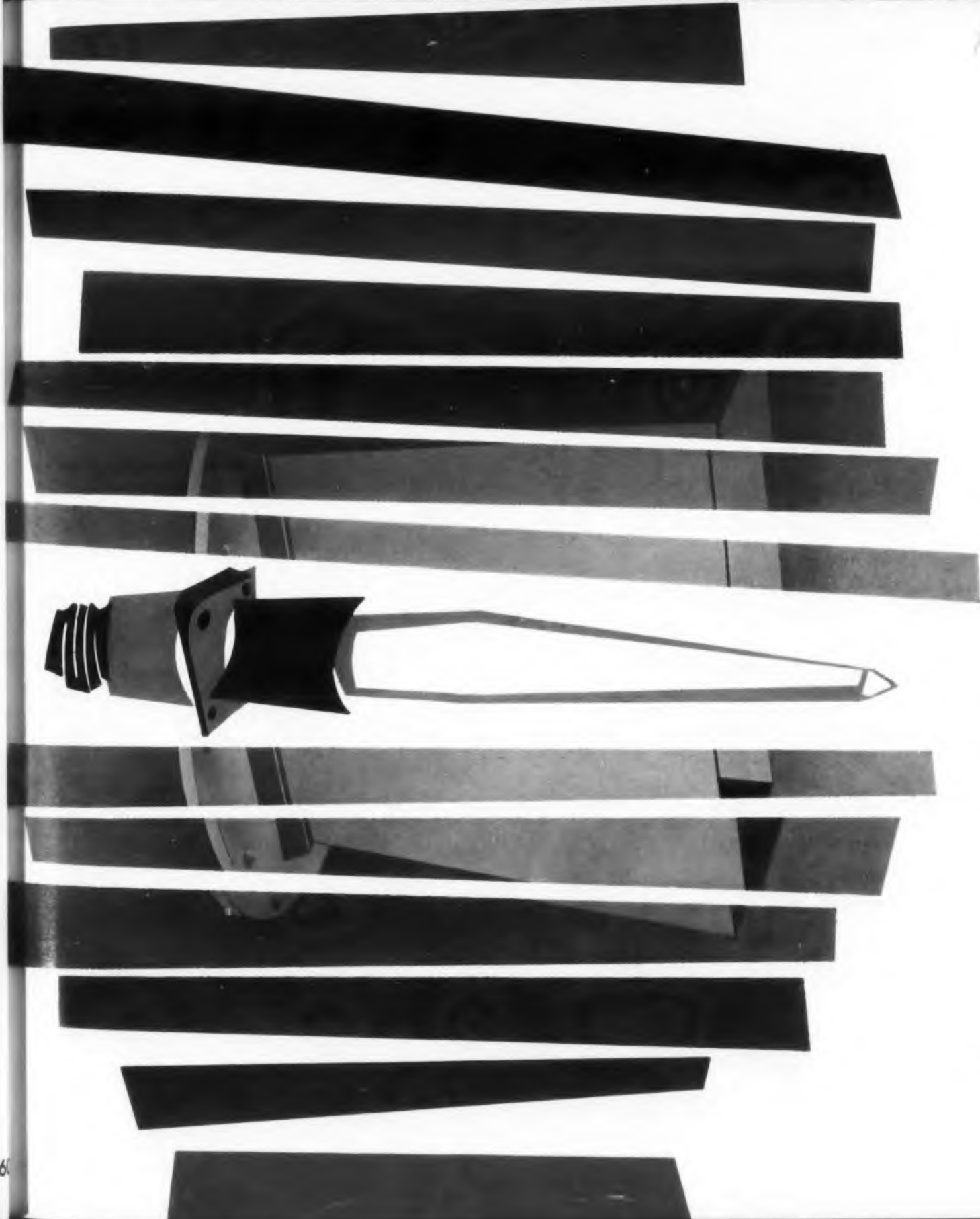


ELECTRONIC DESIGN



AID ELECTRONIC

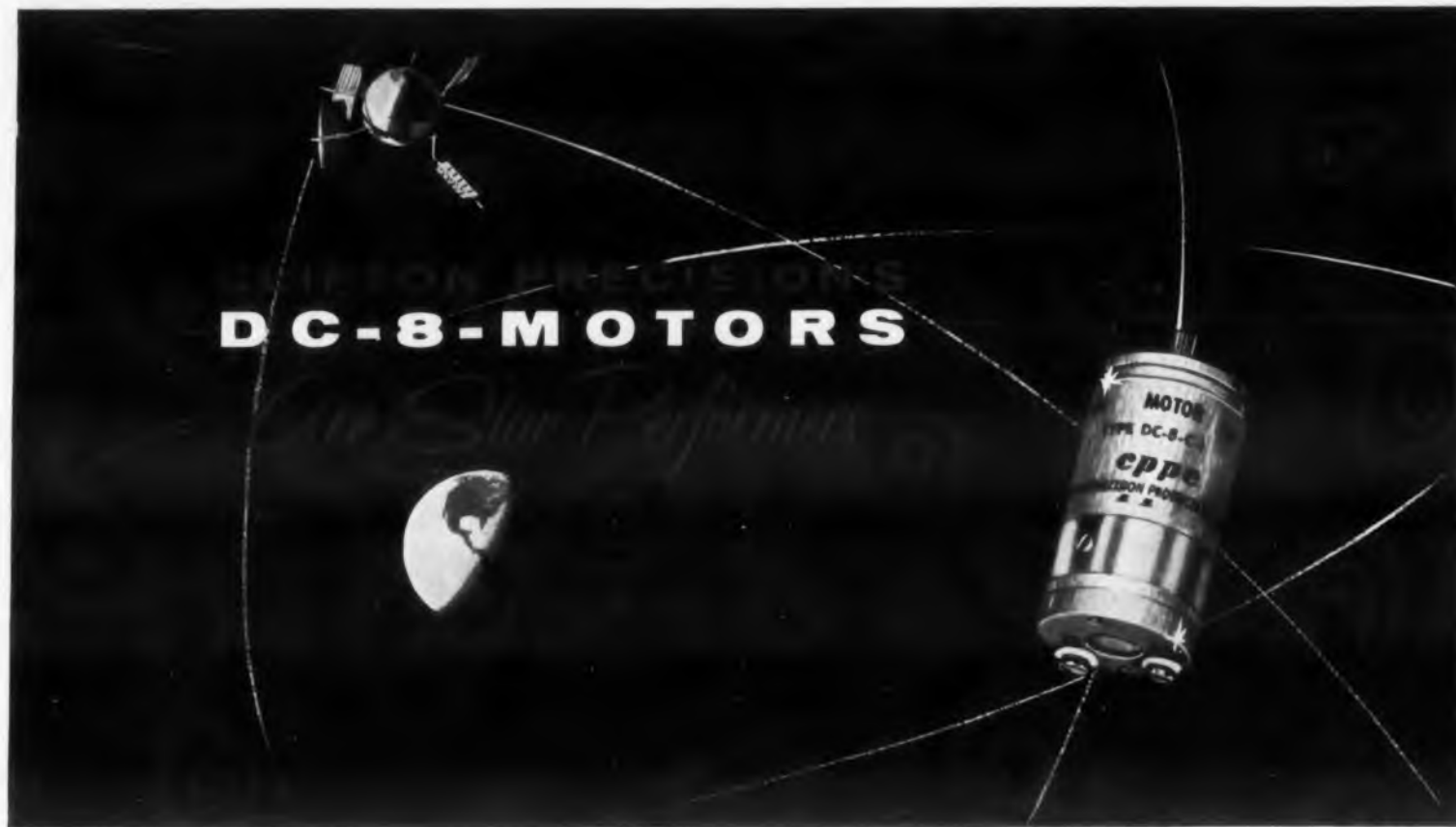
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**Di-optic antenna cuts cross-section
by 50, replaces horn p 76**

ALSO IN THIS ISSUE:

**DESIGNING FOR
MAINTAINABILITY**
An *ELECTRONIC DESIGN* Staff Report
... p 30



DC-8-MOTORS

500 HOUR LIFE GUARANTEE*

Due largely to improved brush design, CPCC size 8 DC motors qualify to catalogue specification after 500 + hours of continuous duty or 200,000 cycles of intermittent duty in controlled environments.

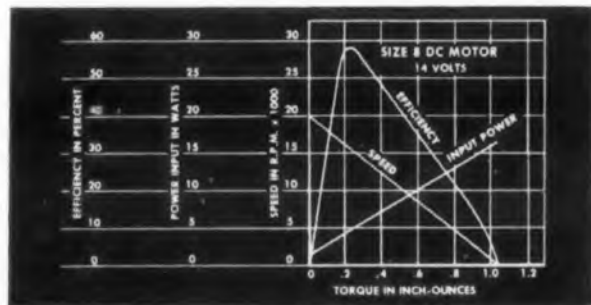
PRECISION CONSTRUCTION

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ENGINEERS—Join a pioneer in the rotary components field. Write David D. Brown, Director of Personnel.

CIRCLE 1 ON READER-SERVICE CARD



COVER: A series of end-fire, dielectric-optical rod antennas has been made possible by combining exotic materials, tight machining, and in-line coaxial feed. Results: reduction in cross section and weight, increase in temperature. In the cover design the artist has broken down the old horn antenna to show replacement by the di-optic antenna. At the same time it shows the size difference between old and new. For the story, see p 76.

Selected Topics In This Issue

Data Processing

Low-Cost Analog System Records
or Plays Back Dc to 400 Cps ... 78

Maintainability

Designing for Maintainability ... 30
Where It Comes From; Where
It's Going 30
Techniques in Designing for
Maintainability 36
Maintainability in Action 42
Check List of 241 Design Fea-
tures for Maintainable Equip-
ment 50
No Time-Base Needed in Signal
Corps Maintainability Specifi-
cations 58
Products for Maintainable De-
sign 64

Microwaves

Di-Optic Antenna Cuts Cross Sec-
tion by 50, Replaces Horn 76

Missiles and Space

Infrared Transmission Materials
Would Be Unaffected by Radia-
tion in Space 74

Science and Technology

What the Two Presidential Candi-
dates Have to Say About
Science 4

Sidelights of the Issue

Technology and Politics

Readers accustomed to circuit drawings and photos of components in our News Department may be a little startled at p 4 of this issue, where the familiar faces of Vice President Nixon and Senator Kennedy are shown.

It is, of course, extremely seldom that *ELECTRONIC DESIGN* finds itself delving into political realms, but in this election year, we felt the role of science and technology to be so important that the candidates' views in this field should be given the widest possible circulation.

Accordingly, Managing Editor James A. Lippke sent telegrams to both men, inviting their answers to several questions which we believed to be highly significant.

Not all the questions were answered directly in the statements supplied to *ED* by the candidates' spokesmen, but both men made their views clear and we feel they are interesting, provocative, and informative.

Report on Maintainability

When *ELECTRONIC DESIGN* was soliciting information from hundreds of manufacturers for its Staff Reports, "Designing for Maintainability," an all too common reply was, "Of course, our product is maintainable. You never have to repair it."

Our report stems from the realization that nothing lasts forever.

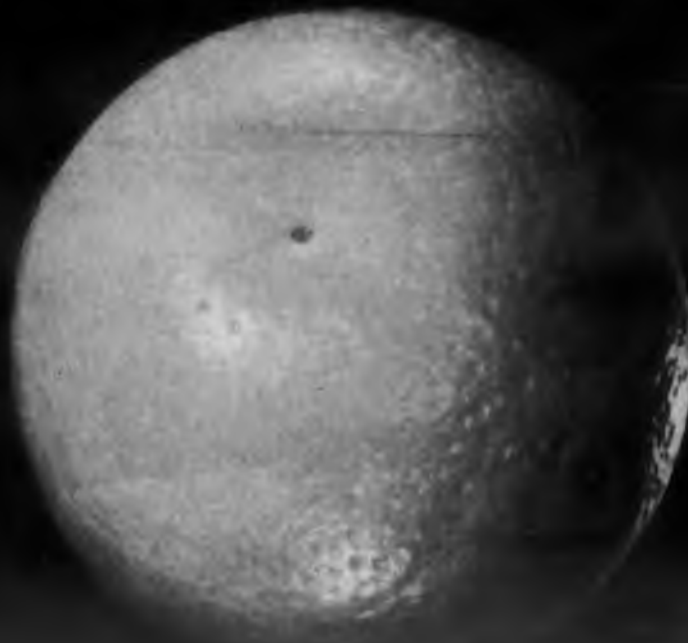
As basic reliability goes up, requirements for maintainability drop, and this report seeks to evaluate and explain just what maintainability is, where it came from, where it is going, and how to design with the concept in mind.

One *ED* editor, incidentally, reported his own experience with maintainability during World War II. In a line shack on a Marine Corps airstrip, he was trying to adjust a radio transmitter with kicks and four-letter words. Suddenly, with the enlisted man's sixth sense of the presence of an officer, he turned around to find a major general glowering at him. The general stared for a minute, then said, "Always like to see young men take an interest in their work. Carry on, son."

Our Staff Report doesn't discuss how to maintain with uninhibited language, but it goes into almost everything else. It starts on p 30.

CIRCLE 2 ON READER-SERVICE CARD >

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To provide this wide and continuous coverage, the SKV makes maximum use of both fundamental and beat-frequency oscillator techniques. Three beat-frequency bands are provided—each optimized for *high stability* consistent with sweep width required. These circuits are carefully shielded and filtered to prevent spurious output signals, and are carefully balanced to preserve pure wave-shapes. The beat-frequency system also provides effective frequency coverage in a single frequency sweep, permitting a continuous single display from 1 kc to 10 mc.

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ELECTRONIC DESIGN News	4
What the Two Candidates Say About Science	4
Ultra-Miniature Preamps for Balloon-Borne Satellite Detector	10
Classified ASW Sessions Featured at NEREM	12
Electronic Wrist Watch Offers Greater Accuracy	18
Wealth of Information Featured at NEC Sessions	20
Washington Report	22
Boiling Liquid Cools Radar Power Supplies	26
Science, Electronics, and Elections	29
An Editorial	

Designing For Maintainability—An ELECTRONIC DESIGN Staff Report	30
Maintainability—Where It Comes From; Where It's Going	30
How maintainability acquired the importance it now enjoys. Why it is due for much more. This Staff Report includes new information on the status of maintainability efforts by the military, and on the status of maintainability's many conflicts.	
Techniques In Designing For Maintainability	36
Principal approaches to designing for maintainability. And more than 100 key features which can be easily overlooked in designing equipment—J. Corso, J. McKendry, G. Grant	
Maintainability In Action	42
How far-sighted manufacturers have incorporated maintainability features in their equipments.	
Check List of 241 Design Features For Maintainable Equipment	50
A check list which will form the heart of the forthcoming Signal Corps Specifications.	
No Time-Base Needed In Signal Corps Maintainability Specifications.	58
A new approach to measuring and specifying maintainability which does not depend on hard-to-measure time factors—R. Redfern	
Products For Maintainable Designs	64
Typical products which engineers can use to enhance the maintainability of their systems.	

Coming Next Issue

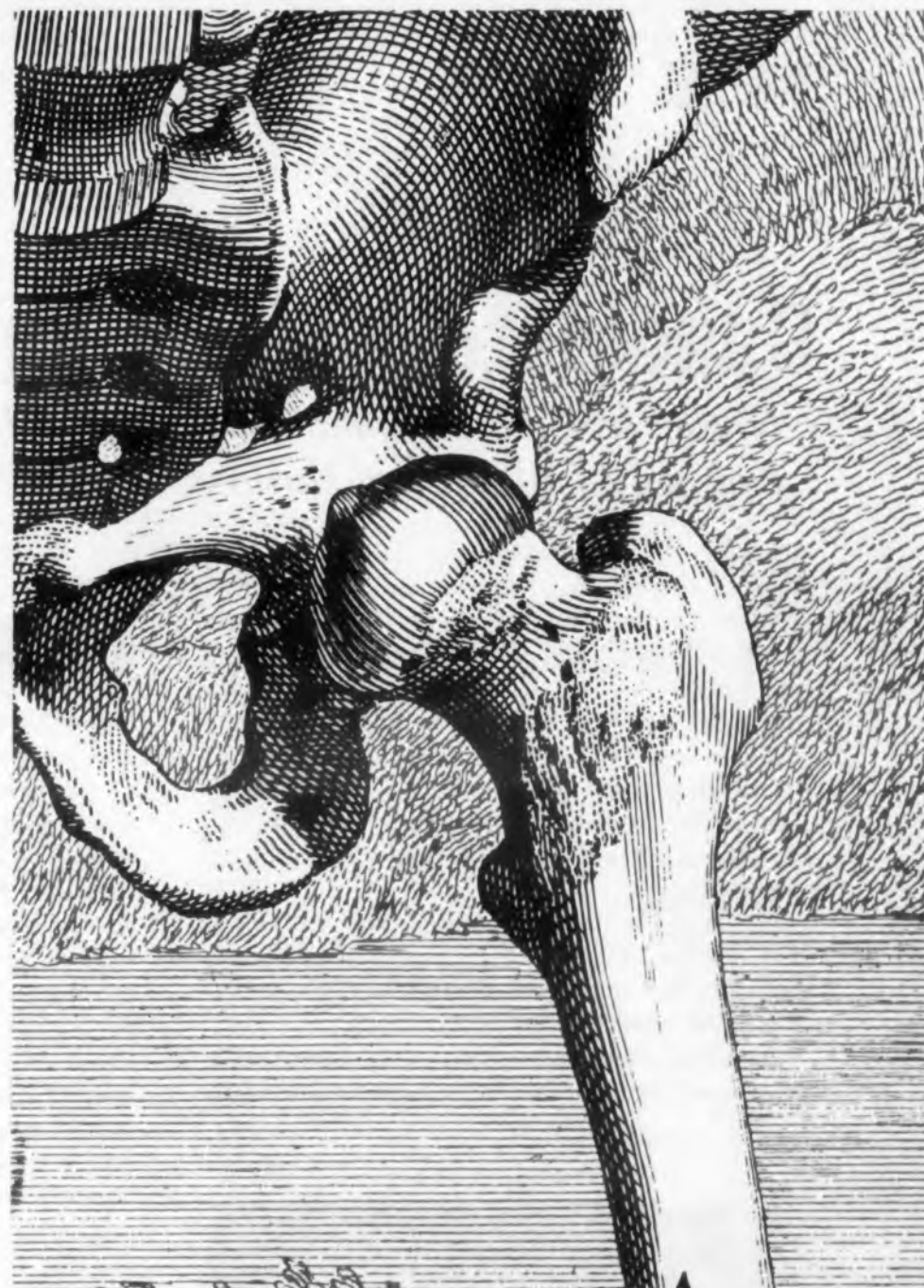
Like many other aspects of the technology, microminiature electronics was foaled out of Necessity by Economy. With the immense cost of orbiting payloads in space, smaller systems to perform better jobs were required. On the ground, as the jobs that computers were expected to do got bigger, so did the computers. In every field, microminiaturization seemed to be the answer.

But there were many problems, and many of them still remain. In the Nov. 9 issue, *ELECTRONIC DESIGN* will publish a Staff Report delineating the problem areas, the advantages, and the approaches to microminiature design.

All-Pass Networks—Part 2: Using the Networks To Shape Transient Response	70
How to use an all-pass network to improve transient response is illustrated by a detailed example—Y. J. Lubkin	
Infrared Transmission Materials Would Be Unaffected By Radiation In Space	74
It would take more than a century's exposure to radiation in space to have an effect on 15 materials tested—T. E. Lusk	
Di-Optic Antenna Cuts Cross-Section By 50, Replaces Horn	76
High-temperature, high-dielectric materials yield versatile microwave radiator.	
Low-Cost Analog Tape System Records or Plays Back Dc to 400 Cps	78
System uses pulse-frequency modulation to record low-frequency data on magnetic tape.	
Design Decisions	128
Pulser Uses 50-V Trigger To Short Four 200-V Diodes	
ELECTRONIC DESIGN Engineering Data	131
Estimation of External Surface Case Temperature Rise For Closed Electronic Equipment	
Ideas For Design	138
Four Extra Diodes Insure Load Sharing In High-Voltage Bridge	
Dual Frequency Oscillator Built With 6EZ8 Tube	
Russian Translations	142
Limiting Values of Active Resistances In R _c Phase-Shift Generators	
New Products	80
New Literature	133
Patents	140
Standards And Specs	146
Careers	148
Your Career	148
Advertisers' Index	152



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CIRCLE 4 ON READER-SERVICE CARD

Candidates' Views on Science and Technology

*Nixon Asks Government-Aided Establishment of Basic-Research Centers;
Kennedy Calls for a 'National Peace Agency' to Coordinate Efforts*

IN THE YEARS since World War II, the U.S. researcher has been thrown into the political arena by the force of great events. But if civilization is to survive and if science and technology is to benefit mankind, he must take an even more active role than he has to date.

These are the general views of both Vice President Richard M. Nixon and Sen. John F. Kennedy as expressed in statements supplied to *ELECTRONIC DESIGN* by the two candidates' spokesmen.

Mr. Nixon called it "essential that we recognize science as a many-purpose tool, fully as necessary to human progress as it is to the security of free men."

He added that "our nation demands a strong science and a vigorous technology to defend it-

self, to advance personal liberty, and to raise standards of living."

Mr. Kennedy said: "Today, while automation is displacing human labor, science and technology is lengthening life, curbing disease, ending famine, and producing the luxuries of life in ever-increasing quantity.

"But these technological blessings are creating economic problems which call for political solutions. Today there is no longer any question but that the world of science and that of politics have a strong interaction."

The remarks of the two candidates came as the result of a telegram sent to each by James A. Lippke, Managing Editor of *ELECTRONIC DESIGN*. In it, he asked the views of both men "concerning the role science and technology should play in the future of the nation." He stated that at the present time "more than 40 independent agencies and administrative departments are engaged in scientific activity, ranging from agronomical research to nuclear detection to Project Mercury." Each candidate was asked if he felt that more centralized responsibility and coordination were necessary, such as the creation of a Cabinet-level Department of Science.

Kennedy Calls For 'Planning'

In response to a question on attacking the problem of disarmament, Senator Kennedy said the immediate necessity was a "national peace agency" for disarmament planning and research to muster the scientific ingenuity, coordination, continuity, and seriousness of purpose which are now lacking in our arms-control effort."

This agency, the Democratic platform plank quoted by the candidate said, "would develop the technical and scientific data necessary for serious disarmament negotiations, would conduct research in cooperation with the Defense Department and Atomic Energy Commission on methods of inspecting and monitoring arms-control agreements, particularly agreements to

control nuclear testing, and would provide continuous technical advice to our disarmament negotiators [See "Design for Peace," *ED*, July 20, p 38]."

The Democratic candidate went on to say that "when the hoped-for goal of disarmament is achieved, vast resources will be freed for peaceful use and, through proper planning, these resources will be applied to wipe out our backlog of public needs and provide this nation and other nations with the means for a new international attack on the problem of world poverty."

Nixon Stresses Decentralization In Basic-Research Program

The Vice President called for new aid for research with a decentralized system. "I believe,



Vice President Richard M. Nixon



Sen. John F. Kennedy

his statement said, "the next Congress should adopt legislation authorizing the National Science Foundation to take the leadership in sponsoring a major new program for basic research.

"By sponsor, I do not mean control, finance, and operate. The program should be conducted through a number of basic-research institutes located in the principal geographic areas of the country. Financial support of these institutes should be as much as possible on joint public and private enterprise with both federal and state governments participating on one hand, and universities, private industry, and foundations on the other. The federal funds should be made available on a matching basis with the state and private contributions.

"The research institutes should be established cooperatively by our universities which engage in graduate research programs. They should be governed by these universities. A liaison with the National Science Foundation would be desirable but essentially the system of administration would be comparable to that of the Brookhaven National Laboratory on Long Island, an inter-disciplinary facility established to explore the peaceful uses of nuclear energy."

The GOP standard-bearer added that the new institutes would complement in an important way the work of existing government-supported research. He also said the institutes should be small rather than large, since "bigness results in departmentalization and compartmentalization" and tends to preclude cross-fertilization of ideas among investigators.

Candidates Stress Information Exchange

Concerning dissemination of scientific information, which the telegram asked about, Mr. Nixon said this would come under the aegis of the proposed new research centers. "A logical extension of the nascent merging of different sciences in a common cause," he said, "is the mutual use of theory, techniques, and instrumentation which once were the province of a single science. This fusion has created a new dimension in science. Its fulfillment is usually beyond the ability of our conventional research structure."

Answering a question on weather-control, the Vice President said: "In 1958, the U.S. produced only 14 Ph. D.'s in meteorology. The meteorology departments of universities cannot hope to provide essential tools for modern research in weather. These include high-altitude airplanes, upper-atmosphere rockets and the means to launch them, giant wind tunnels, and the like. The most logical facility for the job would be a national meteorological institute. Already such an institute has specifically been recom-



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CIRCLE 6 ON READER-SERVICE CARD

mended by representatives of 14 universities who considered the problem, at government request, for many months."

Mr. Kennedy, tracing the history of the Democratic Party's Advisory Committee on Science and Technology, said the committee, if he were elected President, would pursue a program of information dissemination on a national level.

"After the war," Mr. Kennedy's statement said, "scientists entered politics to advocate a civilian agency for the development of atomic energy. In recent years, scientists stimulated public and political discussion of the hazards of radioactive fallout.

"The Democratic Party," he went on to say, "recognized that the citizen-scientist wanted to think about the problems of science and society and to see that his ideas had an effect on national policy. Consequently, the Democratic Party formed its Advisory Committee on Science and Technology.

"This committee recommended, and the Democratic Party accepted, the establishment of an independent government agency for dealing with the technical problems of arms control and with the technology of aiding underdeveloped countries in health and welfare."

The Democratic nominee said these recommendations were incorporated into party policy in the platform adopted at the convention in Los Angeles.

"I know," Mr. Kennedy went on to say, "that the Advisory Committee on Science and Technology will continue to formulate realistic plans for coordination of governmental research, for proper dissemination of scientific information, and for handling the problems which it falls to the government to solve."

'Greater Public Respect and Support'—Nixon

Mr. Nixon said the public should have a new awareness of the researcher, and likened Dr. Jonas Salk's discovery of the polio vaccine to "the capping stone on the pinnacle of a pyramid." He said, "the men who built the rest of the pyramid are the unsung men of science who are known only to their colleagues. They deserve far greater respect and support by the people whom they serve than they now receive."

He added that it was true, if paradoxical, that as technology advances, one thing that can be predicted with certainty is that major breakthroughs will produce the unpredictable. But he added, "Let us be clear that new and unpredictable discoveries should not disconcert us. We must have leadership which is constantly on the alert for them and their implications. For

new knowledge can readily be phased into, modify or even alter former plans. Imaginative leadership must exist not only in the Executive and Legislative branches of government, but in private industry, agriculture, mining, and all parts of the economy."

Mr. Kennedy stressed the military aspect of technological achievement as a pressing problem, and said that "science and technology have brought us to a New Frontier of history."

He said engineers and scientists have "undertaken political action in the past only when conditions forced them to do so," and he cited as an example the development of the atomic bomb, when "a handful of scientists took the initiative." ■■

Electrical 'Memory' Switch Device Stores Multiple-Digit Numbers

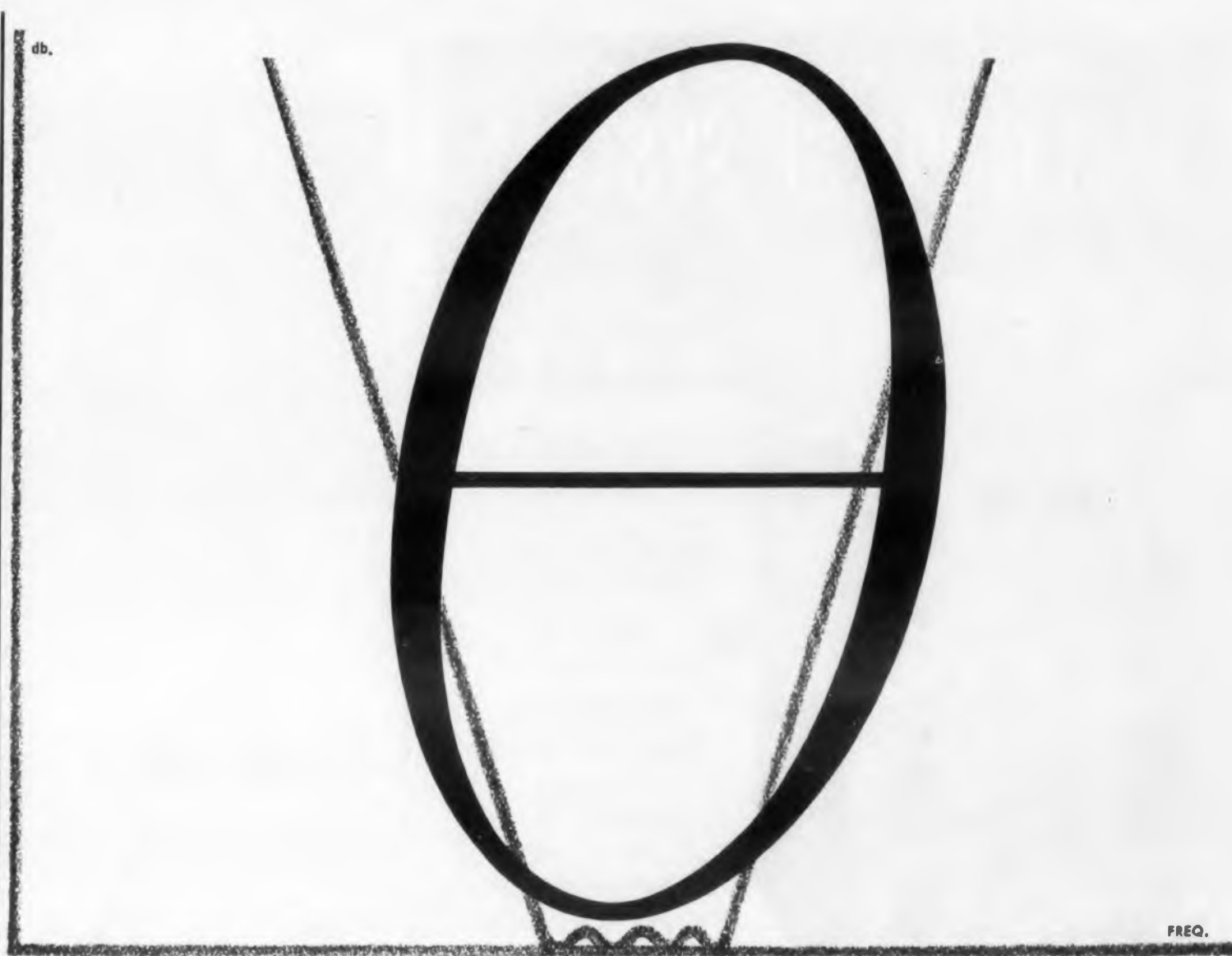
An electrical "memory" switch, capable of storing multiple-digit numbers by using principles of the ordinary combination lock, has been developed by P. D. Shannon of the Massachusetts Institute of Technology Instrumentation Laboratory.

So closely does the switch follow combination-lock principles that Mr. Shannon obtained parts for his first prototype by stripping discarded Laboratory locks. In operation the switch is first "cleared" and then digits are set into it by turning the shaft alternately right and left with one less revolution each time, after the fashion of a combination lock.

Mr. Shannon developed the new device, called the "N-Digit Decade Switch," as a possible method of simplifying automatic control of electrical currents used in testing gyroscopes employed in inertial-guidance systems for missiles and space vehicles.

Accuracy Is Our Policy . . .

Several pieces of erroneous information managed to appear in our Product Feature "Ultra-High Regulation Featured in All-Transistor Supply" (ED, Aug. 3, p 102). The supply manufactured by the Krohn-Hite Corp., Cambridge, Mass., can operate from standard voltage sources of 115 ± 10 v and 230 ± 20 v. Its temperature coefficient is 0.01 per cent per deg C, or 1 mv (instead of 7 mv) per deg C. The 1-mv change applies up to an output of 10v. Beyond that, the 0.01 per cent applies. Under short circuit or overload conditions, the output current will not exceed the selected limit current by more than 30 per cent, rather than 10 per cent.



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vibration at 30G level. *Part #117B-FC-22-4WU*

DISCRIMINATOR—Center frequency held to within 10cps, frequencies equally spaced from center, held to 5.4v peak $\pm 5\%$. *Part #186C-TN-22A-WD*

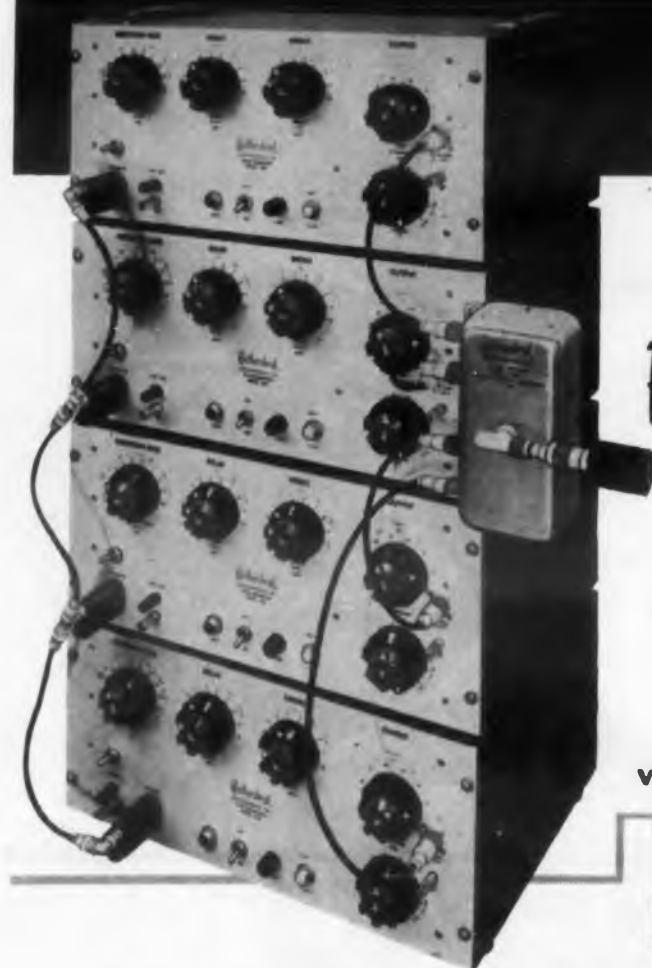
BAND SUPPRESSION FILTERS—2kc wide band attenuated 60db, right next to it a pass band held flat to $\pm 1/4$ db for 150kc. *Part #158-TF15-6R*

If you're faced with tough filtering problems, need additional information or practical application assistance, contact Bulova for engineering specialists to assist in selection of filters best suited to your needs. Write Department 1820, Bulova Electronics, Woodside 77, N. Y.

CIRCLE 7 ON READER-SERVICE CARD

HIGH REPETITION RATE MULTI-PULSE SYSTEM

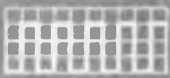
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with the use of a
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produces
**4 INDIVIDUAL
PULSES** of
various specifications

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pulse generators / pulse systems / accurate time delay generators

CIRCLE 8 ON READER-SERVICE CARD

NEWS



Inside Courier ground station. Operator in foreground controls tracking antenna and operates switching and data-processing equipment as satellite passes overhead. Other equipment includes uhf and vhf transmitters and receivers as well as teletype and recording equipment. Ground-based communications and control equipment was designed by ITT.

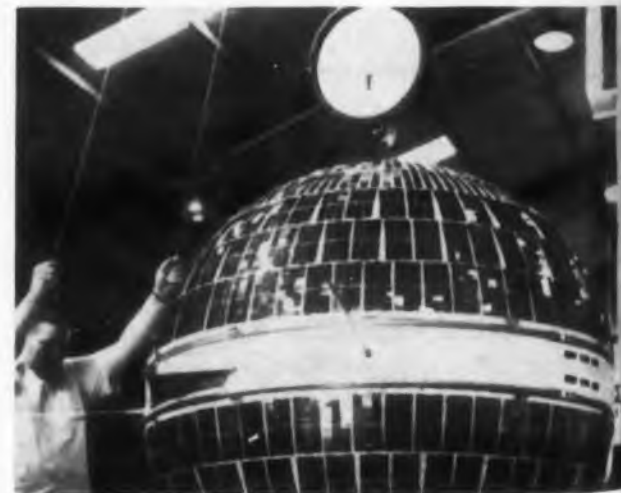
Complexity a Feature of Courier Satellite



Tracking antenna for Courier uses unique spinning dielectric lens at focus to provide error signals for automatic tracking. The 28-ft dish simultaneously handles transmission and reception of uhf and vhf signals. Radiation Inc. designed and built the antennas and other tracking equipment at the Ft. Monmouth, N.J. and Ponce, P. R. tracking stations.

WITH the availability of backup vehicles and payloads, Project Courier staged a quick recovery after failure of the initial launch attempt in August. The now successfully orbiting communications satellite marks a new high in complexity of satellite instrumentation.

The more than 300 lb of equipment carried aloft include 38 separate electronic packages. The detailed description of Courier's electronic system presented in the August 31 issue of ELECTRONIC DESIGN is followed here by photographs illustrating design features of the system. ■ ■



Courier weighs in at 500 lb prior to launching. The satellite is almost completely covered by the 19,150 silicon solar cells needed to power its equipment. Also visible are probe antennas for vhf transmission and one of the notched fin uhf antennas.

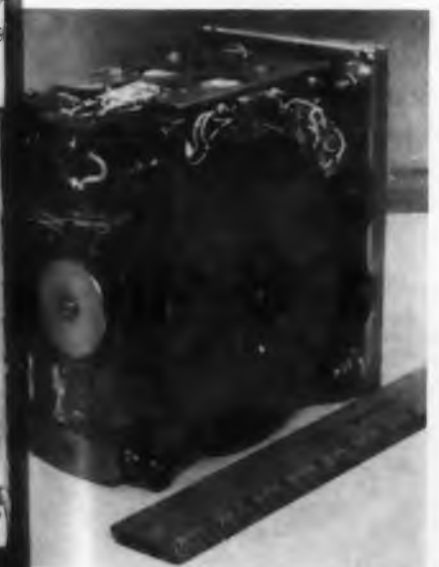
GREATEST PERFORMANCE PER DOLLAR



Miniature tape recorder in payload weighs 5 lb and has a capacity of 3 megabits. Five such 30 ips units are included in the payload; four are for digital communications, the fifth records voice and analog signals. Recorders were developed by DataLab Div. of Consolidated Electrodynamics Corp.



HF telemetry transmitter for Courier handles 30 information channels. The transistorized unit delivers 1.5 w. Philco's Western Development Laboratories is prime contractor for the payload.



Mission transmitter is all-transistorized and crystal controlled. Unit contains 0.25 w for 50 mw power output. Transmitters are carried aboard Courier—another example of reliability through redundancy.

SAT... SILICON SURFACE ALLOY TRANSISTORS

	APPLICATIONS	FREQ. (MIN.)	SPECIAL PROPERTIES
2N495	Amplifier, Switch, Control	f_{max} -8 mc	VCE=25v, TO-1 case
2N496	Switch	f_T -7.2 mc	very low V saturation, TO-1 case
2N1118	Amplifier, Switch, Control	f_{max} -8 mc	electrical equivalent of 2N495, TO-5 case
2N1118A	Amplifier, Switch, Control	f_{max} -8 mc	high beta version 2N1118
2N1119	Switch	f_T -7.2 mc	electrical equivalent of 2N496, TO-5 case
2N1428	Amplifier, Switch, Control	f_{max} -18 mc	low cost, high beta, TO-1 case
2N1429	Amplifier, Switch, Control	f_{max} -18 mc	low cost, high beta, TO-5 case

SADT... SILICON SURFACE ALLOY DIFFUSED-BASE TRANSISTORS

(All TO-9 cases)

	APPLICATIONS	FREQ. (MIN.)	SPECIAL PROPERTIES
2N1198	Switch	f_T -75 mc	superior temperature stability
2N1267	Med. Frequency Amplifier	f_{max} -43 mc	low beta (video amplifier)
2N1268	Med. Frequency Amplifier	f_{max} -43 mc	medium beta
2N1269	Med. Frequency Amplifier	f_{max} -43 mc	high beta
2N1270	High Frequency Amplifier	f_{max} -125 mc	low beta (video amplifier)
2N1271	High Frequency Amplifier	f_{max} -125 mc	medium beta
2N1272	High Frequency Amplifier	f_{max} -125 mc	high beta
2N1472	Switch	f_T -75 mc	very low V saturation
2N1683	Switch	f_T -100 mc	superior temperature stability superior temp. stability... high beta

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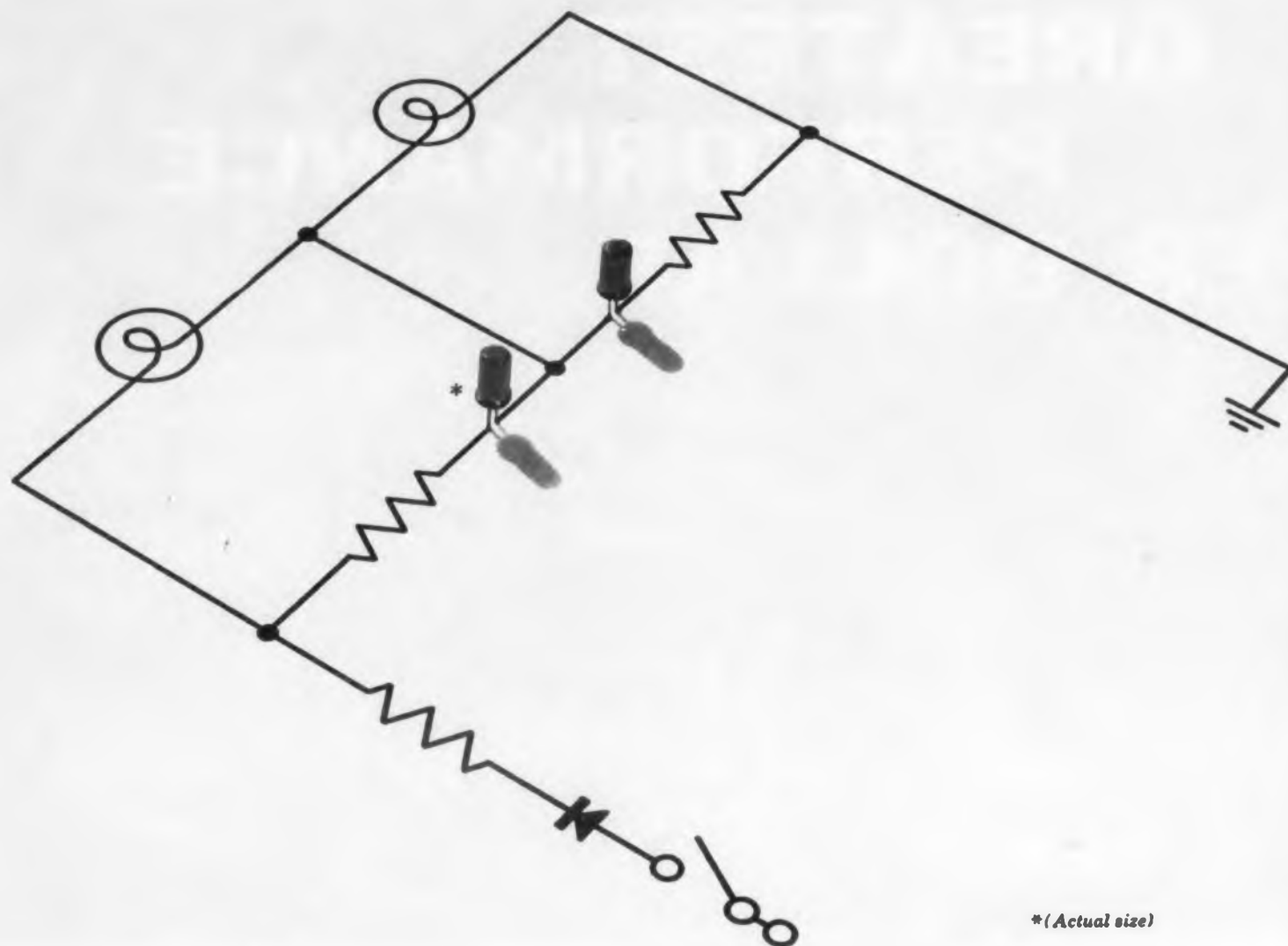
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*SHOCKLEY 4-LAYER DIODES used in Roto-Tellite two-lamp reliability alarm circuit designed by Master Specialties Company, Los Angeles, California.

ALARM CIRCUIT RELIABILITY

When alarm circuits are required by critical military and industrial applications, two lamps are often connected in parallel for maximum reliability. The circuit shown above, now in production by Master Specialties Company, Los Angeles, uses the Shockley 4-layer diode to provide a shunt path around the defective lamp when one lamp fails.

The 4-layer diode, the semiconductor equivalent of a single directional relay, is ideal for alarm circuits where space, weight and positive operation are important. This simple, inexpensive and

dependable device performs a function which formerly required four or five components in alarm and annunciator circuits. It is suitable for circuits of every type—a basic alarm with one lamp or two—flashing or continuous master light indication—high or low power alarm signal.

For application notes on alarm circuits...or on pulse modulators, flip-flops, ring counters, dc to ac inverters, pulse generators...or just plain solid state switching—call or write your local Shockley representative or write Dept. 11-2.

Shockley TRANSISTOR

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STANFORD INDUSTRIAL PARK, PALO ALTO, CALIF.

CIRCLE 10 ON READER-SERVICE CARD



NEWS

Balloon-Borne Telescope

56 High-Gain Units Must Be Packaged in Single Jam-Jar-Sized Cylinder

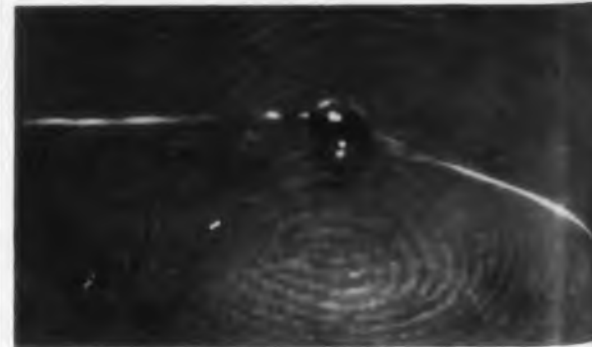
SUCCESS of recently disclosed plans for a balloon-borne infrared telescope to detect unannounced satellites may well hinge on the ability of Electro Optical Systems, Inc. engineers to design the ultra-miniature preamplifiers required in the system. According to Stuart Hauser, project engineer at the Pasadena, Calif. firm, 56 high-gain units (one for each element in the infrared detector array) must be packaged in a 3-1/2 in. diameter cylinder no more than several inches long.

In order to reduce stray pickup on lead wires the preamps must be located immediately behind the detectors. Since the detectors are themselves in the optical path of the reflecting-type telescope employed in the system, the preamps are likewise in the path and should be extremely small so as to minimize light loss.

The following design approaches are currently under study:

- Amplifiers assembled on small, axial stacked disks, with several stacks arranged parallel within the cylinder.
- Several amplifiers assembled on full, 3-1/2 in. diameter disks again stacked within the cylinder.
- Thin, tubular amplifiers extending down the cylinder, with several amplifier bundles stacked in the length of the cylinder.

Molecular-electronic constructions are apparently not in the running for this application as the amplifiers will thus be assembled by high-density packaging of conventional miniature components. Breadboards of each type are being developed and tested and Electro Optical spokesmen appear confident of meeting the Summer



Miniature infrared detector developed by Electro Optical Systems for use in balloon telescope. Unit consists of 0.1 mm lead sulfide element behind 2 mm strontium titanite lens.

