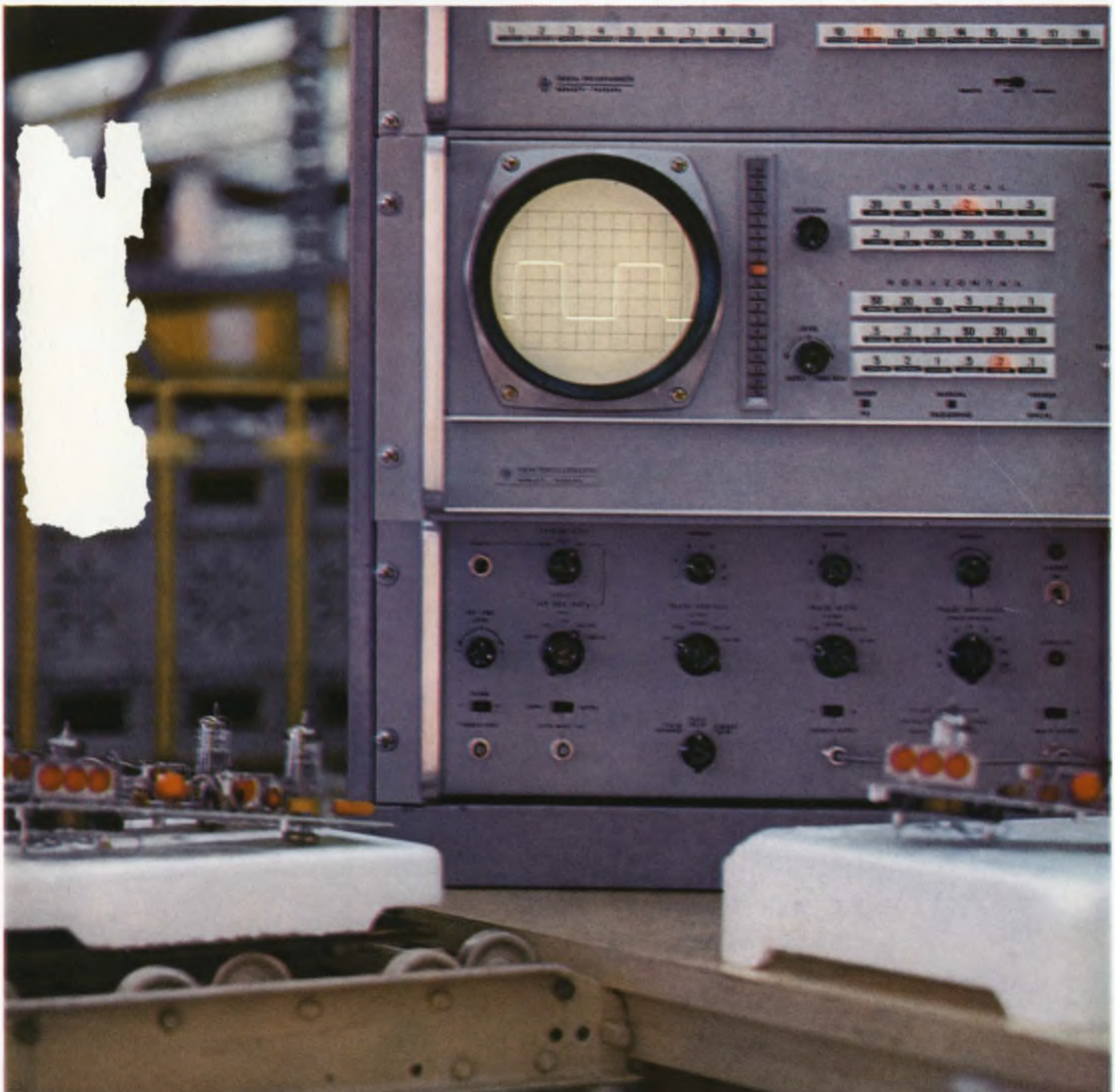
Electronic Design

VOL. 14, NO. 3

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

FEB. 1, 1966

The trace won't drift in this 25 MHz oscilloscope. With push-button control, automated tests are possible even when accurate waveform monitoring is needed. Used as a precision lab instrument, the scope will eliminate errors resulting from dc drift while reducing set-up and calibration time. (See page 90.)



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ON READER-SERVICE CARD CIRCLE 3

VOL. 14, NO. 3

Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

FEB. 1, 1966

NEWS

TECHNOLOGY

PRODUCTS

Departments

ELECTRONIC DESIGN is published bi-weekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N. Y., 10022. James S. Mulholland, Jr., President. Printed at Poole Bros., Inc., Chicago, Ill. Controlled-circulation postage paid at Chicago, Ill., and New York, N. Y. 59,656 copies this issue.

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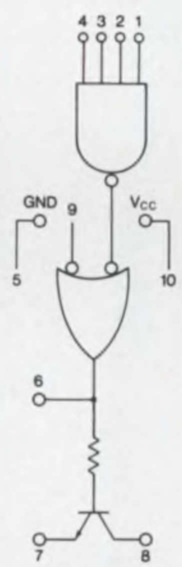

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APPLICATIONS:

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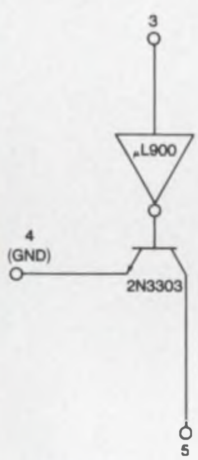

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APPLICATIONS:

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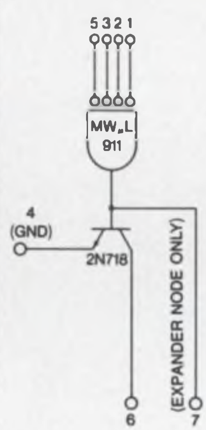
Relay drivers.

Magnetic core drivers.

Interface with discrete circuits.



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APPLICATIONS:

Interface with μL standard resistor-transistor integrated circuits and DTμL diode-transistor logic circuits.

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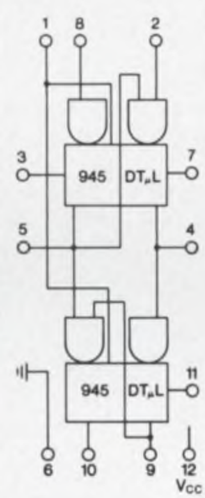
Nixie tube driver.

Interface with discrete circuits.



FSH2500 — DUAL FLIP-FLOP

Compatible with DTμL diode-transistor logic circuits.

APPLICATIONS:

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Shift counter.

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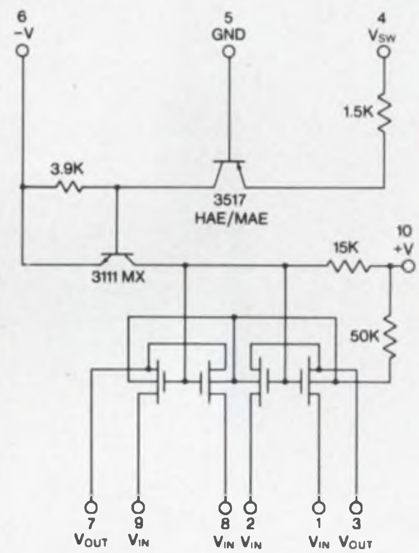

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ON READER-SERVICE CARD CIRCLE 211

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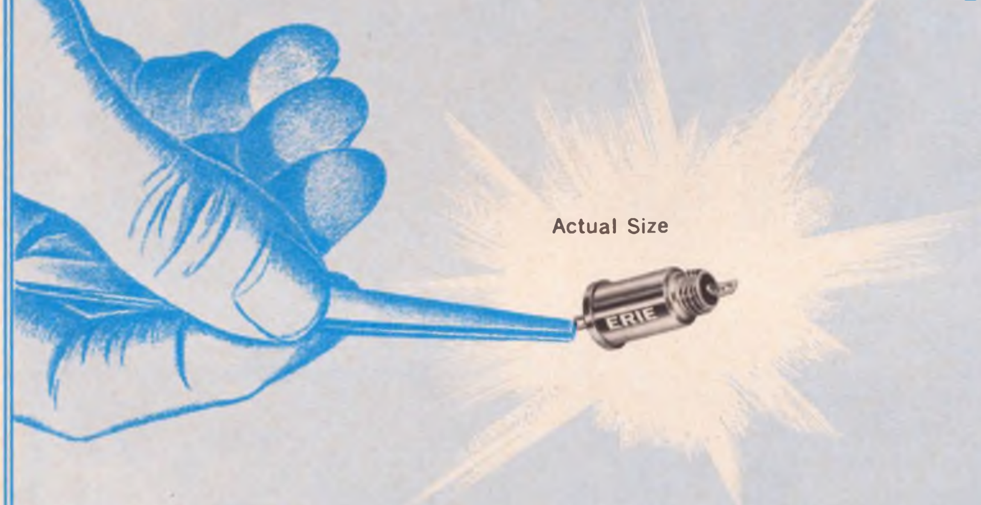

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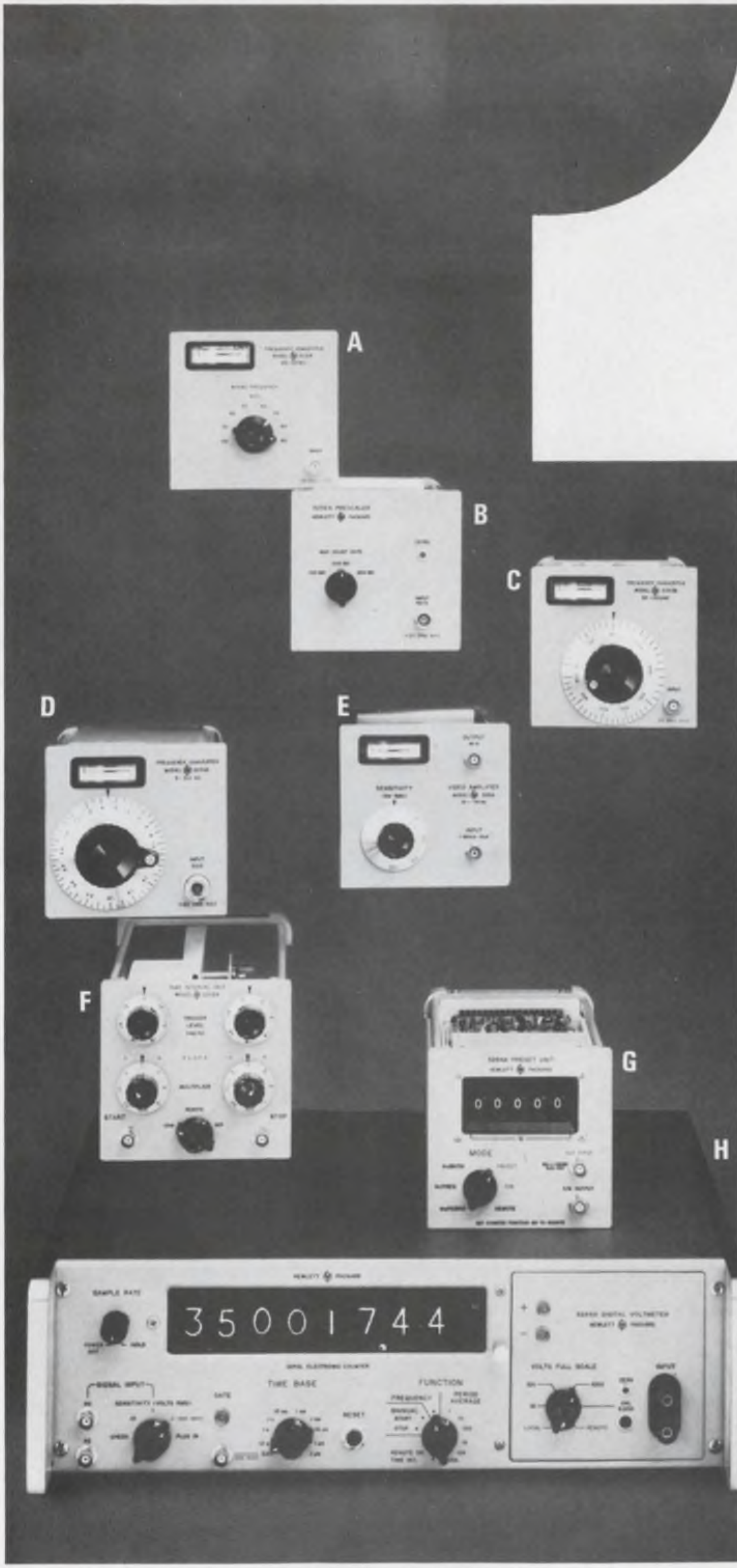

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C 50 MHz to 500 MHz frequency converter, to increase the basic counting rate of the 5245L; 5253B, $500.

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G Preset unit, normalizes measurements to engineering units, divides input frequency by N, counts N events (1 to 100,000); 5264A, $650.

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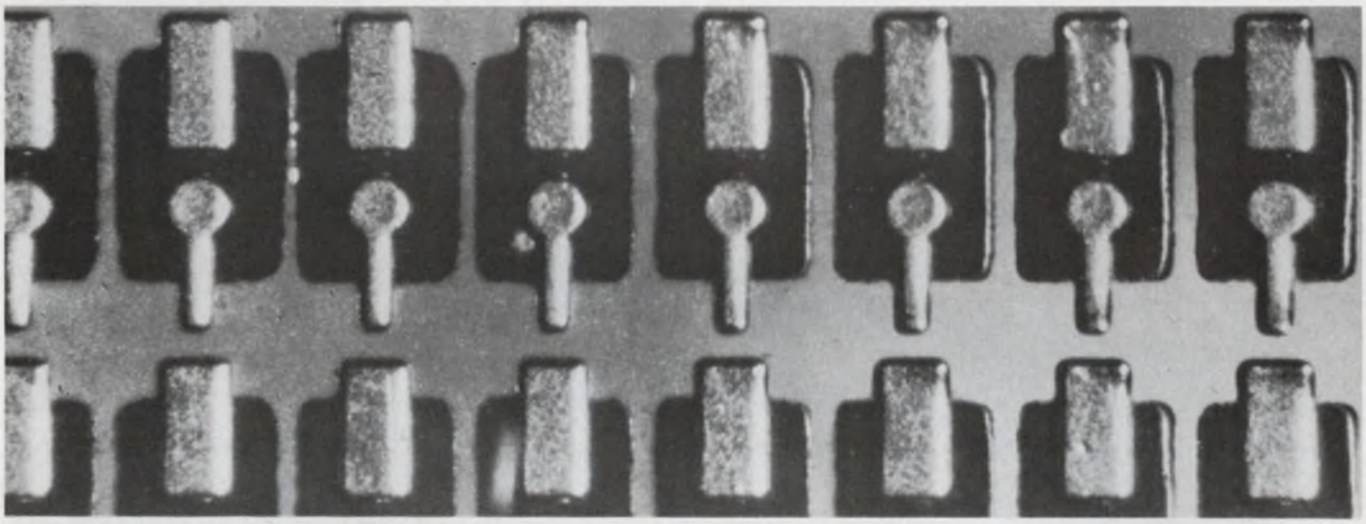
ON READER-SERVICE CARD CIRCLE 5

ED News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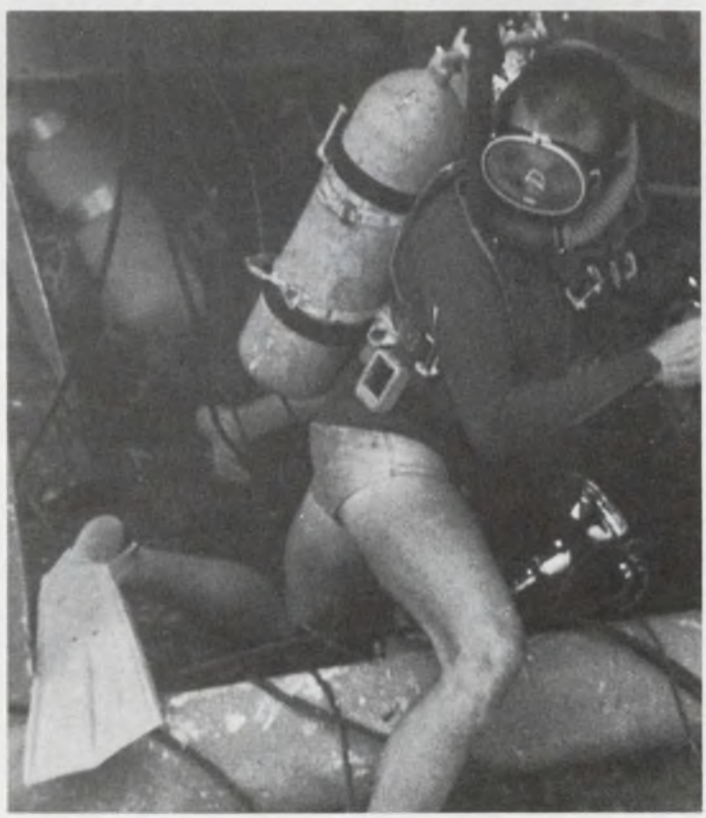
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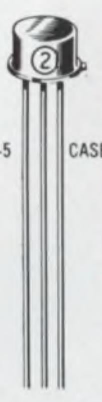
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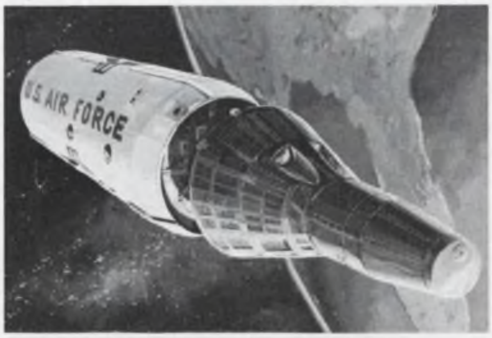
ON READER-SERVICE CARD CIRCLE 7

MOS in budget squeeze



News Report

MOL, post-Apollo are budget victims

The Air Force MOL and NASA's post-Apollo applications programs are major victims of Vietnam war surgery in the President's $112.8 billion budget request for Fiscal 1967, announced just last week. Instead of vast increases, both projects are likely to end up with the same funds they have in the current year—$150 for MOL and $100 million for post-Apollo.

When questioned on the conspicuous absence of additional funds for these big projects, both DOD and NASA officials replied that they were "effectively extending the definition phases for another year."

Total government expenditures for R&D are estimated to total $15.939 billion in the new fiscal year, down slightly from last year's 15.961 billion. Research funds will increase from $5.1 to $5.3 billion.

The defense budget picture is clouded by amended and supplemental requests for Vietnam. At first glance the department's $59-billion request seems to be a drop from last year's $63 billion, with cuts in just about every area. However, supplemental Vietnam expenditures for FY '66 have been estimated at $4.6 billion, and more than double that amount—$10.3 billion—for FY '67. Secretary McNamara's "Defense Posture Statement" to Congress this week is expected to clear some of the fog, as well as go into more detail on budgeted projects.

The DOD had expected MOL funds to go up as high as $250 million in this budget. (E D, Jan. 18, p 31) Though they will just about hold the line instead, a DOD official stated: "We still consider MOL a very important program . . . but it is a difficult program, with substantial technical problems."

Military RDT&E will stay at about $6.9 billion. On the plus side are "strong emphasis" on the Navy's Poseidon missile. "continued development" of Nike X, and "increased emphasis" on a battlefield SAM-D surface-to-air missile. On the negative side are the MOL cuts and the phasing into production of the F-111 fighter. C5A transport and Minuteman III missile programs.

Significant procurement items include the Navy's nuclear carriers, 210 FB-111s, 1000 Minuteman IIIs and an undisclosed number of C5As. The total procurement bill is nearly $18 billion, down from last year's $22 billion.

NASA's shaved request of $5.012 billion indicates a drop-off in scientific goals in deference to continued emphasis on the manned lunar mission. The Apollo-applications program—using Apollo techniques and hardware for unmanned scientific missions beyond the manned lunar landing—appears to be in real trouble. The study program is being phased out of the budget, and nothing has appeared to utilize the study results. Though the agency had hoped to double the $100 million spent on post-Apollo in FY '66 and wound up, like DOD with its MOL, with the same amount for FY '67, a NASA official said: "We have preserved the option to go ahead for the 1968 budget." (See E D, Jan. 18, p 13, 31)

The recent released report of the National Academy of Sciences on Apollo applications was supposed to bolster NASA's budget request. But the report did not spell out specific-enough scientific objectives. The agency still has hopes that the influential academy will be able to convince Congress of the importance of further scientific missions that make use of Apollo experience and hardware. The Apollo program itself has not been affected, with this year's request for nearly $3 billion by far the biggest item on NASA's list. The agency still hopes to land a man on the moon "in this decade."

Other developments of significance in the NASA budget request:

- A stretchout of the Voyager Mars program from 1971 to 1973 and the Advanced Orbiting Solar Observatory cancellation further illustrate cutbacks in scientific goals.
- In advanced research and technology, electronic systems show the only real increase, from $32.3 million to $36.8. Expensive propulsion-system research has fallen off in all three areas, but still totals $132 million.

News Report CONTINUED

■ Weather satellites show an area of more attention, led by the Nimbus. The budget here is up from $39 to $44 million.

■ The new Cambridge Electronics Research Center is expected to be started by July. Two main activities there will be in optical communications and component qualifications and standards. The new budget includes $10 million for the ERC.

Significant items from other department budgets show some gaps. The Federal Aviation Agency expects to complete this year the $220-million design phase of its **supersonic aircraft** (SST) development program. But absent in the budget request are SST appropriations beyond the design phase. The FAA budget will also allot $30 million for continued development of air traffic control systems and landing aids.

The Department of Commerce will spend more money for **computers** for the Census Bureau and Patent Office. **High-speed rail transit** programs—mainly the Northeast Corridor demonstration—will get $13 million to spend in FY '67. The new Environmental Science Service Administration (former Weather Bureau, Geodetic Survey and Radio Propagation Lab and the new Institute of Oceanography) will get more money for R&D (3 million) and for **weather satellites** ($8.5 million).

The Atomic Energy Commission request has no mention of the long-talked-about **200 Bev accelerator** project. This may have been held off for a supplemental request coincident with site selection, due for announcement "soon."

Philco buys General Micro-electronics

Continuing expansion of its microelectronics activities, Philco Corp. last week announced the purchase of General Micro-electronics from its parent company, Pyle-National, of Chicago. The reported sale price was $4.3 million. Another $4.8 million was paid to Pyle-National to repay its loans to GME, Philco said. The company plans to continue operation of GME, a leader in metal-oxide-silicon device technology, at its plant in Santa Clara, Calif.

Western industry group expands

In an annual statement to members, the Western Electronic Manufacturers Association has reported an increase in councils and active members in 1965. The active membership now stands at 367 companies, a growth of 18% since January, 1965. A sixth council of the association was formed in Colorado. The new council already has 17 member companies.

Growth in other WEMA councils includes a 50% gain in members in Arizona and more than 10% each in the Los Angeles and San Francisco units. The association serves the Western electronics industry from two offices, one in Los Angeles and the other in Palo Alto.

Essa I, II weather satellites blastoff

The first weather satellite in the Tiros Operational Satellite system (TOS) is due for launch this week, to be followed by Essa II later this month. The Essa (environmental survey satellite) will be virtually identical to the Tiros IX in design and planned orbit. The Tiros series was considered an interim operational system.

Developed by RCA's Astro Electronics Division, in conjunction with Goddard Space Flight Center, the Essa I will carry two half-inch Vidicon cameras which have a resolution of about two miles. The second in the Essa series will carry two automatic picture transmission cameras.

The third satellite in the Essa series, due for launch in early summer, will carry the advanced Vidicon camera system that was used in the Nimbus weather satellite.

W. G. Shepherd, University of Minnesota vice president, has been elected president of the IEEE for 1966, succeeding Bernard M. Oliver. W. K. MacAdam, AT&T vice president was elected vice president.

An Association for the Advancement of Medical Instrumentation, recently formed in Cambridge, Mass., hopes to improve communication between medical and instrument people. The AAMI can be contacted at PO Box 314, Harvard Square, Cambridge, Mass., 02138.

Oceanographic studies from space may be carried out by the Naval Oceanographic Office, in conjunction with NASA, possibly under the space agency's Apollo applications program. The Navy and NASA recently reached agreement on preliminary plans, but the gloomy future of post-Apollo funding may harm plans.

A data acquisition system for the Concorde supersonic airliner—an English-French project—will be built by Radiation, Inc., under a contract that will probably bring about $2 million. First flight tests for the Concorde are scheduled for 1968, but the craft will probably not fly until 1972.

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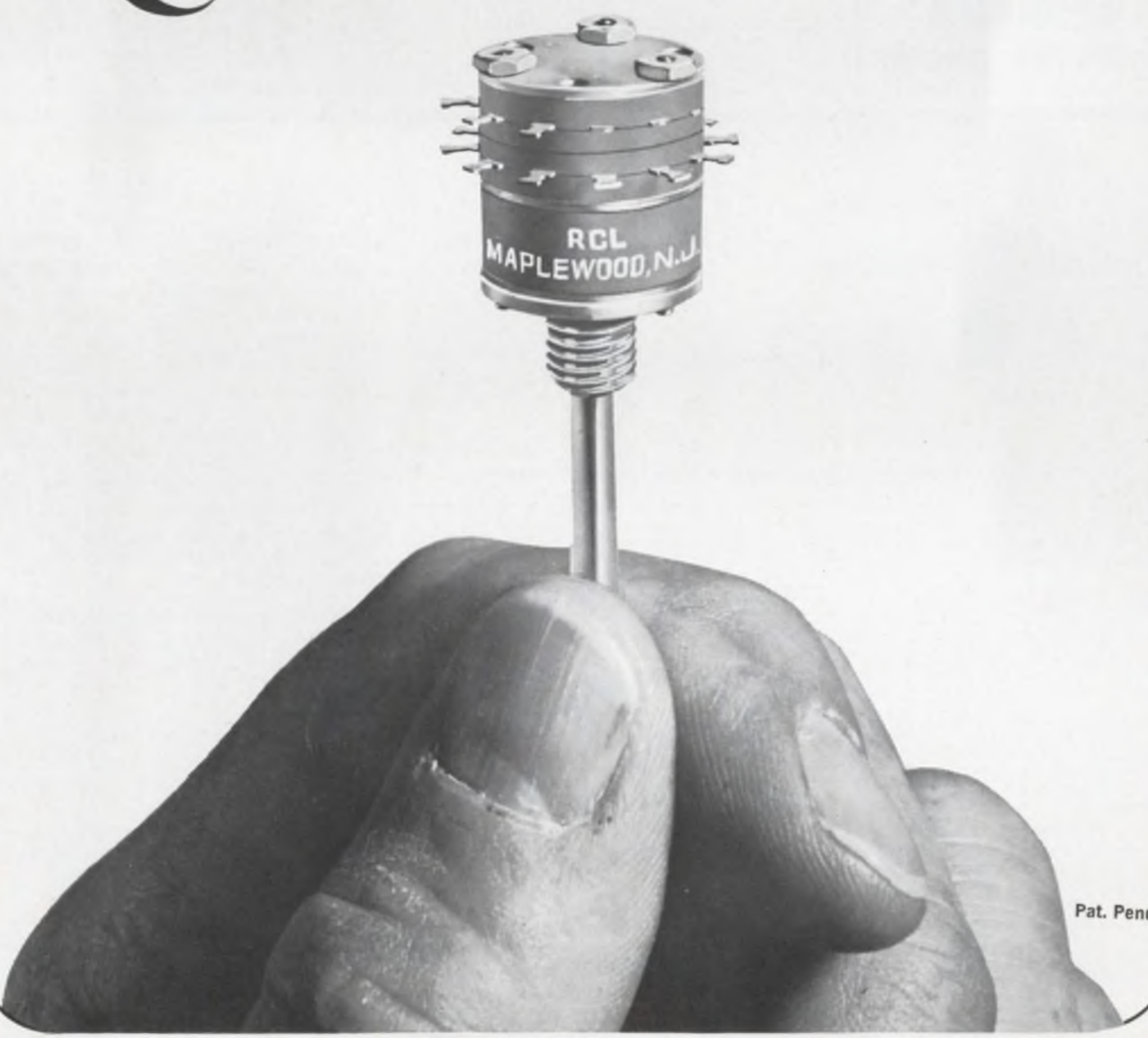

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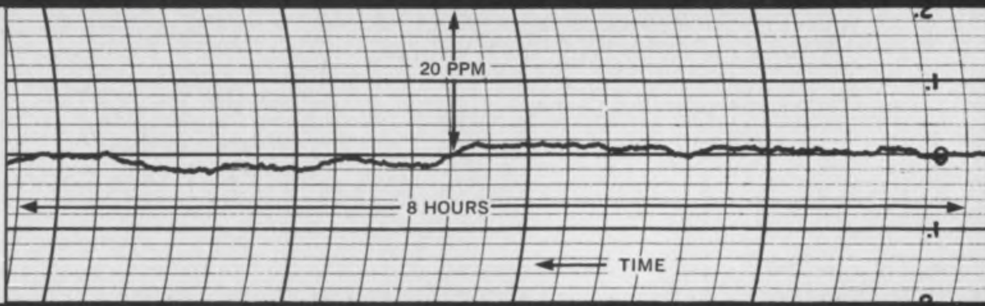

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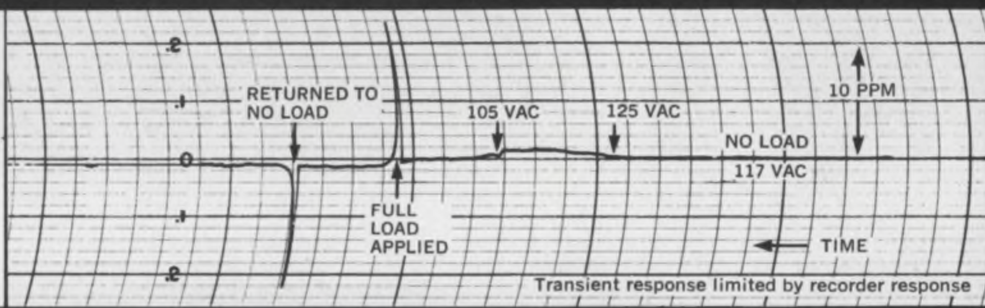

Model TC-100.2BR

Princeton Applied Research Corporation offers a sophisticated line of power supplies providing extremely stable voltage and current outputs whose accuracy is traceable to N.B.S. All models are completely solid state and feature a careful, conservative design leading to highly reliable operation. Indicative of the features found in these units is a unique chopper-stabilized amplifier with a DC open-loop gain of 5 x 10^6, falling off no faster than 6 db/octave to unity gain. This insures extremely low output impedance (less than 10 micro-ohms at DC) and fast transient response without ringing.

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TC-100.2R	0 to 100 V @ 200 ma max.	0 to 100 ma* @ 100 V max.	0.01% of F. S.	0.02% of F. S.	1 mv	1 μa	.001%	.002%	$1,500.
TC-602CR	0 to 6 V 0 to 60 V @ 2 A max.	0 to 60 ma 0 to 600 ma 0 to 2 A @ 60 V max.	0.01% of F. S.	0.03% of F. S.	1 μv min.	10 m μa min.	.001%	.002%	$1,750.
TC-100.2AR	0 to 100 V 0 to 10 V 0 to 1 V @ 200 ma max.	0 to 100 ma* 0 to 10 ma 0 to 1 ma @ 100 V max.	0.01%	0.02%	10 μv min.	10 m μa min.	.001%	.002%	$1,800.
TC-100.2BR	0 to 100 V 0 to 10 V 0 to 1 V @ 200 ma max.	0 to 100 ma* 0 to 10 ma 0 to 1 ma @ 100 V max.	0.01%	0.02%	100 m μv min.	100 μ μa min.	.001%	.001%	$2,200.
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ON READER-SERVICE CARD CIRCLE 9

Showdown near on airborne phone system

An ssb facility is proposed for airline travelers, but the plan is meeting objections in industry. But the FCC may authorize field tests by summer.

Peer Fossen
West Coast Editor

It is early morning. Your jet got off on time, you have had your in-flight breakfast, and have gone over the documents in your briefcase at least three more times. You are on your way to Procurementsville to present an important proposal for your company.

Then it happens. Your flight is put into a holding pattern over the terminal area, and it becomes clear that you will not be able to make that all-important 10:00 meeting.

What can you do? Nothing. Absolutely nothing but sit back, wait for your plane to land, hope that your company presentation will eventually be given another chance, and perhaps curse the lack of a public air-ground radiotelephone system.

That, unfortunately, is today's situation, despite the long-established need for such a communications system. The only way an in-flight commercial passenger can now get in touch with the ground is through the aircraft's operational radio system. For obvious reasons, such use is limited to dire emergencies.

But if today's situation is bleak, there is hope for the air traveler of tomorrow. Having evaluated an FM system that operates in the 450 MHz range and that has been in developmental operation in private aircraft for some years, the Federal Communications Commission is taking a close look at single-sideband (ssb) emission within the alloted frequency spectrum. It hopes to come up with a solution to the public air-ground radiotelephone problem.

A proposed ssb system is being pushed by the Radio Technical Commission for Aeronautics (RTCA), and the FCC has been asked to authorize field tests of it by late summer. Despite a good deal of disagreement in the communications industry over the RTCA's proposed specifications for the system and its time schedule for development, most industry observers believe that the FCC will approve the ssb tests.

Industry blamed for delay

In a nutshell, there has been no public ground-air radiotelephone service so far because the electronics industry has failed to develop a system that can be of wide operational value within the limited FCC frequency allotment. Obstacles remain, despite many years of discussions and planning on the part of the electronics industry, airline and private aircraft owners and operators, aeronautical organizations and the Government.

The development FM system has been in use in some 300 private aircraft, supported by ten ground stations servicing aviation's "golden triangle," whose vertices are New York, Washington, D. C., and Chicago. However, the system is limited to six channels, with only a single channel serving the New York City area.

But the system is cumbersome, with no provisions for hookswitch supervision, which is necessary for automatic call completion. Moreover, an in-air "push-to-talk" requirement is confusing to the party on the other end of the call. Even if an industry-claimed optimized FM system, with 24 to 30 channels within the frequency allotment, were to become a reality, it would not satisfy the FCC.

FCC asks end to FM system

Responding to petitions by the American Telephone and Telegraph Co. and the General Motors Corp. (AC Spark Plug Division) aimed at making the FCC reconsider its June, 1963, proposal to terminate the FM developmental service—the FCC in a Memorandum Opinion and Order (Docket No. 14615, June 30, 1965) stated in part: ". . . . we have found that the present developmental air-ground system cannot provide an adequate service to the public within its present frequency allotment. We have also determined that, in view of the congestion prevalent in the land mobile services, no additional frequency space can be made available in which to expand this service in the vicinity of its present allotment. Consequently we have decided to terminate the present developmental operation within five years."

Simultaneously the commission issued a Notice of Proposed Rule Making (Docket No. 16073), stating: "We are willing to adopt an air-ground radiotelephone system which can provide an adequate public service within the present frequency allotment."

FCC criteria. . . .

The operating criteria for the ssb system set forth by the FCC are:

- Spectrum: 454.675-455.000 and 459.675-460.000 MHz.
- Voice channels: At least 60 2-way channels.
- RF bandwidth: Not exceeding 5 kHz per 1-way channel.
- Emission: Single sideband.

Docket. No. 16073 also poses three questions:

1. Would a 60-channel air-ground system be adequate to accommodate both national and international air travelers in the vicinity of major U. S. air terminals?
2. How many simultaneous radiotelephone conversations should the equipment aboard passenger aircraft be capable of handling?
3. What technical standards should be specified for providing selective signaling in the air-ground radiotelephone service?

The docket goes on to state that if constructive results are produced, a further FCC notice, specifying rules and standards, will be issued; otherwise this docket may be termi-

(airborne phone, continued)

nated and the frequencies made available for other purposes.

. . . and RTCA answers

Responding to the FCC notice, the Radio Technical Commission for Aeronautics recently issued its Report Do. 130, setting forth systems characteristics intended to meet the FCC criteria. The report was prepared by a special RTCA committee (SC-114), consisting of representatives from the electronics industry, FCC, National Business Aircraft Association, Aircraft Owners and Pilots Association, and Air Transport Association of America. E. D. Hart of the Bendix Radio Division was chairman of the committee, Frank White of the Air Transport Association was vice chairman, and C. J. Moncavage of RTCA was secretary. C. A. Rypinski, an independent communications consultant to the committee, was a major contributor to the system presented in the RTCA report. (The basic systems characteristics recommended are shown in the accompanying listing).

In response to the three FCC questions, RTCA's report offers these comments:

1. "The adequacy of 60 channels would be dependent upon customer acceptance and upon the division between private and commercial aircraft. Customer acceptance, particularly in large segments of the private aircraft market, would depend upon the cost, size and weight of the airborne unit, grade of service and the rates. Since telephone traffic generated by an air carrier would be several times that generated by a private aircraft, the mix between private and commercial craft would be a controlling factor in the over-all traffic pattern. It is expected that satisfactory service might be provided to the projected market at most of the major hubs for a five to eight year period.

"The system proposed in this report provides three significant improvements over the present developmental system, as follows: (a) It provides 60 operating channels in lieu of six; (b) It provides 10-channel trunking at each station; (c) It minimizes the need for manual routing—that is, operator intervention.

"It is considered, therefore, that when average demands are considered, the 60 channels will be adequate for some time.

2. "The plan permits the utilization of airborne equipment capable of providing from one through ten simultaneous full-duplex channels. If the system is adopted and implemented, manufacturers would provide airborne equipment with capabilities falling within this range, depending entirely on user demands for simultaneous air-ground circuits.

3. "The plan provides for signaling of various types, including selective signaling. Field trials are necessary to provide confidence for the technique offered."

The RTCA report goes on to urge prompt FCC authorization for field tests of its ssb system, and it suggests that such tests be conducted in an area not serviced by the developmental FM system. Two possible areas mentioned are the West Coast and Fort Worth-Dallas.

Finally, the committee urged the FCC not to terminate the interim six-channel system, "unless and until there is evidence that it would interfere with the adoption, field trial and implementation of a suitable 60-channel ssb system."

Disagreement blocks progress

The forward of the RTCA report states that the association's objective is the solution of problems of air-ground telecommunications "by mutual agreement of its member and participating organizations." But while a specific ssb system is proposed in the report, there is strong evidence of disagreement among the committee members, both

RTCA-proposed specifications for ssb system.

Airborne system

- Full duplex ssb operation on 60 voice channels (or fewer in the case of limited-range aircraft)
- Nominal power; 10 watts PEP per channel.
- An IF shape-factor of 1.25-1, measured at the 60 dB point.
- Voice bandwidth of 300-3000 Hz.
- Long-term frequency stability of two parts in 10 million.
- Receiver sensitivity: 10 dB noise figure or 0.2 μV.
- Acceptance bandwidth of 590 Hz for group pilot carrier ($\pm$500 Hz doppler shift +90 Hz frequency error).
- No squelch required.
- Radiation at upper sideband frequency.
- Out-of-band spurious emission 40 dB down.
- Airborne logic unit to decode signaling, provide channel designation or search, unit ground station identification, frequency-correction decoding, RF output level command decoding, etc.
- 20-pound unit, to operate at -10°C to $+40$°C at a cost of about $4000.

Ground system

- A group center-frequency reference pilot carrier accurate to $\pm$10 Hz of assigned frequency.
- Power: 50 watts PEP per channel.
- Sensitivity, bandwidth, intermodulation and out-of-band emission figures the same as in airborne system.
- System voice frequency translation error of less than $\pm$ 5 Hz within 0.25 μs.

Anticipated problem areas

- Maintenance of frequency stability of the airborne reference.
- Modulation of signal by multipath signals.
- Power requirement for various command functions and voice circuits.
- Frequency-locking in 450 MHz environment.
- Adjacent-channel and co-channel interference and required co-channel protection ratios.
- Level variation of incoming telephone path.

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(airborne phone, continued)

with regard to selection of the system and to its implementation. The disagreement is reflected in the report itself, as well as in the multitude of comments and replies to comments filed with the FCC in response to Docket No. 16073.

For example, the report contains a step-by-step time schedule for the adoption, field test and implementaton of the system. It discusses, with careful wording, the fact that the achievement of any schedule is subject to variables, many of which are unknown. "However," the report goes on, "in an atmosphere of cooperation and in an effort to set forth general guidelines, the following schedule was established as being representative of an optimistic (fast) schedule." In brief, the schedule shows these dates:

- July, 1966—FCC rules permitting start of field tests.
- August, 1966—Availability of first airborne and ground systems for flight test and evaluation.
- Spring, 1969—Terminal equipment to link ground RF systems with the public telephone network.
- Starting in 1971—Final configuration implementation.

Industry objections are strong

AT&T questions the practicality of the ssb system. In the RTCA report the company states: "Based on theoretical studies conducted by our laboratories, there is substantial reason to doubt the feasibility of developing a commercially workable ssb air-ground system meeting the design criteria specified by the commission. How far the present state-of-the-art and accompanying economic considerations would permit approaching these design criteria could only be determined by an extended development program, requiring an estimated three to five years. In our opinion, the chances of achieving the major objectives specified are not sufficient to warrant launching such a program at this time."

Also included in the report are separate views by Motorola, Inc., on a system utilizing FM techniques within the uhf spectrum. These views are concurred in by the General Electric Co., General Motors

(continued on pg 24)

Navy elevates deep submergence effort

Now under Chief of Naval Material, project looks to electronics to solve problems encountered in Sealab II. Sealab III, due next year, is one of five programs.

S. David Pursglove
Washington Editor

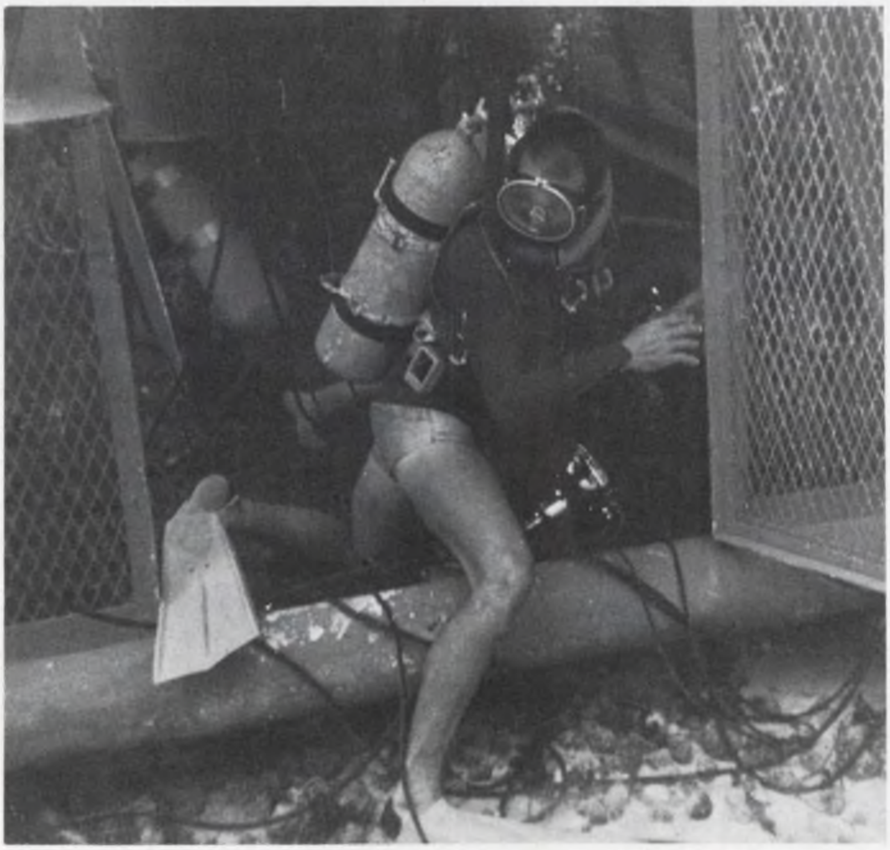
The Navy has given its undersea exploratory work—involving rescue, salvage and habitation of the deep—a more promising future by making the program a fully recognized "project" under the Chief of Naval Material. The effort—called Deep Submergence Systems Project (DSSP) had theretofore been just one of several miscellaneous ones under the wing of the Special Projects Office.

The announcement came as 1400 oceanographers, underwater engineers and antisubmarine warfare specialists—400 more than expected—overflowed a Washington hotel recently to hear a two-day report on one of the Deep Submergence Program's more widely publicized projects, Sealab II. Plans for Sealab III were also outlined.

Project comprised of 5 activities

The Deep Submergence Systems project, stemming from a desire to avoid a repetition of the Thresher submarine tragedy, now consists of five activities:

- Submarine Rescue—includes development of techniques and equipment for locating disabled submarines and improvement of escape systems. Although development of instruments is a significant R&D activity, the major effort here is development of small deep-sea rescue vehicles.
- Small-Object Recovery—aims to develop ways to search the seas down to 6000 feet for missile war heads, practice torpedoes and abandoned aircraft. A search vehicle is to be built to test the techniques. Based on experience with the test vehicle, the project will then design and build two operational craft capable of finding and retrieving objects down to 20,000 feet.
- Large-Object Salvage—aims to develop a collapsible pontoon system to lift sunken ships and other objects from as deep as 800 feet. Attachment of pontoons and preparation of the object for salvage will be done by divers.
- Man-in-Sea Activity—Designed to enable man to live and work in a deep-sea environment at ambient pressure. Sealab is one aspect of the research. Working for weeks at a time from permanent sea-bottom dwellings and mobile quarters open to the sea, swimmers will participate in rescue and recovery operations, maintain bottom-mounted equipment, conduct scientific studies, and take part in military operations of the sort that might be associated with mine defense, amphibious assault or espionage.
- A Nuclear-Powered, Deep-Diving Research Vehicle (NR-1)—Design, development and construction of a nuclear power plant—a small pressurized water type reactor—will be carried out by Vice Adm. Hyman G. Rickover's Naval Reactors Division of the Atomic Energy Commission. Development of the craft itself, however, and of its equipment and instrumentation will be done by the Deep Submergence Systems Project. The NR-1 will be equipped with a small laboratory and facilities for ocean-floor mapping. This activity is believed by many observers to be the one that will prove to be the project's major effort.



Not James Bond, but a Navy Sealab II aquanaut enters the deep-submergence research vehicle, which was under 200 feet of the Pacific Ocean for 30 days.

In announcing the "fundamental changes in the management of our ocean technology program," Navy Undersecretary Robert H. B. Baldwin made it clear that as a separate project, DSSP would receive "in-

(Sealab, continued)

tensified management and focus of effort."

The Navy got the reorganization off to a good start by assigning its respected Chief Scientist for Special Projects, Dr. John P. Craven, as acting manager until a senior officer is appointed in June.

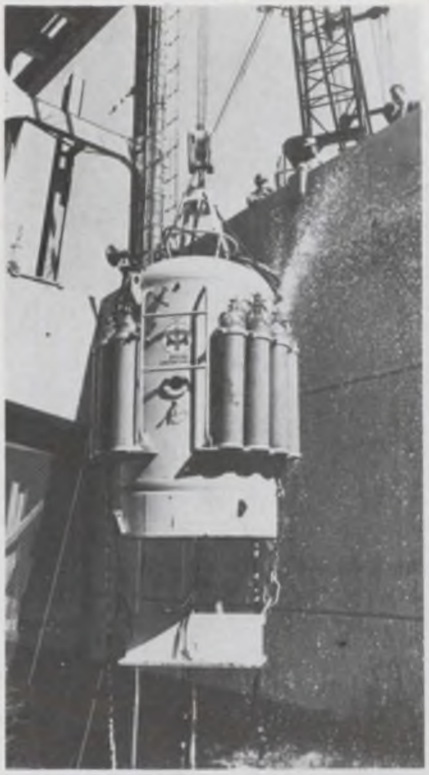
Simultaneously Dr. Robert Morse, Assistant Secretary of the Navy for R&D, has been designated the focal point for department-wide policy supervision of all ocean engineering. He will become chairman of the new Navy Oceanographic Policy and Programs Board in addition to his other offices.

Under the changes, DSSP will assume the status and acquire the prestige of such projects as Polaris, Antisubmarine Warfare, F-111B (Navy version of TFX) and the all-weather carrier landing systems project.

Communications problem critical

The Sealab II demonstration took place last fall off LaJolla, Calif. Aquanauts lived and worked in the deep ocean for 15 to 30 days. As in the case of Sealab I (off Bermuda), the living quarters were in a tank, with a bottom entrance to the ocean. The crew lived in highly pressurized "air"—largely helium —trapped in the upper portion of the tank. The helium replaced nitrogen and thus prevented nitrogen narcosis.

But it was the helium content of the atmosphere that created many of the communication problems that were widely publicized. Because of the much higher speed of sound in helium, human speech acquired characteristics that were described as "Donald Duck-like." Even after 15 days (and in the case of Aquanaut-Astronaut Scott Carpenter, 30 days), the crew could not adjust to the strange speech to the extent that critical instructions could be issued verbally. This was especially true of diver-to-diver instructions outside of the Sealab shirt-sleeve atmosphere. The aquanauts had to fall back on finger sign language and rapping on their oxygen tanks, and this held their total vocabulary to less than a dozen words. Commander Carpenter had some bitter words on this count:



Dam repair work was done using a Westinghouse-built chamber under 200 feet of river water. Workers lived under pressure in the hoisted chamber for a week.

"We desperately need a research program to develop a reliable diver-to-diver communication system that does not encumber him with wires and does not compromise the performance of his breathing apparatus."

Carpenter contrasted the jerry-built, "gee-whiz, it worked" man-in-sea program with the well-funded man-in-space program and summed up the difference in possible emergencies this way:

"A diver's most urgent cry—mayday—can be uttered only with four fingers or four raps. And the raps don't carry very far."

Sealab III due in early '67

Acting Manager Craven indicated that several improved pieces of equipment were under study and likely would be tested in Sealab III, which he announced would get underway "early in 1967." However, no new concepts are involved. Primarily the tests will involve rearrangement of communication equipment.

Dr. Craven also expects to test new suits in Sealab III. A unanimous complaint of the Sealab II crew was that of bitter cold in con-

(Sealab, continued)
ventional diving suits. The crewmen want suits heated either by circulating warm water or by embedded wiring. A Sealab-like crew that repaired a Virginia dam recently wore suits heated by warm water circulated from a surface source. Dr. Craven indicated that a similar suit would be tried by his men. The suit may use water heated by an isotope source that would replace one weight on the diver's belt.

