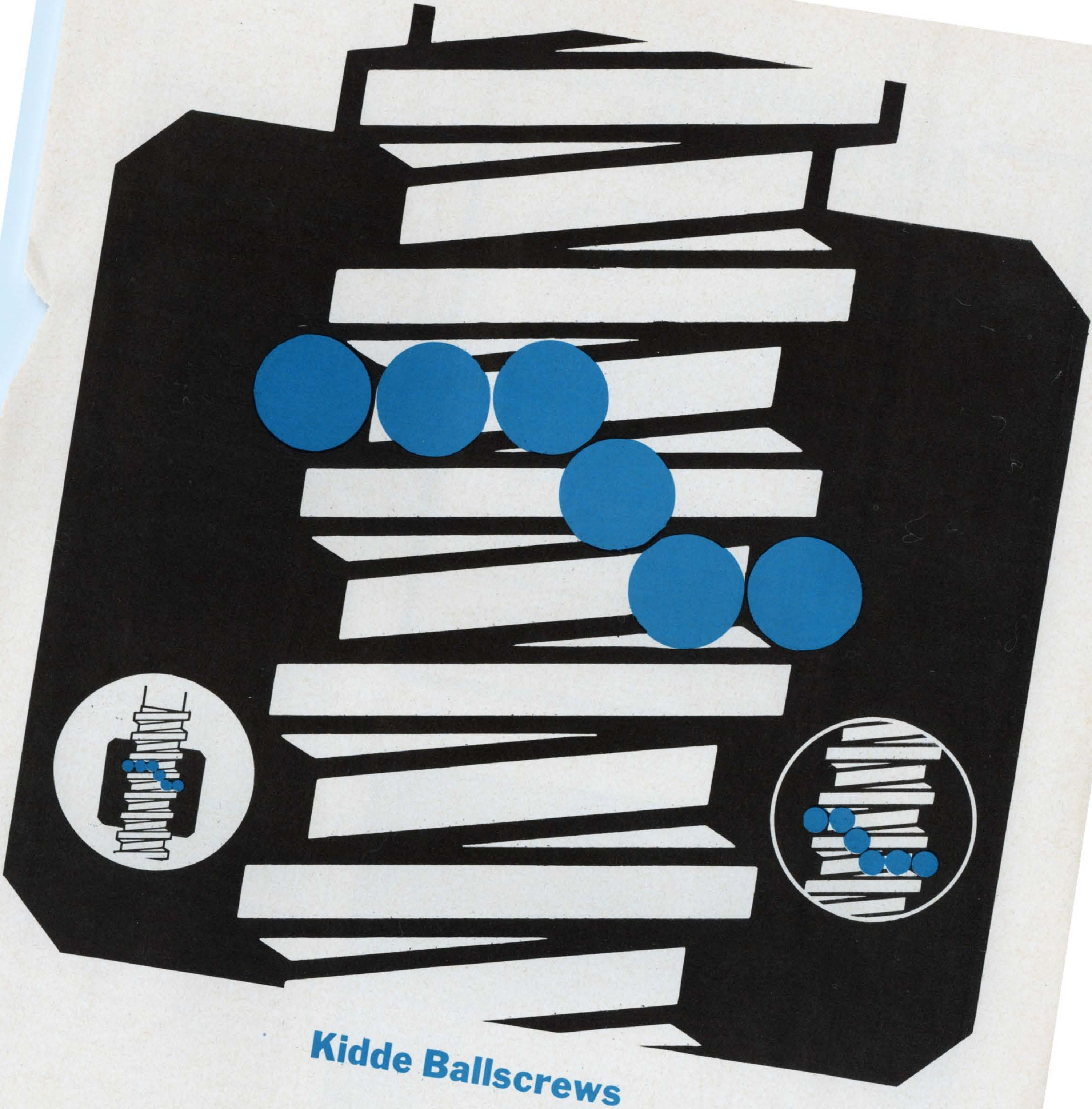
An illustrated folder is now available that describes dielectric products possessing high thermal conductivity. A chart shows adhesives, casting resins, surface coatings, transfer molding powders, silicones and a silicone mastic. Listed under each product are typical mechanical and electrical properties pertinent to the class, such as service temperature, strength, thermal conductivity and thermal expansion, together with dielectric strength, volume resistivity, dielectric constant and loss tangent. Each product is also separately described with emphasis on the handling characteristics of the uncured system, and the outstanding features of the cured system. Photographs illustrate applications for several of the materials. Emerson & Cuming, Inc.