Speeds Ultramin. Preamps

1961 deadline set for testing of the first balloon-borne unit.

The system will include a specially-modified 20-in. focal length Bouwers telescope with optics consisting of a spherical mirror, a concentric corrector plate and an aspheric corrector plate. These elements will be color-corrected for the 0.8- to 2.5-micron spectrum of the detectors. The telescope and electronics package are to be suspended 300 ft beneath the gas bag. In the first unit, no attempt will be made to stabilize the gondola and it has been calculated that natural oscillations of the system may run to 0.5 deg. If stabilization should become necessary, the cab could be stabilized by gas jets or the telescope mounted on a stable platform.

A 0.5-hp electric motor will swing the telescope in azimuth at a rate varying from 0.5 to 2 rotations per second. Initially, the telescope will be aimed about 15 deg above the horizon.

When a satellite is detected, elevation will be increased stepwise after each rotation to a maximum of 75 deg. This will provide a series of intercept signals from which the satellite's orbit can be established.

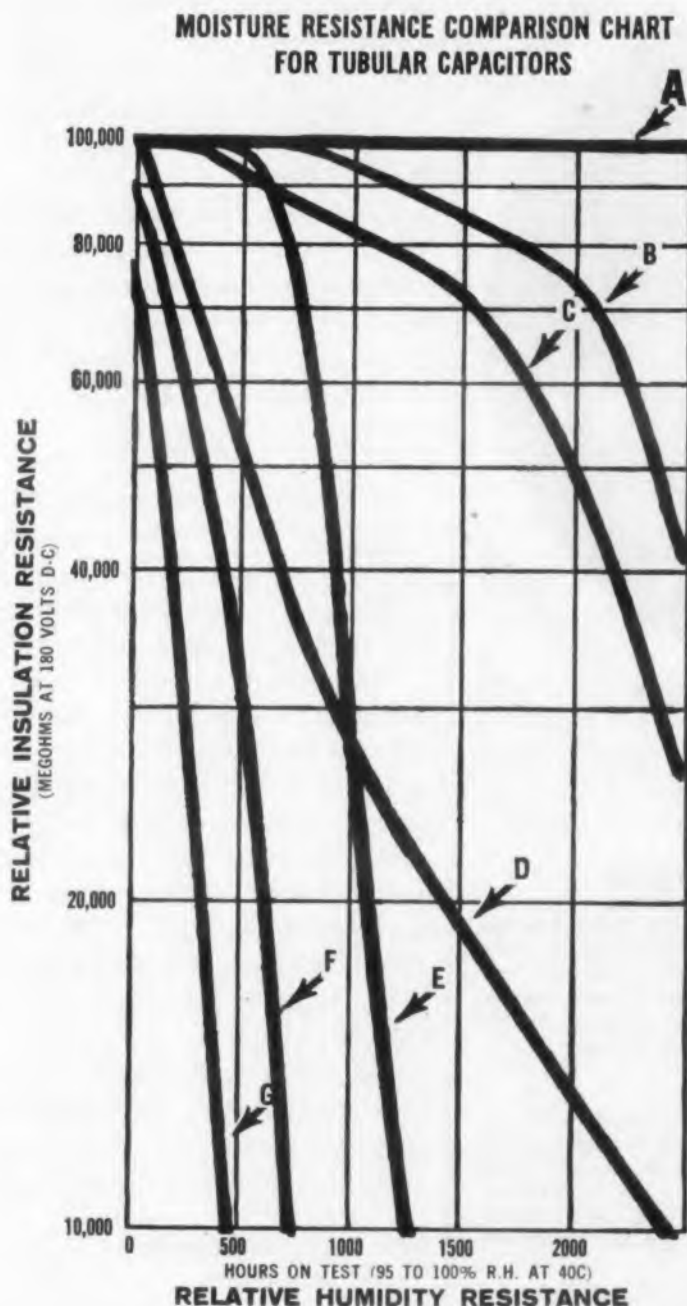
Each of the 56 detectors consists of a 0.1-mm lead sulfide deposit behind a 2-mm strontium titanate lens. The field of view of each detector is approximately 1 milliradian (mrad) x 50 mrad. However, the detectors are arranged in a linear array giving a 3-deg high vertical field of view. Thus, the satellite image moves along the individual elements of the array at each successive sweep of the telescope.

Sampling Rate of 50,000 Per Sec

The detectors are sampled at a rate of 50,000 per sec by an electronic commutator. In addition, each preamp feeds a discriminator which decides, on the basis of established statistical considerations whether the output is due to noise or to the infrared energy reflected or generated by the satellite. Signals are then telemetered to a ground station for interpretation and display. Telemetry is to be fm/fm at 10 w.

The telescope will be ground-controlled as to observation and scan rates. Power supply and winds of 10 ft will permit on-station time of one or two days after which the telescope is returned by parachute. A world-wide surveillance system of this nature would require perhaps 20 telescopes at all times. In addition, the infrared detection system could be modified to provide a missile early warning capability, according to Electro Optical Systems scientists. ■

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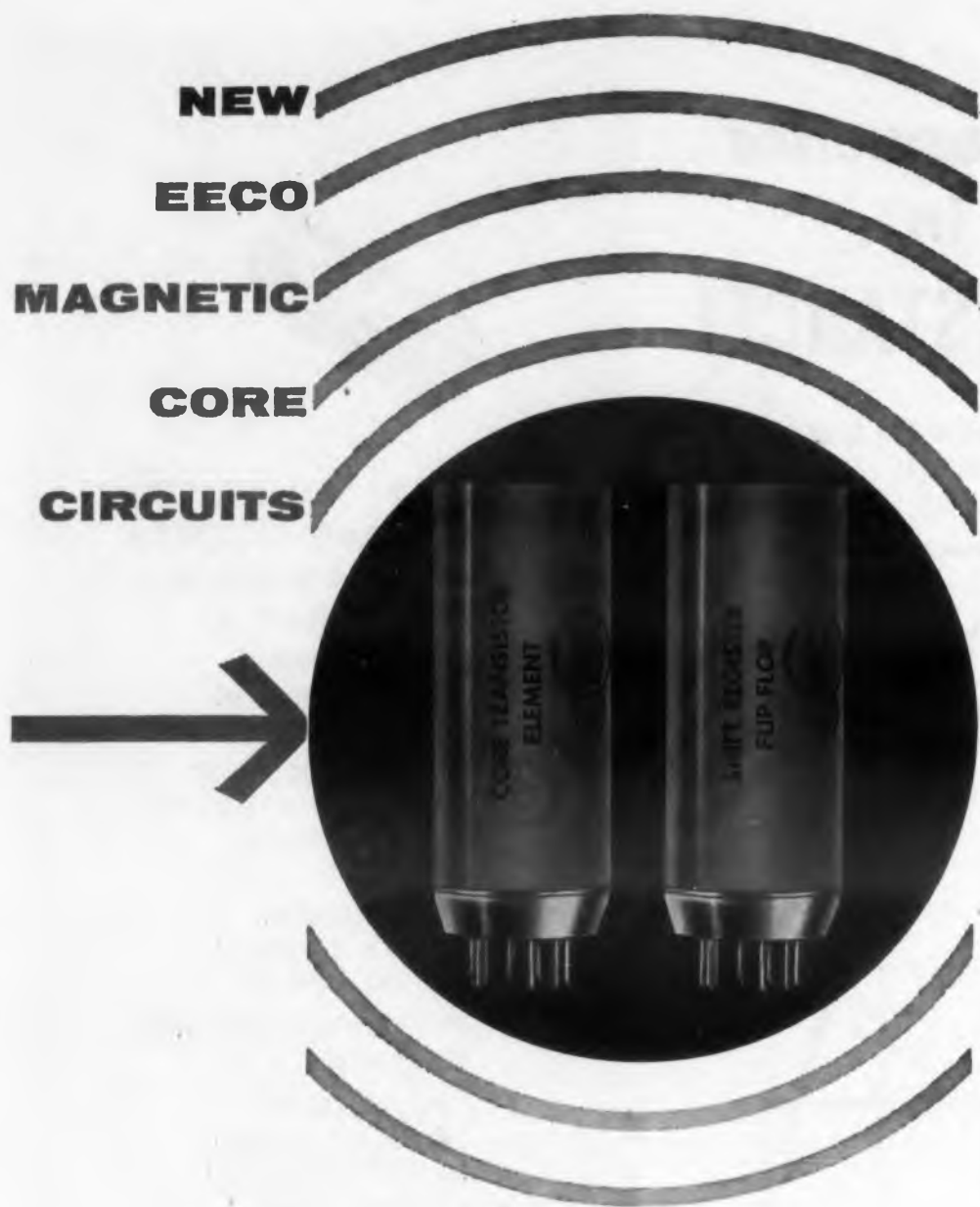
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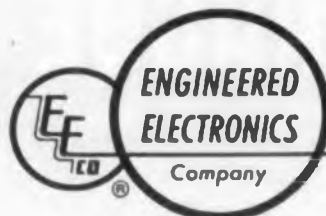
ADVANTAGES

The ability of magnetic cores to maintain one of two discrete states makes them ideal for shift registers, or counters. A pulse sent through one set of windings will set the core to the "High-Level" state. A pulse sent through another set of windings will reset the core to the "Low-Level" state. Thus you get flip-flop action with a single core. In transistor circuits, on the other hand, it is normally necessary to use two transistors for each flip-flop.

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NEWS

SARUS, Echo Papers Key NEREM Meeting

*Navy Will Sponsor Two Classified ASW Sessions;
More Than 100 Papers Scheduled for Delivery*

THE FIRST technical papers delivered on the SARUS and Echo projects will highlight the 1960 Northeast Electronic and Engineering Meeting. It will be the first time that papers on either project have been delivered.

In addition, the Boston meeting from Nov. 15-17 will feature among its 40 technical sessions two classified sessions on anti-submarine warfare. According to the show's sponsors, this will represent the first time the Navy has sponsored classified sessions as part of a national meeting.

A session on Engineering Manpower Utilization will also be a key feature of the meeting with its discussion of practical ways to eliminate wasteful competitive bidding among military contractors.

SARUS, which stands for Search And Rescue Using Satellites, is a system developed by Space Electronics Corp. It is capable of locating quickly and accurately anything on the earth's surface, using miniature emergency transmitters, artificial earth satellites, and ground interrogation stations. Project Echo involves bouncing signals off satellite balloons. Some of the results of these Echo experiments will be detailed in the paper, which will come from Jet Propulsion Laboratories, the organization responsible for the West Coast transmit-receive station used in Project Echo.

Sub-Detection Methods To Be Discussed

The classified ASW sessions will concern themselves with the various methods which can be employed to detect unfriendly submarines, according to L. Mautner of the Hughes Aircraft Co., who will be chairman of one session.

These methods, he said, will include magnetic anomaly, radar, sonar, and others. In addition, the communications problems connected with carrying efficient airborne searches will come under discussion, he said.

For example, Mr. Mautner said, the Julie airborne detection system will be covered, with communications and data problems between sonobuoys and aircraft and also among the search aircraft themselves presumably coming into the realm of discussion.

Engineering Manpower Loss Is a Matter for Concern

The session on eliminating waste of engineering manpower will concern itself with the money now being spent preparing presentations for bids on specific contracts.

At present, the industry has the spectacle of 10 to 20 large firms each spending as much as \$100,000 on proposals during competitions on medium- to large-sized contracts, Mr. Mautner said. Only one of these firms, of course, will be awarded the contract. The waste of engineering talent in the other firms, he said, is a waste of one of this country's most precious resources: engineering manpower.

On an industry-wide basis, the competitive bidding process has made engineers only 50 per cent effective, Mr. Mautner claimed. Two solutions that Mr. Mautner expects will be discussed during the session will be the use of less expensive preliminary competitions and government selection teams. In both

Clearance Needed For ASW Sessions

The two classified sessions on ASW, sponsored by the Navy's Bureau of Weapons, will be open only to those NEREM registrants who have submitted their clearance in advance, certifying their need-to-know. Requests for clearance forms, and non-member requests for these forms, must be on business letterheads and should be addressed to Mr. Lewis Winner, 152 W. 42nd St., New York 36, N. Y.

cases, the objective will be to narrow the competitions down to a half-dozen firms.

Long-Range Proposals Cited As Partly Responsible

The longer-range, more ambitious proposals that have come about as the result of government plans for space exploration have been partly responsible for the worsening situation on competitive bidding, Mr. Mautner told ELECTRONIC DESIGN.

Problems in command and control systems, raised by the audience, will be discussed by a panel of experts, which will include Maj. Gen. Kenneth P. Bergquist of the Air Research and Development Command and Maj. Gen. Clyde H. Mitchel of the Air Materiel Command.

"And there are many problem areas," said Arthur P. Hill of the Mitre Corp., who will be in the chair for the session. He said a few of them were: standardization, centralization, people vs automatic equipment, and complexity and compatibility of equipment.

U.S., Foreign Experts to Speak At 40 Technical Sessions

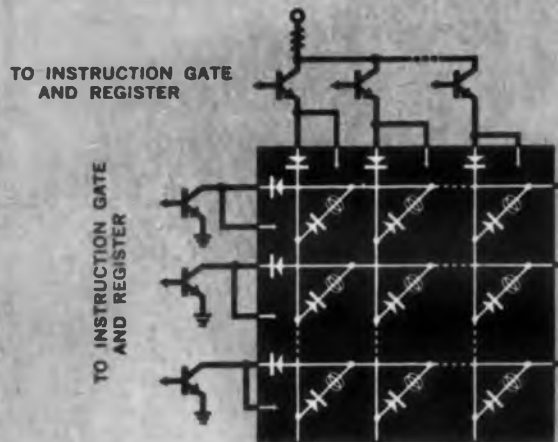
The above are only the keynote features of the meeting, whose sponsors claim many firsts. U.S. and foreign experts will deliver more than 100 papers at the 40 technical sessions. "In fact," according to Lewis Winner, one of the NEREM coordinators, "as far as regional IRE meetings go, this one will beat all the others. It will have the largest number of technical papers and exhibits."

Mr. Winner estimated that 95 per cent of the papers have never been given before and that the balance have only been heard by small, select meetings and never gained wide circulation. He added that there would be 350 exhibits.

A relatively new subject, electro-hydraulic and pneumatic controls, will receive considerable attention at the meeting, Mr. Winner said. B. M. Horton of Diamond Ordnance Fuze Laboratories will present a paper of particular interest on the subject—"Amplification by Fluid-Stream Interaction."

All papers delivered at the meeting will be published in the NEREM-60 Record, which will be distributed free to each technical registrant. The NEREM technical registration fee is \$2 for IRE members, \$4 for non-members. ■ ■

NEW



Typical n-junction matrix for n-stage matrix configuration. Fairchild 2N1613 transistors and FD200 diodes, used throughout, guarantee acceptable leakage, switching speed and conduction values up to 125°C.

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Fairchild's Planar structure for transistors and diodes features the industry's most advanced diffusion and surface passivation techniques. Current leakage is reduced to 10 mA maximum (2N1613) and 0.1 mA maximum (FD200) at 25°C. Maximum values at 150°C are 10 mA and 100 mA.

Surface passivation also prevents significant degeneration of parameters during circuit life which could introduce error or failure in the matrix. This technique also lends itself to precisely controlled manufacture, assuring excellent product uniformity.

2N1613 ELECTRICAL CHARACTERISTICS (25°C except as noted)

Symbol	Characteristic	Min.	Typical	Max.	Test Conditions
β_{FE}	D.C. Current Gain	40		120	$I_C = 150 \text{ mA}$ $V_{CE} = 10 \text{ V}$
$V_{BE(sat)}$	Base Saturation Voltage			1.3V	$I_C = 150 \text{ mA}$ $I_B = 15 \text{ mA}$
$V_{CE(sat)}$	Collector Saturation Voltage			1.5V	$I_C = 150 \text{ mA}$ $I_B = 15 \text{ mA}$
C_{ob}	Collector Capacitance	18	25 pF		$I_E = 0$ $V_{CB} = 10 \text{ V}$
I_{CBO}	Collector Cutoff Current	0.8 mA	10 mA	10 mA	$V_{CB} = 60$ $T = 25^\circ \text{C}$
		1.0 mA	10 mA	10 mA	$V_{CB} = 60$ $T = 150^\circ \text{C}$

FD200 ELECTRICAL SPECIFICATIONS (25°C except as noted)

Symbol	Characteristic	Min.	Typical	Max.	Test Conditions
V_F	Forward Voltage			1.0V	$I_F = 100 \text{ mA}$
I_R	Reverse Current			0.1 mA	$V_R = -150 \text{ V}$
I_R	Reverse Current (150°C)			100 mA	$V_R = -150 \text{ V}$
B_V	Breakdown Voltage	200 V			$I_R = 100 \mu \text{A}$
t_{rr}	Reverse Recovery Time			50.0 m sec	$I_F = 30 \text{ mA}$ $R_L = 150 \Omega$
C_0	Capacitance			5.0 pF	$I_F = 30 \text{ mA}$ $V_R = 0 \text{ V}$
RE	Rectification Efficiency	35%			$f = 1 \text{ mc}$
	Forward Voltage Temperature Coefficient		-1.8 mV/°C		100 mc



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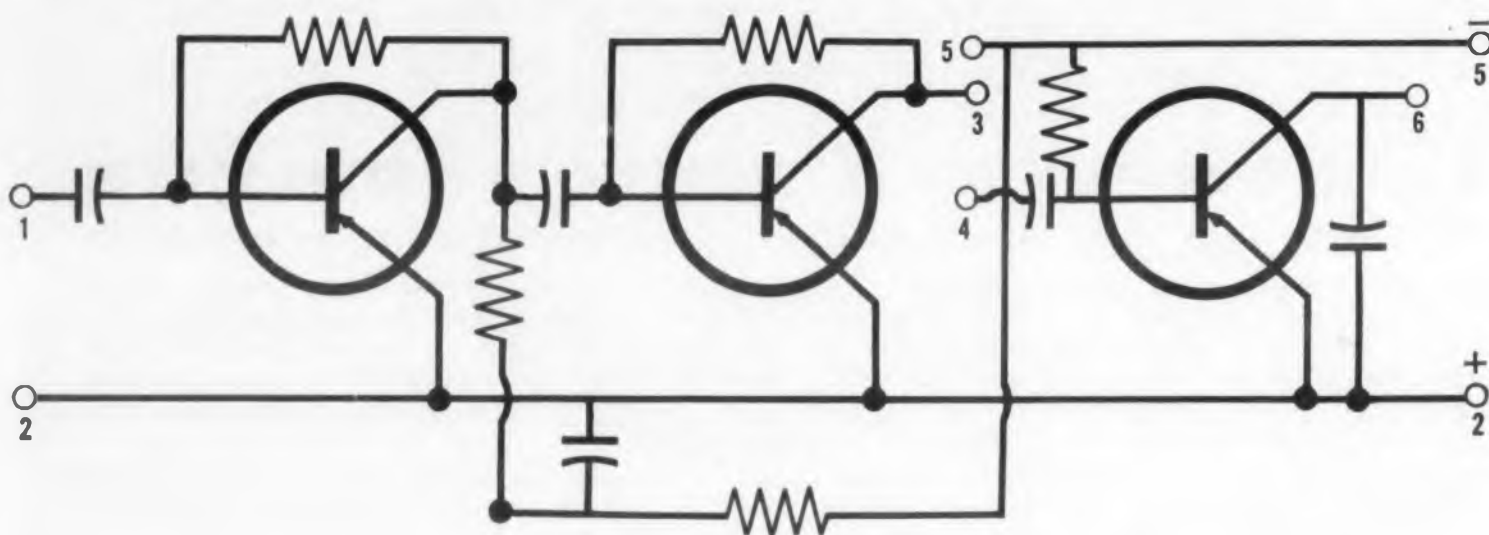
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miniaturization
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**3-stage
Transistor Amplifier***
Size: .250" x .250" x .500"
Component Density
416/in.³ (720,000/ft.³)
ACTUAL SIZE

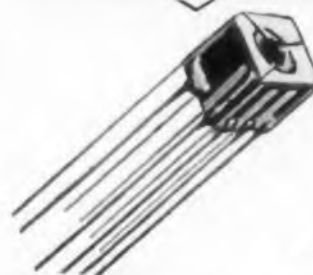


*practical circuit miniaturization now... with
Centralab's **PEC** packaged electronic circuits*

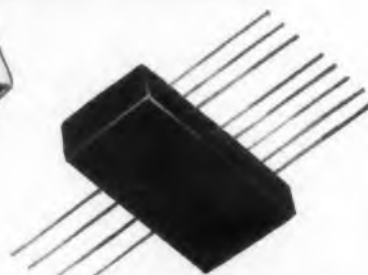
This is the circuit miniaturization technique that permits component densities up to 2,500,000 per cubic foot *today* . . . with semi-conductors, capacitors, fixed and variable resistors integrated in a single component . . . with the size and shape flexible to meet your equipment requirements . . . and sensibly priced for commercial applications. CENTRALAB's engineering department will work with you in designing practical economical PEC circuits to your requirements.

* A similar CENTRALAB 4-stage amplifier received the Certificate of Excellence in the 1959 Miniaturization Awards Competition, sponsored by Miniature Precision Bearings, Inc., Keene, New Hampshire.

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NOR CIRCUIT
Size: 3/8" x 3/8" x 13/32"
8 resistors—1
transistor
171/in.³
295,000/ft.³



FLIP-FLOP CIRCUIT
Size: .245" x .500" x .990"
2 transistors, 6 diodes
8 resistors, 6 capacitors
176/in.³
304,000/ft.³

NEWS

Experiments Prove Feasibility Of Ultra-High-Power Microwave Tubes

The new design concepts for ultra-high-power microwave tubes are being developed by General Electric's Power Tube Dept., Schenectady, N. Y., for classified military applications. One of the tubes will be a multiple-beam klystron which is said to employ unique methods for combining a number of beams in one rf structure within a single vacuum chamber. The other tube, to be known as an "Orthotron," is a cross-field, traveling-wave type.

Although actual prototypes of the two tubes have yet to be built, GE spokesmen stated that laboratory experiments have proven the feasibility of the new operating principles. Accordingly, GE has established a Superpower Microwave Tube Laboratory within the Power Tube Dept. to handle advanced development and production design of these tubes. The first production models are not expected to be available until late 1963.

CW and Pulsed Operation Possible

Both tubes will reportedly be capable of CW as well as pulsed operation, in each case at "substantially higher power levels" than conventional units. Size, power, frequency, and other details of the new tubes remain classified. However, the Orthotron's frequency is said to extend into the "micromicrowave" range. Company officials were also vague as to the number beams that could be combined in the multiple-beam klystron. They indicated, however, that more beams could be added to the present design if required. Both tubes can be either air- or liquid-cooled without imposing any design constraints.

Apart from the classified application for which these tubes are earmarked, GE officials also foresaw their eventual use in long-range communications, satellite and space-probe tracking, radar astronomy, and plasma devices (such as sources of high-power, high-frequency magnetic fields for thermonuclear power generators).

The company also hinted at possible uses in wireless, direct-beam power transmission by microwaves, but did not elaborate.

The new superpower laboratory is headed by E. D. McArthur, who developed the planar triode "Lighthouse" radar tube during World War II. Also on the staff is Dr. D. A. Wilbur, a co-developer of the voltage-tunable magnetron principle and an authority on cross-field interactions.

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CIRCLE 13 ON READER-SERVICE CARD

Combat Communications Network Set by AF, Western Union Contract

A contract for the construction and leasing of a high-speed, high-capacity combat logistics communication network has been signed between the Air Force and Western Union. The new system, known as COMLOGNET, will link more than 450 bases, depots, and civilian suppliers in the continental U.S. and will include entry points for overseas communications.

Initial capacity of the system, to be activated early in 1962 will be 7 million punched cards or an equivalent 100 million words daily. The yearly rental for COMLOGNET will be \$22 million. According to Western Union officials, the \$50 million development costs for the system were not government funded. COMLOGNET will eventually include ten high-speed switching centers using advanced data processing and handling equipment developed by RCA. Computers will be similar to the company's commercial 601 units. Initially, the system will include only five switching centers linking some 240 terminals, but will be gradually expanded to its designed capacity.

Since COMLOGNET will be an integral part of the Air Force's global communications complex, it will be capable of interchanging traffic with other Defense networks on an automatic, compatible basis.

Four of the five centers will have a capacity of 50 message-switching channels and 50 circuit-switching channels. The fifth center provides an additional 50 message channels. Provision is made for modular expansion to 100 message and 200 circuit channels. The channels will have an initial capacity of up to 4,800 bauds, but can be increased to 50,000 bauds by future expansion.

The system emphasizes digital transmission, but includes facilities for analog signals such as voice and facsimile. Bandpass of the analog switching circuits is at least 50 kc. Since all data trunks are link-encrypted, separate analog trunks are provided.

All digital channels will be operated in full duplex to provide simultaneous two-way operation. Switching centers can operate with half-duplex channels for alternate two-way transmission or with open-loop, one-way channels where necessary.

The common language chosen for COMLOGNET is an eight-element code that includes one bit for parity check. Alphanumeric characters are transmitted in accordance with the Air Force's recently adopted Fielddata code. Transmission will be at 150 bauds in the eight-level code. Automatic error detection will limit undetected errors to one in 10 million characters.

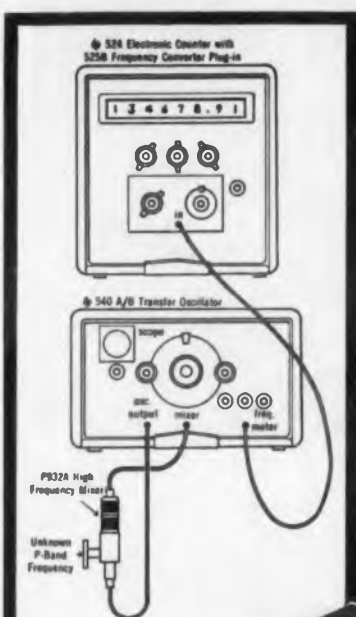
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12.4 to 18 KMC P-Band New **hp** P932A Harmonic Mixer mounts directly in your waveguide system and operates with an **hp** 540A or 540B Transfer Oscillator, as indicated in the block diagram. The 540 Oscillator output is applied directly to the mixer, which generates harmonics and mixes them with the unknown waveguide frequency. The mixer's beat frequency output is applied to the 540's oscilloscope, the oscillator tuned for zero beat scope indication, and the oscillator frequency setting noted. Simple multiplication of the 540 dial frequency by the harmonic number yields the unknown to within 0.5%. Measuring the oscillator frequency on an **hp** 524 series counter increases accuracy of measurement on clean cw signals up to 1 part in 10⁷.

hp P932A maximum input power is 100 mw, minimum video output is 0.1 mv rms with 0 dbm input, output impedance 1000 ohms with 35 μ f shunt, sensitivity approximately -10 dbm. \$250.00.



5 to 12.4 KMC New **hp** 934A Harmonic Mixer operates from 2 to 12.4 KMC, extends the range of the **hp** 540A Transfer Oscillator from 5 KMC to 12.4 KMC and offers the same advantages as the P932A, including the fixed tuned feature eliminating tedious adjustment. Maximum input power is 100 mw, typical sensitivity is -45 dbm at mid-range points, minimum video output is 0.5 mv rms (0 dbm input) and output impedance is the same as **hp** P932A. Model 934A \$150.00.

220 MC to 5 KMC or 12.4 KMC Hewlett-Packard 540 Transfer Oscillators (see diagram) extend the range of the **hp** 524 series counters to 5 KMC (**hp** 540A) and 12.4 KMC (**hp** 540B), making possible frequency measurements with counter accuracy well into the microwave region. These oscillators also measure carrier frequency of pulses, determine carrier frequency and deviation of FM signals, and measure frequency accurately despite high noise. **hp** 540A, \$615.00. **hp** 540B, \$750.00. (Rack mount models \$15.00 less.)

FREQUENCY MEASUREMENT

FREQUENCY RANGE	EQUIPMENT	TOTAL* PRICE
0 - 10 MC	524C or 524D Frequency Counter	\$2,150.00
10 - 100 MC	524C/D + 525A Converter (0-10 MC) (10-100 MC)	\$2,400.00
100 - 220 MC	524C/D + 525B Converter (0-10 MC) (100-220 MC)	\$2,400.00
220 MC - 5 KMC	524C/D + 525B (0-10 MC) (100-220 MC) + 540A Transfer Oscillator (220 MC - 5 KMC)	\$3,015.00
220 MC - 12.4 KMC	524C/D + 525B (0-10 MC) (100-220 MC) + 540A (220 MC - 5 KMC) + 934A Harmonic Mixer (2-12.4 KMC)	\$3,165.00
	524C/D + 525B (0-10 MC) (100-220 MC) + 540B Transfer Oscillator (220 MC - 12.4 KMC)	\$3,150.00
12.4 - 18 KMC	524C/D + 525B (0-10 MC) (100-220 MC) + 540A + P932A Harmonic Mixer (220 MC - 5 KMC) (12.4 - 18 KMC)	\$3,265.00**
	524C/D + 525B (0-10 MC) (100-220 MC) + 540B + P932A (220 MC - 12.4 KMC) (12.4 - 18 KMC)	\$3,400.00

*Based on 524D Frequency Counter \$2,150.00. 524C price \$2,300.00. Counter and Transfer Oscillator prices are for cabinet mounts; rack mounts are slightly lower.

**If coverage 5-12.4 KMC is desired, add 934A, \$150.00.

Data subject to change without notice. Prices f.o.b. factory.



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Type SB3A
Screw mounting with
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Type SS5A
Solder mounting with
0.195" max diam eyelet

Type FU6D
Solder mounting with
0.195" max diam eyelet



Type FA5C
Solder mounting with
0.195" max diam eyelet



Type FB2B
Screw mounting with
12-32 UNEF-2A thread



Type SB4A
Screw mounting with
6-40 UNF-2A thread



Type FB3B
Screw mounting with
1/4-32 UNEF-2A thread

NO PARALLEL RESONANCE EFFECTS AT 1000 MCPS OR LESS.

The exclusive dielectric construction of Allen-Bradley Discoidal Feed-thru Capacitors eliminates all parallel effects normally associated with tubular feed-thru designs. This complete freedom from self-resonance permits the use of much higher capacitance values, providing far greater attenuation of undesired radiation.

Allen-Bradley Discoidal Stand-off Capacitors provide maximum capacity for by-pass purposes in a minimum of size.

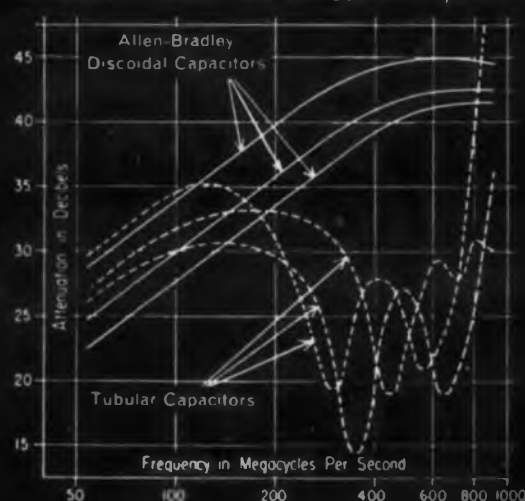
These extremely compact Allen-Bradley capacitors have an unusually rugged structural design, which provides complete and permanently mechanical protection as well as ease of assembly. The gold-plated terminals assure excellent solderability.

Insist on Allen-Bradley quality discoidal capacitors—they have no equal on the market. Write today for Technical Bulletin 5409.

Allen-Bradley Co., 1334 S. Second St., Milwaukee 4, Wis.
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ALLEN-BRADLEY

Discoidal vs tubular feed-thru ceramic capacitors



QUALITY
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NEWS

New TH Microwave Relay

*Large-Scale TWT Application
Is Said to Be First in Country*

A NEW 6,000-mc high-capacity microwave relay system between Denver and Salt Lake City scheduled to enter service early next year is now undergoing final tests by the Long Lines Div. of the American Telephone and Telegraph Co.

The new link, designated TH, affords eight 10-mc transmitting channels in each direction, with each channel having a capacity of 1,860 telephone conversations. Each of the 16 stations in the system will employ a total of 36-444A traveling-wave tubes as oscillators and final amplifiers. According to a Bell Telephone Laboratories spokesman, this marks the first large-scale commercial application of TWTs in this country.

A peak frequency deviation of ± 4 mc is permitted for each of the 16-transmitting channels. In addition, there are four narrow-band auxiliary channels for inter-system communication. Total utilization of space within the 5,925 to 6,425-mc common-carrier band is 90 per cent; only 10 per cent is reserved for group separation and guard bands.

This high percentage of band utilization is primarily due to frequency and polarization interleaving among channels. Adjacent channels are alternately polarized horizontally and vertically. Parabolic horn reflectors and circular waveguides capable of handling both polarizations are therefore used in the antenna and feed system. Polarity-sensitive elements achieve a 20 db discrimination between the two polarizations.

In addition, retransmission of signals repeater station is at a frequency different than that of the incoming signal. Messages received on a low-frequency channel are retransmitted over a high-frequency channel and vice-versa. The typical frequency shift is about 250 mc.

Diodes Permit High-Speed Switching

Four of the 16 transmission channels are held in reserve as protection against equipment failure, propagation difficulties over a particular channel, and for use during routine maintenance. Automatic switching between channels is performed by high-speed diode circuits. Switching time is on the order of 35 msec, of which all but a few microseconds is consumed in set-up time for the switchover. In the event of fading, however, the need for switchover is automatically anticipated and set-up is performed before

lay Being Tested in Rockies

the signal deteriorates to the point where switching is required. Actual switching thus occurs in only a few microseconds. Similarly, the switchovers required during normal maintenance are also set up in advance to minimize switching time. Only in the relatively infrequent case of equipment failure are the full 35 msec required. This rapid switching capability was built into the system in anticipation of future digital data transmission traffic.

Common Microwave Supply Drives 20 Carrier Frequencies

The 20 carrier frequencies are driven from a single 14.826 mc crystal oscillator. The 17th, 24th, 408th, and 425th harmonics are then generated and are appropriately combined by gold-bonded germanium-diode modulators in each transmitter. The two higher-order harmonics are amplified by TWT's before mixing

This common frequency supply permits a sharp reduction in the number of vacuum tubes needed as compared with a system using individual-frequency generators for each transmitter. Elements of the common system are of course provided in duplicate against failure.

The carrier frequency is amplified in the transmitter by a TWT and modulated by an information carrying intermediate frequency in a second gold-bonded germanium diode. The modulated signal is amplified by a second TWT and impressed upon the feed line through an isolator and combining filter.

Receivers employ silicon-diode modulators rather than TWT's to generate the intermediate frequency. While system noise is somewhat increased, this arrangement permits operation of the modulator at the lowest possible level to minimize interference due to cross modulation with adjacent channels. The beat-frequency signals are derived from the common microwave carrier supply in the same manner as for the transmitter.

Broad-Band Traveling-Wave Tube Requires Few Adjustments

The 444A TWT as used in the transmitter output stage develops 5 w. Its broadband performance in the 6 kmc range permits it to be used interchangeably among transmitters with only minor adjustment. One TWT could conceivably serve as the final oscillator for all channels.

TWT gain at 5 w is a minimum of 30 db. The tube's noise figure is 28.5 db. ■■

ADVANCED CBS MEMORY CUBE

Now available for evaluation

For customer evaluation, CBS Electronics offers a working 16-bit *sample* memory cube. Its "new-concept" design features plastic-encapsulated ferrites and deposited conductors, resulting in compactness, light weight, and shock resistance never before achieved.

Check the features, unique construction and technical information. Order the CBS M-267 sample memory cube from stock . . . nominal charge \$50.00. Evaluate for yourself, firsthand, the benefits of its advanced design.

CUSTOMIZED SYSTEMS



After your evaluation of the M-267, CBS Electronics can supply development facilities for custom-designing memory systems for your military computer requirements. This typical CBS customized memory pack, a multi-aperture, nondestructively-sensed, word-organized system, achieves a density of 15,456 bits in less than 23 cubic inches. Other CBS custom designs include nondestructive readout memories and ferrite logic systems. The ferrite cores in the memories meet a wide range of requirements for signal output, switching time, and current drive.

CBS ELECTRONICS, Danvers, Massachusetts, A Division of Columbia Broadcasting System, Inc.

CIRCLE 16 ON READER-SERVICE CARD



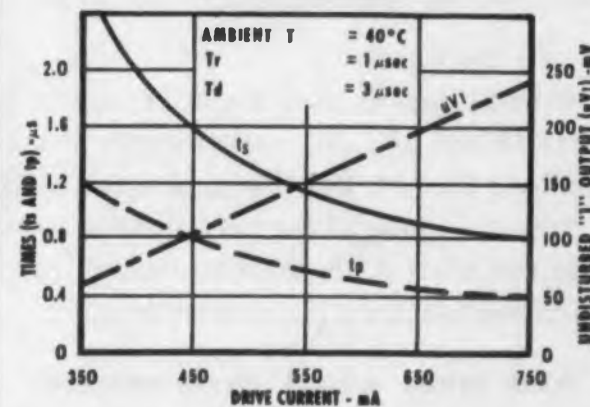
UNIQUE PACKAGING OFFERS MANY FEATURES

Minaturization . . . techniques used result in significant reductions in volume and weight, with densities up to 2,000 bits per cubic inch. Conventional wiring frame and most hand wiring are eliminated.

Uniformity . . . the "ONE" outputs of the 16 bits in the test cube reach amplitudes within $\pm 5\%$ of each other.

Environmental . . . improved temperature, humidity, shock and vibration characteristics are provided, yet encapsulation techniques employed have no adverse effects on the ferrites.

TYPICAL OPERATING CHARACTERISTICS CBS M-267 at 40°C



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...9 basic types

temperature-compensated motor-tachometers

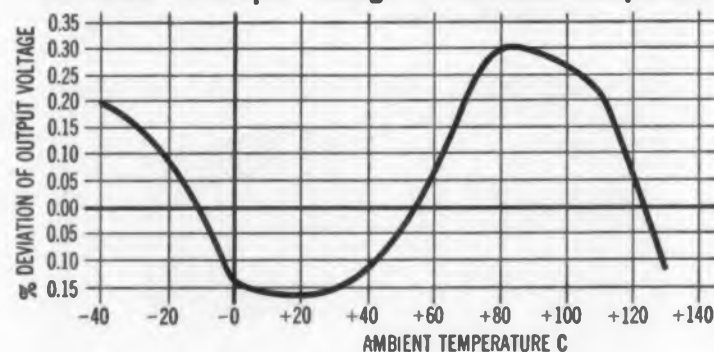
Only at Daystrom's Transicoil Division can you find such a splendid array of temperature compensated high-accuracy motor-tachometers.

Here's the lineup:

4- and 6-pole in Sizes 8 and 11; 4- and 8-pole in Sizes 15 and 18; and a special high-torque 4-pole model in Size 18. But this is only the beginning—it doesn't include all the variations in motor windings and shaft configurations that we can conjure up to meet unusual requirements.

And what about performance? Let us merely assure you that these are the most temperature stable servo components of their kind we've ever had the opportunity to test.

Deviation of Output Voltage vs. Ambient Temperature



Ask to see our specification sheets and then discuss your needs with Daystrom's Transicoil Division.

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NEWS

Electronic Watch

Transistorized Timepiece Employs Tuning Fork

A TRANSISTORIZED wrist watch, called Accutron, has been designed by the Bulova Watch Co., Inc. of Woodside, N.Y. The timepiece is approximately 10 times as accurate as a conventional wrist watch, according to the company. It is guaranteed not to gain or lose more than a minute a month. Accutron has 12 moving parts, compared to 19 in manually-wound watches and 26 in self-winding watches.

All conventional watches "tick," signifying the periodic release of energy through interaction of the escapement and the balance wheel and hairspring mechanisms, causing the gear train to move the hands.

No Tick, but a Hum

The Accutron does not tick; it hums. The humming sound in electric timepieces is caused by the vibrations of a tiny electromagnetically driven tuning fork and its associated index mechanism.

Another external difference is the absence of a winding and setting stem. Accutron's power source is a 1.3-v mercury cell. The setting mechanism is engaged by a small recessed handle on the back of the case adjacent to the screw cap that hermetically seals the opening in the case for the power cell.

The things that make the new Bulova watch unique are:

- The use of a precision tuning fork as the time standard.

- The successful miniaturization of the entire circuit and the mechanical assembly to its 0.5 cu-in. size.

- The development of a highly efficient mechanism and circuit which require such a small amount of power that the self-contained power cell has a life of at least 12 months.

Briefly described, the Accutron is

Has More Accuracy

a wrist watch controlled by a tuning fork. Energy from the power cell, controlled by a transistorized pulser, causes the tuning fork to vibrate continuously at 360 cps. Vibrations are converted mechanically to rotary motions that are transmitted through a gear train to the hands.

Balance Wheel Eliminated

The most recent development in watch design was the electric watch, in which the mainspring was replaced with a battery as the source of power. Use of the battery eliminated the need for winding, but the design retained the balance wheel, which tends to be the weakest part and the greatest source of trouble in a watch. Make-and-break electrical contacts in electric watches are another source of trouble. In the Accutron design, the balance wheel and escapement mechanisms are eliminated, and there are no complicated elements or make-and-break contacts. The Accutron was designed to be serviced by watchmakers.

The greatest difference between Accutron and conventional watches is the use of the tuning fork as the time standard instead of the traditional balance wheel and hair-spring. Attached to one tine of the fork is a tiny finger-like index spring. On the top of the index spring is a jewel that engages ratchet teeth on an index wheel. As the fork vibrates, the jewel-tipped spring moves back and forth with it, advancing the index wheel one tooth for each cycle of the tuning fork.

Micro-miniaturization in the device is perhaps best represented by the index wheel. The index wheel is 0.095-in. in diameter and 0.0015-in. thick; yet, it has 300 precisely machined ratchet teeth. Teeth are separated by a 0.001 in. space. ■ ■

Amperex®

America's Largest Manufacturer of Frame Grid Tubes... Announces

2 NEW RUGGEDIZED AMPLIFRAME* TUBES... 7737 and 7308

SPECIFICALLY DEVELOPED...

Several years ago, when AMPEREX announced the new 6922 and 6688 frame grid tubes for military and industrial applications, they were received with immediate and overwhelming acceptance. However, our applications work in these areas subsequently revealed that there was still room for improvement—as, for example, in the case of video amplifiers which must carry signals from DC to UHF... without microphonics, under extreme shock and vibration conditions. Today, with the new 7737 and 7308 AMPEREX Ampliframes (now in mass production in our Hicksville, Long Island plant), we believe that we have arrived at the ultimate in tube reliability.

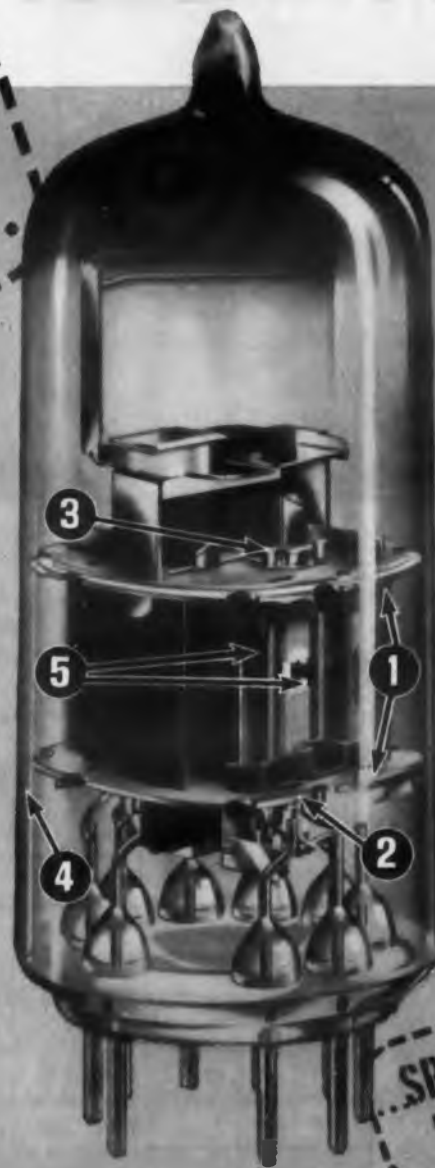


***AMPLIFRAME** a new concept in electron tube construction, designed and mass produced exclusively by Amperex, incorporates the unique Frame Grid... the closest approach to the "ideal Physicists' grid"—electrical characteristics but no physical dimensions. Outstanding features of Amperex Frame Grid Tubes include:

- higher transconductance per milliamper
- tighter Gm and plate current tolerance
- low transit time
- low capacitances
- lower microphonics

SPECIFICATIONS

	7737	7308
Swept Frequency	10 G	10 G
Vibration (50-2000 cps)		
Noise & Microphonics		
Output	190 millivolts	10 millivolts
Plate Supply Voltage	190 volts	100 volts
Grid Supply Voltage	9 volts	9 volts
Cathode Bias Resistor	630 ohms	680 ohms
Plate Current	13 mA	15 mA
Transconductance	16,500 μ mhos	12,500 μ mhos
Amplification Factor	53	33



- 1 Heavy, square mica supports—eliminate mica chipping and flaking as well as loosening of mount when subjected to shock and vibration
- 2 Special mica holes anchor the anode firmly
- 3 Tongue mica dampens cathode movement allows normal expansion and contraction... prevents cathode bowing
- 4 Calibrated, tapered bulb rigidly holds mount... will not allow any movement
- 5 'Ampliframe' grid—rigid frame with fine grid wire under tension accurately maintains close grid-to-cathode spacing

SPECIFICALLY DEVELOPED

for ultra-critical military and industrial applications in high shock and vibration environments

New

Amperex AMPLIFRAME 7737

Premium Quality

BROADBAND AMPLIFIER PENTODE

Extra-rugged, low-microphonic version of the 6688... for critical airborne applications, coaxial cable amplifiers, video and broadband IF amplifiers in communication links and TV equipment.