Visibility nearly impossible

Sealab II divers found the visibility below 200 feet to be almost too poor for effective work, even with the best available lighting. When bottom conditions were good, the best lighting was effective only up to about 20 feet. However, when the divers were trying to work, and stirring up sediment, visibility was often less than five feet. It was virtually impossible to leave the immediate sealab vicinity for exploration, although some excursions were made with long lines to guide the divers back. However, long lines are considered not reliable and not practical for working divers.

Dr. Craven revealed that a program to improve the lighting was under way, based on better use of existing lighting. Capitalizing on the light-wavelength "window" in underwater visibiity at 4800Å, Sealab III is expected to feature a rotating green beacon to help guide its divers back home. In addition battery-powered green markers will be set out and anchored to light paths from the underwater tank to work areas.

Sealab I has not undergone extensive external changes in the new configuration. Bermuda was the scene of the first eight-day undersea living experiment.

Dam work uses same technique

Private industry has a stake in what is being learned in the Sealab program and already is capitalizing on it. Marine Contracting, Inc. of Connecticut used the Sealab technique of underwater living to repair Smith Mountain Dam near Roanoke, Va. Using a system developed by Westinghouse, divers working 200 feet underwater lived in a pressure chamber atop the dam and were transported in a pressurized capsule. (See photo on p 23). They were able to work normal shifts for a week, and they underwent long decompression only once, at the end of their week.

Decompression time varies only with the depth to which the diver has descended and is not a function of the length of his stay. A diver who has descended to 200 feet needs about six days to decompress, whether he was there for a half-hour or for a week, the Navy has learned. ■ ■

(airborne phone, continued)
Corp. and AT&T, except that the latter does not go along with Motorola's claim that FM can give 24 to 30 channels, with provision for a 900-Hz doppler shift and a 900-Hz frequency error at Mach 1 speeds.

Meanwhile, sentiment in the electronics and aeronautical industries, both among RTCA members and non-members, is mixed. Here is a sampling of views expressed (off the record) to ELECTRONIC DESIGN:

"The present FM system is totally inadequate for airline use."

"The present system is of great use to private aircraft and should be continued and expanded, at least until something better comes along."

"FCC does not want to expand the FM system usage. They are afraid it will become too firmly implanted."

"The RTCA time schedule for implementing the ssb system is too pessimistic. Everything needed is in operation in one form or another. It's just a matter of putting it together."

"Let's expedite the system to make FCC look favorably on ssb."

"The determining factor is getting an operational ssb system. It is not a technical one. It is of a political or financial nature."

"Think of what would happen if telephone companies decided to drag their feet."

"The big electronics companies are just stalling for time. They have their own ssb systems under development and do not want us little guys—who are ready to go now—in on the kill."

"If and when the FCC ruling on the ssb system comes, it must be written in such a manner that every company with a capability in the field gets a chance."

The FCC is under pressure from many quarters to make up its mind. Waiting eagerly for that decision are the land and marine mobile communications industries, which want the frequency spectrum now alotted to air-ground radiotelephone, to widen their own markets. And, as if the external pressures were not enough, there is disagreement even within FCC. Three commissioners—Rosel H. Hyde, Robert T. Bartley, and Robert E. Lee—dissented when the Notice of Proposed Rule Making for the ssb system was drafted. ■ ■

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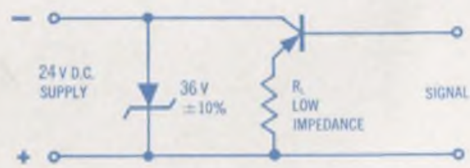

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Batch diodes apply beam-lead method

Batch fabrication of semiconductor devices—diodes now and transistors and integrated circuits in the future—has been advanced by application of the beam-lead technique.

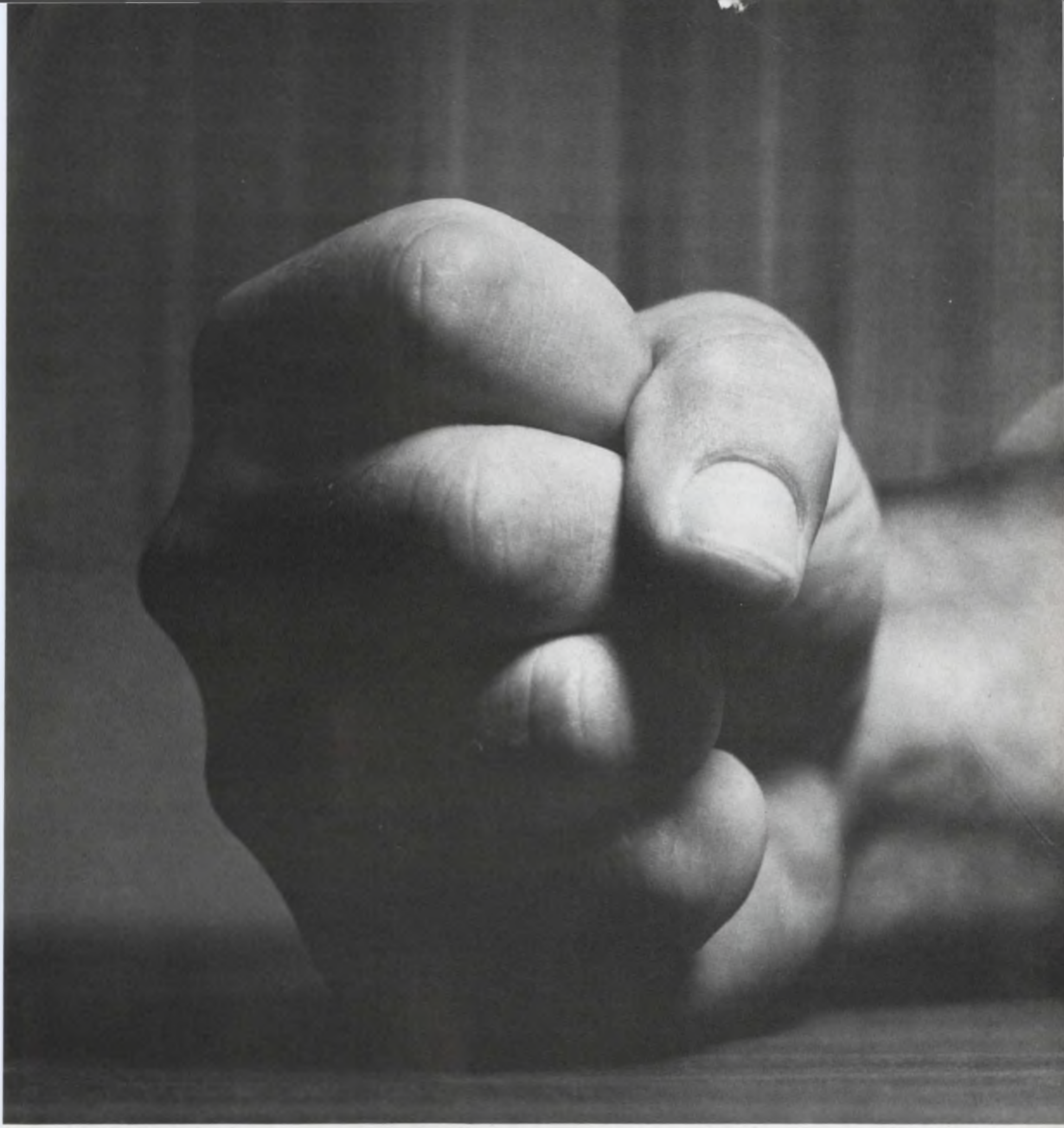
The fabrication method, developed at Bell Telephone Laboratories about a year ago, will be used first in a line of diodes put out by the General Instrument Corp. of Newark, N. J. The major benefit of the beam-lead approach is a potential cost savings. So far, however, General Instrument has not disclosed its immediate pricing plans.

A spokesman at General Instrument says that the technique increases reverse breakdown voltage as much as 10-15 volts in the 100-volt region.

Samples of the "Herculead" beam-lead diodes are available from the manufacturer. ■ ■

Stroller for astronauts

Astronaut Maneuvering Unit for Gemini 9 (under test above) will permit astronauts to venture up to 1000 feet from their spacecraft and remain outside for up to an hour. Developed by Ling-Temco-Vought Corp., Dallas, Tex., the 160-lb backpack includes self-contained life-support, communications, telemetry, propulsion and both manual and automatic stabilization systems. The astronaut will maneuver on a long tether but otherwise will not be dependent on the mother ship.



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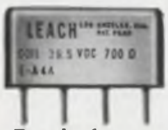

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Lithium batteries promise high yield

A lithium electrode has been used with success in a prototype battery of potentially striking capacity.

The battery reportedly yields 100 Wh/lb— four times the capacity of nickel-cadmium batteries. The yield is higher than today's highest-capacity silver-zinc types. And the 10 amp-hour prototype has exhibited only one-sixth of its theoretical capacity, according to Dr. Robert Shair, vice president of research and development for Gulton Industries, Metuchen, N. J.

Lithium cannot be kept in air, and it reacts strongly with water, so a propylene carbonate electrolyte must be hermetically sealed into the battery. A good electrode consists of a lithium paste applied to a nickel mesh, according to Dr. Shair.

In this prototype the positive electrode is a mixture of nickel fluoride, carbon and powdered metal. Gulton designers included the two latter substances to lower the resistance of the electrode. Further investigation may uncover better positive electrode materials, among the other halides, Dr. Shair said.

Although the developers have successfully recycled the batteries hundreds of times, they have observed some deterioration of the electrodes. Dr. Shair feels that even though a good deal of engineering must yet go into the battery, Gulton should be able to market a commercial lithium battery within two years.

"We foresee a lithium battery so efficient that it will compete with fuel cells for supplying power for a long time in inaccessible equipment," He said. ■ ■

Accuracy is our policy

Equation 2 for "Graph speeds calculation of skin effect" by L. D. Jambor in the November 8 issue, page 51, which also appeared in an accuracy statement in the November 22 issue, should be corrected by a factor of $\frac{1}{2\sqrt{\pi}}$ to read:

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}}$$

Also in the accuracy statement, $1/\epsilon$ — should merely be $1/\epsilon$.

ELECTRONIC INNOVATIONS IN SEMICONDUCTOR PRODUCTS

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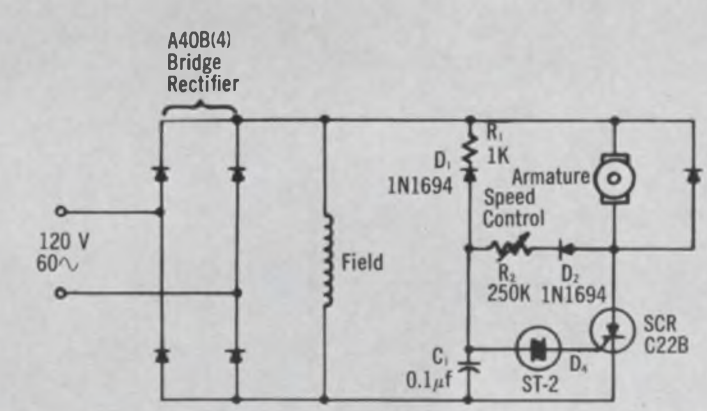
More detailed information on this and several other d-c motor control circuits may be obtained by writing your G-E representative for our Application Note 200.44.



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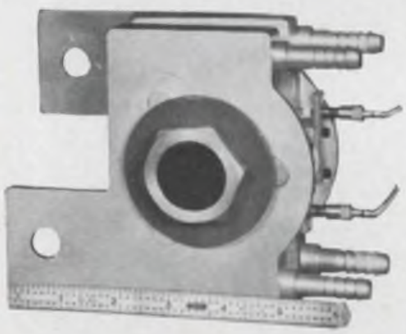
The rating of this SCR switch, the C500X1, is 1200 Amperes RMS, 1800 volts peak in both directions. It can be used directly on 440 or 550 volts a-c service. The all-important surge rating is 4000 Amperes peak for 10 cycles.

You'll find it ideal in severe switching applications such as contactor replacement, primary phase control for plating, battery charging, welding, induction heating, and power supplies as well as for a-c motor speed control.



G-E Water-cooled AC Solid-state Switch

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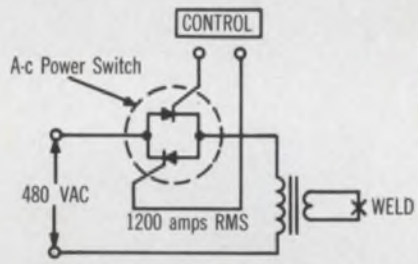

Switch Used in Welding Application

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GENERAL ELECTRIC

First the moon, then what?

Washington Report

S. DAVID PURSGLOVE, WASHINGTON EDITOR

Academy proposals upset NASA

National Aeronautics and Space Administration officials are privately disturbed by the National Academy of Science's recommendations for the space program in the 1970's and early 1980's. NASA had looked forward to the report—"Space Research: Directions for the Future"—as an outline of post-Apollo programs backed by the most influential elements of the scientific community. The space agency still does not have any approved major programs beyond the landing of Americans on the moon. The academy report, which has just been released, was looked to as a guide that would support the agency's funding requests. However, the report plays down manned programs. Its emphasis is on unmanned scientific probes.

The report affirms the Space Science Board's earlier recommendations that the unmanned exploration of Mars should have first priority in the post-Apollo period, with more detailed investigation of the moon's surface and the unmanned exploration of Venus playing secondary roles during that period. However, the new report goes further by completing the priority list in this order: other major planets; comets and asteroids; Mercury; Pluto; interplanetary dust. The academy envisions the use of NASA's large rocket boosters to send instrumented probes to the farther planets, but it fails to dwell on any manned flights other than a continuation of manned lunar surface studies.

MOL in danger

NASA has found some consolation in indications of the Administration's apparent downgrading of the Air Force MOL (manned orbiting laboratory) program. The funds cut from MOL will not go to NASA; however, a slowed or terminated MOL program keeps NASA supreme as manager of America's space activities. A successful Air Force MOL program and a NASA without major national goals beyond Apollo could conspire to turn the total U.S. manned space effort to the Air Force. Although NASA is grateful for the reprieve represented by the MOL slowdown, some observers believe the civilian agency may yet be required to bow to the Air Force in the area of manned space programs.

Safe car buffs staggered by Staggers

Administration supporters of President Johnson's planned program of centralized research on highway safety are somewhat glum over recent remarks of the new chairman of the House Commerce Committee, Rep. Harley O. Staggers (Dem., W. Va.). He spoke at a Washington breakfast given by the Ford Motor Co. at a time when newspaper criticism of alleged unsafe automobile design was at a peak. Ford sponsored the breakfast to announce a newspaper advertising campaign to urge motorists to drive more safely and to publicize the automobile industry's design advances. Congressman Staggers spoke only briefly, but long enough to discourage officials who had hoped the House Commerce Committee would continue the push begun under its retired chairman, Rep. Oren Harris, to persuade the industry to design safer vehicles and to incorporate advanced safety devices. Rep. Staggers' theme: "The human factor in auto accidents is the great problem." The comment has cooled hopes that the current session would see passage of bills promoting research on new roadside and car-mounted warning devices.

Does war promote plowshare business?

Analysts of the defense industry in the many Washington-based "thinking factories" are pondering a viewpoint that emerged from the recent Paris meeting of science advisors to the member governments of the Organization for Economic Cooperation and Development. A study submitted to the meeting by Europeans showed that while there is some spin-off from military R&D to civilian technology, the same result could be achieved more efficiently by pumping the money directly into civilian R&D in the first place. U.S. Presidential Science Advisor Donald Hornig believes that many civilian industries that otherwise would remain in the distant future are actually created now by military and space programs. A new round of high level studies on the impact of military R&D on civilian industry is expected.

Letters

Licensing exams for engineers? Readers are split on the issue

Sir:

Our attention has been called to the editorial in your issue of Nov. 8, 1965: "The Engineer's License—Is it Worth It?" We are always pleased to observe the attention given to engineering registration in the many technical publications of this country, but we regret that in this case there are a number of misstatements.

The purpose of registration laws is only secondarily to uphold a high standard of qualification and ethical practice, except to the extent that these virtues are necessary to carry out the real purpose of the law, which is to protect the public health and safety.

Admittedly registration laws are not perfect in eliminating the incompetent—whether doctors, lawyers, CPA's or other professionals. Certainly, however, experience demonstrates that an examination and licensing procedure to protect the public health and safety are necessary. We hope that you do not suggest that "Tom, Dick or Harry" be allowed to perform engineering services for the public without any proof of qualification. And if the state does not administer the licensing procedure, who should do it?

Before a person can be a specialist in any field he must acquire a knowledge and understanding of the basics of his calling—specialization comes later. . . . The registration boards have wide discretion in formulating the examinations, and in every case the state board provides a variety of examinations to cover particular fields of knowledge and experience.

The suggestion that the various engineering disciplines be noted on each license is a step backward by about 20 years, at least. This was the practice in the early days of registration, but the profession has rather uniformly come to the conclusion that engineering is one profession and should be so identified on the certificates. In our present complex engineering world, it would be impossible to designate every field and branch—in one jurisdiction the board lists some 118 fields of engineering knowledge and practice for examination purposes—but those who pass the examination selected are identified on their certificates as "professional engineer."

None of these comments is meant to imply that registration has reached the point of perfection—far from it. The profession can stand, and sorely needs, all the constructive help it can obtain to improve the registration laws, examinations and procedures. To that end, we warmly welcome your continued interest.

Paul H. Robbins, P.E.
Executive Director
National Society of Professional Engineers
Washington, D. C.

Sir:

Re: Nov. 8 editorial by Maria Dekany. Today is the age of specialization. It becomes more apparent each day that highly specialized skill in a particular area is more valuable than generalized knowledge over a large area. Why should the Electrical Professional Engineer (EPE) be concerned about the stress and strain characteristics of beams, the work of the MPE (Mechanical Professional Engineer)? Or fluid mechanics, the work of the Civil Professional Engineer (CPE)?

Thanks again for airing a subject that needs to be reworked, rearranged and revitalized.

William K. Lacy
General Electric Co.
Huntsville, Ala.

take as needed

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ON READER-SERVICE CARD CIRCLE 18

(License exams continued)

Sir:

I wholeheartedly concur with your analysis of the engineer's license situation, as stated in the Nov. 8, 1965, issue of ELECTRONIC DESIGN.

But in addition to writing editorials, what can you or the nonlicensed engineers do about this?

Howard H. Manko
Director
Solder Research & Development
Alpha Metals, Inc.
Jersey City, N. J.

Sir:

I read with interest your editorial, "The Engineer's License—Is It Worth It?" (ELECTRONIC DESIGN, p 18, Nov. 8, 1965). . . . However, I must say that I take exception to the statements you make about facts concerning the professional engineering examination.

The basic reason for the licensing procedures is not to "reward long experience" nor to "favor new graduates" but to protect the public safety. The reasons for the engineering license are exactly analogous to the reasons for licensing physicians and lawyers; the same New York State Board of Examiners administers these licenses as well as the license for engineers. In most cases no one will fail to agree that a written examination will tend to favor new graduates, who are closer to the fundamentals of the subject matter than are men who have been out of school for some time and have not kept themselves informed on these fundamentals.

The professional engineering license is not granted solely on the basis of the performance given on a written examination but, in general, by the following procedure (I give only the salient points):

1. Passing Parts I and II of a written examination based on a general knowledge of structures and a selection of questions from at least two areas of the engineering field.

2. The candidate must then show evidence of having per-

(continued on p 38)

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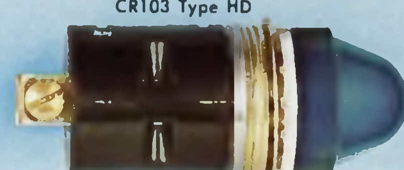

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(License exams continued)

formed a high standard of engineering work for at least four years (graduate studies may be counted toward this). The acceptability of the work is judged by the board of examiners, and, if acceptable, the candidate is permitted to take Part III of the examination. Part III requires a knowledge of engineering economics and a fairly deep knowledge of some engineering specialty.

If one examines the component problems which are involved in the design of even an elementary structure—such as, say, a small residence—it will be noted that they are structural, electrical, thermal and chemical in nature. Does it not, therefore, seem reasonable that the engineer who is to accept the responsibility of signing the design plan should be "familiar with a wide variety of subject matter," even though he cannot be expected to be expert in more than one or two areas of specialty?

A simple perusal of the examinations given in past years will indicate that they have, in fact, been brought up-to-date in terms of the problems that have to do with facilities wherein the public safety is concerned. The examination does not pretend to qualify candidates for high-level research positions or for advanced degrees in engineering.

A chief reason why many fail the professional engineering licensing examination is the lack of serious preparation. Too much dependence is placed on the fact that the examination is an open-book type, and, as a result, many candidates spend too little time actually studying the pertinent subject matter. Those of us who concern ourselves with this problem are constantly urging students to prepare adequately for what is actually not an easy examination for the average engineer (even those just fresh from the classroom).

To aid those who have been out of school for some time, the engineering societies run an entire sequence of review courses designed specifically to prepare candidates for the exam. I was therefore very disturbed to see your editorial dismiss the examination as a hodgepodge and, in the case of the electrical field (traditionally one of the most difficult subjects for students), one which "can be passed with a knowledge of Ohm's law—etc." You will have done any potential candidate for the exam, who believes this, a great disservice if he uses this information to convince himself that he need not prepare to any great extent for the exam; this will be especially true in the case of new students. What student does not reach out for any statement which he can use to rationalize his inattention to a program of study?

In closing, I will mention that I do agree with you in that the engineering license ought to state the specialty of the licensee, although I would personally not like to see the examination itself become less broad in scope than is presently the case.

Velio A. Marsocci
Associate Professor of Engineering
State University of New York
Stony Brook, L. I., N. Y.

NSPE: our readers answer our readers

Sir:

Mr. Freeman and I were pleased to have provoked the criticism in Mr. Biega's letter to ELECTRONIC DESIGN (Dec. 20, p 19).

We readily agree that the National Society of Professional Engineers works to elevate the image and professional standing of engineers. The trouble with NSPE is that it admits only professional engineers (PEs). When Mr. Biega refers to the "low level of support [given to NSPE] by the engineers themselves," he overlooks the fact that engineers are unlikely to support NSPE when they are not even entitled to membership. What support should a non-member give? Should he write encouraging letters, or send donations, or perhaps attend meetings and applaud?

The real question is which of these two alternatives is feasible:

1. 80% of American engineers should spend a semester reviewing academic material that is otherwise useless, just to take the PE exam and join NSPE; or,

2. NSPE should alter its membership requirements to admit unlicensed engineers.

The answer is clear, because NSPE is now considering admitting unlicensed engineers. Thus the onus is *not* on the engineers for failing to support NSPE.

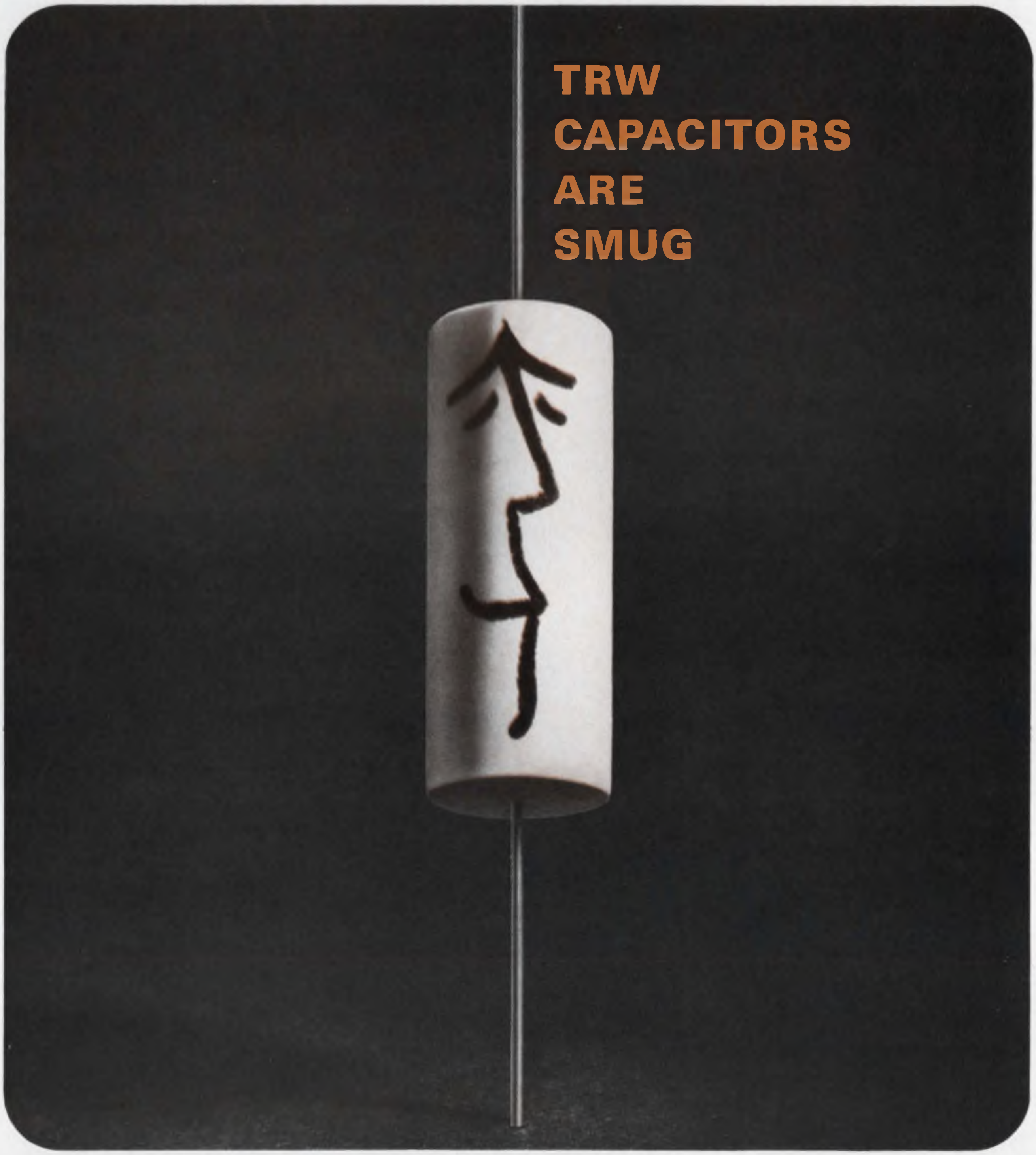
There is a period in every engineer's career when he is much in demand. This is when he has between two and ten years of experience. The average engineer in this country is about 40 and has over 15 years of experience. Most companies would be reluctant to fill their ranks with senior engineers at over $12,000 each. This would be "too many chiefs and not enough Indians."

How do companies assure an ample supply of young engineers? By publicizing the alleged shortage of engineers, thus hoping to attract greater numbers of youths into engineering college. In six years these youths will have B.S.'s and two years of experience, and they'll alleviate the "shortage." But what about 20 years later—where will they be then? There's no shortage of 40-year-old engineers, except men with certain specialties on the frontier of R&D. The average engineer of 40 has far less demand for his skills, and at 50 he has almost none. Apparently the best security is to find some way of remaining 30 years old until retirement. A practical alternative is for engineers to form a strong professional association.

Any organization which seeks to improve the professional standing of the engineer must disillusion the general public by publicizing the complete story about the shortage of engineers. We sincerely hope that NSPE will exert effort in this direction.

We are also grateful to ELECTRONIC DESIGN for providing a forum for these ideas, which do not necessarily reflect the ideas of our employers or co-workers.

Robert Bruce
Jay Freeman
Great Neck, N. Y.



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TRW CAPACITORS

ON READER-SERVICE CARD CIRCLE 23

We're indebted to you . . .

We're happy. Why shouldn't we be? You all but overwhelmed us. We asked you, Do you like ELECTRONIC DESIGN's new format? Your answer: Emphatically, yes, More than 4300 reader-reaction cards were returned to us within 10 days of delivery of the January 4 issue. A majority of more than 100 to 1 expressed enthusiastic approval of the timeliness and quality of our "new product". Many sound observations and suggestions were made. Let me review our initial analysis of your comments and how we are reacting to your suggestions:

- SIZE AND FORMAT. A comment from a subscriber at Sperry Gyroscope Co. was echoed by the thousands—"New size and format easier to hold, easier to read, easier to clip and file, and looks more professional." Of the 4346 cards received, 4308 readers expressed satisfaction while 38 felt that we lost identity and thus made it difficult to quickly sort ELECTRONIC DESIGN from a pile of magazines.

- ADS BETWEEN TECHNICAL ARTICLES. Most readers pinpointed the functional interspersing of ads between articles in the Technology section, typified by a comment from a Union Carbide engineer—"Appreciate not losing the first page of an article following previous one." However, a number of readers indicated a preference for ads grouped at the front and back of the issue, with news and articles in between.

By placing ads between feature articles and technical departments, it is possible to clip one story without destroying its neighbors. We intend to follow this approach for all you "cut and file" readers (and who doesn't cut and file?).

- INSERTS. Although the number of objections to inserts was low, the intensity was quite volatile. Said one reader from HRB-Singer Inc., "Don't like heavy sheets between articles, makes it hard to read."

Hereafter, inserts will be positioned to minimize reader inconvenience.

- WIDE MARGIN TO ALLOW HOLE PUNCHING. Many readers file their articles in loose-leaf binders and, as a subscriber from The Martin Co. suggested, "Keep the inside margin wide enough for punching".

This factor was considered in the redesign. If you carefully tear or clip each page at the inside edge, there is sufficient space for binder holes. Try it and see. Also note the use of a "perfect binding" process (use of glue on each individual page) to simplify page removal.

These are just for openers. You have stirred us with your laudatory remarks, alerted us to your very specific needs and enlightened us to our failings.

To the thousands of you who took the time to write, sincerest thanks from all of us.

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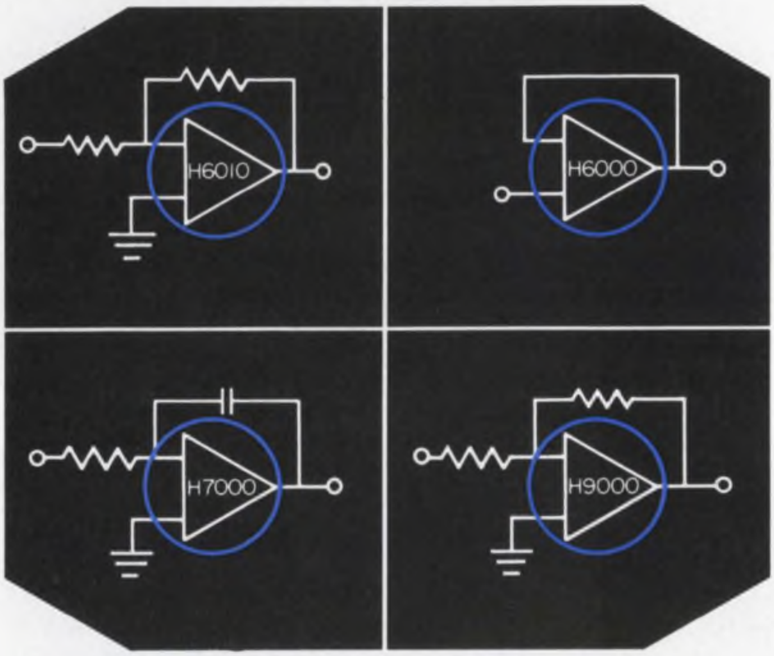

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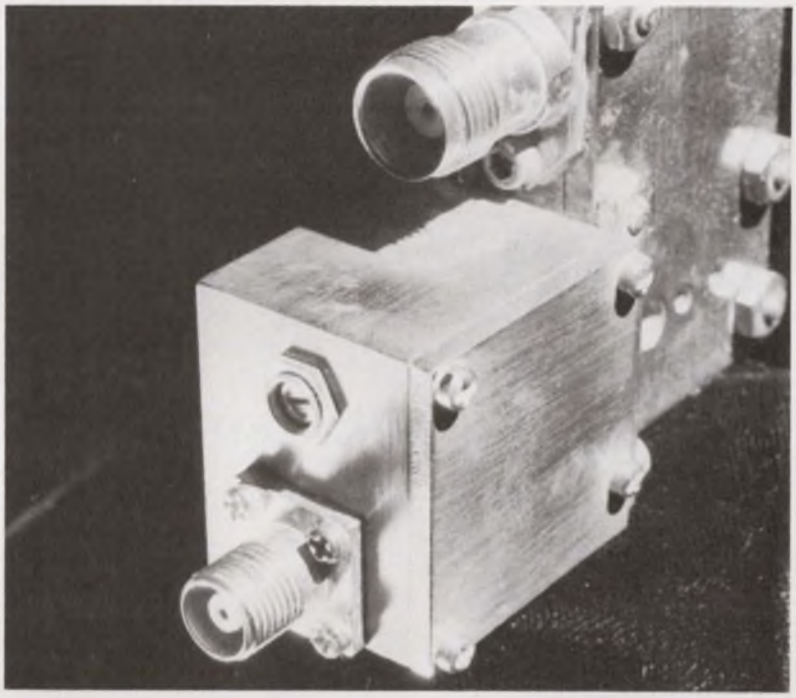
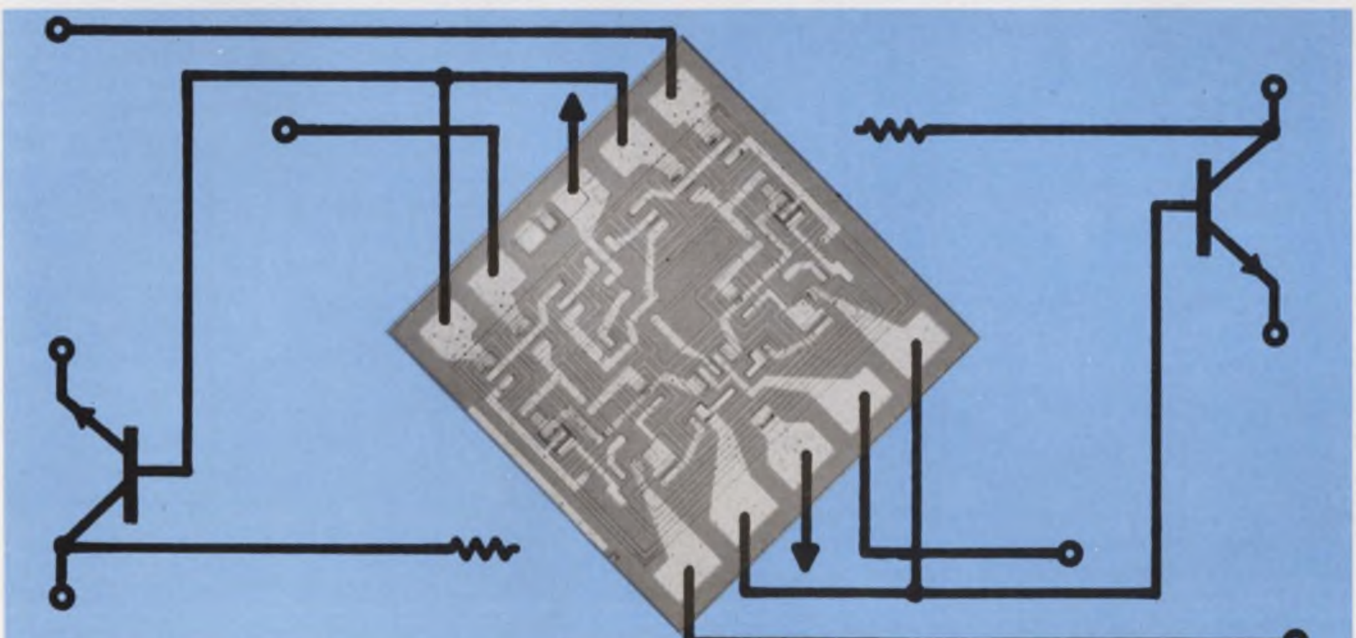


Up frequency with step-recovery diode . . . 44



Discrete components modify off-the-shelf ICs . . . 56

Design efficient multipliers with
the step-recovery diode. For high-order harmonic generation, it's efficient, simple and has low noise.

For high-order frequency multiplication, step-recovery diodes prove to be the all-around champions. Multipliers designed with this type of diode turn out to be more efficient,[1] less noisy, simpler to build and more adaptable to integrated circuits than multipliers using varactor diodes.

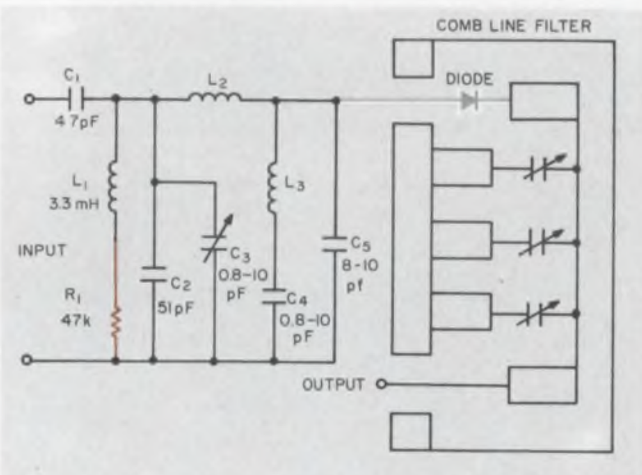
There is no need for idler circuits, and many of the possible modes of parametric oscillation are eliminated.

These compact multipliers, when combined with a stable oscillator, are especially suited as local oscillators in transponders and in other miniaturized microwave receivers. Another major area of application is as low-power transmitters.

The design of step-recovery-diode multipliers is straightforward once the proper diode has been selected.

The primary reason for the effectiveness of this diode is that it is a charge-storage device, with characteristics that closely approximate a perfect nonlinear capacitor.[2] When conducting in the forward direction, the diode stores charge. When the applied signal reverses, the diode conducts for a brief period and then abruptly ceases conduction, producing a waveform rich in harmonic content.

Nick Jansen, Senior Engineer, Motorola Military Electronics Div., Scottsdale, Ariz.



Multiplier circuit is designed for an input frequency of 131 MHz and an output frequency of 2096 MHz. Finding the optimum value of bias resistor R_1 proved to be essential. Even minor deviations from the experimentally found optimum of 47k noticeably reduced the multiplier's conversion efficiency.

Now the primary limiting factor of the step-recovery diode is its power-handling capability. Most available diodes are in the 70 to 100 mW range, with a few having a 1-watt upper limit. Devices with a 2-watt power-output capability at S-band are expected to be commercially available soon.

What are the basic building blocks?

An efficient step-recovery-diode multiplier circuit consists of five basic subsystems:

1. A low-pass or bandpass input filter at the fundamental frequency.
2. A coupling network to transfer the source impedance (normally 50 ohms) down to the impedance presented by the diode (normally 1-10 ohms).
3. The diode and associated bias network.
4. A coupling network to transform the diode impedance to the level of the output circuit.
5. A bandpass output filter at the output frequency.

The input filter and input impedance transformer prevent the harmonic frequencies generated in the diode from coupling back to the primary oscillator and provide conjugate match to the primary oscillator source at the desired input frequency.

The combined effect is the isolation of the nonlinear load reactance of the diode from the primary oscillator. Hence, the primary oscillator will not generate harmonically related ac components.

The output impedance transformer and the bandpass filter must provide high-Q energy storage at the output frequency, match the diode's impedance to the load and provide a reactive termination to unwanted harmonics.

The design of the filters and the impedance transformers is conventional and therefore does not require discussion. Selecting the best diode for the job, however, is not so simple.

The significant device characteristics that should be evaluated when selecting a step-recovery diode are:

- R_s, the series resistance of diode.

- C_j, the junction capacitance.
- τ, the minority carrier lifetime.
- T, the transition time.

Primarily, efficient frequency multiplication depends upon τ and T. However, the selected diode should have a low R_s, and C_j should be low enough so that the diode will self-resonate above the desired output frequency.

The storage time should be as large as possible, since it determines the amount of stored charge during forward bias.

The transition time—the time needed for the diode to recover from a stored-charge condition to a reverse-biased condition—limits the frequency of operation.

For efficient operation, the following conditions must be satisfied:

$$\tau > \frac{1}{f_{in}}, \text{ and } T < \frac{1}{f_{out}}, \qquad (1)$$

where f_{in} is the input frequency and f_{out} is the output frequency.

To assure good conversion efficiency, the minority-carrier lifetime, τ, should exceed the input frequency period by a factor of three.[2] For example, if the product of $Tf_{out} < 0.2$, a conversion efficiency of approximately 40% can be approached. To illustrate the sensitivity of the design, if Tf_{out} is 0.35, the harmonic power output will be 6 dB down from the input amplitude and will be further attenuated 6 dB per octave above f_{out}.

Let's take as a practical example, the design of a 16X multiplier (see illustration). The fundamental frequency is at 131 MHz, the output frequency is to be 2096 MHz. The diode we selected for this multiplier (hp associates, Type 0116), has a minority-carrier lifetime of 30 ns and a transition time of 100 ns.

Applying the previously established criteria, we find that:

$$\tau f_{in} = (30 \times 10^{-9})(131 \times 10^{6}) \approx 4.0,$$

and:

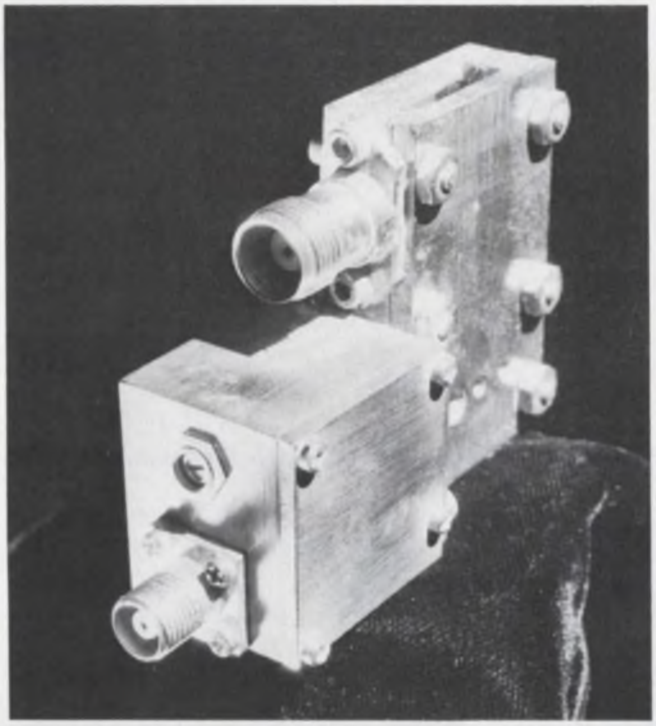
$$T f_{out} = (100 \times 10^{-12})(2096 \times 10^{6}) \approx 0.21$$

Therefore, theory predicts high conversion efficiency for this particular set of conditions.

Circuit design based on experiments

The input circuit of the multiplier is comprised of a 131-MHz lumped-constant bandpass filter (L_2, C_2, C_3), a line-to-diode impedance-matching network (L_3, C_4, C_5) and a bias circuit (L_1, R_1). We experimentally found the optimum value of the bias resistor to be 47k. Relatively minor deviations from this optimum value noticeably reduced the conversion efficiency.

To determine the optimum value of R_1, two variable resistors were connected in series. One provided a coarse adjustment, the other a fine adjustment. These potentiometers were adjusted for maximum power output at the desired harmonic frequency, consistent with a signal clear of spurious noise and parametric oscillations.



Multiplier package has an output frequency of 2096 MHz with an input at 131 MHz.

Since miniaturization was of importance, a comb line filter with a pass band of 40 MHz, centered at 2100 MHz, was selected for the output filter. The resonating elements of the comb line filter are only $\lambda/8$ long; hence, this filter is considerably smaller than an equivalent coaxial cavity or an interdigital filter. The measured insertion loss of the output filter was 1.9 dB, as compared with the theoretical loss of 0.8 dB. However, the walls of the filter were not polished or silver-plated, which would have reduced filter loss.

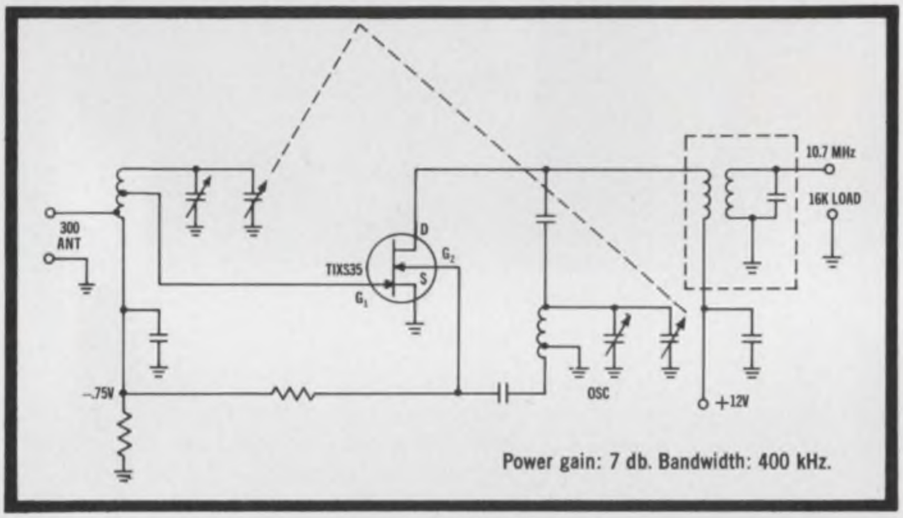
We obtained a conversion efficiency of −8.75 dB (13%), including the 1.9 dB loss in the output filter. Input signal levels up to 50 mW were applied without affecting the linearity of the output signal. The saturated power output of the Type 0116 diode is estimated by the manufacturer to be in the 60-70 mW range.

The measured 3-dB bandwidth is 40 MHz, which is identical to the pass band of the comb line filter. At the output terminal, the fifteenth harmonic is down 39 dB from the sixteenth. All other harmonics are 45 dB or more below the sixteenth. Harmonic content, generated by the multiplier at the input terminal, was measured for the second through the twentieth harmonic and was found to vary from a minimum of 28 dB (fourth) to a maximum of 63 dB (eleventh) below the applied 50-mW signal. ■ ■

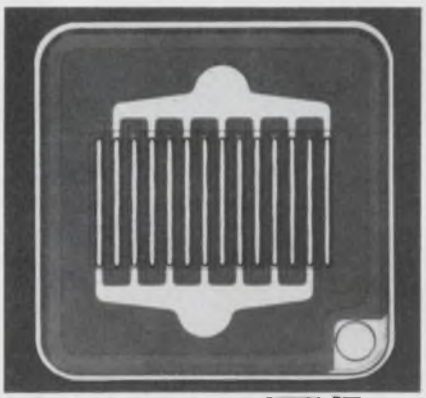
References:

1. R. B. Mouw and F. S. Coals, "Microwave Applications of the Step Recovery Diode," Paper V-8, 1964 PTGMTT International Symposium, New York, May, 1964.
2. R. Hall, "Harmonic Generation with Step-Recovery Diodes," HPA Application Note No. 2.
3. S. M. Krakauer, "Harmonic Generation, Rectification, and Lifetime Evaluation with the Step-Recovery Diode," *Proc. IRE*, July, 1962, p 1665.

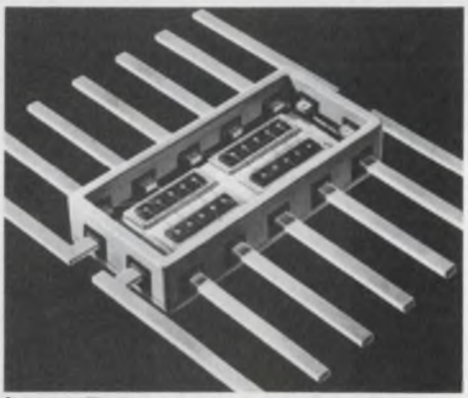
Six Semiconductor Innovations Help



1. Unique autodyne mixer employs TIXS35 FET which functions as both mixer and local oscillator.



2. Symmetrical geometry of TIXS33 FET.



3. Up to 20 diodes may be packaged in a single case.

TI cannot assume any responsibility for any circuit shown or represent that they are free from patent infringement.

1. New tetrode FET attains 8000 μmhos

Very high transconductance, frequency capability into the uhf range — these are the major advantages you get with TI's new TIXS35 N-channel tetrode field effect transistors. These represent a two-to-one improvement over currently available tetrode FETs.

Transconductance is typically 8000 μmhos with substrate gate connected to source, and 10,000 μmhos minimum with gates connected together. Other characteristics: $V_{(BR)GSS}$ = 30 V min; C_{rss1} = 1.4 pF max; C_{iss1} = 8 pF max.

Isolation between gates minimizes "pulling" in mixer applications and greatly reduces skewing problems in AGC applications at IF. In autodyne mixer circuits like the one at left, the TIXS35 reduces circuit components. Circle 71 on Reader Service card for data sheet.

2. New N-channel FET features 60 ohms $R_{DS\ (ON)}$

TI's new TIXS33 field-effect transistor features a very low drain-source resistance of 60 ohms maximum. This makes it ideal for a wide range of switching applications such as low-level choppers and commutators as well as low- and medium-frequency amplifiers.

This planar epitaxial device offers high transconductance ($Y_{fs} > 12{,}000$ μmhos), high drain current ($>$ 25 mA), low leakage ($I_{GSS} < 1$ nA), and low capacitance ($C_{DG} < 5$ pF and $C_{ISS} < 20$ pF).

Symmetrical geometry makes drain and source leads interchangeable. This permits use in multiplex and sample-hold circuits and allows replacement of older devices with non-standard lead configurations. Package is the TO-72 (four-lead version of the TO-18). Circle 72 on Reader Service Card for data sheet.

3. High-density diode arrays save space, improve product

Custom monolithic and discrete diode arrays, combining up to 20 diodes in standard flat-pack, low-profile TO-5 and TO-18 packages, are available from TI.

Benefits include high-density packaging, compatibility with integrated circuits, uniformity of parameters, and close thermal tracking. Core drivers, diode AND gates, common-anode and common-cathode arrays are typical of devices that are available. Circle 75 on Reader Service Card for information.