CIRCLE NO. 365

Where aluminum is used

A booklet entitled "Uses of aluminum" which details aluminum applications ranging from siding to the F-111 jet, describes applications in construction, transportation, electrical packaging, consumer durables, machinery equipment and the aerospace industry. The 32-page catalog is illustrated and is designed to give the reader an overall look at aluminum and its market. An introductory section gives information about basic aluminum characteristics and a brief history of its development. The Aluminum Association.

CIRCLE NO. 366



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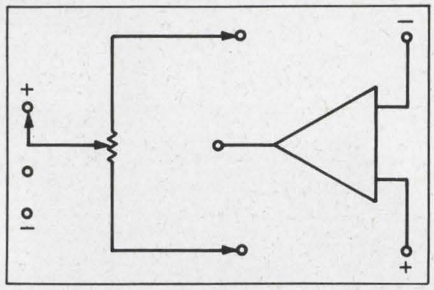
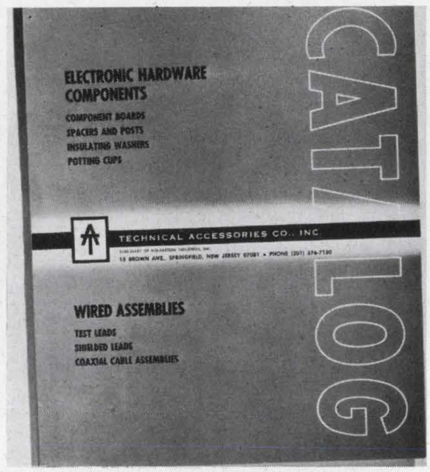


Short form op-amp catalog

A brochure dealing with the manufacturer's two series of standard and FET-model operational amplifiers is available. Both series start with economy general-purpose units and span the entire spectrum of specifications to premium-quality models. The units may be ordered chopper stabilized and come in four-case sizes including flat-pack models. GPS Instrument Co., Inc.

CIRCLE NO. 356



Electronic components

A catalog which contains specifications, dimensions and pricing on the manufacturer's line of various electronic-hardware components is available. The brochure, which is designed for the designer and engineer, contains information on wired assemblies, test leads, shielded leads and coaxial cable assemblies. Technical Accessories Co.

CIRCLE NO. 367

Lamp-base manufacture

A semi-automatic machine for solderless assembly of miniature-lamp socket-base contacts to wire leads is described. The machine, model NREC, increases production rates to as much as 2,500 units per hr by eliminating manual handling of small parts. Edward Segal, Inc.

CIRCLE NO. 368

Etched metal parts

A brochure providing information on photoetching techniques employed in the production of precision parts for industrial and consumer products includes technical details on ease and speed of etching various materials. Special notes on designing parts for optimum results, and typical examples of close-tolerance, intricate parts possible are discussed. Tech-Etch, Inc.

CIRCLE NO. 369

Opto-electronic relays

A 28-page catalog describing a line of solid state and reed relays including time delay, time interval and frequency-sensitive relays is available. The units utilize a miniaturized, ruggedized design and are recommended for military and industrial applications. Solid State Electronics Corp.