New

Amperex AMPLIFRAME 7308

Premium Quality

HIGH-GAIN TWIN TRIODE

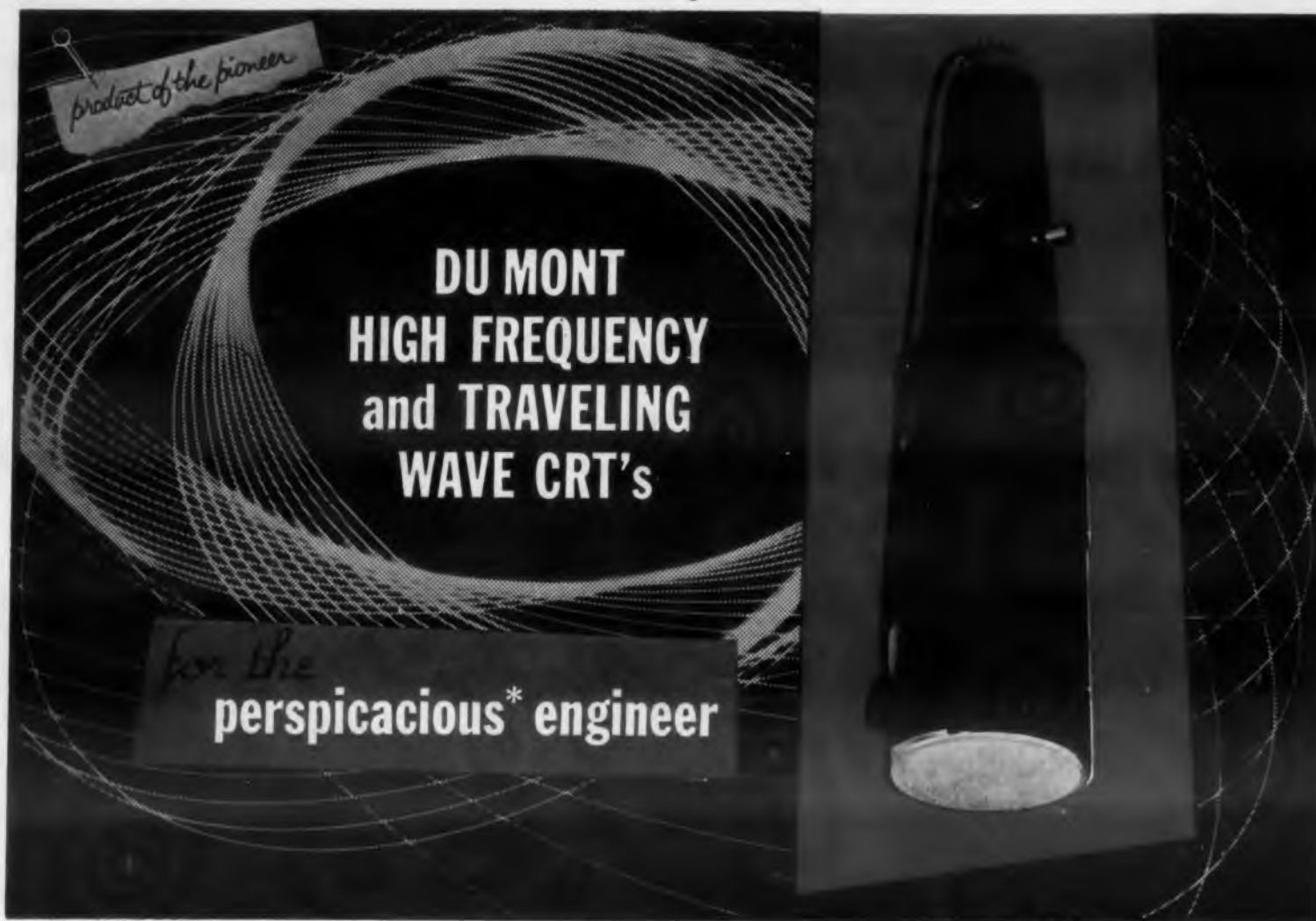
Extra-rugged, low-microphonic version of the 6922... for use in radar, oscilloscopes, computers, broadband amplifiers and critical airborne applications.



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about Ampliframe tubes for ultra-critical military and industrial applications

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*Of acute mental vision or discernment, keen.

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SPECIALTY FEATURES

SBHP—High sensitivity; astigmatism and pattern adjustment electrodes for distortionless displays

SXP—High vertical sensitivity; low capacitance

K1409—Type C r-f coaxial connectors and special deflection plate mounting for UHF applications. Integral mu-metal shield.

K1524—50 ohm distributed deflection system using Type C r-f coaxial connectors. Integral mu-metal shield.

K1546—High voltage, high writing speed

K2082—Traveling wave vertical deflection plates, high sensitivity.

K1870—50 ohm distributed vertical deflection; Type C r-f coaxial connectors. Extra horiz. and vert. deflection plates for introduction of timing marks. Interplate shield reduces crosstalk between adjacent deflection plates. Integral mu-metal shield.

Shaded areas indicate traveling wave types

TYPE	A ₁ (KV.)	A ₂ (KV.)	SENSIBILITY (V/TRACE WIDTH)		USEFUL SCAN (IN.)		USEFUL SCAN (TRACE WIDTHS)		FREQ. 3 db DOWN (Mc.) (VERT.)	WRITING SPEED [†] (TW/US.)						
			HOR.	VERT.	HOR.	VERT.	HOR.	VERT.								
SBHP	10	1.65	1.54	0.33	3.9	1.6	195	80	220	9000						
	12	2	2.90	0.94	4.25	1.6	220	80	460	9000						
K1409	30	7.5	2.5	1.75	4.2	2.8	420	280	1650	120,000						
K1524	35	10	2.2	0.65	3.5	0.75	435	90	2800	205,000						
K1546	24	4	4.2	1.0	4.0	1.6	160	105	325	33,600						
K2082	12	1.4	1.65	0.43	3.94	1.97	120	60	4100	9000						
			D ₁ D ₂ D ₃ D ₄ D ₅ D ₆ D ₇		D ₁ D ₂ D ₃ D ₄ D ₅ D ₆ D ₇		D ₁ D ₂ D ₃ D ₄ D ₅ D ₆ D ₇									
K1570	35	10	1.4	1.6	1.0	0.55	4.5	3.5	1.25	1.75	650	575	200	280	1400	205,000

[†] Writing speed determined at 25 ua beam current. Tests made on 35 mm Tri-X film, 4.7 to 1 reduction ratio, f/1.5 lens.

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CIRCLE 19 ON READER-SERVICE CARD

NEWS

Midwest Is "Stagnancy" Center, Stanford Provost Says at NEC

The Midwest, dulled by insufficient research funds and by unimaginative challenge to graduate students, has been cited as the center of "electronic stagnancy" by a leading educator.

Largely responsible, according to Dr. Frederick E. Terman, Provost of Stanford University, are a lack of new-product development and waste of intellectual resources at local universities. He made his remarks at the National Electronics Conference, held in Chicago Oct. 12-15.

Although present industry in the Midwest is not in dire straits, Dr. Terman said, both East and West Coast companies will enjoy progress at the Midwest's expense, unless a drastic change in policy goes into effect. The key to progress, he pointed out, is the stimulation of advanced graduate training for local students who will have the incentive to remain and contribute to the Midwest's development. Present students at Midwestern institutions, he said, tend to switch to schools in other areas for advanced training and then to remain in those areas for employment.

Midwesterners Blame Geography, But Critics Dispute Contention

Midwestern representatives at the conference said geographic climate was a key excuse, but critics suggested lack of aggressive leadership and failure of local industry and educational groups were primarily to blame for the situation.

Conference sessions on microminiaturization drew large crowds eager to glean the latest development trends, which were outlined in 12 papers. Representatives from Bell Telephone Laboratories, Motorola, General Electric, Lockheed, and Wright Air Development Center discussed progress in thin-film efforts in the micro-min field. Although deposition techniques are capable of supplying high-density assemblies, additional time and study are needed to achieve high yield and reliability.

In addition, they said, the approach must be equipped with some reasonable degree of mechanization to lure customers other than space-program contractors.

Highlighting the new-product announcements from NEC were epitaxial transistors by Rheem Semiconductors Corp., Mountain View, Calif., Motorola, Inc., Phoenix, and Sylvania Electric Products. The new devices, with their lower collector resistance and highly improved switching times, are expected to find rapid use in high-speed computer applications.

Better Instrumentation Is Required To Show Astronauts' Stress, Strain

Designers of instrumentation for measuring physiological parameters have not kept pace with those producing devices for instrumenting machine systems. Needed, in the space effort especially, are a battery of instruments for monitoring stress and strain patterns of space travelers.

This theme ran through the American Rocket Society's Conference on Anatomy of Manned-Space Operations, Oct. 10-12 in Dayton, Ohio.

Dr. S. A. Talbot, Johns Hopkins Medical School, Baltimore, told participants in the conference that not only should such parameters of physiological environment as departures from normal air pressures, oxygen, carbon dioxide, temperature, humidity, and ventilation be measured and monitored, but the more difficult psychological and physiological parameters constituting the "strain pattern" must also be monitored. Included in these measurements would be data on normal and abnormal systolic pressure, respiration, hearts rates, brain activity as indicated by electroencephalograph (EEG) measurements, changes in bodyweight (despite conditions of weightlessness), and waste elimination.

Greater Challenge for Designers Seen in Different Situations

Dr. Talbot said that many other physiological measures might be required, depending on specific situations. Some of these greater challenges would be measures of electrocardiogram pattern, perspiration, galvanic and other reflexes, and sensory activity.

He added that in addition to devices for measuring and monitoring actual patterns of stress and strain, equipment has to be developed for analyzing and remedying the causes of strains and impaired performance.

Designers are attacking the problem areas described by Dr. Talbot. At the conference, Capt. George Potor Jr., Wright-Patterson Air Force Base, Dayton, Ohio, reported on designs that solve or approach solving some of the problems.

These include an amplifier with a stable common-mode rejection reportedly well over 100,000 to 1. Input impedance is 500 K, output impedance, 20 K, and amplification is 2,000. Another amplifier, designed in Europe for EEG equipment fits eight channels and a battery power supply into a 1.5-x-5-x-7-in. volume. A versatile electrode of new design has also been developed at Wright Air Development Div. It consists of a conductive cloth, silver deposited on nylon, stretched on a flat sponge-rubber pad. Although its resistance is about 50 K, it is said to be an important improvement over existing electrodes because it operates dry.



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Cannon's full line of audio-electronic plugs fulfill all the requirements for use with microphones, radio, television, amplifiers, tape recorders, computers, control devices, and many other audio and instrumentation applications. Available through Cannon Sales/Engineering Offices and authorized Distributors throughout the world. For information on this or other products, write for literature to:



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CIRCLE 20 ON READER-SERVICE CARD

NEMS-CLARKE Type DCA-1000 and DCA-500

DIVERSITY COMBINER



THE Nems-Clarke Diversity Combiner greatly reduces the problem of data reduction from separate recordings by combining outputs of receivers operating with separate antennas. A single output from the combiner contains all information received from 2, 3 or 4 receivers.

SPECIFICATIONS

S/N Improvement, for Equal Input S/N's—	4 inputs, 5-6db; 3 inputs, 4-4.7db; 2 inputs, 2-3db
Response Time	.....2 milliseconds, approximate
	Bandwidth Position 500kc 100kc
Maximum Data Frequency Range	.....100cps-85kc 100cps-35kc
Recommended IRIG Telemetry Signals	.....FM/FM PDM/FM
Minimum Available Noise-Frequency Range	.....up to 130kc up to 70kc
Input Data Phase Shift	.....25 degrees maximum between any two inputs
Overall Gain	.....Variable up to +10db
Maximum Output Level	.....10 volts RMS
Overall Frequency Response	.....±2db, 100cps-200kc
Input Power	.....120 volts, 50-400 cps, 150 watts
Size	.....19" wide, 7" high, 15" deep

NEMS-CLARKE CO.

A DIVISION
OF VITRO
CORPORATION
OF AMERICA



919 JESUP-BLAIR DRIVE
SILVER SPRING
MARYLAND

PRECISION ELECTRONICS SINCE 1909

CIRCLE 21 ON READER-SERVICE CARD

WASHINGTON REPORT



Ephraim Kahn

PRIVATE USE OF SPACE SATELLITES is an almost distant prospect, though experiments will start in a matter of months. Statements by T. Keith Glennan of NASA that the "nation's great communications organizations" are seriously considering "the undertaking of substantial expenditure from their own corporate fund for the development of such systems" raises far more basic questions than have been answered. There is general agreement, to be sure, that private enterprise should participate to the maximum possible extent in development of space communications. There are major differences, however, when it comes to deciding what is appropriate for private enterprise and the reward that private enterprise should reap for its participation. The new Administration's attitude will be controlling; present policy (to the extent it has been formulated) is at best firm only through Jan. 20, 1961.

CONGRESS WILL UNDOUBTEDLY take this up next year. In fact, both Senate and House space committee staffs are looking into it now. The Commerce Committees too, may interest themselves from the standpoint of communications. So will executive agencies FCC, NASA, and the DOD. But before any problems can be solved to the mutual satisfaction of both government and industry, some fundamental decisions have to be made.

THE BASIC QUESTIONS are raised quite starkly by Glennan's statement. One is that of patent policy. The appropriateness of turning over to industry for use as a profit a huge amount of government-paid R&D is certain to be raised. The question whether there should be government regulation—and how much—is another. If there is to be control, who will exercise it? Can private industry handle the international problems involved? Would it be proper to grant a state communications monopoly to any firm? If so should it be one of the existing companies? Or should provision be made for entry of new comers into the area on equal terms?

YET TO BE DECIDED, too, is the almost philosophic question of the motivations of the firms which seek to get into the field. It is known that NASA has already had conferences with five or six companies. The feeling in some government circles is that no solution will be reached without a good deal of statesmanship on all sides, and that it will take a lot of soul-searching to come up with the decision which will do the least harm and the most good.

GOVERNMENT OFFICIALS are certain to be wary of any industry approach that plays a mini-max game—which tries to treat obtaining a favorable position in space communications as a purely economic problem in which the objective is to put in as little money as possible consistent with obtaining a pre-eminent position.

VALUE-ENGINEERING PROVISIONS will be written into Air Force contracts soon. Hitherto, the Air Force has tried to push contractors to make components cheaper—without adversely affecting reliability—but it has not incorporated this concept in its contracts. Now proposed legal language is being studied. The formal value-engineering program will be applied both to prime and subcontractors. It will, for all practical purposes, be inseparable from contract management. Technically speaking, the objective is to save money by re-engineering and by modifying specifications. In effect, this could boil down to a change of suppliers, elimination of needlessly elaborate devices, and keeping a sharper eye on overhead costs.

CHARGES OF OVERCOMPLEXITY in the Minuteman and other missile programs have been dismissed by Air Force experts as exaggerations based on insufficient knowledge. Minuteman has been pushed forward to 1962, they acknowledge, even though this means that reliability will fall short of perfection during the first year or so. They insist, however, that even so it will be cheaper than either Atlas or Polaris in terms of cost-effectiveness. Minuteman costs will run, a recent study shows, about 45 per cent for hardware and 55 per cent for on-the-ground costs, including construction. Increasing complexity, though not to be sought for its own sake, is a fact of life. "We simply couldn't do the things we're doing if we didn't have such complex equipment," is the general tenor of comment.

OFFSHORE-BUYING POLICY REVERSAL will have limited impact on electronics. Largely because of Treasury pressure, the military abruptly switched from granting preferential status to foreign purchasing of goods meant for allies of the U.S. to favoring American sources of supply unless it "is essential to support overriding U.S. foreign policy and Military Assistance Program objectives." Foreign purchases will be paid for "to the maximum extent" with foreign currencies held by this country. In any case, contracts for foreign goods will be let "only if they conform to sound military procurement practices."


COURIER SATELLITE IS PRACTICAL for low-priority military communications, according to Army officials (see p 8). Though usually considered a first step toward far more complicated devices, its early performance has indicated that it could be used operationally right now. Long-term reliability—and budget considerations—would be major factors if a decision to set up a Courier satellite system ever has to be made. As things stand, a single satellite of this type probably could handle all the Army's bulk, low-priority, "store-and-forward" messages for the next three years or so.

SLAP ON THE WRIST to small business—an unusual occurrence—has been administered by the Air Force Deputy Chief of Staff for Materiel, General Bradley. Aware of Congress' tender feelings for little firms, the military rarely criticizes them. But Bradley has noted that they are sometimes guilty of "overreaching" in their search for government contracts—that is, they try to get contracts which they are incapable of performing satisfactorily. At the same time, Bradley notes, they sometimes fail to bid on purchases that they could handle very well.

BABCOCK

ars, are crowding the iron. which will soon have to be enlarged.

New 4-Pole 10 Amp Relay Is Smallest, Most Sensitive



COSTA MESA, CALIF.—A new concept in design and construction of multi-pole miniature relays is said to be the basis for the small size and low sensitivity of a new 4 pole, double throw ten amp series announced by Babcock Relays, Inc. Designated the BR-14, the series is available in two contact configurations, BR-14X with heavy duty AgMgNi contacts rated to 10 amps (resistive @ 28 V DC or 110 V AC) and BR-14Y with light-weight AgMgNi 5 amp contacts. Ten mounting styles are available, some compatible with mounting configurations of existing 4 pole types. Designed for operation between -65°C and $+125^{\circ}\text{C}$, the BR-14 Series is rated to 25 amps, min. overload, with max. coil dissipation of 6 watts. Operate and release time is 7 millise. max. with drop-out adjustable between 10% and 40% of pull-in. Life expectancy is better than 300,000 operations, at rated load for some models. The BR-14 Series meet Mil R 5757C and 25018 requirements. Request technical bulletin BR-595.

The Indian laurel tree, chosen for planting in downtown Los Angeles streets, may eventually grow large, buckling pavements and blocking sidewalks. All planted less.

SPECIFICATIONS
 Vibration: 30g, 10-2000 cps
 Shock: 50g, 11 millise.
 Dielect. Str.: 1250 V
 Insul. Res.: 10,000 M Ω
 Life: 100,000 ops. min. @ 125°C
 Duty: Continuous
 Temp. Range: -65°C to $+125^{\circ}\text{C}$. Overload: 25 amps, min.
 Weight: 3 oz. max
 Mil. Spec.: Meets Mil R 5757C and 25018

BABCOCK RELAYS, INC.
 1640 Babcock Avenue, Costa Mesa, California

BABCOCK

CIRCLE 22 ON READER-SERVICE CARD

All New Hughes 10 mc MEMO-SCOPE® Oscilloscope

2 PRECISION INSTRUMENTS IN 1



CONVENTIONAL MODE

- DC to 10 mc Band Pass
- Sweep Range: 0.1 μ secs/division;
5 X Magnifier for speeds to .02 μ secs/division;
Multiplier for sweeps long as 10 secs/division
- Rise Time: 35 nanoseconds
- Built-in Delay Line (0.25 μ secs)
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- Electron Beam Position Indicators
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STORAGE MODE

(All features of Conventional Mode, PLUS:)

- 1,000,000"/sec Writing Speed
- Unlimited Storage Time
- Fast Erase (Less than 150 millisecs)
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- Single Shot Trigger
- Photograph or Trace Directly Off Scope Face

This unique, high frequency instrument combines the benefits of a precision laboratory oscilloscope and a Hughes storage oscilloscope. The new Model 105 MEMO-SCOPE oscilloscope provides high frequency response (10 mc) and fast writing speed (1,000,000 inches/sec). And, in addition, it can store non-recurring transients on the scope for any desired period, keeping them visible until intentionally erased.

For complete details or an interesting demonstration of the MEMO-SCOPE oscilloscope and its many accessories, write, teletype (TWX INGL 4117) or call collect: HUGHES Industrial Systems Division, P.O. Box 90904, International Airport Station, Los Angeles 45, California.

For export information, please write: Hughes International, Culver City, California.

CREATING A NEW WORLD WITH ELECTRONICS

HUGHES

INDUSTRIAL SYSTEMS DIVISION
HUGHES AIRCRAFT COMPANY

CIRCLE 23 ON READER-SERVICE CARD

NEWS

Broad Use of Optical Masers Seen by Experts at BTL Meeting

Leading scientists predicted wide use of optical masers in scientific, industrial, and military systems at a recent demonstration of such a device by the Bell Telephone Laboratories. New applications transcending the already proposed communications, radar, and death-ray systems were foreseen by Drs. Arthur L. Schawlow and Charles H. Townes, who in 1958 first suggested the development of optical masers.

The control of chemical processes by optical-maser beams was considered a likely possibility by Dr. Schawlow. "We know that many chemical and physical reactions are affected by light and we now can look forward to a source of intense, highly controllable light for this purpose," Dr. Schawlow said. The optical maser was also seen as a tool for studying the interactions between light and matter so as to discover new effects of light upon physical and chemical processes.

Dr. Schawlow also suggested the possibility of shifting the orbit of a satellite by the light pressure of continuously applied optical maser beams. This could prove feasible for the remote control of lightweight bodies. One can envision maser "duels" in which an enemy observation satellite is shifted with maser beams while the enemy uses the same technique to keep the vehicle in its assigned orbit.

Dr. Townes predicted significant increases in measuring accuracies through use of optical masers. Velocity measurements by optical doppler methods and distance measurement at ranges of many miles by interference patterns could give accuracies several orders of magnitude higher than present methods, Dr. Townes said.

Both scientists agreed that currently available materials limited masers to optical frequencies, but that ultraviolet and X-ray masers might eventually be developed.

CHANGES IN PRICE AND AVAILABILITY

GALLIUM ARSENIDE TUNNEL DIODES have been reduced 93 per cent in price by Canadian General Electric Co., Ltd. The new prices are now \$5.17 each and \$6.90 each in large quantities to original equipment manufacturers. They previously sold for \$63.25 each and \$97.75 each.

Broad-Band Communications System Sends, Receives, 'Intelligent Noise'

A new broad-band military-communications system, known as "Phantom" system, will receive and transmit "intelligent noise or static" without interrupting or causing static on local radios.

It represents a different approach from the conventional narrow-band military communications technique in which each transmitter and receiver is allocated a specific narrow bandwidth to avoid interference and to crowd as many channels as possible into the electro-magnetic spectrum.

In broad-band communications the transmission bandwidth is many times larger than the intelligence bandwidth, or signal being relayed. For military communications broad-band techniques provide three types of security: security against jamming because of the tremendous amounts of power required to interfere with the transmitted signal; transmission security since the average power is spread over a wide bandwidth making the signal extremely difficult to detect; and message security in that even if the signal is detected, it can be made very difficult for an unauthorized listener to understand what is being transmitted.

The system is under development at General Electric's Military Electronic Dept. of Syracuse, N.Y.

Raytheon Hot-Spot Detector



A lipstick-size electronic device developed by Raytheon Co. of Waltham, Mass., is reported the smallest-known infrared detector and is capable of spotting objects warmer than the human body from miles away. Used in detection units, it peers through the night to pick out heat emitted by aircraft, missiles, launching pads, and rocket-test areas. The detector generates no telltale beam from which the enemy might trace its location. Its long-range operation, small size, and metal casing make it particularly applicable for aircraft and missiles.

◀ CIRCLE 24 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960

New Chassis-Trak Utility Slides Support 15 Times Their Own Weight

Three Models— TILT, TILT-DETENT, and NON-TILT

With the introduction of the C-230 Utility Slide, Chassis-Trak can now offer a complete line of electronic cabinet slides in a capacity range from 50 to 275 lbs. The new Utility Slide can be used in any standard rack and in any type of mobile or stationary installation where the chassis load does not exceed 100 lbs.

Chassis-Trak's famous "pencil thin" design is an outstanding advantage of the new C-230. A pair of these fully-extendable slides take up only .620" of usable chassis space—far less than any other slides of equal capacity.

Made of hard, cold-rolled steel, each slide is cadmium plated and then coated with Poxylube 75. This is a bonded film of molybdenum disulfide which provides permanent dry lubrication and protects the metal against solvents, acids and corrosion.

Chassis-Trak C-230 slides are available in seven lengths—12" to 24"—and in a choice of tilt, tilt-detent or non-tilt models. The detent model locks in three positions—90° up, horizontal, and 90° down—for convenience in servicing both tube and circuitry sections.

For complete details and specifications on the new C-230 Utility Slide, write for Engineering Data Sheet No. 1600.



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CIRCLE 25 ON READER-SERVICE CARD

'TWIXT TRIMMERS...

there's little difference in shape

not much difference in size

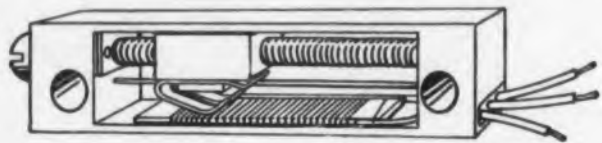
*but a **BIG DIFFERENCE INSIDE***

Reliability thru proven manufacturing techniques is inherent in TIC Trimmers. TIC Standard Trimmers are not only dependable but are **AVAILABLE FROM STOCK** throughout the nation for fast deliveries.

And as an extra feature TIC has simplified your selection — military types in a choice of 4 mountings — all have a temperature range of -55°C to -225°C .

TIC box trimmers with recessed lid are designed for the most efficient four point sealing against moisture and dust.

Standard box trimmers are individually subjected to bubble testing.



All welded connections and dual contacts on both resistance element and slip rings are quality manufacturing features of TIC Trimmers.

COMPARE you'll see the **BIG DIFFERENCE INSIDE**

distributed nationally by **AVNET**

TYPE

RTW-W1 (Wire Leads)

RTW-L1 (Solder Lugs)

RTW-L2 (Solder Lugs)

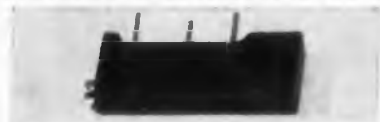
RTW-P1 (Printed Circuit Pins)

25 turn lead screw adjustment (9000°). Standard Resistance Values: 50 — 100K ohms. Non-standard values between 10 ohms and 125K ohms available on special order. Values below 10 ohms and between 125K and 225K ohms also available through the use of special techniques.



Subminiature TPC-P1 for printed circuit application.

37 turn lead screw adjustment (13320°). Standard Resistance Values 50 — 30K ohms. Non-standard values between 10 ohms and 30K ohms available on special order.



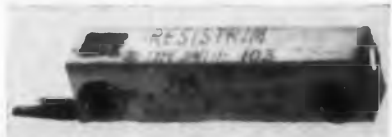
TYPE RWT-C1 (Wire Leads)

25 turn lead screw adjustment (9000°).

Commercial type, low cost trimmers have a temperature range of -55°C to $+85^{\circ}\text{C}$. Anodized metal cases and eyelet mounts permit stacking multiple units in limited areas.

Standard Resistance Values 50 — 20K ohms.

Non-standard resistance values between 10 ohms and 25K ohms available on special order.



For full details write, wire, or call

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CIRCLE 26 ON READER-SERVICE CARD

NEWS

Boiling Liquid Cools Radar Power Supplies

**Corona Prevention Is Provided;
Development Allows Size Reduction**

HIGHER and higher power levels for microwave-radar transmitting tubes have led to the use of liquid ebullient cooling in high-voltage power supplies for these systems.

The ebullient cooling process makes use of a fluid with a high heat of vaporization to remove heat from components through boiling. Corona prevention is also provided.

A packaging technique to take advantage of this process has been developed by Raytheon Co.'s Missile Systems Div. under a program in progress since 1954. A high-voltage power supply, and also the klystron it is feeding, is contained in a flexible Teflon liner which is first evacuated and then filled with an inert fluorocarbon fluid. As the unit operates, heat is first removed by convection currents, but as the boiling point of the fluid is reached, ebullient cooling begins — transferring large amounts of heat from high dissipation elements.

A Number of Liquids Tried

Extensive tests of many possible coolants for the ebullient process by Raytheon indicated that no one fluid was suitable for all applications. For the initial applications of the technique Freon F-114, which boils at about 36 C and remains liquid to -94°C — meeting the military requirements for operation down to -65°C . This fluid has the advantage of low cost but causes decomposition of silicone rubbers, requiring careful materials selection for power supplies, according to Lee Renaud, Raytheon's Missile Systems Div., at the recent Electronics Packaging Conference at Boulder, Colo.

Currently Raytheon is using FC-75, produced by Minnesota Mining & Manufacturing Co., for ebullient cooling. This fluid was found to be essentially inert except for minor reactions with most silicones — allowing use of most high-voltage cables. Boiling temperature is about 100 C, so that operation at

15 psia internal pressure is possible with component temperatures remaining below 110 C, according to Mr. Renaud.

Silicone Pads Protect Liner

The flexible liner covering the power supply expands or contracts to compensate for effects of volumetric changes in the fluid with temperature variations. Sharp corners on components in the supply are covered with a thin silicone rubber pad to prevent puncture of the liner.

Size Reductions Are Significant

Designing for ebulliently cooled equipment allows significant size reductions for many supplies, such as magnetic cores, high voltage rectifiers, and resistors. Power resistors, for example, can be uprated to dissipate five times the normal power, Mr. Renaud said.

An airborne power supply built by Raytheon using FC-75 for ebullient cooling occupies 0.6 cu ft. Electronic circuits dissipate some 700 w and klystron dissipation is about 1,500 w. This power is absorbed by an external coolant flowing



Breadboard layout of 15-kv dc, 125-ma power supply designed by Raytheon for ebullient cooling using Minnesota Mining's FC-75. Miniaturization of many high heat dissipation components is possible using the ebullient cooling approach.

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Hot klystron boils fluorochemical fluid with high heat of vaporization. Klystron is packed inside its power supply in the new flexible liner packaging approach.

through an FC-75 vapor condenser. Maximum output of this supply is 15 kv dc at 125 ma, regulated for line voltage and load changes.

Placing the klystron inside the power-supply package eliminates the need for a multi-pin, high-voltage connector designed for corona-less operation at high altitudes, which offers a difficult mating problem. Careful shielding to protect stray pickup and testing of the high voltage cable between the supply and the exterior klystron is also eliminated.

Plastic Foam Lowers Fluid Required

Since FC-75 is expensive, low thermal dissipation areas within the supply are filled with lightweight plastic foam to reduce the amount of fluid required.

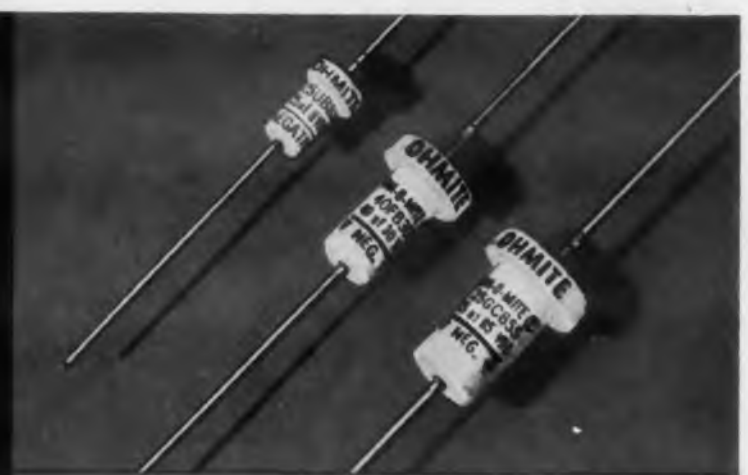
In response to questions at the Packaging Conference Mr. Renaud indicated that the properties of FC-75 were not affected by long periods of boiling under Raytheon tests. It is necessary to maintain an adequate supply of fluid to handle heat transfer requirements, he commented, or there is danger of burning out the klystron. Even with advanced sealing techniques there still will be some leakage of fluid over long operating periods, he commented. ■ ■

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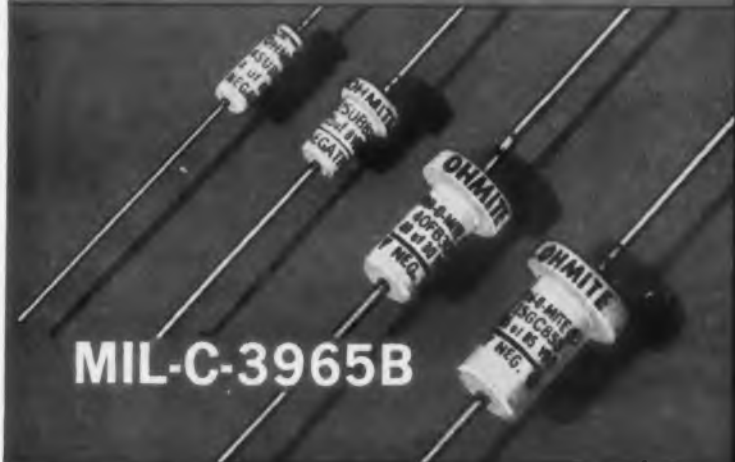
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CASE SIZE	COMML.	MIN. MFD.	VOLTS		MAX. MFD.	VOLTS	
			85°C	125°C		85°C	125°C
T1*	U	1.7	125	85	30	6	4
T2*	F	9	125	85	140	6	4
T3*	G	25	125	85	330	6	4

*Styles CL44 Uninsulated and CL45 Insulated.

STRAIGHT-SIDE TAN-O-MITE SERIES TS CAPACITORS

Case	Comml.	Min. Mfd.	85°C	125°C	Max. Mfd.	85°C	125°C
T1†	SUB	1.7	125	85	30	6	4

†Styles CL64 Uninsulated and CL65 Insulated.

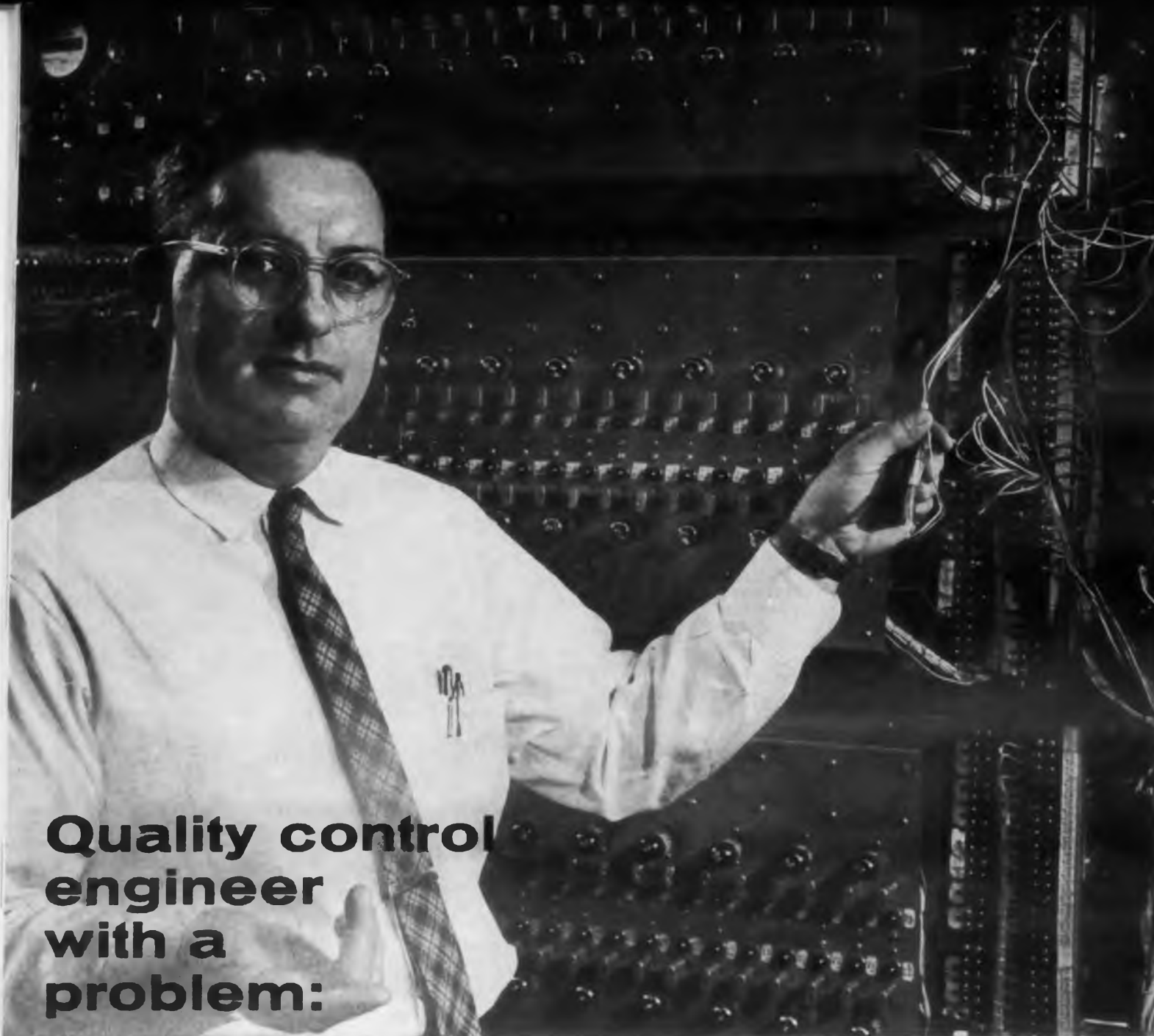
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CIRCLE 27 ON READER-SERVICE CARD

Send for Bulletin 159



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problem:**

"I can't test every relay!"

You shouldn't have to! Besides, quality can't be "tested into" relays—it has to be built in at every step of the production cycle. At General Electric it is.

Not simply individual tests for shock, vibration, etc., but *complete* quality control is what gives General Electric relays exceptional reliability.

Quality control begins with stringent material tolerances General Electric demands of its vendors, monitored by frequent appraisals on everything from tool calibration to their reporting procedures, and checked by G.E.'s careful processing of incoming materials. Result: less than 1% of incoming material must be rejected.

Quality control continues with equally exacting measures in our own plant:

- Of average relay manufacturing time, General Electric spends 30% in planned quality checks—much more for specials.
- More than 25% of total factory floor space is used to test relays.
- Advanced equipment and techniques are used, including the unitized testing console. This automatic, on-line testing center eliminates human error from production acceptance tests, eliminating another variable of relay reliability.

But, quality control doesn't end here. General Electric quality control even follows relays into the field to analyze

malfunctions and, if necessary, re-assess testing procedures, or design.

It all adds up to complete quality control—a highly developed monitor and feedback network that guides General Electric's manufacturing process through the consistent production of industry's most reliable sealed relays.

For information on our special customer-requested testing program, or more on quality control, see your G-E Sales Engineer. General Electric Co., Specialty Control Dept., Waynesboro, Va.

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GENERAL ELECTRIC SEALED RELAYS—UNMATCHED FOR RELIABILITY

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General Electric sealed relays for the '60's



MICRO-MINIATURE

Small and light for military use, the General Electric Micro-miniature's dual-coil construction provides a highly efficient magnetic circuit, requiring minimum operating power. A balanced armature combined with extremely high tip forces gives the relay exceptional resistance to shock and vibration. It is available in current-calibrated and voltage-calibrated forms, SPDT or DPDT. Other specifications:

Operating Sensitivity: 200 milliwatts; 300 milliwatts.

Vibration: 20 G's, 55-2000 cps (except for certain mounting forms).

Shock: 50 G's per MIL-R-5757C.

Ambient Temperature: -65C to +125C.

Operating Time: (25C) 6 milliseconds maximum.

Release Time: 5 milliseconds maximum.

Contact Rating: 2 amps resistive at 28 VDC or 115 VAC.

Life: 100,000 operations minimum at rated load.

Dielectric Strength: 1000 V rms except 700 V across terminals.

Insulation Resistance: 1000 megohms minimum.

Contact Resistance: .05 ohms maximum at rated load.



MINIATURE: Long-life type; rated 5 amps at 28 VDC; in 2- or 4-pole double-throw and 6PNO forms. Ideal for ground applications.



4-POLE MICRO-MINIATURE: Welded construction, exceptionally long life. Rated 2 amps at 28 VDC, or 115 VAC resistive; requires only 10 milliwatts per pole.



GRID-SPACED MICRO-MINIATURE: Long-life crystal-can type, rated 3 amps at 28 VDC, operating sensitivity 300 mw; 16 mounting for ms; 30 G's vibration to 2000 cps.

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Section A792-17
Schenectady, New York

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GENERAL  ELECTRIC

CIRCLE 29 ON READER-SERVICE CARD

EDITORIAL

Science, Electronics, and Elections

That science and technology has not become an election issue in 1960 comes as no great surprise. Few, if any, can see any issue at stake. But is there really no national policy involved?

Will the benefits of science and technology—new materials, new control over our environment—automatically benefit mankind? Bertrand Russell has said science can enhance among men two great evils, tyranny and war. Are we fully aware of what is at stake?

More scientific and technical information is necessary if we are to make policy decisions on the control of nuclear testing and disarmament. The nation's emphasis on basic research is important; governmental policy must be conducive to free inquiry into all of nature. The Presidential candidates' views on these matters are important. How the candidates view the dissemination of scientific information, both to researchers and the public at large, is vitally important. Secrecy defeats scientific inquiry. If the voters do not understand the issues involved, they cannot make informed decisions at the polls.

Scientific objectivity must be separated from political opinion. This has hardly been achieved so far in the U.S., as is indicated by the official reports on the danger of nuclear radiation. If scientists and engineers are to perform the role proposed for them by Prime Minister Macmillan as the first step towards disarmament, they must be able to shun political pressures.

In the past, we have had little way of knowing if our actions have been consistent with our national objectives. We have not yet taken advantage of operations research, or systems research, to determine if the many variables at stake are being properly interrelated. We need such research if we are to achieve any success in, for example, disarmament and weather control.

Britain's new Minister of Science has said, "My purpose is to make the voice of science coherent and articulate under government encouragement and in one sense to make science self-governing under governmental inspiration."

Is not this the challenge before us now? The President has a responsibility in these areas and if he does not lead, it is up to those in the technical professions to see that the issues are clear.

(For the views of the two candidates on scientific subjects, see p. 4.)

James G. Thompson

Bryant Memory Drums For Every Storage Application

Whatever your immediate or long-range computer requirements, Bryant is equipped to provide "right now" response to your needs for prompt delivery of custom-designed memory drums, standard storage units, read/record heads, and other precision memory system components.

Remember—Bryant Magnetic Memory Drums offer these special features:

- Time-proven reliability
- Super-precise ball bearing suspension
- Dynamic runout less than .0001"
- Dynamically balanced at operating speed
- Precision integral-drive induction motors
- Exclusive tapered drum design



GENERAL MEMORY

Capacity—20,000 to 2,500,000 bits @ 130 bits per inch . . . Tracks—40 to 420 . . . Speed—600 to 24,000 rpm . . . Size—5" dia. x 2" long to 10" dia. x 19" long . . . Access time—As low as 2.5 ms (one head per track).



MASS MEMORY

Capacity—Up to 6,210,500 bits on a single drum . . . Tracks—Up to 825 . . . Speed—900, 1800 or 3600 rpm . . . Size—18.5" dia. x up to 34" long . . . Access time—As low as 16.6 ms (one head per track).



BUFFER APPLICATIONS

Capacity—Up to 225,000 bits . . . Tracks—Up to 150 . . . Speed—Up to 60,000 rpm . . . Size—3" to 5" dia. x 1" to 8" long . . . Access time—As low as 0.25 ms (4 heads per track @ 60,000 rpm).



AIRBORNE SYSTEMS

Capacity—60,000 to 180,000 bits . . . Tracks—50 to 150 . . . Speed—Up to 18,000 rpm . . . Size—As small as 6" dia. x 6" long . . . Weight—As light as 7 lbs. . . Access time—As low as 3.3 ms (one head per track).



SPECIAL PURPOSE MEMORIES

Analog recording . . . Multispeed operation . . . Speed—As low as 2.5 rpm . . . Aerodynamic heads for high density, high frequency recording . . . Flux-sensitive heads for low-speed playback . . . Air bearing drums . . . Magnetic Disc Files for mass storage up to 150,000,000 bits.

For more detailed information, or if you'd like to discuss your particular storage drum application problems, contact your Bryant Representative, or write direct.

60-C-1

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A DIVISION OF EX-CELL-O CORPORATION
EX-CELL-O FOR PRECISION **XLO**

CIRCLE 30 ON READER-SERVICE CARD

Designing for Maintainability



An *ELECTRONIC DESIGN* Staff Report

George Rostky
Associate Editor

Contents

- 30 Maintainability—Where It Came From;
Where It's Going
- 36 Techniques in Designing for Maintainability
- 42 Maintainability in Action
- 50 Check List of 241 Design Features
For Maintainable Equipment
- 58 No Time-Base Needed in Signal Corps
Maintainability Specifications
- 64 Products for Maintainable Designs

Only recently an infant stepchild of reliability, maintainability philosophy has emerged as an important new discipline. Often in conflict with the demands of its elder, reliability, it has aroused the increasing interest of both industry and the military.

All three military services have spent large sums of money for maintainability studies, but by their very

Maintainability—Where It

GONE are the halcyon days when the electronics engineer had merely to design equipment to work. They have been replaced by an era wherein, seemingly, each day brings new disciplines, new requirements and new challenges.

With a touch of bitterness, some engineers have dubbed these days "the age of over-the-shoulder men." But they have learned to live with the needs of the age. Overcoming a psychological hurt, they have come to expect and, at times, to respect the words of thermal-design engineers, packaging engineers, human-factors engineers, quality-control specialists, production men, and, of late, reliability engineers.

Had the quest for reliability been more successful, it is likely that the parade of new disciplines might have halted. Alas, though equipment reliability increased, it was no match for the soaring needs of the times. Realists appraised the situation coldly and concluded that: If an equipment *can* fail, it *will*.

And maintainability was born.

Almost everybody seemed to agree, "If we can't make an equipment last forever, let us at least design it so we can keep it going as long as possible, so we can fix it in a hurry when we need to—with the men available and with the tools available."

Engineers Must See Designs As Technicians See Them

As with so many fine ideas, this was more easily said than done. Some electronic design engineers, trained to design "the best," or worse, "the most sophisticated" equipment, found it hard to design *simple* equipment to perform complex tasks. These highly trained men found

...ity, the nature, many maintainability techniques will continue to clash with some requirements of other disciplines.

...imp... demands... reasing... How to evaluate these conflicts, how to decide on optimum trade-offs, and how best to measure maintainability itself continue to be areas of much-needed additional research. Estimates of the annual cost of maintenance range from a low of 0.6 up to a high of 12 times

the initial equipment costs, and it is essential that more electronic design engineers become proficient in the art of designing for maintainability.

It is with this objective that ELECTRONIC DESIGN's editors have prepared this Staff report and have invited guest contributors to participate in this presentation of maintainability's past, present, and future.

It Comes From; Where It's Going

...elec-... equip-... by an... w dis-... nges. ... neers... r-the-... live... cho-... d, at... n en-... s en-... ction... it hard to believe that their beautiful designs could fail in the field. But somehow, fail they did.

They simply didn't stop to think that the man who had to repair the equipment, a man with no engineering degree, might have to work in bitter cold (with gloves), in sweltering heat (with sweat), or in storm-drenched mud.

Even with the full understanding of the electronics designer, the road to maintainable equipment is not a smooth one. There are many obstacles, many roadblocks, and many conflicting requirements. There are times when maintainability features must be traded off for greater reliability. And there are many features which may enhance maintainability but degrade reliability.

Plug-in modules, for example, cornerstones of maintainable equipments, may be anathema from the viewpoint of reliability. Plug and connectors are weak links in reliable equipment.

Interdisciplinary Conflicts Breeding New Disciplines

Conflicts like this one, between maintainability and other disciplines, are beginning to breed a new discipline—availability. This new discipline (also called readiness, or operational availability), is supposed to lead to a harmonious unification of maintainability, reliability, and still another discipline—supportability. This last is largely a recognition of the logistics involved in keeping equipment working in the field.

In essence, availability is a philosophical concession to the approach of the line officer: "I don't care how much reliability it has, nor how much maintainability it has. What I want to know is—when I need it, is it ready?"

Availability embodies the quest for the best

compromise between the various disciplines for a given system. The need for maintainability itself varies very widely, depending on many factors. As such, maintainability has enthusiastic supporters and equally enthusiastic antagonists.

Military Sees Maintainability In Widely Different Lights

The Air Force, the Army Signal Corps, and the Navy's Bureau of Ships are strong supporters of maintainability efforts. Naval Ordnance, on the other hand, is quite unfriendly to the concept, and insists on greater efforts to improve equipment reliability.

In a talk before the First EIA Conference on Maintainability of Electronic Equipment, H. A. Wilcox, head of the Weapons Development Dept. of the U. S. Naval Ordnance Test station in China Lake, Calif., presented his position this way:

"Your design for easy maintenance has to take into account dirt, rain, ice, heat, cold, vibration, and tooth-tingling shocks in handling. And it has to cope with the bored, curious, intelligent man who wants to take it apart to see how it works—confident that the 'tuning up' he gives it will improve its operation and relieve a dull afternoon.

'If Repair Is Allowed, Repair Becomes Necessity'

"It is my conviction," Mr. Wilcox elaborated, that most field repairs reduce instead of enhance the reliability of the item 'fixed.' "Repair is a self-justifying operation. If repair is allowed, the reliability drops so low that repair automatically becomes a necessity."