You Improve Performance, Reduce Cost

4. New diodes employ oven for high stability, low cost

TIXD746 – 759 temperature-compensated reference diodes offer temperature coefficients as low as 0.001%/°C and voltage ratings from 3.3 to 33 volts. Cost is less than conventional multi-junction reference diodes.

The unique unit comprises a Moly/G® diode within a self-regulating polycrystalline semiconductor oven as shown at right. The oven holds 120°C within ± 8°C from —55°C to +100°C and within ±2°C from —10°C to +50°C. Temperature is held within 1°C over a 10% voltage change. The oven operates on 24 V ac or dc.

Typical applications include regulated power supplies, high-frequency crystals, differential amplifiers, and instruments requiring voltage reference. Circle 73 on Reader Service Card for data sheet.

5. Simplify assembly with TI customized light sensor arrays

Now you can reduce manufacturing costs, increase reliability, improve performance, and minimize optical crosstalk with PC-board light sensor and light emitter arrays from TI.

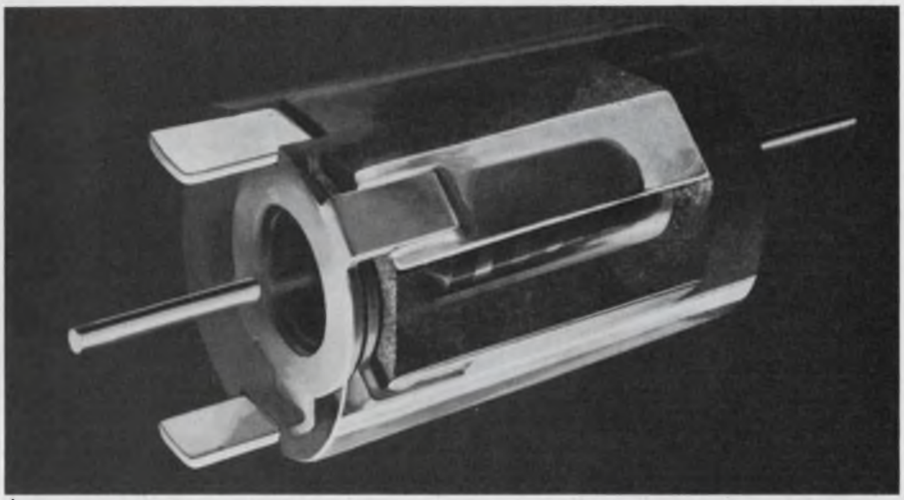
You can reduce assembly, testing and inventory costs because TI arrays are preassembled and pretested units ready for installation. Reliability is improved because PC-board design is inherently more rugged than individually wired sensing devices. All components are hermetically sealed for long life.

LS600 planar light sensors give high, uniform sensitivity. Typical output is 1 mA, light, and 0.01 μA, dark, at 25°C. Sensitivity can be matched to ±20% across arrays. Lens confines admission angle to 10° off axis, minimizing optical crosstalk with close sensor spacing. Circle 74 on Reader Service Card for information.

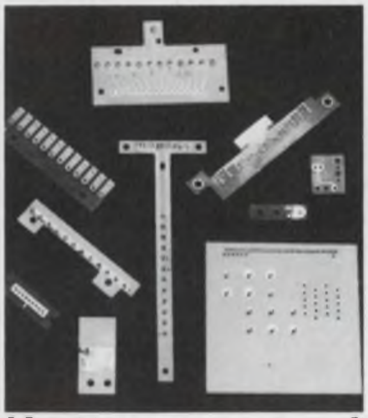
6. 400 V power transistors permit simplified circuitry

TIP04 NPN silicon transistors feature 400 volt minimum $V_{(BR)CBO}$ — permitting simplified circuitry for high-power line-operated equipment and circuits with inductive or capacitive loads.

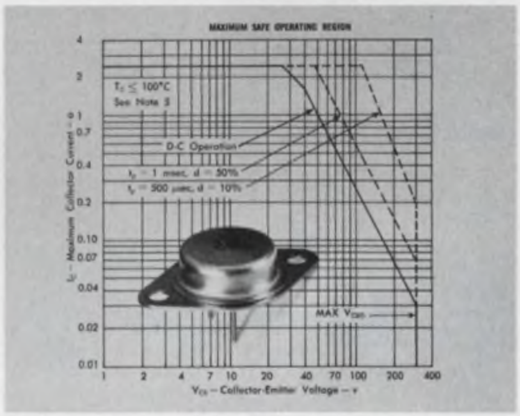
Low saturation voltage (1V max at 2A) gives high efficiency. Low leakage (I_{CEX} = 10 mA max at 400 V and 100°C T_C) permits high-impedance bias circuitry for high gain. Other features include an f_T of 3 MHz and fast switching speed. Circle 76 on Service Card for data sheet.



4. Unique construction of TIXD746 — 759 series temperature-compensated reference diodes.



5. Typical light sensor arrays produced by TI.



6. High voltage capability of TIP04 permits simple circuitry.

TEXAS INSTRUMENTS
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21658

Design coincidence detectors that are simple, yet reliable; that restore signal levels and provide the complement of the exclusive-OR.

In designing exclusive-OR circuits, it has always been considered essential to have the complement of the input signal. When it was not readily available, it was created by added circuitry. This approach to the design of exclusive-OR circuits can increase cost considerably, especially if many such circuits are needed.

The solution to this problem is a simple and reliable circuit, shown in Fig. 1 and in the photo.

It provides the complement of the exclusive-OR economically, restores signal levels and has high fan-out.

Basically the exclusive-OR circuit produces an output of a logic "1" when one and only one input is a logic "1," or:

$$Y = A\overline{B} + \overline{A}B$$

When there are more than two inputs, the exclusive-OR is commonly referred to as a modulo-2 adder. In this case the output is a logic "1" when there is an odd number of logic "1" inputs.

The truth table in Fig. 2 shows the operation of an exclusive-OR circuit and of the circuit in Fig. 1. It is clear from this table that a circuit providing the complement of an exclusive-OR is really a coincidence detector, since only when both inputs are identical will there be a logic "1" output.

Operation is simple

The logical "0" and "1" are assigned respectively to ground and to $+V$.

The technique is based on voltage division. The critical components in the circuit are R_3, R_4, R_5 and R_6. Resistors R_1 and R_2 are made equal.

When inputs A and B are at a logic "0", Q_1 and Q_2 are cut off and the output is $+V$. When one of the inputs is a "1" and the other is a "0," the input is a voltage source of $+V/2$ in series with $0.5\ R_1$.

R_3, R_4, R_5 and R_6 are selected so that point D becomes sufficiently positive to drive Q_1 into saturation, but Q_2 remains cut off. The output is now clamped to ground through Q_1.

If both A and B are at $+V$, then the driving source is a voltage of $+V$, through an equivalent resistance of $0.5\ R_1$. The voltage at Q_2 is now sufficiently positive to drive it into saturation.

When Q_2 is in saturation, point D is clamped to ground through CR_1 and Q_2. If Q_1 and Q_2 are high-quality-silicon switching transistors and CR_1 is a germanium diode, then the voltage at point D will be approximately 0.4 volt ($V_{CR1} = 0.2$ V, $V_{CE} = 0.2$ V).

Since the required V_{BE} to drive Q_1 into saturation is approximately 0.8 volt, Q_1 will be cut off and the output voltage will be $+V$. A V_{BE} of 0.4 volt might be sufficient to cause a small collector current to flow, thus degrading the output signal when A and B are logic "1"s.

Several remedies are shown in Fig. 3. All of these methods effectively raise the voltage difference between the required turn-on voltage of Q_1 and the clamped voltage at point D when Q_2 is in saturation. These modifications further increase the reliability of the circuit.

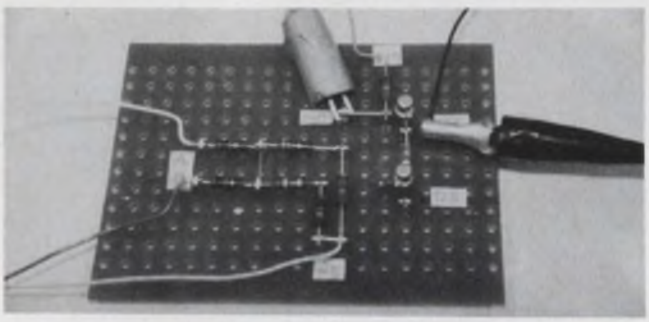
Note that in Fig. 3, only those portions of Fig. 1 are repeated which are modified by the added components, shown in white.

If there are more than two inputs, the circuit is readily usable as a multi-input coincidence detector. However, the input resistors must be carefully evaluated, to provide clear-cut voltage differences for the logic states.

To fully appreciate the advantages of the circuit in Fig. 1, let us introduce more conventional circuits used to generate the exclusive-OR.

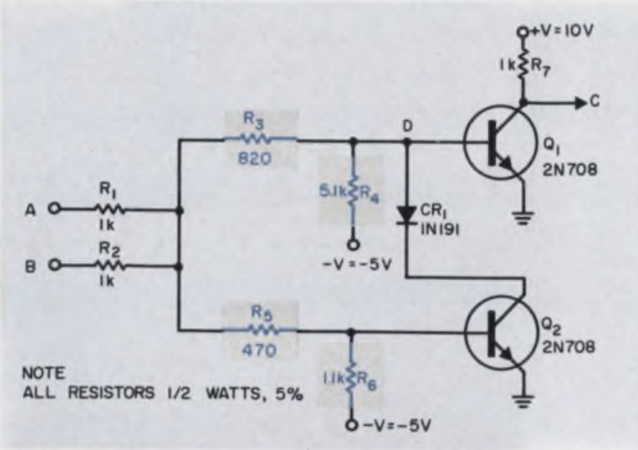
Even if the complement of the input is available, the circuits are complex, as shown in Fig. 4. If the complement has to be provided through additional circuits, shown with the dashed lines in Fig. 4, then expenses can really mount up.

With integrated circuits, Figs. 4b and c are somewhat more economical than 4a and d, because two types of cans will supply all the circuitry. For Figs. 4a and d, three different types of cans are needed, even though the circuits are simpler. Besides, the latter ones do not restore the signal level and have low fan out. Amplifiers are then advisable if they are to drive several circuits. ■ ■



Complement of exclusive-OR is provided by this simple circuit. Clamps tie components to test setup.

Gilbert I. Starr, Project Engineer, The Bendix Corporation, Teterboro, N. J.



1. **Economical and reliable circuit** functions as the complement of an exclusive-OR with the minimum number of components. Ground potential represents a logic "0"; +V represents a logic "1." Components critical to the operation of the circuit are shown in color.

Exclusive-OR and its complement

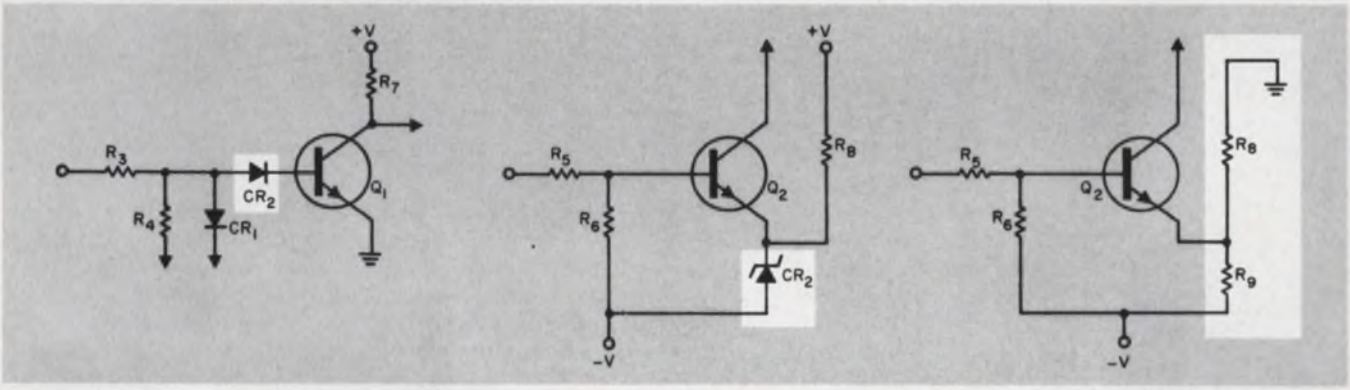
A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

(a)

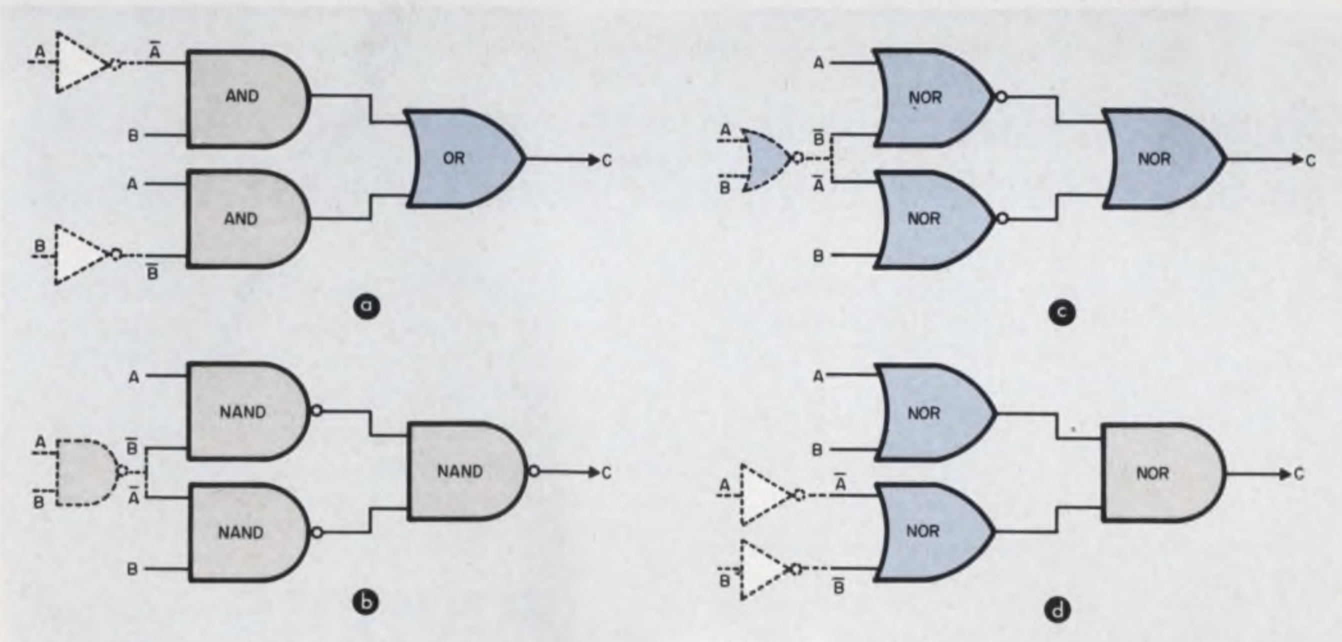
A	B	C
0	0	+10
0	+10	0.2
+10	0	0.2
+10	+10	+9.7

(b)

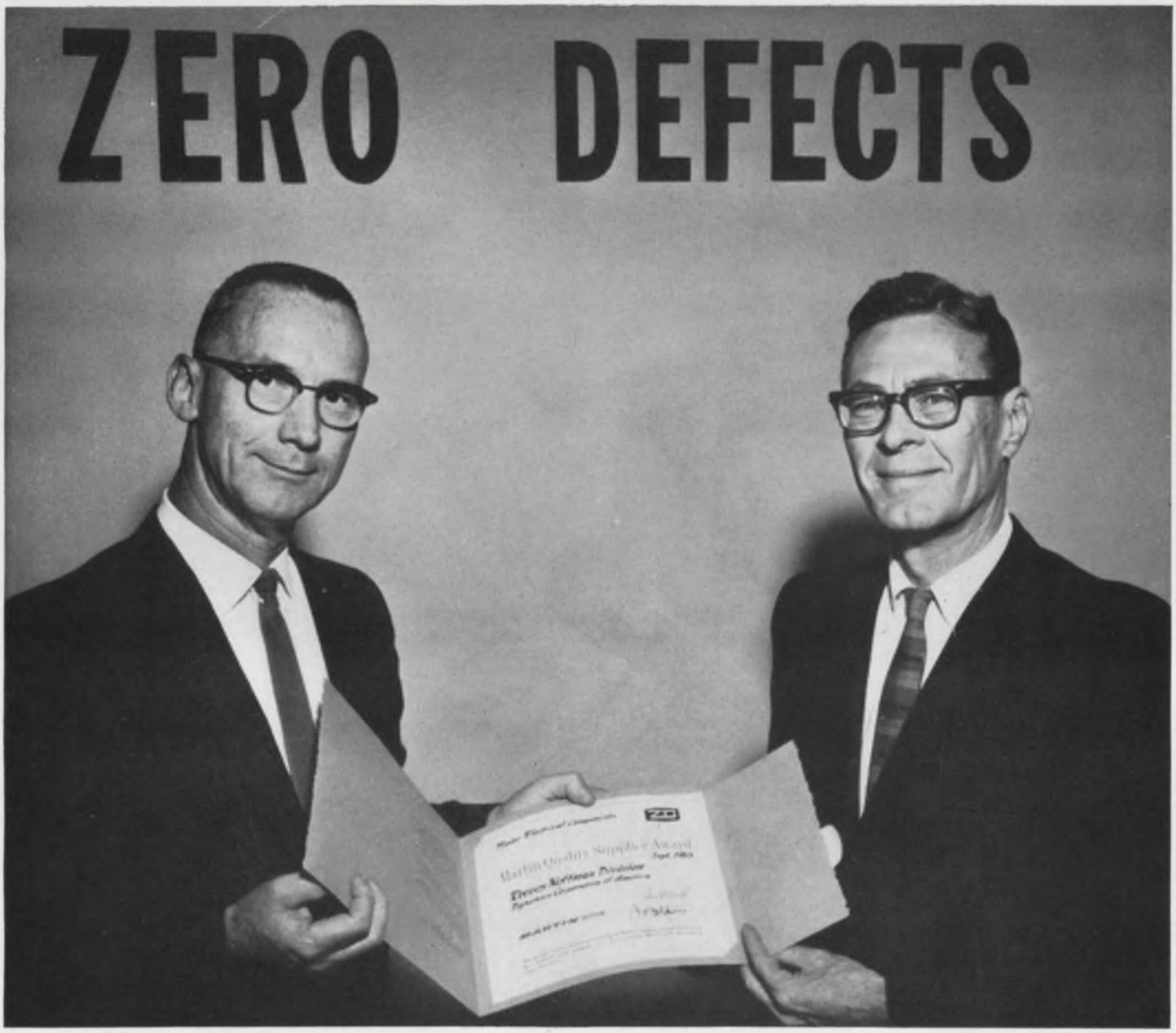
2. **Exclusive-OR** circuits produce an output of "1" when one of the two inputs is a "1" (a). The circuit in Fig. 3 has an output of +V, or logic "1," when both inputs are identical. This is the complement of the exclusive-OR. The circuit may also be used as a coincidence detector.



3. **Voltage difference** between the turn-on voltage of Q_1 and the saturation voltage of Q_2 can be increased with either one of these circuits. This modification, indicated in white, increases the reliability of the circuit in Fig. 1.



4. **Exclusive-OR circuits** use both the signal and its complement. If the complement is not available, up to two inverters may be needed—shown with dashed lines. The configurations of (b) and (c) are the most economical if integrated circuits are used—only two types of cans are needed. Circuits (a) and (d) are simple but do not improve the signal level, have low fan out and need three types of IC cans. These may also need output amplifiers.



Albert Canning (left) presents Martin's Quality Supplier Award to Horace Potter, president of Reeves-Hoffman.

Reeves-Hoffman is the first crystal manufacturer to earn Martin's coveted "Zero Defects" award!

With delivery of over 1,000 defect-free crystal-controlled filters for the highly reliable Bullpup missile, Reeves-Hoffman becomes the first and only crystal manufacturer to earn Martin-Orlando's Zero Defects Award.

The product that won the award was a complex miniature network package, which consists of crystals, glass-to-metal seals, temperature controlling and other circuitry.

In making the presentation, Mr. Albert J. Canning, technical requirements chief, quality, of Martin-Orlando, said in part: "This award from the Martin Company for Zero Defects is intended to reflect the thousands of systems components that Reeves-Hoffman has previously delivered. . . . It represents excellence in performance."

We think it is important to note that the award is also based on management cooperation and the meeting of scheduled delivery dates. Shipping defect-free products merely qualifies a supplier for the award, but does not guarantee it.

Whether our products are for outer space, undersea or "down-to-earth" applications, we do our utmost to deliver "zero defects" shipments on time. We invite your inquiries.

REEVES-HOFFMAN
DIVISION OF **DCA**

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ON READER-SERVICE CARD CIRCLE 25

Small-capacitor measurements pose formidable problems. Here is a method for measuring temperature coefficient and drift to an accuracy ot 1%.

Ever try to measure temperature coefficient and drift for a low-value capacitor? If so, you know that stray capacitance in the measuring set-up may well turn out to be larger than the value being measured.

In spite of this, the measurements must often be made accurately, because proper operation of the circuit may hinge on keeping the capacitance value within small limits despite wide temperature swings.

The following method will yield temperature coefficient and drift measurements that are accurate to within 1%.

Measurement section uses bridge

The measurement portion of the test set-up is a commercial capacitance bridge. Its design allows for the extension of the measurement terminals as well as the exclusion of all capacitances to ground without sacrificing accuracy. Since the final bridge measurement includes the capacitance of the test specimen plus the open-terminal capacitance of the specimen mounting terminals, the design objective was to reduce the level of the open-terminal capacitance so that it becomes insignificant. The factors that determine the open-terminal capacitance are:

- The capacitance of the bridge terminals.
- The capacitance of the extension leads.
- The rigidity of the extension leads and terminations.
- The measurement frequency.

The measurement frequency is always defined, but the other factors are a function of the test set-up's physical design. In the set-up employed (Fig. 1), a rigid coaxial cable pair is used to connect from the bridge input to a specially designed feedthrough panel assembled to the door of a temperature chamber. The front of the feedthrough panel contains standard BNC receptacles, with their center conductors wired through and terminated at the back of the panel with solder standoffs.

Fig. 2 shows the back of the panel, with its standoffs, an oil tank and a thermocouple probe. Mounted test capacitors are shown soldered to the standoffs. The final design of the panel was influenced by the knowledge that if any portion of the bridge extension leads is within the temperature chamber, an inaccurate measurement could result. This is because of the change in cable capacitance introduced by a temperature change.

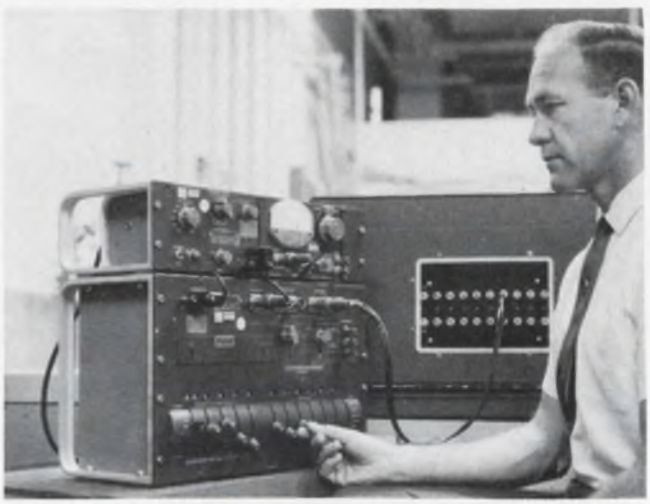
To determine the extent of such temperature-induced errors, the capacitance of an eight-foot length of coaxial cable was measured at an ambient temperature of +25°C. Another measurement was made with two feet of the cable inside a temperature chamber stabilized at +125°C. The cable capacitance was 4 pF less than at +25°C. The same measurement was also made at −55°C, and the cable capacitance was found to be 13 pF more than at +25°C. These differences are significant and can completely mask the actual temperature coefficient and drift of low-value capacitors.

Changes in the routing of the cable also caused variations in cable capacitance. This indicated that the test set-up must be identical for all measurements (system rigidity) to ensure repeatable results.

With the test system used, the average open-terminal capacitance for a terminal pair is 0.022 pF at +25°C, and the greatest change over the temperature range of −55°C to +125°C is 0.003 pF. The open-terminal capacitance is thus reduced to an insignificant value and may be disregarded.

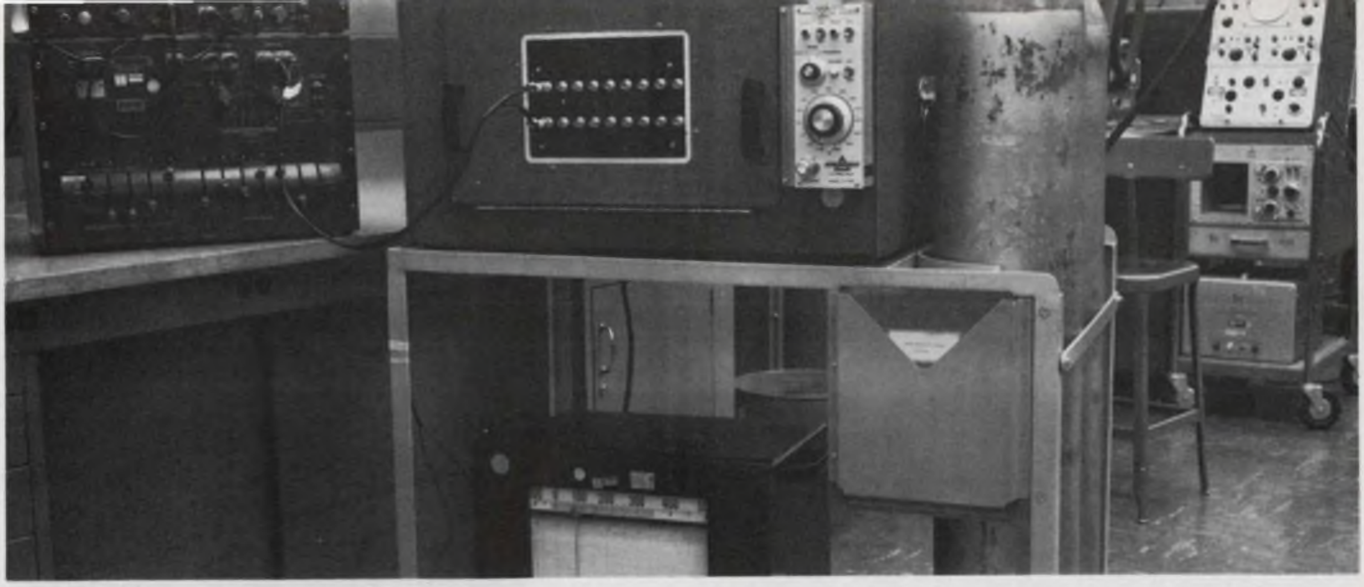
Environmental-control is important

Reducing the open-terminal capacitance of the test-specimen terminals does not in itself insure accurate test results. The environment sur-



Small capacitors can present big problems, says author Ray as he sets up a capacitance bridge.

James A. Ray, Senior Research Engineer, Lockheed Missiles and Space Co., Sunnyvale, Calif.

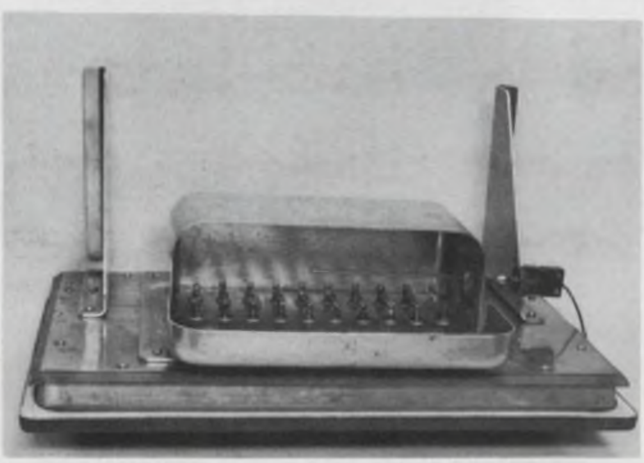


1. **Test system** consists of a capacitance bridge, a temperature chamber with a special feedthrough panel and a temperature recorder. A rigid coaxial cable pair connects the bridge input to the feedthrough panel.

rounding each test specimen must also be closely controlled. It was found that the geometry of a part can cause inconsistent test results in a forced-airflow environment. This was demonstrated by using a feedthrough panel that permitted test specimens to be mounted in a forced-airflow temperature environment.

Temperature gradients measured before the test specimens were mounted to their standoffs were found to be no more than 0.7°C in any direction. The test specimens were then mounted, and the gradient measurements repeated. Drastic changes were observed. It was found that each specimen acted as an airflow barrier, creating air turbulences which altered the gradients in the mounting area. This condition is over-come by mounting the test specimens in an oil bath.

Fig. 2 shows the rear of the feedthrough panel with capacitors mounted in the oil tank, which is filled with chemically inert silicon oil to a depth that completely immerses the capacitors. The thermocouple probe senses the oil temperature and transmits an output to the calibrated temperature recorder (Fig. 1). Temperature gradients in the oil-filled tanks are less than 0.5°C, and sensing with a single thermocouple is satisfactory. The gradient changes experienced in a forced-airflow environment are not present in the oil bath, even with changes in specimen orientation, location or geometry.



2. **Back of feedthrough panel** holds the standoffs for mounting the test capacitors, an oil tank and a thermocouple probe. Temperature gradients in the oil bath are less than 0.5°C in any direction.

Using the system

Temperature coefficient and drift of test capacitors are determined by a series of measurements and calculations. Test specimens are soldered to the standoffs and immersed in silicon oil, and the capacitance of each is measured after temperature stability is reached. Stability is attained when two capacitance measurements, taken at 15-minute intervals, show no significant difference. The same procedure is repeated at the temperatures of interest. Typical temperatures and their test sequence are: +25°C, −55°C, +25°C, +125°C and +25°C. The first +25°C measurement and that made at −55°C are used to compute the low-temperature coefficient. The second +25°C measurement and that made at 125°C are used to compute the high-temperature coefficient. The three +25°C measurements together are used to compute the capacitance drift.

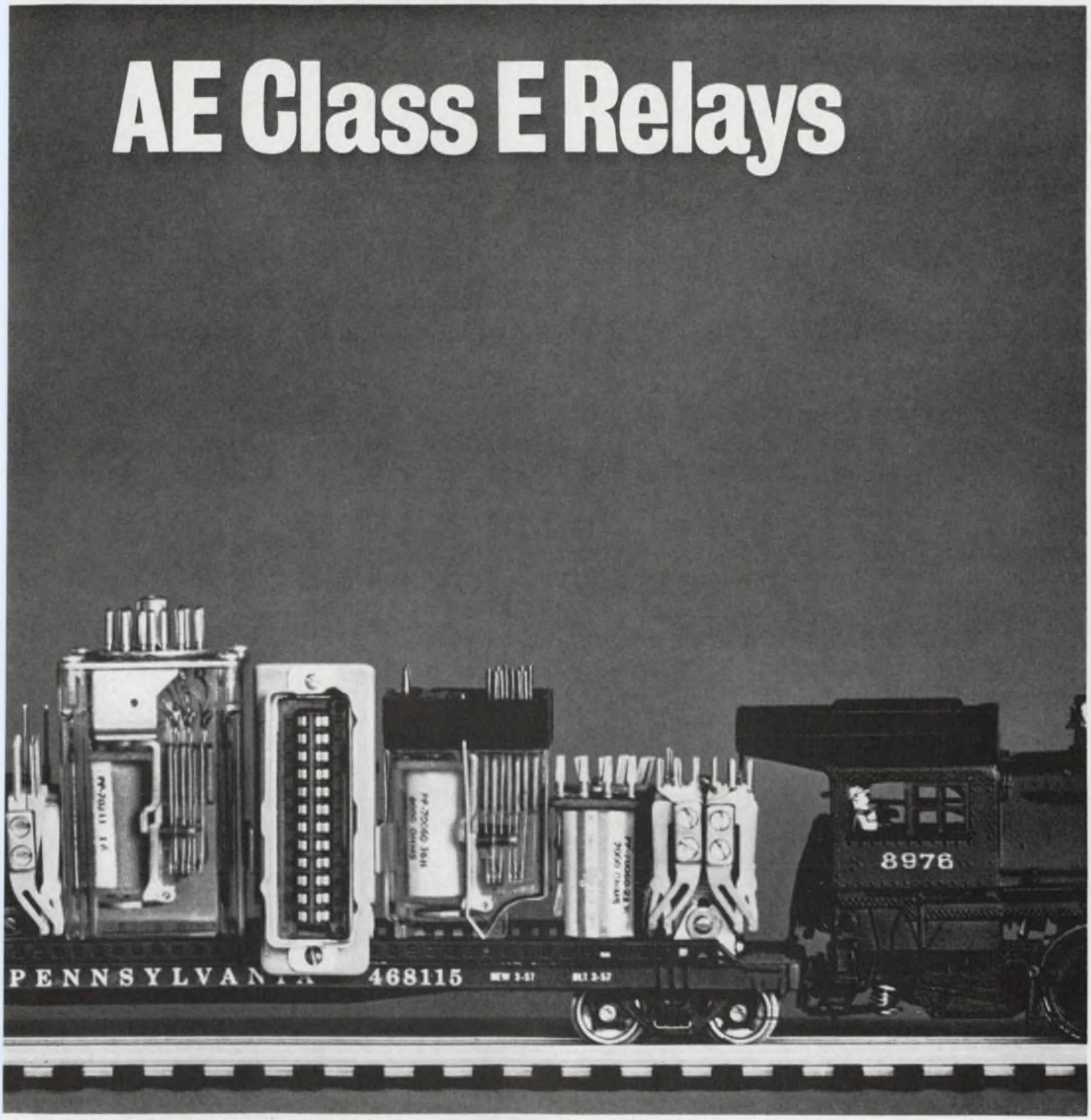
After the measurements have been made, the temperature coefficient is computed as follows:

$$TC = \frac{(C_2 - C_1) \times 10^6}{C_1(T_2 - T_1)},$$

where TC = temperature coefficient in parts per million per degree centigrade.
C_1 = capacitance, in picofarads, at +25°C.
T_1 = +25°C.
C_2 = capacitance, in picofarads, at the low (or high) temperature.
T_2 = low (or high) temperature in degrees centigrade.

The capacitance drift is then calculated by taking the greatest single difference between any two of the three +25°C measurements and dividing it by the intermediate +25°C measurement. ■ ■

you can't make with



E Relays are available in hermetically sealed enclosures with either hook terminals or plug-in headers. Or plastic dust covers that snap on to the chassis- or printed-circuit type of socket.

For full information on the limitless variations in mounting and connections for AE Class E Relays, ask for Circular 1942-C. Write to the Director, Relay Control Equipment Sales, Automatic Electric Company, Northlake, Ill. 60164.

AUTOMATIC ELECTRIC

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ON READER-SERVICE CARD CIRCLE 27

Avoid over-integration by designing linear circuits with off-the-shelf items. External discrete parts may be added whenever needed.

If you're out to put monolithic integrated microcircuits into your analog equipment, your best approach is *not* to try to integrate the system totally.

Instead, you'd be better off designing around off-the-shelf linear microcircuits and including external discrete components where they're needed. In this way, you'll benefit not only from the low cost of off-the-shelf units, but the discrete parts will provide operating flexibility and allow you to accomplish functions which could not be integrated economically.

This article covers the design of eight types of commonly used circuits around off-the-shelf linear microcircuits:

- Sine-wave oscillator.
- Voltage-to-frequency converter.
- Logarithmic amplifier.
- Multiplier.
- Servo current driver.
- Voltage comparator.
- Positive peak detector.
- Double-ended limit detector.

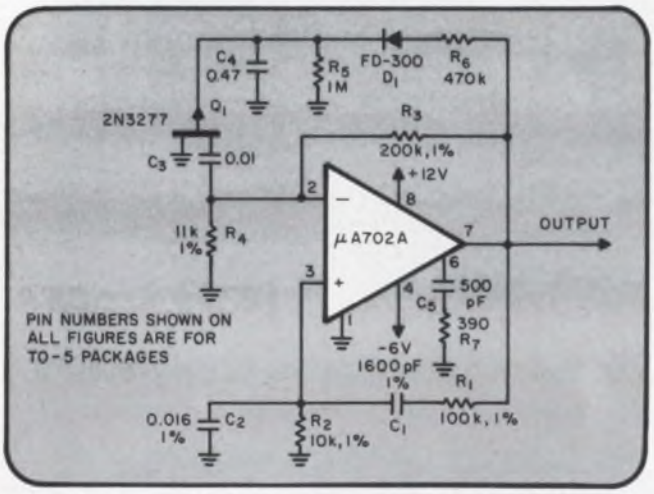
The microcircuits used are the μA702A wideband dc amplifier, [1,2,3,4] the μA709 high-performance operational amplifier,[5] the μA710 high-speed differential comparator,[6] and the μA711 dual comparator,[7] all available from Fairchild Semiconductor Tables 1 and 2 briefly summarize the characteristics of these devices. Similar design techniques can be used with other available linear microcircuits, although values will differ.

Sine-wave oscillator has stable gain

A μA702A wideband dc amplifier is the central element of the phase-shift oscillator shown in Fig. 1. Negative feedback is applied through R_3 to the inverting input of the amplifier. The feedback stabilizes the gain and makes it essentially independent of the integrated-circuit's characteristics. The RC network (R_1, C_1, R_2 and C_2) applies positive feedback to the non-inverting input.

The circuit will oscillate at the frequency at which the phase shift through the RC network is zero if the positive feedback is equal to, or greater than, the negative feedback. However, it is desirable to hold the positive feedback exactly equal to the negative feedback. If the positive feedback is greater, the output of the oscillator will build up until it becomes nonlinear, distorting the output sine wave.

R. J. Widlar, Application Engineer,
J. N. Giles, Application Engineer, Fairchild Semiconductor, Mountain View, Calif.



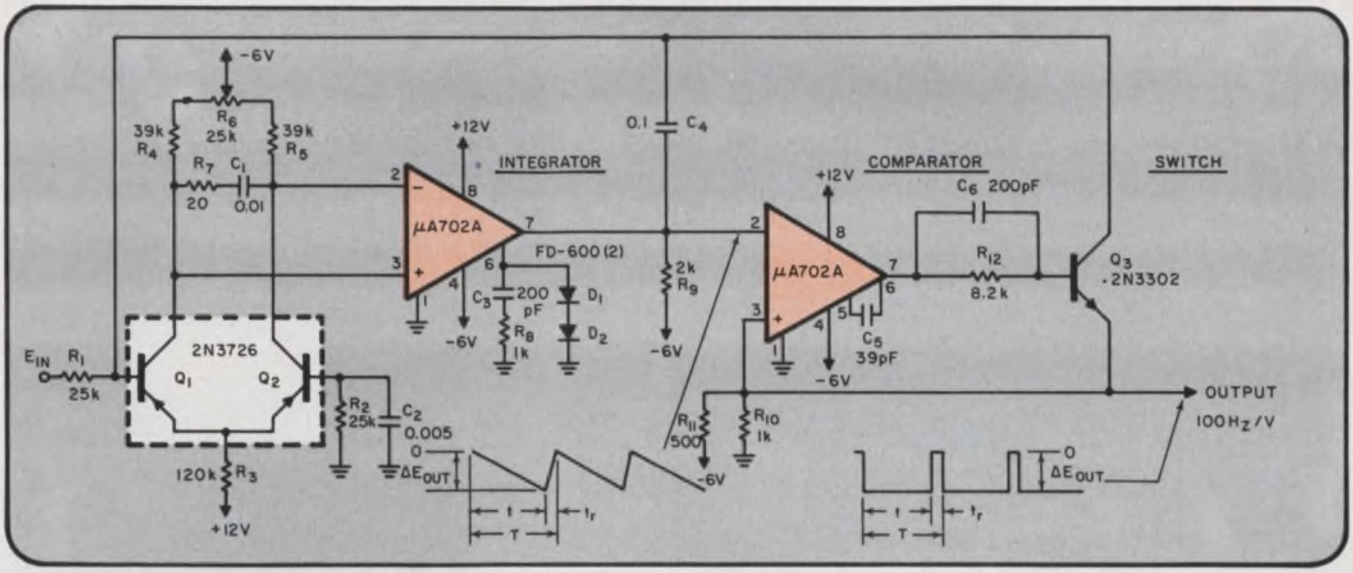
1. **One kHz sine-wave oscillator** applies negative feedback to the inverting input of the IC amplifier to stabilize the gain and make it independent of the integrated-circuit characteristics.

Table 1. Typical characteristics

	μA702	μA709
Input offset voltage	2	1 mV
Input offset current	0.7 μA	50 nA
Input bias current	4 μA	200 nA
Temperature coeff. of input offset voltage	5 μV/°C	——
Common-mode rejection	80	90 dB
Input voltage range		±8 V
Voltage gain	2600	45,000
Output resistance	200	150 Ω
Input resistance	25	400 kΩ
Output voltage swing	±5.3 V	——
R_L = 10 kΩ	——	±14 V
R_L = 2 kΩ	——	±13 V
Power consumption	70	80 mW
Power supply sensitivity	50	25 μV/V
Open-loop bandwidth	1 MHz	

μA709: High performance operational amplifier (T_A = 25°C, V_S = ± 15 V)

μA702: Wideband dc amplifier (T_A = 25°C, V^+ = 12.0 V, V^- = −6.0 V)



2. **Voltage-to-frequency converter** overcomes low gain and high input-current requirements of the μA702A wideband dc amplifier by adding a discrete pnp matched pair at the front end.

The positive and negative feedbacks cannot be made equal with a simple adjustment. Any small component change will either stop the oscillation or distort the output. This difficulty is overcome by using an agc circuit, composed of a diode detector and FET amplifier, to hold the gain at the precise value required to sustain oscillation at the desired output level.

If $R_1C_1 = R_2C_2$, the frequency at which the phase shift through the RC network is zero (and therefore the frequency of oscillation) is given by:

$$f = \frac{1}{2\pi R_1 C_1}. \qquad (1)$$

The attenuation through the network at this frequency is:

$$\eta = \frac{1}{1 + 2\left(\frac{R_1}{R_2}\right)}. \qquad (2)$$

For oscillation to be possible, the amplifier gain must make up for this loss. For $R_1 = 10 R_2$, the amplifier gain must be exactly 21. Such a large ratio of R_1 to R_2 is chosen to keep the signal level across the FET low enough to avoid distortion.

The output of the amplifier is rectified by D_1 and filtered by C_4. This voltage, which varies as the ac output of the amplifier, is fed to the gate of the FET and controls its drain-to-source resistance. Thus the output of the amplifier is held at a constant level. The filter capacitor, C_4, must be large enough for the agc loop to be stable. The value of C_3 is also important for agc stability. To change the frequency of oscillation, C_1, C_2, C_3 and C_4 should all be changed proportionally. The ac output level is determined by the ratio R_6/R_5 and the characteristics of the FET.

With the component values shown, the frequency of oscillation is 1 kHz and the peak-to-peak output voltage is about 8 volts. The stabilization time from initial turn-on is approximately 50 ms.

Table 2. Typical characteristics

	μA710	μA711
Input offset voltage	1	1 mV
Input offset current	0.5	0.5 μA
Input bias current	25	25 μA
Temperature coeff. of input offset voltage	5	3 μV/ C
Input voltage range	±5	±5 V
Differential input voltage range	±5	±5 V
Voltage gain	1200	1500
Output resistance	200	200 Ω
Positive output level	+3.1	+4.5 V
Negative output level	—0.5	—0.5 V
Power consumption	110	130 mW
Response time	40	40 ns
Strobe release time	——	12 ns

μA710: High speed comparator
(T_A = 25°C, V^+ = 12.0 V, V^- = −6.0 V)
μA711: Dual comparator
(T_A = 25°C, V^+ = 12.0 V, V^- = −6.0 V)

Voltage-to-frequency converter uses transistors

An excellent example of the design approach involved in adapting an off-the-shelf microcircuit to a special need is the voltage-to-frequency converter in Fig. 2. The circuit consists of an integrator, a voltage comparator and a switch.

The output voltage of the integrator is a negative-going ramp which falls at a rate directly proportional to the dc input signal. When the ramp reaches a pre-determined negative level, it is sensed by the comparator which drives the switch to reset the integrator output to zero.

The time for the integrator output to go from zero to the preset level is inversely proportional to the input voltage. Thus, the operating frequency will be proportional to this voltage.

The μA702A was chosen for the integrator because of the fast slewing rate required during the reset interval. However, this amplifier by itself does not have enough gain to make the integrator function properly over a wide dynamic range. In addition, this application frequently requires lower input currents than are practical with the μA702A.

Both these limitations were overcome by using a discrete *pnp* matched pair (Q_1 and Q_2) in front of the amplifier. This composite amplifier has a gain greater than 25,000 and input currents less than 0.5 μA. The offset voltage of the input transistors is conveniently balanced out with the potentiometer (R_6).

Because of the high gain of the complete amplifier, frequency compensation is done at two points, with R_7, C_1 and R_8, C_3. The integrating capacitor is C_4. The clamping diodes (D_1 and D_2) prevent overloading of the comparator under abnormal operating conditions.

A second μA702A is used as a voltage comparator at the output of the integrator. A threshold voltage of -4.0 volts is supplied to the non-inverting input of the comparator from a resistive divider (R_{10} and R_{11}). When the output of the integrator falls to -4.0 volts, the output of the comparator rises rapidly from -5.0 volts, turning on Q_3, which supplies positive feedback to the non-inverting input of the comparator. Q_3 saturates and drives approximately 11 mA into the summing node of the integrator. It also holds the non-inverting input of the comparator very near to ground potential.

When the integrator output, which is being driven positive by the switch current, reaches zero, the comparator output swings negative and turns off Q_3. The cycle is then repeated. In Fig. 2, R_{12} limits the base drive of Q_3, while C_5 and C_6 decrease the on and off times of the switch.

The time required for a given change in the output voltage of the integrator is given in terms of the input voltage and circuit values by:

$$t = R_1 C_4 \frac{\Delta E_{OUT}}{E_{IN}}. \qquad (3)$$

Similarly, when Q_3 is turned on, the reset time is:

$$t_r = C_4 \frac{\Delta E_{OUT}}{I_{C_3}}, \qquad (4)$$

or:

$$t_r \cong R_{11} C_4 \frac{\Delta E_{OUT}}{V^-}. \qquad (5)$$

The output of the integrator swings from zero down to a voltage determined by the resistive divider, R_{10} and R_{11}, so:

$$\Delta E_{OUT} = \frac{R_{10} V^-}{R_{10} + R_{11}}. \qquad (6)$$

Therefore, the period for one cycle of operation is:

$$T = \frac{C_4 R_{10} V^-}{R_{10} + R_{11}} \left(\frac{R_1}{E_{IN}} + \frac{R_{11}}{V^-} \right). \qquad (7)$$

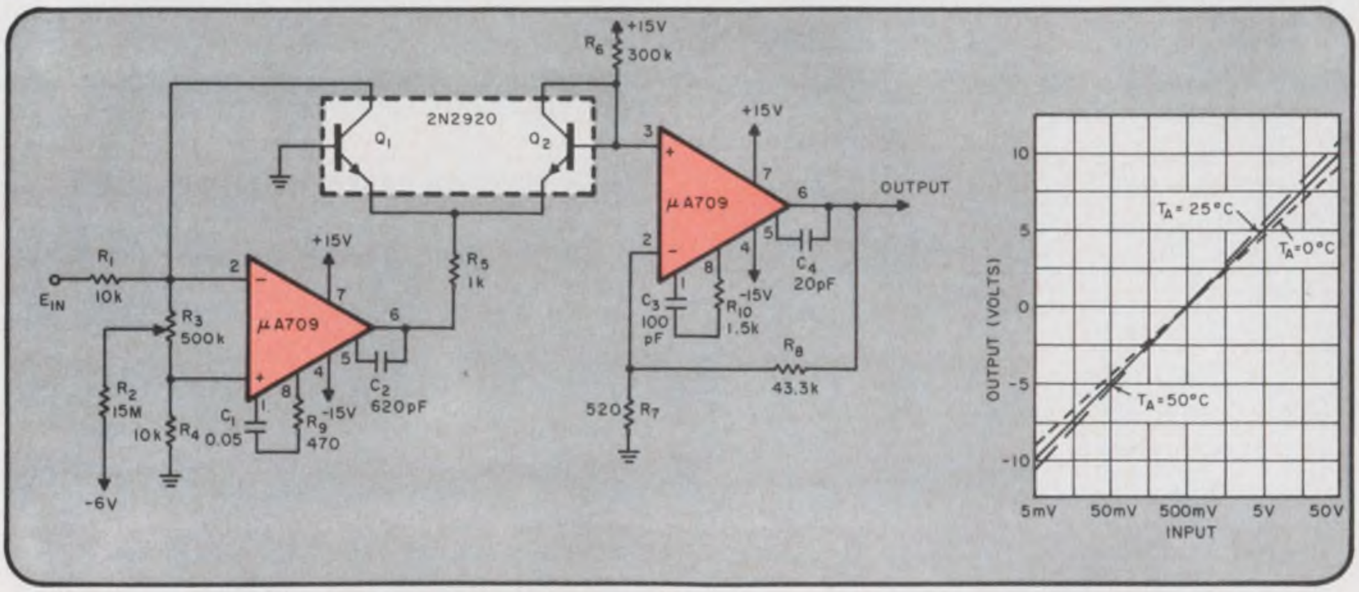
Since $\dfrac{R_1}{E_{IN}} \gg \dfrac{R_{11}}{V^-}$,

$$f \cong \frac{(R_{10} + R_{11}) E_{IN}}{C_4 R_1 R_{10} V^-}, \qquad (8)$$

which gives a conversion factor of 100 Hz/V.