CIRCLE NO. 370

Integrated power supplies

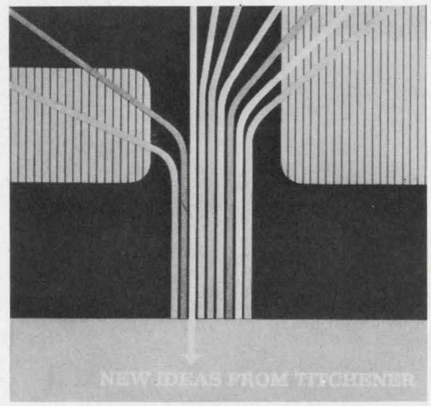
A twelve-page brochure entitled "Integrated power supplies using hi-pac$_{(R)}$ process" covers the unique features of the Hi-Pac$_{(R)}$ power supplies, provides technical information and illustrates product applications. Solitron Devices, Inc.

CIRCLE NO. 371

Patchcord programing

A 24-page brochure entitled "Versatility in Patchcord Programing Systems," covers the manufacturer's line of products for patchcord programing. Included in the presentation are schematics and illustrations. Anderson Electric Corp.

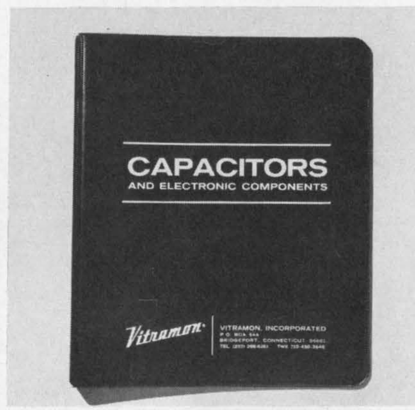
CIRCLE NO. 372



Cut wire design costs

A brochure entitled "New Ideas from Titchener" discusses various ways to keep costs down when designing with steel wire. Included are 15 fastening and welding techniques used with wire forms and assemblies. E. H. Titchener & Co.

CIRCLE NO. 373



Capacitor components

The catalog consists of 21 data sheets, either two or four pages apiece, which can be easily removed for updating and filing purposes. Each data sheet contains detailed specifications, typical curves, photos and diagrams. A handy capacitor selector locates the exact component you need. The vinyl-bound, three-hole catalog contains information on five new products and thin-line, high-current, high-voltage, chip, wafer, and high-reliablity capacitors. Vitramon, Inc.

CIRCLE NO. 374

Modular products

A 10-page catalog of modular products which includes price lists has been published. The booklet explains operational amplifiers, linear amplifiers, analog function modules and logarithmic amplifiers. Optical Electronics, Inc.

CIRCLE NO. 375

Contact manufacturing

Facts on a recently-patented manufacturing process, which reduces the amount of silver in certain contacts by 70% are provided in this literature. In addition arcing and erosion have been reduced and improved mechanical life has resulted. Users of electrical contacts and contact sub-assemblies should find this information of interest. Deringer Metallurgical Corp.

CIRCLE NO. 376

Balancing machines

A balancing-machine catalog, covering machines for use by the aircraft industry in manufacturing and maintaining of propellers, jets, landing gear, and helicopters, includes the manufacturer's pivot arrangement and compensator in an easily-read dial. Balancing machines for helicopter's tail-rotor assemblies, rotor assembles and cooling fans are graphically displayed. Micro Poise Engineering.

CIRCLE NO. 377

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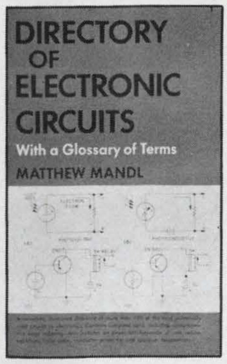

Directory Of Electronic Circuits With Glossary Of Terms, by Matthew Mandl, saves you time in experimental assembly or design with analyses of over 150 most commonly used circuits. Get quick, illustrated circuit identification, applications, description in every field of electronics including computers, communications, and industrial controls. Emphasizes solid-state components and circuit applications. An ideal fingertip guide for designing or improving an existing design to meet the exact performance characteristics you need. Pub. Sept. 1966, 226 pp., $10.60. Order your free 15 day examination copy by circling the number to the right.