He emphasized the fact that an ordnance item,

whose sole use is in wartime, should be designed for long shelf life, almost no maintenance, and absolutely no field repair. Insisting that reliability should be uppermost and that equipment must be maintenance-free, Mr. Wilcox summarized his attitude by saying that "test equipment should in fact be eliminated altogether."

BuShips Awards Contract To Find Practical Yardstick

Holding the opposite position, the Navy's Bureau of Ships awarded a contract to Federal Electric Corp. of Paramus, N.J., to establish a practical procedure for measuring and predicting the maintainability of fleet electronic equipment during the design stage. This recently completed two-year study is the first step in a long range BuShips program to develop a practical method of numerically specifying maintainability in procurement contracts.

BuShips' Capt. William I. Bull points to special Navy problems which emphasize the need for better maintainability. In common with the other services, the Navy has the problem of a low reenlistment rate (12 to 14 per cent) for first-cruise electronics technicians. But the Navy has mission times which average up to 90 days—far more than the other services.

And where the Army and Air Force can use experienced contract technicians, the Navy normally can not. Captain Bull emphasizes the point that shipboard equipment can rarely go back to the factory during a mission. Naval equipment must have as much self-sufficiency as possible.

Mr. F. N. Stehle, head of the BuShips Reliability and Maintenance Unit, goes a step further in describing the special position of the Navy. The

Designing for Maintainability



STATUS

size of a ship, he points out, can have a profound effect on the type of maintenance it can support. A destroyer, with relatively few instruments of a given type, and with a relatively small crew, has requirements which differ vastly from those of a carrier.

Air Force Publishes First Maintainability Specifications

The Air Force, another enthusiastic backer of maintainability, holds the distinction of being the first to publish a maintainability specification, Mil-M-26512. Published in June, 1959, it is still the only military specification on maintainability. (The Signal Corps expects to publish one early next year and the Navy hopes to have one by the end of the year.)

Mil-M-26512 defines maintainability in terms of repairability and serviceability. It then defines repairability as a product of two probabilities—the probability of correcting a failure in a given time with a given expenditure of manpower, and the probability of the system then operating satisfactorily for a given time.

The parameters given to determine repairability include the time to diagnose and isolate malfunctions, the time to repair malfunctions, the manpower and skill levels required for repair, and the time the equipment operates satisfactorily without corrective maintenance.

Sidney Hirshon, who deserves most of the credit for developing the specification, recognizes that it has generated differences of opinion—some of them rather sharp. He points out that the Air Force will continue to improve the specification of maintainability and that Mil-M-26512 is now undergoing revision. Bulletins are being published which will amplify and clarify some of the less clear aspects of the spec.

The Air Force's Col. George Getz, attempting to get to the root of the maintainability problem, suggests that the situation would be much improved if manufacturers (and electronic designers) knew who their customer was. A very important part of the composite customer, says Col. Getz, is G. I. Joe.

Knowing Customer Through Market Research Can Help

He suggests that companies producing equipment for the military services should conduct

some kind of market research so they could better understand their customer and his needs. They should know the proposed environment for equipment they design in terms of the skill, tools, and test equipment available as well as the physical environment.

To help manufacturers know their customer better, the Air Force has conducted several tours of AF maintenance technicians through contractors' factories. Results of these tours, which the Air Force hopes to continue, were highly satisfactory to the Air Force and the contractors, though not always too flattering to the design engineers.

In one case, a corporal, a maintenance technician, educated (and embarrassed) a rather tall design engineer who had mounted a display high on an equipment console. The 5-ft, 3-in. corporal couldn't read the display. In this case, the designer solved the problem quickly. He tilted the display down so it could be read by a short or a tall man.

The Air Force, the Navy's Bureau of Ships, and the Army Signal Corps can all be counted as strong supporters of maintainability.* Naval Ordnance holds an opposite position. The "half-way" position can be found at the Bureau of Naval Weapons.

Mr. Henry Thoman, head of the Material Coordination Unit of the Avionics Div. of BuWeap, favors maintainability and is very much impressed with the advantages possible from the use of expendable modules but he leans most heavily toward reliability.† In most cases where a trade-off is necessary between a maintainability feature and a reliability feature, Mr. Thoman says, he would have a tendency to favor the reliability feature.

The different military attitudes toward maintainability find their counterparts in attitudes in industry. It would be hard to find an authoritative executive in industry who would be outspoken in his opposition to maintainability. Instead one finds people who are lukewarm in their support or who offer conditional support. These men are primarily concerned with the harmful effect which too much emphasis on maintain-

* The Signal Corps approach to measuring and specifying maintainability differs substantially from other approaches which depend heavily on measuring time. It is therefore presented separately in this report as an article entitled "No Time-Base Needed in Signal Corps Maintainability Specifications, p 58."

† The Bureau of Aeronautics, now integrated in the Bureau of Naval Weapons, sponsored the National Bureau of Standards research which resulted in the report "Expendable Modules as Bases for Disposal-at-Failure Maintenance." This report is available at \$2.25, from the Office of Technical Services, Washington 25, D. C.

ability may possibly have on reliability efforts.

As typical of this concern, one can take the comments of W. Van Alan Clark, Jr., president of The Sippican Corp. of Marion, Mass.

"First," he says, "we feel very strongly that undue concern with maintainability has tended to cause designs which require maintenance. In general, complex electronic systems come apart too easily, which means that they do come apart. We feel that the emphasis we find on easy field maintenance has not only made equipment less reliable than it should be, but has had a highly undesirable effect upon the skill and training of the field-maintenance personnel. The military, in particular, are finding the cost of training field-maintenance personnel to be astronomical. Were the equipment to be designed with larger, swappable or chuck-away units, field personnel could concentrate on how the system works, and not worry about individual component or circuit behavior."

Call for Equipment Design For Different Modes of Maintenance

Mr. Clark goes on to recommend that equipment be designed for different modes of maintenance at different positions in the logistic train. As an example, he cites a computer, designed to be disassembled a large number of times in its "shop" mode, which could be put in a "ready" mode by welding every connection and having no mechanical joints of any kind.

This computer could make about four round trips from "shop" to "ready." But this limitation on round trips from service to repair was well compensated by a very high basic reliability and compactness.

Some Observers See Trend To Factory Repair of Equipment

Unlike most observers, Mr. Clark sees trends to performing almost all electrical maintenance at the source. "Maintenance activities," he comments, "can damage equipment terribly. Diagnosis of what is wrong in most equipment is best carried out by specialists who have known the equipment during its design and development stages.

"Equipment is becoming much more compact, which means that it is easier to transport to rear areas or to factories for maintenance. Finally, transportation to any point of the globe is now really rapid, and the money which may be spent maintaining a complex electronic device dwarfs the cost of flying out a sub-system and flying back the other section for factory overhaul."

In supporting these views, Mr. Clark gives an example in which "... one fourth the volume of a modular design we are now building is taken

up by an idiot-proofed test connector; we pay this price to make sure that field experts don't wreck the machine."

Speaking in a similar vein, Mr. W. L. Kirchoff of the Walkirt Co. at Inglewood, Calif., says: "Some of the novices in the industry tend to overemphasize maintainability to the detriment of economy, and even to the detriment of maintainability itself."

"This sounds conflicting," Mr. Kirchoff admits, "but it really isn't." Take the case of the trend toward modular circuitry, where a circuit comprised of perhaps 20 components is unitized as a plug-in device. Modular circuitry certainly enhances maintainability.

"Yet, we still encounter people in the field (although their ranks are thinning) who insist that each component in this modular circuit shall be replaceable. They theorize that it is uneconomical to discard a \$20 package for the sake of a burned-out 10-cent resistor. They then have created 'maintainability' to the degree that each component may be replaced."

Though Mr. Kirchoff and Mr. Clark may be lonely in their over-all views on maintainability,

they are by no means alone in their attitudes on module size.

Controversy Continues On Module Size and Throw-away

Many of the strong supporters of maintainability are strongly opposed to replacing individual components in the field. There is still a lot of discussion on just how large a module should be and the question of throw-away modules is still a matter of controversy. But there are very few who would advocate making low-cost components (like resistors) accessible in the field except in situations where the equipment design is such that the maintenance technician can find a faulty resistor very quickly.

The whole problem of module size is a very touchy one, interrelated as it is with problems of module cost, time required to locate a fault, component density, spare-parts inventory, skill-level of personnel required, length of mission, and others.

In general, it is easier and faster to track a malfunction down to a faulty module and to replace that module with a good one than it is to

locate and replace a faulty component. No one denies this.

But it is easier, in general, to provide logistic support in the form of individual components which can serve an entire system than it is to store spare modules for the many equipments which make up a system.

Even where the module-replacement formula is adopted, this still leaves open the question of whether to repair faulty modules in the field (at leisure), whether to return them for factory repair, or whether to throw them away.

The last choice, of course, affords an advantage in that throw-away modules lend themselves most readily to encapsulation and to the improved reliability which encapsulation may impart.

But, to throw away or not to throw away, that is the question. It has by no means been resolved, although there is growing support for the throw-away concept. A recent National Bureau of Standards study, based on analyzing tube modules only, concluded that, for airborne equipment, an optimum module would include four to eight tubes. Thus study found that the cost of procuring, maintaining, and supporting expendable modules was practically the same as the cost with repairable modules.

Study of Fire-Control System Compares Four Philosophies

On the other hand, a study of expected costs of different maintenance philosophies for the Polaris submarine fire-control system gave opposite conclusions. In this study, total cost using the throw-away philosophy is greatest.

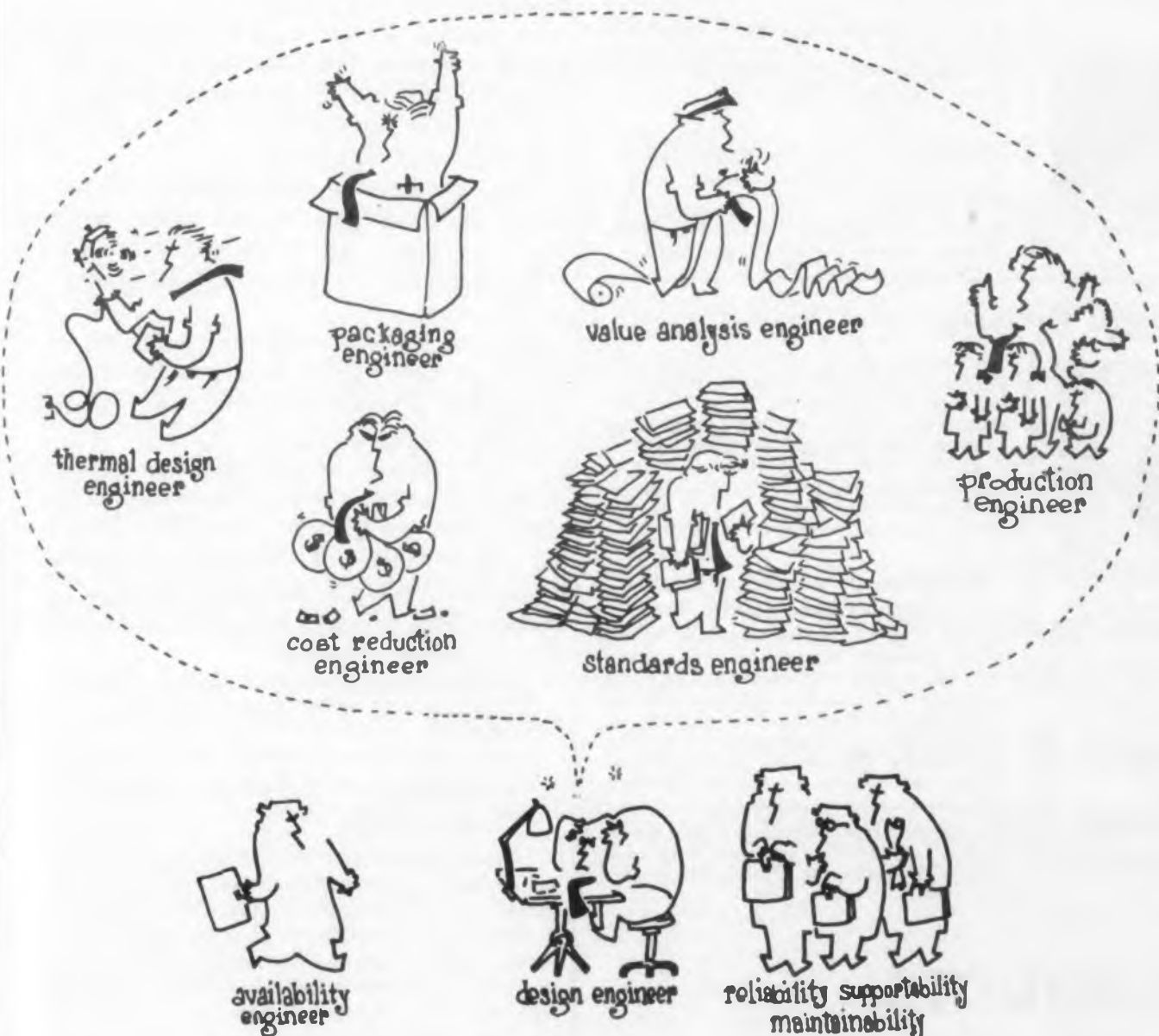
Describing this economic analysis by the General Electric Co. in Santa Barbara, Calif., Ernest J. Mosbaek gives results for four maintenance philosophies—use of throw-away modules, repair on the submarine, repair on a tender, and repair at the factory.

In this study, using throw-away modules proved most expensive; repair at the factory was next; repair on a tender followed, and repair on the submarine proved least costly. Using throw-away modules, the study found, would be two and one-half times as costly as the system requiring repair aboard the sub.

Conflicting Results Show Need For Separate Systems Studies

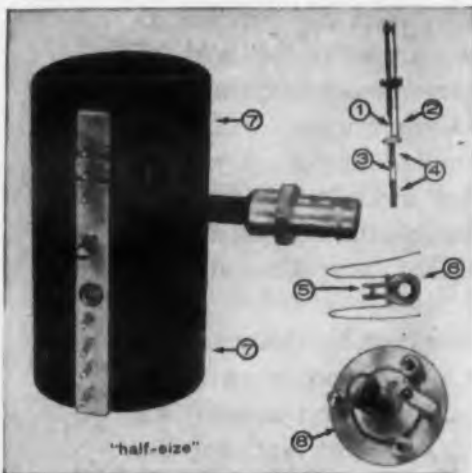
The apparent conflict between the findings for a submarine system and those for airborne equipments leads to an important conclusion: One cannot design for maintainability in general.

One can only design maintainability into a specific system. One must know its specific en-



Nickelonic News

DEVELOPMENTS IN NICKEL AND NICKEL ALLOYS AND THEIR APPLICATIONS



Designers insure magnetron reliability with 4 nickel alloys

WALTHAM, MASS: Recently announced by Raytheon Company, the #6177 Magnetron is compactly designed for height finding, other airborne radar uses. Size is small, weight only 1 lb, range is 4261-4300 megacycles at 1 watt.

To insure the magnetron's operating reliability, Raytheon designers use 4 nickel alloys in 13 critical parts. (8 parts are numbered in above photo.) Designers report why:

Electronic Grade "A" Nickel offers outstanding purity in ribbon (1).

Inco "220" Nickel assures proper outgassing in washer ring (2), tube (3), tube shield (4).

Another nickel-chromium alloy retains non-magnetic characteristics in reed (5), and reed coil support (6).

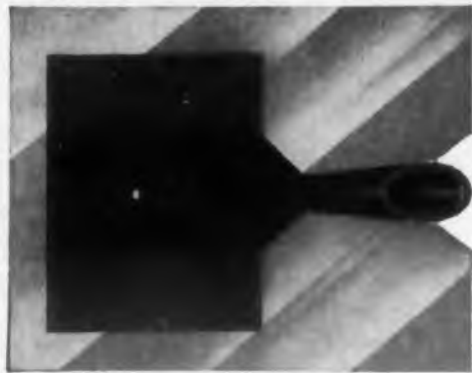
Alnico (nickel-iron alloy) magnets provide stability (7); cupro-nickel pole support provides strength, non-magnetic characteristics (8).

Pertinent Literature: Send for 51-B; "Nickel Alloys for Electronic Uses" (see box, below) and T-15; "Engineering Properties of Nickel."

Newly Revised Booklet—"Nickel Alloys for Electronic Uses"—gives you facts on 17 freely available nickel alloys useful in the electronics industry... facts on typical applications, physical and chemical properties, available mill forms. Ask us for your copy.

Metal that acts like air wraps half-mile vacuum

UPTON, N. Y. In the huge new 25-Bev Synchrotron at Brookhaven National Laboratory, Inconel "X" age-hardenable nickel-chromium alloy—"a metal that acts like air"—is used to contain a ½-mile-long proton beam vacuum cavity.



Tube of low-magnetic Inconel "X" alloy carries Synchrotron's 25-Bev proton beam between magnet jaws. Tube's assembled, in sections, into a circle ½ mile around.



Inspecting one of Synchrotron's 240 magnets. This one weighs about 17 tons. Inconel "X" tube fits into narrowest gap between jaws.

Principal reason for the selection of Inconel "X" alloy, reports Brookhaven, was its high electrical resistivity. This resistivity, about 740 ohms per circular mil-foot, results in the avoidance of high eddy currents. In addition, the low magnetic permeability of Inconel "X" alloy, approximately the same as air, has virtually no effect on the strong magnetic field passing through the tube walls to guide the proton beam.

Inconel "X" also benefits vacuum cavity tube in other ways

Its high structural strength permits thin-wall construction—tensile strength after heat treatment, above 130,000 psi. Other physical properties important to this application—the alloy's low vapor pressure, good degassing, freedom from porosity.

Inconel "X" alloy provides good fabricability, too—tube is formed in sections from 0.078-inch sheet, welded and flanged.

Pertinent Literature: Send for 51-B; "Nickel Alloys for Electronic Uses."

Monel speeds sound brazing of resistor caps



Close-up of Monel caps soundly brazed to wire winding and leads of semi-finished resistor. Made by Sage Electronics Corporation, 302 N. Goodman St., Rochester 7, N. Y.

ROCHESTER, N. Y.: Monel* nickel-copper alloy now makes possible, fast, sure brazing of connections in resistors designed for severe service by Sage Electronics Corporation (see photo, left).

In the caps, Monel alloy also gives excellent resistance to corrosion in murderous environments... and provides essential strength for anchoring leads.

Monel boosts durability in other electronic components, too

In one magnetron, for example, Monel alloy provides an output flange and mounting plate with the toughness and strength needed for 6000-hr life. In fastenings, Monel alloy stands up against both corrosion and hard knocks. In backing for contact points, Monel alloy contributes important strength and brazing properties.

Pertinent Literature: Send for 51-B; "Nickel Alloys for Electronic Uses" and T-5—"Engineering Properties of Monel and 'R' Monel."

*Inco trademark

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Designing for Maintainability



STATUS

vironment, the specific costs of supporting the system (with supplies, test equipment, and maintenance men), and costs of down-time or failure.

There are no absolute rules though there are useful guides. One approach is provided by R. E. Kuehn, manager of reliability engineering at IBM Corp. In a paper presented before the Second EIA Conference on Maintainability of Electronic Equipment, Mr. Kuehn recommended that throw-away modules be designed to have a mean-time-to-failure of 2.5 times the design operating life.

Mr. Kuehn provided economic justification for the throw-away module (in aircraft equipment) on the basis of the costs of unreliability and on the higher reliability and volumetric efficiency of the non-repairable module.

In addition to lower cost, he cited supplementary, hard-to-measure advantages of the throw-away module. Using non-repairable units, he said, gives 50 per cent more volume and a 40-per cent lower failure rate.

The contradictory evidence provided by different maintainability studies shows, not only that each system must be studied separately, but it highlights another fact as well: Maintainability is still young.

Some of the pioneering works in this field are only four years old.* At that time, maintainability was a rather unnoticed stepchild of the discipline of reliability.

Its recognition as an important discipline, when it began to stand on its own feet, began three years ago with the First EIA Conference on Maintainability of Electronic Equipment in December 1957. The second conference,† held in May 1958, solidified maintainability's position as a recognized discipline.

The third such conference will be held in San Antonio on Dec. 5, 6, and 7.‡ This conference

* See bibliography for a brief list of some of the important maintainability studies.

† Papers presented at the first and second conferences are included in "Maintainability of Electronic Equipment," available from Engineering Publishers, P. O. Box 2, Elizabeth, N. J. at \$6.00 for both. Papers to be presented at the Third EIA Conference on Maintainability of Electronic Equipment, are included in "Maintainability of Electronic Equipment—Vol. 3," now available from the same publisher at \$10.00.

should resolve or at least shed more light on many of the problems that confront design engineers. For example, Dr. M. J. Marcus of IBM's Military Products Div. will identify those factors which remain invariant from one hardware system to the next.

Other speakers will nail down other elusive aspects of designing for maintainability, such as how to determine the operational availability of complex systems, how to evaluate automatic test equipment, and how to forecast the requirements for spare parts.

The Third EIA Conference on Maintainability of Electronic Equipment will surely add maturity to a young field which is growing, and indeed, must grow, very, very rapidly. ■ ■

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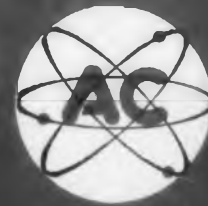
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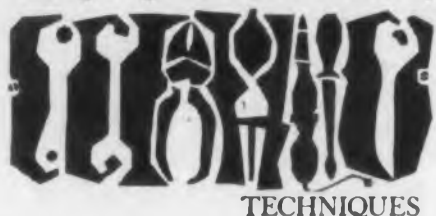
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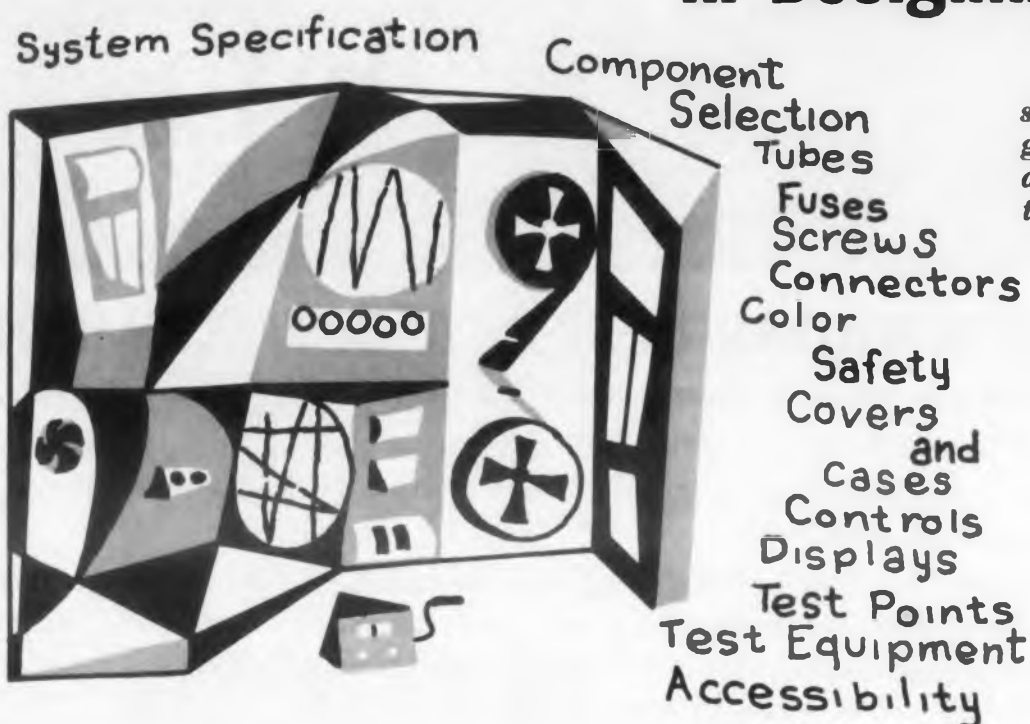
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CIRCLE 911 ON CAREER INQUIRY FORM, PAGE 149



Techniques

in Designing for Maintainability



Though no single maintainability technique can serve all systems with equal value, the guidelines, the general approach, and the specific suggestions in this article should prove invaluable to all designers of maintainable equipment.

J. F. Corso, J. M. McKendry, G. Grant

HRB-Singer, Inc.

A unit of the Singer Military Products Div.

Singer Manufacturing Co.

State College, Pa.*

SOLUTION of the maintainability problem lies mainly in the designer's hands. The designer must realize that each of the three phases in the maintenance process brings about unique problems.

In fault detection, a technician must sense a change which has some visual, auditory, or tactual consequence. The best way to solve this problem is to display indicators of degraded performance in such a way that the probability of detection is maximized.

The second phase, fault localization, involves a complex problem which mixes elements of problem solving with those of information display. This problem is best solved by decreasing complexity and increasing the probability of information transfer.

Finally, the third phase, fault correction, is primarily a problem of accessibility and skill.

These problems in the maintenance process have stimulated several approaches to their so-

lution. Each approach has brought with it further problems of its own. One approach attempts to improve the proficiency of the technician by training. But the turnover of military maintenance personnel is so great that there is not sufficient time to train these people.

Another approach tries to provide equipment with maximally effective maintenance manuals. Benefits here are limited by the design techniques which may be available.

A third approach tries to head off troubles before they occur by periodic replacement of parts. But this technique assumes that electronic components gradually wear out in some predictable fashion—a belief which, for the most part, has been contradicted by a large body of research.^{1,2}

Offering most promise is the approach of designing for maintainability. But here it is essential that positive steps be taken as early as possible to avoid costly equipment redesign.

Specific suggestions to help the designer through various decisions he must make are presented here.

Maintainability Starts With System Specification

Preliminary engineering work traditionally begins with a careful study of customer demands and ends with the production of a preliminary

system description of the proposed equipment in block-diagram form.

The first important step during this phase is to fix responsibility for maintainability. This is best done by assigning one person to the job of insuring that suggestions provided in available guidebooks¹ are followed. The second step is to study the maintenance structure of the potential user. This should reveal the levels of maintenance support which are available, the skill level of the servicing technicians working at each level, and the peculiarities associated with each work environment.

As the equipment begins to take shape in the form of a rough block diagram, the designer should remember two more points. At this point in the operation he should:

- Try to choose elements or stages with clearly defined output characteristics. The best choice from the technician's viewpoint is something which works in an "all-or-none" fashion.
- Try to eliminate complex feedback loops which confuse the troubleshooter. If the designer cannot eliminate complex feedback, he should provide additional checks on interacting stages. One way is to provide a switch to decouple the feedback.

When a tentative block diagram is available,

*Mr. Corso is also Professor of Psychology at The Pennsylvania State University, University Park, Pa.

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the designer can make two more decisions—one on packaging, one on checkout facilities. Recent research³ has shown that some packaging techniques are more effective than others.

Four Packaging Techniques Serve Different Needs

Four of the important packaging techniques are:

1. **The Standard Method.** This technique has no clearly defined rationale other than a compromise between conflicting demands such as heat dissipation, weight and size limitations, impedance difficulties, etc. The technique prevails in radios and TV sets. It provides little uniformity from one equipment to the next so the technician must learn each new layout. He may have to study complex schematics to understand how different elements work together.

2. **The Circuit-Grouping Method.** With this technique, each individual circuit is in a plug-in module, and similar circuits are grouped in one location. This method is particularly conducive to the use of automatic test equipment.

3. **Component-Grouping Method.** Here, all similar components are grouped in one place on the equipment. For example, all tubes are together, all transistors are together, and cheap components like resistors and capacitors are on separate plug-in boards which are mounted under the chassis. Justification for this method is that components which require much time to replace can be checked by a mass-replacement technique that still keeps costs low. There is also great potential for a simplified checkout procedure when all the elements in one place are similar.

4. **Logical-Flow Packaging.** Here, modules and sub-assemblies parallel stages on a block diagram so their layout makes sense to the technician. Simple input and output checks can be provided for each unit and interaction effects can be handled by separating feedback loops from the main line so the loops appear to have a unidirectional signal flow.

Logical Flow Method Best, Standard Method Worst

Investigations have shown³ that the circuit grouping, component grouping, and logical flow

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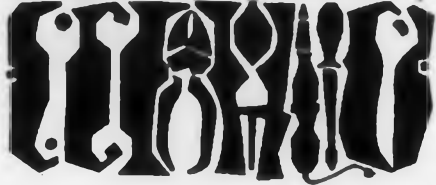


2 Navy missile cruisers employ this large reflector.



3 92-inch Cassegrain antenna built for U. S. Army Nike-Hercules radar.

CIRCLE 33 ON READER-SERVICE CARD



methods are all superior to the standard method in reducing fault localization time. The logical-flow method is best.

Clearly Identified Test Points Simplify Checkout Procedures

Clearly identified test points can simplify system checkout procedures. These points should be visible from the top of the equipment and should have jacks so test equipment can be attached easily. Two levels of test points should be used and they should be differentiated by color coding if possible.

The first set should help isolate a fault to a particular equipment in a complex system. The second set should help localize a trouble to a specific subassembly within a unit. The same process can be applied again, at a later stage in design, to provide test points to pinpoint a trouble to a specific module. The test-point system is much easier to achieve with the logical-flow method of packaging.

Intermediate Design Phases Become More Specific

In the intermediate phases of design, the work usually starts with specification of circuits and ends with specification of components. Hence, the work becomes progressively more concrete and the maintainability suggestion becomes more specific.

Standardized Circuits can provide three substantial advantages: a saving in design time, a saving in manufacturing cost, and a saving in maintenance time employed for increased reliability and increased familiarity on the part of technicians.

Circuit Simplification, an important maintainability consideration, can best be achieved using these procedures:

1. Use standardized circuits where appropriate.
 2. Design and package similar circuits in the same manner for interchangeability and quick substitution checks.
 3. Avoid circuits with critical characteristics and close-tolerance parts.
 4. Standardize component layout.
 5. Package each functional change separately.
 6. Avoid criss-crossing of signals between circuits.
- Test Points** should be provided to monitor im-

portant circuit parameters. Highest priority should be given to those parameters which yield most information⁴ in troubleshooting. Most important tube-circuit parameters are:

Pin voltages, Output waveform, Input-signal voltage, Output-signal voltage, Input waveform.

Less important tube-circuit parameters are:

Grid-signal voltage, Plate-signal voltage, Grid waveform, Plate resistance, Plate waveform, Cathode-signal voltage, Cathode waveform.

Most important transistor-circuit parameters:

Output-signal voltage, Output waveform, Pin voltages.

Important transistor-circuit parameters are:

Input-signal voltage, Collector-signal voltage, Base-signal voltage, Emitter-signal voltage.

Less important transistor-circuit parameters:

Pin resistances, Input waveform, Emitter waveform, Base waveform.

The data for transistor circuits are not as well substantiated as those for tube circuits.

Prototype Layout should lead to rapid location, rapid removal, and rapid replacement of faulty components.

Component Selection Has Two Prime Guideposts

Component selection should be guided by two dictates: (1) Choose reliable components. (2) Choose components which can be removed and replaced easily.

Beyond these principal considerations, special attention can be given to different component types.

With Tubes—

1. Avoid selected tubes.
2. Don't use tubes in applications which require the use of parameters not controlled by procurement specifications. For example, don't use a thyratron as a noise source.
3. Orient miniature tube sockets with their gaps facing one direction to expedite tube replacement.
4. Make tubes accessible so replacing them does not require unit disassembly.
5. Secure tubes and other plug-in items with positive-holding clamps which are easily released.

6. Space unshielded tubes at least 1-1/2 tube diameters apart.

With Fuses—

1. Fuse each unit of a system separately.
2. Put fuses on front panels where they can be seen and replaced without removing other parts.
3. Provide spare fuses in a convenient location.
4. Have fuses replaceable without tools.
5. Remember that fuses in unpressurized areas of aircraft cannot be replaced in flight.
6. Use indicator-type fuse holders.

With Screws—

1. Use screws with enough tensile strength to take normal wear.
2. Don't use too many screws. If four screws will hold a plate, do not use 16.
3. Use as few types as possible. Alternation between slotted-head and Phillips-head screws forces the repairman to dig through his tool box.
4. Where different type screws are needed, be sure they can be identified readily.
5. Use different sizes for screws with different threads to avoid screws being forced into wrong holes and stripped.
6. Use bolts which require only a few turns to be secured or loosened.
7. Use rack-mounting bolts or nuts which are semi-permanently attached to rack members to avoid the need for holding both nut and bolt.

With Mechanical Fasteners—

1. Avoid hardware requiring non-standard tools.
2. Use captive fasteners.
3. Favor hand-operated fasteners which require no tools.

With Connectors—

1. Make cables accessible.
2. Fan them out in junction boxes if other test points with the same information are not provided.

Other Considerations Follow Component Selection

After choosing and using components optimally from the maintenance viewpoint, the designer must consider other factors which play an important role.

With Color-Coding—

1. Use vivid, attention-getting, permanent colors.
2. Use no more than 10 colors with one equipment.

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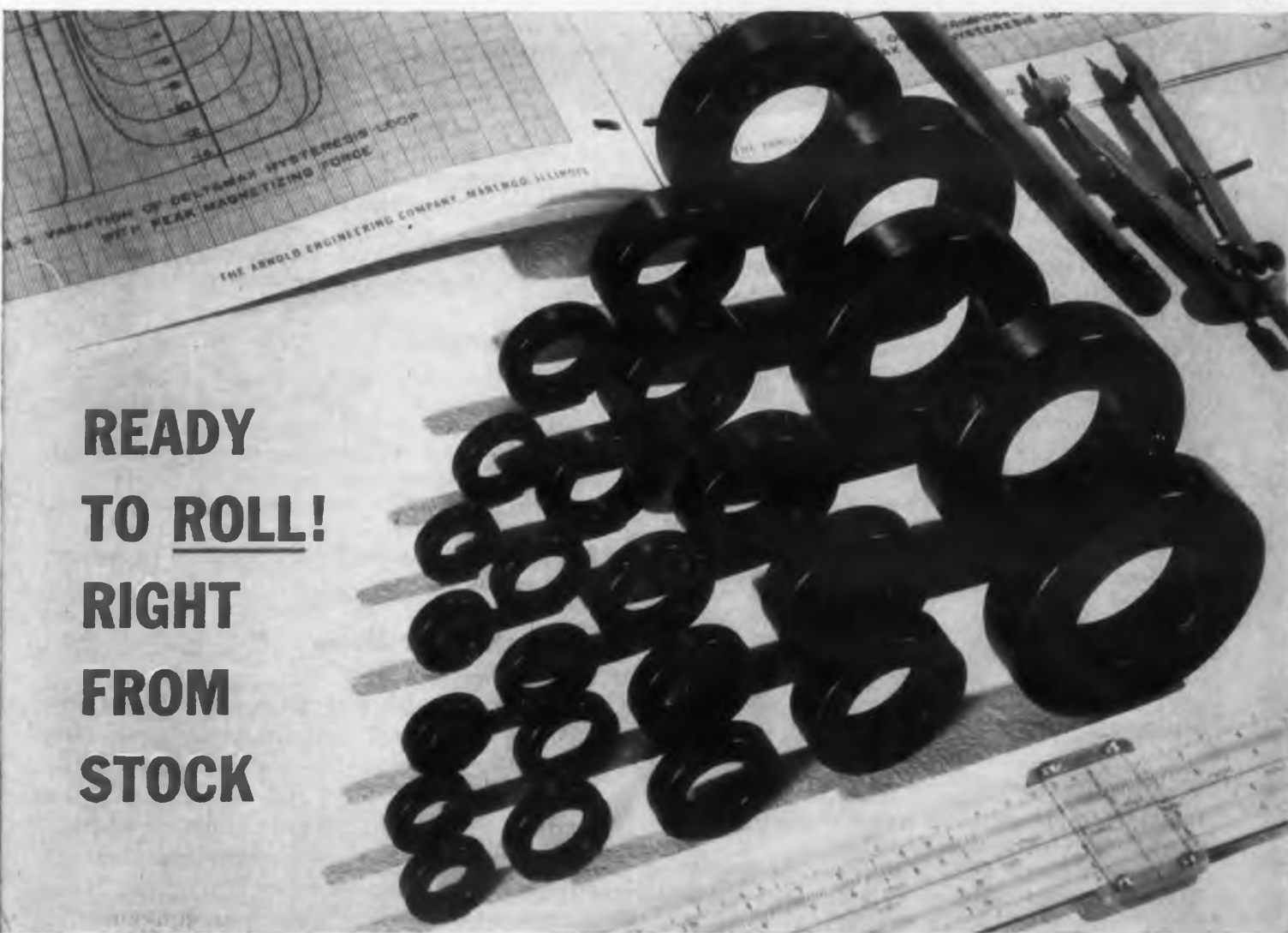
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3. Keep the meaning of a particular color consistent throughout a prime equipment and its maintenance support.

For Safety—

1. Provide means to disable each interlock temporarily, so equipment can be serviced with power on.
2. Use an indicator to show when power is on.
3. Place checkpoints away from dangerous components or potentials.
4. Leave extra space around high-voltage parts.
5. Don't expose hot leads on disconnected plugs and connectors.

With Covers and Cases—

1. Mount chassis requiring frequent removal on roll-out racks or slides.
2. Have roll-out chassis lock automatically in a servicing position.
3. Provide limit stops to prevent pulling a chassis out too far. But have units free to open their full distance and remain open without being held.
4. Design cases to be lifted from units rather than the reverse. Cases are lighter.
5. Design cases to slide easily without interfering with wiring.
6. Make the method of opening covers obvious or attach a permanent instruction plate to the outside of the cover.
7. Make it obvious when a cover is in place but not secure.
8. Make ventilation holes small enough so test probes or other conductors cannot be inserted inadvertently.
9. Provide extra-large holes to pass mounting screws through covers or shields.
10. Make cases and covers larger than their units so wires and other components aren't damaged when cases are put on or taken off.
11. Use guides, guide pins, or tracks to prevent cases from cocking to one side.
12. Fasten panels, covers, and access doors with captive springbolts or screws, drawer bolts, trunk fasteners, dogs, levers, and latches to provide quick and easy access to interiors.
13. Design and space fasteners to be consistent with the required degree of enclosure and frequency of required access.
14. Use the same type fastener for covers and cases on a given equipment.
15. Use quick-acting fasteners for dust covers.
16. Use fine-threaded screws for pressurized units.
17. Design for only one access panel to be opened for removing and replacing a unit.
18. If opening space is a problem, use double-hinged doors.

(continued on p 40)



With Controls—

1. Minimize the number of controls and indicators.
2. Make all controls, knobs, switches, and dials uniform when they are used for a similar purpose.
3. Use selector switches for scales and functions rather than multiple jacks.
4. Arrange controls by order of operation.
5. Distribute tasks for both hands equally.
6. Identify control positions unambiguously.
7. Design controls to turn in a way compatible with the usual human tendencies—clockwise for increase, counterclockwise for decrease.
8. Mount often-used controls at elbow height but have them near displays they affect, if possible.
9. When order is important, design equipment so controls will not operate unless proper sequence is followed.
10. Position knobs and settings for a particular instrument in the same place on new models.
11. Prefer less complex controls such as toggle switches, jacks and plugs, pushbuttons, and selector switches.
12. Wire toggle switches so "on" is in the upper or right-hand position, and "off" is in the lower or left-hand position.
13. Don't require too much finger pressure on push buttons.
14. Provide enough spring loading so selector switches are not left between detents.
15. Design linear-control knobs, so a slight movement of the knob does not result in a disproportionately large display change and large movement of the knob does not produce a disproportionately small display change.
16. Use hand-operated knobs for frequently used controls rather than tool-operated knobs.
17. Increase the size of knobs as the force required to operate a control increases.
18. Locate maintenance controls where they can be seen and operated without disassembly or removal of any part of the installation.
19. Have maintenance controls screwdriver-adjustable, and those which are used also as operating controls knob-adjustable.
20. Keep controls away from high voltages and hot tubes.
21. Keep adjustments in a single area.
22. Use round knobs for smooth, continuous movements in operation.
23. Use bar or pointer-type knobs for detent-type switching.

With Displays—

1. Locate displays used in system checkout so they can be observed from one position.
2. Mount checkout displays at proper eye height.
3. Arrange displays so an operator can't cover a display while manipulating a control.

4. If a display must be located in a difficult viewing position, provide a mirror.
5. Arrange dial elements to be coplanar to avoid parallax.
6. Have display devices providing special warnings and cautions as near as possible to parts of the equipment to which they apply, and have them indicate that they are directly usable without further corrections or interpretations.
7. Have display scales provide only the information actually needed.
8. Make the indicators on center-null displays fall out of the in-tolerance position if power fails.
9. For increasing functions, have a pointer move clockwise past a fixed scale or have a moving scale move counterclockwise past a fixed pointer.
10. Provide for pilot-lamp replacement from the front.
11. Distinguish between different scales in the same instrument.
12. Make apertures in open-window dials wide enough to show at least two numbers.
13. Use similar scale progressions on dials on the same panel.
14. Provide displays which show when an instrument is not operating properly.
15. Use numerical scales only when a technician must have quantitative information.
16. Avoid irregular scale breakdowns.
17. Differentiate scales by color coding.
18. Label displays with the functions indicated.
19. Avoid the need for scale conversion. If arbitrary scales are essential, list necessary conversions in a table attached to the instrument.

With Test Points—

1. Label test points clearly.
2. Indicate standards and tolerances at each test point.
3. Show location of all test points on a plate on the outside of the equipment.
4. Label test points to correspond with similar designation on schematics.
5. Label test points with the designation of the unit being tested.

Test Equipment Planning Must Take Place Early

Early in the planning stages, the prime-equipment designer must consider the types of tests and test equipment which will be required, the maintenance procedures and materials, and the logistics support. He will have to decide whether tests should be made by general-purpose test equipment, built-in monitoring equipment, or automatic or semiautomatic-checkout equipment.

In specifying test equipment, the designer must remember that technicians often do not use certain test equipments because they believe they are inaccurate, inoperative, or difficult to operate. It is therefore essential that test-equipment design be simplified. The following measures can help.

With Test Equipment—

1. Provide a simple method for checking the accuracy of test equipment with an auxiliary calibration instrument.
2. Build in some signal which will indicate when the equipment is functioning and when it is not.
3. Provide devices to show that a correct manipulation has been performed before actual testing is done.
4. Minimize the amount and variety of test equipment required by a procedure.
5. Obviate conversion of one type of reading to another, such as milliwatts to dbm.
6. Use standard test equipment at all echelons of repair.
7. Provide sturdy test equipment in square or rectangular form, with recessed or hinged handles.
8. Provide adequate storage space for leads, adapters, and other removable items in the lid or cover.
9. Have closing of the lid shut off power.
10. Provide break- and scratch-resistant windows for dials.
11. Keep dial pointers stationary while equipment is being transported.
12. Prefer selector switches to plug-in connections.
13. Where plugs are necessary in test equipment, use plugs with pins that are stronger than those which would be used for regular equipment.
14. Attach test leads to test equipment permanently.
15. Use shock mounts on fragile test equipment.
16. Design for eye appeal. Drab and unattractive equipments invite rougher treatment.

Write Maintenance Manual For User—Not Designer

To help the maintenance technician, each equipment should have a good maintenance manual. It should be scaled to his exact needs at each logistic level.

In general, the manual should be kept as simple as possible. Its preparation should begin in the early design stages and its development should parallel design progress. In its final form, it should be written by a communications specialist in the language of the maintenance man—not the designer.

Manual Should Include—

1. Essential test voltages and waveforms.
2. Typical performance limits.
3. Typical maintenance routines.
4. Symptoms of malfunctioning equipment related to probable causes.

Whole Must Be Accessible As Well As Parts

So much of designing for maintainability entails accessibility to parts of equipment that some designers, in concentrating on parts accessibility, forget over-all accessibility. Designers, in all cases, must consider the environment in which equipment must operate.

It is of little use to provide rear-access doors on an equipment which must be mounted rigidly against a wall. It is just as bad to provide access to the top of an equipment which will stand just a few inches from the roof of a van.

It may be a fine practice to mount seldom-used controls behind an access port, but the advantage is negated if the access port is too small for a hand or a tool to get into and move. ■ ■

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Binary	773	13 bits	128 counts
	0-773	oil-filled unit for increased life	
Binary	710	10 bits	1024 counts
	707 (707D*)	7 bits	128 "
Binary	713 (713D*)	13 bits	128 "
	717 (717D*)	17 bits	128 "
	719 (719D*)	19 bits	128 "
	0-713	oil-filled unit for increased life	
Self-Decoding Binary	740	10 bits	1024 counts
	723 (723D*)	2,000 counts	200 "
B/C/D	724 (724D*)	20,000 "	200 "
	733 (733D*)	3,600 "	200 "
	734 (734D*)	36,000 "	200 "
	735	360,000 "	200 "
Sine/Cosine	757-S**	4 quadrants per turn	7 bits per quadrant ± limit 1
	758	4 quadrants per turn	8 bits per quadrant ± limit 1
	758-S**	4 quadrants per turn	8 bits per quadrant ± limit 1
Gray	708	8 bits	256 counts

*Contain isolation diodes for multiplexing

**Servo driven, hermetically sealed

CIRCLE 35 ON READER-SERVICE CARD



Maintainability in Action

HUNDREDS of features can contribute to equipment maintainability. Though almost all these features seem obvious, and though it would seem that even a modicum of "common sense" would dictate their use, truly maintainable designs stand out as exceptions rather than the rule.

Many of these design features are small points, mere details, easily overlooked in the scramble to rush an equipment into production. Presence of these details is rarely noticed. Their absence is recognized immediately by the maintenance technician whose colorful comments it might be good for the designer to hear.



Fig. 1. Swing-out door provides rf shielding and drip-proofing for drawer-mounted chassis in this piece of Lockheed equipment.



Fig. 2. Push-to-unlatch catches give quick access to drawer-mounted chassis.

Recent military emphasis on maintainability has prompted many manufacturers to become conscious of this discipline. Other manufacturers have been designing for maintainability for years. Results of some efforts are shown here.

Key Feature, Accessibility, Embodies Other Features

Accessibility is probably the most important single feature in maintainable equipment. A very broad quality, it encompasses many other features. It is served by roll-out and swing-out cabinets, conveniently placed test points, open con-



Fig. 3. Chassis slides out to give top access, then tilt up for bottom access.

struction, quick-acting fasteners and couplings, properly grouped controls, well designed layouts, modular construction, and a host of other design features. Examples of accessibility can be seen in virtually all maintainable equipments.

Accessibility at many levels is incorporated in a complex system designed by Lockheed Electronics Co. of Plainfield, N. J. The photographs in Figs. 1 to 3 show several levels of access.

Output Monitors Give Front-Panel Fault Warning

Richard Holmberg, manager of LEC's Shipboard Electronics Dept., cites other aspects of the equipment which further improve its maintainability. Monitors, attached to the output of each pulse-circuit board, energize front-panel lights, whenever there's a malfunction. The equipment thus localizes a trouble to an individual plug-in circuit board which can quickly be replaced.

On analog circuits, pulse monitors are not effective, so another approach is used. Meters are provided to monitor signals between individual modules, and test signals are provided to further isolate a fault to a module. A separate module tester can check every module in the system.

Computer Like an Open Book, Gives Rapid, Easy Access

An unusual approach to accessibility is apparent in the PB-250 general purpose computer manufactured by Packard Bell Electronics Corp. in Los Angeles. The computer (Figs. 4 to 6) is book-shaped.

Industrial designer Bernard Caminker and mechanical designer Jack Peterson are responsible for the unusual mechanical features of this computer. In addition to these maintainability features, the machine also includes a diagnostic test routine.

For error diagnoses, a special tape is run



Fig. 4. Book-shaped Packard Bell computer slides out of "book-case" in rack version; sits on cast base in desk-top model.



Fig. 5. Computer opens to expose pages of wiring and input cables which travel up spine and branch out to logic modules.