Logarithmic amplifier has wide dynamic input range

An excellent logarithmic amplifier may be designed by utilizing the highly predictable and nonlinear characteristics of bi-polar transistors. If V_{BE} is greater than $4kT/q$, where q is the charge of an electron, k is Boltzmann's constant and T is the absolute temperature, the variation in collector current with emitter-base voltage for a bi-



3. **Logarithmic amplifier** adds matched transistor pair to μA709 amplifier. Emitter-base voltage differential between the transistors is proportional to the log of their collector currents with Q_1 used as a feedback element.

polar transistor is given by:[8]

$$I_C \propto \exp\left(\frac{qV_{BE}}{kT}\right) \tag{9}$$

This expression holds for high currents where emitter-contact and base-spreading resistances become important and for low currents where collector-leakage currents cause inaccuracy. The expression is valid for operation over at least six decades of collector current with well-made silicon transistors.

Using the expression given above, it can be shown[9] that the emitter-base voltage differential between two matched transistors operating at different collector currents is:

$$\Delta V_{BE} = \frac{kT}{q} \ln\left(\frac{I_{C1}}{I_{C2}}\right) \tag{10}$$

In the circuit of Fig. 3, transistor Q_1 is used as the feedback element around a μA709 operational amplifier. The negative feedback forces the collector current of Q_1, or I_{C1}, to equal the current flowing into the summing node of the amplifier. Hence:

$$I_{C1} = \frac{E_{IN}}{R_1}. \tag{11}$$

The collector current of Q_2 is determined by the positive supply voltage and R_6 as:

$$I_{C2} = \frac{V^+}{R_6}. \tag{12}$$

If Q_1 and Q_2 are a matched pair of transistors, Eq. 10 can be used to give:

$$\Delta V_{BE} = \frac{kT}{q} \ln\left(\frac{R_6 E_{IN}}{R_1 V^+}\right) \tag{13}$$

Since the base of Q_1 is grounded, this voltage is presented to the input of the second amplifier. The gain of this stage is $(R_7 + R_8)/R_7$, so that:

$$E_{OUT} = \frac{kT\,(R_7 + R_8)}{qR_7} \ln\left(\frac{R_6 E_{IN}}{R_1 V^+}\right). \tag{14}$$

This shows that the output voltage is proportional to the logarithm of the input voltage. It can be seen from Eq. 14 that the coefficient of the log term is proportional to absolute temperature, which gives it a thermal sensitivity of 0.3%/°C. The over-all transfer function of the amplifier is given for various operating temperatures in Fig. 3. The dynamic range of the amplifier is 80 dB.

Resistors R_2 and R_3 in Fig. 3 are used to provide an offset adjustment, which increases the dynamic range for small input signals. R_5 is used to limit the loop gain of the input amplifier so that it can be frequency compensated. R_7 is chosen to be equal to the diode impedance of Q_2 to minimize the effect of the input bias current of the output amplifier. The slope of the log characteristic is determined by R_8, while R_6 determines the zero crossing.

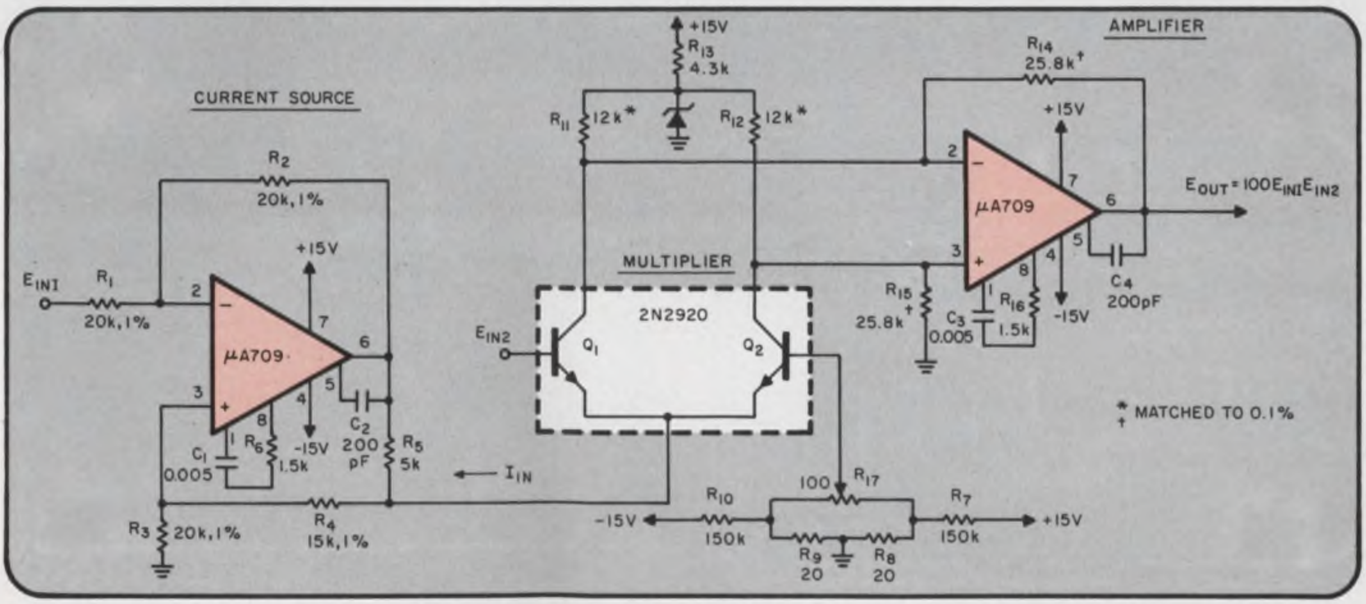
Multiplier with transistor pair

Another interesting use for the nonlinear properties of the bipolar transistor is in the multiplier circuit in Fig. 4. The basic multiplying element is the transistor pair, Q_1 and Q_2. Its operation can be understood from the following.

The small signal transconductance of a transistor can be obtained by differentiating Eq. 9:

$$\frac{dI_C}{dV_{BE}} = \frac{qI_C}{kT}\ . \tag{15}$$

Next, let's consider a matched transistor pair in a differential configuration as shown in Fig. 4. With the differential input voltage at zero, the input current supplied to the emitters will split equally between the two transistors; the differential output current will be zero. Hence, Eq. 15 can be rewritten in terms of the differential



4. **Multiplier circuit** also uses an external transistor pair, Q_1 and Q_2—this time as the basic multiplying element. The output of the current source is proportional to a positive input voltage at E_{IN1}.

output current, the input current to the emitters and input voltage as:

$$I_{OUT} = \frac{q}{2kT} I_{IN} E_{IN2} . \qquad (16)$$

The differential output current is proportional to the product of the differential input voltage and the current supplied to the emitters.

In Fig. 4, the first μA709 supplies a current proportional to a positive input voltage to the emitters of Q_1 and Q_2. Using standard operational amplifier theory, this current can be shown to be:

$$I_{IN} = \frac{E_{IN1} R_2}{R_5 R_1} . \qquad (17)$$

A second input voltage is supplied to the differential pair. Combining Eqs. 16 and 17 and setting $R_1 = R_2$, the output current of the differential pair is:

$$I_{OUT} = \frac{q}{2kTR_5} E_{IN1} E_{IN2} . \qquad (18)$$

The output of the pair is connected to a second μA709, which converts the differential current to a single-ended, zero-referenced voltage. The output voltage of this amplifier will be $E_{OUT} = R_{14} I_{OUT}$, for $R_{14} = R_{15}$ and $R_{11} = R_{12}$. Hence:

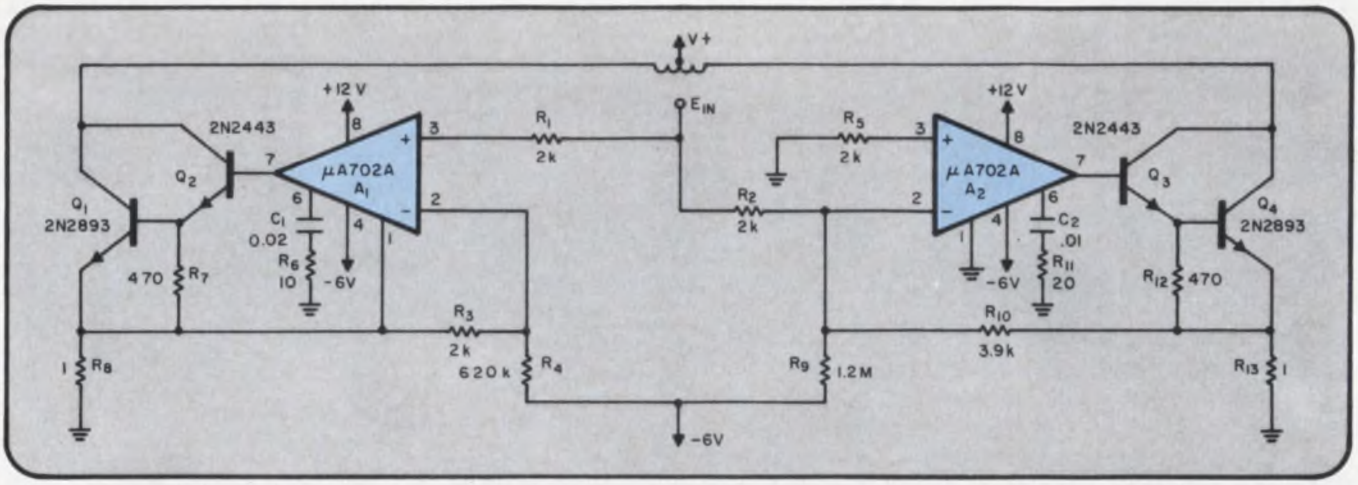
$$E_{OUT} = \frac{qR_{11}}{2kTR_5} E_{IN1} E_{IN2} , \qquad (19)$$

which shows that the output voltage is proportional to the product of the two input voltages.

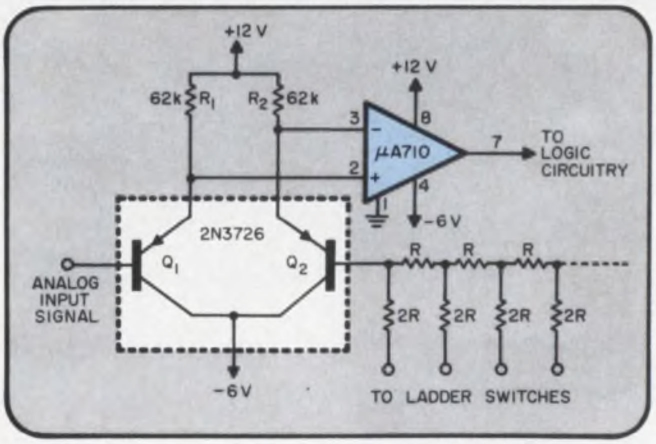
There are several details that help make the circuit work right. One is that the resistor pairs, $R_{11} - R_{12}$ and $R_{14} - R_{15}$, must be very closely matched (to within 0.1%). An adjustment is provided for nulling the offset of Q_1 and Q_2. This adjustment should be made when the current-source is at its maximum value. It should also be noted that Eq. 16 is a small-signal approximation. Thus, the voltage input to the differential pair should be kept small. Restricting the input voltage to ± 20 mV gives linearity acceptable for most applications. Note that E_{IN2} can be a bipolar signal and E_{IN1} must be a positive voltage.

Servo current driver uses a μA702A

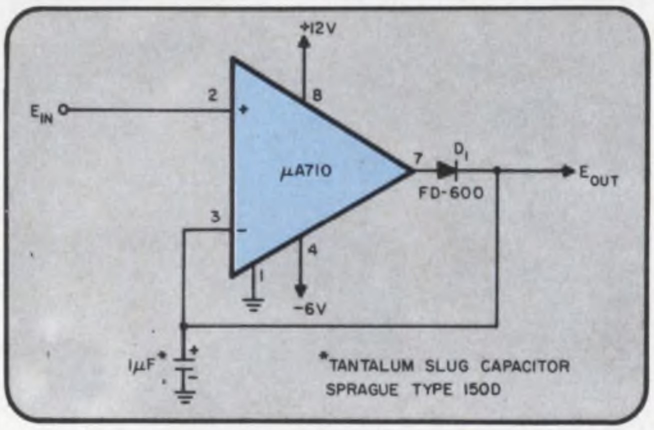
A fairly typical example of an application where an operational amplifier would normally not be considered, but where a μA702A can be used



5. **Servo current driver** obtains push-pull phase inversion by using one operational amplifier for positive input signals and the other for negative ones. The μA702A permits the output stage to be biased at very low quiescent currents with no risk of thermal runaway over a full temperature range.



6. **Voltage comparator** reduces input current requirements by adding pnp pair in front of μA710 differential comparator element.



7. **Positive peak detector** measures peaks of very fast pulses with an externally modified μA710 differential comparator element.

effectively, is shown in Fig. 5. This is a push-pull class-B servo current driver.

The output current of opposite sides is sensed across R_8 and R_{13}. One μA702A (A_1) functions as a unity-gain, non-inverting amplifier which makes the voltage across R_8 equal to the input voltage for positive input signals. For negative input signals, A_2 functions as a unity-gain, inverting amplifier which forces the voltage across R_{13} to equal the input voltage. Thus, phase inversion for the push-pull amplifier is obtained.

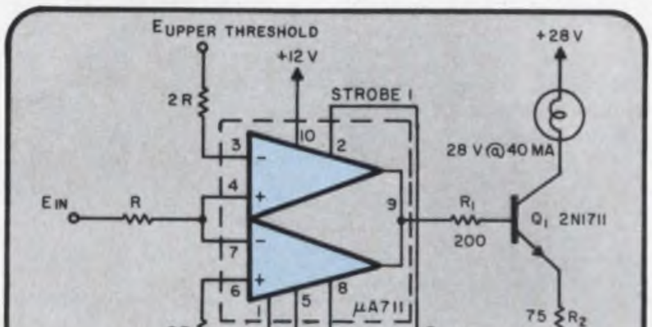
The quiescent output current of the amplifier is determined by R_1 and R_9; the values shown give a quiescent current of approximately 20 mA on each side. The circuit will give a $\pm$2-A output current for a $\pm$2-volt input signal. Input resistance is 4k.

The excellent dc characteristics of the μA702A permit the biasing of the output stage at very low quiescent currents, without running the risk of thermal runaway or of encountering a dead zone —even for full temperature-range operation. Also, the low offset and high gain allow good accuracy without wasting an excessive amount of the supply voltage across the current-sensing resistors. Since the output transistors are included within the feedback loop, their characteristics have a negligible effect on over-all performance.

One unusual aspect of this circuit is that the ground terminal of A_1 (pin *1*) is connected to the current-sensing resistor, R_8. This provides bootstrapping on the common-mode range of the amplifier so that it can be operated above its usual common-mode limit of +0.5 volt without exceeding the ratings.

Voltage comparator for all logic forms

Basically, a voltage comparator does the same job as an operational amplifier. Operational amplifiers are, in fact, used frequently as comparators. However, in many applications, the comparator is expected to recover rapidly from saturation, which is its normal operating state. Additionally, the large output swing desired for operational amplifiers is often a disadvantage when the comparator must drive low-level logic circuits. The μA710 is a differential comparator designed to overcome such limitations of operational amplifiers. It features extremely fast recovery from saturation and its output is compatible with practically all integrated logic forms.



8. **Double-ended limit detector** uses integrated-circuit dual comparator. The circuit is designed for automatic go/no-go test equipment.

One of the most obvious applications for this device is as the voltage comparator in an A/D converter. For very high-speed systems in which the ladder network has a low impedance, it can be used alone. However, when speed is not the prime objective, the ladder impedance is generally high enough so that the μA710 introduces significant error due to loading. In this case, a transistor pair can be used in front of the μA710 to reduce the input current. This is shown in Fig. 6. A *pnp* pair is used here so that the full $\pm$5-volt input range will still be available.

The speed of the comparator is affected somewhat by the addition of the input stage. This is due primarily to the collector-base capacitance of the input transistor loading the ladder network. The transistors selected for this application have a low collector-base capacitance and should load the ladder with a total capacitance of less than 10 pF.

Peak detector measures fast pulses

One difficult problem that can be solved with the μA710 is the accurate measurement of the peak amplitude of very fast pulses. A peak detector which does this is shown in Fig. 7. The input signal is applied to the non-inverting input of the μA710. The output is taken from a large capacitor connected to the inverting input.

If the voltage on the input terminal is greater than that on the output, the comparator output will swing positive and charge the capacitor rapidly through D_1. When the input voltage drops below the voltage on the capacitor, the output of the μA710 swings negative and the diode becomes reverse biased. This leaves the capacitor charged to the peak value of the input signal.

Because of the low offset and fast response of the μA710, this circuit can measure the amplitude of pulses less than 100 ns wide with a 5mV accuracy. The decay time of the voltage developed across the capacitor is determined by the input bias current of the comparator and is approximately 20 ms/volt. If the peak detector is to follow more rapidly varying signal, a resistor can be inserted between the output and the negative supply voltage. The peak detector barely loads the signal source since the maximum load current is about 25 μA, and this only occurs at the peak of the signal.

The circuit functions as a unity-gain feedback amplifier at the peak of the input signal, with C_1 providing frequency compensation. Hence, C_1 cannot be made much smaller than the 1 μF indicated, or the circuit will oscillate at the peak of the input signal, giving erratic operation. Larger values of capacitance can, however, be used.

Double-ended limit detector is sense amplifier

The μA711 dual comparator was designed primarily as a core-memory sense amplifier. However, it is versatile enough to be used in a number of other applications.

In one of these, Fig. 8, the circuit gives a positive output for input signals below a preset threshold or above a second, independently adjustable voltage threshold. This output is fed to a lamp driver, so that whenever the input signal goes outside the tolerance limits, the lamp will light. A feature of the circuit is that the limit detector can be disabled when it is not being used by applying a zero-logic signal to the strobe terminals, In addition, up to eight dual comparators can be wired with common outputs and be used to feed a single lamp driver.

To make the accuracy dependent only on offset currents rather than on bias currents, the relative values of the source resistances for the signal and reference voltages should be as indicated in the schematic. Ideally, these resistances should be as low as possible. The lamp driver is designed so that its peak output current is limited during the initial turn-on of the bulb when the filament resistance is low. This is accomplished with R_2. Series resistor R_1 limits the output current of the comparator when the lamp driver saturates.

Off-the-shelf philosophy

These applications demonstrate the practical use of off-the-shelf integrated circuits in linear circuit design. The intent here is to show that the possibility of using these devices in a wide variety of applications should not be overlooked in fear of having to design and buy a custom package.

Low cost, through the inherent high-volume process involved, is the most significant advantage of monolithic integrated circuits. In addition, the use of integrated circuits can reduce the expense of assembly and testing. For the low volume user this cost edge can be acquired through the use of already standardized packages which are then modified to perform a specific function by the use of external discrete components. ■ ■

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Simplify dc amplifier design by using FETs. Their high-input-impedance and zero-temperature-coefficient attributes also improve performance.

Dc amplifiers have traditionally been plagued by stability problems. But if the amplifier uses a field-effect transistor (FET) as the active element, performance variations with temperature are no longer a risk.

This is largely due to the zero-temperature-coefficient property of the FET. To take advantage of it, you must know how to arrange the biasing. Once the biasing conditions are understood, the FET can be used to provide stable performance in a host of dc amplifier circuits. These include simple amplifiers, memory stages, electrometers and source-followers.

In addition, the high-input impedance of the FET simplifies the amplifier design. The engineer need not bother with costly, complex multi-stage networks to achieve high R_{in}. Thus, this impedance property and the temperature coefficient attribute give the FET distinct advantages over bipolar transistor and tube dc amplifiers.

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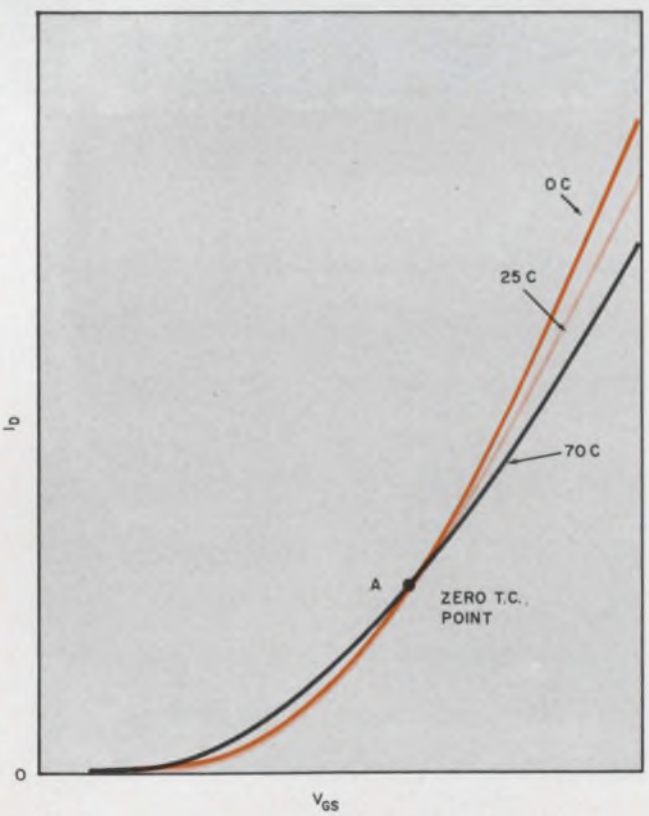
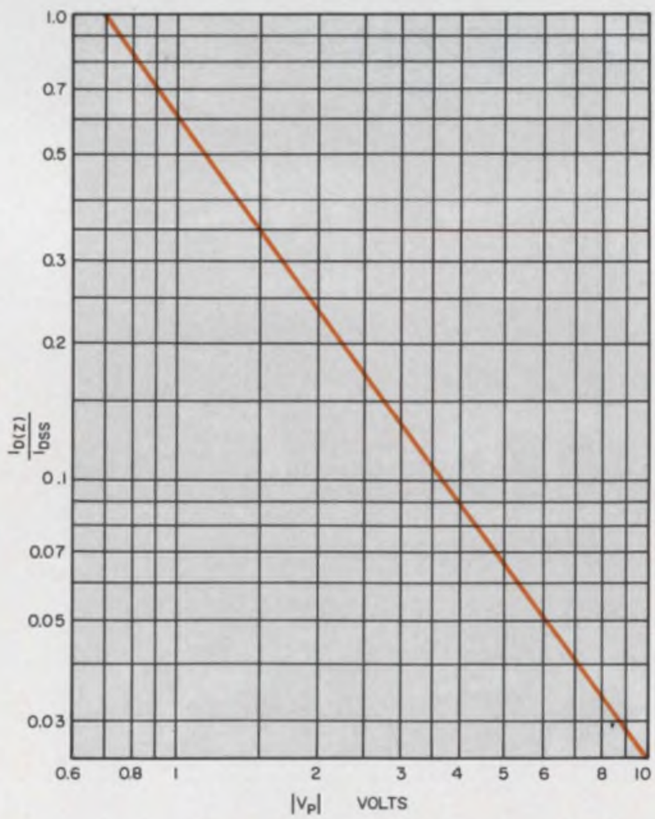
(This article is a condensation of a Dickson Applications Note, "FET DC Amplifiers." The complete article may be obtained by writing to Dickson at the above address and requesting Vol. 1, No. 6 of its Application Note Series.)

Zeroing-in on temperature effects

Consider the transfer characteristic of a typical FET taken at three temperatures (Fig. 1). Note that the drain current for this unit varies for every possible gate bias voltage except that corresponding to point A. For higher gate voltages, the drain current increases with increases in temperature to produce a positive temperature coefficient. Smaller values of gate voltage produce a negative temperature coefficient where the drain current decreases with increases in operating temperature. At point A, however, the drain current remains constant as temperature is varied and the



1. **FET transfer characteristic** (drain current verses gate bias voltage) shows the effect of temperature variations. Note the zero temperature coefficient point (A) for one value of gate bias.



2. **Optimum bias is determined** by measuring the drain characteristic at different temperatures. This yields the normalized value of drain current at a given pinchoff voltage to yield the most stable temperature performance.

temperature coefficient is essentially zero.

Two opposing effects are present which affect the temperature coefficient in opposite ways. The first effect is due to a variation in the barrier or contact potential, which has a negative temperature coefficient of about 2.2 mV/°C, thus resulting in a positive temperature coefficient for I_D when the gate voltage is held constant.

The percentage change in I_D due to barrier-potential variation would be a function of g_{fs}/I_D and would be greatest for FETs having a low pinchoff voltage. For FETs with a very low value of V_P, this effect dominates, and the net temperature coefficient of I_D will be positive.

If the value of V_P for a FET is very high, then the changes in barrier potential will produce very little variation in I_D, and the net effect will be dominated by the change in resistivity. (The resistivity variation is the second temperature effect.) This will result in a net negative temperature coefficient.

FETs having an intermediate value of pinchoff voltage may have a temperature coefficient for I_D which is either positive or negative. It depends upon the bias condition. At one critical value of V_{GS}, the temperature coefficient is zero. A theoretical analysis indicates that this zero temperature-coefficient bias point occurs when the ratio I_D/g_{fs} is equal to approximately 0.32 volt.

Combining the above requirements with the normal theoretical characteristic equations for FETs, the theoretical values of the gate voltage and drain current required to yield the optimum bias point for n-channel FETs are derived. Thus,

$$V_{GS(Z)} \approx V_P + 0.64, \qquad (1)$$

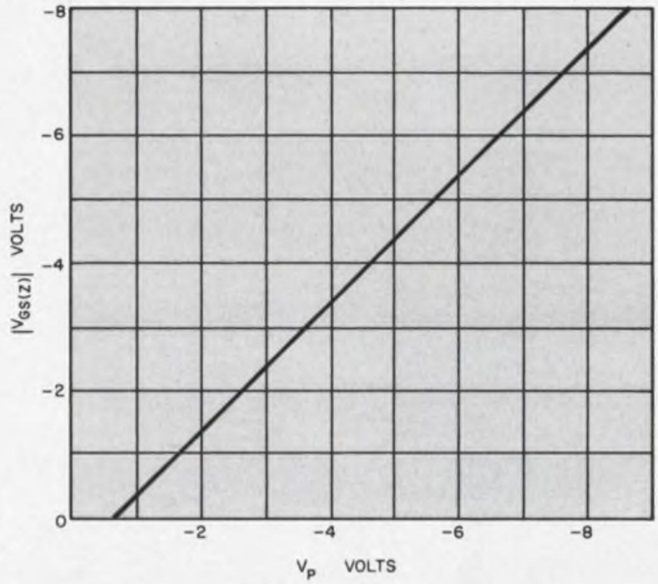
$$I_{D(Z)} \approx I_{DSS}\frac{0.64}{V_P}^2, \qquad (2)$$

where $V_{GS(Z)}$ and $I_{D(Z)}$ are the gate voltage and drain current, respectively, that produce the zero coefficient. V_P is the pinchoff voltage and I_{DSS} is the drain current at zero gate bias.

Several n-channel FETs (five different types) exhibiting a wide spread in parameters were tested to determine the optimum bias point. This was done by plotting the characteristic curves at different temperatures, as shown in Fig. 1, and then reading the bias-condition values from the resulting intersection point. Figure 2 illustrates the results for the optimum drain current normalized to the I_{DSS} value.

The empirical results indicate that the zero-temperature-coefficient bias point will occur at I_D equal to I_{DSS} or at a V_{GS} of zero for an n-channel FET with V_P equal to -0.7 volt.

The results of a plot of the measured gate voltage for zero temperature coefficient as a function of the pinchoff voltage are given in Fig. 3. The theoretical Eq. 1 is plotted as a dotted line. The empirical relationship is not as well-behaved and as predictable as one would like. One observation would be that the actual gate voltage required to give a zero temperature coefficient usually seems to be nearer to zero than theoretical predictions would indicate.



3. **The FET gate voltage** required to produce a zero temperature coefficient for the drain current varies as a function of the pinchoff voltage.

Measurements on a number of n-channel FETs indicated that the actual magnitude of drift in equivalent V_{GS} was within about 15% of the value predicted by:

$$D = 2.2\,[\,1 - \sqrt{I_D/I_{D(Z)}}\,] \qquad (3)$$

Bias makes the difference

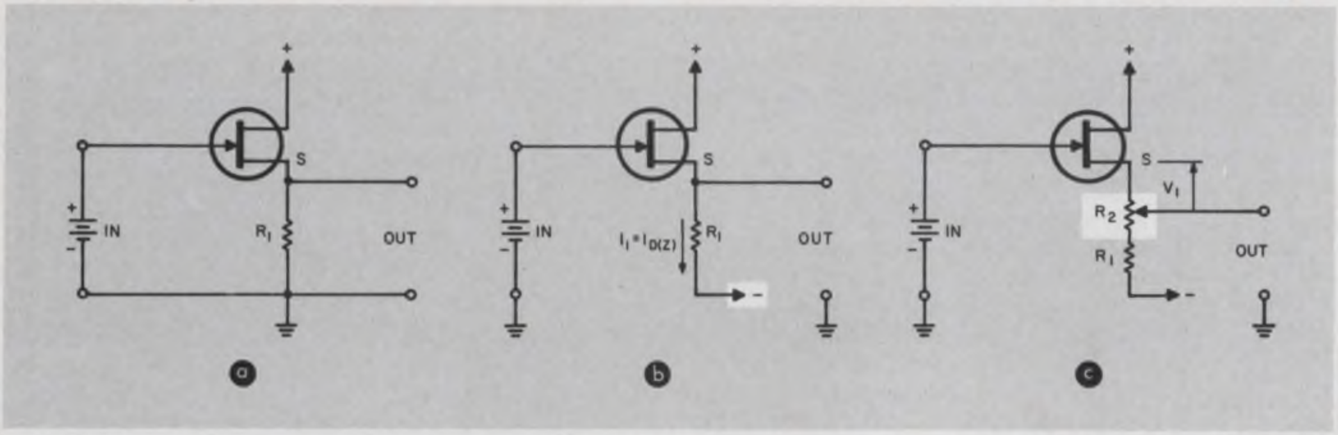
We will now consider several basic dc amplifier circuits and discuss their component and bias requirements along with the characteristics typically achievable. In some circuits it will be assumed that the source providing the input signal establishes a dc return path to ground for the gate. In the other circuits, the assumption is that a resistor of between 1 and 10 meg is connected across the input terminals.

Source-followers. Since one of the primary reasons for the use of a FET in dc amplifiers is the very high resistance, the source-follower circuit is fairly common. Fig. 4a illustrates the simplest form of a FET source-follower. The output load resistor provides the bias conditions that may be chosen to provide a negligible temperature drift, and, in turn, the critical gate voltage and the critical drain current are given by:

$$R_1 = V_{GS(Z)}/I_{D(Z)} \qquad (4)$$

Note that Eq. 4 tells us—for FETs with a relatively low value of pinchoff voltage—that the load resistance value required to give temperature stability may well be too low to give adequate voltage gain for the stage.

For this circuit, the typical voltage gain for the temperature-stabilized source-follower will be less than 0.5. It works best with FETs having an intermediate value of V_P. There will be a dc offset between the output and input voltages even with the input made zero. This will be equal to $V_{GS(Z)}$ and may be eliminated by the use of a differential



4. **The FET makes a simple source-follower** because of its high input impedance (a). When unity gain is desired, the source uses a separate negative supply to obtain the proper current biasing (b). By placing a potentiometer in the source leg (c), the offset voltage becomes adjustable through zero.

amplifier as the succeeding stage.

Better performance may be obtained from the source-follower circuit in Fig. 4b, where a separate negative power supply provides the critical bias current which is made equal to $I_{D(Z)}$. The value of R_1 in this case will be much greater than before, and hence the voltage gain may easily approach unity.

This circuit may be used with FETs having pinchoff voltages close to the -0.7 volt ideal. This will yield a zero temperature coefficient for zero gate voltage and thus have negligible offset voltage in the source-follower.

A simple circuit modification (Fig. 4c) will allow the removal of the offset voltage for non-ideal FETs and yet retain negligible drift and a voltage gain which is close to unity. The value of $V_{GS(Z)}$ here, however, must be small in comparison with the negative supply voltage to prevent any loss in voltage gain.

Common-source dc amplifiers. The FET may be used in the common-source mode to give a voltage gain greater than unity and yet have the capability of negligible drift. Fig. 5 shows a typical circuit arrangement to achieve this.

Potentiometer R_2 provides an adjustable gate bias voltage, which may be set equal to $V_{GS(Z)}$ for minimum drift. Variable resistor R_1 used for the drain load will allow the adjustment of the dc output level. The output cannot be made equal to zero without additional circuitry, but this adjustment will assure that the same offset is obtained.

The voltage gain of the common source FET amplifier is approximately equal to $g_{fs} R_1$ if the drain resistance of the FET is much greater than R_1 and if the dc resistance seen between the source and ground is negligible. Voltage gains of 10 or more are practical.

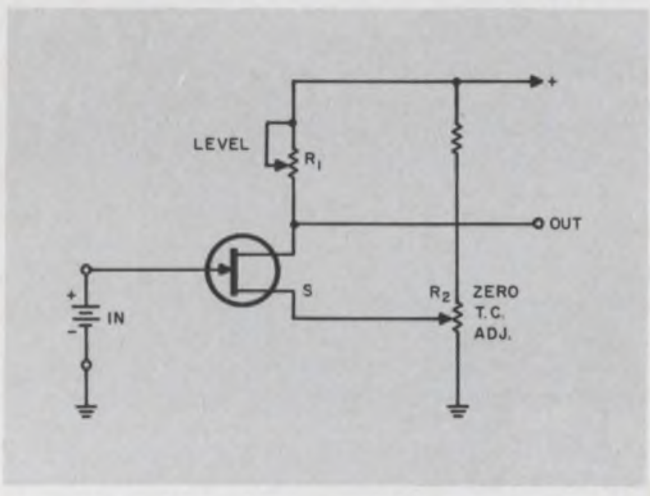
Putting FETs to work

Two FETs may be connected together in a differential-amplifier mode as shown in Fig. 6a. While one of the main reasons for going to a differential pair with bipolar transistors is to reduce the net drift, the typical drift that may be achieved with FETs in the differential mode is often worse than that which may be obtained from a single stage whose bias point is carefully set at the optimum condition.

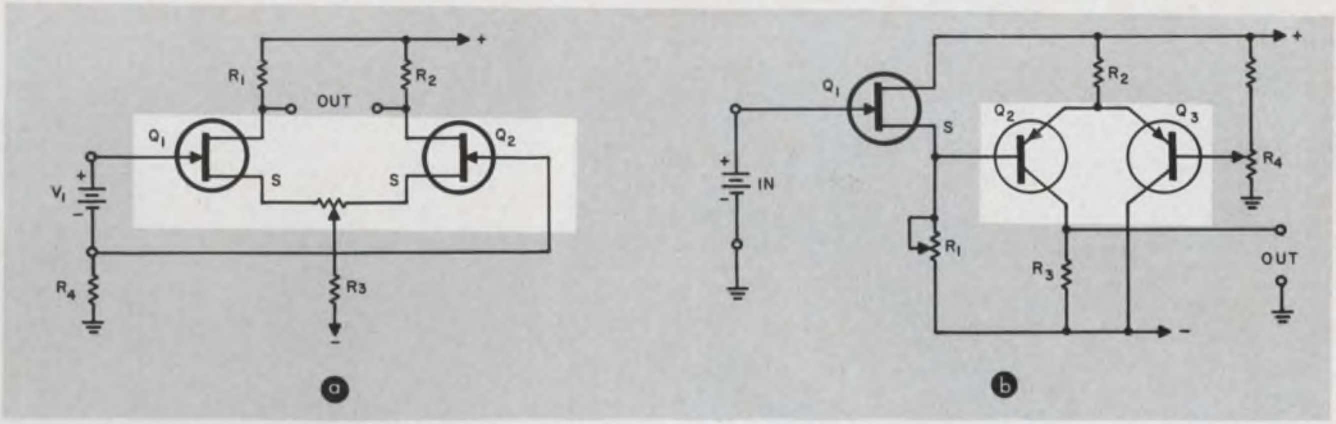
Balanced operation of the FET differential amplifier requires matched FETs having approximately equal g_{fs} and I_{DSS} and optimum bias conditions. This approach is economical, therefore, only if high input resistance is required along with substantial common-mode rejection. The common-mode rejection may be improved by replacing R_3 with a current source. Some dc return from the gates to ground must be present and is simulated in Fig. 6a by R_3.

The FET source-follower may be followed by a bipolar matched differential pair as shown in Fig. 6b. The over-all drift may be controlled by varying the bias current for the FET, which is normally operated near its optimum bias condition. This approach has the benefit of a possible zero voltage offset between input and output.

Electrometer-type circuits. The limiting value of the FET's input resistance is due to the various leakage currents which flow out of the gate. These develop an error signal across the



5. **Voltage gains of 10 or more** are practical in the common-source FET dc amplifier. This circuit (shown simplified) also exhibits negligible drift.



6. **In the basic FET differential amplifier** (a), care must be taken to match the g_{fs}, I_{DSS} and biasing. Otherwise, the circuit will be less stable with temperature variations than single-ended amplifiers. Zero offset voltage between input and output is achieved by going to a bipolar differential pair preceded by a FET source-follower (b).

source (generator) resistance with fluctuations in operating temperature. This variation is somewhat exponential, as is the case with most leakage currents associated with reverse-biased semiconductor junctions. Hence, it may not be balanced out with the control of the drain current, which produces a relatively linear temperature coefficient.

The problem is usually not too severe unless the generator resistance of the source is quite large or unless the maximum operating temperature is high. Under either of these conditions, compensation of the drift due to leakage currents is required and may be accomplished to a respectable degree.

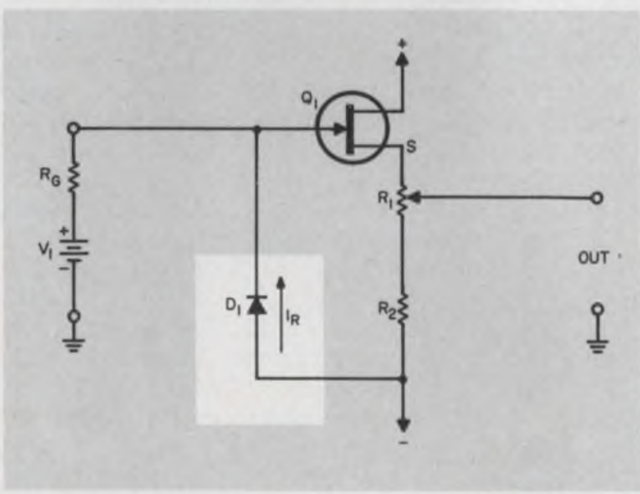
One simple way is to add another source of leakage current which is equal in magnitude but opposite in polarity. This is done in Fig. 7, where the reverse-leakage current of diode D_1 is matched with the sum of the I_{DG} and I_{SG} leakage currents of the FET.

The simple compensated FET source-follower amplifier may be extended a step further as shown in Fig. 8 to allow the measurement of very small dc currents. An operational amplifier, connected in a negative-feedback servo loop, attempts to maintain the net input current into the FET gate equal to zero. This is achieved by developing a current through R_2 that will be exactly equal in magnitude but opposite in polarity to that provided at the input terminal. Resistor R_4 is set to give zero voltage offset between the input terminal and the output of the FET source-follower. It is adjusted with the input shorted to ground.

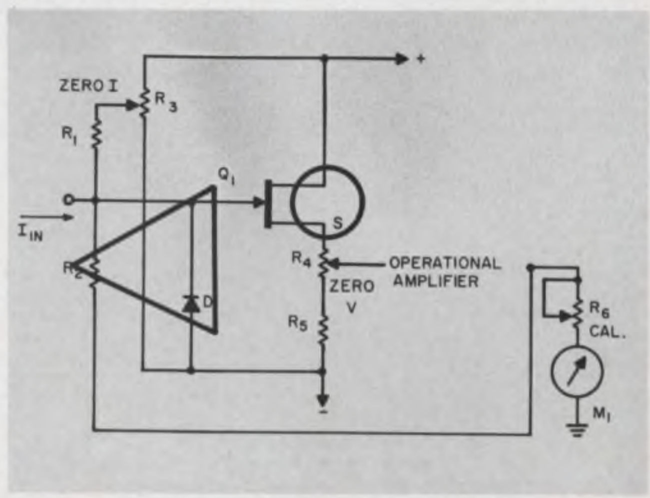
A second zero adjustment is provided by R_3, which may insert a small positive or negative input current through R_1 to compensate for any small net current flowing in the gate circuit. This yields zero voltage at the output of the operational amplifier when no current is supplied to the input. This arrangement is capable of current measurement down to and beyond the picoampere range.

Analog memory circuits. High-input-resistance dc amplifiers may be modified slightly to provide an analog memory capable of rather long memory times. The leakage-current-compensated source-follower in Fig. 7 is used in conjunction with a low-leakage memory capacitor, C_1, placed across the input terminals (Fig. 9a).

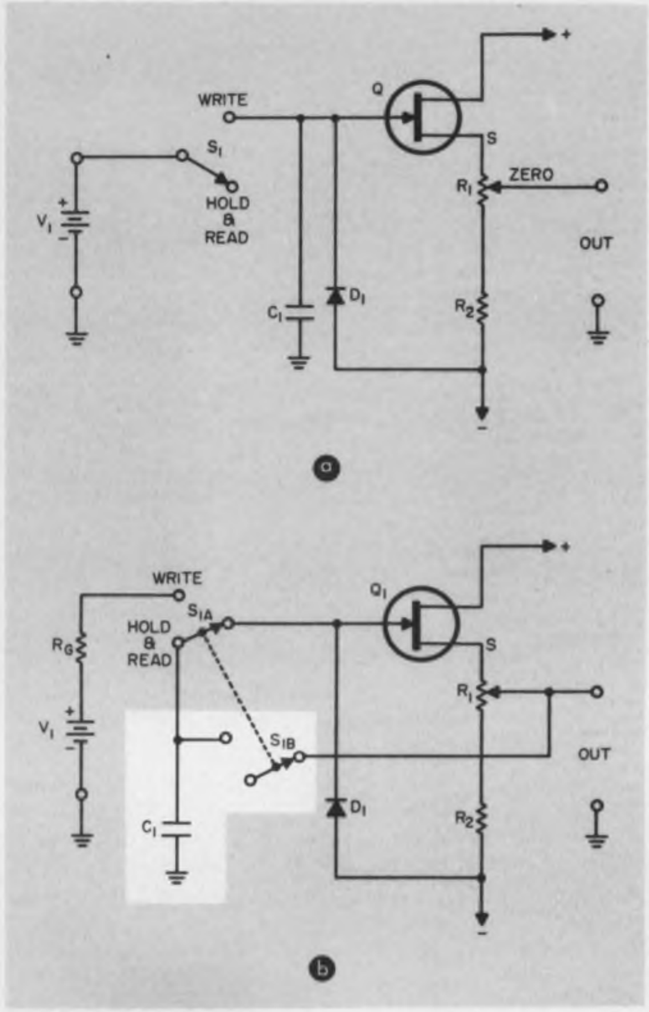
Switch S_1, as shown, connects the voltage to be remembered to the memory capacitor during



7. **The FET may be used as an ultra-high input-resistance voltage amplifier.** Diode D_1 provides leakage-current compensation for the FET.



8. **Very low currents,** down into the picoampere region, may be measured by using a FET followed by an operational amplifier with a negative-feedback servo loop.



9. **Analog memory circuits** capable of very long memory times are achieved by using a compensated FET source-follower (a). Addition of another switching function (b) prevents memory capacitor **C**$_1$ from loading the input.

"write" and then disconnects the input during memory "hold" and "read." The action of S_1 may be accomplished by a low-leakage mechanical switch, reed relay or by a carefully designed solid-state switch using FETs in a chopper mode.

The memory time may reach several minutes with a reasonable match in leakage currents. Even longer periods are possible with very careful matching and some degree of temperature control.

In certain applications, the relatively large memory capacitor, which may be 1 μF or so, may severely load the input source or may demand too long a time for accurate "write" operations. This problem is easily remedied by the addition of another switching mode, as shown in Fig. 9b.

The memory capacitor is connected to the output of the source-follower during "write." Thus, the relatively low output resistance will charge C_1 rapidly and without loading the input source at all. Then, for memory "hold" and "read" operations, the memory capacitor is switched to the input of the source-follower, which is now removed from the input voltage. In either of the above memory circuits, the outputs may be monitored during "write," "hold" and "read" without affecting the memory accuracy. ■ ■

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ON READER-SERVICE CARD CIRCLE 31

Try designing your career. You can get to the top without a plan, but it's unlikely. Here are some ideas to help smooth your way.

Last month the fellow in the seat next to me on a plane from Chicago to Cleveland told me of a plan he had laid out for his career. He would stay just so long on his present job, then he would move to a better job, spend so much time on that, then to the next step up and stay so long there. Eventually he expected to land in the top echelons of his company. This was no company training plan, his company had no such plan. This was a plan he had worked out for himself.

"You're assuming a lot in that plan, aren't you?" I asked.

"Certainly I am," he agreed, "but it's better than drifting, don't you think?"

I did think it was better than drifting, but, I said, "You'll get mixed up in company politics."

"I know that, but I'd be in politics no matter what I did, wouldn't I? So why not use the company's political set up to help me get ahead?"

You may say, "Why should this interest me, our company has no politics?" I have been told that hundreds of times, but each time I explain that I am not speaking of the dirty, sticking a knife in your back stuff, the man agrees that politics do figure in the promotions in his company.

Just ask yourself, "Why was my boss given his job?" Then, "Weren't some other men considered for the job? Why weren't they chosen?" When you have answered those questions, you will know what I mean by company politics. It's all those human factors that influence decisions affecting people and projects in your company. If you know what these factors are, you can put company politics to work for you. Your gain is that you will be considered for promotions when you should be considered.

How much career planning have you done? You may say, "I'm doing it every day by my ideas, my designs, my work." That's fine, but are you doing the other things that can help you advance in your company? A career can and should be planned step by step with the same care you use on any of your project designs. Thousands of engineers have done it, and they have found it much more profitable than drifting.

Ed J. Hegarty, Consultant, Mansfield, Ohio

This article is based upon material appearing in Mr. Hegarty's latest book, "How to Succeed in Company Politics" (McGraw-Hill Book Co., 256 pages, $5.95). He is the author of 10 other books dealing mainly with personal development, sales and sales training.

Your plan for advancement.

In planning any advancement within your company, here are the points you should consider:

1. **There are politics in all companies**, some good and some bad. Most are part of normal competition and good management.
2. **Analyze how far you want to go** in your company and what jobs ahead are possible for you. Analyze your own capabilities. Then decide what you want and go after it.
3. **Start training yourself** for the job ahead, since you advance one job at a time.
4. **Do a good job where you are,** an outstanding one if possible. Any advancement will come from what you do on the job you now hold.
5. **Know your competition**—the men who are capable of being advanced to the job you want. Respect this competition, cooperate with it and associate with it.
6. **Find the people who control promotions** in your company. Try to impress them.
7. **Be loyal to the boss,** the department and the company. Instead of complaining about rules, work regulations or management decisions, try to figure out why they are justified.
8. **Make the best possible first impression.** In all your contacts, present an image of competence.
9. **Make friends of everybody**—those above you, those at your level and those among the supporting troops.
10. **Conform.** Most managements are afraid of the radical in looks, in dress and in actions. Let someone else carry the placards in the protest line.
11. **Reconcile yourself to the tradeoffs.** Each time you move up, you'll find the bigger job more demanding. Face the fact that you have to trade some freedom for the extra pay the job brings.

Do you have what it takes?

Do you think you have what it takes to be promoted? You may say: "I have seniority. I have as much education and experience as anyone."

Both of these may be good qualifications, but in your company are these the qualifications that push a man ahead? It might be smart to check on what has counted in past promotions in your company.

Usually, you'll find that the man who got promoted was doing a good job where he was. I ask men how the boss feels they are doing on the job. They say, "I must be doing all right, he never says anything." I'd suggest you ask him. You may think you are doing all right, but the boss may see a number of ways in which you can improve. If he does and tells you so, you can act accordingly.

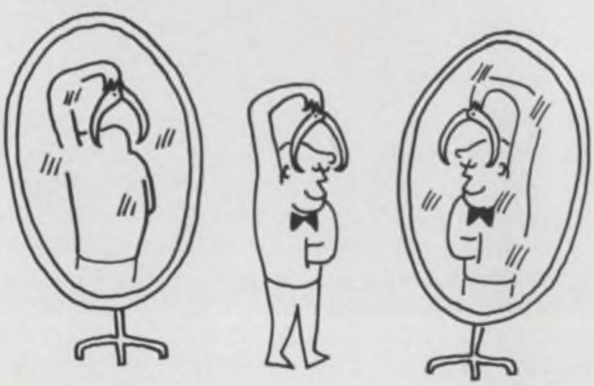
Next, how do you stand on education? Do you have the training needed for the jobs ahead? The training of an executive is a continuous process. You should be learning more every day, and this learning should not be confined to what you learn on the job. Ask your boss what training he suggests for you. By asking how you are doing, he sees that you want to do better and that you want to get ahead. But to hold any higher job, you have to prove that you can handle the one you are doing. On any higher job, you can assume you will need more education and training. One trainer put it this way, "On the basis of the job you are doing, would you promote you?"

What are the jobs ahead?

You advance one job at a time. This is the rule in most companies. Why not make a list of the jobs to which you might advance. Then take a look at the next step up. Suppose that you'd have to supervise the work of several men. (This is probably the toughest task for a man who has had only his own job to worry about and now is asked to supervise the work of others.) What do you know about supervision? Every year hundreds of helpful books are written on supervision. Have you read any of them? Such books are full of ideas to help you hold your next job—the one in which you may have to direct several men. If you are successful with them, management may give you a job that calls for managing more men.

How far do you want to go?

Every man has or should have a goal to shoot for in his company. What's yours? Is it the top job? This is the first question to ask in any career planning. Do you need to get to the top job to be happy? Some men do and some don't. Is your goal to be the vice president in charge of engineering in your company? Perhaps you don't want to shoot that high. In selecting, aim at a job that's possible for you. You may never make out in that



top spot, but you might be excellent in a number of jobs one step below the top. Perhaps you are already satisfied and want to stay where you are. This too calls for planning. Your company may consider the job you have now as a training job, and it may want to move another man into it so he can get the experience you are now getting. In maneuvering to stay on your present job, you may give the impression that you do not have the ability to advance to a better job.

Who is your competition?