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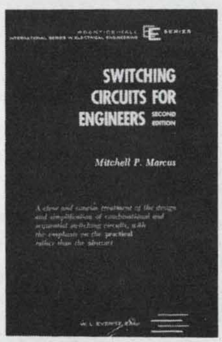
Switching Circuits For Engineers



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Video And Data Switching Systems

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48 Page Catalog of Lock Nuts

The MacLean-Fogg Lock Nut Company's new catalog No. 880 is the largest such book ever published to deal solely with locking fasteners. Each of the company's wide variety of products is treated comprehensively. The locking principle of each fastener is described. The advantages are stated and materials, finishes, sizes and shapes are covered in detail. Application sketches are given with each product to show how it is used in product assemblies. In addition to data on M-F Products there is a variety of technical information on threaded fasteners including torque-tension data, nut and bolt threads, and a bibliography of reference works on fastening.

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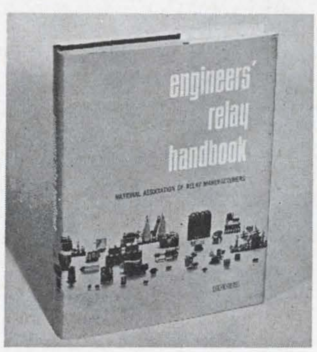
Engineers' Relay Handbook



A definitive work that is fast becoming a standard reference text for the relay user. Prepared and edited by the National Association of Relay Manufacturers, this book is a complete guide to the principles, properties, performance characteristics, application requirements, specifications, and testing of relays. Systems and product engineers will find the *Handbook* an indispensable help in determining the correct types of relays for their applications. For further information about this unique sourcebook, write Dept. ED.

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Designer's Datebook

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For further information on meetings, use Reader Service card.

Oct. 23-27
AIAA Meeting and Technical Display (Anaheim, Calif.) Sponsor: American Institute of Aeronautics and Astronautics; A. G. Kildow, AIAA, 1290 Sixth Avenue, New York, N. Y. 10019.

CIRCLE NO. 469

Oct. 23-25
National Electronics Conference and Exhibition (Chicago) Sponsor: IEEE; National Electronics Conference, 228 N. La Salle St., Chicago, Ill. 60601.

CIRCLE NO. 470

Oct. 23-27
Business Equipment Exposition and Conference (New York) Sponsor: BEMA; L. C. Messick, BEMA, 235 East 42 St., New York, N. Y. 10017.

CIRCLE NO. 471

Nov. 1-3
Northeast Research and Engineering Meeting (NEREM) (Boston) Sponsor: IEEE; IEEE Boston Office, 31 Channing St., Newton, Mass. 02158.

CIRCLE NO. 472

Nov. 6-8
Applied Superconductivity Conference and Exhibition (Austin, Tex.) Sponsor: U.S. Atomic Energy Commission, University of Texas; G. D. Cody, RCA Laboratories, Princeton, N. J. 08540.

CIRCLE NO. 473

Nov. 6-8
Reliability Physics Symposium (Los Angeles) Sponsor: IEEE; A. Coppola, Rome Air Development Center (EMERS), Griffiss Air Force Base, New York 13440.

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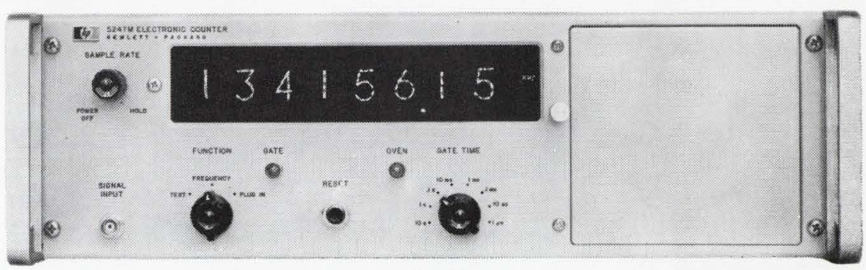

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