Fig. 6. Back of book exposes connections and plug-in modules of which there are only 13 types.

through the machine and pushbuttons can select any of 13 levels of test. The machine will print out any failures and identify a specific function group responsible.

If a technician finds, for example, that an adder group is at fault, he can remove an entire group of perhaps four or more cards, replace them with spares, and test the other cards separately. To simplify this maintenance job, Packard Bell hopes to have a special card tester available in a few months.

Book-Type Package Serves Large Computers, Too

The book-type package can be used in large computers as well as in small ones. It is used, in fact, in one of the largest-scale, general-purpose computers available, the 1604, manufactured by Control Data Corp. of Minneapolis.

In the 1604 (Figs. 7 and 8), pages of the book are substantially larger than they would be in a small computer, and there are eight of them, each with room for 1,000 PC cards.

Mr. C. T. Casale, senior engineer responsible for the layout of the 1604, cites additional maintainability features. Scope access to every single card in the machine is provided, even with the computer operating. In the storage sections of the machine, replaceable magnetic-core arrays are located near their associated PC cards.

The storage section on each of the eight chassis is identical so maintenance personnel need learn the locations of only a small number of cards. Within each storage section, cards are grouped along the same functional lines.

Functional grouping is used throughout the computer so maintenance men rarely have to refer to diagrams. The computer console can reveal any failure in any chassis, then a built-in algorithm, the Storage Sweep mode, can be cycled through the core storage to pinpoint an ailing PC card.

Sit or Stand to Reach Maintenance Controls

To further enhance accessibility and ease in fault location, the 1604 has a combined maintenance and operator's console with all necessary controls. Maintenance and operator switches, though they are separate, are positioned so they can be used from either a sitting or standing position.

Diagnostic routines and a high order of accessibility are by no means unusual in computers.

Virtually every computer manufactured in the



Fig. 7. Pages in the book-shaped layout of large-scale, Control Data Corp. computer can hold 1,000 PC-card modules as well as magnetic-core arrays.

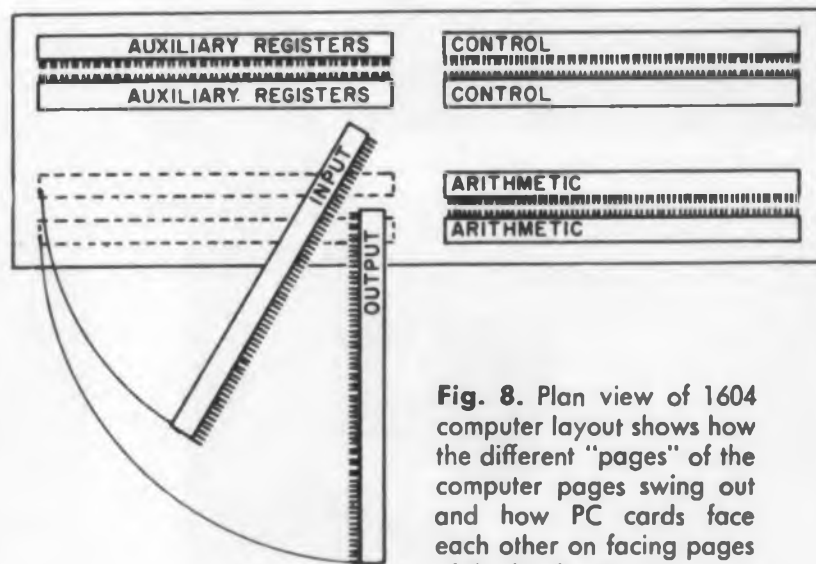


Fig. 8. Plan view of 1604 computer layout shows how the different "pages" of the computer pages swing out and how PC cards face each other on facing pages of the book, allowing air to be forced up from the bottom of the cabinet between the cards.

Designing for Maintainability



Fig. 9. Only 11 basic modules serve entire numerical control system designed by Hughes Aircraft Co. Unusual modules have components neatly stacked in cordwood fashion and soldered in slots in plastic spacers.

past few years shows a great deal of attention to improved maintainability and reduced downtime.

Sophisticated Routines Can Pinpoint Troubles

Several sophisticated routines appear in the Mobidic computer, developed at Needham, Mass., by Sylvania's Data Systems Operations. These routines differ from most others in that,



with the aid of a special manual, they can localize a fault to a small group of transistors, or even to a single transistor. A preventive maintenance system in Mobidic can be used to force all marginally operating transistors to fail during a scheduled maintenance period.

Describing some of Mobidic's maintainability features, Joel Cohen and Lewis Whitaker point to the console. It has built-in alarm indicators

that quickly indicate certain types of machine malfunctions or program errors.

Cordwood-Stacked Modules Instead of Printed Circuits

A departure from the conventional, PC-card modules appears in Hughes Aircraft Co.'s NC-200 numerical control system for machine tools. In this system, according to Don Davern who heads the machine-tool controls group, most components that can fail are in the logic circuits. These are packaged in modules of which there are only 11 basic types (Fig. 9), and these can be stored in a spare-parts kit.

If the machine-tool control system should stop working, even an unskilled workman can simply pull out and replace one module after another until the machine starts again. All modules are clearly labeled and keyed to the chassis.

Accessibility Features Take Many Forms

A variety of accessibility features can be seen in some of the equipment manufactured by Radio Engineering Laboratories, Inc. of Long Island City, N. Y. Figs. 10 to 14 show a number of these features, including wheel-out carriages for klystron assemblies, swing-out and lift-out doors, and some unusually simple coil supports.



Fig. 10. Receivers (above), for the Atlantic Pact, manufactured by Radio Engineering Laboratories, provide front- and rear-door access.



Fig. 11. Convenience outlets (left) on NATO communications receiver allow test equipment and tools to be plugged in right at working area.



Fig. 13. Entire klystron carriage (left) rides on wheels on NATO "Ace High" 10-kw power amplifiers. Tracks guide entire assembly which can be rolled in or out for maintenance.



Fig. 12. Stepped coil supports (right), easily turned aside with a few turns of a screwdriver, allow large coils on klystron carriage to be lowered easily, then returned to their exact original position.

Plug-in modules can be used to house not only conventional electronic components, but electromechanical components as well. The amplifier of Fig. 15 includes a number of such plug-in modules (Fig. 16). Each is secured to the chassis by two screws. The front panel has connectors for making all system interconnections as well as a convenient test-point area.

A key part of the HU2K-1 helicopter automatic stabilization system, this particular module concept was evolved in broad terms by the Kaman Aircraft Corp. of Bloomfield, Conn., with the final design detail and manufacturing accomplished by John Oster Manufacturing Co. in Racine, Wis.

99 Per Cent Plug-In in Digital Voltmeter Series

Some rather new devices showing very close attention to maintainability factors are the digital voltmeters manufactured by Non-Linear Systems, Inc. of Del Mar, Calif. In these meters, plug-in stepping switches can be changed in three minutes rather than the two to twelve hours normally required. Voltage-divider decade resistors are also packaged in plug-in containers so they, too, are completely interchangeable.

In the Series 20 instruments (Fig. 17), four of the circuit boards are completely interchange-



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Fig. 14. Performance-monitor panels on BMEWS communications equipment, designed by REL, are mounted on hinges which are secured through special slottings. Panel can be swung out or removed entirely.

CIRCLE 36 ON READER-SERVICE CARD

Designing for Maintainability



ACTION

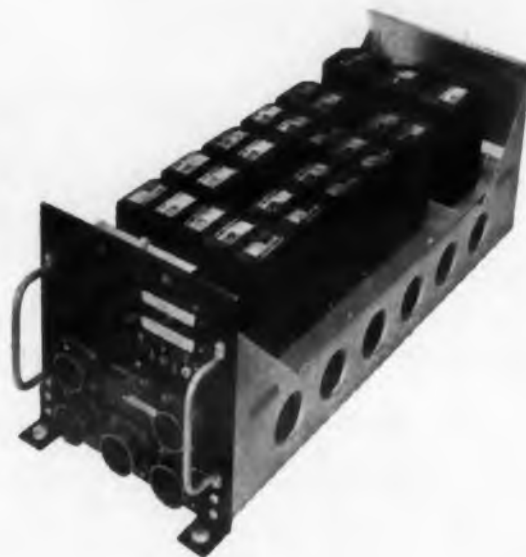


Fig. 15. Some of the plug-in modules in this amplifier (left) contain conventional electronic circuits. Others house mechanical assemblies. Module design is joint effort of Kaman Aircraft Corp. and John Oster Manufacturing Co.

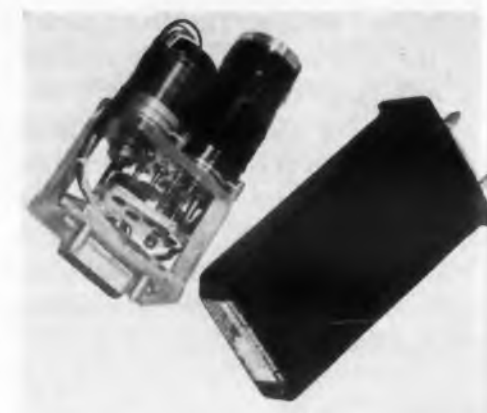


Fig. 16. A typical electro-mechanical module (right) before and after being hermetically sealed.

able. A failure of any one of them does not cause the instrument to fail completely. Instead, the malfunctioning circuit board can be inserted in the least significant decade and the voltmeter can be used as a three-digit instrument rather than a four-digit instrument.

Test-equipment manufacturer Hewlett-Packard of Palo Alto, Calif., has several approaches to improving maintainability. In each equipment, H-P lays out components to assure accessibility. Internal controls required for periodic maintenance and/or recalibration are grouped and clearly identified.

Infrequently used controls are normally not accessible to the operator. This reduces the possibility of accidental or unintentional adjustment. Frequently used calibration controls are often grouped behind access doors so the instrument can be calibrated without being removed from its cabinet.



Fig. 17. More than 99 per cent of the components on this Non-Linear Systems digital voltmeter are on plug-in modules. Even the digital readout snaps out for easy lamp replacement.

H-P also provides manuals with very thorough maintenance information and troubleshooting procedures.

Different Techniques Needed For Different Requirements

Mr. R. E. Young, electronics manager at Sir W. G. Armstrong Whitworth Aircraft Ltd. of Coventry, England, reports on a number of techniques used to improve equipment maintainability. The "open" construction illustrated in Fig. 18 maximizes access to components. The standard base on which the components are mounted also serves as an excellent heat sink.

Of course, where high component density is a paramount consideration, this approach is not satisfactory; the one shown in Fig. 19 is better. Here, specific functions are isolated within appropriate equipment blocks which are easily withdrawn from a larger assembly. The isolation helps eliminate undesirable interaction between circuits during tuning and adjustment.

In this Armstrong Whitworth Aircraft equipment, each module is laid out to protect vulnerable parts from damage during service. Thus, when a module is placed on its side for service, it will rest on a pair of pillars or on a sturdy, metal-cased capacitor.

Patchboard Test-Point Area Provides Circuit Nerve Center

Engineers at Hagan Chemicals & Controls, Inc. in Pittsburgh rely heavily on the use of modular construction to improve maintainability. Each module has a patchboard (Fig. 20), with test points wired to important circuit junctions.

Product-engineering manager, Robert Nelson, points to an additional advantage of these access points in an analog control system. For special system requirements, they can be wired to ex-

ternal relays or switches to provide additional circuit flexibility.

In the Hagan equipment, the use of access points is carried over to a system nerve center (Fig. 21), where interconnections between operational-amplifier modules, panel-control stations, transducers, and final control elements are

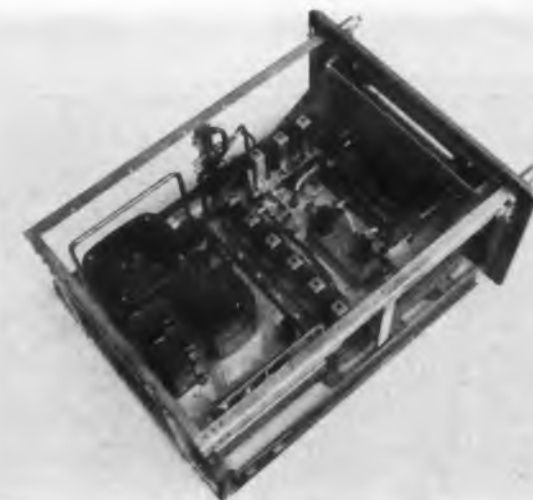


Fig. 18. Airy, open construction in this Armstrong Whitworth Aircraft Ltd. uhf receiver makes everything easy to get at. But component density is low.



Fig. 19. For higher component densities, AWA isolates functions to specific plug-in blocks.

brought to another patchboard. There, each module is identified by a number and each wire by a letter.

Centralized Nerve Center In Pull-Out Drawer

A particularly convenient application of the "nerve-center" approach appears in Minneapolis-Honeywell's load and frequency-control system. All critical test and calibration points in this system are brought out to a single, pull-out drawer (Fig. 22), providing a centralized, accessible, test area. The Honeywell system also uses plug-in modules for all major components of the system.

Expendable Module Concept To Lower Operation Cost

The plug-in module has become an accepted feature in a vast array of equipments in the past few years. It was popular even before great emphasis centered on maintainability. But with the growing emphasis on maintainability, a new type module has come to be recognized, and with it, a new philosophy has come to receive more and more serious attention.

In about 1 cu-in., the new type module is, of course, the expendable one—designed to be thrown away if it should fail. Lear, Inc. of Grand Rapids, Mich., has designed such a module—a hermetically sealed, oil-filled, throw-away module with components mounted on a flexible pc board (Fig. 23).

Roy Malarik, responsible for the design of the Lear module, points out that the most complex of these standard modules, a seven-transistor amplifier, has a predicted mean time to failure of 2,200 hr and a price of about \$180. These characteristics compare very favorably with the optimum module size proposed by the National Bureau of Standards.*

The NBS study, considering only vacuum-tube modules, concluded that an optimum expendable module should have from four to eight tubes; it should have an average mean time between failures of 1,000 to 2,000 hr; and it should cost between \$95 and \$185.

Varied Approaches to Power-Supply Design

That there are different approaches to maintainability is apparent in the power supplies

* The NBS report, "Expendable Modules as Bases for Repair-at-Failure Maintenance," is available at \$2.25 from the Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. A digest of this report appears in ELECTRONIC DESIGN, Aug. 17, 1960, pp 106-150.



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CIRCLE 37 ON READER-SERVICE CARD

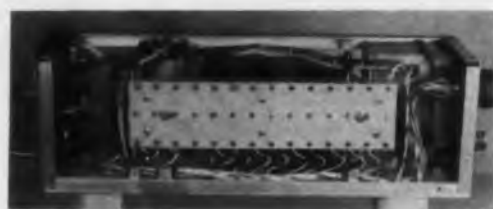


Fig. 20. Chassis patchboard gives access to important circuit junctions in this piece of equipment designed by Hagan Chemicals & Controls.

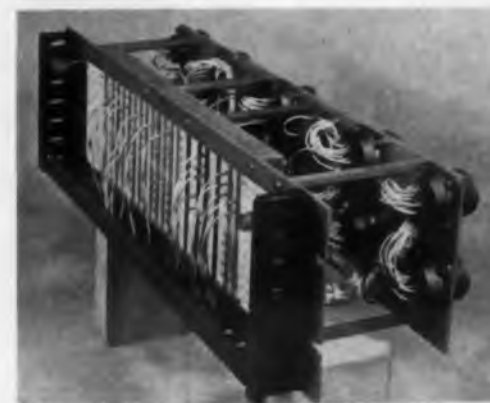


Fig. 21. System patchboard serves as nerve center for entire equipment.

designed by two manufacturers—Mid-Eastern Electronics, Inc. of Springfield, N. J., and Victory Electronics, Inc. of Westbury, N. Y.

Mid-Eastern, a test-equipment manufacturer who made no power supplies, conducted a survey and learned that power-supply users were complaining. They objected to the fact that if something went wrong in a power supply, it was extremely difficult to troubleshoot the unit since parts layout was awkward and parts were inaccessible. The power-supply users also complained about the use of balanced amplifiers with selected transistors.

In response, Mid-Eastern provided a line of 19 power supplies using pre-assembled, standard, plug-in modules (Fig. 24). Three of the modules are interchangeable for all models in the series. Five other modules can be used for a variety of different voltage-current combinations. The entire series uses identical color coding.

Since there are no selected parts in the units, and since they all are designed along identical

lines, a technician who learned to repair any model could easily repair all 19.

Power Supply in Two Parts To Reduce Down Time

A somewhat simpler approach to power-supply design appears in the supplies manufactured by Victory Electronics. Reasoning that the basic power supply, with a transformer, choke, and silicon diodes is quite reliable, and that elements for close regulation—transistors and feedback circuitry—are less reliable, Victory designed two separate units.

A basic supply provides 1 per cent regulation. A separate regulator, for 0.25 per cent regulation or one for 0.05 per cent regulation, can be mounted on the basic supply without any change of wiring. Both basic supply and external regulator can be operated independently.

By separating the more complex regulator from the basic supply, Victory feels that maintainability is enhanced.

Flat-Tray Chassis Simplify Component Testing

Another approach to accessibility appears in the marine radio-telephone equipment manufactured by Pearce-Simpson, Inc. of Miami. Engineers at Pearce-Simpson design all chassis as basically flat trays. They never use deep chassis as designers at the company feel that deep chassis invariably cover up many components and make testing and replacement difficult if not well-nigh impossible.

In component placement, they try to avoid layer construction. But where they must cover one component with another, they make the more reliable component the one which is the more inaccessible.

Integral Units Needed In Individual Subassemblies

At Shepherd Industries, Inc. in Nutley, N. J., the concept of individual subassemblies is used



Fig. 22. Centralized test and calibration area, mounted on a pull-out drawer, serves as nerve center in Minneapolis-Honeywell control system.



Fig. 23. Lear's expendable module, with flexible PC board, has all input, output, and reference signals conveniently available for maintenance at the header. The 1 cu-in. module is available with several basic configurations.



Fig. 24. Basic modules can be used in 19 different power supplies designed by Mid-Eastern Electronics.

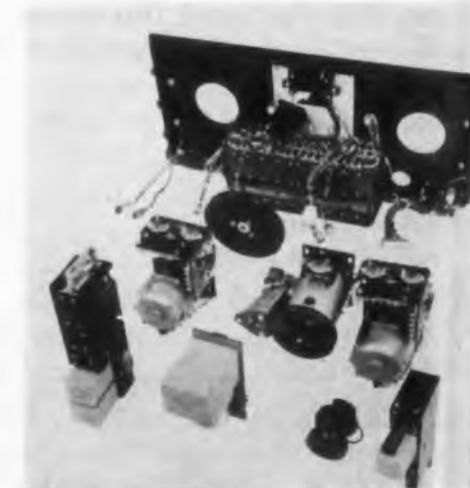


Fig. 25. Integrated, individual subassemblies fit together easily in Shepherd Industries' tape transports.

in the design of tape transports. But in the Shepherd equipment, each subassembly must constitute an integral unit as shown in Fig. 25. Most subassemblies in the tape transport are easily removed by releasing a connector and unscrewing four bolts. Test points are located on PC boards with their associated circuitry.

An important feature cited by William Murphy, manager of electronic circuit development, is the close-tolerance spacing from the mounting surface of magnetic heads to the first track. If it ever becomes necessary to replace a head, it is necessary only to unplug and unscrew the old head and replace it with a new one. In most cases, no adjustment is necessary to align the head on the transport.

Large, Round-the-Clock Systems Need Special Features

Large systems, especially those which must operate on a round-the-clock basis, often require special maintenance features not necessary with systems designed for intermittent operation. One example is the Air Traffic Control Beacon Ground Station designed by Telecomputing Corp. in Hollywood.

This system features a standby channel which can be switched into operation at any time. It can be operated, tested, or serviced without affecting the operating channel. For those portions of the circuit that cannot be channelized, spare units are installed next to operating units so connections can be switched rapidly. All units in the system are designed for servicing from the front of the system.

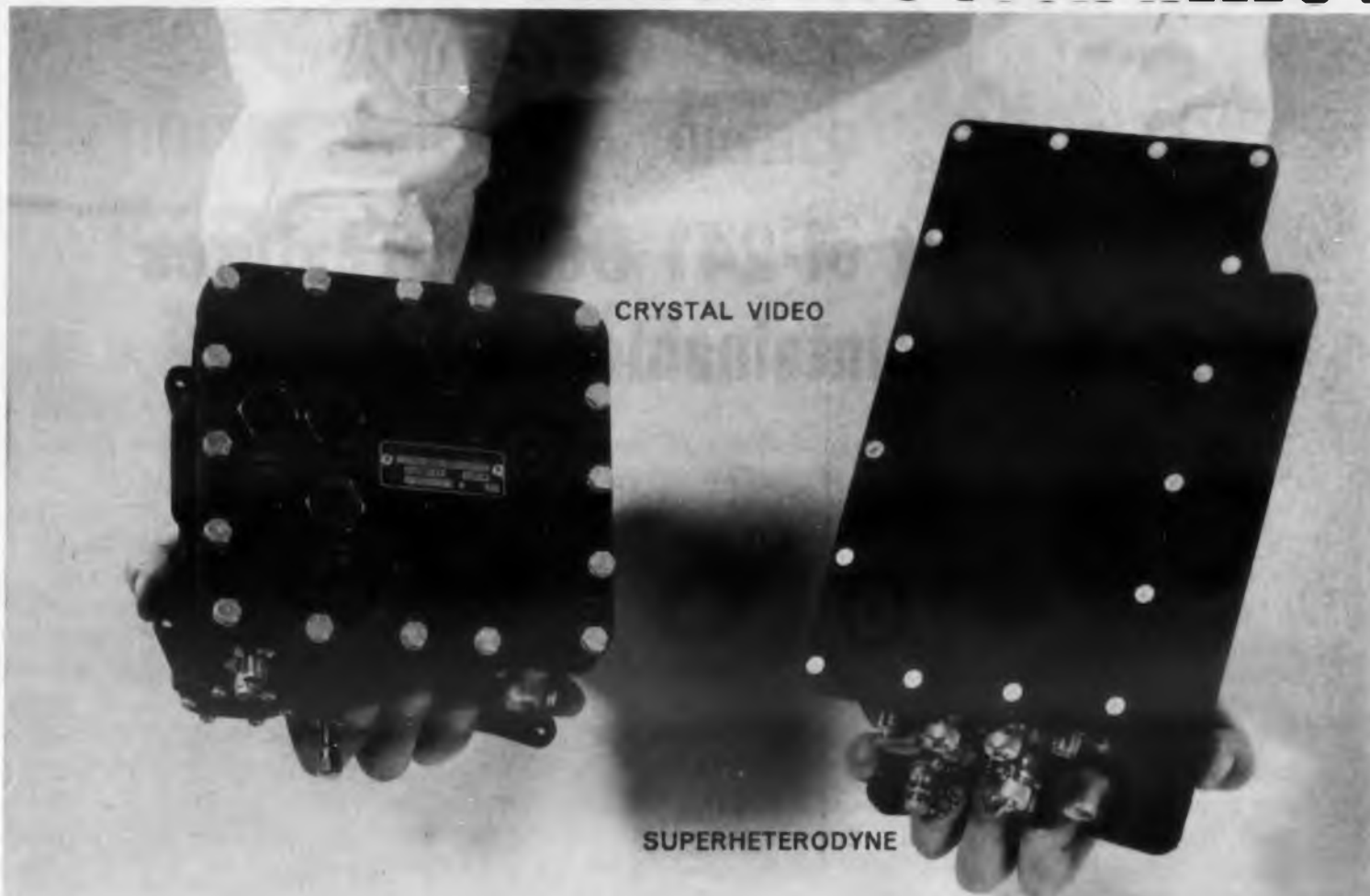
In addition, small components, terminals of large components, test points, and adjustments are accessible when the front door of the unit is opened. Small components are mounted on vertical terminal boards that swing 45 deg to the right or left to improve access in the equipment. All wiring is color-coded and symbol designations of all components are marked adjacent to the components.

Common Features Mark All Maintenance Units

To the extent that any equipment is designed for maintainability, it will share certain features with all other such equipments. If not in the details, then certainly in the broad concept, each will show attention to the needs of the maintenance man.

From the broadest viewpoint, these needs reduce to two—the need to localize faults quickly and the need to put a system back in operation quickly. The success of any maintainability effort can be measured by these two yardsticks. ■ ■

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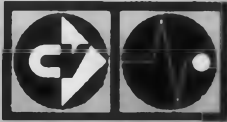
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CIRCLE 39 ON READER-SERVICE CARD



Check List of 241 Design Features For Maintainable Equipment

IN "NO TIME-BASE Needed in Signal Corps Maintainability Specifications," (p 58), author Robert Redfern cites the key role played by a check list of design features for maintainable electronic equipment.

Implicit in Mr. Redfern's approach is the concept that it is a lot easier to determine, for example, if all displays can be observed from one position, than it is to measure the average time required by a technician with average skills to localize an average fault and to effect an average repair under average environmental conditions. And the more easily obtained results are more meaningful and more useful in arriving at

an evaluation of the maintainability of a given equipment.

With the kind permission of the copyright holders, American Institute for Research, of Pittsburgh, Pa., *ELECTRONIC DESIGN* is pleased to present this checklist. It is taken from a research report, "Development of an Index of Electronic Maintainability," authored by M. R. Munger and M. P. Willis, and prepared by AIR for the U. S. Army Signal Material Support Agency.

The editors of *ELECTRONIC DESIGN* feel that this check list should prove of great value to all electronics engineers who must design equipment for maintainability.

Displays and Controls

1. Are all displays in equipment checkout located so they can be observed from one position?
2. On units with operator's display, are maintenance displays behind an access door on the operator's panel?
3. On units without an operator's panel, are maintenance displays on an accessible face of the equipment?
4. Are all displays located so they can be observed without disassembling or removing any portion of the installation?
5. Do labels tell which block in the block diagram of the equipment is being monitored?
6. Do labels tell what function is displayed rather than just what electrical characteristic is indicated?
7. Do display scales give only information needed by the maintenance technician?
8. Where center-null displays are used, is the circuit designed so the indicator will not rest in the in-tolerance position if power fails?
9. Are moving-pointer, fixed-scale indicators used for displays for adjustment procedures?
10. Are all-or-none type displays used when they will convey sufficient information?
11. Are numerical scales used only when the maintenance technician needs quantitative information?
12. Do display scales show the tolerance band as well as correct reading? Tolerance band should be shown as a single, center-scale colored area.
13. If arithmetic must be applied to measured data, are decimal transformation factors provided (in the manual or on the equipment) to simplify the calculations?

14. Do display scales have only enough graduations to give the required accuracy without interpolation becoming necessary?
15. Are special calibration points provided either on the dial face or on a separate overlay if the edges and midpoint of the tolerance range are not sufficient for accurate calibration?
16. Do loud auditory signals supplement telelights for displays that are not constantly monitored when it is important to note changes in their indications immediately?
17. Do indicators provide immediate adjustment information during the adjustment procedure?
18. Are all adjustment controls located on a single panel?
19. Are all controls located where they can be seen and operated without disassembling or removing any part of the installation?
20. Are front-panel maintenance controls covered by an access door?
21. Are controls placed on the panel in the order in which they normally are used?
22. Are controls numbered in the sequence of their operation when they are used in a fixed procedure?
23. Do knobs for precision settings have about 2-in. in diameter?
24. Do labels state the function of the controls?
25. Are control-position markings descriptive rather than coded?
26. Are scales on controls fine enough to give only required accuracy?
27. Do controls move smoothly except at detents?
28. Do multiposition selector switches have sufficient spring loading so a switch cannot be left between detents inadvertently?

29. Are push-buttons spring-loaded so they do not produce inconvenient pressure against the finger?

30. Do tool-operated controls take a screwdriver or other medium-size tool?

31. Does each step in adjustment procedure require only one control to obtain an in-tolerance indication?

32. Are all related displays and controls put on the same panel?

33. Is each display placed so it can be read accurately and conveniently while the control is operated?

34. Are display labels and control labels correlated so the display label suggests which controls affect the reading?

35. When large display movements are required, are they obtained through small control movements?

36. When fine adjustments are required, are they obtained through large control movements?

37. Where a precise setting in a wide range of display movement is required, is a coarse-fine control provided?

External Accessibility

1. Are maintenance accesses installed on equipment faces that will be accessible when the equipment is installed?
2. Is each access labeled uniquely so each one can be clearly named in job instructions?
3. Does each access label indicate the items which are accessible?
4. Does each access label indicate what auxiliary equipment is to be used at the access?
5. Does each access label indicate the recommended time period for performing maintenance operations?
6. Is a transparent cover or a quick-opening metal cover used for visual-inspection?
7. Are access openings without covers used where they are not likely to impair performance?
8. Are hinged doors used instead of cover plates held by screws?
9. If there is insufficient space for opening hinged doors, are cover plates with captive quick-opening fasteners used?
10. Are no more than four screws used in screw-fastened access plates?
11. On hinged access doors, is there some means to hold the door open?
12. Are all units and parts labeled fully?
13. Are parts, such as resistors, capacitors and tubes, marked with relevant information about their electrical characteristics?
14. Is each terminal labeled with the same code symbol as the wire attached to it?
15. Are labels etched or embossed into the components or chassis rather than painted or stamped on the surface?
16. Are labels visible?
17. Is the color code explicit in job instructions and/or on a panel of the color-coded equipment?
18. Is the meaning of a particular color consistent for a given application (resistor, capacitor, wiring)?
19. Do color-coded markings resist chipping, and are they located away from points of physical wear?
20. Is each wire labeled uniquely to facilitate tracing?
21. Is there an overload indicator for each major component even if it may be desirable to keep overloaded circuits operating?

22. Are capacitors and other parts that retain heat or voltage after the equipment is turned off located where technicians are not likely to touch them while changing parts such as tubes?

23. Are internal controls such as switches and adjustment screws located away from high voltages?

24. If screwdriver adjustments must be made blind, are the screw shafts vertical so the screwdriver will not fall out of the slot?

25. Are screwdriver guides provided on adjustment points near high voltages?

26. Are controls located away from high-voltage points and hot tubes?

27. Are internal displays lighted when necessary?

28. Are units that frequently must be pulled out for checking mounted on roll-out racks, slides, or hinges?

29. Are stops always provided on roll-out racks and drawers to prevent their being dropped?

30. Is it easy to override stops for replacement of racks and drawers?

31. Can units in drawers and slide-out racks be pulled out without breaking electrical connections?

32. Are units and assemblies positioned so replacing one unit does not require removing other units for access?

33. Are parts mounted in an orderly array on a two-dimensional surface and not stacked on one another?

34. Are parts mounted on one side of a surface and associated wiring (including printed or soldered circuits) on the other side?

35. Are easily damaged components (such as miniature tubes) mounted so they are protected from damage?

36. Are parts such as resistors, capacitors, tube sockets, etc., mounted on subassemblies rather than on the unit's chassis?

37. Are all replaceable parts made accessible by fold-out construction or other special construction techniques when necessary?

38. When fold-out construction is used, are parts and wiring positioned to prevent damage when the assembly is opened or closed?

39. Are hinged assemblies braced or otherwise held in the "out" position while they are being repaired?

40. Are easily damaged conductors such as waveguides, high-frequency cables, or insulated high-voltage cables protected?

41. Are field-replaceable units independently mounted to the housing and not to each other so only the unit to be replaced need be moved?

Test Points

1. Are test points accessible?

2. Are internal test points clustered where they will be most accessible when installed?

3. Are test points located so parts of equipment do not impede access to them?

4. Are test points grouped conveniently for sequential checking?

5. Is each test point labeled uniquely?

6. Is each test point labeled with the proper signal (with tolerance limits) that should be measured there?

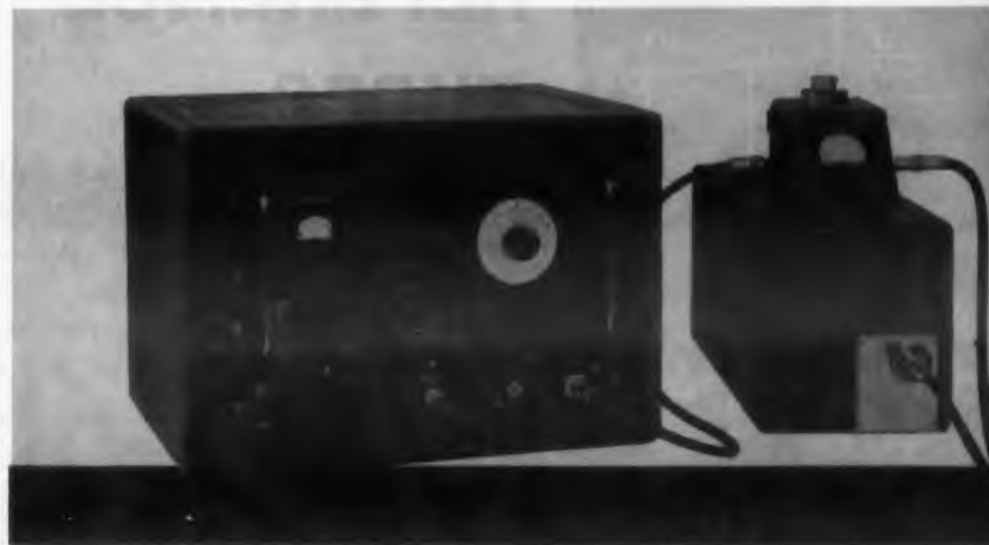
7. Does each test-point label indicate the unit whose output is available at the test point?

8. Are test points color-coded so they can be easily located?

9. Are luminescent markings used so test points

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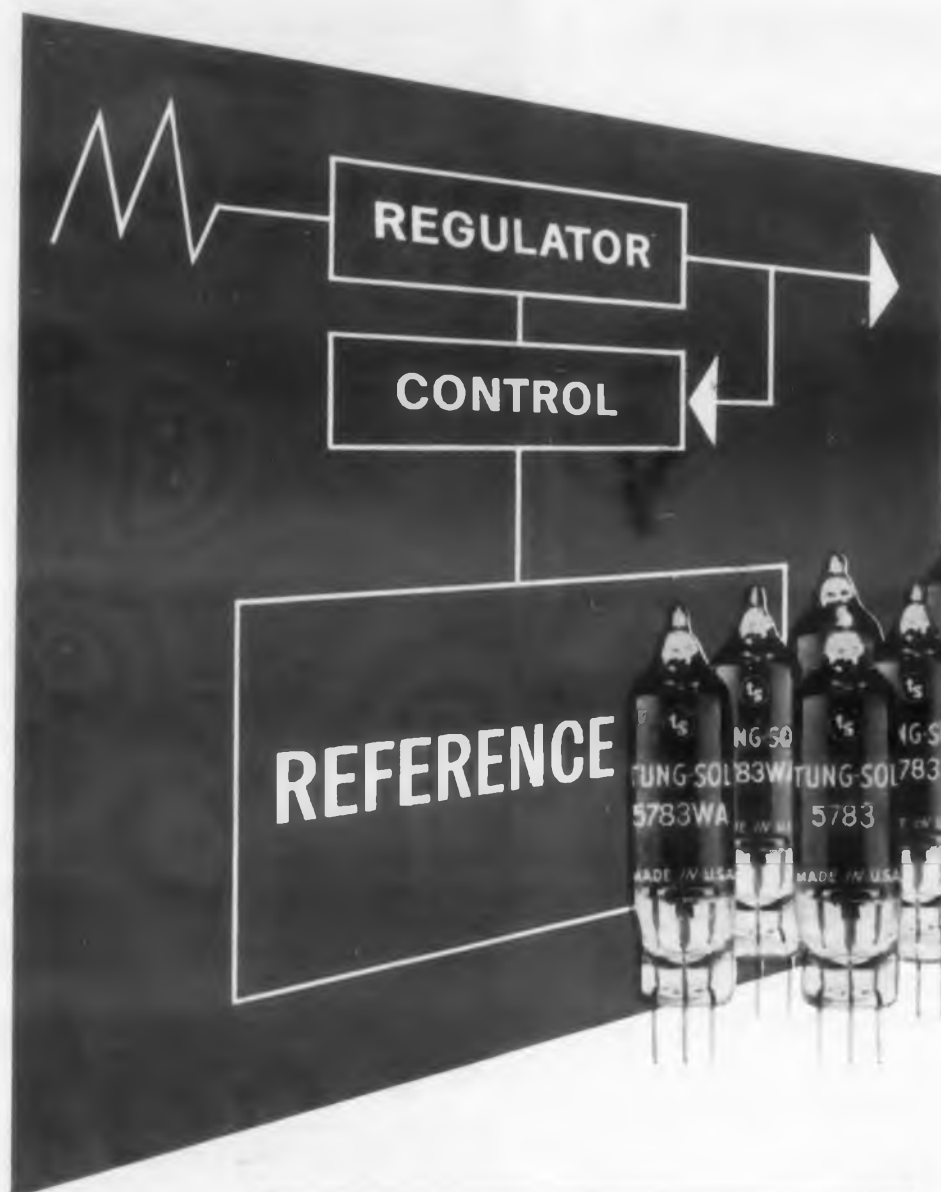
Sierra 290B Test Set

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TUNG-SOL VOLTAGE REFERENCE TUBES



A regulated power supply is only as stable as its reference element.

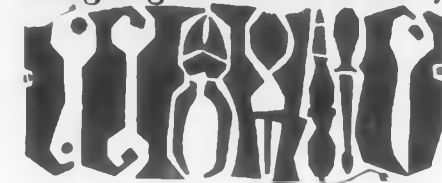
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CIRCLE 41 ON READER-SERVICE CARD

Designing for Maintainability



CHECK LIST

can be read in very low illumination?

10. If maintenance procedures require a test probe to remain connected to a test point without being held by the technician, does the test point have a quick-disconnect fastener?

11. Is there an exposed test point at the input and output of each group of major units?

12. Is there an accessible test point at the input and output for each major unit or assembly?

13. Are there test points for the direct check of all replaceable parts?

14. Is there an accessible test point at the input and output of each circuit or stage?

15. Are cables "fanned out" in junction boxes for checking if standard test points are not provided?

16. For non-permanent connections, do test leads require only a fraction of a turn for attachment to prime equipment receptacles?

17. Are test points located close to the controls and displays used with these test points?

18. Is each test point used in an adjustment procedure associated with only one adjustment control?

19. Does the signal available at each test point indicate clearly when the associated control is in the required position?

20. Is the test point located so the technician at the control can read the signal available at the test point?

21. Are all signal inputs for alignment procedures available in one standard signal generator?

22. Are units activated by a triggering pulse that has a self-triggering capability?

Cables and Connectors

1. Can units that are difficult to connect when mounted be moved to a more convenient position for connecting and disconnecting their cables?

2. Are cables long enough so each functioning unit can be checked in a convenient place?

3. Are cable harnesses designed so they can be fabricated in a shop or factory and installed as a unit?

4. Are cables routed so they cannot be pinched by doors, lids, etc.?

5. Are cables routed so they will not be walked on or used for hand holds?

6. Are cables routed so they are accessible to the technician and are not under floor boards or behind panels that are difficult to remove?

7. Are cables routed so they need not be bent sharply when connected or disconnected?

8. Can cables with attached connectors pass easily through walls, bulkheads, etc.?

9. Do plugs and receptacles have painted arrows or other indications to show proper position of keys for aligning pins?

10. Are plugs and their corresponding receptacles coded alike?

11. Can plugs be quickly disconnected?

12. Are the pins in each plug clearly identified?

13. Are plugs designed so it is impossible to insert any plug in the wrong receptacle?

14. Do aligning pins or keys extend beyond electrical pins?

15. Are unkeyed, symmetrical arrangements of aligning pins avoided?

16. Are plugs having a self-locking safety catch used instead of plugs that must be safety-wired?

17. When a portion of the equipment is removable, does the cable connecting the removable portion to the rest of the equipment have a plug and receptacle that will disconnect before the cable breaks?

18. Is the equipment designed so receptacles are "hot" and the plugs are "cold" when disconnected?

19. Are cables connected to equipment by plugs and receptacles rather than by pigtailling?

20. Are field-replaceable assemblies and subassemblies plug-in rather than solder connected?

21. Can connectors be reached easily for replacement or repair?

22. Does the design of connectors prevent electrical contacts from being short-circuited by external objects?

23. Are connectors located far enough apart so they can be grasped firmly?

24. Are terminals for soldering far enough apart so work on one terminal does not damage neighboring terminals or other parts?

25. Are terminals and other connections for soldering long enough so insulation and other surrounding materials are not burned by the soldering iron?

26. Are U-lugs used rather than O-lugs?

27. Are connectors designed to prevent excessive tightening?

28. Are connectors for auxiliary equipment designed so no tools are required for their operation?

29. If tools must be used to operate connectors, are standard hand tools sufficient?

30. Do connectors for auxiliary equipment operate in a fraction of a turn or with quick snap action?

31. Is no more than one full turn of a connector required to connect test equipment to a test point?

32. Can wires be unsoldered and removed from lugs without damaging the lugs?

Internal Accessibility

1. Is accessibility to parts impeded by large parts that are difficult to remove?

2. Are components placed so there is sufficient space to use a test probe, soldering iron, and other tools without difficulty?

3. Are units placed so structural members do not prevent access to them?

4. Are components placed so all throw-away assemblies or parts are accessible without removing other components?

5. Is equipment designed so it is not necessary to remove any assembly from a major unit for troubleshooting?

6. Can screwdriver-operated controls be adjusted with the handle clear of obstructions?

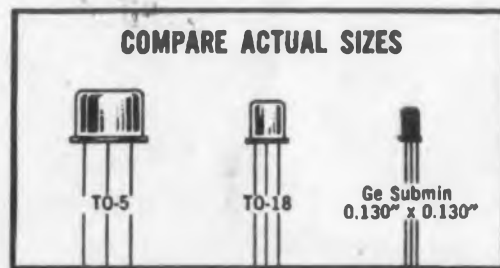
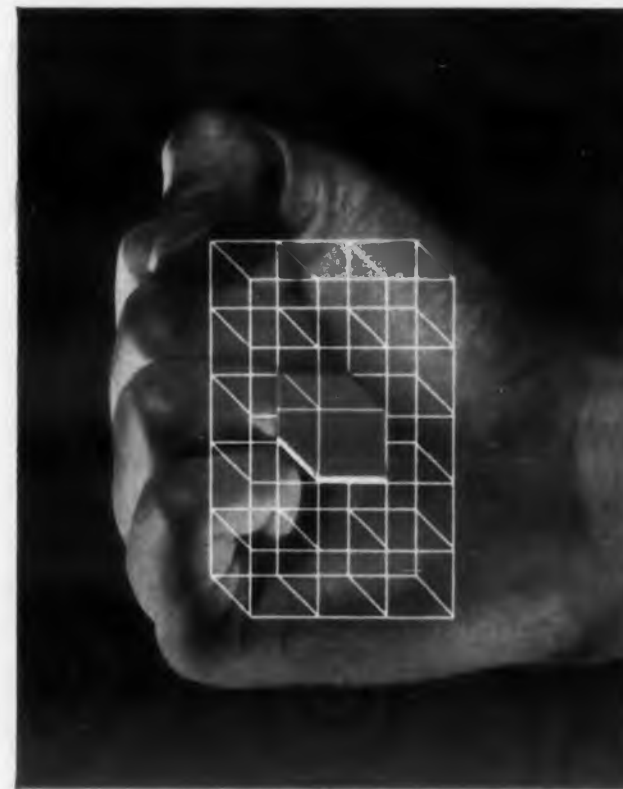
7. Are units laid out so maintenance technicians need not retrace their movements during checking?

8. If field-maintenance procedures require tube replacement, is it possible to do this without removing units?

9. Are units placed so tubes can be replaced without removing assemblies and subassemblies?

10. Are units placed so resistors, capacitors, wiring,

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Squeeze Fifteen Cubic Inches
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	Raytheon Submin	Standard TO-5
Volume, cu. in.	0.00109	0.0231
Packing Density, no./cu. ft.	1,000,000+	70,000
Packing Density, no./cu. in.	600+	41
Weight, oz.	0.005	0.040

Where reliability is a must, these submins are tops. Welded package provides truly hermetic seal. Meets MIL-S-19500B: 96-hr. salt spray, 20,000 G centrifuge, 100/2000 cps variable frequency vibration at 20 G, 1/2ms mechanical shock at 1500 G, 0° to 100°C thermal shock in water, 10-day moisture resistance cycle, tem-

perature cycling. Storage and operating life match AQL's of military specifications at 100°C effective junction temperature.

These new germanium submins are equivalents of standard Raytheon transistors in electrical performance and reliability. Write for data sheets today.

GERMANIUM SUBMIN TYPE	TO-5 EQUIVALENT	VCE Max. volts	fab typical mc	hFE typical	Cob typical pf	ICBO typical μA	RSAT typical ohms
PNP 2N799	2N404	-24	12	45	12	2	1.3
PNP 2N805	2N428	-15	17	80	12	2	1.1
PNP 2N811	2N416	-12	10	80	12	2	65*
PNP 2N813	2N417	-10	20	140	12	2	100*
NPN 2N815	2N388	20	8	110	9	3	3.5
NPN 2N821	2N440	15	10	70	9	3	3

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SEMICONDUCTOR DIVISION

RAYTHEON

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CIRCLE 42 ON READER-SERVICE CARD

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CIRCLE 43 ON READER-SERVICE CARD

Designing for Maintainability



CHECK LIST

- etc., do not interfere with tube replacement?
11. Are all miniature tube sockets oriented with the gap facing one way?
 12. Where tubes must be inserted through small accesses, is there an external indication of the proper position insertion (such as, matching stripes or dots on the tube or plug top and on the cabinet)?
 13. Are all fuses located so they can be seen and replaced without the necessity of removing other parts or subassemblies?
 14. Are fuse assemblies designed and placed so no tools are required for replacing a fuse?
 15. Do edges of accesses have internal fillets of rubber, fiber, or plastic to protect the technician's hands or arms?
 16. Are there safety interlocks on accesses that lead to high-voltage equipment?
 17. Do access openings permit the most direct possible access?
 18. Is sufficient room provided for the various tasks performed on the equipment with one hand?
 19. Is enough room provided for tasks requiring insertion of two hands and two arms through the access?
 20. If the technician must see what he is doing inside the equipment, does the access provide enough room for hands or arms and for an adequate view?
 21. Are irregular extensions such as bolts, tables, waveguides, and hoses easily removed before the unit is handled?
 22. Do access doors have whatever shape is necessary to permit passage of necessary components and implements?
 23. Are units removable from the installation along a straight or moderately curved line?
 24. Are heavy units (more than 25 lb) within normal reach of a technician?
 25. Are provisions made for supporting units while they are being removed or installed?
 26. Are there rests or stands on which units can be set to prevent damage to delicate parts?
 27. Is a special guide tool attached to the access when an adjustment control under the access would otherwise be difficult or dangerous to locate?
 28. If the technician must work on the equipment with the power on, is a cheater switch provided that automatically resets when the access is closed?
- ### Cases
1. Do fasteners for assemblies and subassemblies fasten or unfasten in a maximum of one complete turn?
 2. If bolts are used, is the number of turns required to tighten or loosen them minimized (less than about 10 turns)?
 3. When tool-operated fasteners are necessary, do these fasteners require only standard hand tools?
 4. Are combination head mounting bolts that have a deep internal slot and hexagonal head used?

5. Do all bolts requiring high torques have an external hexagonal head?

6. Are mounting bolts made semi-permanently captive (for example by providing snap-on collars)?

7. Are mounting bolts and fasteners clearly labeled as such?

8. Are screws with different threads made in different sizes to prevent their being forced into the wrong holes and consequently stripped?