As you move up in your company, you will have competition. Others might want that top job too. Make a list of these fellows and analyze them. Try

to rate them, not on your likes or dislikes, but on their ability to get ahead. These are the men who will also be considered for the jobs you get as you move up the ladder. What have they got that you haven't? You will probably be able to cross off some men because they lack the ambition or desire to advance. This will leave you with a smaller list. These men are your competition.

It's good company politics to know these men, to work with them and to cooperate with and speak well of them. When one man read this in my book, he wrote me, "That's sure good advice, some day one of these jokers may be your boss." Today they are competition. By working cooperatively with them, you impress management with your ability to get along with others.

Who does it pay to impress?

The key to any advancement is the list of men above you. If your company has the right men, it can go on to greater success. Without them, it has to struggle to stay alive. Thus, every company wants men who are ambitious and who will train themselves to handle top jobs. But to move up to a more important job, you have to impress someone that you are one of those ambitious men.

Who is this someone—or is it more than one person? Someone above you has the power to recommend you for a better job, and it will pay you to know who that is. Then you can go out of your way to impress that man or group.

What counts in promotions?

Performance, achievement and ability—are these the only factors that count in promotions, or are other factors also involved, subtle and personal factors never overtly mentioned but nevertheless important in determining who will progress and who will not? Is there any friendship or clannishness involved—school ties, loyalty, family or other such factors that help determine who is promoted? All of these factors are important in some companies. What is important in yours? It pays to find out and include these factors in your career plan.

Your image is important.

In moving about in your company, you are broadcasting two images: the image of first impression and the image of competence.

Keep in mind that first impressions are very important. You look at me and form an opinion. I look at you and form another. Of course, further acquaintance can change that first impression, but why not make that first impression as good as possible? Little things like shined shoes, a hair cut, neat or sloppy dress can mean a lot the first time you meet the man who has the power to promote you. There are things you can't change

about your looks: whether you're tall, short, thin, fat, etc. But you can try to make the most of what you have. You might ask, "What has my appearance to do with my ability as an engineer?" Nothing, maybe. But it has a lot to do with what a stranger thinks of you.

Check the executives in your company as to looks and dress. Why not try to make an impression on them by dressing appropriately. One executive told me of an engineer he sent back to the office to get a coat, a shirt and a tie. "Here we were going before the operating committee to get approval of our year's budget," he explained, "and this joker shows up in a sport shirt." The executive did not want that sport shirt to make the wrong impression on the committee. You can't look like an expert in a sport shirt.

Remember that as you move about in your office, in the cafeteria and through the halls or aisles of the office and factory, people see you and form this first impression. Some of these eyes belong to the men who have some say about your promotion. You may say, "I hate this conformity." Okay, hate it, but go along with it, if you want to advance toward the top.

You also advance your personal stock by broadcasting an image of competence. You build this image by your performance on the job, by appearing willing and anxious to learn, by listening to suggestions and by stating your ideas clearly so that the other fellow understands them. Building this image among those who count takes time and constant effort. Without it you are lost in the competition. So why not ask yourself now, "What is my image of competence today, and what can I do to make it better?" One fellow might improve his image of competence by keeping his big mouth shut and listening more. Another might improve his if he stopped critizing others and their work.

The ability to make decisions, to bring to the boss problems with suggested solutions instead of just problems, to present ideas so they can be understood are all factors in building this image of competence.

Choose your friends wisely.

Pal around with the "comers." In making up your list of competitors for promotion, you checked off some you felt destined to be executives of the future. Make these men your friends, the ones with whom you go to lunch, play golf and discuss ideas. You are judged by the company you keep, so keep company with the group on the way up.

What does the bigger job cost?

On every job you move up to, you have to give up a little of something you have now. As you get into the upper echelons you have to give up more and more. You'll have less free time, you'll see less of the wife and kids. More of your time will be demanded by that big job.

The other evening, a wife of a big executive told me, "I seldom see him any more, he's got that company for a wife." She has her own car, she belongs to the country club, her children are in better schools. Most of these advantages come because of his job and the money it brings in. If you aim for one of these top jobs, it may save trouble later if you explain all this to the wife and get her on your side. For if you are to go up to the bigger job, you have to forfeit some of the freedom you have now.

You don't have to play.

You don't have to accept any of these ideas, but they are the "rules of the game." You won't advance in your company if you refuse to play according to the rules. You may make some small advancement, but you'll never get up near the top. In deciding what to do, you are the key man, your wants and desires come first. Follow these suggestions, and your road to the top will be easier. Buck them and you may get nowhere. ■ ■

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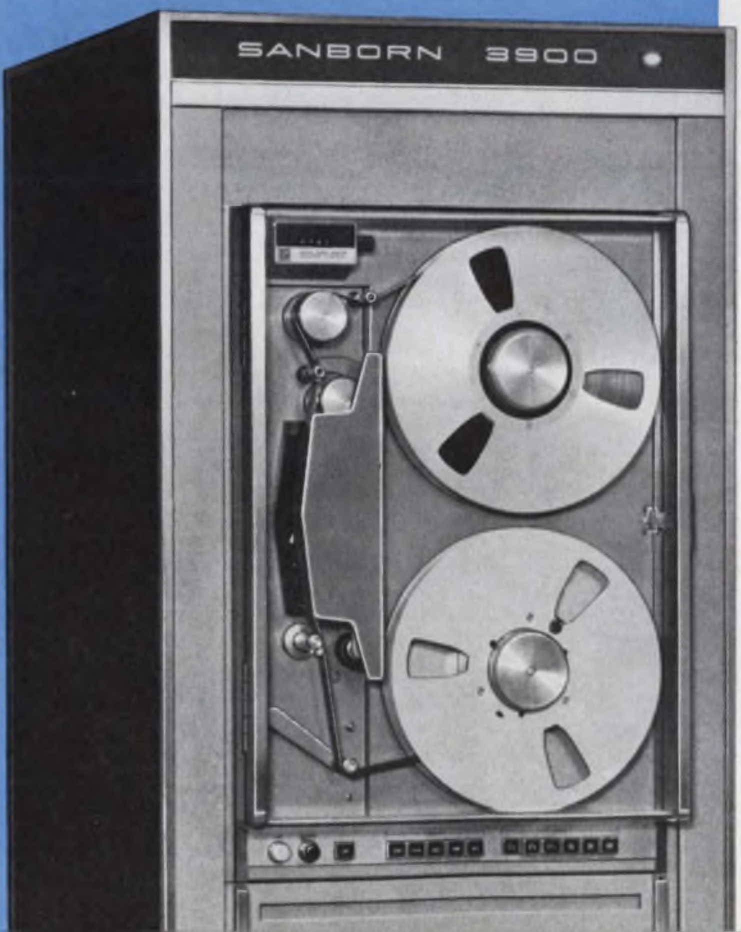
These new systems have the same improvements in performance, reliability and operating ease as the low bandwidth models, for instrumentation tape recording with complete IRIG compatibility. The tape transport, key to superior system performance, is of a rugged and simple Hewlett-Packard design which reduces costs without sacrificing uniform tape motion; six electrical speeds are pushbutton-selected (1⅞ to 60 ips) without idler or capstan change. Other standard features include provision for edge track for voice commentary, adjustable input/out levels, built-in 4-digit footage counter accurate to 99.95%, and easy snap-on reel loading. The transport needs no maintenance except occasional cleaning of the tape path.

Check the system specifications here and call the H-P Field Engineer in your locality for complete technical data and application engineering assistance. Offices in 48 U.S. and Canadian cities, and major areas overseas. Sanborn Division, Hewlett-Packard Company, Waltham, Massachusetts 02154. Europe: Hewlett-Packard S.A., 54 Route des Acacias, Geneva, Switzerland.



representative specifications

DIRECT MODE

Tape Speed	Bandwidth	Frequency Response	S/N Ratio Filtered	Minimum RMS Unfiltered
60 ips	300-250 KC	±3 db	35 db	29 db
15 ips	100-62.5 KC 300-44 KC	±3 db	32 db 38 db	27 db
1⅞ ips	50-7 KC 300-5 KC	±3 db	30 db 39 db	26 db

*Measured with bandpass filter at output with an 18 db/octave rolloff

FM MODE

Tape Speed	Bandwidth	Frequency Response	FM Center Carrier Frequency (Nominal)	S/N Ratio* Without Flutter Comp.	Total Harmonic Distortion
60 ips	0-20 KC	+0, −1db	108 KC	45 db	1.5%
15 ips	0-5 KC	+0, −1db	27.0 KC	45 db	1.5%
1⅞ ips	0-625 cps	+0, −1db	3.38 KC	40 db	1.8%

*Noise measured over full bandwidth, min. rms at zero freq. dev., with lowpass filter placed at output. Filter has 18 db/octave rolloffs.

TAPE TRANSPORT

Maximum Interchannel Time Displacement Error: ±1 microsecond at 60 IPS, between two adjacent tracks on same head.

Tape Speeds: 60, 30, 15, 7½, 3¾, 1⅞ ips standard; 0.3 to 120 ips optionally available.

Tape: 3600 feet, 1.0 mil, ½" (7 channel), 1" (14 channel).

Controls: Line (Power), Stop, Play, Reverse, Forward (fast) and Record are pushbutton relays. A receptacle at the rear of the transport is provided for remote control operation.

Drive Speed Accuracy: ±.25%.

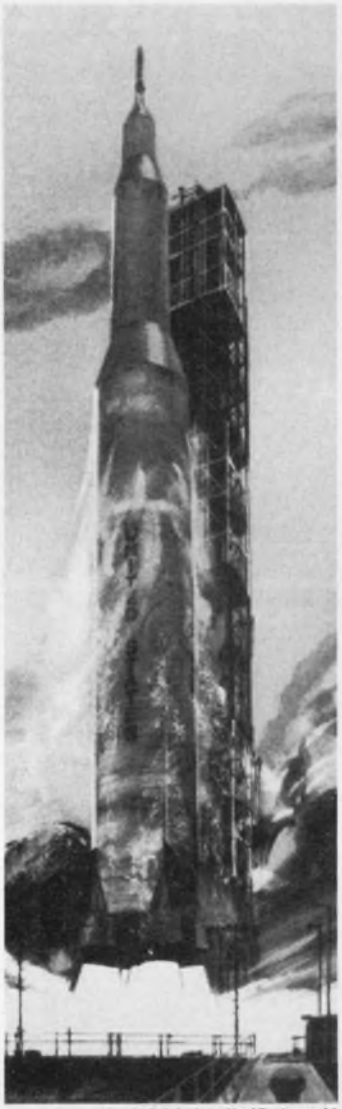
FLUTTER

Speed	Bandwidth	Flutter (p-p)
60 ips	0-200 cps 0-10 KC	0.2 % 0.6 %
30 ips	0-200 cps 0-5 KC	0.2 % 0.8 %
15 ips	0-200 cps 0-2.5 KC	0.25% 0.6 %
7½ ips	0-200 cps 0-1.25 KC	0.5 % 0.65%
3¾ ips	0-200 cps 0-625 cps	0.5 % 0.8 %
1⅞ ips	0-200 cps 0-312 cps	0.8 % 1.2 %

HEWLETT PACKARD hp SANBORN DIVISION

ON READER-SERVICE CARD CIRCLE 232

Senior Computer Engineers



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ON READER-SERVICE CARD CIRCLE 891

Terminal Block Selector

These represent a cross section of the broad Curtis terminal block line. Moldings are of black thermosetting phenolic.

"W" SERIES Track-type system utilizes snap-in modular assemblies for unlimited build-up combinations. Rated at 600 volts, 25, 50 or 75 amperes, depending on type. Available (two or three poles per assembly) with terminal bar and #6-32 screws or tubular connectors, with or without captive pressure pads on screws. Also single pole, high current tubular connector and fuse holder assemblies. Rubber covers and white fiber marking strips available. System requires no end pieces or mounting clamps — only two parts required to make up any length of block. Track prepunched and plated.

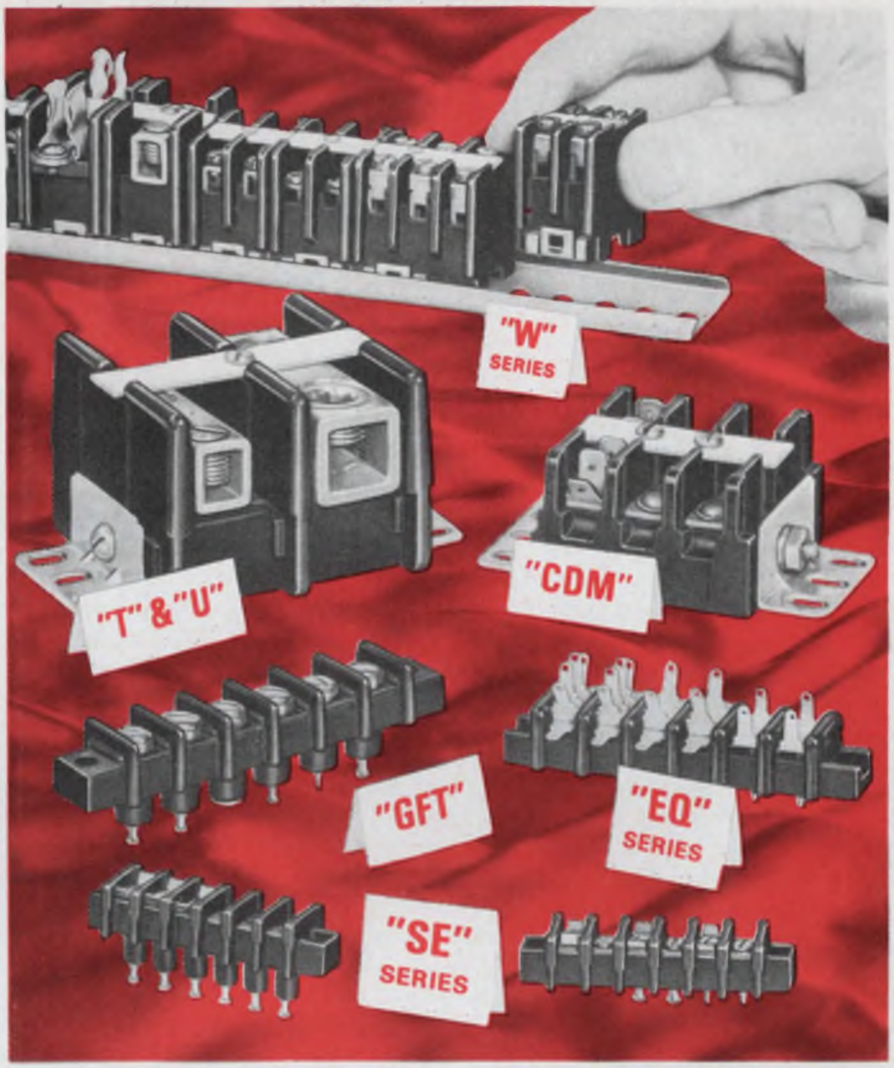
"T" & "U" Rugged, heavy-duty, high current, factory assembled modular build-up blocks. Type "T" rated 600 volts, 125 amperes, has 1 to 6 terminals with high pressure, solderless connectors for AWG No. 16 to No. 1/0 wire. Type "U" rated 600 volts, 250 amperes, has 1 to 4 terminals with high pressure, solderless connectors for AWG No. 6 to 250 MCM wire. Aluminum mounting brackets. White fiber marking strips. Also longer lengths.

"CDM" Compact, modular build-up concept for control of power circuits. Rated at 600 volts, 30 amperes. Brass terminal bars with No. 10-32 washer head screws take up to AWG No. 10 wire. Available 1 to 50 terminals per block, factory assembled with aluminum mounting brackets and white fiber marking strips. Also available with male .250" x .032" quick-disconnect tab terminals in various configurations with 2 or 3 tabs replacing one or both terminal screws.

"GFT" Popular, fully insulated feed thru series for compact, neat chassis mounting. Rated at 300 volts, 20 amperes with terminals on $^7/_{16}$" center to center spacing. Available in lengths of 1 to 18 poles with internal screws, printed circuit pins, or turret-type solder (with or without axial taper pin receptacle) connections.

"EQ" SERIES Quick-disconnect tab terminals with choice of 2, 4 or 6 .110" x .020" tabs per pole. Rated at 300 volts, 7 amperes for 2 tabs, 15 amperes for 4 or 6 tabs. Available with 1-22 terminal poles per block with integral mounting brackets. Also with .062" dia. feed thru pins for soldering to printed circuit boards.

"SE" SERIES Miniature, compact series (terminals on $^1/_4$" center to center spacing) rated at 300 volts, 5 amperes. Available in lengths of 1 to 18 poles with #2-56 screws, clamps, or 2, 4 or 6 .110" quick-disconnect tab terminals per pole. Variations include surface mount, feed thru, or insulated feed thru with internal turret-type solder connections or printed circuit pins.



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ON READER-SERVICE CARD CIRCLE 34

MOS-FET circuit stores input voltage peaks as dc

When a high-input impedance MOS-FET is used in shunt with a sampling capacitor, the result is a stable, linear detector that converts input peaks to a dc level. The circuit also provides a fast response and a low output impedance.

The conventional diode-capacitor combination used to store the peak amplitude of incoming signals has several inherent limitations. When a relatively small capacitor is used, the loading effect of the sampling circuitry will result in a short time constant. With a larger capacitor, the circuit is hard-pressed to reach the full-charge level when short-duration input pulses are sampled. Furthermore, diode nonlinearity adversely affects the results in both cases.

In the MOS circuit shown, Q_1 initially has both its emitter and base at zero volts. When the base goes positive by a voltage greater than the emitter-base voltage drop of the transistor, Q_1 becomes forward biased. When the input voltage is either removed or reduced, the transistor becomes back-biased, due to the voltage stored in C_1. The emitter returns to its initial point at the rate by which C_1 is discharged. This is determined by the leakage of C_1, Q_1, Q_3 and the gate current of Q_2.

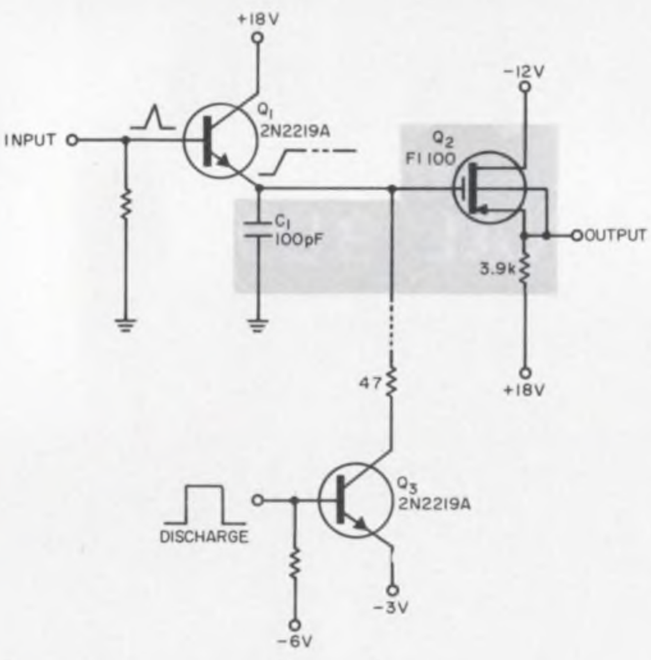
C_1 must be small in order to insure that the emitter-base drop remains constant for the range of charging currents required. But the very high impedance of the MOS yields a relatively long time constant (over 10 seconds) that is limited almost entirely by leakage. Thus the capacitor-size restriction is largely obviated. Since the source-follower does not permit unity gain, $V_{out} < V_{in}$. However, the two are proportional, and a 1:1 relationship can easily be restored if required.

By turning on Q_3, which is normally off, the circuit can be quickly discharged. Q_3 may also be used to block transient reception at the input.

Transistor Q_1 must have a low I_{ebo} at relatively high BV_{ebo} levels. Since Q_2 operates in a linear mode, it may be either a p-channel or n-channel device. The linearity is within 1% over a 10:1 range (from 0.5 to 5.0 volts) for the component values shown.

Thomas Skopal, Associate Engineer, Computer Test Corp., Cherry Hill, N.J.

VOTE FOR 110



MOS stage and shunt sampling capacitor is used to store input peaks as dc levels.

Neon lamp arrangement forms 60-Hz divider

A simple, compact, line-synchronized trigger source providing 60-Hz pulses is obtained when two neon lamps are used in the timing network. Employed as a test device for pickup, display and storage systems, this stable circuit (source) also has a division capability by factors two through six.

The 60-Hz rate is of great importance because of its relationship to the vertical scan rate of TV-type equipments with which the circuit is used. The field rate in these equipments is normally 60 per second and, therefore, the trigger source becomes a fundamental timing device. The schematic of the trigger source appears in Fig. la.

The instability usually associated with simple neon circuits has been circumvented by the rectifying and reference elements. The large sawtooth ripple excursion (Fig. 1b) is vital in maintaining synchronism of the neon firing with the

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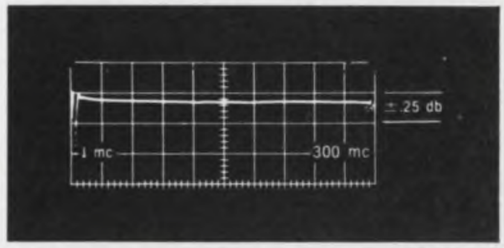

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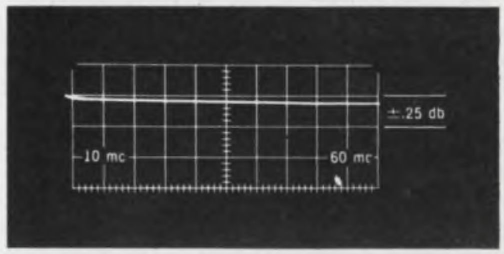

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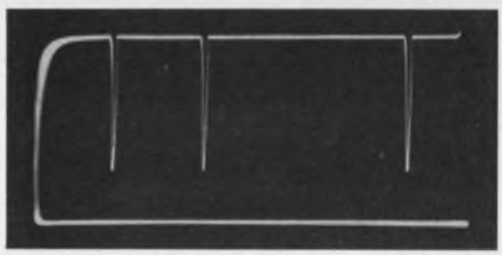
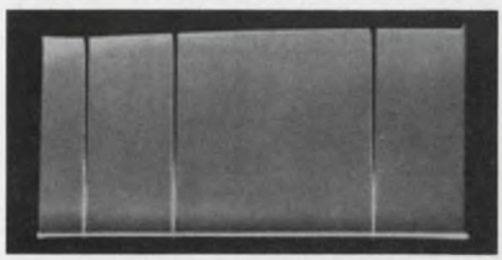


Detected Turn-Off Markers



Undetected Turn-Off Markers

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ON READER-SERVICE CARD CIRCLE 35

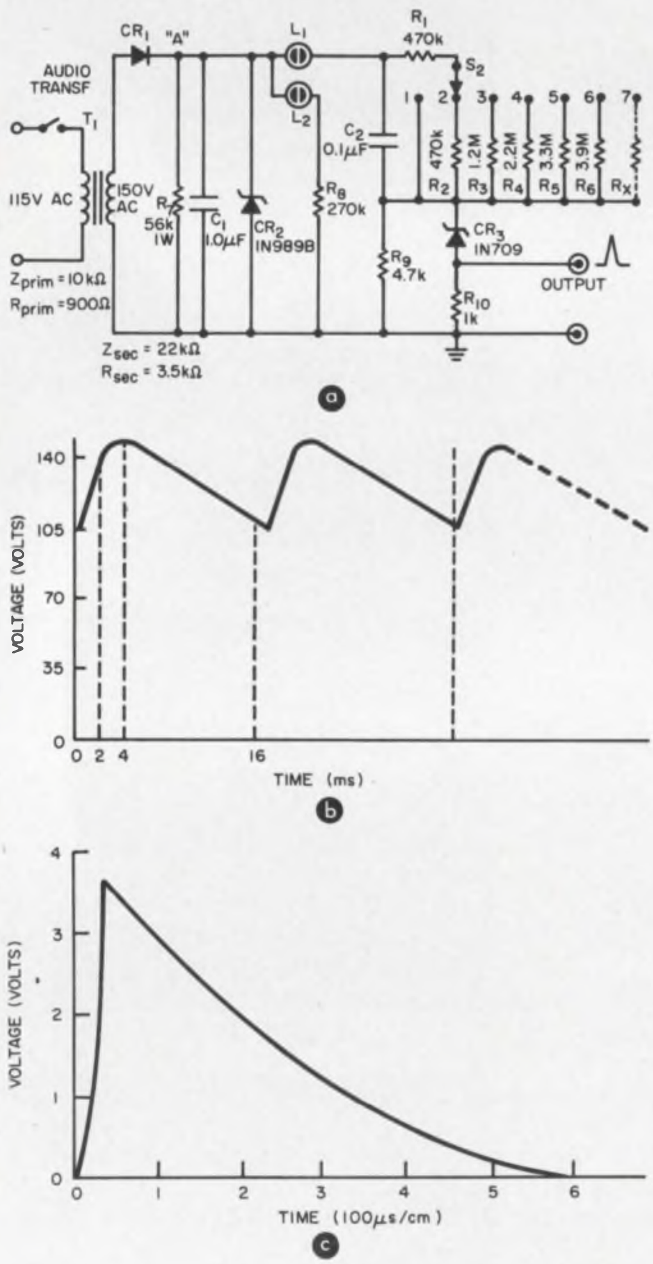
60-Hz line. The positive extreme of the sawtooth is limited by zener diode CR_2, thus providing a constant peak voltage for timing capacitor C_2. CR_2 also makes the circuit insensitive to normal line voltage fluctations.

Unstable operation of the neon at the higher division rates is usually caused by the dark environment within the small minibox. Elimination of this problem is accomplished by the addition of neon lamp L_2. This second lamp is placed in close physical proximity to L_1 and continuously pulsed with the 60-Hz sawtooth, thereby exerting sufficient influence on L_1 to stabilize it.

The upper narrow portion of the current pulse appearing across R_9 is made available at the output (Fig. 1c) through the divider arrangement of CR_3 and R_{10}. The frequency, or the division rate, is determined by the positioning of selector switch S_2. An additional position (7) on the switch will provide stable division by a factor of 10 by simply adding a 6.8 MΩ timing resistor.

O. R. Harper, Engineer, U.S. Army Electronics Command, Fort Monmouth, N. J.

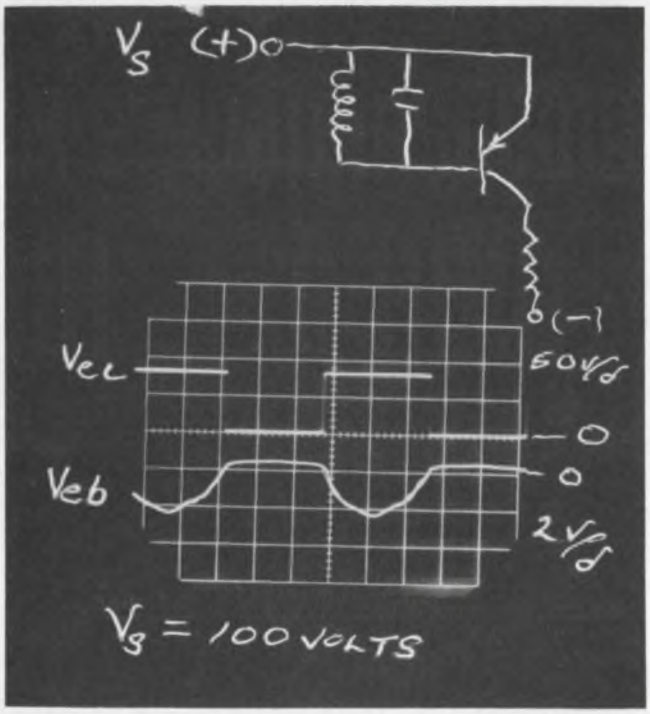
VOTE FOR 111



Stable synchronized 60-Hz trigger source and divider are formed by neon lamp timing circuit (a). Rectified line voltage at point A maintains synchronism of lamp with line because of its large sawtooth ripple (b). Output is derived from current pulse across R_9 (c).

Iron mightier than pen for polaroid data marking

The very common soldering iron can be put to advantage in the recording of data on polaroid pictures. It can be used for writing, retracing, drawing or labeling purposes.



Writing on polaroid pictures is a snap when a soldering iron is used instead of the pen. A hot, fine-point tip quickly and easily produces clear linework on the laboratory photograph.

The results (see photograph) are especially clear when a very hot, fine point iron is used. They are quickly and easily obtained and are superior to results achieved with other makeshift schemes.

Dan R. Cole, Research Technician, Skil Corp., Chicago, Ill.

VOTE FOR 112

Transistor bridge circuit monitors two voltage sources

Two transistors and two diodes in a bridge configuration provide a simple means of monitoring two voltage sources. Both the amount and direction of any unbalance between the sources

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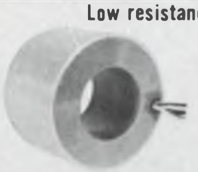

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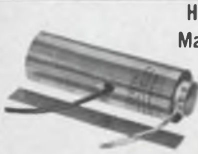

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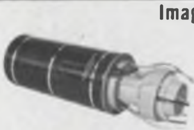

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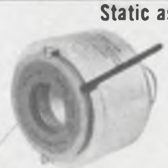

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ON READER-SERVICE CARD CIRCLE 36

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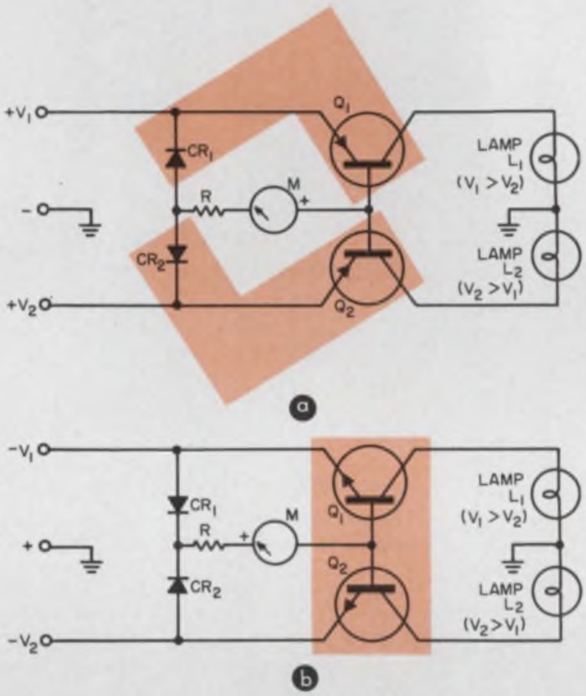
are indicated by a meter-lamp arrangement.

The circuit (Fig. 1a) operates as follows: with $V_1 > V_2$, current flows through the base-emitter junction of Q_1, the milliammeter, M, and CR_2. M therefore indicates the amount of unbalance. When $V_1 - \Delta V = V_2$, where ΔV is the voltage necessary for lamp indication, lamp L_1 turns on and indicates the unbalance direction. An unbalanced $V_2 > V_1$ produces a similar meter deflection and indication on lamp L_2.

The magnitude of ΔV depends on the meter resistance, R, and the type of semiconductors (germanium or silicon) in the bridge legs. For



Transistor-diode bridge arrangement (color) monitors two voltage sources with respect to negative ground (a). Meter **M** and lamps **L**$_1$ and **L**$_2$ indicate unbalance amplitude and direction. Npn's are used in positive system (b).

$R < 100$ ohms, ΔV can be reduced to approximately 0.7 volts by using germanium-type transistors and diodes. R, however, must be chosen to limit the base current in the maximum-unbalance case.

Meter scaling can be achieved by the proper choice of a meter shunt. Fig. 1b depicts the circuit for the monitoring of voltage sources referenced to a negative ground. The only major differences are the substitution of npn for pnp type transistors and the reversal of the diodes and the meter.

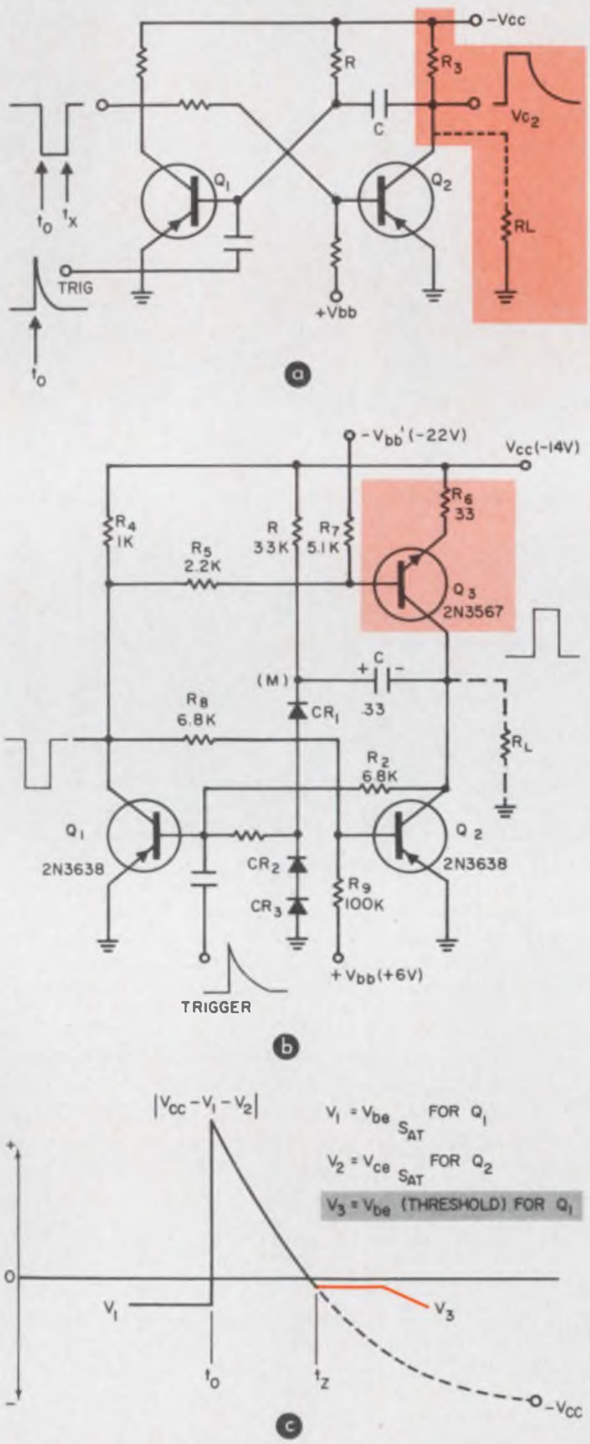
R. W. Stinson, Design Engineer, Western Electric, New York, N. Y.

VOTE FOR 113

Modified monostable flip-flop has improved duty cycle

The replacement of the output resistor by a transistor in the basic monostable flip-flop results in the improvement of the multivibrator's on-time to off-time ratio. This low-impedance substitute provides faster charging and requires less input trigger power.

In the conventional flip-flop (Fig. 1a), the output (collector of Q_2) contains an RC function primarily determined by the R_3C product. The



Duty cycle of basic monostable flip-flop (a) is limited by load placed on collector of $\mathbf{Q_2}$ and by the presence of $\mathbf{R_3}$ (when a trigger occurs before $\mathbf{V_{c2}}$ has reached $\mathbf{V_{cc}}$). The modified flip-flop (b) replaces $\mathbf{R_3}$ with a low-impedance source ($\mathbf{Q_3}$ — $\mathbf{R_6}$) to overcome the duty-cycle limitation. The trigger turns $\mathbf{Q_1}$ and $\mathbf{Q_3}$ off, thus turning $\mathbf{Q_2}$ on and establishing the switching threshold at point **M** (c).

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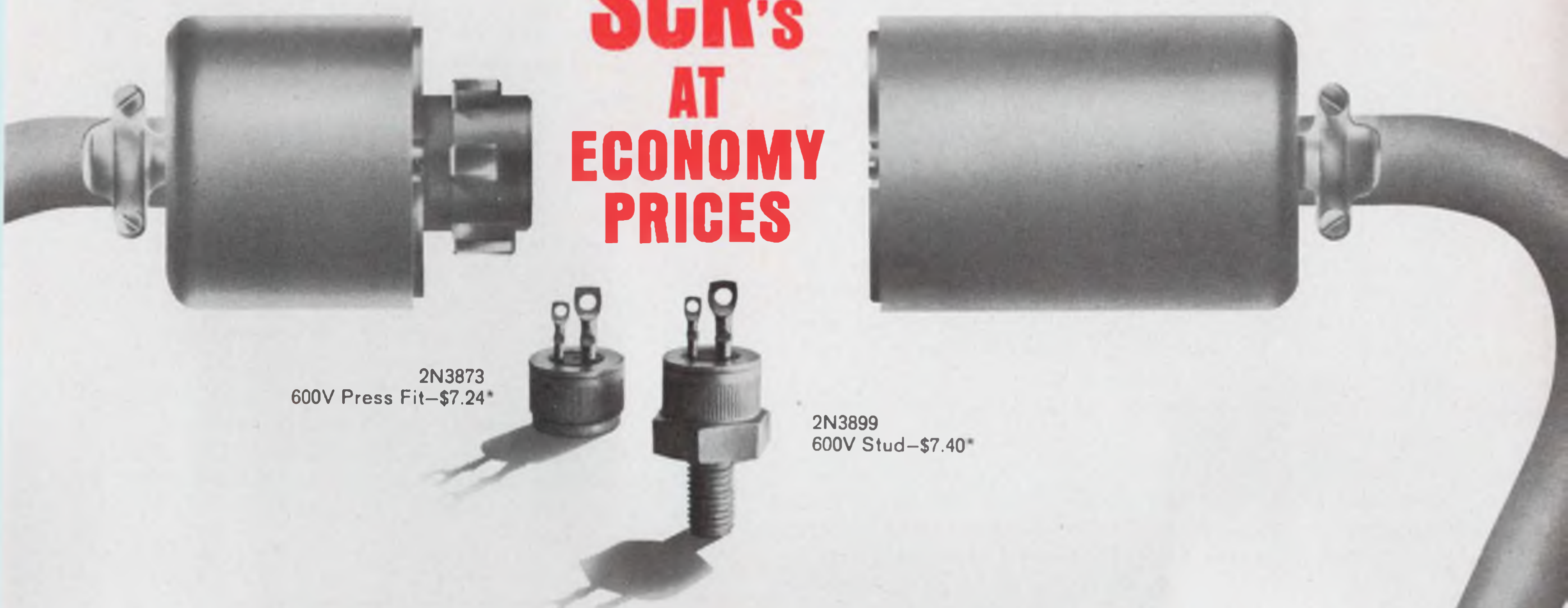

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output pulse width varies as a function of the voltage here (V_{c2}) when the input trigger is applied before V_{c2} reaches V_{cc}. Moreover, when the output stage is loaded by R_L, V_{c2} is lowered and the pulse width (and duty cycle) decreases.

Thus, where the duty cycle varies or otherwise does not allow V_{c2} to reach V_{cc}, or when a load is placed on Q_2, substantial advantages are offered by the modified circuit (Fig. 1b). The principal modification is the replacement of R_3 (Fig. 1a) with Q_3 and R_6. Q_3 is off when Q_2 is on. During the period that the monostable is switching back to its stable state, it is likely that all transistors are conducting in some fashion. R_6 must then be by the modified circuit (Fig. 1b). The principal large enough to prevent the flow of disastrous collector currents and thermal runaway in Q_2.

A positive trigger turns Q_1 and Q_3 off. Q_2 comes on, producing approximately the waveform of Fig. 1c at the junction of R and C. This condition exists for a period τ when the threshold voltage of CR_1 and V_{be} (of Q_1) is reached. Q_1 starts conducting. When Q_3 begins to conduct, the switching action is hastened by the positive feedback provided by R_2. R_2 also allows R to be larger, since R need not furnish a saturating base current to Q_1. The extra power supply, $-V_{bb}$, can be avoided by diodes placed in series with R_6 and R_5. CR_3 can be replaced by a transistor that features a low saturation resistance. The transistor substitute can be turned on by Q_3. A waveform at the collector of Q_2 will not have the RC-decay limitation because C is charged through R_6 and r'_{sat} of Q_3. This combination is typically of the order of 50 ohms. The fast charging of C allows a considerable variation of duty cycle without sacrificing pulse-width repeatability. The low effective resistance of Q_3 and R_6 tolerates the presence of either a lower R_L or a changing R_L without affecting the pulse width $(R'_L + R_6 + r'_{sat})$.

The equation for the pulse width can be shown to be:

$$t = RC \ln \frac{V_{cc} + V_{c2} - V_4 - V_5}{V_{cc} - V_6}, \qquad (1)$$

where $V_4 = CR_{1\,sat} + V_{be\,sat}$ (of Q_1), $V_5 = V_{ce\,sat}$ (of Q_1) and the threshold $V_6 = V_{be}$ (Q_1) + CR_1.

The circuit is used as a 5:1 frequency divider in a 600 pps line. The pulse width is approximately 7.5 ms, which provides a one-half cycle period before the monostable is reset. In this time, C can charge to within 1% of the value to which it would charge if it weren't retriggered. Thus the output pulse width is very nearly 0.69 RC.

David E. Smead, Project Engineer, Auto Data, Inc., San Diego, Calif.

VOTE FOR 114

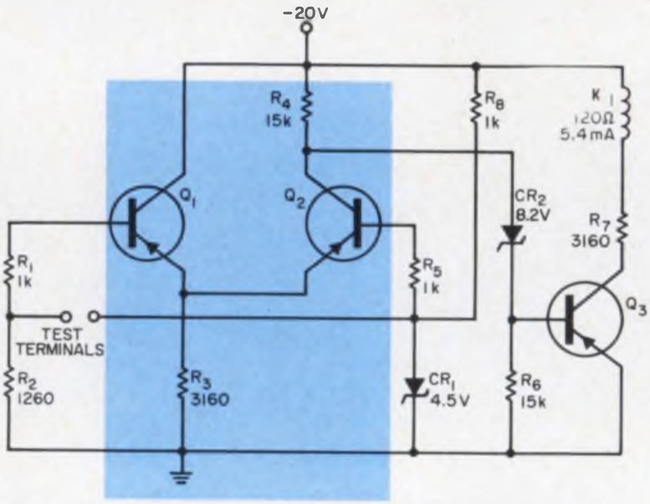
Difference amplifier forms short-circuit detector

A single-ended differential amplifier and a relay-driver stage combine to function as a go-no-go detector. It is suited for detecting terminal shorts in small, nonfunctional printed-circuit boards that may contain semiconductors.

These boards, which are commonly found in production-line setups, occasionally pose an additional need for a resistance-limit check. The detector also fulfills this requirement. Moreover, it exhibits a sharp transition between the go and no-go conditions and does not induce any harmful currents into the device being checked.

In the detector (see illustration), Q_1 and Q_2 form a differential amplifier with a single-ended output. Zener diode CR_1 provides the reference voltage for the amplifier as well as the voltage for the test terminals. When the terminals are open, Q_1 is turned off and the voltage at the collector of transistor Q_2 is -4.5 volts. Also, zener diode CR_2 is nonconducting, and the output (Q_3) is turned off.

With a short across the test terminals, transistor Q_1 conducts heavily and thereby increases the current through feedback resistor R_3. This results in a shift of the voltage at the collector of Q_2 to -8.5 volts. This voltage is sufficient to break



Differential amplifier forms the heart of a go-no-go short-circuit detector. Relay **K**$_1$ is energized when the test terminals exhibit zero potential.

down diode CR_2. With CR_2 conducting, a current high enough to saturate transistor Q_3 flows. As a consequence, relay K_1 is operated. It may trigger an audio or visual indication of the short circuit or may actuate a stepping switch.

The detector uses germanium alloy, medium-gain, low-frequency, switching-type transistors. It indicates shorts for resistances of up to 5 ohms with a transition range (at that point) of about one-tenth ohm. The upper limit may be altered by varying the value of R_2. Using the component values shown, the circuit limits the maximum current through the test terminals to 4 mA, a value which is safe for most semiconductors.

It is of interest to note that this detector can also be used in a complementary fashion; that is, to check that the resistance of certain electrical paths is not above a pre-calibrated, nominal value.

J. R. Fallon, Planning Engineer, Western Electric Co., Inc., New York, N. Y.

VOTE FOR 115

Low Cost Test Signals

10 MHz to 1000 MHz

—with the 3200B VHF OSCILLATOR

Using the new Frequency Doubler Probe 13515A

The VHF Oscillator Model 3200B is designed for general purpose laboratory use including receiver and amplifier testing, driving bridges, slotted lines, antenna and filter networks, and as a local oscillator for heterodyne detector systems in the frequency range from 10 to 500 mc.

The push-pull oscillator is housed in a rugged aluminum casting for maximum stability and extremely low leakage; six frequency ranges are provided for adequate bandspread on the slide-rule dial. Internal CW operation is provided; AM and pulse modulation may be obtained through the use of a suitable external source. The RF output is coupled through a waveguide-below-cutoff variable attenuator; in addition, an electrical RF level vernier is included as a front panel control.

An optional accessory Frequency Doubler Probe, Model 13515A incorporates a solid-state doubler circuit and provides additional frequency coverage from 500 to 1000 mc.

Features:

±0.002% Frequency Stability

External AM and Pulse Modulation

Waveguide-Below-Cutoff Output Attenuator

Solid-State Power Supply

Data subject to change without notice.

SPECIFICATIONS 3200B

Frequency range: 10 to 500 Mc (MHz) in six bands: 10 to 18.8 Mc; 18.5 to 35 Mc; 35 to 68 Mc; 68 to 130 Mc; 130 to 260 Mc; 260 to 500 Mc.

Frequency accuracy: within ±2% after ½ hour warmup (under 0.2 mw load).

Frequency calibration: increments of less than 4%.

Frequency stability (after 4-hour warmup under 0.2 mw load): short term (5 minutes) ±0.002%; long term (1 hour) ±0.02%; line voltage (5-volt change) ±0.001%.

RF output:
- **Maximum power** (across 50-ohm external load): >200 mw (10 to 130 Mc); >150 mw (130 to 260 Mc); >25 mw (260 to 500 Mc).
- **Range:** 0 to >120 db attenuation from maximum output.
- **Load impedance:** 50 ohms nominal.

RF leakage: sufficiently low to permit measurements at 1μv.

Amplitude modulation: externally modulated.
- **Range:** 0 to 30%.
- **Distortion:** <1% at 30% AM.
- **External requirements:** approximately 15 volts rms into 600 ohms for 30% AM, 200 cps to 100 Kc.

Pulse modulation: externally modulated.
- **External requirements:** 1 volt peak pulse into 2000 ohms. 5-volt rms sine wave will provide useable square-wave modulation.

Power: 105 to 125 v or 210 to 250 v, 50 or 60 cps, 30 w.

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Weight: net 15 lbs. (6, 8 kg), shipping 19 lbs. (8, 6 kg).

Accessories available: 13515A Frequency Doubler Probe; 501B, 514B, 517B Output Cables; 502B, 506B Patching Cables.

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Frequency range: 500 to 1000 Mc (MHz) with the 3200A/B operating at 250 to 500 Mc.

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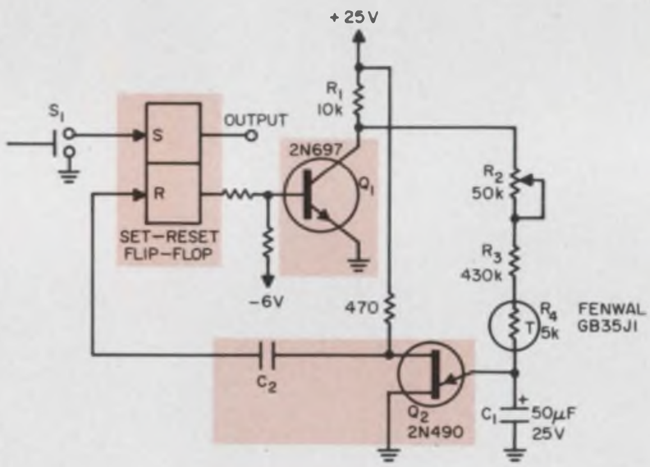
A twenty-second one-shot multivibrator, stable to within one second from −55°C to +125°C, can be made by combining a conventional set-reset flip-flop with an inverter and unijunction transistor (UJT). A potentiometer in the UJT charging network provides for variable reset adjustment.

Referring to the circuit diagram, the closing of S_1 sets the flip-flop and turns off Q_1. When Q_1 is turned off, C_1 begins to charge to +25 volts through resistors R_1 and R_4. When the breakdown voltage of Q_2 is reached, the UJT discharges C_1 and resets the flip-flop through C_2.



Set-reset flip-flop, inverter and UJT combine to form stable time-delay network. Output of one shot is 20 seconds in duration and is held to ±1.0 second over temperature range −55°C to +125°C.

The time-delay stability is attributed to the careful selection of R_1, R_4 and C_1. R_1 must be chosen such that the $I_{cbo(max)}$ (of Q_1) voltage drop across it will be negligible. The choice of C_1 is critical in that its leakage current at high temperatures must be small in comparison to its charging current (the Sprague type-137D used has a maximum leakage current of only 5 μA at 125°C). Thermistor R_4 compensates for the change in capacitance with temperatures and for the slight leakage of C_1.

Aaron Mall and Jack Shaul, Development Engineers, Bendix Corp., Baltimore, Md.

VOTE FOR 116

IFD Winner for Oct. 25, 1965

Carl Andren, Associate Engineer, Applied Physics Laboratory, Silver Spring, Md.

His idea "Symmetry amplifier compensated by FET current-source diodes" has been voted the $50.00 Most Valuable of Issue Award.

Cast Your Vote for the Best Idea in this Issue.

Tube #	Screen Size	Feature	Focus	Deflection	Resolution	Trace-width	Fiber Dia. Microns
KC 2486P	8⅜" x 1⅝"	Large presentation In-line scan tube	Electrostatic	Magnetic	200 li./in.	.005	15
K 2252P	2½"	High-resolution, Electrostatic deflection	Electrostatic	Electrostatic	800 li./in.	.0012	10
KC 2287P	3"	Uniform-scan high resolution	Electrostatic	Magnetic	1500 li./in.	.0007	5
K 2226P	3"	High resolution	Magnetic	Magnetic	1000 li./in.	.001	8
KC 2474	12"	Direct plotting High brightness, contrast	Electrostatic	Electrostatic	100 li./in.	.01	50

Background above: Microphoto of fiber-optics bundle mosaic.

(and it's recordable — thanks to DuMont's Fiber-Optics Leadership!)

DuMont's leadership in fiber-optics technology has resulted in a whole *family* of CRTs having significant advantages over conventional means of display: up to 30 times more efficient presentation of spectral information, superior resolution and contrast, curved-field compensation, elimination of parallax, to name a few.

Take our new KC2427P, the 3", high-resolution CRT shown above (it's the CRT used in the world's first fiber-optics 'scope). In addition to one-shot writing speed of 10^{12} trace widths/sec, this new CRT has 1.0 mv/trace fs sensitivity (2.0 mv/trace sensitivity with a gain-of-8 amplifier), 500 lines/in resolution, 2.5 ns risetime at 100 mHz, a 1000-mHz band-width capability with *unlimited* scan rate, distributed deflected structure to capture broad-band transients, electrostatic focus and deflection, and a faceplate held within 1 mil of *absolute* flatness.

DuMont offers fiber-optics CRTs with a variety of options: Screens to 12" for large-screen presentation or for direct plotting or recording. You can have a choice of phosphors (including high-UV types) on aluminized or unaluminized screens, cladded or uncladded fibers ranging in diameter down to 4 microns.

For whatever application—high-speed, high-resolution direct recording, image coding, large-screen presentation, direct plotting, or direct coupling to other optical devices — DuMont is sure to have the *right* fiber-optics CRT for you.

Happy surprise – you'll find fiber-optics CRTs significantly *smaller* and *less expensive* than their conventional counterparts.

Write or call for *informed* applications assistance, or to ask for our new 1966 48-page Catalog listing *over 4000* tubes that we make.

WORLD'S LEADING MANUFACTURER OF DISPLAY TUBES

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DU MONT ELECTRON TUBES

A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

CLIFTON, N.J.

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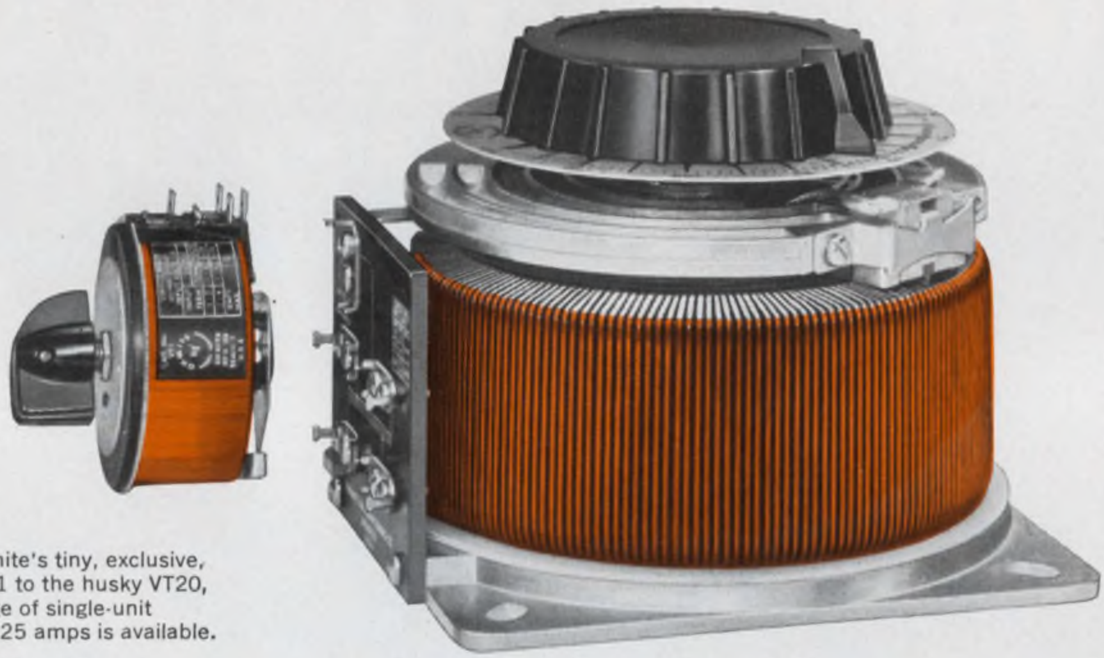
...that's the story of "Ohmitran" *v.t.*® variable transformers



From Ohmite's tiny, exclusive, 1-amp VT1 to the husky VT20, a full range of single-unit ratings to 25 amps is available.

SATISFY yourself . . . eliminate irritating variable transformer difficulties with Ohmite's famed reliability and long service life. In any piece of equipment, an Ohmite component indicates that there has been no compromise with quality.

MEET virtually all your requirements from Ohmite's big selection. Single units start with a tiny (and exclusive) 1-amp model, extend through heavy-output models of 25 amps. For single and/or ganged models, voltage inputs begin below 40 volts, run to 480 volts. There are assemblies for 3-phase applications, too, plus models in stationary or portable cases—with meters if you like. Most are stocked for fast delivery.

EASE engineering headaches by taking advantage of Ohmite's ready-to-ship stock of standard units, or willing advice and service on units for special applications. Bone up on the broad aspects of Ohmite's complete variable transformer service by requesting *Catalog 500*.

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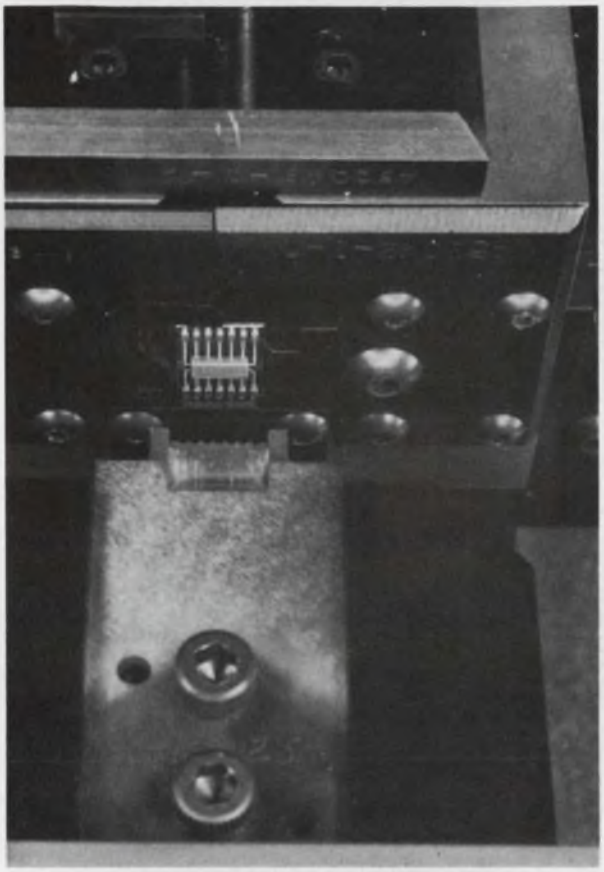
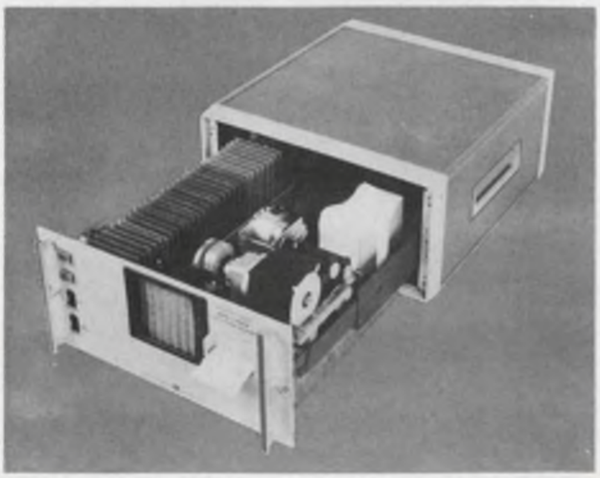
ON READER-SERVICE CARD CIRCLE 42

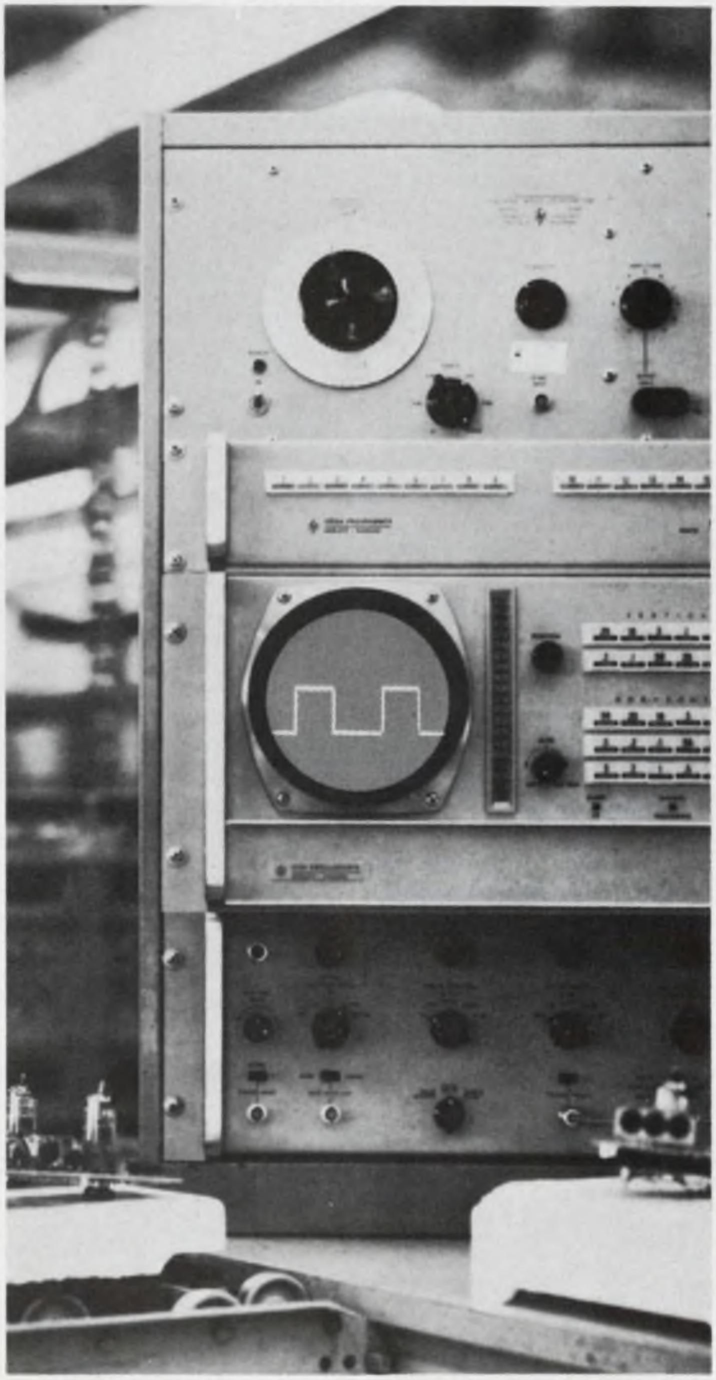
ED Products



A faster way to mount flat-packs . . . 114

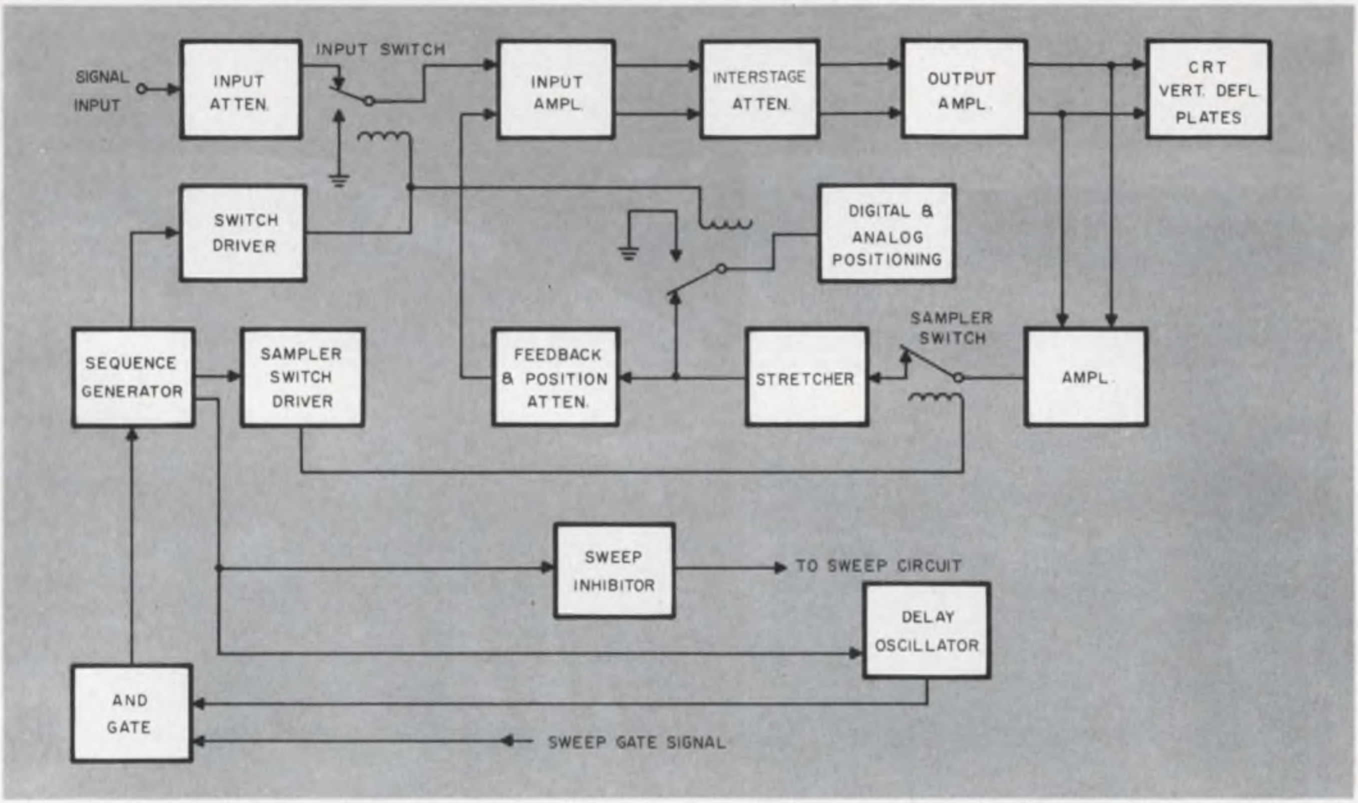


Forty-eight columns of alphanumeric soup . . . 122



For production or lab work, you don't need dc drift . . . 90

No dc drift in pushbutton scope, programed operation now possible



At best, dc drift in an oscilloscope is a bother, at worst it can be a disaster. In eliminating this drift in the new Model 155A oscilloscope, Hewlett-Packard of Colorado Springs offers more convenience in laboratory scope measurements and fully programmable operation on the production line. Beyond the stabilization circuitry shown above, and the programming boards and cables, the 155A is a standard 25 MHz instrument with specs generally comparable, if not superior to others in its price range. The pushbutton controls are also a handy extra.

The effects of driftless operation will be particularly valuable in measurements at dc levels. When this is required, as in pulse analysis for instance, the drift introduced by the amplifiers and controls of a conventional scope can make life pretty difficult. In some cases the error caused by drift can become great enough to drive the trace completely off the face of the scope.

With the drift eliminated, the trace stays put indefinitely. And, in a programed system, it can be recalled to the same position at any time. The operator can make detailed waveform measurements by simply selecting the proper program.

Front-panel controls of the 155A include illuminat-

Drift stabilizer operation

The stabilizer circuitry corrects for oscilloscope drift through a feedback loop. The delay multivibrator changes state, activating one leg of the "AND" gate 350 ms after completion of the previous correction. When the sweep in progress ends, the other side of the "AND" gate is armed, triggering the sequence generator.

The sequence generator grounds the oscilloscope input and removes positioning voltage, commands that a sample be taken, and inhibits the sweep. With the input grounded, each side of the amplifier should be at the same voltage. If not, drift has occurred and correction is made.

The sampler circuit senses the drift and feeds this voltage back to the amplifier input to correct the difference. The sampled voltage difference is also stored on the stretcher to maintain the correction. At the end of the 2 ms sampling period the sampler switch is opened and 1 ms later the input is reconnected. Simultaneously, the position voltage is reestablished and added to the drift correction voltage which has been stored on the stretcher. The sweep is inhibited for two more ms and then is allowed to return to normal operation.

HIGH Q encapsulated HIGH Q wafer HIGH K encapsulated

Now, JFD Uniceram® Fixed Capacitors Come THREE ways

High Q Uniceram High Q ceramic fixed capacitors offer a unique combination of small size, exceptional stability and a guaranteed minimum Q of 5000 . . . with up to ten times more capacitance per unit volume than competitive units . . . up to .206 mfd/in^3.

GLASS ENCAPSULATED—105 models, with capacitance values from 0.5 to 3000 pf, provide the ultimate in High Q, reliability and stability. All models meet or exceed requirements of MIL-C-11272B.

WAFERS—Uniceram High Q capacitors are also available as unencapsulated wafers with metalized edges. 88 low-cost units, with capacitance values from 0.5 to 3000 pf, offer the same outstanding electrical properties. These wafers are ideally suited for hybrid integrated circuits, can be soldered directly to printed circuit boards or used as discrete components.

High K ENCAPSULATED—A High K series of Uniceram ceramic fixed capacitors with up to 1 mfd capacitance per unit volume is also available. These glass encapsulated units meet or exceed requirements of MIL-C-11015C. Volumetric efficiency . . . up to 48 mfd/in^3.

WAFERS—Uniceram High K capacitors will soon be available as unencapsulated wafers, also.

WRITE FOR CATALOG UNM 65-2

ON READER-SERVICE CARD CIRCLE 141

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THE AMERICA KNOWS BEST!

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JFD MID-ATLANTIC-MARYLAND, P. O. Box 7676, Baltimore, Md. 21207
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JFD MIDWESTERN-OHIO, P. O. Box 8086, Cincinnati, Ohio 45208
JFD WESTERN, 9 Morlan Place, Arcadia, California 91006
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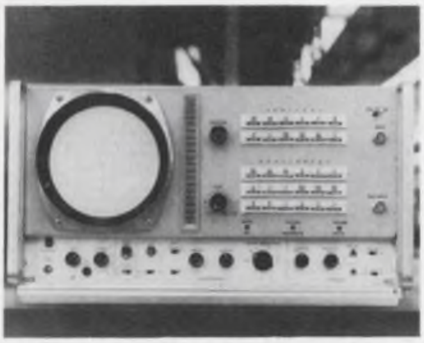
Precision Piston Trimmer Capacitors ■ Metalized Inductors ■ LC Tuners ■ Ceramic Fixed and Variable Capacitors ■ Fixed and Variable Distributed and Lumped Constant Delay Lines



ed pushbuttons for sweep and sensitivity control, level and position verniers, as well as the conventional horizontal and vertical controls.

Pertinent specifications are as follows:

Sensitivity: 12 calibrated ranges from 5 mV/cm to 20 V/cm. Vernier allows continuous adjustment and extends sensitivity to 50 V/cm.

Bandwidth: Dc coupled, dc to 25 MHz; ac coupled, 2 Hz to 25 MHz.

Dc stability: Dc stabilization maintains zero offset base line within ±0.1 cm.

Input impedance: 1 megohm shunted by approximately 50 pF.

Internal sweep: 18 calibrated ranges from 0. μs/cm to 50 ms/cm. Accuracy is typically within 1%, always within 3%. Vernier allows continuous adjustment and extends slowest sweep to 0.25 sec/cm.

Position: Base line can be offset ±5 cm in 1 cm steps and ±25 cm in 5 cm steps. Accuracy is ±2% on the settings. Vernier control allows continuous ±2 cm adjustment.

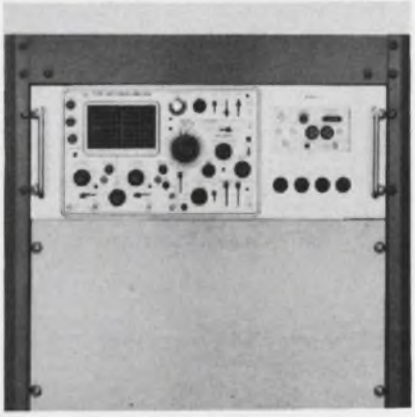
Magnification: X5 expansion extends fastest sweep to 20 ns/cm. Times 0.1 slows 10 ms/cm, 20 ms/cm, 50 ms/cm decade to 0.1 sec/cm, 0.2 sec/cm, 0.5 sec/cm. Accuracy is typically within 3%, always within 5%.

Triggering: Internal or external at 40 Hz to greater than 25 MHz, also from line voltage. Base line displayed in absence of input signal.

Programmable functions include: Sensitivity, input coupling, vertical positioning, sweep time, trigger source, and trigger slope.

P&A: $2150; May. $2450 with programing capability. A companion programer, Model 1550A, is $600. Hewlett-Packard, 1900 Garden of the Gods, Colorado Springs, Colo. Phone: (303) 636-5111. *Circle No. 251*

50-MHz oscilloscope



A new compact, 50-MHz, dual-trace rack-mount oscilloscope, type R453, was developed primarily for service in high-speed applications. The type R453 gives dual-trace sensitivity to 20 mV/div at 50 MHz, to 5 mV/div at 40 MHz, and the channels can be cascaded to obtain 1 mV/cm sensitivity at 25 MHz, single trace. Signal delay allows viewing the leading edge of the trigger waveform.

Price: $2035. Tektronix, Inc., P.O. Box 500, Beaverton, Oregon. Phone: (503) 644-0161.

Circle No. 252

Audio generator

The Model 378 produces a very low-distortion sine wave signal over repeatable settings at discrete levels between 1 cps and 110 kilocycles. Frequency is selected by switching between 1% resistors and capacitors. The output level can be set between 0 and 10 volts rms (or between −70 and +22 dB) on a 4-1/2-in., D'Arsonval 2% full-scale accuracy meter.

Price: $49.95 (kit), $69.95 (wired). Electronic Instrument Co. Inc., 13101 39th Ave., Flushing, N. Y. Phone: (212) 762-6000.

Circle No. 253

Pulse generator

Model 110A pulse generator features a 4.0 ns rise-time and an external triggering provision. Pulse repetition rate is variable from 4 Hz to 40 MHz, pulse width from 10 ns to 5 ms. Simultaneous positive or negative outputs are available to 10 V with up to 70 dB attenuation in single or double modes.

Pulse delay settings range from 10 ns advance to 50 ms delay and transition times are variable.

Price: $1250. Datapulse Inc., 509 Hindry Ave., Inglewood, Calif. Phone: (213) 671-7713.

Circle No. 254

Dual-scale thermometer

Five standard temperature ranges are available in the Model TM1004 Thermist-O-Meter, beginning with a low range of −58° to +32°F, up to a high range of +212° to +302°F, with both Fahrenheit and Celsius indications. Accuracy of 1% of full scale, mercury cell power for one year's operation, and battery check indication are specified.

P&A: $120; stock. Rustrak Instrument Co. Inc., Municipal Airport, Manchester, N. H. Phone: (603) 623-3596.

Circle No. 255

Sigma slide rule

A new, 10-in. slide rule said to provide exceptionally smooth slide action, lasting hairline adjustment and extreme dimensional stability. The 1737 sigma slide rule is made of bamboo and laminated with white facings.

Eugene Dietzgen Co., 2425 N. Sheffield Ave., Chicago, Ill. Phone: (312) 549-3300.

Circle No. 256

Random noise generator

A three-band noise generator covers a range of 5 Hz to 5 MHz. Output flatness is ±1 db from 10 Hz to 500 kHz and ±3.5 dB from 500 kHz to 5 MHz at maximum RMS output of 3 volts.

P&A: $495; stock to 30 days. Elgenco, Inc., 1550 Euclid St., Santa Monica, Calif. Phone: (213) 451-1635.

Circle No. 257

Squarewave generator

A compact, general-purpose square-wave generator provides simultaneous positive and negative-going pulses with a risetime of 1 ns or less. It can alo provide a positive-going pulse of 0.5 V to 12V into a 50 ohm load or up to 130 V when unterminated. Risetime of the high amplitude pulses are below 12 ns.

Repetition rate of either output is selectable in decade steps from 10 Hz to 100 kHz. A continuously variable multiplier provides coverage between steps and extends the maximum rep rate to 1 MHz.

A trigger output produces both positive and negative triggers of 0.4 V into 50 ohm with a rise time of about 50 ns.

P&A: $590; early 1966. Tektronix, Inc., Box 500, Beaverton, Oregon. Phone: (503) 644-0161.

Circle No. 258

Milliohmeter

Model 502A portable millohmeter features 13 overlapping ranges from 10^{-3}-10^{3} ohms. Power through the sample is less than 2 μwatts, and a voltage limiter holds the maximum voltage across the sample to 25 millivolts.

The unit can be set in the limiting mode where the maximum improper-range power is 65 μwatts. Accuracy is $\pm 3\%$ full-scale.

P&A: $425; 30 days. Kiethley Instruments, 12415 Euclid Ave., Cleveland, Ohio. Phone: (216) 795-2666.

Circle No. 259

Digital voltmeter

Accuracy of one part in twenty thousand is available on this digital voltmeter. Model 2025 converts analog to digital readings on a scale of 19999 without reducing accuracy.

Conversion time is constant at 20 ms. The unit has six operating modes, 2 built-in Standard Cell for checking performance, and greater than 25,000 Meg input impedance. Accuracy is specified at 0.01% of the reading $\pm$one digit.

IERC, Dynamics Corp. of America, 135 West Magnolia, Burbank, Calif. Phone: (213) 849-2481.

Circle No. 260

Synchro null detector

A combination of a synchro bridge and a phase angle voltmeter is said to permit the complete range of commercial synchros to be measured with 2 seconds of arc accuracy. The instrument is also available in a console with a combination of a phase angle voltmeter and any one of the following: Synchro, bridge simulator, resolver/synchro or resolver bridge.

P&A: From $1800; 30-60 days. North Atlantic Industries, 200 Terminal Dr., Plainview, L. I., N. Y. Phone: (516) 681-8600.

Circle No. 261

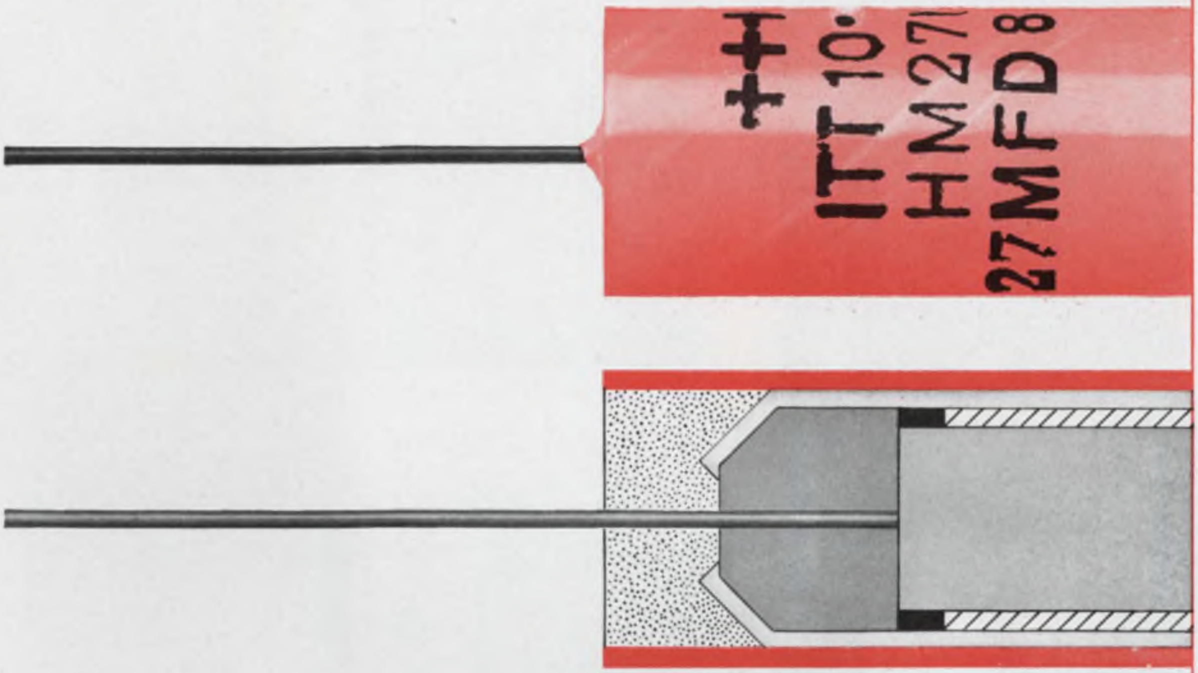
Ohmic thermometers

A family of 11 resistance thermometers enables measurement and control of temperatures. Ranges cover $-328°$F to $+500°$F, sizes from 0.125 to 12-in. long, and 0.125 to 0.278-in. diameter, in both body and tip-sensitive styles.

Designed for use with resistance measuring equipment, their high resistive change of several ohms per degree permits long, spliced leads with minimal loss of accuracy.

Price: $11-$59. Minco Products, 740 Washington Ave. N., Minneapolis, Minn. Phone: (612) 338-6753.

Circle No. 262



Why ITT wet tantalum capacitors can't leak

Every ITT Red Cap® wet tantalum capacitor gets a "total stress" seal that, unlike the ordinary single-crimp seal, positively prevents electrolyte leakage. To accomplish this, ITT inserts a teflon end seal, then spins down the open end of the can until end seal, anode and insulating washer are under a predetermined compressive force.

Seal integrity is further insured by the addition of an epoxy end fill. Since the epoxy's expansion coefficient is less than that of the can, temperature cycling cannot relax the spun seal.

If you're tired of electrolyte leaks and the problems that go with them, here's an easy solution. Order the ones that can't leak — the Red Caps® — from your ITT Capacitor distributor or from ITT Semiconductors, 3301 Electronics Way, West Palm Beach, Florida.

ITT

ON READER-SERVICE CARD CIRCLE 45

Dc measurement system

A new precision dc potentiometric measuring and calibration system has better than 10 ppm accuracy from 0-2.011,111 volts. Guideline Type 960-S has provision for remote digital readout, and features potentiometer resolution of 1 part in 2 million. Thermal emf generation is less than 0.1 μV, and the system has auto calibration facilities.

P&A: $4110; 45 days. Hallmark Standards, 1995 Palmer, Larchmont, N. Y. Phone: (914) 834-6630. *Circle No. 263*

Null microvoltmeter

A solid state null detector and microvoltmeter is available in either line or rechargeable battery versions. The new instruments, Models 845A and 845AB feature input impedance of 10 Meg on ranges of 1 microvolt to 1 millivolt and 100 Meg on ranges of 300 V to 1 kV.

Input isolation is 10^{12} ohms. Nineteen end-scale ranges cover 1 microvolt to 1000 volts.

P&A: $350-$395; stock—30 days. John Fluke, Box 7428, Seattle, Wash. Phone: (206) 776-1171. TWX: (910) 449-2850.

Circle No. 264

Coating measuring unit

The thickness of anodic and organic coating on aluminum, stainless and other non-ferrous alloys can be non-destructively measured by the Permascope type EC3. The instrument is direct-reading, calibrates in seconds and covers two standard ranges of 0 to 0.0015-in. and 0 to 0.005-in. Other ranges up to a maximum 0.080-in. are available on special order.

Twin City Testing Corp., 533 S. Niagara St., Tonawanda, N. Y. Phone: (716) 693-6303.

Circle No. 265

3 Gc frequency meter

The 331C operates as a frequency meter and a signal generator at frequencies up to 3000 MHz. Accuracy is ± 5 parts in 10^{10}, drift, better than 1 part in 10^{9} per day.

The principle is that of a heterodyne wave meter. A comparison oscillator is controlled by a MHz crystal source. Frequency is displayed on three dials, for the last four Nixie tubes. Signals as small as 10 microvolts can be measured.

Data Instruments Div., Pennsauken, N. J. Phone: (609) 662-3031.

Circle No. 266

RIGHT NOW you have 8 lever styles . . . a choice of 7 colors . . . ac or dc operated . . . screw, spade, lug or wire lead terminations . . . SPST, SPDT, 2-circuit, DPST or DPDT circuit arrangements . . . up to 6 amp ratings.

Here's design freedom at its best. Greater styling flexibility than ever before. Another major extension of industry's already most complete line of quality switches.

What's more, they're time-tested devices. With quick make-quick break contact action that reduces wear. Lengthens switch life.

And they're insulated for greater safety. High dielectric superstructure provides long insulating path. Result? No shocks from metallic tool, appliance and instrument housings.

GET A SAMPLE. Examine it. Try it out. See it add glamor to your product.

When you're ready to order, you can expect fast service from complete stocks of your nearby Cutler-Hammer distributor. For information, write on company letterhead to Cutler-Hammer, Milwaukee, Wisconsin 53201.

CUTLER-HAMMER DESIGNER-LINE SWITCHES / *ENGINEERED FOR VALUE*

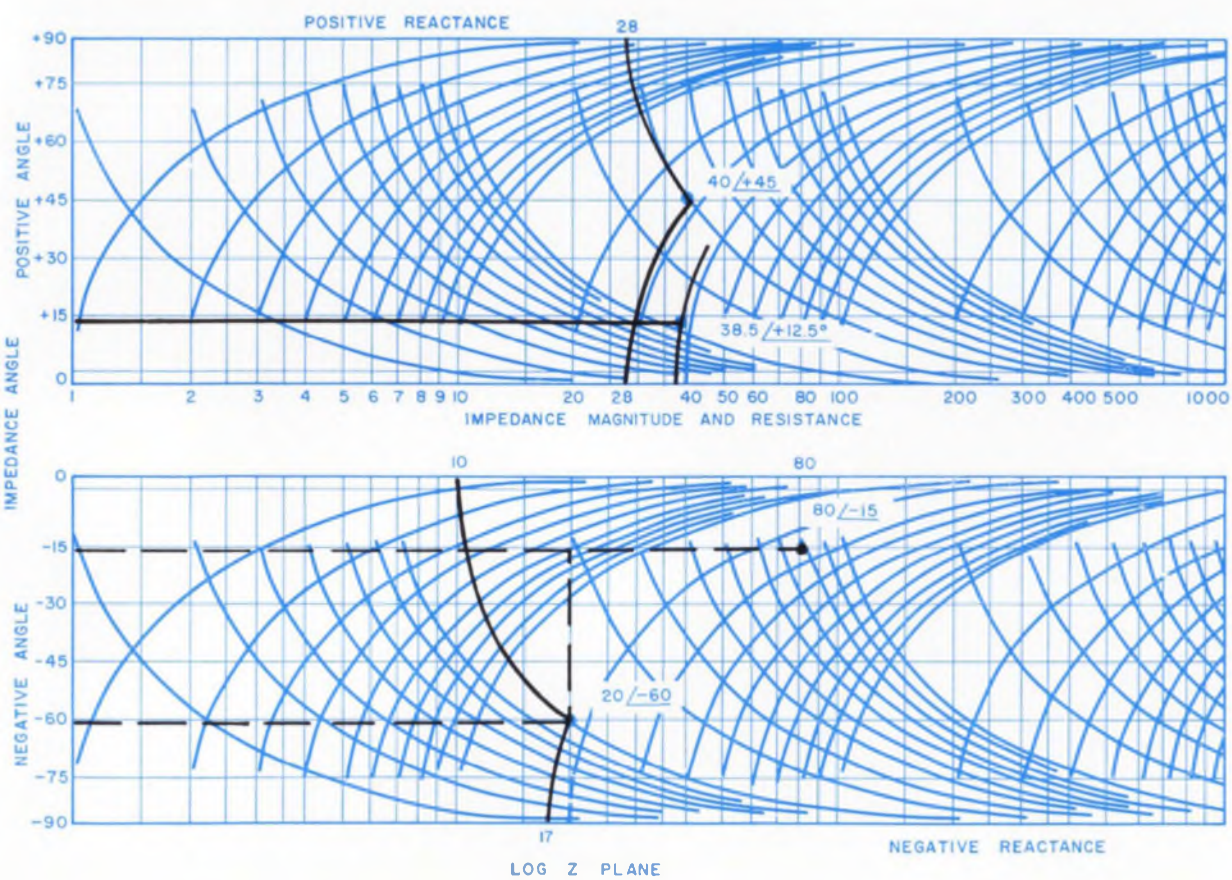
Multiply phasors the easy way

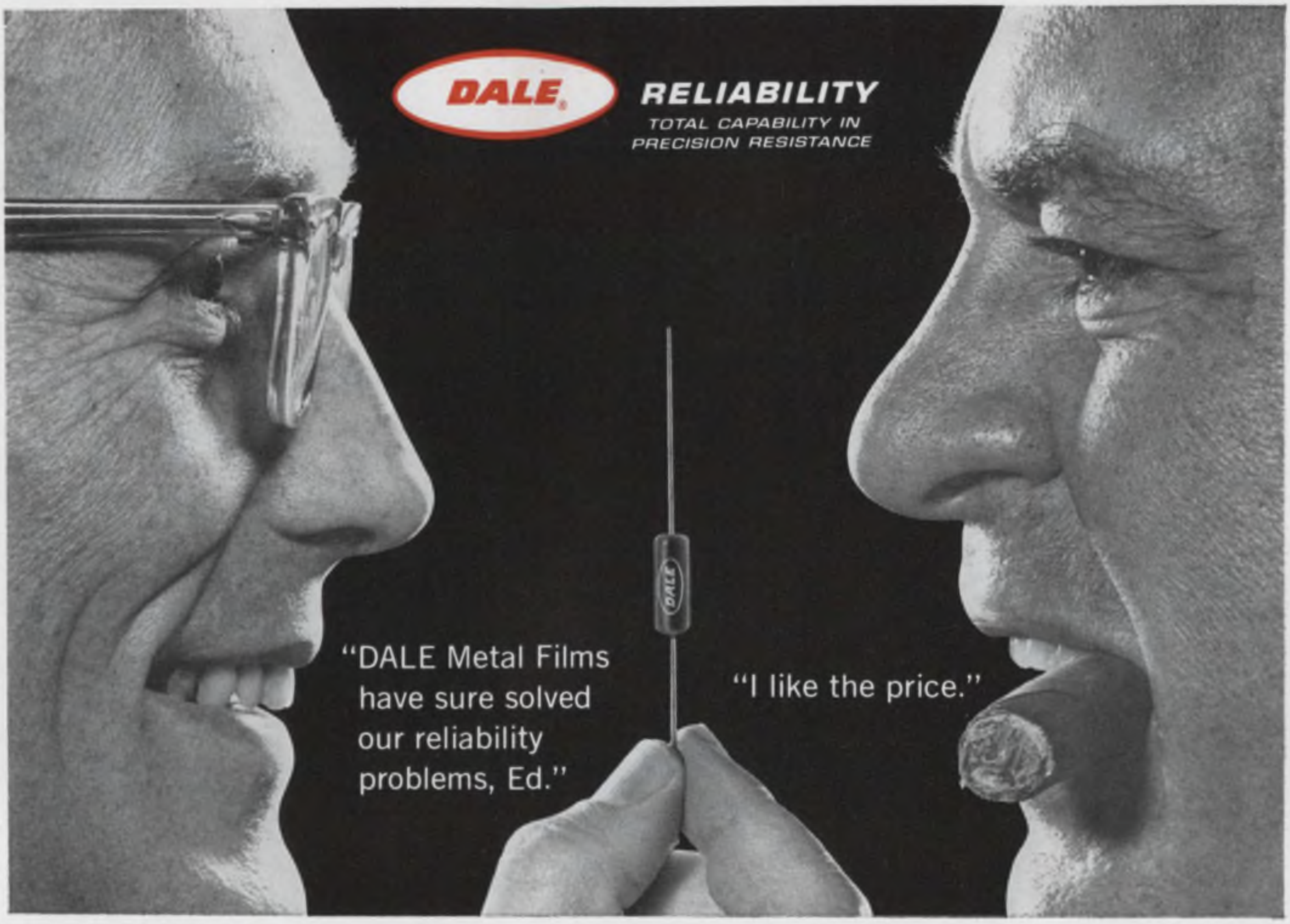
Irving Karmin
Senior Project Engineer
Loral Electronics Co., N. Y.

This article was published in the August 2 Issue of ELECTRONIC DESIGN, page 34. Unfortunately one complete set of construction lines that was to illustrate the ease of vector multiplication was omitted from the graph. Since the absence of these lines somewhat hinders the understanding and appreciation of this graphical method, we are publishing the corrected graph, along with the example the author used to illustrate the multiplication of vectors.

Multiplication: We simply add the angles and add the magnitudes in the log scale. For example, multiply $20 \angle -60$ by $4 \angle +45$. The angle of the resulting phasor is $-60 + 45 = -15$.

To find the magnitude, locate Point $20 \angle -60$ (shown with broken black lines); then locate the point $4 \angle +45$. Measure the distance of Point 4 from the abcissa with a ruler. Add this distance to Point 20; the result is 80. Therefore, the final result is $80 \angle -15$.





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LOW NOISE CONSTRUCTION. Maximum for standard resistance range: 0.10 micro-volt per volt over a decade of frequency. Low and intermediate values: below 0.05 micro-volt per volt. Terminating band of low-resistance metal alloy is deposited in same vacuum as metal film element resulting in *oxide-free*, low-noise contact area between film, terminating band and press-fit cap.

CONTROLLED T.C. Ten standard T.C. codes from 0 ± 150 ppm/°C to 0 ± 25 ppm/°C available in operating temperature range of −55°C to +175°C. Close matching between pairs or sets available.

GOOD HF CHARACTERISTICS. Low reactance gives excellent stability at high frequencies. Non-helixed or laterally adjusted units supplied for extremely critical applications above 100 mc.

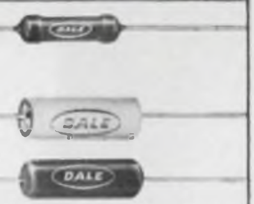
SPECIAL REQUIREMENTS. Special terminals, special matching, special pre-conditioning, special networks and mountings can be quickly supplied by our Special Film Products Department.

WRITE FOR CATALOG A

DALE ELECTRONICS, INC.

1328 28th Avenue, Columbus, Nebraska

Also Sold by Dale Electronics Canada, Ltd., Toronto, Ontario, Canada



MFF Epoxy coated. Meets electrical and environmental requirements of Char. B, C, D, E; MIL-R-10509E, but is dimensionally smaller.

MFH Hermetically sealed in ceramic tube. Meets requirement G; MIL-R-10509E.

MF Transfer molded in epoxy. Meets all requirements of Char. B, C, D, E; MIL-R-10509E.

DALE TYPE	MIL TYPE	125° C RATING	RESISTANCE RANGE	DIMENSIONS (L×D.)
MF 50	RN-50 (Proposed)	1/20 watt	49.9 Ω to 60K Ω	.140x.065
MF-1/10	RN-55	1/10 watt	49.9 Ω to 200K Ω	.250x.093
MF-1/8	RN-60	1/8 watt	30 Ω to 550K Ω	.406x.140
MF-1/4	RN-65	1/4 watt	30 Ω to 1 Megohm	.593x.203
MFS-1/2	RN-70	1/2 watt	49.9 Ω to 2 Megohms	.750x.250
MF-1	RN-75	1 watt	49.9 Ω to 6 Megohms	1.093x.375
MF-2	RN-80	2 watts	100 Ω to 15 Megohms	2.188x.375

Tolerance: ±1% standard; ±.5%, ±.25%, ±.1% available.

ENVIRONMENTAL SPECIFICATIONS*

	DALE T.C. CODE	Applicable Char. of MIL-R-10509E
Dale MF resistors are manufactured to the environmental specifications of MIL-R-10509E. Characteristics D, C or E apply depending on T.C. Code specified at purchase.	T-1 (100 P.P.M./°C)	D
	T-2 (50 P.P.M./°C)	C
	T-9 (25 P.P.M./°C)	E

*Specifications for MFF and MFH are similar, but vary dimensionally.

Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 801

TOO SMALL TO BE A LIFESAVER?*

NOT IF YOU'RE DESIGNING ELECTRICAL CIRCUITS

In the race toward smaller circuits and higher density packaging, some electrical design engineers are sinking in a sea of overlarge components. Those in the know are being buoyed up by Magnetics' miniature powder core line—moly-permalloy cores as small as 0.110" I.D.

Designers involved with highly critical inductor stability factors are welcoming another Magnetics innovation—guaranteed temperature stabilization in miniature powder cores. The "D" type limits the change in inductance to ±0.1% from 0 to +55 degrees C. The "W" type limits the change from ±0.25% from —55 to +85 degrees C. Our new "M" type limits the change to ±0.25% from —65 to +125 degrees C. A wide selection of core sizes and permeabilities broadens the engineer's design scope even more. And all of these sizes are designed so they can be wound on present miniature toroidal winding equipment.

If you are faced with a problem of compacting a circuit design, it will pay you to investigate the condensing potential of Magnetics' miniature powder cores line. For the complete story, write Dept. ED-30, Magnetics Inc., Butler, Pa.

Actual size of Magnetics' 0.110" I.D. powder core

MAGNETICS inc. ®

Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 802

more watts per dollar

Check the specs and the price ($145) and you will find: Sorensen's new QRB40-.75 "ranger" delivers 1½ times the watts per dollar of most competitive power supplies... with no stinting on performance.

CONSTANT CURRENT... Unit can be externally converted to a highly regulated (0.15%) constant current supply.

CURRENT LIMITING... Provides automatic protection against short circuit or overload. Also acts to provide automatic transfer from the normal constant voltage mode to a constant current mode whenever the load demands more current than the limiter has been set to supply.

RESOLUTION... Output can be finely adjusted to 4mv on the 40-volt model; 3mv on the 30-volt model; and 2mv on the 20-volt and 15-volt models.

OTHER QRB FEATURES include programmability, series/parallel operation, and remote sensing.

For complete data on the QRB series and other Sorensen products send for the new, 140-page "Controlled Power Catalog and Handbook." Write Sorensen, Richards Avenue, South Norwalk, Connecticut. Or use reader service card number **200**.

ELECTRICAL & MECHANICAL SPECIFICATIONS

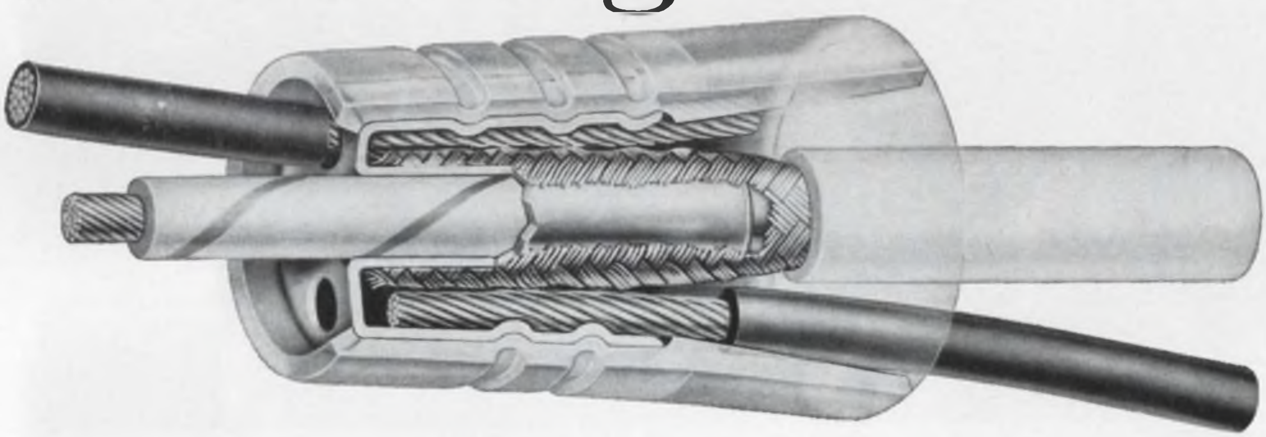
MODEL NUMBER	OUTPUT VOLTAGE RANGE (VDC)	OUTPUT CURRENT (AMPS.)	% REG. (LINE & LOAD COMB.)	RMS RIPPLE	RESP. TIME (MICROSEC.)	TEMP. COEF. (%/°C.)	CABINET SIZE INCHES WIDTH	HEIGHT	DEPTH	RACK PANEL INCHES HEIGHT	WEIGHT (LBS.)
QRB15-2	0-15	0-2	±(0.01% + 1mv)	0.15mv	50	±0.015	8¼	5⅛	9	5¼	10.75
QRB20-1.5	0-20	0-1.5	±(0.01% + 1mv)	0.15mv	50	±0.015	8¼	5⅛	9	5¼	10.75
QRB30-1	0-30	0-1	±(0.01% + 1mv)	0.15mv	50	±0.015	8¼	5⅛	9	5¼	10.75
QRB40-.75	0-40	0-.75	±(0.01% + 1mv)	0.15mv	50	±0.015	8¼	5⅛	9	5¼	10.75

Sorensen represented in California by Ward-Davis Assoc., 770 S. Arroyo Parkway, Pasadena, Phone 213-684-2840; 1020 Corporation Way, Palo Alto, Phone 415-968-7116; 3492 Pickett Street, San Diego, Phone 714-297-4619.

Sorensen

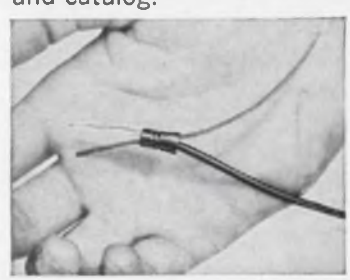
ON READER-SERVICE CARD CIRCLE 803

Uniring grounds a shielded cable in less time than it takes to heat a soldering iron.



Uniring combines inner and outer ferrules in unitized construction. Simply insert a stripped conductor and tap wire, then crimp. One crimp does it. No heat. No burnt cables.
Result: A vibration-resistant, noise-free connection that is mechanically and electrically stable. A uniform connection that takes virtually no time to make.

Uniring terminations are color coded for fool-proof size selection. And the insulated Uniring employs a nylon sleeve that's flared for fast, easy insertion of the shielding braid and tap. (These connectors are also available uninsulated.) No other type of connector is as fast, as reliable, or as low in cost to use. Time and labor savings offered by the compression method of grounding and terminating shielded cable are recognized by the military and referred to in MIL-E-16400 and MIL-I-983. Burndy Uniring terminations conform in all details to MIL-F-21608 (dated 1/5/59). Send today for a free sample and catalog.