9. Are the heads of mounting bolts and fasteners unobstructed by nearby components or structural members?

10. Are only standard hand tools used in replacing assemblies and units?

11. Are guide pins always provided on units and assemblies for alignment during mounting?

12. Are the holes in covers and shields through which mounting screws must pass to the basic chassis large enough so a screw can pass even without perfect alignment?

13. Are cases designed so they can be lifted off units rather than units lifted out of cases?

14. Are cases made enough larger than the units they cover so that wires and other components will not be damaged when the cases are put on and removed?

15. Are guides and tracks provided to help prevent cases from tilting?

16. When the edge of a case must be slid over rubber stripping or other sealing material, does the sealing material adhere tightly enough so it does not buckle or tear, damaging the seal or jamming the case?

17. Is the method of opening a cover obvious? If not, is an instruction plate attached to the outside of the cover?

18. Do covers and cases have rounded corners and edges for safety?

19. Is it obvious when a cover is not in place and not secure?

20. Are no more than six fasteners used to secure a case?

21. Are the same size fasteners used for all covers and cases on a given piece of equipment?

22. Do covers and cases have their own stock reference in the event they must be replaced?

23. Are ventilation holes in covers made small enough so test probes or other conductors cannot be inserted inadvertently and touch high-voltage sources?

24. Do units weighing more than 10 lb have convenient handles to facilitate removing, replacing, or carrying?

25. Are handles provided on small, light units that otherwise would be difficult to grasp, remove, or hold without gripping delicate components?

26. Are handles provided on covers to facilitate holding the cover and carrying the unit?

27. Are handles placed over the center of gravity of units so they do not tip when being lifted or carried?

28. Are handles the technician must grip firmly at least 4-1/2 in. high and 2 in. deep?

29. Are handles and grips comfortable?

30. Are handles and grips placed where they are not likely to catch on other units, wiring or structural members?

31. Do heavy units have recessed grips near the back to facilitate handling? (continued on p 56)

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CIRCLE 44 ON READER-SERVICE CARD

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DATE: SEPTEMBER 18, 1960 OUR ORDER # 93-534

SOLD TO: SHIP TO:

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1315 GLENWOOD AVENUE
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QUANTITY DESCRIPTION SHIPPED DATE QUANTITY PRICE

20,000 FT.	12-2 CABLE IN ACCORDANCE WITH MIL-C-3756B			
25,000 FT.	CO-03 MCF (3/16) SJO 0375 IN ACCORDANCE WITH MIL-C-3432A			
100,000	COS-2 (18) IN ACCORDANCE WITH MIL-C-3884			

MATERIAL TO BE SOURCE INSPECTED IN ACCORDANCE WITH APPLICABLE SPECIFICATIONS

CONTRACT #16135-PP-60-C1-C8

THIS ORDER IS ACCEPTED SUBJECT TO CONDITIONS PRINTED ON REVERSE SIDE HEREOF.

SHIPPING SCHEDULE

WE WILL SHIP FROM WILLIAMSTOWN, MASSACHUSETTS

ITEMS 1 AND 2 - OCTOBER 15, 1960

ITEM 3 - NOVEMBER 1, 1960

By: _____

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CIRCLE 45 ON READER-SERVICE CARD

Designing for Maintainability



CHECK LIST

Lubricants and Tools

1. Has a lubrication schedule been made for all lubrication requirements?
2. Can lubrication requirements be satisfied by standard lubricants listed in SB-38-5-3?
3. Are lubrication points provided if lubrication is required?
4. Are lubrication points plainly identified?
5. Are lubrication points accessible?
6. Can lubrication be applied with standard tools and devices?
7. Can mechanical components such as gear trains be lubricated without disassembly, or are they designed so that they do not require lubrications?
8. Is the equipment accompanied by a comprehensive list of tools needed for all maintenance tasks?
9. Have tools been specified to cover all maintenance procedures?
10. If special tools are required have they been provided with the equipment?
11. Is each of the tools provided adequate?
12. Are tools that must be used near high voltages adequately insulated where the technician is likely to touch them?
13. When screws must be rotated through many revolutions are speed tools provided if downward force on the equipment will not be harmful?
14. Do screwdrivers have clips to hold free screws that cannot be held easily with the fingers?
15. Do screwdrivers for small-sized adjustment screws have funnel-like shields that aid placement on the adjustment point and prevent slipping off?

Manuals

1. Are check lists provided for routine procedures?
2. If it is necessary to adjust controls with interacting effects, is a step-by-step procedure provided for alternate adjustments?
3. Is step-by-step instruction rather than a narrative paragraph format used to detail maintenance procedures?
4. Are tables and charts used whenever data can be organized in tabular form?
5. Are measurement data referenced to the measurement procedures to be used?
6. Can relationships and interconnections between circuits and between units be determined easily on the schematic diagram?
7. Are waveforms and voltages indicated on the diagram?
8. Do drawings and photographs in the manuals adequately identify the physical features of the equipment to facilitate location?
9. Is nomenclature used consistently in the manuals and does it correspond with markings on the equipment?
10. Is information provided in the manual about the required signal characteristics and tolerances at each test point?

Test Equipment

1. Are instructions for using test equipment written in step-by-step format?

2. Is a signal provided that shows when test equipment is warmed up?

3. If it is not feasible to use such a signal, is the warm-up time required clearly indicated near the warm-up switch?

4. Is there a simple check to indicate when test equipment is out of calibration or is otherwise malfunctioning?

5. Are useful data presented directly on test equipment displays, rather than data which require multiplication or other manipulation?

6. If manipulation of display values is required, are conversion tables provided for the user on the test equipment?

7. If it is not feasible to provide a conversion table, is the transformation factor indicated beside each switch position or display scale that uses the factor?

8. When more than one scale must be viewed, are they and their associated control knobs clearly differentiated by labeling and color coding?

9. Are selector switches provided on test equipment instead of plug-in connections?

10. Are there devices such as circuit breakers and fuses that will prevent damage if the wrong switch or jack position is used?

11. Are there devices such as warning lights, power switches that open automatically when the test-equipment lid is closed, and written warnings that insure the test equipment's being turned off after use?

12. Are the purposes of the tester and cautions in its use indicated on its outer surface?

13. Is there a label on every item the technician must recognize, read or manipulate?

14. Are the outer case and removable parts of items of test equipment clearly labeled using official nomenclature?

15. When adaptors must be used, are they a part of the test-equipment removable items?

16. Are storage compartments for accessories fastened?

17. Is portable test equipment rectangular for convenient storage?

18. Are handles on the outside case of portable test equipment recessed or hinged so they do not take up excessive storage space?

19. Is adequate storage space provided in the lid or cover of test equipment for storing removable items such as leads and adaptors?

20. Are proper locations for the items that go into the storage space indicated?

21. Is there provision in the lid or a special compartment for storing instructions for using the test equipment?

22. Are normal plugs used to connect test equipment and/or bench mock-ups to the outputs and inputs of field replaceable units?

23. Have intercomponent cables been provided to eliminate a mock-up?

24. Is a newly designed mock-up specified only when there is no currently produced mock-up that can be adapted for use?

25. Can test equipment be connected to the prime equipment within about 2 min? ■ ■



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Westinghouse announces a family of tunable X-Band Magnetrons available now for airborne radar service—and new production facilities to meet your requirements at all times. These high-performance magnetrons feature improved stability, minimum frequency drift, excellent spectrums, high efficiency and low voltage operation. The new family not only features Type WL-7008, but also includes Types 7110, 7111, 7112 and 6865A. Some of their typical performance characteristics are as follows:

- Frequency range: 8500 to 9600mc
- Peak power output: 220 Kilowatts
- Pulse widths: up to 2.8 microseconds
- Heater voltage: 13.75 volts
- Frequency range excursion: 7 seconds at 1500 rpm shaft speed

For full information, contact your nearest Westinghouse industrial tube representative, or write: Westinghouse Electric Corporation, Electronic Tube Division, Elmira, N.Y.

YOU CAN BE SURE...IF IT'S **Westinghouse**
Electronic Tube Division Elmira, N.Y.

CIRCLE 46 ON READER-SERVICE CARD





No Time-Base Needed In Signal Corps Maintainability Specifications



Robert Redfern, who was an engineer with the Signal Corps for 16 years, has spent most of the past three years developing maintainability criteria for Signal Corps communications-electronic equipment.

An associate member of the EIA Sub-Committee on Maintainability and of the Task Group on Measurement, Reporting, and Evaluation Techniques, he has played a very important role in developing a detailed, objective procedure for evaluating equipment maintainability during the development cycle. He gives credit for this procedure to American Institute for Research, which developed it under a Signal Corps study contract and which holds a copyright on other than U.S. Government use.

Robert E. Redfern

Chief of Technical Operations
Maintenance Methods Div.
U.S. Army Signal Materiel Support Agency
Fort Monmouth, N.J.*

THE SIGNAL CORPS has an answer to the challenge of specifying and measuring maintainability. A three-fold approach, it establishes a quantitative maintainability requirement for equipment types, specifies the quantitative value of design features, and provides the method for measuring degree of attainment.

Without relying on hard-to-measure *time*, the approach deals exclusively with the equipment design or configuration on the premise that, in terms of a development program or contract, hardware is the only facet the designer can control. A corollary Signal Corps program is aimed at improving the military maintenance system to support the maintainable equipment.

Any quantitative measure of maintainability should consider all facets affecting equipment maintenance; it should be readily understood by all levels of technical and semi-technical personnel; and it should be quickly computable without recourse to lengthy computation.

A measure should provide a clear-cut yardstick by which the worth of an item of equipment, from the standpoint of maintainability,

can be evaluated objectively.

Such a measure should provide the basis for maintainability specifications of a precise, definitive nature which permits a more exacting control over the kind of equipment procured for military use. In addition, a maintainability index should provide equipment designers and developers with a means of checking on the quality, as far as maintenance goes, of their design plans. For these measures or scores to be meaningful, it is necessary to establish minimum acceptable scores for each factor.

Bibliography Shows Wide, Confusing Variety of Definition

A survey of existing maintainability bibliography reveals a confusing variety of definitions of maintainability indicative of the variety of concepts engendered by the peculiarities of the missions of each sponsoring service or agency. Indicative of the variety are the following:

1. Department of Defense defined maintainability as "a quality of the combined features and characteristics of equipment design which permits or enhances the accomplishment of maintenance by personnel of average skills, under natural and environmental conditions in which it will operate."

2. AGREE (Advisory Group on Reliability of Electronic Equipment) coined the following: "Maintainability is defined as the reciprocal of

mean net time to repair failures, where both failures and repairs take place under specified simulated field conditions."

3. RCA, under contract AF 30(602)1623, sponsored by Rome Air Development Center (RADC) said: "Maintainability is the average man-hour requirement rate for all maintenance performed per unit of equipment complexity, with existing personnel under the specified environmental and usage conditions."

4. American Institute for Research, under RADC Project No. 7502, Wright Air Development Center (WADC) Task No. 71502 stated: "Maintainability is a function of the rapidity and ease with which maintenance operations can be performed to help prevent malfunctions or correct them if they occur."

5. The Navy developed a maintainability formula based on down-time for corrective and preventive maintenance related to an average at-sea period.

6. Enticingly concise is the definition proposed by Capt. J. L. P. McCallum of the Navy's Bureau of Weapons: "Maintainability is the ease with which the device can be kept operating."

Each of these definitions provides a concept of maintainability directly related to the approach or field of interest of the sponsoring organization. None, however, provides the basis for evolving a quantitative measure of the maintainability of the hardware product at the point

*Now with IBM Corp., Federal Systems Div., Owego, N. Y.

of emergence from development. Indeed, some even contain terms which, in themselves, raise problems of definition.

To establish a basis for expressing the Signal Corps concept of maintainability a new definition was evolved, expressed as "the degree of facility with which an equipment can be retained in, or restored to, serviceable operation. It is a function of parts accessibility, internal configuration, use and repair environment, and the resultant time, tools, and training required to effect maintenance."

Maintenance Tasks Broken Down to Job Segments

The basic step in developing an index is to identify the elements of the general term "maintenance." The job segments, or elements, are broken down as follows:

1. **Checking** (preventive and corrective). (a) Inspections, (b) Control checks, (c) Test equipment checks.

2. **Adjusting** (preventive and corrective). (a) Mechanical adjustments, (b) Electrical adjustments.

3. **Servicing**. (a) Lubricating, (b) Replenishing, (c) Changing.

4. **Troubleshooting**. (a) To major unit, (b) To sub-unit, (c) To part.

5. **Replacing** (preventive and corrective). (a) Major units, (b) Sub-units, (c) Parts.

6. **Repairing**.

Each of these maintenance elements is affected, to varying degrees, by the factors of equipment design and the conditions of use. The illustration portrays the interaction of the factors of design and conditions of use upon the elements of maintenance.

'Maintenance Consequence Areas' Reveal Poor Maintainability

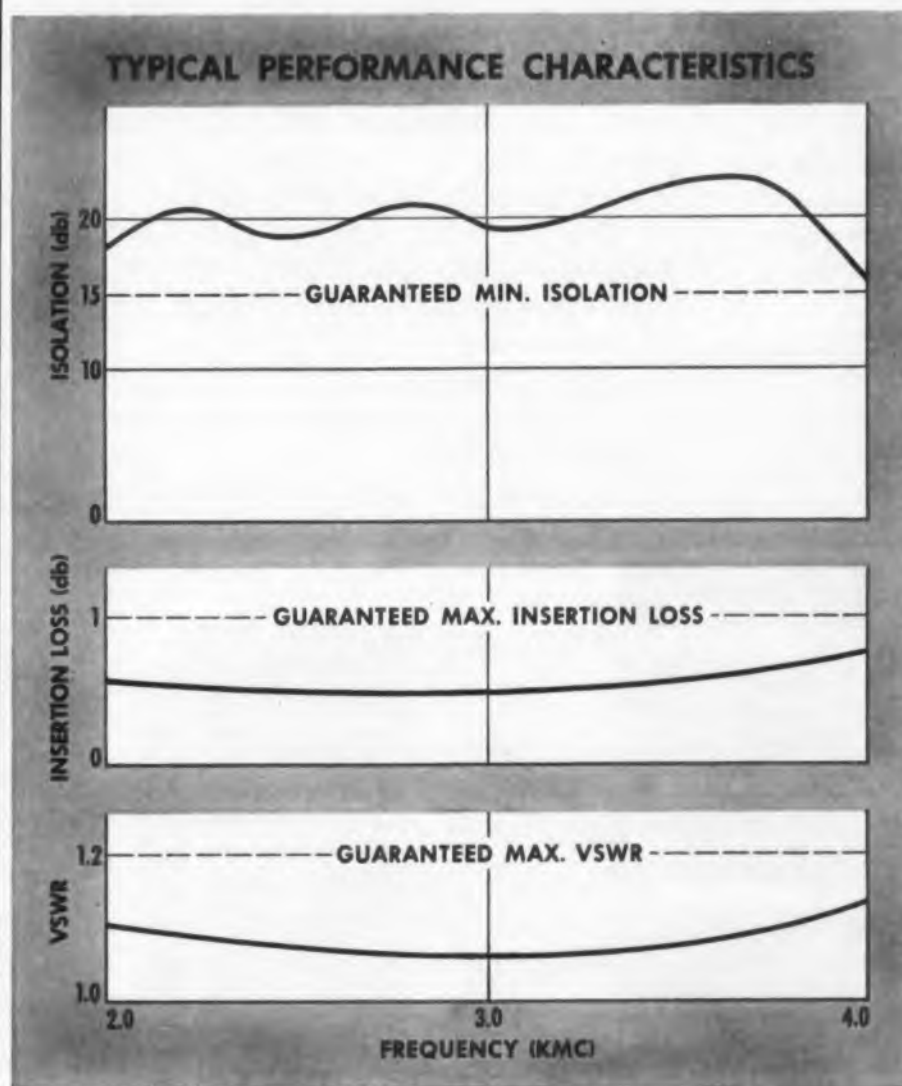
To establish the relationship between design features and conditions of use, the concept of "maintenance consequence areas" was developed. A maintenance consequence is defined as the way in which inadequate design for maintainability affects maintenance load and operations, or mission accomplishment. Analysis of all identified consequences results in consolidation into five primary consequence areas, namely:

1. **Equipment down-time**—the time required to perform preventive and corrective maintenance which prevents operation of the equipment during a period of scheduled operation. This total time does not include maintenance lag time, which is the time lost due to unavailability of parts, personnel, etc. Down-time is generally expressed in terms of equipment hours.

2. **Maintenance time**—the total time required to carry out all preventive and corrective main-

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Octave Bandwidth Coaxial Isolators from 1-11 kmc



BROADBAND coaxial ferrite load isolators from 1-11 kmc (with octave steps from 1 to 8) are now available from Sylvania for almost every microwave application. They are especially well suited to test equipment and other wide band applications.

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Designing for Maintainability



TIME-BASE

tenance actions. This total time is expressed in terms of man-hours.

3. **Logistics requirements**—the demands made on the logistics system in terms of tools, parts, personnel, facilities, etc., to support maintenance.

4. **Equipment damage**—the probability that damage to the equipment will result during the act of performing normal maintenance actions.

5. **Personnel injury**—the probability of injury to maintenance personnel during performance of normal maintenance actions.

These maintenance consequence areas are not completely independent variables. There is considerable interaction among the five areas. The exact nature of this interaction, however, depends on the specific equipment and its maintenance support.

Five Consequence Areas Show Equipment Maintainability

It is necessary to use all five consequence areas adequately to describe the effects of de-

signed maintainability on a particular maintenance situation. The five consequence areas provide, in effect, a profile of maintainability.

By using this consequence-area approach, the relationship of design features to the field requirement for maintainability can be developed. This is done by comparing the degree of consequence, or score, resulting from the absence of specific design features, with the tolerance the field has for meeting the resultant consequences, expressed as a design standard.

Time-Based Index Has Many Drawbacks

At this point we note the significant departure in the Signal Corps method of measuring maintainability from other proposed methods, and from the reliability approach.

Time is the prime element in determining reliability and this same element is the basic factor in practically all other approaches to the measurement of maintainability. The measurement of time in relation to maintenance, however, has many limitations or drawbacks, namely:

1. Time to effect a sample repair in the laboratory environment cannot reflect the multiplicity of field conditions that combine to degrade that measurement.

2. There is no determinable "average" condition or environment under which one can time maintenance actions.

3. There is no "average skilled" personnel representative of the wide range of "butchers and bakers turned technicians" who must perform field maintenance under a wide variety of constraints.

4. There is no known "average" time for simulating time required to assemble the tools, test equipment, parts, etc., required to effect any sample failure repair under the wide variety of field maintenance and logistics conditions.

5. The sample of repairs used to demonstrate the time element is normally based on the most common and repetitive types of failures revealed by experience. A determination of high maintainability based on this sample does not reveal the possibility of very low grade maintainability resulting from random failures of unsampled items which may be induced by new design concepts, new circuit applications, unfamiliar skill requirements, side effects of other repairs, and other stresses too numerous to mention.

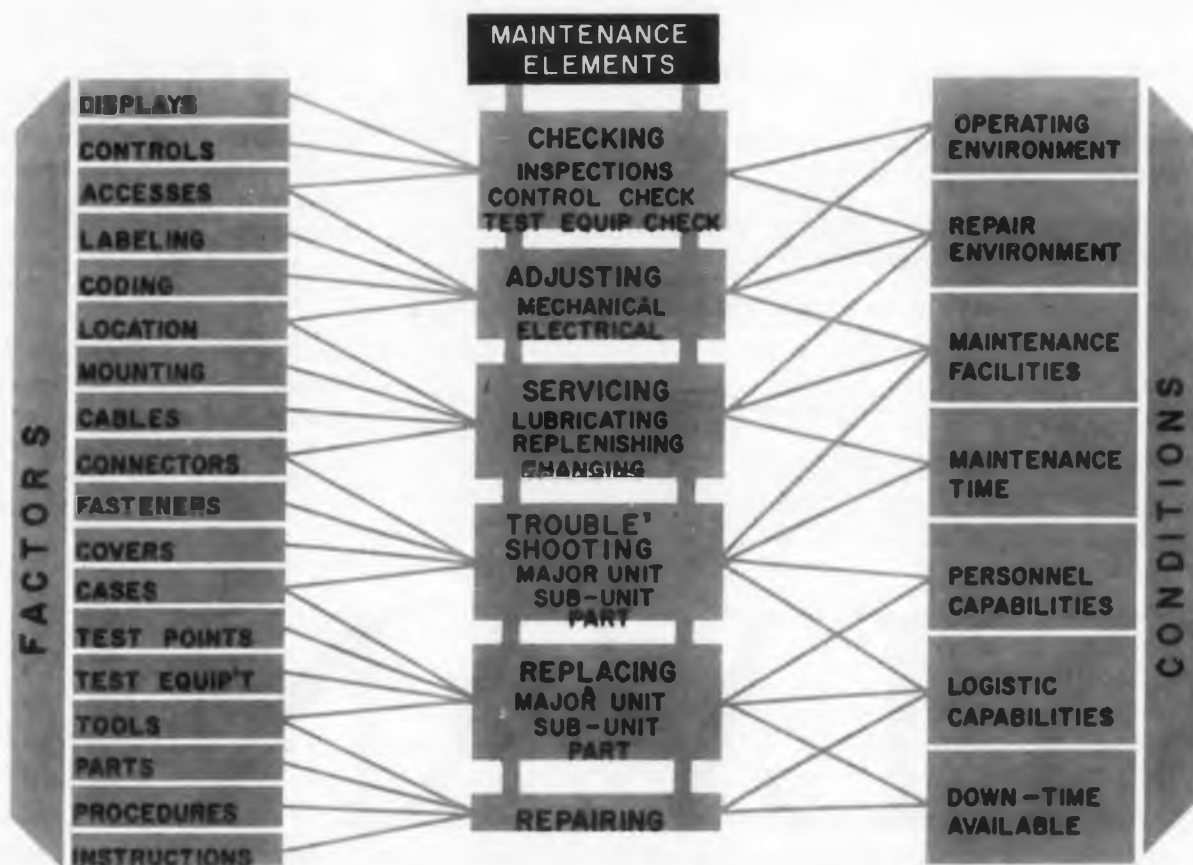
6. Time, as an element to be measured, requires the expenditure of time in effecting the trial or test, thus contributing considerable delay time at the end of the development cycle if maintainability acceptance is to be determined before going into production. The alternative is to barge into production and make an after-the-fact determination of maintainability by the compilation of data logs. This is obviously unacceptable since it does not preclude introducing a maintenance problem in the field.

241 Design Features Affect Equipment Maintainability

The first task is to identify those design features which affect or influence the maintainability of equipment. This resulted in a listing of 241 features, applicable to communications-electronic equipment, which were general enough to be pertinent to the variety of equipment types involved and yet specific enough to allow positive determination as to whether the feature had been incorporated in a specific equipment.*

These design features were submitted to many experienced field-maintenance personnel who rated each feature on a five point scale indicating its relative importance in each of the consequence areas. These relative values, from 0 to 5, provide the "weighting factor" for each design feature by which the equipment can be ranked. Estimates of reliability of the relative importance of the different features were computed and results showed a high degree of confidence in the reliability of the assigned weights.

The design features were arranged in nine design-factor groupings for sequencing equip-



Strong interrelationship exists between design factors, maintenance job elements, and maintenance conditions for any equipment.

*These features are included in this issue as "Check List of 241 Design Features for Maintainable Equipment."

ment evaluation and providing rapid readout of the areas in which an equipment was weak or strong from a maintainability viewpoint.

The nine design-factor areas are (1) displays and controls, (2) external accessibility, (3) test points, (4) cables and connectors, (5) internal accessibility, (6) cases, (7) lubricants and tools, (8) manuals, and (9) test equipment.

Design feature scores are computed for each design-factor area as well as for each of the five consequence areas. To standardize the scoring in each of these areas the scores are converted to a base of 100. To convert the total raw scores, the total "yes" (indicating presence of the design feature in the equipment) scores are divided by the total "yes" scores plus the total "no" scores. The result is multiplied by 100 to eliminate the decimal. All design features not applicable to the specific equipment being evaluated are eliminated from consideration in the scoring.

Maintainability Scores Can Relate to User's Requirements

For the scores obtained under this or any other procedure to be significant, they must relate to a requirement, or standard, representing the user's minimum acceptable maintainability requirements.

To obtain these standards a questionnaire was administered to a comprehensive cross-section of command personnel who expressed their requirements on a hundred-point scale for each consequence area under six different equipment family-type groupings.

Weighting Factors Help Engineer Evaluate Trade-Off

Having acquired a means for measuring maintainability, it became possible to establish a technical requirement, or specification, of maintainability in precise, definitive, and quantitative terms. Even more important it became possible to delineate specific design features which would enhance the maintainability of the product.

The weighting factors for each feature give the design engineer valuable guidance when it becomes necessary to trade-off between maintainability features or between a maintainability feature and another feature, such as packaging, form factor, producibility, and reliability.

The Signal Corps approach to the specification of maintainability requirements is contained in a correlated set of documents which are designed to eliminate duplication, repetition, and reiteration of philosophy, policy, guidelines, and criteria.

The first in the series, "Maintenance Engineering for Signal Corps Equipment," is a general specification of maintenance-engineering requirements which will be incorporated in the design

1960 NOVEMBER 1960				
MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
	1	2	3	4
5	6	7	8	9
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24
25/30	26	27	28	29

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Designing for Maintainability



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and development of all Signal Corps systems and equipment.

It includes an explanation of the maintainability concept and approach, definitions of terms, an outline of the guidance factors to be found in associated specifications, and the program for coordination and guidance between the design engineer and the maintenance engineer during each phase of the development. Also included are general design requirements applicable to the whole field of Signal Corps equipment.

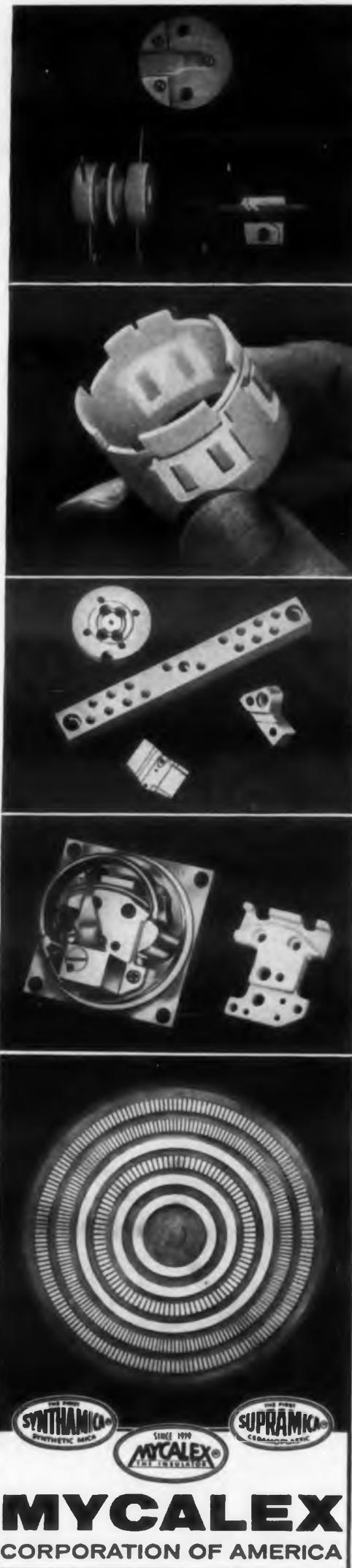
Next is a set of documents covering a category or family of equipments. Titled "Maintainability Design Requirements for Signal Corps Equipment," the set currently includes the following category types: permanent installation, fixed field installation, mobile and/or operator-carried, airborne, test equipment, and electro-mechanical.

Specification Gives Scores For Five Consequence Areas

Only the appropriate category specification is included in the documentation on any specific contract. This specification gives the first quantitative maintainability requirement in terms of the minimum acceptable score to be achieved in each of the five consequence areas. It also includes a delineation of the maintenance concept for the specific type of equipment and the support facilities, personnel, and skills available.

The third in the series is a check list format under the title "Maintainability Design Factors for" The blank is filled in with the specific nomenclature of the particular equipment under development and the check list is marked to provide specific details such as: design for throw-away, modular design requirement, number of modules recommended, cost limit for encapsulated throw-away modules, permissible down-time out of each operating period.

This three-part break-down of the documentation has one major important feature. Designers frequently employed on Signal Corps projects quickly become familiar with the general requirements and program in "Maintenance Engineering For Signal Corps Equipment." Detailed study is not required for each and every project. By the same token, if his field of activity is limited or generally associated with one of the cate-



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gory types he is soon familiar with the guidance and requirements found in the Maintainability Requirements for that category type. This means that to get quickly to the core of the specific maintainability factors applicable to a specific project he has only to refer to the specified equipment requirements detailed in the third document, the check list.

The fourth and final document is a "Handbook of Maintainability Design Features for Signal Corps Electronic Equipment." This has five tables of design features covering the five consequence areas. Each design feature related to a consequence area is listed with its associated weighting factor for that consequence area. By setting the 241 design features in a handbook the designer is provided with a handy reference work.

Pass-Fail Evaluation Depends on Weighing Scores

Evaluation of an equipment becomes a process of weighing the variations of the obtained scores over and under the specified minimum acceptable score. The weighing must take into account the relative importance of the consequence area in relation to the maintenance plan for the equipment, the magnitude of the variation from the standard, and the effect on the accomplishment of the specific mission of the equipment and its using organization.

In some cases it may be possible to accept a low score in one area because it is more than compensated by a predominance of high scores in other areas. Changes to maintenance-support planning may be possible to reduce the effect of low scores in the logistic support area. On the other hand a low score in the down-time area for an equipment having high operating time requirements signals an imperative need for improvement in this area regardless of how well it might score in other areas.

The capability of identifying problem areas, or maintenance "soft-spots," by studying low-scoring design-factor areas, will permit adjustment of maintenance planning to provide increased maintenance support capability to compensate for low-maintainability design. Equally important will be the identification of specific areas to receive increased attention in future redesign or development of similar equipment.

References

1. DOD Directive No. 3232.1, 3 Nov. 1955, "Department of Defense Maintenance Engineering Directive."
2. DOD Directive No. 3222.1, 5 July 1956, "Approval of New Electronic Equipment and Systems for Service Use."
3. American Institute for Research—Signal Corps Contract DA 039 SC-66488, "Development of an Index of Electronic Maintainability." Research Report ASTIA No. AD 219 988.

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Products for Maintainable Designs



Fig. 1. Grant slides provide access to equipment which must be mounted in "impossible to reach" places on Douglas Interceptor.

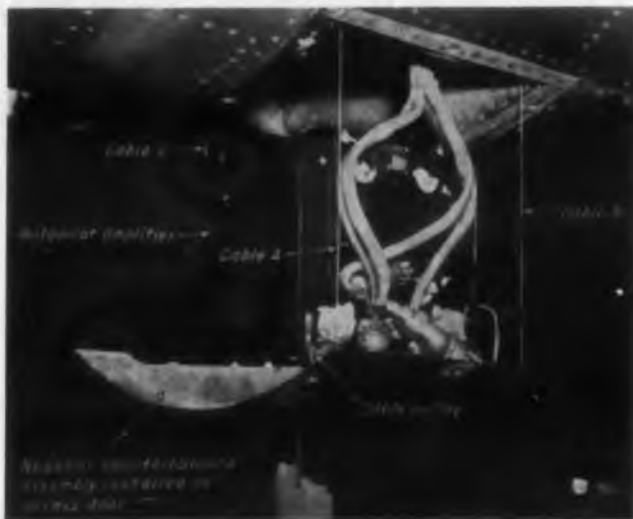


Fig. 3. Neg'ator assembly counterbalances 36-lb assembly in Republic's F-84G Thunderjet.

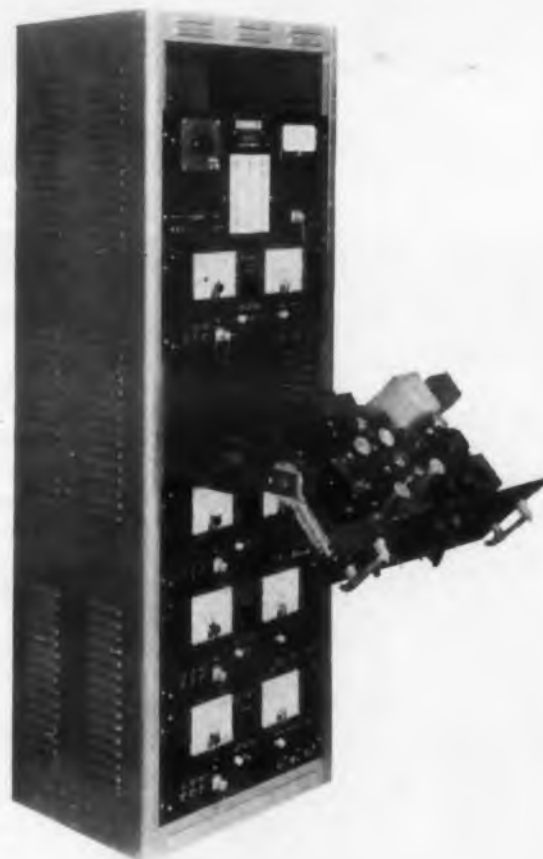


Fig. 2. Chassis-Trak slides give access to the electronic equipment from virtually any angle.

HOW COMFORTING it would be if a manufacturer would offer a product to solve all maintainability problems. A vast array of problems could be wiped out in one fell swoop.

Unfortunately, just as there is no single concept to lick the maintainability problem, there is no one product that will by itself make an equipment maintainable.

But there are many products and product types that can enhance the maintainability of a given equipment and, in some cases, can make the big difference between a product that's easy to maintain and one that's not.

Two paramount features of maintainable equipment are ease in fault location and accessibility. Of these two, the latter might well be voted more important, since accessibility so often serves to simplify fault location as well as to facilitate testing and servicing parts.

Prime Need, Accessibility, Served at Many Levels

Accessibility, in its turn, is served by many products, at many levels. At the broadest level it is served by doors which swing out of the way to expose entire racks of equipment. At a lower level it is served by slides which allow chassis to be withdrawn from cabinets to any extent and allow them to be tilted through a wide arc for easy inspection and servicing. Slides such as those manufactured by Grant Pulley & Hardware Corp. of West Nyack, N.Y. (Fig. 1), and by Chassis-Trak, Inc. of Indianapolis (Fig. 2), are available for a wide range of loads and a wide range of environmental conditions.

Another approach, shown in Fig. 3, improves equipment accessibility by allowing even heavy equipment to be suspended by cables. Weight of the equipment is counterbalanced by a Neg'ator



Fig. 4. Taylor Wiring duct allows for neat, easy-to-get-at inter-chassis cabling. Here the duct is used in a large bank of relays.

assembly, manufactured by Hunter Spring Co. of Lansdale, Pa.

At another level, wiring ducts, such as those made by Taylor Electric, Inc. of Detroit (Fig. 4), simplify tracing faults related to inter-chassis cabling.

For use between modules or other types of packages, there is an array of quick-disconnect connectors to speed access. An unusual product in this array is the recently announced, quick-disconnect terminal strip (Fig. 5), manufactured by Infrared Industries, Inc. of Waltham, Mass. This device combines the accessibility of the conventional barrier strip with the fast-replacement feature of the quick-disconnect connector.

On the module level, there is now available a very wide variety of plug-in circuits and components. Particularly for computer, industrial control, and military applications where down-time must be minimized, the increasing cost and complexity of plug-in devices can be seen. One such

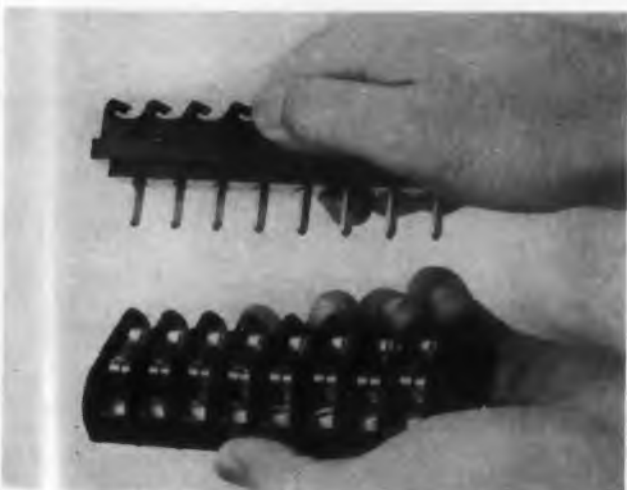


Fig. 5. Infrared Industries' quick-disconnect terminal strip combines barrier-strip test points with quick-disconnect connector.

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0-7	0-15	*TO7-15	8 3/4	19	15
0-7	0-10	*TO7-10	7	19	15
0-7	0-5	*TO7-5	5 1/4	19	15
0-7	0-3	*TO7-3	3 1/2	19	12 1/2
0-14	0-20	*TO14-20	15 3/4	19	16
0-14	0-10	*TO14-10	8 3/4	19	15
0-14	0-7.5	*TO14-7.5	7	19	15
0-14	0-5	*TO14-5	5 1/4	19	15
0-14	0-3	*TO14-3	3 1/2	19	12 1/2
0-32	0-30	TO32-30	15 3/4	19	16
0-32	0-15	TO32-15	8 3/4	19	15
0-32	0-10	TO32-10	7	19	15
0-32	0-5	TO32-5	5 1/4	19	15
0-32	0-3	TO32-3	3 1/2	19	12 1/2
0-36	0-30	TO36-30	15 3/4	19	16
0-36	0-15	TO36-15	8 3/4	19	15
0-36	0-10	TO36-10	7	19	15
0-36	0-5	TO36-5	5 1/4	19	15
0-36	0-3	TO36-3	3 1/2	19	12 1/2
0-60	0-15	TO60-15	15 3/4	19	15
0-60	0-7.5	TO60-7.5	8 3/4	19	15
0-60	0-5	TO60-5	7	19	15
0-60	0-2.5	TO60-2.5	5 1/4	19	15
0-60	0-1.5	TO60-1.5	3 1/2	19	12 1/2

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† NARROW RANGE MODELS			DIMENSIONS IN INCHES		
VOLTS	AMPS	MODEL NUMBER	H	W	D
5-7.5	0-30	T6-30	15 3/4	19	16
5-7.5	0-15	T6-15	8 3/4	19	15
5-7.5	0-10	T6-10	7	19	15
5-7.5	0-5	T6-5	5 1/4	19	15
5-7.5	0-3	T6-3	3 1/2	19	12 1/2
7-11	0-15	T9-15	8 3/4	19	15
7-11	0-10	T9-10	7	19	15
7-11	0-5	T9-5	5 1/4	19	15
11-14	0-30	T12-30	15 3/4	19	16
11-14	0-15	T12-15	8 3/4	19	15
11-14	0-10	T12-10	7	19	15
11-14	0-5	T12-5	5 1/4	19	15
11-14	0-3	T12-3	3 1/2	19	12 1/2
14-17	0-15	T16-15	8 3/4	19	15
14-17	0-10	T16-10	7	19	15
14-17	0-5	T16-5	5 1/4	19	15
17-20	0-15	T19-15	8 3/4	19	15
17-20	0-10	T19-10	7	19	15
17-20	0-5	T19-5	5 1/4	19	15
20-23	0-15	T22-15	8 3/4	19	15
20-23	0-10	T22-10	7	19	15
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22.5-27	0-30	T25-30	15 3/4	19	16
22.5-27	0-12	T25-12	8 3/4	19	15
22.5-27	0-10	T25-10	7	19	15
22.5-27	0-5	T25-5	5 1/4	19	15
22.5-27	0-3	T25-3	3 1/2	19	12 1/2
25-31	0-30	T28-30	15 3/4	19	16
25-31	0-12	T28-12	8 3/4	19	15
25-31	0-10	T28-10	7	19	15
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25-31	0-3	T28-3	3 1/2	19	12 1/2
31-33.5	0-30	T32-30	15 3/4	19	16
31-33.5	0-12	T32-12	8 3/4	19	15
31-33.5	0-10	T32-10	7	19	15
31-33.5	0-5	T32-5	5 1/4	19	15
31-33.5	0-3	T32-3	3 1/2	19	12 1/2
33.5-36	0-30	T35-30	15 3/4	19	16
33.5-36	0-12	T35-12	8 3/4	19	15
33.5-36	0-10	T35-10	7	19	15
33.5-36	0-5	T35-5	5 1/4	19	15
33.5-36	0-3	T35-3	3 1/2	19	12 1/2

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G-E Silicone Varnishes provide excellent protection against moisture and high operating temperatures. Applications include conformal protective coatings for printed circuits, resistor coatings, transformer impregnation, etc. New varnishes cure at low temperatures.

New Silicone Dielectric Greases maintain physical and electrical properties from -65°F to 400°F , offer protection against moisture and oxidation. Used as corrosion inhibitors, lubricants, heat transfer media and release agents.

Silicone Rubber Wire Insulation withstands soldering heat without damage; matches or exceeds vital properties of insulation costing three times as much. Provides long service life at 500°F ; momentarily withstands temperatures up to 5500°F . Flexible as low as -150°F , it resists moisture, ozone, nuclear radiation.

Send for technical data, "Silicones-for-Insulation." Section L 1031, Silicone Products Department, Waterford, New York.



Designing for Maintainability



PRODUCTS

device is a plug-in dial timer (Fig. 6), manufactured by Automatic Timing and Controls, Inc. of King of Prussia, Pa.

The plug-in concept has been applied on the component level as well as on the level of complex units and subassemblies. Even at this level, ease of replacement can often justify the added cost of the plug-in feature. A wide variety of components—resistors, capacitors, rectifiers—has been made available in plug-in form. One of these is a plug-in silicon rectifier (Fig. 7), which is manufactured by International Rectifier Corp. of El Segundo, Calif.

New Encapsulents and Strippers Yield Access to Potted Parts

One of the greatest objections to encapsulation, the problem of testing and replacing small parts,

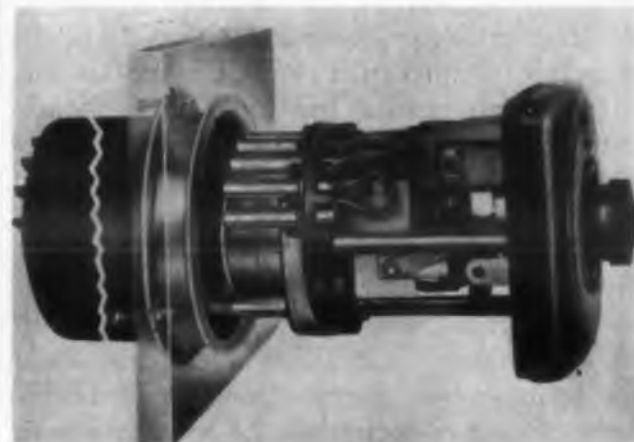


Fig. 6. Plug-in timer, by Automatic Timing and Controls, provides long, keyed, guide pin to insure accurate alignment and to protect electrical contacts.



Fig. 7. International Rectifier Corp.'s plug-in rectifier extend plug-in concept to component level.

GENERAL  **ELECTRIC**

CIRCLE 52 ON READER-SERVICE CARD

Inland d-c torque motors provide direct drive servo positioning . . .

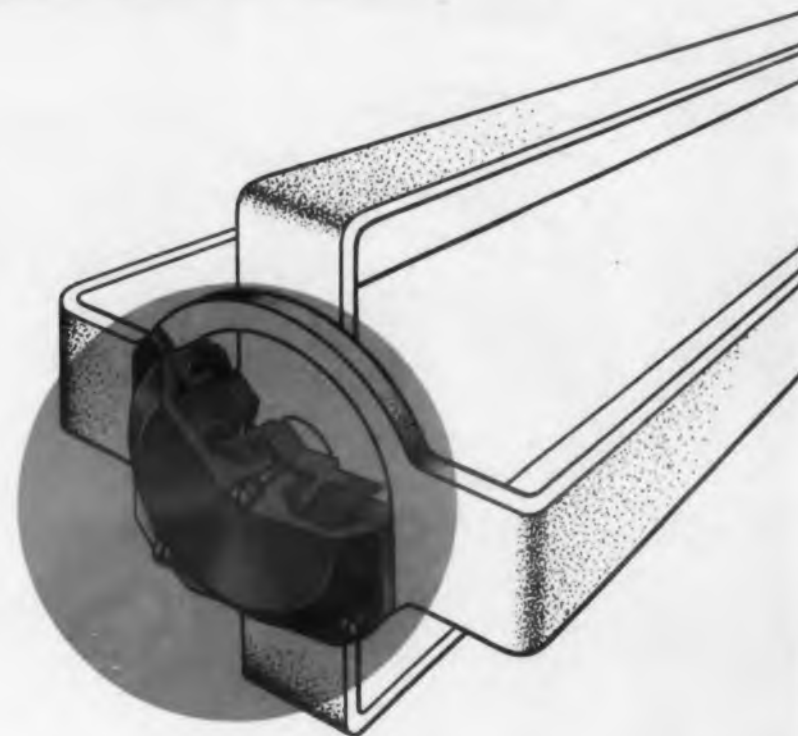
NO GEARS, NO BACKLASH

Complete range . . . 0.1 to 3,000 pound-feet

Inland offers a complete line of compact d-c torquers for airborne, shipboard or ground service stabilization and tracking systems. Increased system accuracy has been achieved by mounting the torquers directly on the driven member. This completely eliminates gear backlash and other problems normally associated with gear trains, reduces substantially over-all friction error, and improves the over-all constant of the system. In addition, Inland's d-c torquers combine the compact pancake shape with very high peak torque, low input power, and high angular resolution.

Exclusive commutator and brush rigging design

Inland has achieved this compact pancake shape while maintaining the low-power input to high-torque output ratio of a d-c torquer.



INLAND AMPLIFIERS—Inland makes a wide line of control amplifiers for systems duty with Inland torquers. Write for technical details.

COMPARE THESE RATINGS WITH A TYPICAL SERVO MOTOR-GEAR TRAIN COMBINATION

	T-2136-A	T-2136-B	T-2136-D
Peak torque, oz. in.	35	35	35
Volts at peak torque, stalled at 25°C	26.0	20.6	33.5
Amps at peak torque	1.6	2.0	1.3
Total friction, oz. in.	0.8	0.8	0.8
Rotor Inertia, oz. in. sec ²	.007	.007	.007
Weight, oz.	9	9	9
Dimensions (inches):			
O.D.	2.81	2.81	2.81
I.D.	1.00	1.00	1.00
Thickness	.63	.63	.63

For complete data on these or other Inland d-c pancake torquers, address Dept. ED, Inland Motor Corporation of Virginia, Northampton, Massachusetts.



INLAND MOTOR CORPORATION
OF VIRGINIA
A SUBSIDIARY OF KOLLMORGEN CORPORATION
NORTHAMPTON, MASS.

CIRCLE 53 ON READER-SERVICE CARD



Fig. 8. Dow Corning Corp.'s transparent Dielectric Gel heals itself after being pierced by test probes.

has been largely overcome by some new products. These include strippers that flake away epoxy and polyester encapsulents without harming most circuit components, transparent potting compounds which heal themselves after being pierced by test probes, and encapsulents which can easily be cut or torn away from faulty components and can just as easily be mended.

Two types of strippers are available from the Electronic Components Div. of Telecomputing Corp. in Van Nuys, Calif.—a liquid type, Tele-Solv, and a gelatinous Tele-Solv G that can be applied to surfaces which can't be immersed in a liquid.

A transparent, pierceable encapsulent, Di-electric Gel, (Fig. 8), is offered by Dow Corning Corp. of Midland, Mich.