BURNDY

Norwalk Connecticut

63-13

ON READER-SERVICE CARD CIRCLE 804

Control-panel relays

BF relays are developed for automatic machinery control panels. Easier wiring, protection against corrosive and contaminated environments, and simplified mounting procedures are featured. A timing range from 0.2 to 60 seconds is provided by mounting the BT timer on the BF relay. In addition to the BT 4-pole timer, two timed and two stationary contacts are standard.

Westinghouse Standard Control, Beaver, Pa. Phone: (412) 775-2000.

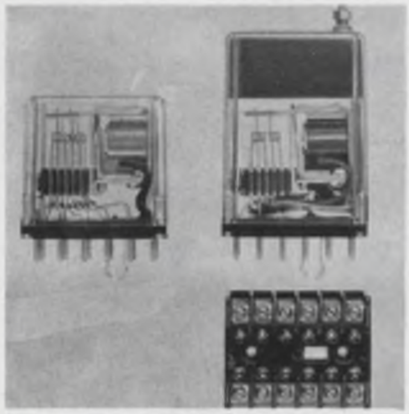
Circle No. 267

Decimal shaft encoder

Life expectance of the Decitrak encoders is projected for 50 x 10^6 revolutions. Citing a figure of 2 x 10^6 as normal for brush encoders, the company attributes their extended life projections to changes in brush configuration, alloy and current/voltage control circuitry. Decimal output from this unit can be used to drive such display units as printers and lamp banks.

Theta Instrument Corp., Saddle Brook, N. J. Phone: (201) 487-3508.

Circle No. 268



Plug-in relays

Bulletin 114 multi-pole plug-in relays come in three types: time delay, latching, and multi-pole/multi-purpose. The modular relays are guaranteed for 10 million operations. Measuring 2-19/32 x 1-15/32 x 2-5/8-in., and encased in Lexan, the relays are applicable to a variety of industrial control circuit uses.

Relay contacts are rated at 10 amps, 115 Vac. Standard coils are rated to 230 Vac.

Ward Leonard Electric Co., Mount Vernon, N. Y. Phone: (914) 664-1000. TWX: (914) 699-4997.

Circle No. 269

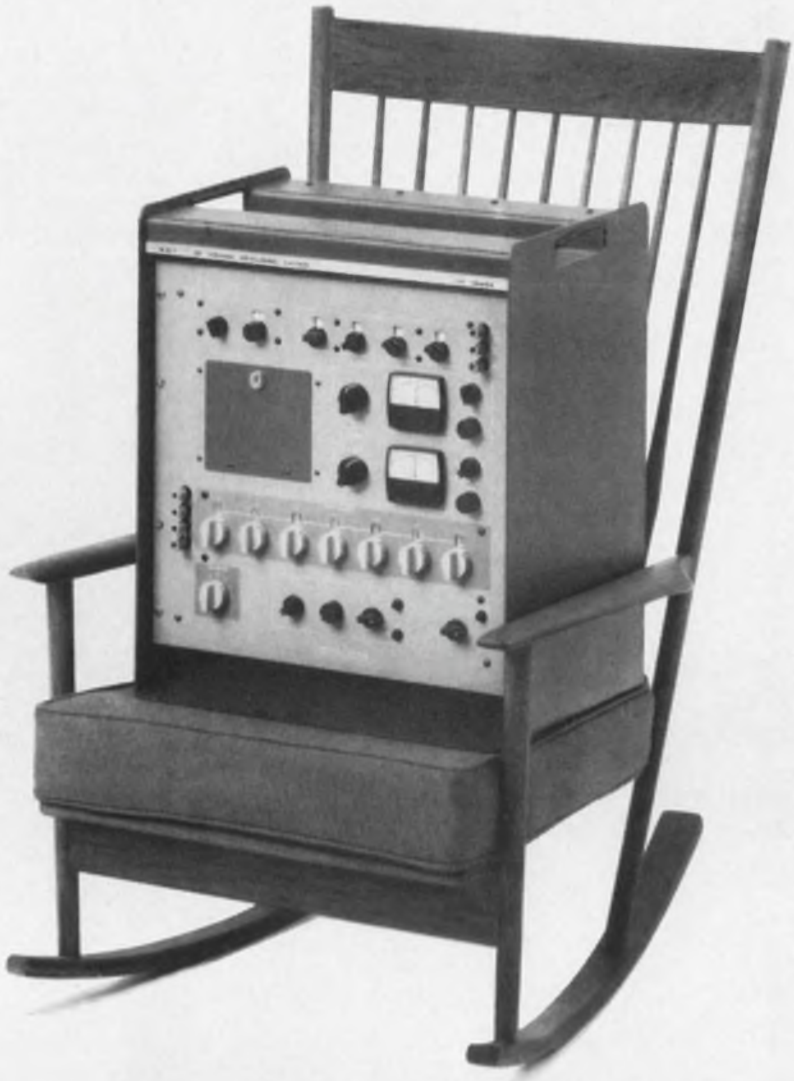
8-day timer

Model 4651 Magnetic sequence timer is designed for undersea operation. After eight days, this timer emits a signal—such as needed to separate an undersea buoy from its anchor, and eight hours later, another contact closes—to shut off all power, for example.

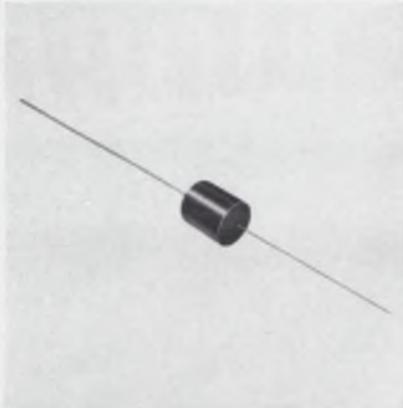
Output relay contact rating is 2 amps at 28 Vdc, the unit weighs 600 grams, and the black anodized aluminum case measures 4 x 3-1/2-in.

C & K Components, 103 Morse, Newton, Mass. Phone: (617) 926-0800. TWX: (617) 924-7970.

Circle No. 270



Temp sensing resistors

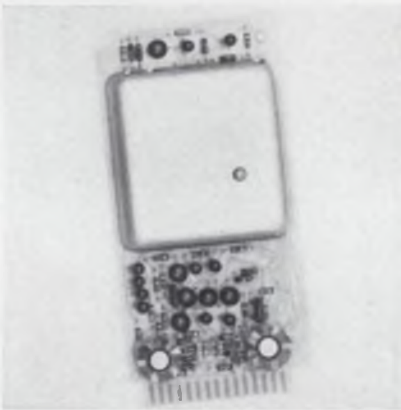


A miniature temperature sensing resistor has a temperature coefficient of 4500 PPM/°C. It is suggested as a replacement for silicon resistors. Any value between 1 ohm and 5 K, can be ordered in this type SM-04 TS resistor. The unit is rated at 0.04 watt, and measures 0.09 x 0.150-in. long.

P&A: about $1.00 per hundred; 2 weeks. Riedon Division, On Mark Engineering. 11728 Vose, N. Hollywood, Calif. Phone: (213) 875-0610.

Circle No. 271

Differential amplifier



Model AD20 all-silicon amplifier provides dc gain of 2 x 10^8 and unity crossover at 5 MHz, for use in operational or potentiometric amplifier circuits. Full-scale output is ±20 V, up to one watt at currents up to 100 mA. Output slewing limit is better than 15 volts per μs. Input offset voltage has a stability of 2 μV per °C.

Price: $203 each, 10-29. Newport Laboratories, P. O. Box 2087, Newport Beach, Calif. Phone: (714) 646-9295.

Circle No. 272

Modular ladder networks

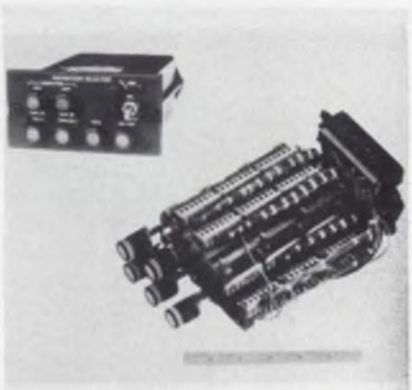
A series of miniature plug-in ladder networks use wirewound, film, and integrated components to achieve accuracy of better than half the least significant digit in ladders up to 14 bits. Response time is better than 1 μs.

Each network is accompanied by a digital tape confirming its conversion accuracy.

General Resistance, Inc., 430 Southern Blvd. Bronx, N. Y. Phone: (212) 292-1500.

Circle No. 273

Switch systems



Control-panel mounted push-button switches replace relays or multiple displays, thus conserving space. The system design allows fewer display instruments, and selection of navigation equipment by priority, first pilot/copilot, then navigator—with each knowing what gear is on the line. It actuates up to 24 switch contacts simultaneously. Contacts carry up to 2 amps.

Transco Products Inc. 4241 Glencoe Ave., Venice, Calif. Phone: (213) 391-7291.

Circle No. 274


In 1939, Julius Schmidt made this electric toothbrush.
Don't make the same mistake he did.
His mistake? He shelved his idea after listening to short-sighted criticism. ("Foolish!" "Kid's toy!" "Never sell!")
So his electric toothbrush went unpatented and unproduced.
Twenty years later, the power toothbrush was an overnight success. Sonotone, pioneer in the development of rechargeable batteries, helped make this possible.
Do you have a "foolish" product idea? Perhaps the profitable difference is Sonotone cordless power. Call us in. Give us all the necessary technical data and we'll dig right into it.
Chances are we'll come up with something. After all, Sonotone makes rechargeable sintered-plate, nickel-cadmium batteries for everything from Titan rockets to cordless shavers. This experience equips us to handle any special problem. Your special problem.
Please don't be shy about asking for help. Remember Julius Schmidt!
Sonotone Batteries ®
portable power for progress

Electrochemical timer

An electrochemical timer that weighs about 2 grams and sells for as little as $14.85 is designed to meet the specifications of MS 90386 (WP). The unit consumes only 50 mW of power compared to 1.5 to 4 W for previous devices filling a similar need. The qualifications of MIL-I-81219 are met. Indication of current is provided by the transfer of mercury across an electrolite gap.

Curtis Instruments, Inc., 351 Lexington Ave., Mount Kisco, N. Y. Phone: (914) 666-8051.

Circle No. 275

High-Q inductors

The "Micro-Red" subminiature shielded inductor in the envelope size 0.335-in. long by 0.125-in. diameter was specifically designed for high-density circuitry.

The unit has exceptional Q values, ranging from 40 to 85 over the inductance range of 0.10 μH to 10,000 μH. It is offered in 61 predesigned values, and is engineered to meet MIL-C-15305, class 1, grade B.

Available from stock. Lenox-Fugle Electronics Inc., 475 Watchung Ave., Watchung, N. J. Phone: (201) 376-7300.

Circle No. 276

Rocker switches

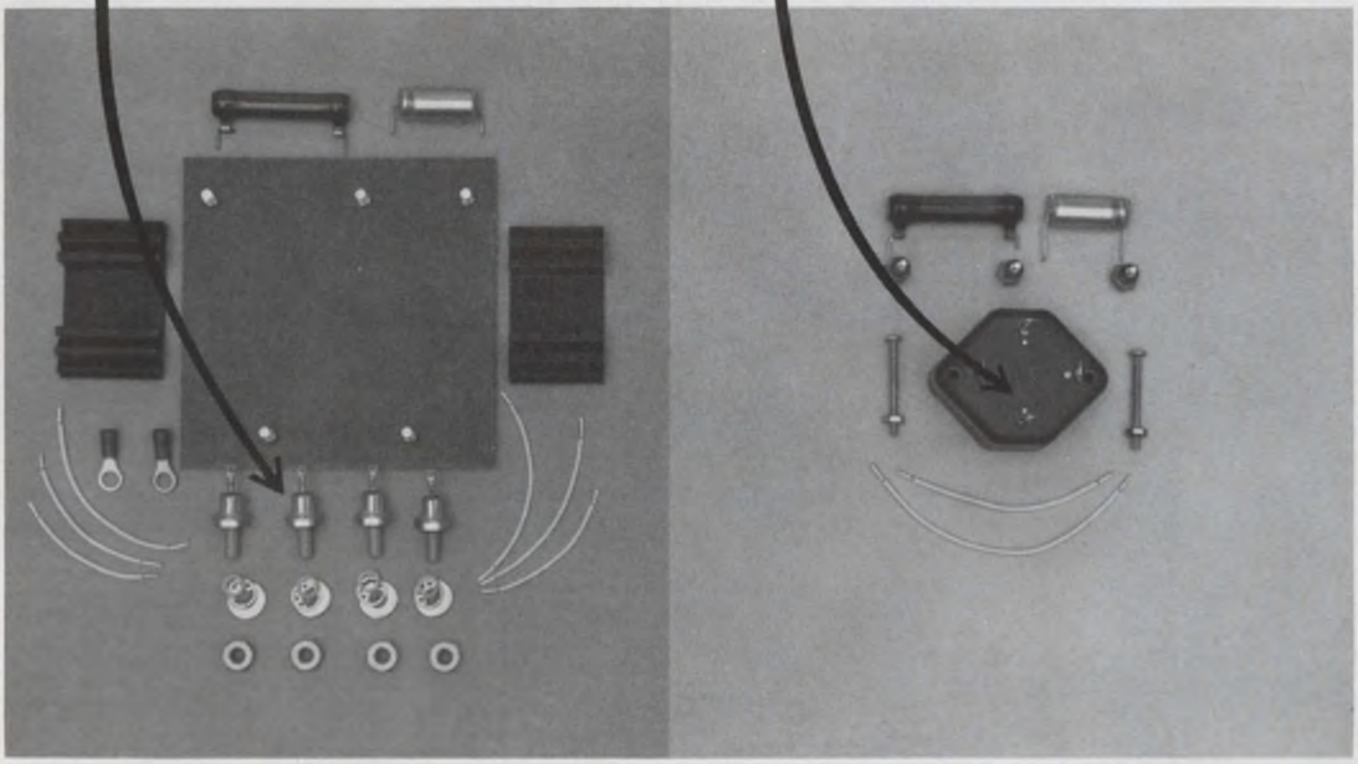
Rocker-type switches in five circuit arrangements (spst, spdt, dpst, dpdt, and 2-circuit) have a snap-in mounting feature. These switches have silver-plated contacts and no exposed metal parts. Two and three-position types, with either maintained or momentary contacts are available. They are UL and CSA approved with ratings up to six amps, 125 Vac, and 0.5 amp at 30 Vdc.

Cutler-Hammer, 4201 N. 27, Milwaukee, Wis. Phone: (414) 442-7800.

Circle No. 277

The 4 rectifiers used in this 10-amp bridge cost $4.57* — the bridge takes 6 minutes to build...

This Motorola 10-amp bridge costs $3.65† — takes only 75 seconds to install!



You, too, can simplify your designs, reduce costs and increase the reliability of your circuits with Motorola Molded Rectifier Bridges. They provide these advantages:

▪ reduction of assembly-steps by up to 75%. ▪ elimination of bridging "heat-sinks", mounting hardware, and intercomponent connections. ▪ no dirt and grime-catching corners and crevices common to unencapsulated or "finned-type" assemblies. ▪ 3-step "source-tested" — (1) individual rectifiers tested and matched before assembly (2) bridge assembly tested before encapsulation (3) final molded bridge tested before shipment.

Now, with the addition of the MDA972 series, Motorola offers a complete molded bridge line up to 16-Amps, covering all your applications down to 1-amp, in a variety of case sizes, shapes and terminal configurations.

44 types immediately available in any quantity

- MDA920 series: 1A, 25-600 V
- MDA942 series: 1.5A, 50-600 V
- MDA952 series: 6A, 50-600 V
- MDA962 series: 10A, 50-600 V
- *New* MDA972 series: 16A, 50-600 V

Contact your franchised Motorola distributor now for evaluation units from his "off-the-shelf" stock — determine for yourself how these ready-to-use, easy-to-install rectifier bridges can save you TIME AND MONEY.

*Estimated average cost for 4 stud-rectifiers per current major manufacturers' published prices.

†Price for MDA962-3, 200 volts, in 100-up quantities.

POWER UP WITH . . .

MOTOROLA Semiconductor Products Inc.

BOX 955, PHOENIX, ARIZONA 85001

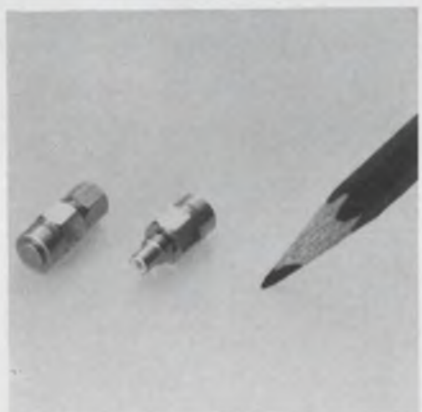
Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CIRCLE 53

Slotted terminals

A subminiature Press-Fit standoff incorporates a slotted terminal to aid in soldering leads. Designated ST-SM-750 SL, the terminal has a Teflon bushing with a major diameter of 0.172-in. and is designed for insertion into chassis of 0.085-in. maximum thicknesses. Bushings can be supplied in any of the 10 EIA colors for coded installations.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600. TWX: (710) 566-1110.

Circle No. 278



Coaxial terminations

Coax connectors of the 60-001-0000 line are designed to mate with any standard MIL-C-22557 components. The screw-on connector provides a vswr of 1.1 from dc to 4 GHz and is specified for operation from dc to 12.4 GHz with a max vswr of 1.20. The units are also available in snap-on, slide-on and screw-on jack configurations. They are said to reduce residual errors in testing applications.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600. TWX: (710) 566-1110.

Circle No. 279

New low-cost Daystrom Model 333 commercial trimmer has knurled finger-tip adjustment knob. It also has an Allenhead for fine adjustment . . . 4 to 1 ratio, nominal. Designed for PC board use, it requires approximately ½ cubic inch of space. Price is another unusual feature—only $1.45 in 100 lot quantities!

Model 333's unique resistance element is the same as used in MIL-type Squaretrim® pots for high resolution, linearity, and low noise. Also, it is vibration and shock resistant.

This is just one of the special-purpose Daystrom units—from industry's broadest line of subminiature square-trimming potentiometers. Chances are that we can fill your most exacting requirements with a standard, off-the-shelf model.

See your Weston distributor for catalog, prices and evaluation units. **Weston Instruments, Inc., Archbald Division, Archbald, Pennsylvania 18403.** Phone: (717) 876-1500.

Only Weston's exclusive wire-in-the-groove offers **LOCKED-IN LINEARITY**

From Weston's broad trimmer line

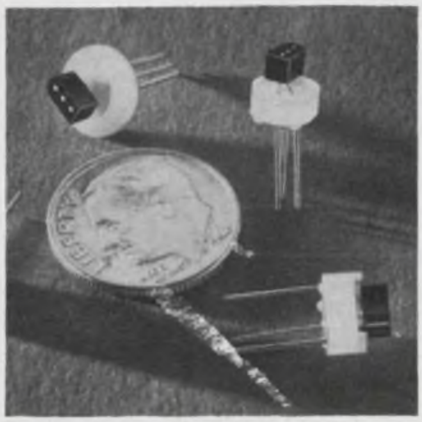
actual size

Model 333 — ½" by 9/16" by 3/16". Dual adjustment: knurled finger-tip knob and Allenhead. For PC board mounting. Resistance: 50Ω to 10k, up to 50k on special order. Rating: 0.2w @ 40°C in still air.

Series 200 — ⅜" Squaretrim, 0.150" thick, slotted or Allenhead adjustment screws. This is only one of a full line of ⅜" pots. Operation: from −55 to 150°C. Resistance: 10Ω to 50k. Rating: 1w @ 50°C in still air.

WESTON® *prime source for precision . . . since 1888*

ON READER-SERVICE CARD CIRCLE 55



Transistor pads

New additions to the Transpad transistor mounting pad line include nylon pads for the recently introduced three-inline plastic molded transistors. Mounting to three holes at 90 degrees is aided by the #10170 and 10171 for 0.100 and 0.200-in diameter circles respectively. The 10218 accomplishes automatic lead conversion to TO-5 configuration. All are molded of natural-color nylon stock.

Milton Ross Co., 511 Second St. Pike, Southampton, Pa. Phone: (215) 355-0200.

Circle No. 280

Pressure transducer

Designated series 2201, a new instrument in the Teleflight line of pressure transducers is designed for airborne and ground support applications. The 2201 has a hysteresis error as low as 0.05% and a repeatability error less than 0.05%. The sensing element is four active 350-ohm foil strain gages in a Wheatstone bridge. Ranges are 200 to 5000 psis or psia.

Price: From $350. Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y. Phone: (716) 694-4000.

Circle No. 281

If you work with AC--work with ACton

PRECISION PHASE MEASUREMENT

PRECISION PHASE METER 329-B. Delivers almost unlimited use and application flexibility in measuring phase directly 0°-360° full scale; twelve 30° scales for precision reading. Frequency range 30 cps-500kc. Three standard plug-in modules: Buffer amp — accuracies up to ± 0.5°; Hi-gain preamp-1mv sensitivity; Precision phase shift generator. Special plug-ins available. All solid state.

PRECISION DIGITAL PHASE METER 331. Large, four-digit presentation provides direct reading 0°-360° to accuracy of ±0.5°. Frequency range, 30cps-40kc. Provisions available for printer output, AC and/or DC outputs for voltmeter reading. Inputs directly usable, 0.2-150 volts. Solid state throughout.

PRECISION DELAY MEASUREMENT

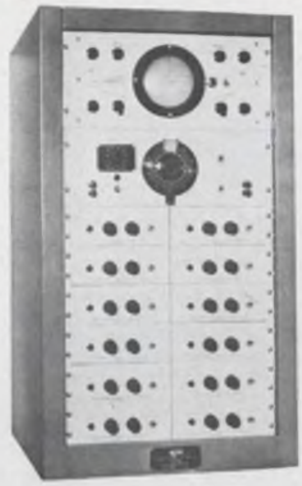
TRANSMITTER

RECEIVER

PRECISION DELAY SET 460. Separate transmitter and receiver facilitate either open or closed loop uses. ±5μs accuracy 0-4ms, in each of twenty 200μs ranges. Standard carriers 0.5-50kc, others available. Applicable to telephone and data transmission lines, filters, networks and many communications systems. Solid state throughout.

PRECISION DELAY EQUALIZER 475-A. Six cascadable modules each provide 0-2.5 ms of delay equalization and a series total of 15ms, continuously adjustable. Six standard frequencies are 1kc, 1.4kc, 1.6kc, 2.0kc, 2.4kc and 2.8kc. Others on special order. Applicable to most compensation requirements; ideal companion to 460-A Delay Set above.

PRECISION STANDARDS, ANALYZERS



PRECISION PHASE STANDARD 70N0. Self-calibrating instrument provides accuracy of ±0.03° in continuously variable phase settings 0°-360°. Up to twelve standard crystal controlled frequency selections, 30cps-50kc; others available. For the comprehensively planned laboratory or standards department in calibrating all types of phase devices and instruments. All solid state.

RAYSPAN SPECTRUM ANALYZER SERIES 100. Real-time analysis of all types of physical, doppler and medical signals with analysis bandwidths to 100kc. Utilizes 100, 250 or 500 magnetostrictive filters with selectable 3db bandwidths. Up to 100,000 samplings per second; preserves all spectral events as they occur. Chart type recording illustrated; scope accessories equally applicable. All solid state.

PRECISION MEASUREMENT INSTRUMENTS
20 YEARS
1946 1966

. . . AND MAKING NEW HISTORY IN SCIENTIFIC INVESTIGATION • ELECTRON MICROPROBES, FAR INFRARED SPECTROMETERS. **ACton starts with AC.** If you work with it, call us.

ACTON®
Laboratories, Inc.

531 Main Street • Acton, Massachusetts
a subsidiary of BOWMAR INSTRUMENT CORPORATION

ON READER-SERVICE CARD CIRCLE 57

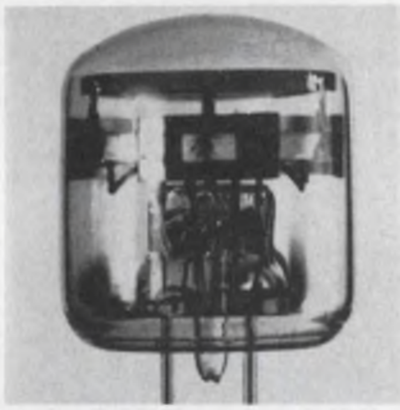
COMPONENTS

Oscillators for ICs

The FD41 series of oscillators are designed for use with integrated circuits. Operating voltages range as low as 3 Vdc with oscillator stabilities as high as ±0.015%. Unit temperature range is 0° to 60°C at frequencies from 1 Hz to 50 MHz. Output voltage is 3.5 to 4 V square wave with less than 20 nsec rise or 1 to 2 V sine wave with a distortion of less than 5%.

P&A: $87.50-$227.50; 4-5 weeks. Accutronics, Inc., 12 South Island, Batavia, Ill. Phone: (312) 879-1000. *Circle No. 282*

2.5 MHz crystal

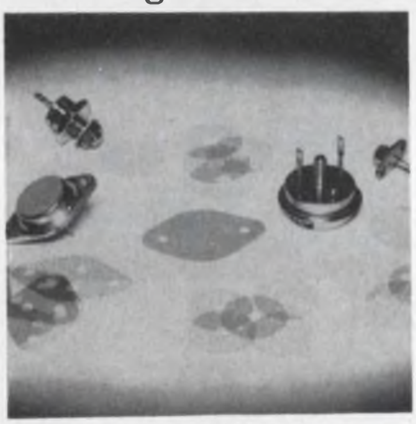


Operating at the fifth overtone, a 2.5 MHz precision crystal is suitable for use in secondary frequency standards. After 21 days, stability is 0.5 x 10^{-9} per day. Stability is effected less than 1 x 10^{-7} by a shock of 30 G's for 11 ms. Drive level is 50 to 75 μs and the unit's operating temperature range is +42° to +57°C.

Availability: 8-10 weeks. CTS Knights Inc., Sandwich, Ill. Phone: (805) 786-2141. TWX: (805) 786-2130.

Circle No. 283

Insulating wafers

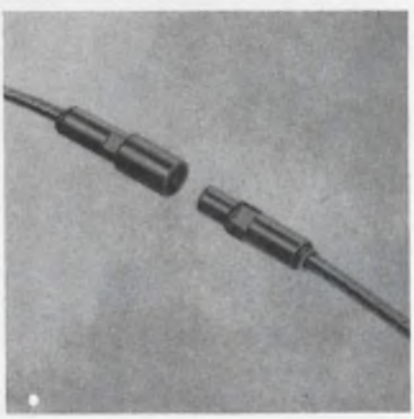


Pre-punched mica or Teflon wafers are available for insulating a transistor body from the heat sink. They are offered in configurations to fit all transistor base sizes. The relatively low thermal gradient of thin layers of mica or Teflon is said to give electrical isolation with little effect on heat transfer from transistor case to chassis.

P&A: $8.00-$50.00/thousand; 3 weeks. Perfection Mica Co., 1322 N. Elston Ave., Chicago, Ill. Phone: (312) 384-2122.

Circle No. 284

Coax connector



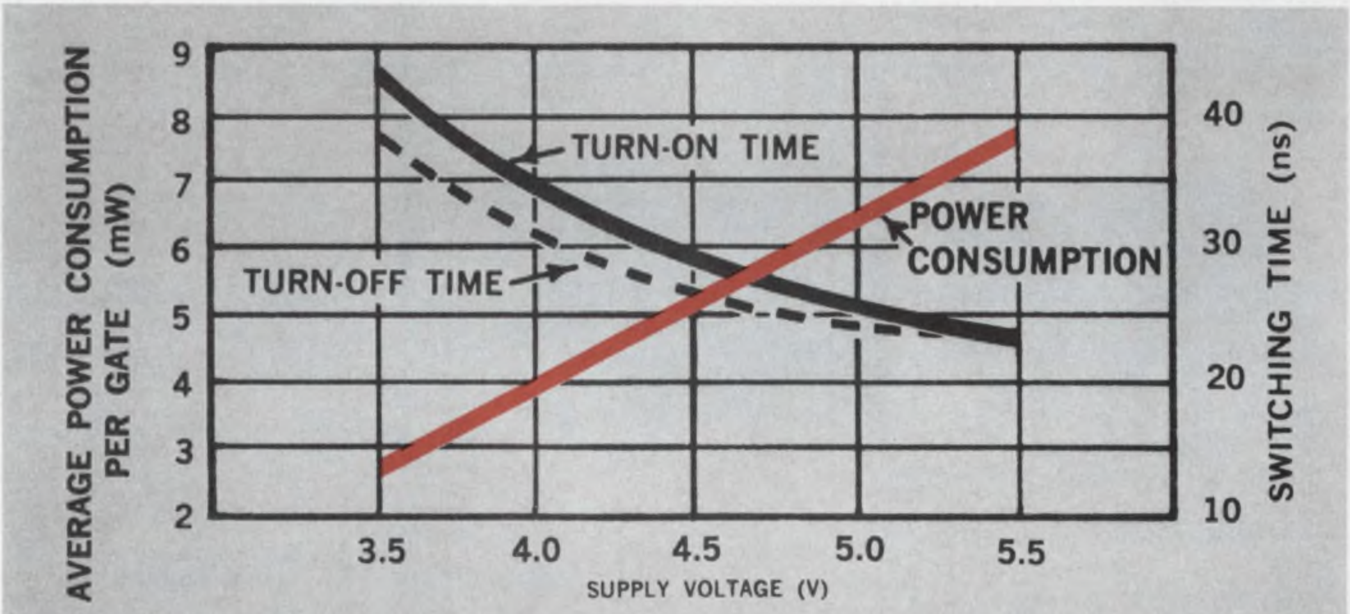
Protected spring fingers that cannot be over deflected is the leading feature of a new line of push-on coaxial connectors. The MD series are also said to be interchangeable with other competitive connectors now in use. Other features include collet-cable grip, crimped or soldered center contacts and provisions to avoid cold-flow trapping of a mating pin.

Tynax Engineering Co., 31 East Santa Clara St., Arcadia, Calif. Phone: (213) 445-2920.

Circle No. 285

Why sacrifice high speed for low power in aerospace systems? You can get both in Signetics SE 400 series integrated circuits.

Signetics SE 400 series provides:
40% to 70% less power consumption than comparable devices while maintaining equal or greater speed and noise immunity,
50% reduction in flip-flop can-count with a new dual binary,
off-the-shelf delivery



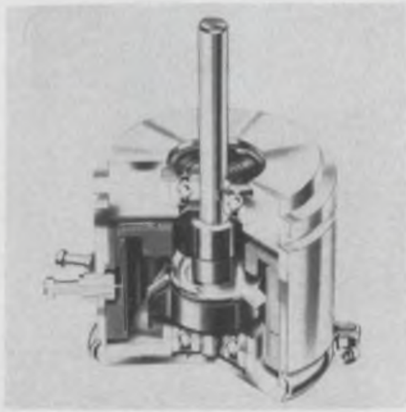
SPEED-POWER CHARACTERISTICS OF SE400 FAMILY

This family of four full MIL range integrated circuits features a dual 5 Mc Binary element operating on less than 9 mW per flip-flop. Like the other members of the family, it was designed for maximum speed consistent with low power operation. The family is intended for use in applications where high density packaging and the ability to drive high capacitances associated with multilayer printed circuit boards are important considerations. For complete data and specifications, write today.

SIGNETICS INTEGRATED CIRCUITS
A subsidiary of Corning Glass Works,
811 East Arques Avenue, Sunnyvale, California
Tel.: (408) 739-7700 TWX: (910) 737-9965

Signetics SE 400 series elements include a Low Power Dual AC Binary, a Dual NAND Gate, a Dual Driver-Buffer, a Quad NAND Gate.

ON READER-SERVICE CARD CIRCLE 59



Mil-spec potentiometers

The requirements of MIL-R-12934D, RR0900 are met by the 2540 series potentiometers. The new servo-mounted pots offer a ±0.5% independent linearity and are gangable up to six units. Using a dual contact wiper design, they will withstand up to 50 G's shock. Power rating is 1.25 watts at 85°C. Resistances range from 10 ohms to 100 K.

Amphenol Controls, 120 S. Main St., Janesville, Wis. Phone: (608) 754-6616. TWX: (608)653-8321.

Circle No. 286

Self-powered timer

A modular digital-output timer is self-powered by a 1.3-volt mercury cell that lasts for a minimum of one year. Accuracy is guaranteed to ±2 seconds per day. The basic timer module weighs about three ounces and is provided with electrical contacts rated at 25 mA at 28 Vdc. The timer can provide contact closures for any second, minute, hour or day in any combination.

Basic units priced from $455. Bulova Watch Co., Inc., Bulova Park, Flushing, N. Y. Phone: (212) 335-6000. TWX: (212) 672-0344.

Circle No. 287

Phase-shift circulators

Two new S-band differential phase-shift circulators provide maximum insertion loss of 0.5 dB and isolation of 20 dB minimum. The 30 Mw CSH32 operates 2.6 to 3.1 GHz with a maximum vswr of 1.15. The similar CSH24 operates 2.8 to 3.2 with a vswr of 1.2. Average power for the two units is 30 and 32 kW respectively based on a 2:1 mismatched load. Waveguide for both is RG-48/U.

Raytheon Co., 130 Second Ave., Waltham, Mass. Phone: (617) 899-8400. TWX: (617) 894-8591.

Circle No. 288

Frequency extender

A YIG-tuned frequency extender covers the 1 to 4.5 GHz range in two bands. The unit, designated FE 1-4.5 converts the input signal to a 60 MHz IF. Tuning is said to be resetable to ±0.5%. It uses its own YIG preselector to track across the range, avoiding mechanical drive and an image rejection of 70 dB min.

P&A: $8500; 30 days. Communication Electronics Inc., 6006 Executive Blvd., Washington Science Center, Rockville, Md. Phone: (301) 933-2800. TWX: (301) 365-8667.

Circle No. 289

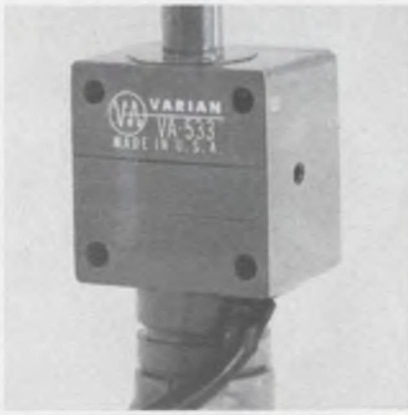
Ku-band circulator

A lightweight, differential phase-shift circulator provides protection of Ku band airborne radar systems. Average power is 100 watts and peak power 100 kilowatts across the CKuH5's frequency range of 15.9 to 17.1 GHz. Isolation is 30 dB or more, while insertion loss does not exceed 0.4. Maximum vswr is 1.15. The CKuH5 has UG541/U flanges and mates with a RG-91U waveguide.

Raytheon Co., Special Microwave Devices Operation, 130 Second Ave., Waltham, Mass. Phone: (617) 899-8400. TWX: (617) 894-8591.

Circle No. 290

Klystron oscillators



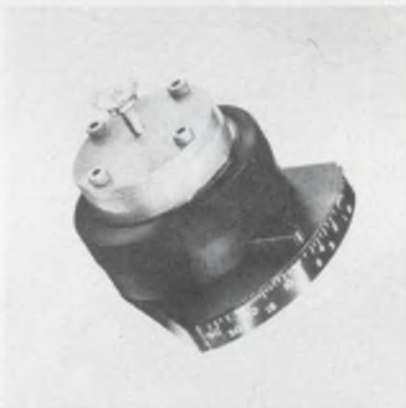
Designed primarily for pumping parametric amplifiers, the VA-533 two-cavity klystron oscillators are capable of providing 1 to 10 watts at any fixed frequency from 12.4 to 18 GHz.

These conduction-cooled units are also suitable for applications in doppler systems and for use in test-set power-sources.

P&A: $2,000 or less: 60 days. Varian Associates, 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Circle No. 291

Microwave attenuators



A line of semi-precision attenuators covers a full waveguide band with an 0-50 dB range. Called Model 511, these units have RF sections identical to the manufacturer's precision 510 series.

They provide flat attenuation proportional to the $\cos^2$ of the angle of rotation of the center circular sections. Accuracy is 5% or 0.25 dB across the 12.4 to 140 GHz region.

TRG, Control Data, Route 110, Melville, N. Y. Phone: (516) 531-0600.

Circle No. 292

Shielded BWO

Designated the WJ-2004, an X-band BWO features unsaturated magnetic shielding in a compact package measuring 2 x 2 x 6-in. Performance exceeds the environmental requirements of MIL-E-5400, Class II. Weight is under two pounds. It covers the frequency range of 9.5 = 13.0 GHz with a minimum power output of 10 mW.

Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. Phone: (415) 326-8830. TWX: (910) 373-1253.

Circle No. 293

Microwave reflector

The TM series of reflectors are tower-mounted flat units for periscope use to 13 GHz. The enclosed reflector panel is fabricated of solid aluminum, without perforations. A modified gimbal mounting structure (Omni Mount) is used. Five models are available with sizes from 4 x 6 feet to 12 x 17 feet. All mount to a 4-1/2-in. pipe or directly to tower members.

Microflect Co. Inc., 3575 25th St. SE, Salem, Oregon. Phone: (503) 363-1128.

Circle No. 294

EASTMAN 910® Adhesive...

bonds steel-to-phenolic-to-ceramic in minutes

In the manufacture of Motorola's lightweight Handie-Talkie radiophones, a miniature phenolic insulator is quickly bonded to a steel chassis with one drop of EASTMAN 910 Adhesive. Another drop of this versatile adhesive is then used to secure a tiny ceramic potentiometer to the plastic. Farther along the assembly line coil forms and plastic bushings are secured in place with clear, thin EASTMAN 910 Adhesive without danger of plugging adjacent terminals or through-holes. (Bonds remain intact through 5 seconds' immersion in molten solder at 475°F.)

EASTMAN 910 Adhesive will form bonds with almost any kind of material. Without heat, solvent evaporation, catalysts or more than contact pressure, this clear, thin adhesive forms strong bonds between well-mated surfaces in seconds to minutes. Try it on your *toughest* jobs.

For technical data write to the Chemicals Division, Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Company, Kingsport, Tenn. EASTMAN 910 Adhesive is distributed by Armstrong Cork Company, Industry Products Division, Lancaster, Pa., and Loctite Corp., 705 N. Mountain Road, Newington, Conn.

Here are some of the bonds that can be made with EASTMAN 910 Adhesive

Among the stronger: *vinyls, phenolics, cellulosics, polyesters, polyurethanes, nylon; steel, aluminum, brass, copper; butyl, nitrile, SBR, natural rubber, most types of neoprene; most woods.* Among the weaker: *polystyrene, polyethylene* (*shear strengths up to 150 lb./sq. in.*).

There is no adhesive like EASTMAN 910® Adhesive

SETS FAST—Makes firm bonds in seconds to minutes.

VERSATILE—Joins virtually any combination of materials.

HIGH STRENGTH—Up to 5,000 lb./in? depending on the materials being bonded.

READY TO USE—No catalyst or mixing necessary.

CURES AT ROOM TEMPERATURE—No heat required to initiate or accelerate setting.

CONTACT PRESSURE SUFFICIENT.

LOW SHRINKAGE—Virtually no shrinkage on setting as neither solvent nor heat is used.

GOES FAR—One-pound package contains about 30,000 one-drop applications. (Or in more specific terms, approximately 20 fast setting one-drop applications for a nickel.)

The use of EASTMAN 910 Adhesive is not suggested at temperatures above 175°F., or in the presence of extreme moisture for prolonged periods.

See Sweet's 1966 Product Design File 8a/Ea.

Now available! EASTMAN 910 Surface Activator When certain surface conditions inhibit rapid bond formation, use of EASTMAN 910 Surface Activator is recommended to restore the rapid polymerization of EASTMAN 910 Adhesive.

ON READER-SERVICE CARD CIRCLE 64

YOUR SHORTEST ROUTE

to what's new in Semiconductor Coolers

WAKEFIELD DISTRIBUTOR PRODUCTS CATALOG

The latest designs in Heat Sinks are as near as your nearby authorized WAKEFIELD Electronic Distributor. His name is in our catalog along with the full line he stocks: milliwatt to high power coolers, circuit board coolers, extrusions, thermal joint compound, DELTA BOND 152 Thermally Conductive Adhesive.

NC-680-1.0

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WAKEFIELD ENGINEERING, INC.

DELTA DIVISION

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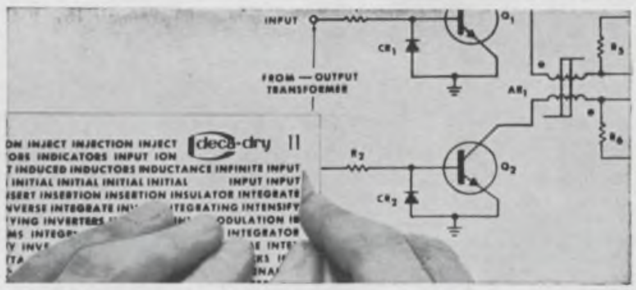
ON READER-SERVICE CARD CIRCLE 65

NEW EASY-TO-TRANSFER



Titles, Codes, Words, Letters, Numbers in Seconds

DECA-DRY ELECTRONIC MARKING KIT

Contains hundreds of standard titles, codes, words, letters and numbers in dry transfer form. Rub lightly with a pencil and instantly they transfer onto prototypes, control panels, printed circuit masters, schematics, drawings, electrical and mechanical components. Titles appear crisp, sharp, professional giving all drawings and equipment the look of quality printing. Won't move, crack or peel. Produces razorsharp copies in most reproduction processes. Find out more about it! Write today for a free sample.

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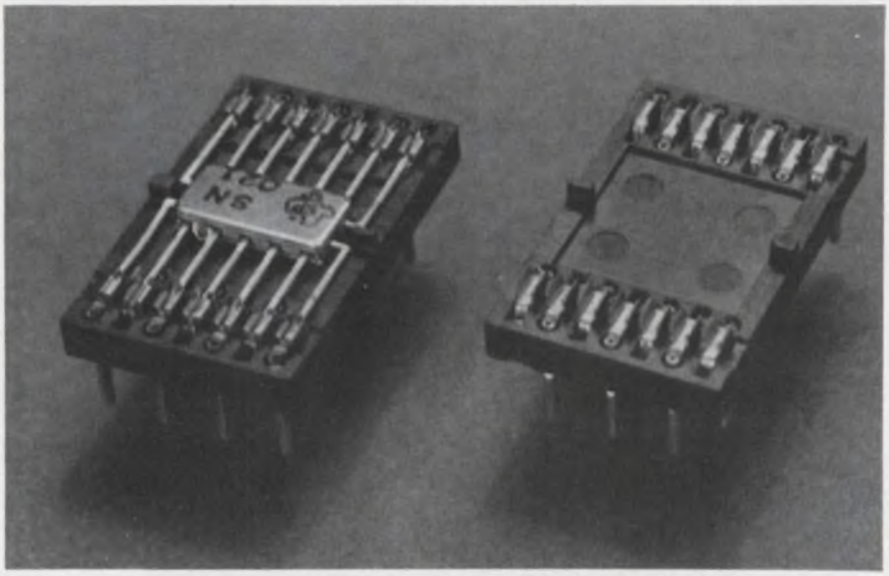
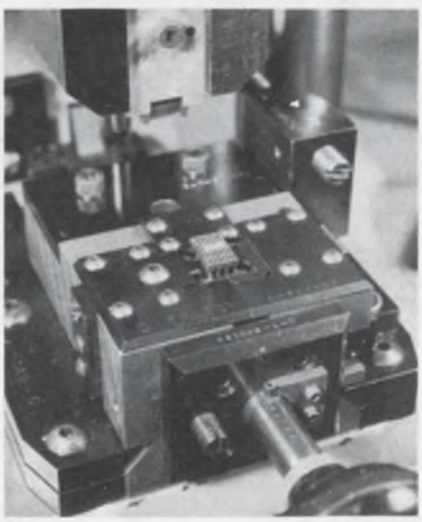
ON READER-SERVICE CARD CIRCLE 66



Crimp-type flat pack carriers allow semi-automatic production

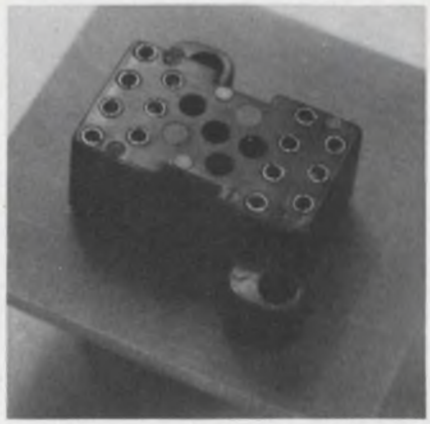
There is still no fool-proof "easy" way to mount integrated-circuit flat packs but a new system from Amp, Inc., of Harrisburg, Pa., represents a long step in that direction. Many of the usual handling problems that, in the past, have limited flat pack usefulness are solved by a triple-function carrier and receptacle combination designed for crimped lead connections. The carrier prevents handling damage during production operations, serves as a test fixture for quality control and operational testing, and allows standard production-line connection techniques to be used.

Both speed and economy are cited as advantages in this new mounting system. Production rates range up to 100 or more units per hour with a spoilage rate of virtually zero. In one application investigated by Amp engineers, a computer manufacturer was allowing 14 man-hours to mount and interconnect a system comprised of 90 flat-pack devices. Amp estimated that this job could be done in only one hour using their semi-automated system and Termapoint interconnection techniques.



A fully automated flat-pack assembly machine will probably await industry standardization in shipping containers. Some manufacturers now provide disposable carriers but there is no standardization. Some simply ship the devices loose. The new Amp process requires that the device be positioned on the carrier by hand before the assembly is placed on the assembly jig to be crimped. A crimping press is offered on a lease basis and a manual crimping tool will soon be available. Once on the jig, a single stroke crimps up to fourteen leads simultaneously.

From this point in a production schedule, usual modular engineering can be used. After any required testing, the carrier can be mounted directly on a PC board or mated with a special receptacle to



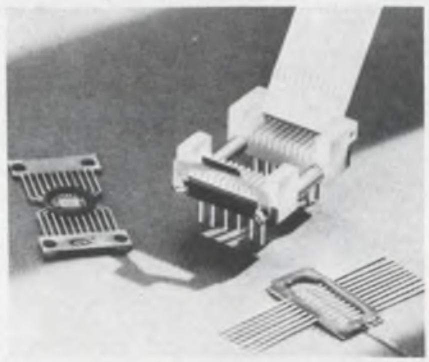
become a 14-pin functional module.

Carrier and receptacle design includes both polarizing and keying posts to make sure that the carrier is mounted in proper phase with the receptacle and that the carrier is plugged into the correct circuit board or receptacle.

Contact material is beryllium copper and the carrier body is of compression molded phenolic.

P&A: \$4-\$5, reducing to half in production lots; 2 weeks. Amp, Inc., Harrisburg, Pa. Phone: (717) 564-0101. TWX: (717) 564-4103.

Circle No. 295



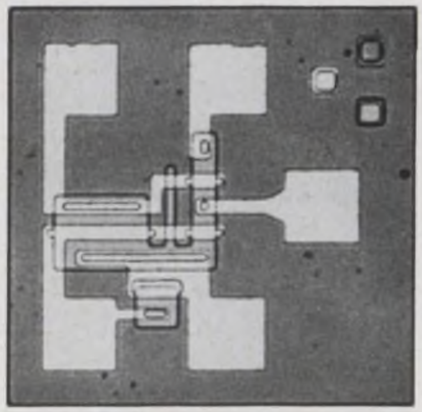
IC flat-pack test socket

A new test socket for integrated circuit flat packs features low capacitance and low contact resistance. High temperature Dialyll insulators permit accurate testing to 220°C. Spring tempered beryllium copper contacts are hard gold-plated over nickel, and are formed to provide wiping action on closing the socket lid.

These sockets accommodate up to 22 leads on 0.050-in. spacing. The design accepts any package size from 1/8 x 1/4-in or larger.

Available from stock. Azimuth Electronics, P. O. Box 463, Denville, N. J. Phone: (201) 361-0085.

Circle No. 296



MOS ME family includes 15 units

A group of 15 MOS microcircuits includes a 90-bit shift register with 542 MOSTs on a single chip. Other circuits in the group are a 12-bit shift register, a four-stage binary counter, eight different multiplexer gate devices, a dual full adder, and more in the way of NOR circuits, emitter following drivers, and a new MOST series-shunt chopper.

The 90-bit MEM-4090 operates in computer memory systems at a clock memory frequency up to 1 MHz. It can be operated as two parallel 45-bit delays, or in series for the full 90 bits.

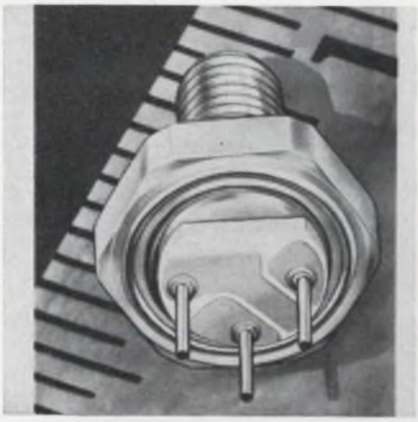
The 12-bit MEM-507 contains the equivalent of 200 MOSTs, and operates at a clock frequency of 500 kHz. The MEM-1050 is a four-stage binary up-down counter with a frequency range from dc to over 1 MHz and an input impedance of 10^{12} ohms. It also contains the equivalent of 200 MOSTs.

The multiplexer gates (MEM 2001 and MEM 5001-5007) are arrays of silicon p-channel, insulated gate enhancement mode FETS.

These units are joined by the less complex dual full-adder MEM-1000, a 3-input and 2-input NOR with buffer (MEM-901), and four emitter follower drivers (MEM-4000). Included in the lot is a new MOST series-shunt chopper (MEM-590).