Expendable Modules Simplify Fault Location

The concept of designing modules for throw-away, which has received so much attention re-

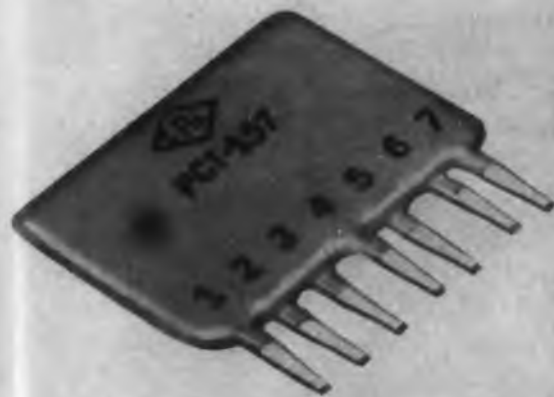


Fig. 9. Centralab's packaged electronic circuits provide built-in failure indication. If a resistor or capacitor should short, the heat generated will discolor the PEC and a dark brown spot on the coating will show the location of the burned out component.

Testing insertion characteristics of X-band filter with Alfred Swept Generator. It consists of Alfred Microwave Oscillator and Alfred Microwave Leveler. This combination electronically sweeps frequency linearly with respect to time while maintaining RF power virtually constant across the band.



Save Test Time, Assure Test Accuracy

with ALFRED'S new SWEPT Microwave Generator.....

The scope patterns tell the story. Top pattern shows constant power input from Alfred Swept Generator to component (filter) under test. With known input, variation in output is due to filter characteristics. Lower pattern is especially significant, showing continuous, flicker-free display, 8 to 10 kmc. Any changes in stubs or irises are immediately reflected. Measurement accuracy is assured at every frequency, not just at selected points.

THIS TECHNIQUE CAN BE USED FOR MOST PRESENTLY KNOWN MICROWAVE TESTING APPLICATIONS. HERE'S WHY IT'S FASTER THAN CONVENTIONAL SIGNAL GENERATORS:

- * *Continuous Display* allows immediate measurements — no plotting needed. Trace can be recorded if desired.
- * *Sweep Technique* eliminates time-consuming "point-to-point" frequency and power setting methods of conventional signal generators. Sweep range is continuously adjustable with 1% accurate Direct Reading Slide Rule Dial.
- * *"Quick Look Readout"* eliminates calculations in setting sweep range.
- * *Adjustable Frequency Markers* allow rapid, broadband calibration of scope or recorder trace.

Key specifications for Signal Generators available for coverage from 1 to 12.4 kmc

Frequency—Controls: Continuously adjustable with direct calibrated dial. Calibration accuracy: 1%. Stability: $\pm 0.02\%/hr$. Residual FM: $\pm 0.0025\%$. **Power Output (Minimum):** 10 mw ± 1 db. Continuously adjustable from zero to maximum. **Attenuation Range:** Up to 20 db. **Sweep—Selector:** Recurrent Sweep, Single Sweep, Single Frequency, and External on panel switch. **Time:** 100 to .01 seconds, continuously adjustable. **Monitor Output—Sweep Out:** Positive linear sawtooth, 45 volts peak. Panel BNC connector. **Amplitude Modulation—Internal Square Wave:** RF output is alternately 0 and unmodulated CW value. Frequency 800 to 1200 cps, adjustable by panel control.

SOME MORE FACTS YOU SHOULD KNOW

- * *Frequency Ranges.* The Swept Generator is available in five ranges to 12.4 kmc — 1 to 2, 2 to 4, 4 to 8, 7 to 11, 8.2 to 12.4.
- * *Stability.* At any single frequency, stability of the Swept Generator equals that of a conventional signal generator. Spurious modulation is low.
- * *Power Output.* Greater than a signal generator: 10 milliwatts as compared to 1 milliwatt.

FUNCTION OF THE LEVELER It holds power output constant to ± 1 db over standard frequency ranges, and better than ± 1 db over narrower ranges. The Leveler serves as a broadband attenuator with up to 20 db dynamic range control, providing constant output over a wide range. It can be used as a general purpose instrument for a wide variety of oscillators and amplifiers.

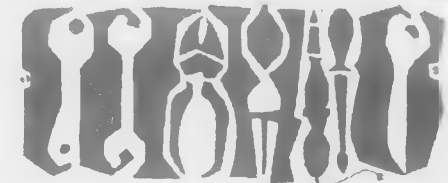
For more details on the Alfred Swept Generator — please contact your Alfred sales engineering representative, or write direct. Please address: Dept. 36.

ALFRED ELECTRONICS

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PALO ALTO, CALIFORNIA

CIRCLE 54 ON READER-SERVICE CARD

Designing for Maintainability



PRODUCTS

cently, is by no means a new one. Examples of throw-away circuits which have been available for years are the packaged electronic circuits (Fig. 9), sold by the Centralab Div. of Globe-Union, Inc. in Milwaukee. These PEC's can house as many as 20 resistors, capacitors, transistors, and other small components. Cost of one of these packaged circuits can be significantly lower than the cost of tracing a fault to an individual component, and the time saved can be substantial.

Fasteners, Clamps, and Seals, Can Speed Access

One of the more troublesome but less recognized areas of designing for maintainability lies in the means of fastening and sealing. An inordinate amount of time can be wasted in searching for lost nuts or in testing around a sealed enclosure with the hope that the trouble isn't really in the enclosure.

Fortunately, many recent developments in both fasteners and seals have minimized these problems. Captive fasteners have been one approach to avoiding lost nuts and bolts. Another approach has been the use of inserts like the Banc-Lok insert manufactured by the Boots Corp. of Norwalk, Conn. (Fig. 10). This one-piece fastener is pressed into a prepared hole where it provides

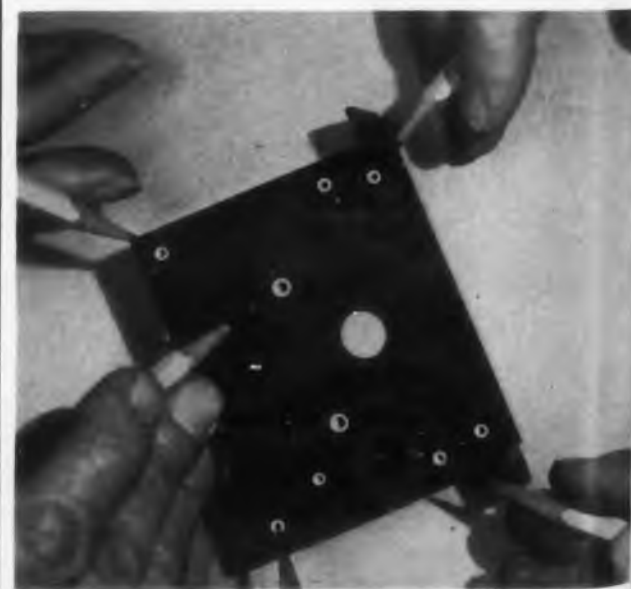


Fig. 10. Boots Corp.'s Banc-Lok inserts eliminate need for tapping and eliminate problems of lost nuts.



Fig. 11. Timber-Top's Synclamps require only screw-driver space between components being mounted.



Fig. 12. Parker seals are removable, re-usable.

vibrationproof screw threads with self-locking action in sheet metal, plastic, metal castings, wood, and composition materials.

From a maintainability viewpoint, any fastener should hold something securely; it should allow the component to be removed easily and quickly; and it shouldn't have loose parts which may get lost. One particularly simple device that satisfies these requirements is the Synclamp (Fig. 11), made by Timber-Top, Inc. of Freeport, Long Island, N.Y. A quick-release synchro clamp, it locks and unlocks simply with the turn of a screw.

Many of the problems usually posed by seals are averted with one-piece, molded-in-place seals. One such product, the Gask-O-Seal, manufactured by Parke Seal Co. of Culver City, Calif. can provide hermetic sealing with an easily removable and even re-usable seal. It can be used for waveguide seals (Fig. 12), and for sealing vacuum or pressurized enclosures.

Of course, there are hundreds of products which, used properly, can enhance the maintainability of an equipment. Used improperly, even the best of them will not improve a basically bad design. ■ ■



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A dozen SPEED CLIPS now do the job of fastening upholstery to the steel seat of Cramer Posture Chairs. Before the switch to Tinnerman SPEED CLIPS, an expensive formed-steel rim was spot-welded to the seat to do this job.

SPEED CLIPS save Cramer at least 46 cents—or 62% of fastening cost—on each chair... they eliminate the rim-forming and spot-welding operations... permit faster, easier assembly... simplify disassembly if the chair ever needs re-upholstering. Working jointly with Cramer's engineering staff, Tinnerman fastening specialists were able to provide all these advantages without sacrificing product quality.

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benefit greatly, too, if you'll enlist the aid of this Tinnerman team. You can arrange for a free FASTENING ANALYSIS of your product simply by calling in your nearby Tinnerman representative. You'll find him listed in the "Yellow Pages" and in Sweet's PD File under "Fasteners." Or write direct to:

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CIRCLE 55 ON READER-SERVICE CARD

All-Pass Networks

Part 2

Using Networks to Shape Transient Response

An all-pass network, which shifts phase but does not introduce attenuation, is readily applicable to improving another network's transient response. In this second of a series of articles on all-pass networks, Yale Jay Lubkin illustrates this application with a detailed example. A pulse transformer is chosen as the network whose transient response is to be improved. The succeeding article will describe how all-pass networks can vastly improve delay lines.

Y. J. Lubkin

Loral Electronics Corp.
The Bronx, N.Y.

THE PHASE-SHIFT, or all-pass, network is an excellent tool for shaping another network's transient response. By minimizing phase distortion, for example, it improves rise time.

This method of improving rise time will be used to demonstrate the application of phase-

shift networks to transient response. A phase correction network for a pulse transformer will be designed using results obtained in Part 1 of this series (See *ED*, Oct. 12, 1960, p 36).

After choosing the all-pass network, the transformer's transient response will be computed to demonstrate that minimizing phase distortion improves rise time. This will be done with the differential equations of the phase shift network.

Finally, the network will be designed again,

this time using only the transient response; no frequency calculations will be required.

The significant parameters of a pulse transformer are primary inductance, turns ratio, leakage inductance, and distributed capacitance. The significant parameters of the associated circuitry are source and load impedance.

In most transformers, the primary inductance has little effect on the rise time and the other transformer parameters have little effect on the

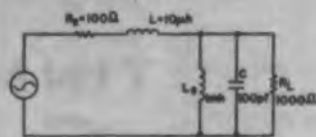


Fig. 1. Equivalent circuit for the leading-edge response of a pulse transformer.

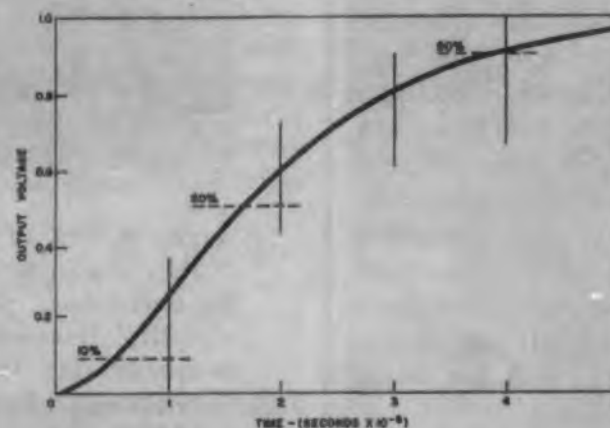


Fig. 2. Leading-edge response of pulse transformer to unit step.

Table I: Model Computations for Solving Difference Equation

t	e^{-t}	g	g'	x''	x'	x	$g-h$	h
0.0	1	0	0	0	0	0	0	0
0.1	0.905	0.0045	0.0905	0.362	0	0	0	0.0045
0.2	0.809	0.027	0.164	0.583	0.0362	0	0	0.027
0.3	0.741	0.037	0.222	0.728	0.0945	0.0036	0.0018	0.035
0.4	0.670	0.062	0.268	0.707	0.1673	0.0101	0.0068	0.055
0.5	0.606	0.091	0.303	0.656	0.2380	0.0268	0.0185	0.072
0.6	0.548	0.123	0.329	0.556	0.3036	0.0506	0.0386	0.084
0.7	0.496	0.157	0.347	0.417	0.3593	0.0810	0.0658	0.091
0.8	0.449	0.192	0.359	0.284	0.4010	0.1169	0.0990	0.093
0.9	0.406	0.239	0.365	0.112	0.4294	0.1570	0.1370	0.102
1.0	0.368	0.264	0.368	-0.009	0.4406	0.1999	0.1785	0.088
1.1	0.333	0.301	0.366	-0.146	0.4397	0.2440	0.2220	0.079
1.2	0.301	0.338	0.361	-0.249	0.4251	0.2880	0.2660	0.072
1.3	0.273	0.372	0.355	-0.372	0.4002	0.3305	0.3093	0.063
1.4	0.247	0.407	0.346	-0.455	0.3631	0.3705	0.3505	0.056
1.5	0.223	0.443	0.335	-0.518	0.3176	0.4068	0.3887	0.054

Input: $g=1-(1+t)e^{-t}$
 $g'=te^{-t}$

Equations for Generating
 Difference Solution:

$$x''=4ag'-2ax'-r^2x$$

$$x'(t+\Delta t)=x'(t)+x''(t)\Delta t$$

$$x(t+\Delta t)=x(t)+x'(t)\Delta t$$

$$(g-h)(t)=1/2x(t)+1/2x(t-\Delta t)$$

Initial Conditions: $x(0)=0$ $x'(0)=4ag(0)=0$ $x''(0)=4a[g'(0)-2ag(0)]=0$

pulse fall. Hence it is customary to consider three different equivalent circuits for the transformer: one for the pulse rise, one for the body of the pulse, and one for the pulse fall.

It also is customary to refer all parameters to the primary so calculations can be made without considering turns ratio.

The analysis to follow is based on a pulse transformer with the following characteristics: primary inductance, $L_s = 1$ mh; Leakage inductance, $L = 10$ μ h; distributed capacitance, $C = 100$ pf; turns ratio, 1:1; source impedance, $R_s = 100$ ohms; load impedance, $R_l = 1,000$ ohms. Such a transformer might be used as interstage coupling for 100 to 300 nsec pulses.

Seek Leading-Edge Response

We are interested in the leading-edge transient response. The conventional equivalent circuit for this condition is shown in Fig. 1.

The transient response of this transformer is very easily calculated (see Millman and Taub, *Pulse and Digital Circuits*, pp 263-265).

The response to a unit step is:

$$h(t) = 1 - (1+t)e^{-t}$$

where t is measured in units of 10^{-8} sec, and is shown in Fig. 2. (Note: In all figures, the amplitude has been normalized so that $h(\infty) = 1$.)

The transformer is critically damped, because $C = L/R_s$, and, hence, the response to a unit step has no overshoot and no ripple. The rise time is about 33.5 nsec, and the delay to the half-

maximum-amplitude point of the output is about 17 nsec.

Frequency-Response Solution

If we define

$$\alpha = R/(R + R_s), \quad \tau = R_s C = L/R \quad (1)$$

then, from Millman and Taub, the gain, A , and phase shift, ϕ , are

$$A = \sqrt{4\omega^2\tau^2 + \left(\frac{1}{\alpha} - \omega^2\tau^2\right)^2} \quad (2)$$

$$\phi = \arctan \frac{2\omega\tau}{\frac{1}{\alpha} - \omega^2\tau^2}$$

where $\tau = 10$ nsec, and $\alpha = 0.9$.

Fig. 3 shows the gain, phase shift, phase error, and cosine of the phase error for the transformer as a function of ω . The phase error, $\Delta\phi$, is defined by

$$\Delta\phi(\omega) = \omega \left. \frac{d\phi(\omega)}{d\omega} \right|_{\omega=0} - \phi(\omega) \quad (3)$$

The phase error is the difference between the actual phase shift and the value that would result if phase shift were exactly proportional to frequency.

Were the phase error identically zero, all frequencies would be delayed by the same time and no dispersion would occur. In this event,

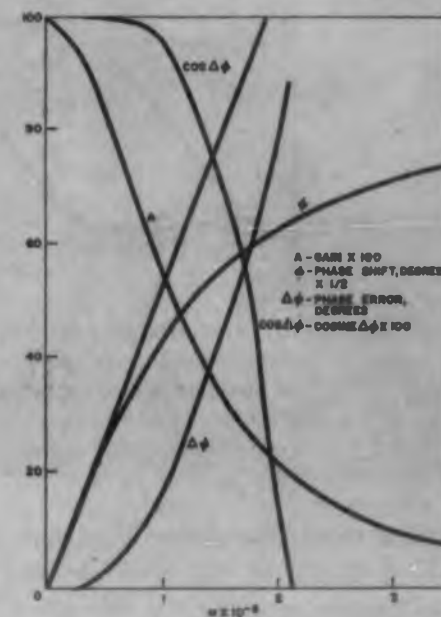


Fig. 3. The gain, phase-shift, phase error and cosine of phase error of the pulse transformer as a function of ω .

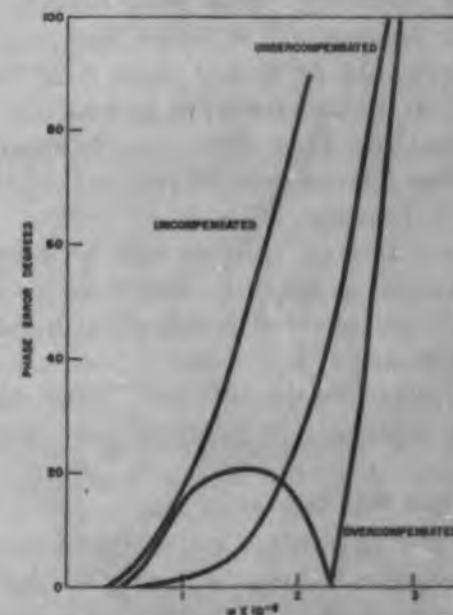


Fig. 4. Cascading a duopole (under- or over-compensated) with the pulse transformer makes phase error more linear and also increases frequency at which given phase error exists.

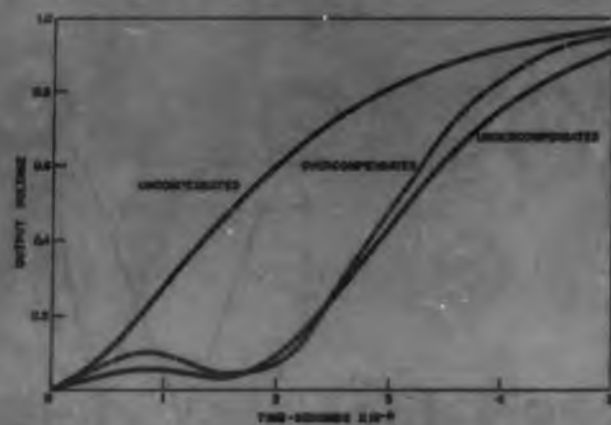


Fig. 5. Cascading a duopole (under- or over-compensated) with pulse transformer improves rise time of unit-step response but introduces a delay.

the rise time would be determined only by the amplitude response of the network, and would be the minimum possible for the given amplitude response.

Zero Phase Error Impossible

Identically zero phase error is not possible for lumped parameter systems, although it may be closely approximated for practical purposes.

To simplify the equations, all times (t , τ) will be in units of 10 nsec, and all frequencies (ω , a , r) in units of 100 mega radians per sec.

Fig. 3 shows the phase error becomes quite large for frequencies at which the gain, A , is still appreciable. At 90 deg phase error the gain is 0.2. This situation results in poor rise time. The actual rise time, 33.5 nsec, is appreciably longer than the rise time determined only by the amplitude response, 20 nsec.

A single duopole section will be used as a phase-correction network. Reference to Fig. 3 shows the phase error of the pulse transformer is about 90 deg at $\omega = 2$ and is about 20 deg at $\omega = 1$. Hence the duopole must have about 70 deg excess phase shift between these points.

Most Errors Not Serious

As a first approximation to the desired network, consider a duopole having 90 deg phase shift at $\omega = 1$, and 270 deg at $\omega = 3$. The range of nearly optimum networks is quite wide, so errors due to non-optimum choices or to component drift are not serious.

Because a equals one-half the bandwidth between points of 90 deg and 270 deg phase shift, $a = 1$ in this case. The frequency of 180 deg phase shift is

$$\omega = \sqrt{a^2 + r^2}, \text{ so that } r = \sqrt{3}.$$

Fig. 4 shows the net phase error of the pulse transformer and duopole. The duopole phase shift and phase errors are readily determined from the transfer function (substitute $s = j\omega$) and are

$$\phi = 2 \arctan \frac{2a\omega}{r^2 - \omega^2} \quad (4)$$

$$\Delta\phi = \frac{4a\omega}{r^2} - \phi \text{ radians}$$

The resultant phase characteristic is much more linear than that of the pulse transformer alone; the frequency for a given phase error is increased by almost $\omega = 0.9$. Thus, the frequency for 90 deg error has been increased from $\omega = 2.1$ to $\omega = 2.75$.

Compensation Has Its Price

The phase error with the calculated duopole network is monotonic, i.e., phase error increases with frequency for all frequencies.

By overcompensating and accepting some extra phase shift at low frequencies, it is possible to reduce the phase error at higher frequencies. This usually results in improved rise time at the expense of ripple.

We may obtain overcompensation by increasing the duopole phase shift in the critical frequency range. With 90 deg phase shift at $\omega = 1$, as before, and 270 deg phase shift at $\omega = 2.5$, instead of at $\omega = 3$, the new duopole has $a = 0.75$, $r = \sqrt{2.5}$.

The phase error of the transformer and the second duopole is shown in Fig. 4. Note that the frequency for 90 deg error has been increased to $\omega = 2.85$, and that an error of 20 deg has been introduced at $\omega = 1.5$.

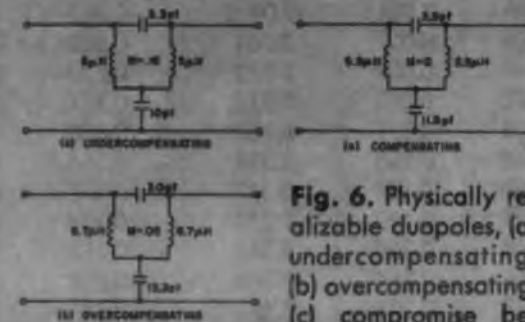


Fig. 6. Physically realizable duopoles, (a) undercompensating, (b) overcompensating, (c) compromise between (a) and (b) that eliminates mutual coupling.

The transient response of the transformer alone and with each of the corrective networks is shown in Fig. 5. The rise time is materially improved with either network, but an additional delay has been introduced.

The response with the overcompensating network has a faster rise time and slightly less delay, but also has much more ripple. The peak ripple with the overcompensating network is about 10% of the final amplitude, and this may prove objectionable for some applications.

Mutual Coupling Used

Circuit values for the corrective duopoles are shown in Fig. 6. These values are obtained by substitution in Fig. 1 of the previous article. The undercompensating duopole has positive mutual coupling between the inductors and the overcompensating duopole has negative mutual coupling.

By choosing a duopole representing the average between the two already considered, and having $r = 2a$, the coupling may be eliminated.

The response with such a network would be an average of the responses of the other two networks. It is apparent that the network designer has a great deal of freedom.

The network responses are calculated by obtaining the differential equation for the duopole and solving it by means of difference equations. The technique is particularly easy for all-pass networks, and the following can serve as a model.

Solution Uses Difference Equation

For a duopole, the transform of the output is related to that of the input by:

$$H = \left(\frac{s^2 - 2as + r^2}{s^2 + 2as + r^2} \right) G$$

By cross-multiplying and combining terms,

$$(s^2 + 2as + r^2)(G - H) = 4asG \quad (6)$$

The transfer function is obtained directly from the differential equation of the network by substituting s for d/dt and s^2 for d^2/dt^2 . Therefore by substituting back we obtain the differential equation:

$$(g - h)'' + 2a(g - h)' + r^2(g - h) = 4ag' \quad (7)$$

where ' means d/dt .

This is an equation for the difference between the input and the output of any duopole in terms of the input waveform.

The difference solution is obtained by starting with the initial conditions at $t = 0$ (which here are $(g - h) = (g - h)' = (g - h)'' = g' = 0$). Then select a suitable calculation interval, Δt , (the size of the interval depends on the accuracy desired) and systematically generate answers for time intervals after zero by applying the relation:

$$x(t + \Delta t) = x(t) + x'(t)\Delta t \quad (8)$$

where x stands for $(g - h)$ or $(g - h)'$.

From the differential equation, calculate $(g - h)''$ at any value of t , after g' , $(g - h)$ and $(g - h)'$ have been calculated for that particular value of t .

The first steps of the calculation for the undercompensating duopole are shown in Table 1. The time interval chosen is $t = 0.1$.

Input Minus Output Obtained

This procedure gives $(g - h)$ as a function of time, and h may be calculated by subtracting $(g - h)$ from g . The difference-equation procedure gives a solution delayed by half the sampling interval, Δt . Hence the obtained solution is not $(g - h)(t)$, but is $(g - h)(t - \frac{1}{2}\Delta t)$.

The response shown for the undercompensating duopole was calculated using $\Delta t = 0.1$ and that for the overcompensating duopole was calculated using $\Delta t = 0.2$. The duopole parameters were $a = 1$, $r^2 = 3$.

Time-Response Solution

From the previous discussion, it is evident that, while networks can be obtained without much difficulty using the frequency response approach, the calculations involved may become somewhat tedious, particularly if the designer is interested in calculating the time domain frequency response.

By using results established in the previous article (ED, Oct. 12, 1960), it is possible to avoid most of the calculations if the designer is interested only in approximate solutions in the time domain. The duopole's response to low frequency signals (frequency less than some ω_0) is:

$$h_2(t) = g(t - 4a/r^2) + \frac{4a}{r^4} (1 - 4a^2/3r^2) \quad (9)$$

$$g^{(3)}(t - 4a/r^2) - \dots$$

where $g^{(n)} = d^n g/dt^n$

This equation gives the waveform at the output of the duopole in terms of the derivative of the input. As a first approximation, neglect all derivatives of the input waveform beyond the third.

In general, for band-limited inputs, this will lead to results that are quite erroneous near the beginning of the input waveform, but fairly accurate after $4a/r^2$ sec. This is indicated in the equation because it shows no output before $4a/r^2$ sec.

Optimum Parameters Obtained

Fig. 7 shows the input waveform, $g(t) = 1 - (1 + t)e^{-t}$ —the pulse transformer output—and its third derivative, $(t - 2)e^{-t}$. By rewriting the duopole's response equation as

$$h_2(t) = g(t - d) + kg^{(3)}(t - d) \quad (10)$$

where $d = 4a/r^2$ and $k = \frac{4a}{r^4} (1 - 4a^2/3r^2)$

we see we can alter h by changing the value of k . Thus, an optimum k , and hence an optimum network can be obtained with little computation. By choosing d , we can then find a and r .

Fig. 7 also shows that $g^{(3)}$ is very nearly zero for $t > 1.5 \times 10^{-3}$, so we expect the phase shift network to have little effect on the input waveform, aside from the delay, beyond that point. It appears from experience that optimum networks have delays ranging from the time at which g equals $g^{(3)}$ to the time at which $g^{(3)}$ goes to zero. Here the delays range from about 1.1 to about 1.6.

We would expect the maximum effect of the corrective network to occur at about half this time. Therefore, select k so the output of the corrective network is zero at a time between 0.55 and 0.80.

The greater this time, the less the rise time of the corrected signal. The values of k that give zero network output between 0.55 and 0.80 lie between 0.15 and 0.36.

If the values $d = 1.33$, $k = 0.247$ are chosen, the resulting corrective network is the undercompensating network previously discussed. The values for the overcompensating network are $d = 1.2$, $k = 0.336$, and those for the network without mutual inductance are $d = 1.18$ and $k = 0.273$.

Fig. 8 shows the output of the undercompensating network calculated by solving the difference equation and also calculated from the time-response equation (Eq. 9). For $t > 4a/r^2$, the difference is fairly small. ■ ■

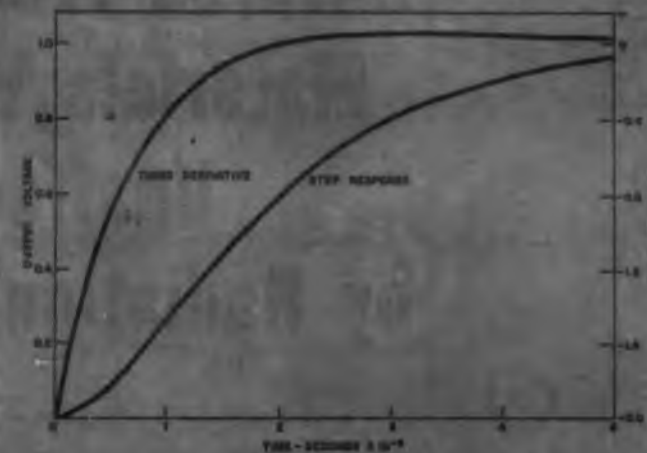


Fig. 7. Input to duopole is step response of pulse transformer because duopole is cascaded with transformer. Input and its third derivative figure in computing response of duopole.

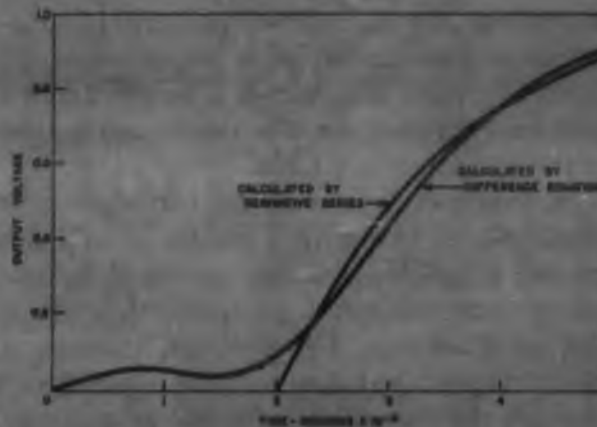


Fig. 8. Output of undercompensating duopole solved by derivative series and by difference equation. The difference between two solutions is small after time equal to delay associated with each term of derivative series.

Infrared-Transmission Materials Would be Unaffected by Radiation in Space

Thomas E. Lusk
General Electric Co.
Ithaca, N.Y.

THE TRANSMISSION efficiency of 15 common infrared optical materials would not be affected adversely by exposure to the highest known levels of gamma radiation in space.

To affect the materials' transmission properties adversely would require their being exposed perpetually to the heaviest known gamma-radiation level in space for more than a century.

The infrared transmission properties of the 15 materials were tested after exposure to three levels of gamma radiation— 0.975×10^4 , 1.58×10^6 , and 1×10^8 roentgens. The results are indicated in the accompanying table.

However, only four of the materials—germanium, silicon, Irtran AB-1 (similar to MgF_2) and arsenic trisulfide—presently are used in space-vehicle infrared optics. In space, they are subject to irradiation by electrons, protons, and electrons-produced X-rays as the satellite passes through the Van Allen belts and solar flares.

The negligible effect of gamma radiation on these four materials is shown in detail in Fig. 1, a through d.

Different Radiations Have 'Same Effect'

Of course, the effects of gamma radiation are considerably different from those produced by electrons and protons. However, if the assumption is made that damage depends only on roentgen level, then the change produced by equal roentgen levels of gamma, electron, and proton radiation would be the same.

Approximately, a maximum of 100 roentgens per hour is encountered in the inner Van Allen Belt and the solar bursts, and 10 roentgens per hour in the outer belt. The solar bursts can be neglected in computing an approximate life time

of materials in space, because the bursts usually exist only a few days a month.

Hence, a dose of 10^6 roentgens will be accumulated in about 1.1 years in the inner Van Allen belt. The damage produced in the laboratory by 10^8 roentgens will take about 110 years to develop in the inner belt. This also assumes the vehicle remains in the radiation belt all the time and that the infrared optics are exposed to the direction of radiation.

Radiation Source in Lab was Cobalt-60

The radiation-source for the laboratory tests was cobalt-60. The dose rate was 1.95×10^5 roentgens per hour. This rate did not produce appreciable heating in the samples, although the ambient temperature may have reached a maximum of 30 to 35 C because of absorption of radiation by the lead pig.

At least two samples of each material were tested (with the exception of silver chloride, a

The safest assumption about infrared transmission materials in space would be that transmission efficiency is affected adversely by normal levels of radiation. However, tests, supervised by Dr. W. R. Langdon, and described here by Thomas E. Lusk, showed it would require more than a century of exposure for maximum, known radiation in space to affect the materials adversely.

spinel and silicon-monoxide-coated single crystal silicon, where only one sample of each was available). Before the initial irradiation, the samples were optically polished so all samples of a particular material were of almost equal thickness.

Hence, when the infrared transmission between 1 and 14 microns was measured on a Perkin-Elmer Model 112 spectrometer, all samples of a particular material had the same transmission within the ± 2 per cent reproducibility of the spectrometer.

The infrared transmission of all samples was determined before the initial irradiation and after each dose.

The measurements usually were made within five days after irradiation. (No attempt was made to determine the transmission within any specific time interval after irradiation.)

No transmission measurements were made at wavelengths shorter than one micron. ■ ■

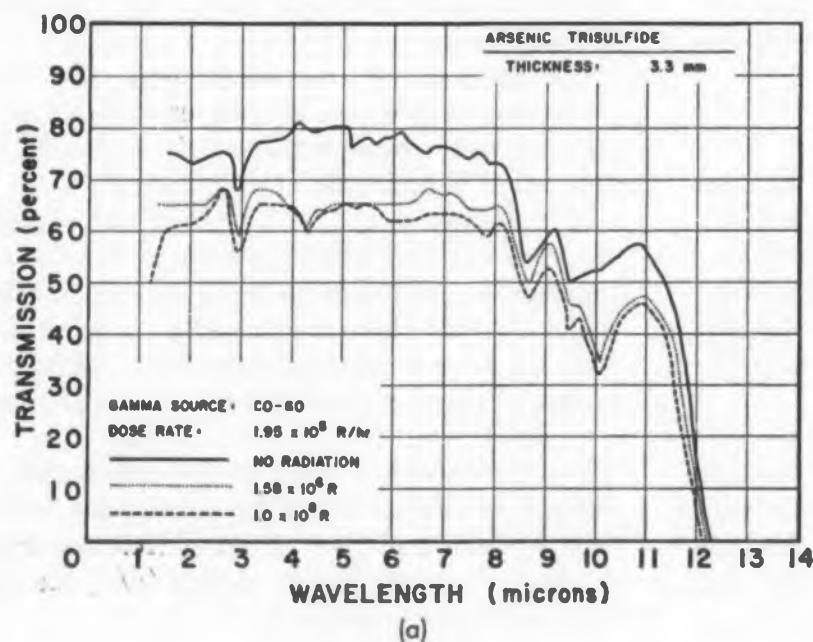
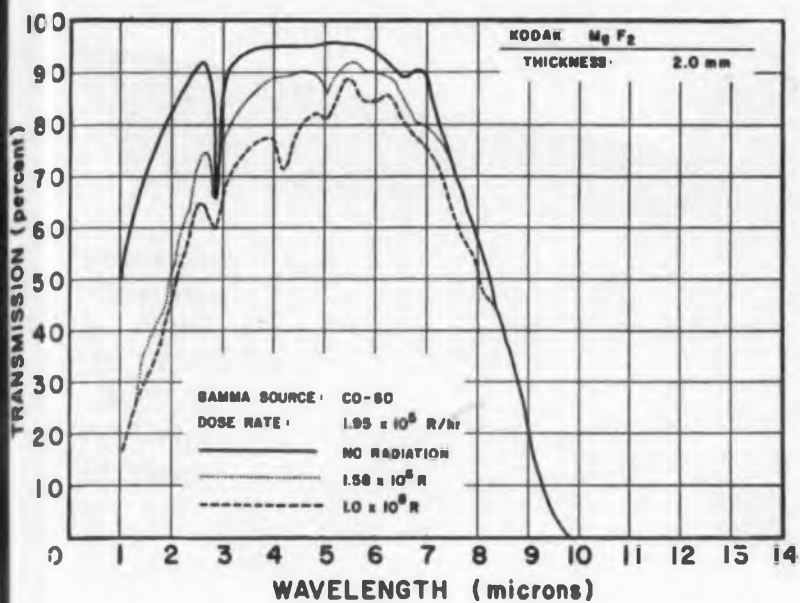
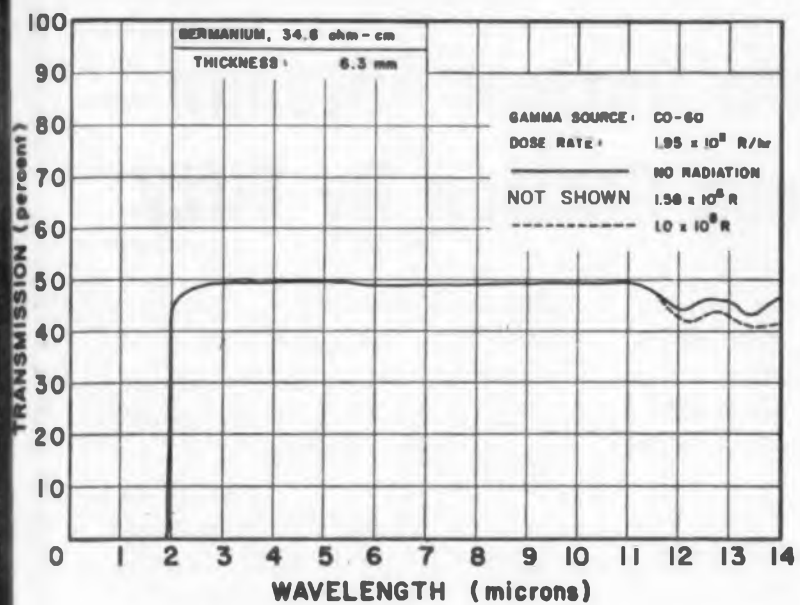


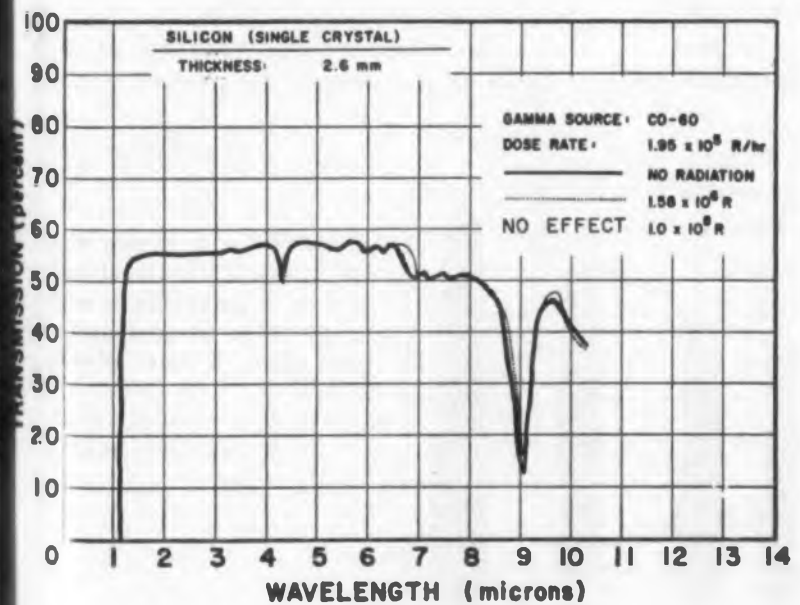
Fig. 1. Effect of high-level radiation on transmission efficiency of four materials presently used in infrared systems for space vehicles—(a) arsenic trisulfide, (b) magnesium fluoride (similar to the material known commercially as Irtran AB-1), (c) germanium and (d) single crystal silicon. For highest known levels of space radiation to produce even these negligible effects would require materials to be exposed to radiation for more than a century.



(b)



(c)



(d)

Per Cent Change in Infrared Transmission Efficiency Due to Radiation

Material	Thickness	Radiation Level (Roentgens)	Infrared Wavelength in Microns														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Germanium Single Crystal (34.0 ohm-cm)	6.3 mm	10^8			0	0	0	0	0	0	0	0	0	0	-2	-2	-2
Silicon Single Crystal	6.3 mm	10^8		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Silicon Boron doped	6.3 mm	10^8	-6	-4	-4	-4	-4	-4	-4	-6	-5	-14	-14	-8	-8		
Silicon coated SiO for 4μ	2.5 mm	10^6		+14	+2	+1	-2	-5	0	0	0	0	0	0	0		
		10^8		+10	+1	+2	-8	-9	0	0	0	0	0	0	0		
Kodak 80-20 Arsenic modified Selenium	4.0 mm	10^8	0	-2	0	-1	-2	0	-2	-2	-2	-2	-2	-4			
		10^6	-32	-32	0	-6	-8	-4	-10	0	0						
Kodak Mg F ₂	2.0 mm	10^6	-32	-34	-6	-18	-14	-9	-13	-3	0						
		10^8	-5	-4	-6	-4	-2	-20									
Corning CaAl ₂ O ₃ #X-745 pm	2.0 mm	10^8		-5	0	-2	0	0									
Corning #0160 Glass	2.0 mm	10^8	-15	0	-2	+6											
Corning Pyrex #7740	2.1 mm	10^8	-10	-6	-8	-2											
As ₂ S ₃	3.3 mm	10^6	-9	-10	-8	-15	-14	-12	-9	-8	-1	-14	-8	-2			
		10^8	-26	-14	-11	-16	-14	-15	-13	-11	-5	-16	-10	-4			
Mg O	5.0 mm	10^8	-10	-8	-4	-4	-4	-6	-2	0	0						
Lox-Grade Kel-F	2.3 mm	10^8	-6	-5	-14	0											
AgCl	6.3 mm	10^6	0	-4	-4	-2	-6	-14	+6	+21	+10	+6					
		10^8	0	-4	-4	0	-4	-10	-6	-2	-3	-3					
Sapphire	2.0 mm	10^8	-12	-2	0	-4	-4	-12									

DRAFTING

TRENDS



In a typical application of the POST Diazo Materials Selector Chart, a draftsman, supervisor and reproduction specialist solve a special print-making problem in short order.

Solve unusual reproduction problems with new Diazo Selector Chart

Keeping up with rapid developments in graphic reproduction and communication techniques is a difficult job these days, even for the experts.

From the engineer's and draftsman's point of view, it's largely a matter of sorting out the specific information which helps him do a better job.

The new POST Diazo Materials Selector Chart does just that—provides a condensed, tabular reference piece that helps you anticipate the ideal diazotype prints for various needs before they occur. This convenient chart gives brief information on sensitized papers, intermediates and specialties in terse "what, when, why and where" style.

If you're concerned, for instance, with print distribution to different departments, units or groups, then prints on a variety of colored stocks might be the answer.

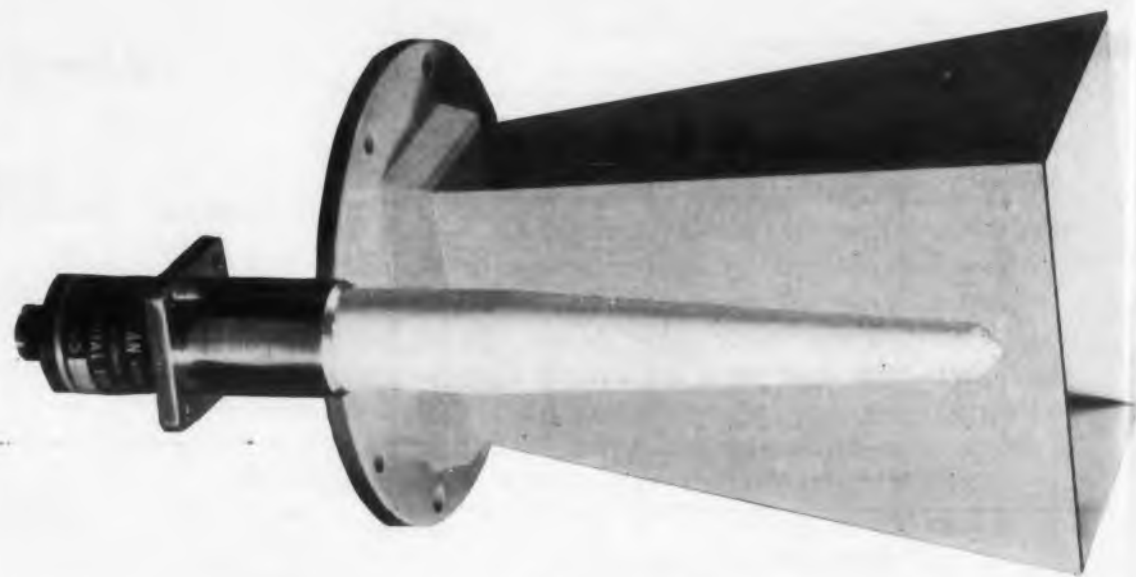
Increasing print production from diazo equipment with a lower-power light source . . . making legible prints from worn old tracings . . . even making copies from an opaque print . . . all can be handled by use of new Post 206M-14, a fast, extra-sensitive whiteprint paper.

Suppose a design conference calls for a poster, actual size, made from a large engineering drawing, rigid enough for display, tough enough for extreme handling and on-the-spot sketches? Post diazo-sensitized cardstock in 32 or 50 lb. weight can turn the trick on standard reproduction equipment, ammonia process or semi-moist. For many more helpful solutions to similar situations, ask for your personal file-size copy, of the Post Selector Chart, available from your Post dealer or Frederick Post Company, 3644 North Avondale Avenue, Chicago 18, Illinois.



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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

CIRCLE 57 ON READER-SERVICE CARD



Dramatic 50-to-1 reduction in cross-section is emphasized by this comparison with a standard horn, represented symbolically on the cover illustration.

Dielectric Optical Antenna Cuts Cross-Section By Fifty

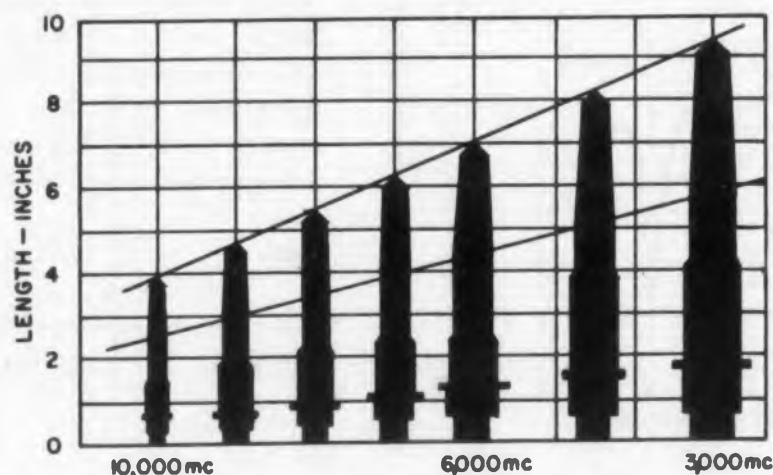
A NEW high-dielectric end-fire rod antenna duplicates the gain, directivity and other characteristics of a standard microwave horn while drastically reducing cross section to as little as 1/50 that of a horn.

The antenna's in-line coaxial connector allows missile and space-vehicle designers to fully exploit this aerodynamic advantage. The unit, developed and manufactured by Don-Lan Electronics Co., 1131 Olympic Blvd., Santa Monica, Calif., is said to be the first commercially available broadband rod antenna of this type and characteristics.

Much of the success of this novel de-

sign lies in the choice of advanced sintered materials. Beryllium oxide and aluminum oxide are used when higher temperatures are involved. Range B units are available for ranges up to 2000 F, while antennas can be supplied to operate at as high as 3,100 F. Lower cost materials are used in range A units, available for environments up to 300 F.