Prices: (in 50-99 quantities) MEM-4090, $46.80; (in 100-199 quantities) MEM-507, $29.60; MEM-1050, $37.50; MEM-2001, $23; MEM-1000, $18.90; MEM-901, $7.10; MEM-4000, $5.25; MEM-590, $25.10. General Instrument Microelectronics Div., 600 W. John, Hicksville, N. Y. Phone: (516) 681-8000. TWX: (516) 433-9162.

Circle No. 297



Be-to-metal assemblies

Intended for use in high frequency power transistors, a line of beryllia-to-metal assemblies is offered for a variety of semiconductor packages. Precise metallized patterns for semiconductor devices can be provided with definition between segments as close as 0.010-in. and a flatness of 0.001-in. Leads can be brazed in either radial or vertical configurations.

Advac Products Inc., 174 Richmond Hill, Stamford, Conn. Phone: (203) 325-3881.

Circle No. 298

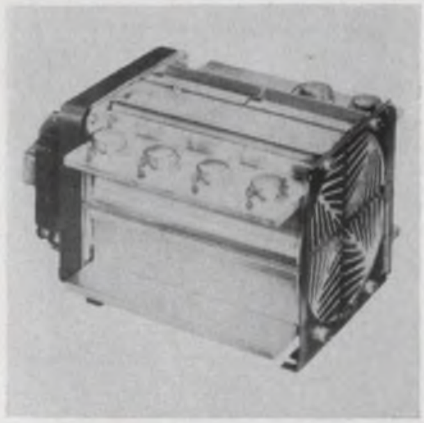
Slip ring capsule

A subminiature slip ring capsule contains 60 circuits. Only 1.03-in. long by 1.125-in. diameter, the unit withstands shock and vibration in accordance with MIL-STD-202B.

Operating temperature is 0-85°C, non-operating from −55° to +100°C. Dielectric strength is 500 Vac at 60 Hz, insulation resistance is 500 Meg at 500 Vdc, and contact resistance variation (noise) is 15 milliohms. Current capacity is 2 A on 10 circuits, 500 mA on 50.

Electro-tec, Box 667, Ormond Beach, Fla. Phone: (305) 677-1771.

Circle No. 299



Semiconductor cooler

Series FCA-820 cooling package can accommodate up to 32 semiconductors, or more, if stacked. Increased fan size and a new fin extrusion design are said to increase efficiency.

These packages can eliminate ducting and baffling, and their low thermal resistance can cut down on the number of semiconductors needed in a regulatory circuit.

The units are factory assembled to the specifications. Two module types are available: the 820-A "shelf-type" and the 820-B to provide lower thermal resistance for stud-mounted rectifiers.

Wakefield Engineering, 139 Foundry, Wakefield, Mass. Phone: (617) 245-5900.

Circle No. 351

Silicon mesa dice

Silicon meša passivated dice have electrical characteristics encompassing the entire range of computer, zener, and silicon diode specifications.

Typical sizes are 0.02 x 0.02 x 0.007-in. Recovery and capacitance characteristics less than 2 ns and 2 pfd are obtainable. Dice meet, or exceed MIL-S-19500 and MIL-STD 202. Termination temperatures greater than 350°F will not alter characteristics. Substrate, thin film, and matrice configurations can be engineered.

P&A: \$1.50-\$0.50; stock. Micro Semiconductor Corp., 111250 Playa Court, Culver City, Calif. Phone: (213) 391-8271. TWX: (213) 871-5209.

Circle No. 352

Opens fresh design horizons...

microminiature solid cermet discrete resistor

Explore new design areas with these Ceradot® pellet resistor characteristics available only from CTS:

- To ± 1% tolerance.
- 15 watts/cm^3 power to size ratio.
- Won't short out under any operating conditions.
- Extreme stability under extreme environments.
- 15 ohms to 200K ohms resistance range.
- Not affected by radiation.
- Operates at 175°C hot spot without leads.
- Available with leads or terminating surfaces for soldering or welding.

Current CTS Ceradot applications include numerous aerospace, military and industrial microcircuits, such as discrete components inside transistor cans and flat packs, microwave loads, temperature compensated transistor circuits, load resistors, etc. How can Ceradot's unique characteristics help solve your design problem?

EXPERIMENT WITH CTS CERADOTS

Designers' Kit contains an assortment of pellet resistors in these sizes: .050" dia. x .030"; .050" dia. x .062"; .100" dia. x .030" and .100" dia. x .062" in random resistance values. Uses: in prototypes, development programs, testing and experimental microcircuits. Kit price $10.00. Immediate delivery.

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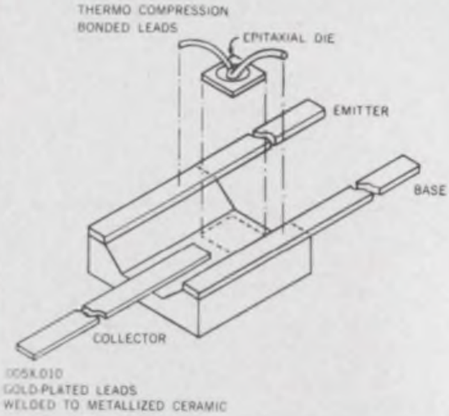
CTS of Canada, Ltd., Streetsville, Ontario
CTS Microelectronics, Inc., Lafayette, Ind.
CTS Research, Inc., Lafayette, Ind.
CTS Knights, Inc., Sandwich, Ill.

ON READER-SERVICE CARD CIRCLE 81

Microcircuit transistor

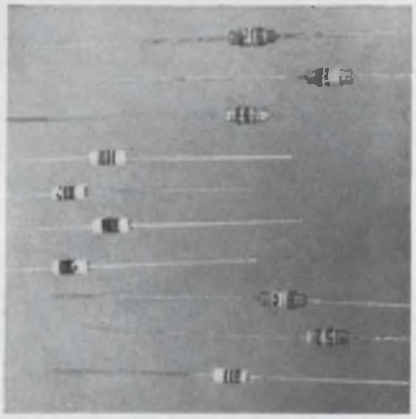


A new double-diffused *npn* silicon transistor is designed for thin-film and other micro-circuit packaging as a vhf-uhf amplifier. Performance figures are 14 dB gain at 450 MHz, noise figure less than 4 dB. Selected versions are available with noise figures down to 2.5 dB at 450 MHz.

Most of the manufacturer's other transistors are also available in the new packaging configuration.

P&A: from $24.75; 10 days. KMC Semiconductor, Parker Road, R D #2, Long Valley, N. J. Phone: (201) 876-3811. *Circle No. 353*

Volt-variable caps

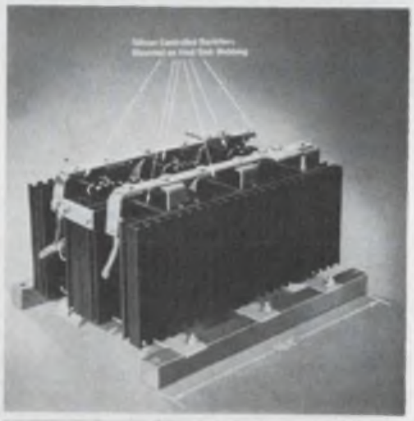


A series of all-epitaxial voltage variable diodes, the Varactron line, includes a total of 299 different devices. These include JEDEC types 1N4786-4815, 1N950-956 and V20G-100G plus the manufacturer's types VG107-339 and VM200-985. All use the P+NN+ construction with dc ratings as high as 150 volts.

P&A: From $2.00; most from stock. Teledyne Inc., Crystalonics Div., 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. TWX: (617) 499-9156.

Circle No. 354

Hybrid SCR bridge

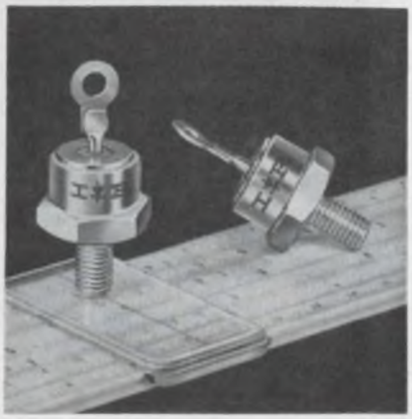


A new hybrid silicon-controlled rectifier bridge assembly for applications in motor controls and ac regulator power supplies functions under a wide variety of adverse environments. The assembly is available in single-phase or three-phase configurations and features outputs which are up to 140 amps and PRV ratings as high as 1.3 kV.

International Rectifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281.

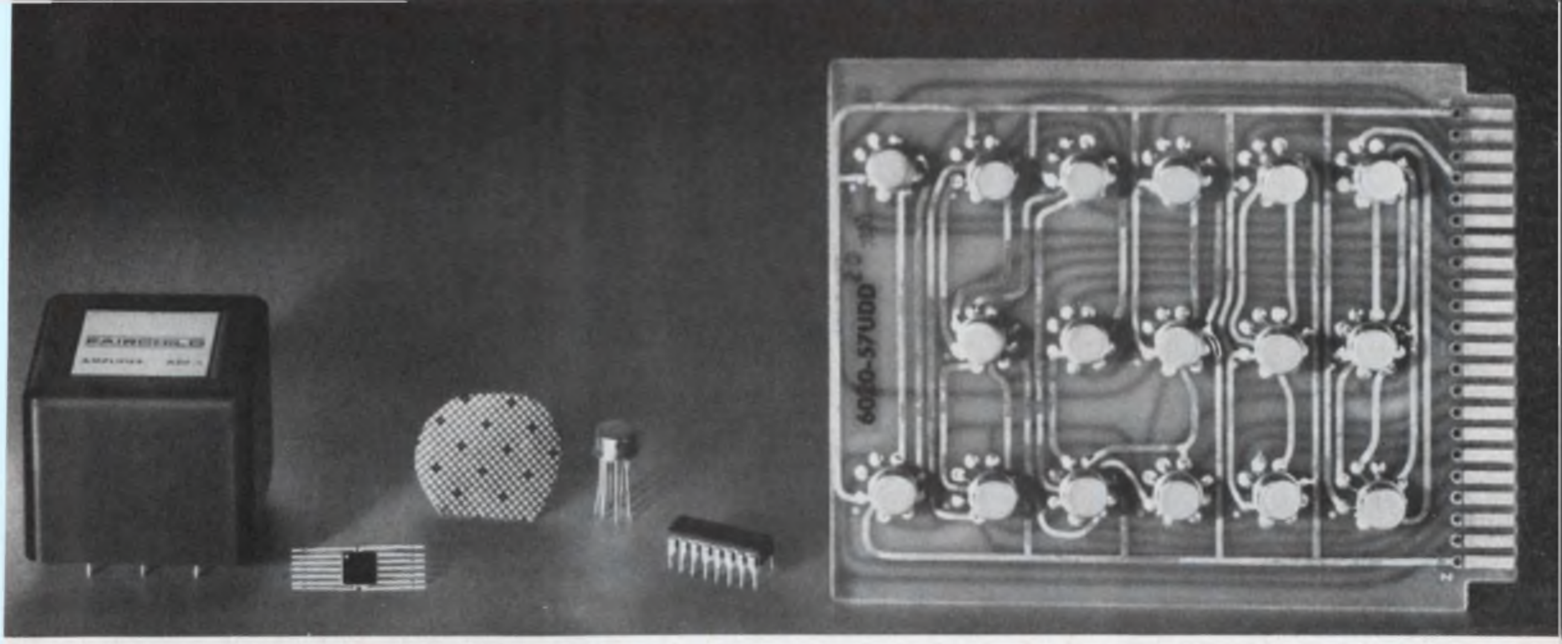
Circle No. 355

Commercial rectifiers



Having a 15 to 40 amp range, the 40HF series of rectifiers are rated from 100 to 400 volts PRV. Standard and reverse polarity, double diffused junction, hermetic sealing and hard-solder assembly are also featured in this series of rectifiers for industrial and commercial equipment. Other applications include battery chargers, motor drives, field control and motor armature control.

International Recitifier, 233 Kansas St., El Segundo, Calif. Phone: (213) 678-6281. *Circle No. 356*



Test all these circuits five ways with one system:

Fairchild Series 4000MA

1. Function Check. Each test sequence includes logic performance check. If the circuit passes, the system will automatically switch to the next test mode.

2. DC Testing. The 4000 makes sixty tests per second with resolution of ±.1mV and ±.1nA. Readout is Go/No-go with optional direct digital display or data logging.

3. Linear Measurements. The 4000 automatically measures: input offset voltage, input bias current, input common mode rejection ratio, open loop voltage gain, output impedance, output voltage swing, V+ and V− supply current, total device power, input common mode ratio, differential voltage gain, output common mode voltage, maximum voltage between V+ and V− terminals, BV_{CBO} at $10\mu a$ and up, differential input impedance and open loop voltage transfer function.

4. Switching Time. An automatically programmed switching time option measures storage time; propagation delay; pulse rise time, fall time and width; saturation voltage and pulse height and sag.

5. AC Voltage Measurements. Sinusoidal measurements can be made on a variety of circuits, with ±1% accuracy.

Economical Testing. The simple magnetic disc programming lets an inexperienced operator switch to 36 different test programs on a single disc in just seconds. This means you can program and test printed circuit cards, integrated circuits, flat packs, dual in-line packs, potted modules and even micrologic wafers at a single test station.

For a complete list of options and the full range of Series 4000 capabilities, get in touch with your nearest representative or write Fairchild Instrumentation.

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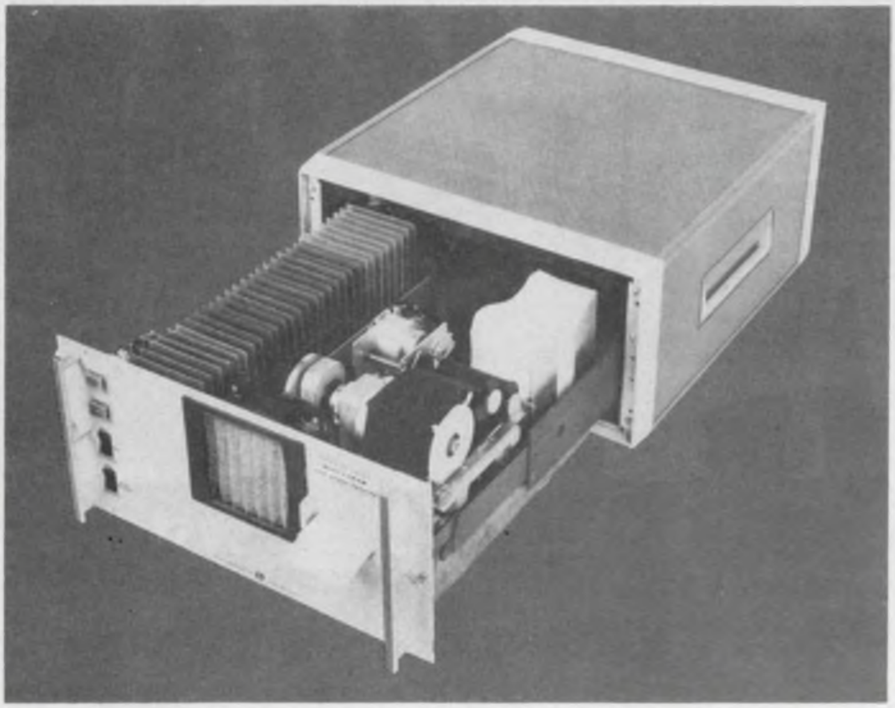
844 CHARLESTON RD., PALO ALTO, CALIFORNIA, 962-2451 ■ TWX: 910-373-1256 ■ FAIRCHILD INSTRUMENTATION, A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORP.



Alphanumeric printer gives 20 lines per second

The new "Minitype" high-speed printer handles up to 48 characters per line, at speeds of 20 lines per second, alphanumeric, or 40 lines per second, numeric.

Developed for the Polaris program, this unit handles telemetry, counter, computer, and similar printouts. It prints on any paper (no cogwheels). The unit accepts binary codes up to six digits with logic levels of any two positive or negative voltages having more than three volts difference.

The 8-3/4-in. high unit can be housed in a 19-in. rack-mount, or in a table-top cabinet. It has modular solid-state electronics, and carries a one-year unconditional guarantee. Options include decimal point insertion, zero suppression, mixed input codes, special type, and expandable capacity (48 columns max).

Among the machine's points are no loss of speed from multiple-copy printing, and no guarantee voidance if the unit is run without paper.

P&A: 20 col, $4480; 48 col, $7280; 60 days. Shepard Labs, 480 Morris, Summit, N. J. Phone: (201) 273-5255.

Circle No. 357

3-lead testing computer

SCAT 26 is a testing computer for all two and three lead semiconductors and components. It makes up to 20 measurements in 400 ms, stores all results, sorts them against its program, and classifies them into 11 matrix categories.

All voltage and current tests, limit, saturation, breakdown, β, leakage, and such things as integrated circuit drain can be made as differential measurements in any order. Current mode, dc, and pulsed dc measurements are made within the range of 1 nA to 1/2 A, 0-300 V.

Applications include quality control, troubleshooting, and inspection.

P&A: $12,000; 30-60 days. Continental Device, 12515 Chadron, Hawthorne, Calif. Phone: (213) 772-4551.

Circle No. 358

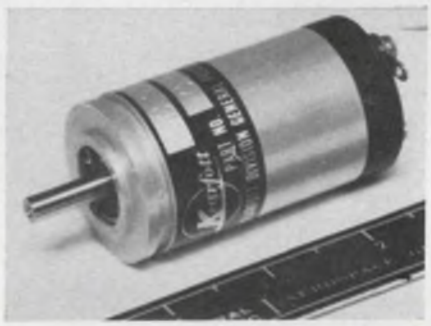
1 Microsec memory

The ICM-40 coincident current, random-access core memory features integrated circuitry, with operating speeds of 1 μs full cycle, and access time of less than 500 ns.

The 5-1/4-in. high unit mounts in a standard relay rack, and permits word capacities to 16,384. Operating modes include clear/write, read/restore, and read/modify/-write cycles, while outputs memory busy, information available, and end-of-cycle. Hold-address control is also available.

Operating ambient temperature range is 0-50°C. Separate power supplies contain power-failure sensing, non-volatile start/shut-down, over voltage, over load, and line-transient protection.

Computer Control Co., Old Conn. Path, Framingham, Mass. Phone: (617) 879-2600. *Circle No. 359*



Low ripple dc tach

A size 8 DC tachometer-generator, CMO 9608 001, exhibits little variation in output despite temperature fluctuation. Speed-sensitive output voltage varies less than 0.01%/°C within operating range −54°C to +100°C. Output voltage is 3 v/thousand rpm, with output impedance of 225 ohms. Linearity is 0.5% to 3600 rpm, and bidirectional error is 0.2%. Max speed is 12,000 rpm, friction torque is 0.15 in. oz., rotor moment of inertia is 2 gm cm^2.

General Precision, Kearfott Div., Aerospace Group, Phone: (201) 256-4000. TWX: (201) 256-5926.

Circle No. 360

A DC VOLT-OHMMETER WITH NO RANGE SWITCH!

More time saved—Put an end to tedious, time-consuming manual range switching with the new Hewlett-Packard 414A Autovoltmeter. Just touch and read . . . range and polarity change automatically. You read range and polarity on the digital readout above the analog meter.

More accuracy—And the analog meter lets you measure ±5 mv to ±1500 v full scale, 12 ranges, with an accuracy of ±0.5% of full scale ±0.5% of reading; 5 ohms to 1.5 megohms, 12 ranges, accuracy 1% of reading ±0.5% of full scale.

All this for just $650!

More uses—The 414A is the world's first "touch-and-read" analog volt-ohmmeter with accuracy anywhere approaching what you require for trouble shooting, tweaking, peaking and nulling, probing a circuit without a schematic. Use it for maintenance testing, on the production line, in the lab.

In the dc voltage function you simply touch the point to be measured and in less than 300 msec read the range and polarity on the digital display and the precise dc measurement on the individually calibrated, mirror-backed taut-band meter. Automatic ranges are selected and displayed for resistance measurements, too.

More noise rejection—Ranges also can be selected and held manually, and a Down Range control feature lets you drop to the next lower range merely by pushing a front-panel button.

Input resistance is 10 megohms on the 5 and 15 mv ranges, 100 megohms on 50 mv range and above. The 414A is insensitive to 60 cps signals with peak value less than 7 times the full-scale dc level of range in use in "Hold" position (rejection is 20% of reading when using Auto-ranging).

To get the true significance of this automatic instrument, you need to see it perform on your bench. Call your Hewlett-Packard field engineer for that convincing demonstration. Or write for complete information to Hewlett-Packard, Palo Alto, Calif. 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

Data subject to change without notice. Price f.o.b. factory.

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1033

ON READER-SERVICE CARD CIRCLE 85

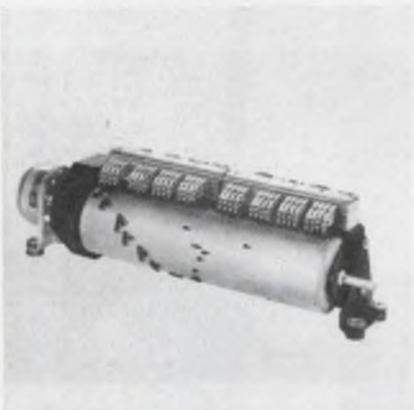
FM multiplex

A solid-state, 48-channel FM voice multiplex unit is designed for microwave relay use. Designated MC-30, this equipment features toll quality performance, modular construction or battery operation. Power options permit 24 Vdc, 48 Vdc, or 120 Vac input. It is said by the manufacturer to be suited for applications requiring transmission of voice, vhf base station control, telemetering, data and facsimile.

Motorola Inc., 1450 N. Cicero Ave., Chicago, Ill. Phone: (312) 379-6700.

Circle No. 361

Programing switch



Designed for high density switching requirements, a new Actan programing switch features two and three tiers of contacts stacked on top of each other.

By stacking the banks of form C contacts up to three high, two or three times as many electrically discrete circuits as before may be simultaneously programed. The switch is available as either time-based, pulsed, or manual.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600. TWX: (710) 566-1110.

Circle No. 362

Broadband hf antennas

A line of 108 different transmitting and receiving antennas consist entirely of prefabricated parts. An antenna to satisfy highly individual requirements can be supplied quickly and at moderate cost.

Among the salient characteristics that can be supplied as specified are: frequency range (seven ranges from 6.5 to 32 MHz through 2.5 to 32 MHz), power capacity (20 kW average, 10 kW average or receiving capacity only), input impedance (50 ohms coaxial, 300 ohms balanced or 600 ohms balanced) and radiation pattern (for short, medium or long distances). The antennas, designated series 1700, range from 45 to 210 feet in height, depending primarily on the frequency range. The units are supplied in kit form for field erection. All parts of the radiating curtain are made to be assembled with nuts, bolts, and cotter pins. The assembled antennas will withstand 100 mph winds, and corrosive elements, such as salt spray.

Granger Associates, 1601 California Ave., Palo Alto, Calif. Phone: (415) 321-4175. TWX: (415) 492-9377.

Circle No. 363

Phantoms score victories in Viet Nam.

Geminis rendezvous in Space.

While these products make news, MCDONNELL has many new projects in progress.

McDonnell's wide-ranging aeronautic, astronautic, automation and electronic programs need talented and experienced personnel.

A 26-year history of growth and achievement has shown a year-by-year increase in employment levels without experiencing a major dip in the upward trend. *Planned* accomplishment sets McDonnell ahead of most companies in the industry.

McDonnell provides company benefits that are modern and contain many innovations. (For example, UN Day and NATO Day are paid holidays; educational assistance gets up to full sponsorship, reduced work weeks.)

Living in the St. Louis area is a gracious change of pace from the noise and clutter of the larger cities. Better living at less cost will inspire frequent visits to restaurants, shows and cultural centers that vie with heralded facilities on both coasts.

Schools are plentiful, *not overcrowded*, and have AAA ratings which put them above par with most schools in the nation.

Enjoy seasonal weather cycles that average 33.8° in winter and 77.4° in summer. The full range of recreation outlets provides an opportunity to enjoy living at a relaxed, unhurried pace.

These facts should satisfy the *inner* man. The professional in you will also be surprised at the way things have a way of getting done, without red tape, and they get done right. Whether launched before a watching world or in secret on some far corner of the globe, it has become characteristic of products built by McDonnell that they work.

Join the McDonnell Team for professional growth, job potential, recognition and stability.

Requirements exist for the following positions:

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Aircraft Maintenance Engineers
Technical Data Engineers
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Aerodynamics Engineers
Guidance & Control Engineers
Loads & Weights Engineers
Operations Analysts
Propulsion Engineers
Thermodynamics Engineers
Stress Engineers
Structural Dynamics Engineers
Electronic Systems Engineers
Reconnaissance Specialists
Flight Test Engineers
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ON READER-SERVICE CARD CIRCLE 893

Digital printer

Model 610 digital printer and 620 printer-control comprise a paper-tape recording system for digital thermometers, counters, voltmeters, and other instruments. Readouts in two groups of four digits permit the reading of two instruments, or the identification coding of one.

Accessories are available to provide print identification and various input scanning functions.

Price: $750. United Systems, 918 Woodley Rd., Dayton, Ohio. Phone: (513) 254-3567.

Circle No. 364

Closed-circuit TV

Third generation closed circuit TV cameras will fill a broad range of military, industrial, commercial, medical, and educational uses.

The remote-control TE-22-A and the local-control TE-20-A are 11-1/2 inches long, 5-1/2 inches in diameter, and weigh nine pounds without lenses.

Price: TE-20-A, $1295; TE-22-A, $1350. General Electric, Visual Communications Products, #7-315 Electronics Park, Syracuse, N. Y. Phone: (315) 456-2226.

Circle No. 365

Dynamic testing

The Automatic Tester Interface enables users to combine standard test equipment to automatically record data from dynamic testing of integrated and semiconductor circuits.

When coupled with a Tektronix 567 scope, a Tektronix 262 programer, and an IBM 562 card summary punch, Model 5320 lowers the cost of dynamic testing, while testing up to eight parameters.

Price: $1275. Radiation Inc., P. O. Box 220, Melbourne, Fla. Phone: (305) 723-1511.

Circle No. 366

2 microsecond memory

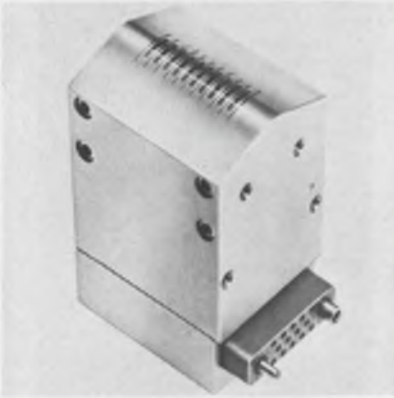
An integrated core memory system with full-cycle time of 2μs is designated MUA. Supplied in any of four access modes (random, sequential, random/sequential, and sequential interlaced), the user can select from a variety of circuits and features.

Word capacities range from 64 to 4,096, with two to 30 bits per word. Half cycle time is 1.25 μs, and access time is 950 ns.

Fabri-tek Inc., Amery, Wis. Phone: (715) 292-0900.

Circle No. 367

Magnetic tape heads



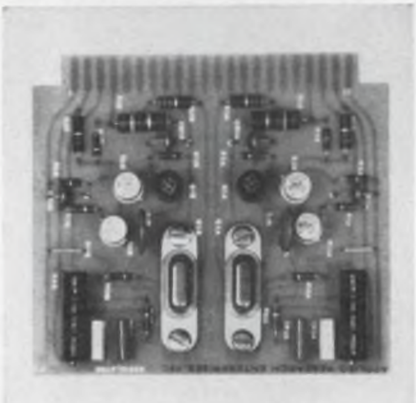
Magnetic tape playback heads with built-in amplifiers are designed for low-signal applications from 100 Hz to 2.5 MHz. These units are supplied with up to 20 channels per inch of tape width, with either differential or single-ended output.

Operational temperature range is between −55° and 85°C. Output impedance is 50 ohms maximum.

Western Magnetics Div., GJM Inc., 1733 Flower, Glendale, Calif. Phone: (213) 245-7311.

Circle No. 368

Voltage monitor



The model AVC-100 is designed to monitor both upper and lower limits of ac voltage in systems applications. When preset points are reached, the module will fire an internal solid-state switch. Both upper and lower limits of the voltage monitor are adjustable to 1/2%.

Price: $150. Applied Research Enterprises Inc., 30 Park Row, Stamford, Conn. Phone: (203) 348-2302.

Circle No. 369

Servo motor-generator

Model 20023, 115-Vac servo motor-generator has one fixed, and one variable voltage phase, and can be supplied with alternate output shaft configurations.

The unit measures 5-3/8 x 1-7/8-in., and meets MIL-E-5272, MIL-STD-202, and MIL-I-26600 environmental specs. The two-phase, 400-Hz motor has speeds from 10,300 to 11,750 rpm, and max. operating torque of 1.20-in./oz. The generator has an output voltage of 0.2 V ± 10% at 1,000 rpm, and pulse linearity of ±0.5% at 0 and 3000 rpm.

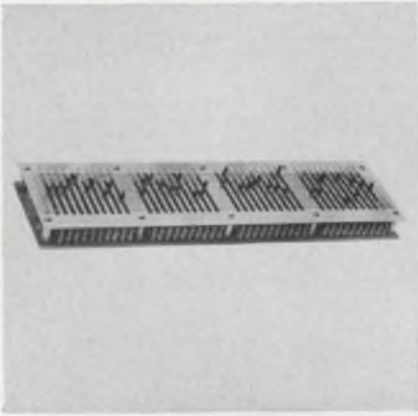
Electrokinetics Div., Varo, Inc., 402 E. Gutierrez St., Santa Barbara, Calif. Phone: (805) 963-2055. TWX: (805) 449-7200.

Circle No. 370

Accuracy is our policy

In the article, "Is 60-cycle pickup degrading the performance of your dc amplifiers?" [E/D, December 20, p 34], Fig. 1 was labeled incorrectly. The portion labeled "a" should have been "b," and vice versa.

Selector switch



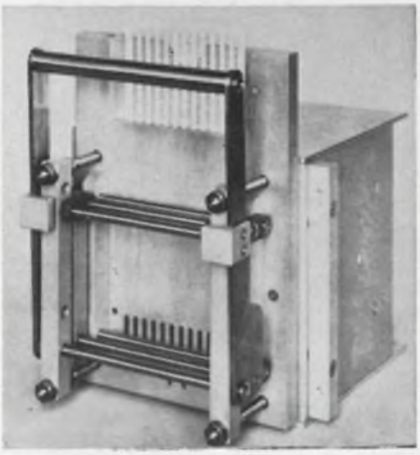
A manual crossbar-type selector switch provides 400 crosspoints between its 10-connector printed-circuit base, and 40 transverse slider rails.

Contact resistance is 0.05 ohms, maximum, while current carrying capacity is 3 amps, 125 V ac or dc. Make or break current is 1 amp at 15 Vdc; 150 mA, 125 Vac.

P&A: $55.00 each; 25% discount on 25 units. Cherry Electrical Products Corp., P. O. Box 438, Highland Park, Ill. Phone: (312) 432-8182.

Circle No. 371

Punched card sensors



The JM3C reads from 1 to 40 columns of any punched card. Insert the card, close the handle, and individual switches read the card: closed for a hole, open for no hole. Other units can be made with as few as 24, or as many as 1400 switches, allowing programing and other automated functions. Military, commercial, and industrial applications are suggested by the manufacturer.

Taurus Corp., Academy Hill, Lambertville, N. J., Phone: (609) 397-2390. TWX: (609) 490-3063.

Circle No. 372

Solid-state scopes

Three solid-state, drift-free oscilloscopes include a computer-display scope, a monitor scope for low frequency data display, and another low-frequency scope for complex data.

The computer-display scope features high resolution and linearity. For alphanumeric and vector displays it has 12 μs jump-scan time.

KM 402 monitor scope has 25 line/cm resolution, and 1% linearity. Direct-coupled amplifiers give full scale, undistorted vertical deflection to 7 kHz, down 3 dB at 50 kHz. A 14-in., aluminized CRT makes this scope applicable in telemetry, or other high-speed XY plotter applications.

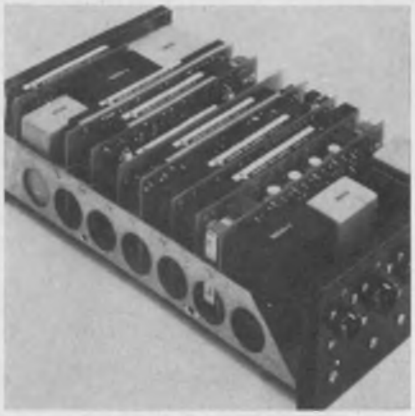
Model KS707 is a 17-in. magnetically deflected scope with calibrated linear time base and provision for triggered or recurrent sweeps. Specs are similar to those of the KM402.

ITT, Industrial Products Div., 1591 Bledsoe St., San Fernando, Calif. Phone: (213) 367-2211. TWX: (213) 764-5911.

Circle No. 373

POWER EQUIPMENT

Phase sensing converter



Transfer stability of 0.2% and linearity to 0.1% over a temperature range of −40° to +75°C are the leading features of the PSC-419 phase-sensitive converter. The unit is designed for a MTBF of 10,000 hours per MIL-HBK-217. It meets the requirements of MIL-T-21200 and provides a ±10-v output for an input of 10 mVac. Output impedance is 0.2 ohm.

North Atlantic Industries, 200 Terminal Dr., Plainview, N. Y. Phone: (516) 681-8600.

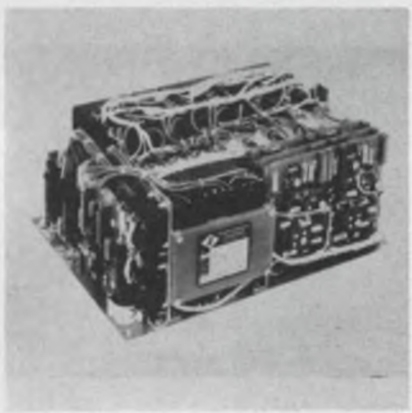
Circle No. 374

Dc power supply

A line of subminiature power supplies provide outputs at any fixed level from 3.3 to 28 Vdc, 40 mA. Package size is 1 x 3 x 1-1/4-in. The supplies are complete with transformers, rectifiers, filter and regulator and either single or dual outputs are available. Other features include floating outputs, allowing either positive or negative voltages to be tapped.

P&A: $40-$52; stock. Ferrotran Electronics Co., Inc., 693 Broadway, New York, N. Y. Phone: (212) 254-5810. *Circle No. 375*

Multiple TWT supply

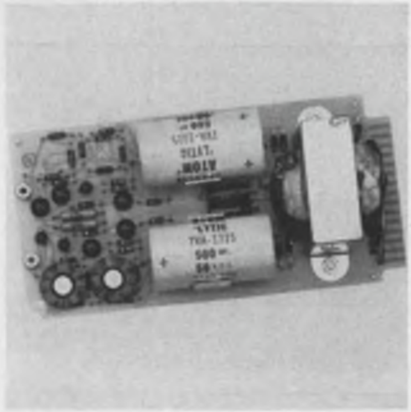


Four traveling-wave tubes can be driven by the Model PM 1414 programmable supply. Section #1 of the unit provides 2 kV at 1 amp and 8 kV at 0.1 amp with 5% duty cycles. Continuous 7.0 Vac and −100 Vdc is also provided. Section #2 provides 1.0 kV and 4.5 kV at 12% duty cycle as well as the continuous voltage. Supplies #3 and #4 are identical 1.0 kV, 7 Vac and −50 Vdc units.

Pioneer Magnetics Inc., 1745 Berkeley St., Santa Monica, Calif. Phone: (213) 393-0136.

Circle No. 376

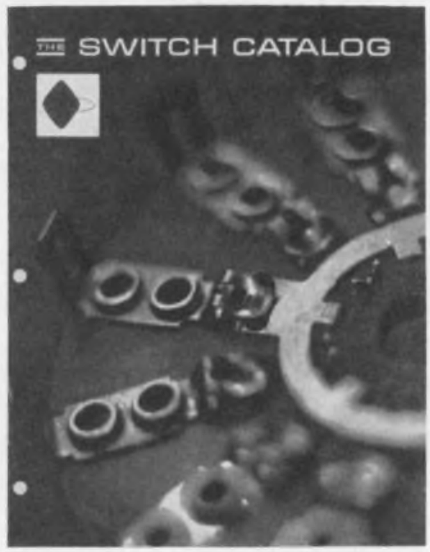
Dual dc supply



The model P100 all-silicon supply provides two independently adjustable voltage sources that have a 100 mA capability. Range of voltage adjustment for each source is from 8 to 18 volts. Ripple and noise are held to 0.05% for a ±10% line change and 0.2% from full-load to no-load. Voltage overshoot for a 100 mA step load change is less than 0.15 V.

Price: $95. Newport Laboratories, P. O. Box 2087, Newport Beach, Calif. Phone: (714) 646-9295. *Circle No. 377*

New Literature



Switch catalog

Engineering information and specifications on the manufacturer's line of switches are included in this eighty-page catalog. Special functions, insulation, and MIL specs are included between the four-color covers. Oak Mfg.

Circle No. 378

Thermistor thermometers

Laboratory and industrial test thermometers using interchangeable thermistors sensors to achieve multi-point and multi-range systems are described in a 24-page catalog. Twenty-one standard probe designs are illustrated and priced with full specifications. Atkins Technical Inc.

Circle No. 379

Epoxy resins

Two types of epoxy resin are described in Bulletins SC:65-32 and SC:65-38. The first lists the typical properties, curing agents and laminate preparation and properties of resin 1045-A-80. The second contains a series of graphs illustrating the viscosity variation of resin 840 as well as property listings and casting procedure. Shell Chemical Co.

Circle No. 380

Filter manual

An 80 page technical brochure discusses fundamental design data of filters and multiplexers. Frequency ranges from dc to 12 GHz are considered, and sample specifications given. *A copy of this Filter Technical Manual, M-100, may be obtained by letterhead request to: American Electronic Laboratories Inc., P.O. Box 552, Lansdale, Pa.*

Flexible couplings

Miniature flexible couplings, universal joints, and allied power transmission accessories are listed in a 40-page catalog along with prices for the various models. The catalog is aimed at design engineers working with servomechanisms, automatic control, remote control or other power take-off drives from electromechanical equipment. Fourdee, Inc.

Circle No. 381

Interference reduction guide

A two-volume guide to interference reduction includes the background and techniques necessary to enable the engineer to minimize interference generation and susceptibility. Both Vol. 1 (AD 619 666D) and Vol. 2 (AD 619 667D) are illustrated.

Copies are available for $7.00 (Vol. 1, 221 pp) and $7.50 (Vol. 2, 364 pp) from Clearinghouse, U.S. Department of Commerce, Springfield, Va.

Diodes and transistors

Two catalogs describe germanium gold-bonded diodes and germanium transistors, both alloyed-junction and diffused alloyed-junction types. The transistor brochure, T-5001, gives specs for 145 types, including computer, HV, bilateral, drift, audio, and photo transistors. The diode catalog, T-4002, covers 200 types for all voltages and includes fast-recovery types. General Instrument.

Circle No. 382

Frequency changers

Twenty-four dc-to-ac inverter models, 20 ac-to-ac frequency changer models, plus 3 high-surge inverter models are described in catalog 138a. All units are solid state. The inverters and frequency converters have power ratings ranging from 15VA to 500 VA, and are available with either square wave or sinusoidal outputs. The high-surge inverters have surge ratings up to 1500 VA. Electronic Research Associates.

Circle No. 383

Medical power sources

An explanation of the Certified Cell Program and of the use of high-reliability power sources in medical electronics is given in this full-color booklet. Charts and graphs illustrate test results. The areas of study include cardiac situations involving the Stokes-Adams syndrome and electrical control of the bladder and urinary tract, among others. Mallory Battery Company.

Circle No. 384

Transformer catalog

Catalog P1065G describes characteristics, outline dimensions, connections, charts and illustrations of a complete line of manual and motorized 50/60 cycle variable transformers. Data also cover line connectors, 40-volt types, oil-cooled and explosion-proof models, multi-winding assemblies, positioner systems, full-range controllers, ac power supplies, packaged transformer primaries and slidewire resistors. Superior Electric Co.

Circle No. 385

Current regulators

Typical characteristics, complete specifications, and ordering information on two lines of current-regulating circuit components are contained in Catalog No. 1001. The four-page catalog deals with the "Currector" series of current regulating devices and the "Negistor" series of negative resistance units. Telonic Engineering Co.

Circle No. 386

Communications equipment

Radio equipment for high-frequency communications and the aviation services is described in a 16 page illustrated catalog. The publication covers a variety of broadband hf antennas, hf transmitter-to-antenna interface equipment, broadband hf power amplifiers and ionosphere sounders for communications and research. Granger Associates.

Circle No. 387

CRT scan recorder

A high resolution, intensity modulated recorder series is described in a new brochure. The trace image from the cathode ray tube is traced on photosensitive paper in real time. Federal Scientific Corp.

Circle No. 388

Operational amplifiers

Small quantity prices for solid-state encapsulated dc operational amps, accessories, and other standard items are listed in a newly lowered price list, PA-071-12/65. Nexus Research Laboratory.

Circle No. 389

Gyros

Application notes, general description, design features and performance characteristics of a wide variety of gyros are contained in a new 28-page brochure. Included is a description of a group floated rate integrated gyros as well as a series of degree-of-freedom ball bearing rate integrating gyros. General Precision, Inc., Kearfott Division.

Circle No. 390

Diode reliability

The results of a three-year diode reliability study program involving 15,700,000 diode hours of 100°C life test at rated conditions, are available in a 60-page report, TR-108. During the program 7,885 units were life tested. Unitrode Corporation.

Circle No. 391

Waveform display analyzer

Brochure No. LP-3607 describes a graphic input/output device called the Waveform Display Analyzer. The device provides the means for analyzing and evaluating a wide varity of data and can be coupled with any large digital computer, according to the manufacturer. Illustrations are included. General Precision Inc.

Circle No. 392

Relay catalog

A new 160-page catalog gives engineering and purchasing data on 11 major manufacturers' relay lines. Kierulff Electronics.

Circle No. 393

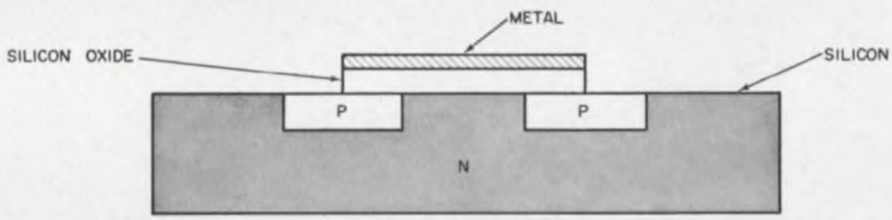
Application Notes

Designing with MOS FETs

Whether you prefer to call them MOS FETs, MOSTs, IGFETS or MOSFETs, the development of the metal-oxide field-effect silicon transistor is an important area to watch. In a paper called "Designing with MOS Semiconductors," Dr. J. Leland Seely, manager of integrated circuits engineering at the Microelectronic Division of General Instrument Corp., offers a solid but readable report on the basic design features of MOS FETs.

The paper covers basic structure, and operational theory, applications, integrateds, the resistor problem and several complex circuits. The paper concludes with an operational description of a 21-bit shift register diffused on a single chip that Seeley describes as a "giant step" in the development of monolithic circuitry. He says, "It is significant and typical of the power of this new technology that such a complicated circuit can be made to economically acceptable yields."

Circle No. 394



SCRs/power diodes

Application note 200.37 offers advice on increasing power and frequency with high speed SCRs and power diodes. The note, by Neville Mapham of the Rectifier Components Department of General Electric, covers a variety of important parameters and typical trouble spots in the use of these devices. General Electric Rectifier Components Dept.

Circle No. 395

Operational amps

This 17-page application note discusses advantages and disadvantages of the three principal Operational Amplifier configurations. Early conclusions show that inverting amplifiers provide highest accuracy and permit gains less than unity. The non-inverting configuration gives high input impedance, and the differential is ideal for push-pull outputs.

Also analyzed are input and output impedances, loop gain, gain errors, dc drift, common-mode limitations and more. Analog Devices.

Circle No. 396

VCXO brochure

Eight pages on voltage controlled crystal oscillators (VCXOs) include a graphic and theoretical discussion, block diagrams, frequency bandwidth graphs, and a specifications guide for the manufacturer's products. Damon Engineering.

Circle No. 397

Vswr detector

An 8-page note covers error analysis procedures and methods of determining vswr values instantly over a broad range of frequencies from 1 MHz to 4 GHz with the "Rho-tector" vswr detector. A nomograph gives the effect of cable attenuation on input and load vswr. Telonic Engineering.

Circle No. 398

ME components

An eight-page brochure gives performance characteristics of micro-circuit resistors and capacitors.

The brochure contains 13 charts, a nomograph and a table. Providing a wide range of design information. Corning Glass Works.

Circle No. 399

What's our line? Electronic Chemicals. Only Mallinckrodt makes such a complete line . . . just for the electronics industry. Look what's in it: Czochralski crystals ❶ up to 1¼ inches in diameter. TransistAR® Etchants ❷ including the first Ammonium Fluoride offered in convenient solution form. Dip, paint-on and diffusion dopants ❸ . . . quality found nowhere else. Solvents with unusually low particulate levels . . . such as Trichloroethylene TransistAR ❹, the industry's standard cleaning solvent. For higher device yields, be sure of the purity and compatibility of your chemicals. Rely on the technical competence of Mallinckrodt . . . a company that knows electronics, as well as electronic chemicals. It'll pay off. ❺ You can check it.

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Flow switches

Applications for flow switches in air conditioning, heating, water treatment, liquid transfer and air flow systems are discussed in this new guidebook FS-GB. McDonnell and Miller, Inc.

Circle No. 701

Varactor diode theory

The basic concepts of harmonic generation with non-linear reactances are presented in an application bulletin directed to communications design engineers. The report deals with the two basic circuit approaches: the series and the shunt configurations. Equations and formulas are included.

A discussion of filters devotes special attention to double-tuned bandpass filters for suppression of spurious responses.

In conclusion, as a specific example, a tripler design, is given in which a 1N4885/H4A varactor driven by an 8458 twin tetrode provides 22 watts at 450 MHz.

Copies of the report, S-124, can be obtained by writing on company letterhead to Amperex Electronic Corp., Hicksville, N. Y.

Reprints Available

The following reprints are available free and in limited quantities. To obtain single copies, circle the number of the article you want on the Reader-Service Card.

Basic Thin Film Techniques (No. 740)

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Designer's Datebook

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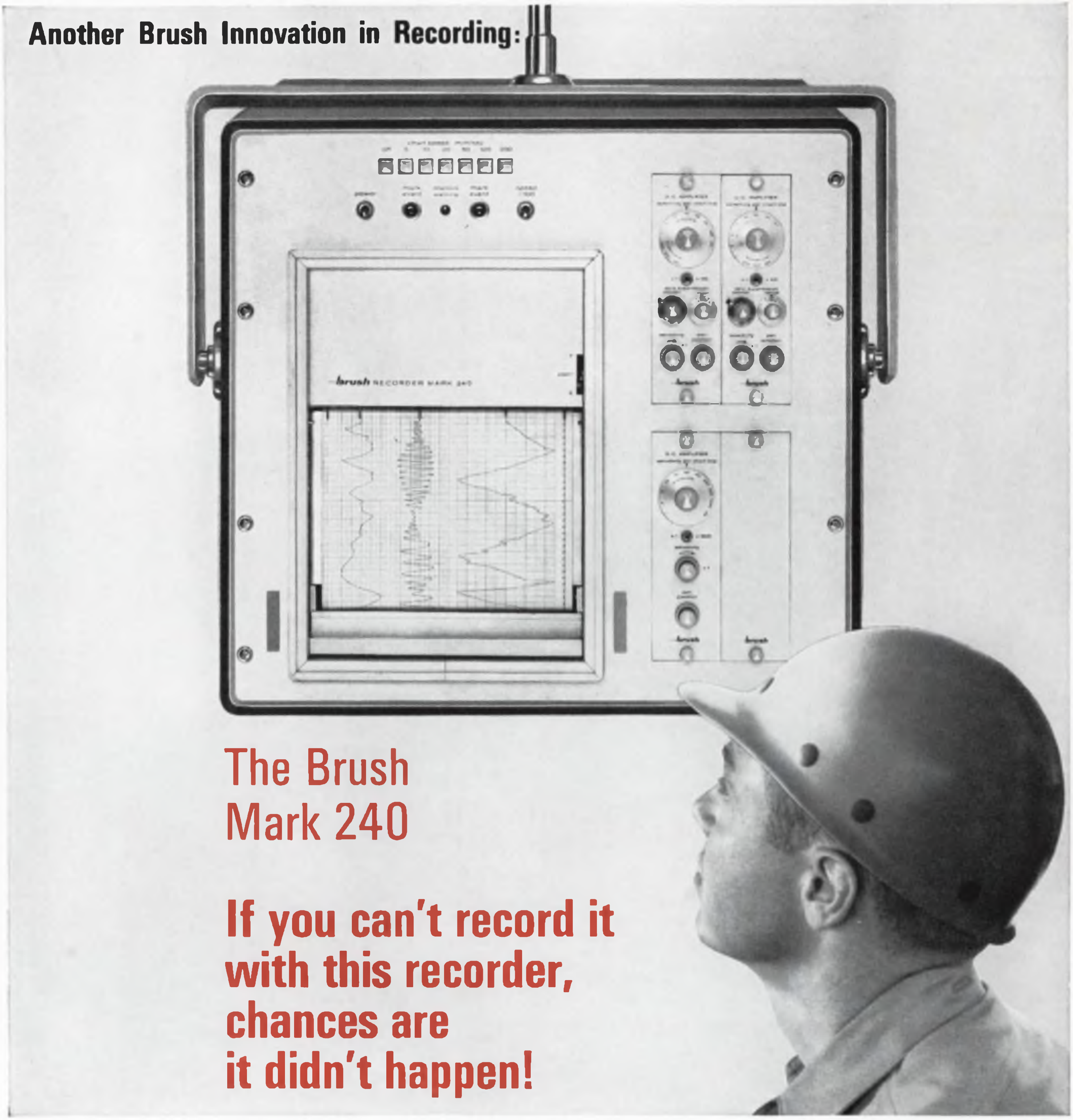

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