The extremely high and uniform density of these materials permits production machining tolerances to be held to 0.0001 in. These tight tolerances lead to beam-pattern repeatability as close as ± 1 deg in a 50-deg pattern. The high dielectric constant of the material (in the



Antennas are available for 1,500-mc to 10,500-mc applications. Over-all length for 10-db gain varies from about 4 in. to about a foot.

range of $K = 15$) makes the small size and light weight possible (weight is 1/5 to 1/10 that of an equivalent standard horn).

Further bonuses arising from the choice of materials are the excellent dimensional stability over wide temperature and shock conditions, and negative moisture absorption. These characteristics lead to stable rf performance.

Available units cover the frequency range of 1,500 mc to 10,500 mc. As indicated in the graph, over-all dimensional scale is a function of frequency and gain desired. The vswr for any 5-per-cent bandwidth within this range is 1.30 to 1.0. Insertion loss is negligible, while efficiency is at least comparable to a standard horn.

The compact antenna lends itself to broad design flexibility. One unclassified application is in the Talos missile. Antennas are available with linear or circular polarization for multiple-element installations in small diameter missiles. The antenna has been adapted for multi-element phase or amplitude-monopulse systems. Additional size and weight saving is accomplished by eliminating the need for balanced mechanical mounting in compact search systems.

The unit can be attenuated electrically and can be cycled from linear to elliptical polarization at high speeds.

For a single-element antenna, price varies from \$175 to \$475, depending on quantity. Multiple arrays are priced by quotation. Most of these units are available from the manufacturer within 30 to 60 days, while some units can be delivered sooner.

For further information on this lens antenna, turn to Reader-Service Card and circle 251.

1940 1941 1942 1943 1944
Certi-Crimp* • A-MP-O-LECTRIC • Plasti-Grip • SOLISTRAND • Plasti-Bond • AMP-O-MATIC • Amplifilm • AM

4 1945 1946 1947 1948 1949
TION • COPALUM • Ampli-Bond • DYNA-CRIMP • TERMALUM • FASTON • AMPLIVAR • CERTI-SEAL • PING • A

49 1950 1951 1952 1953 1954
MPOWER • DIAMOND GRIP • AMPORTAPOWER • AMP EDGE • Certi-Crimp • A-MP-O-LECTRIC • Plasti-Grip •

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more than 15,000 different AMP circuit termination products. This is the common denominator which spells out unquestioned reliability in all our products including the AMPin-cert connector line. ANOTHER AMP FIRST! Now AMP offers tape-fed, automated application of AMPin-cert contacts. Production levels of up to 1,500 terminations per hour can be achieved with standard A-MP-O-LECTRIC® machines. Also, the AMPORTAMATIC crimping tool is available for tape-fed terminations in hard-to-reach locations.

Visit us at the A.E.S. Show, Los Angeles; Oct. 26, 27 and 28, 1960, Booths 313 to 315.

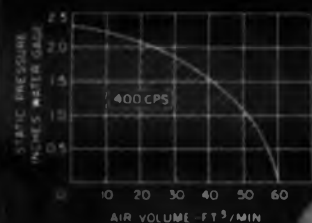
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CIRCLE 58 ON READER-SERVICE CARD

*Built to aircraft
and missile
specifications*



Aximax 2

The Aximax 2 vane axial fan is designed for tightly packed "black boxes" aboard aircraft or missiles where maximum cooling is mandatory with a minimum of space and weight loss due to the fan. Air delivery of 60 cfm free air is attained from a fan only 2" in diameter by 1.5" in axial length. Weight is 4.5 ounces.

Variation in driving motors include constant speed 20,000 rpm, 10,000 rpm as well as variable speed Altivar versions. The latter vary their speed inversely with density thereby approaching constant cooling with a minimum of power drain and noise.

Power requirements vary from 400 cps for the standard unit to 1600 cps for special designs, 1 or 3 phase, sinusoidal or square wave. The Aximax 2 meets MIL-E-5400B and other individual missile specifications. Write today for complete technical information to —



ROTRON mfg. co., inc.
WOODSTOCK, NEW YORK

In Canada: The Hoover Co., Ltd. Hamilton, Ont.

CIRCLE 59 ON READER-SERVICE CARD



Electrocardiogram can be recorded on home-type magnetic tape recorder via Mnemotron pulse-frequency modulator/demodulator.

Low-Cost Analog Tape System Records or Plays Back Dc to 400 Cps

LOW-FREQUENCY data, even down to dc, can now be recorded accurately on conventional home tape recorders, thanks to a new device with the mnemonic name, Mnemotron.

Manufactured by a company of the same name, Mnemotron Corp., 1 N. Main St., Spring Valley, N.Y., the M102 Analog Tape Recorder System is sensitive enough to resolve voltages as low as 6 mv. It can accept voltages as high as 3 v on one range and 10 v on the less sensitive range.

With appropriate transducers and pre-

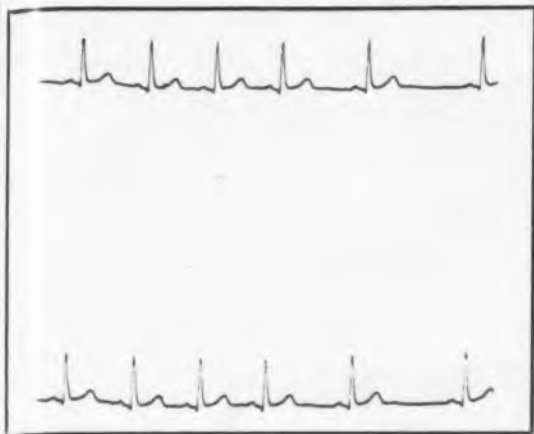
amplifiers, this recorder/reproducer system can record and play back variables such as pressure, temperature, strain, speed, and of course, any phenomena which can be measured with a dc meter.

Output from the instrument can be used as input to computer devices or as input to a scope. By viewing the output on a scope, an engineer can select those data he deems most useful for permanent recording on paper.

Input information can be in any form. It may, for example, be in the form of transients like those which might be de-



Information on tape is demodulated and transcribed onto paper by analog converter unit.



Electrocardiogram recorded directly on paper (bottom) and simultaneously recorded on magnetic tape and transcribed back to paper through Mnemotron units shows high accuracy (0.2 per cent full scale) of the modulator/demodulator.

rived from an electrocardiogram. The information is used to frequency-modulate a pulse carrier with a center frequency of 7,200 pps. With full modulation, this carrier can be driven from 4,000 to 11,000 pps. The frequency-modulated pulse train is delivered to, and recorded by a conventional tape recorder.

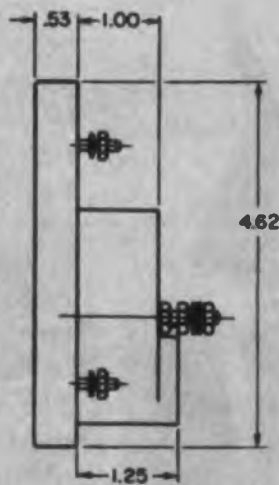
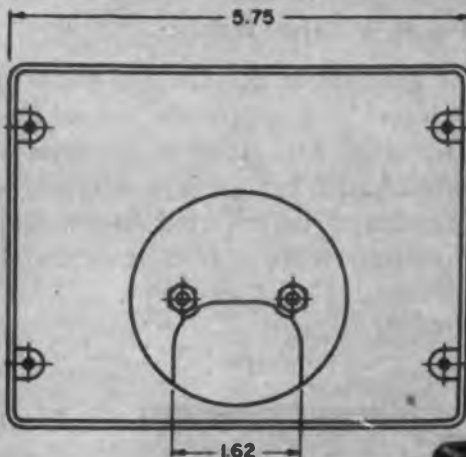
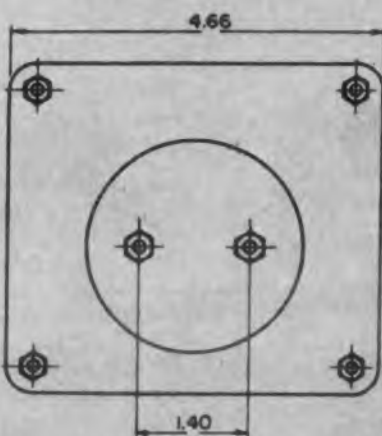
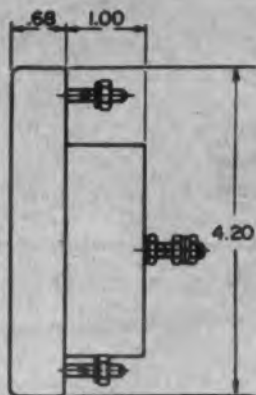
To retrieve the recorder information, one feeds the frequency-modulated pulse train from tape back into the Mnemotron. The usually distorted pulses from the pulse train are used merely as triggers in reconstituting the original pulses. The M102 converts the time-voltage integral of the pulses into varying dc-voltage levels which can be recorded on an oscillographic recorder.

By suitable selection of the record and playback tape speeds, one can expand or contract the time scale on the final record. Thus, one can extend the effective frequency response of oscillographic recorders or X-Y plotters.

The M102, a 2-channel converter, is offered alone (for \$895), or with a companion tape recorder as a complete 2-channel analog tape recorder system (for \$1,290). Delivery time for the 2-channel system is 15 to 30 days. Delivery time is longer and prices are higher (by about \$450 per converter channel) for 4-, 6-, 7-, and 14-channel systems.

A Model M100A system is available for an additional \$50 per channel. It allows one to record and play back simultaneously on the same channel.

For more information on these analog tape recorder systems, turn to the Reader-Service Card and circle 252.



Standard instruments: Black Lance pointer, easy to read black markings on white dial, 100° arc. Model 1751—Size: Rectangular—4.66" x 4.20"; 4" long scale. Accuracy: ± 2% full deflection as DC instrument. Model 1761—Size: Rectangular—5.75" x 4.62"; 4.5" long scale. Both models available as: DC ammeters, milliammeters, microammeters, voltmeters (1000Ω/volt).

NEW WESTON PANEL METERS PROVIDE THREE IMPORTANT DESIGN ADVANTAGES...

- Exclusive magnetic shielding
- Sustained accuracy—up to $\pm 0.5\%$
- Ranges tailored for special applications

Long-term accuracy and reliability are special features of Weston's new line of panel instruments. Accuracy—in Model 1761—is up to $\pm 0.5\%$ of full scale deflection when supplied with knife edge pointer and mirror scale. Exclusive CORMAG® self-shielded mechanisms are used in both Models 1751 and 1761. The meters may be mounted on magnetic or non-magnetic panels without special adjustments... are immune to the effects of stray fields and nearby instruments. Housed in dust and moisture-resistant Bakelite cases with glass windows, they are supplied in a wide variety of standard ranges.

Special range meters with conventional magnetic construction are available where higher current sensitivity, lower resistance, special ballistic characteristics and controlled scale distribution are required.

Call your Weston representative for details, or write for Catalogs 01-109 and 01-110—which contain technical information on this new line of precision panel meters. Weston Instruments Division, Daystrom, Inc., Newark 12, New Jersey. International Sales Division, 100 Empire Street, Newark 12, New Jersey. In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
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CIRCLE 60 ON READER-SERVICE CARD

NEW PRODUCTS

Covering all new products generally specified by engineers designing electronic original equipment. Use the Reader's Service Card for more information on any product. Merely circle number corresponding to that appearing at the top of each description.



Multimeter Expands Increments At Any Point In The Range

358

Type 5880 incremental multimeter permits increments of any range to be expanded and displayed on an external servo recorder. The instrument consists of a Simpson 270 multimeter, a suppressor power supply and an attenuator. The range is the same as that of the Simpson multimeter; typical accuracies are 1.5% for dc and 2% for ac. The servo recorder permits expansions of $\pm 1\%$; the attenuator enables the expansion to be adjusted to any value from 1% to 100%. Applications for the unit are wherever a strip-chart recorder is used to display voltage, current or resistance.

Tensor Electric Development Co., Inc., Dept. ED, 1873 Eastern Parkway, Brooklyn 33, N. Y.
Price: \$250.

Availability: 30 days.



Electrostatic Printer Tubes Translate Signals Into Printed Words

357

These electrostatic printer tubes can translate electronic signals into printed words and pictures on paper at the rate of 20,000 characters per second or more than 10,000 lines of computer information per min. The QV130 and the QV131 tubes have 3-in. matrices and were designed for short copy printing. The QV132 and the QV133 are 10-in. printer tubes and can print electronically stored or transmitted information on full page sheets. The tubes resemble flattened cathode-ray tubes with wire matrices across their faces. Tiny wires, 0.0001-in. thick and spaced 250 to the inch extend through the face of the tube. The varying cathode-ray beam current inside the tube passes through the matrix, depositing electrostatic charges on the paper as it passes against the tube.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton, Mass.



Eight-Inch Ignitron Handles 100,000-Amp, 20-Kv Pulses 356

A deceptively small ignitron, the GL-7703 is capable of passing and controlling a two-billion volt-ampere pulse. The tubes rating of a 100,000-amp, 20-kv pulse represents four times the power handling capacity of the GL-7171, up to now the most powerful ignitron produced by the manufacturer.

The new ignitron is simple in construction, and weighs less than 2 lb. The tube is 8-in. tall and has a 2-in. diam. A proprietary refractory metal is used for the anode in place of the usual graphite. This improved anode reduces fouling, while an oversize anode bushing gives the tube its large voltage-handling capacity. The usual pulse rate in capacitor discharge is 1 ppm. Half-cycle peak current is 60,000 amp for a 120-usec pulse and 100,000 amp for a 20-usec pulse. According to the manufacturer, the new tube will find use as a super crowbar for power supplies that require a means for rapid discharge of energy.

General Electric Co., Power Tube Dept., Dept. ED, Schenectady 5, N. Y.

Price: \$145 ea.

Availability: From stock.

Tunnel and Backward Diodes For Computer Applications 359

These germanium units meet the requirements of logic circuits and other computer applications. The backward diodes can also be used in low-level rectifier and detector circuits. Characteristics of the tunnel diodes are: peak current, 5 or 1 ma; peak-current tolerances, 2%, 5% or 10%; peak-to-valley ratio, 8:1; capacitance, 6 pf per ma; temperature range, -55 to +100 C. The backward diodes have these specs: shunt capacitance, 3 pf; forward voltage drop, 30 mv; leakage current, 400 mv. Forward voltage in the backward diode is 15% of the peak current of the companion tunnel diode.

Transitron Electronic Corp., Dept. ED, 168 Allison St., Wakefield, Mass.

NEW
FROM

JFD

Miniature Maglag Lines
put more time
in less space!



actual size model J1

Performing all functions of lumped constant delay lines (except reproduction of input amplitude characteristics in the output), new Maglag Lines offer a versatile combination of capabilities. Utilizing a timing element made of a magnetic core and a switching transistor network, they deliver a wide range of delay time values from 2 μ sec. to 1 sec. or more. Input and output are completely isolated, making output pulse rise time independent of input pulse characteristics. JFD Maglag

Lines permit the use of different input and output impedances and impedances can assume values within wide ranges.

JFD Maglag Lines can be furnished with taps to select a variety of delays, or the delay can be made to vary with infinite resolution by manual means or by voltage variations.

Investigate the unique qualities of this new JFD component by writing today for Bulletin 83.

Here is an example of the many possible combinations of Maglag characteristics

MODEL J1 MAGLAG LINE SPECIFICATIONS:

DELAY.....	20-50 μ S (Adjustable)	OUTPUT PULSE AMPLITUDE.....	App. 5 V.
INPUT PULSE WIDTH.....	3 to 30 μ Secs.	OUTPUT IMPEDANCE.....	App. 5,000 Ω
INPUT PULSE AMPLITUDE.....	7-100 V.	POWER INPUT.....	App. 125 MW at DC Voltages of 2.5 V. and 20 V.
INPUT IMPEDANCE.....	50 Ω App.	SIZE.....	2 1/4 X 2 1/2 X 1 1/4 = 6 cu. in.
OUTPUT RISE TIME.....	0.16 μ Secs.	WEIGHT.....	Approx. 6 oz.
OUTPUT PULSE WIDTH.....	Same as Input		

JFD

JFD ELECTRONICS CORPORATION

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7311 Van Nuys Boulevard, Van Nuys, California

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15 Moore Street, New York, N. Y.

VARIABLE TRIMMER PISTON CAPACITORS * FIXED METALIZED INDUCTORS * LC TUNERS, FIXED AND VARIABLE,
DISTRIBUTED AND LUMPED CONSTANT DELAY LINES * PULSE FORMING NETWORKS * DIPLEXERS

CIRCLE 61 ON READER-SERVICE CARD

IN PRECISION INSTRUMENTATION EPSCO DELIVERS ITS SPECIFICATION



IF YOU NEED 0.01% ACCURACY IN VOLTAGE REFERENCES

FEATURES:

- Accurate to 0.01%, stable to 0.005%
- 1 μ V resolution down to zero volts
- Output impedance less than 0.006 ohms
- Direct reading: more speed, fewer errors
- Adjustment-free, drift-free operation
- Built-in null meter
- Self-contained, portable or rack mount

SPECIFICATIONS:

REFERENCE OUTPUTS:

Voltages . . . ± 100 v d-c, 200 v d-c

Current . . . 5 ma d-c

Resistance . . . 1 ohm max.

Absolute accuracy . . . $\pm .01\%$ initially

Drift . . . $\pm .02\%$ per year, $\pm .005\%$ max. during first hour after ten-minute warmup

SELECTABLE OUTPUTS:

Decimal voltage range . . . ± 111.112 v d-c

Binary voltage range . . . ± 100.0008 v d-c

Current . . . ± 15 ma

Epsco Secondary Standard Voltage References outperform all others on the market — as proven by 5 years of outstanding service in the most critical and demanding applications.



These precision instruments perform a wide range of functions in research and production calibration and testing. Available from stock in 4 standard models. For full details, call or write for Bulletin #26001.

Epsco  **INSTRUMENTS**

A division of Epsco, Incorporated, 275 Massachusetts Ave., Cambridge 39, Mass. Telephone UNiversity 4-4950

CIRCLE 62 ON READER-SERVICE CARD

NEW PRODUCTS

Three Companies Offer

The two major advantages of the epitaxial transistor are the virtual elimination of the collector series resistance and a large decrease in the storage and turn-off times. The basic process in making epitaxial transistors consists of depositing a very thin layer, about 1/2-mil thickness, of high resistivity semiconductor material on a thicker substrate of very low resistivity material. Since the active part of the transistor is all within the high resistivity material, this process, in essence, provides a method for handling 1/2-mil thick semiconductor slices.

Rheem's RT409 Silicon Unit Is Similar To 2N697

The silicon epitaxial transistor, type RT409, is a 60-v collector breakdown unit and otherwise meets the general specifications of the 2N697 series. The typical collector-to-emitter saturation voltage at 150 ma has been reduced by a factor of two. The V_{CE} for the RT409 is 0.35 as compared to 0.7 for the 2N697. Compared under similar test conditions, the typical storage time for the epitaxial unit is less than 100 nsec, for the 2N697 it is 400 nsec. Because the power dissipation is low, the RT409 may be operated at higher current levels. Other epitaxial transistors in the firm's line, to be announced soon, such as the 2N699, 2N699A, 2N657 and RT5004, will be made available at first in the TO-18, TO-5 and the firm's Microbloc packages.

Rheem Semiconductor Corp., Dept. ED, 350 Ellis St., Mountain View, Calif.

Price: \$170 ea for developmental units.

Availability: Six weeks after receipt of order.

NEW ... FROM ESC



MINIATURE MODULAR COMPUTER DELAY LINES

... designed for printed board mounting

Module No.	Delay	Size
15-89	100 msec.	$\frac{3}{8}$ " x $\frac{1}{2}$ " x $3\frac{5}{8}$ "
15-90	75 msec.	$\frac{3}{8}$ " x $\frac{1}{2}$ " x $3\frac{5}{8}$ "
15-91	20, 10, 10, 5 msec.	$\frac{3}{8}$ " x $\frac{1}{2}$ " x $3\frac{5}{8}$ "
15-92	50 msec.	$\frac{3}{8}$ " x $\frac{1}{2}$ " x $2\frac{1}{4}$ "
15-93	20, 20 msec.	$\frac{3}{8}$ " x $\frac{1}{2}$ " x $2\frac{1}{4}$ "
15-94	10, 5 msec.	$\frac{3}{8}$ " x $\frac{1}{2}$ " x $2\frac{1}{4}$ "

As a group these miniature, modular, lumped constant delay lines constitute an adjustable delay line. They offer great flexibility in design by providing adjustable delays ranging from 5 msec. to 335 msec. or greater, if additional units are employed.

Impedance — 93 ohms with a maximum pulse attenuation of .5 db and pulse rise time of 30 msec. (max.) for any module.

Modules with variations of rise time, delay or impedance can be supplied upon request.



ESC

WRITE TODAY FOR COMPLETE TECHNICAL DATA.

exceptional employment opportunities for engineers experienced in computer components... excellent profit-sharing plan.

ELECTRONICS CORP. 534 Bergen Boulevard, Palisades Park, New Jersey

Distributed constant delay lines • Lumped constant delay lines • Variable delay networks • Continuously variable delay lines • Step variable delay lines • Shift registers • Video transformers • Filters of all types • Pulse-forming networks • Miniature plug-in encapsulated circuit assemblies

CIRCLE 69 ON READER-SERVICE CARD

Off-axial Transistors

Motorola Offers Low-Cost Type 2N834

363

This epitaxially grown silicon-mesa transistor, type 2N834, gives increased performance on all device parameters. A comparison with standard silicon-mesa transistors indicates the epitaxial devices have higher breakdown voltage, higher frequency response, lower storage time, and at the same time, lower saturation voltage and lower collector capacitance. Breakdown voltages are in the order of 90 v and storage time as low as 12 nsec. Collector saturation voltage is reduced from 0.4 to 0.14 v, typical. At 50 ma saturation voltage is typically 0.28 v. They are capable of delivering 0.5-w power output with 10-db gain at 100 mc. Current gain-bandwidth product is 500 mc, collector capacitance is 2.0 pf.

Motorola Semiconductor Products, Inc., Dept. ED, 5005 E. McDowell Road, Phoenix, Ariz.
Price: \$18 ea in quantities of 100.

Availability: From stock.

Pennsylvania's Germanium Types Resemble 2N702 and 2N711

364

Designated types SYL2300 and SYL2301 these epitaxial transistors are of the germanium diffused-base mesa type. They are electrically similar to conventional mesa transistor types 2N702 and 2N711, with improved performance characteristics. For the same saturation voltage and switching time. For equivalent transistor dimensions, the saturation collector current of 50 ma is reduced by a factor of 3.5, typically 0.15 v at 50 ma for the off-axial units. Typical switching storage times are reduced by a factor of 4.

Sylvania Electric Products, Inc., Dept. ED, 100 Third Ave., New York 17, N.Y.

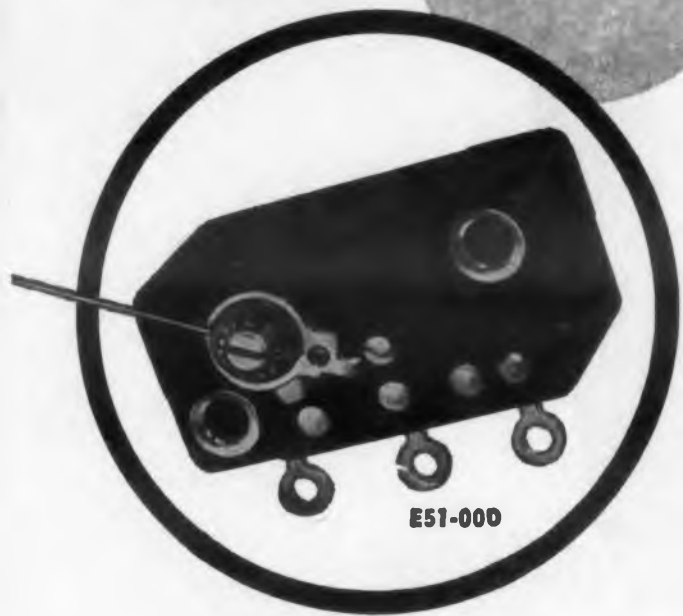
Availability: Sample quantities immediately available, production quantities in November.

New

FEATHER
TOUCH

SNAP
ACTION

COIN
SWITCH



E51-000

- Feather touch operating torque (4 inch-grams max.)
- Friction-free blade pivot
- Lateral rock-wipe contact action
- Positive stops molded in case
- Rated: UL 5 amps/250 V a-c

Extremely low operating force and precise tolerances provide positive electrical control for pressure indicators, sensing timers or relays, office machines and vending machines. Operating force can be varied by length of actuator wire.

Your switching problems may find solution from over 8,000 Cherry switch variations. Write for complete literature today!



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PRODUCTS CORPORATION**
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CIRCLE 67 ON READER-SERVICE CARD

NEW PRODUCTS

Laboratory Oscilloscope 589

Vertical amplifier flat from 20 cps to 4.9 mc



Model 600 oscilloscope, for industrial and scientific applications, has a regulated power supply. A sweep frequency pulse on the panel terminal is for transformer ringing testing. Wide-band vertical amplifier is flat within 1 db from less than 20 cps to 4.9 mc. Two-range vertical sensitivity is from 20 mv per in.; horizontal amplifier response is uniform within 2 db from less than 20 cps to 200 kc. Linear sawtooth sweep is 10 cps to 100 kc. Input calibration voltage is 10 v, peak-to-peak. Power requirements are 105 to 125 v, 50 to 60 cps, 75 w.

Jackson Electrical Instruments Co., Dept. ED, 124 McDonough St., Dayton, Ohio.

Price: \$335.

Availability: Stock to 2 weeks.

Tape Verifier and Duplicator 565

For punched tape



Model 1429, used in conjunction with tape readers and perforators, automatically verifies and duplicates error-free tapes in one operation. It can be used on up to eight channels in any code structure. Characters in disagreement are displayed for possible correction. The unit operates on 115 v at 60 cps, weighs 30 lb and is made for rack mounting.

Tally Register Corp., Dept. ED, 1310 Mercer St., Seattle 9, Wash.

Price: \$850; fob Seattle.

Availability: 45 days.

HIGH SPEED SOLID STATE DIGITAL TELEMETER

1
5th



THE SIZE OF EXISTING EQUIPMENT

AEC of N. J. MCH series multicodeers are solid state digital commutator coders capable of accepting data in three forms; time multiplexed analogs and digital data, both serial and parallel. The equipment is designed for the utmost compactness (240 cu. ins.) minimum weight (11 lbs.), low power consumption (600 ma normal at 28U DC) and reliability compatible with a wide range of environmental conditions encountered in missile applications.

Specification sheets are available on Model—MCH-3 (31 channels at 1400 samples / sec max.)

MCH-6—(63 channels at 710 samples / sec max.)

MCH-12—(127 channels at 355 samples / sec max.)

Systems accuracy: An honest tenth of 1% from input to coded output.

Modified units for special application and environments are available upon request.



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Electronics
Corporation**

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METUCHEN, N. J.

TWX METU. 78

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SANTA MONICA

CIRCLE 68 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1968

Picture Tubes 511

Square corners expand viewing area

Nearly square corners on these 19- and 23-in. picture tubes have expanded their useful viewing areas to more than 95% of the area needed to display all the picture information transmitted. The 19-in. tube deviates no more than 15/16 in. from true flat. Both tubes use magnetic deflection with a diagonal deflection angle of 114 deg, are electrostatically focused, and require no ion trap.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, PO Box 284, Elmira, N.Y.

Silicon Transistor 540

Has a minimum beta of 30

Type C106 symmetrical silicon transistor features a minimum beta of 30 in both directions and a maximum saturation resistance of 5 ohms at 10 ma collector current. The unit is designed for low-level applications, choppers, multiplexers, bi-directional switches and high-precision analog circuits requiring low saturation resistance with high "off" to "on" switching ratio.

Crystalonics Inc., Dept. ED, 249 Fifth St., Cambridge 42, Mass.

Oscillographic Recording Systems 514

Are direct-writing and photographic

These multi-channel recording systems combine the immediate readout of "direct-writing" and the high-frequency response of photographic recording. The direct-writing portion provides clear, inkless traces and is used to monitor events in the dc to 100 cps frequency range. The photographic recorder provides a frequency response to 500 cps. Trace overlap makes possible the recording of two events on a common base line.

Sanborn Co., Medical Division, Dept. ED, 175 Wyman St., Waltham 54, Mass.



The FSU-1P Crusader recently set new coast to coast speed record. CAI camera control system with Edison Time Delay Relay was used to automatically provide sharp, clear aerial photographs of the entire flight.

HERE'S WHAT A CUSTOMER SAYS ABOUT EDISON TIME DELAY RELAY...

"The CAX-12 servo power unit is a very vital part of the intricate 'brain' of the automatic camera control system, and naturally, we must have absolute reliability in all components. Therefore, as you know, we have relied on Edison Thermal Time Delay Relays since the original design of this CAX-12 and similar units. Since space for this type of equipment is at a premium, the compact size was a most important factor in original selection, but our units must also withstand severe environmental testing, involving vibration, moisture, shock, pressure fluctuation and extremes of temperature. Needless to say, the Edison Relay met all of these exacting requirements in our laboratories, and we've been specifying Edison ever since!"

(The above letter was received from Chicago Aerial Industries)

Chicago Aerial Industries has developed a camera control system that allows one jet pilot to do the job of ten expert aerial photographers... automatically.

Heart of this new unit is the CAX-12 servo power unit. It accurately synchronizes film speed with speed of the jet—changes lens openings in response to electronic signals—regulates shutter speed and controls driving motor on cameras.

Because this power unit is vital to the camera control system component reliability is a must. That's why CAI relies on

Edison's Thermal Time Delay Relay being inserted in the CAX-12 servo power unit.

Edison Thermal Time Relays exclusively for CAX-12.

Edison's line of miniature time delay relays are available for a wide range of electronic applications. They are light, small, rugged and offer these advantages:

- Designed to withstand vibration frequencies to 1500 CPS
- Exceptionally high rate of contact closure
- Permanent calibration and hermetic seal
- Extremely rigid mechanical structure using high-strength, high-expansion alloys.

Thomas A. Edison Industries

INSTRUMENT DIVISION

88 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 66 ON READER-SERVICE CARD

YOU CAN SPECIFY savings in weight, improvements in performance, increases in reliability for your electronic systems from this box. This is Sperry's Speci-File—a complete electronic and physical biography of the traveling wave and klystron tubes offered by Sperry Gainesville. To speed your specifying, to make it more accurate, and to secure the benefits of outstanding microwave tube performance for your systems, order your free Sperry Speci-File today. Just fill in and mail the attached coupon.



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Section D-101
Sperry Electronic Tube Division
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NEW PRODUCTS

Variable Speed Drive 512

Fractional hp

This fractional hp variable speed drive features compactness and lightness. Speed ranges are from 1.2 to 4660 rpm with up to 10 to 1 variation and are available in 1/4, 1/2 and 3/4-hp ratings. Large diameter pulleys are provided for cooler running, longer lasting belts. Electrical characteristics include: single phase; three phase; drip-proof; totally enclosed and explosion-proof. It is available with right-angle and helical gears.

Sterling Electric Motors, Inc.,
Dept. ED, 5401 Telegraph Road,
Los Angeles 22, Calif.

Servo-Amplifier 515

For amplifying microvolts

Servo-amplifier, model SA-60C-4, is a compact, high-gain unit designed to amplify microvolts with stability. The unit will accept a low-level, balanced ac signal directly from a transducer. Specifications include: line voltage, 105 to 130 v; maximum voltage output, 140 v across 5 K at saturation with 90 μ v input; power, 115 v \pm 10%, 60 cps, 1 phase, 50 w.

Schaevitz Engineering, Dept.
ED, P.O. Box 505, Camden, N.J.

Pushbutton Switches 518

Have modular construction

These are general purpose switches of modular construction that permit the use of two to 48 or more push-buttons in any array. Of light-weight construction, the switch has a life of 500,000 operations according to the manufacturer's claim. Any number of buttons in the general purpose switch can be interlocked. Each push-button can represent an 8 pdt switch or a 4 pdt switch. Other combinations are available on request.

Telex Inc., Special Products Div.,
Dept. ED, 1633 Eustis St., St. Paul,
Minn.



NEW CBS

HIGH-POWER



TRANSISTORS

Advantages

- High power output: up to 30 w Class A, 100 w Class B, 1000 w switching
- High voltages . . . high current gains . . . and high working currents
- Low-distortion ring emitter construction
- Hermetically welded JEDEC TO-36 male industrial case

Characteristics

All these CBS high-power transistors have: Max. dissipation, 150 watts* for a typical thermal resistance of 0.5° C/W; max. collector current, 15 amperes; junction temperatures, -65 to +100°C.

Type	Max. W. Diss.*	Max. Thermal Res°C/W	Max. V _{CEO}	Max. V _{CES}	h _{FE} (I _C = 5A)	
					Min.	Max.
2N173	70	1.0	60	50	35	70
2N174	85	0.8	80	70	25	50
2N277	70	1.0	40	40	35	70
2N278	70	1.0	50	45	35	70
2N441	70	1.0	40	40	20	40
2N442	70	1.0	50	45	20	40
2N443	70	1.0	60	50	20	40
2N1100	85	0.8	100	80	25	50

*25°C base mounting temperature.

save costs • space • weight

You can now replace two 40-watt or four 20-watt paralleled power transistors with one CBS PNP high-power transistor. This one design change brings you important transistor . . . component . . . assembly . . . space . . . and weight savings. New economies become possible in power supplies and amplifiers and in high-power switching circuits.

Note the wide line of these CBS PNP high-power transistors, their pertinent characteristics and many advantages. Ask for complete technical data. Order these money-saving units today . . . at factory prices for quantities up to 1000 . . . from your Manufacturers Warehousing Distributor.

CBS semiconductors

Reliable products through Advanced Engineering

CBS ELECTRONICS, Semiconductor Operations, Lowell, Mass. • A Division of Columbia Broadcasting System, Inc.

Sales Offices: Lowell, Mass., 900 Chelmsford St., GLenview 2-8961 • Newark, N. J., 231 Johnson Ave., TAlbot 4-2450 • Melrose Park, Ill., 1990 N. Mannheim Rd., EStebrook 9-2100 • Los Angeles, Calif., 2120 S. Garfield Ave., RAYmond 3-9081 • Atlanta, Ga., Cary Chapman & Co., 600 Trusco Way, S. W., PLaza 8-4506 • Minneapolis, Minn., The Heimann Co., 1711 Hawthorne Ave., FEderal 2-5457 • Toronto, Ont., Canadian General Electric Co., Ltd., LEnnox 4-6311

CIRCLE 63 ON READER-SERVICE CARD

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CBS Manufacturers Warehousing Distributor

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EM: 4-6154

John A. Becker Co.
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BALdwin 4-1071

Lafayette Radio
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AXtel: 1-7000

Bell Electronic Corp.
Los Angeles, Calif.
PLEasant: 2-7191

New York 13, N. Y.
WEstrn: 6-5300

Busacker Equipment Corp.
Houston, Texas
JACKson: 9-4626

Boston 10, Mass.
HUBbard: 2-7850
Newark 2, N. J.
MAREt: 2-1661
Plainfield, N. J.
PLAINfield: 6-4718

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Seattle, Wash.
MA: 4-4355

Elwyn W. Lay Co.
Paramount, Calif.
NEvada: 6-8339

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BEekman: 3-2980

D & H Distributing Co.
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SARatoga: 7-5100

Newark Electronics Corp.
Chicago 6, Ill.
STate: 2-2944

Durrell Electronics
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TWInbrook: 3-7020

Olive Industrial Electronics, Inc.
St. Louis 30, Mo.
VOLunteer: 3-4051

Electronic Center, Inc.
Minneapolis, Minn.
FE: 8-8678

Pace Electronic Supplies, Inc.
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ROdney: 3-6300

Electronic Expeditors, Inc.
Milwaukee 12, Wisc.
WOODruff: 4-8820

Phila. Electronics, Inc.
Philadelphia, Penna.
LOCust: 8-7444

Electronic Parts Co.
Albuquerque, N. M.
AL: 6-0946

Santa Monica Radio Parts Corp.
Santa Monica, Calif.
EXbrook: 3-8231

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Melbourne, Fla.
PARKway: 3-1441

Stack Industrial Electronics Inc.
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Electronic Wholesalers, Inc.
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Radio and Electronic Parts Corp.
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UT: 1-6060

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Detroit 35, Mich.
BROADway: 3-2900

General Radio Supply Co., Inc.
Camden, N. J.
WALnut: 2-7037

Summit Distributors, Inc.
Buffalo, New York
GRant: 3100

Graham Electronics Supply Inc.
Indianapolis 4, Ind.
MElrose: 4-8487

Swico, Inc. Electronic Supply Div.
Fort Worth, Texas
ED: 2-7157 • RI: 8-2229

Harvey Radio Co., Inc.
N. Y. C. 36, N. Y.
JUDson: 2-1500

Telrad Electronics
San Diego, Calif.
AT: 1-7754

Hudson Radio & TV
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United Radio, Inc.
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CIRCLE 64 ON READER-SERVICE CARD

Specialists in precision displays

Celco YOKES

Celco YOKES FOR CHARACTER DISPLAYS & HIGH RESOLUTION APPLICATIONS



Deflection yokes for difficult character displays and high resolution problems are another achievement in advanced design and engineering at Celco.

Celco Deflection Yokes permit rapid presentation of random character and alpha numeric displays. Low hysteresis, high accuracy and fast Recovery time with emphasis on spot approach to absolute zero, assures highest performance of magnetic deflection character displays.

Celco High Sensitivity Yokes minimize the deflecting currents required from the deflection drivers, resulting in high efficiency for your system.

For best utilization of the New High Resolution CRT's CELCO YOKES assure minimum defocusing at large deflections.

The construction of our yokes makes it possible to achieve sensitivities, linearities, responses and distortion-free deflecting fields not possible with the usual types of yoke.

Celco FOR STANDARD, COMMERCIAL & MILITARY APPLICATIONS

Single units or production quantities immediately available in wide range of inductance - resistance - Recovery time - pin cushion corrected or optimum focus as required. Also available 2-1/8" and 2-1/2" neck CRT yokes.



TYPE BY

Transistorized encapsulated yokes for 70° 7/8" neck CRT and 1" neck image storage tubes.



TYPE AY

Push-pull or single ended yokes for 52°, 70° and 90° deflections for 1-7/16" neck CRT.



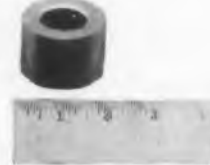
TYPE RY

Rotating deflection yokes for PPI displays. Gears, bearings, slip rings and contact assembly included.



TYPE CF

Electromagnetic focusing coil for 7/8", 1" and 1-7/16" neck CRT.



TYPE MY

Miniature light weight deflection yoke coils or assemblies for incorporation into customer housings.

Celco ENGINEERED YOKES FOR PRECISION DISPLAYS



TYPE DP

Dual purpose yoke custom designed. Deflection system plus axial off-centering coils.



TYPE HS

Special high sensitivity deflection yoke with critical damping provisions.



TYPE PI

Plug in type encapsulated deflection yoke for rapid insertion.



TYPE ER

Encapsulated rotating, 4 axis slip ring precision deflection yoke.



TYPE MS

Miniature deflection yoke for rotating or fixed coil radar system.



Write for CELCO DEFLECTION YOKE Catalogue & Design Sheets or for assistance Call your nearest CELCO Plant listed below.

Celco

Constantine Engineering Laboratories Company

Main Plant: MAHWAH, N. J. DAvis 7-1123

• Pacific Division - Cucamonga, Calif. - YUkon 2-2688

NEW PRODUCTS

AC Signal Amplifier 523

Has an operation life of 2,000 hr

All transistor ac signal amplifier model 853-001 has an operation life of 2,000 hr. It weighs 4.5 oz and was designed to amplify the output of a piezzo-electric, crystal type linear accelerometer to the level required by telemetry systems. Specifications are: gain, .5 to 50; input impedance, 300 megohms minimum; bandwidth, 2 cps to 100 kc; output impedance, 500 ohms max; output level, 2.5 v dc for biasing subcarrier oscillators and held to ± 0.1 v over 0 to 100 C; limiting voltage 6 v peak-to-peak.

Western Design Div. of U.S. Industries, Inc., Dept. ED, Goleta Calif.

DC Power Supply 532

Uses transformer for current balance

Model P529A power supply uses a trimmer transformer to give a current balance of almost 100% from no-load to full-load conditions. It is an unregulated transformer-rectifier type and is completely stable. Output is 26 to 31 v dc with a ripple voltage of 1 v peak, obtained from an input of 196 to 210 v, 300 to 420 cps. The power supply is rated at 100 amp, measures 10.5 x 5.5 x 15 in. and has an efficiency of 89%.

International Telephone and Telegraph Corp., Dept. ED, 67 Broadway St., New York 4, N.Y.

Logic Inverter Circuits 524

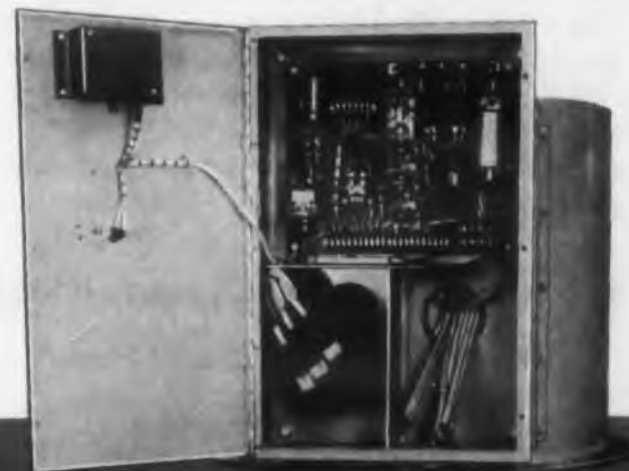
Provide logic inversion with level restoration

These three transistorized logic inverter circuits are designed to provide logic inversion with level restoration. The T-136 is a dual inverter containing two identical inverter circuits; the T-137 is a buffered inverter circuit and the T-138 is a combination of 1/2 of the T-136 and the T-137. Each unit will operate at frequencies up to 250 kc.

◀ CIRCLE 70 ON READER-SERVICE CARD

At Bogue Electric Mfg. Co....

where stability is vital



RED / LINE

Timing relays guard against extreme heat



In the high cycle motor generators produced by the Bogue Electric Mfg. Co., the stability of the thermal relay is a vital operating factor. That is why Bogue design engineers selected G-V Red/Line Thermal Timing Relays over all others to delay the operation of the water pressure protective circuit while water pressure is built up in the cooling coils during starting of the motor generator. The Timing Relay then inserts the protective circuit and thus dangerous extremes of heat are avoided, insuring the efficient performance of the generators. So, at Bogue the high quality of G-V Timing Relays is "paying off".

More and more companies are finding the reliable performance of G-V Red/Line Timing Relays makes them best for their products. G-V Red/Line Relays will "pay off" in your product, too. Your customers appreciate the importance of high quality, reliable components. G-V Red/Line Timing Relays are specially designed for industrial applications. They have the precision, reliability and long life needed to "pay off" in industrial use.

Your G-V distributor has them in stock now. Call him or write for Bulletin 131 today.



G-V CONTROLS INC.
Livingston, New Jersey

G-V

three units have power requirements of ± 12 v dc.

They are packaged in containers 7/8 in. diam \times 2-3/16 in. seated height and plug into standard 9-pin miniature tube sockets.

Engineered Electronics Co., Dept. ED, 1441 E. Chestnut Ave., Santa Ana, Calif.

Adjustable Meter Relays 519

Have external magnet meter movement

Model 29XA front adjustable meter relay has a dual adjust contact arrangement and an external magnet meter movement. Voltage and current rating for adjustable contacts is 500 mw, 5 to 15 v dc on resistive or diode protected inductive loads. Mechanical adjustment is within two angular degrees. Non-locking contacts may be positioned along the instrument scale arc by means of an external front adjusted gear drive.

Simpson Electric Co., Dept. ED, 5200 W. Kinzie St., Chicago 44, Ill.

Transistorized-Relay Drivers 536

Will operate most general purpose relays

These two transistorized-relay drivers will operate most of the general purpose relays now available. They will switch a resistive load at frequencies up to 1 kc at currents up to 400 ma and at voltages up to +30 v for the T-139 and +45 v for the T-141. These drivers must be provided with diode clamping to protect against back surges when used to operate relays. The turn-on signal is -3 v nominal, turn-off is -11 v. nominal. Both units have the same power requirements, ± 12 v dc. They are packaged in containers measuring 7/8 in. diam \times 2-3/16 in. seated height and plug into standard 9-pin miniature tube sockets.

Engineered Electronics Co., Dept. ED, 1441 E. Chestnut Ave., Santa Ana, Calif.

CIRCLE 71 ON READER-SERVICE CARD

NEW PRODUCTS

EIR Meter

574

Current range is 10^{-9} to 10 amp



Model 810 EIR meter has a current range of 10^{-9} to 10 amp $\pm 2\%$ dc and $\pm 3\%$ ac. Resistance range is 10 ohms to 10 meg, center scale, with 5% accuracy. Voltages can be measured from 1 mv to 1 kv ac $\pm 3\%$ over the range of 20 cps to 1 mc and from 1 mv to 1 kv dc $\pm 2\%$. Input impedance is 10 meg. The instrument requires 117 v ac $\pm 10\%$ at 50 to 60 cps, weighs 18 lb and can be supplied in rack and cabinet models.

Smith-Florence, Inc., Dept. ED, 4228 23rd Ave. W., Seattle 99, Wash.

Price: \$445.

Availability: 60 days.

Sine-Wave Power Supply

590

Provides regulated 117 v ac at 1 kva



This transistor-regulated sine-wave power supply, designated model PS3210 Sineverter, provides a 117 v nominal regulated output at 1 kva. The unit is not damaged by overload, short-circuit or open-circuit operation. Line regulation is better than 6%; load regulation, better than 5%. Frequency is 60 cps $\pm 1\%$. Efficiency is 70% min. Power input is 105 to 125 v dc. Unit is designed for rack mounting, measures 15 in. high and 17-1/2 in. deep. Weight is 180 lb.

Power Sources, Inc., Dept. ED, Burlington, Mass.

Price: \$1995 ea.

Availability: 30 days.

Instruments that Stay Accurate



After More Than 600 Separate Inspections — One Panel Instrument

Sounds like a lot of inspecting, but it's one of the things that makes possible Simpson's fine panel instruments.

Take pivots, for example, which support the rotating armature of a meter movement. Because Simpson quality standards are so high, Simpson makes its own pivots which require more than 60 separate inspections during manufacture. Among these are 100% inspection under a 100X microscope and sampling inspection under a 400X microscope to check radius, cone angle, finish and other characteristics. One result is pivot points with a radius tolerance maintained to within .000010". Moreover, Simpson inspects each and every group of pivots for correct hardness so they won't deform under rough use.

Through such meticulous care as this, Simpson is able to offer you panel instruments with accuracy limits that are 100% guaranteed . . . instruments with conservative ratings on which you can rely . . . instruments that stay accurate . . . instruments you can specify with confidence.

Write for Catalog 2059A.

Simpson

ELECTRIC COMPANY

5202 West Kinzie Street • Chicago 44, Illinois
Phone: EStebrook 9-1121
In Canada: Bach-Simpson Ltd., London, Ont.

Pressure Switch

586

Activated by 5 to 300 psig



The model 6266 pressure switch can be pre-set to actuate in the 5 to 100 psig range with a tolerance of ± 1 psig. Operating temperature is -65 to $+180$ F. The switch can endure a 300% overpressure and can mount directly on pressure fittings or built into pressure-fitting hardware. Housing is stainless steel. Diaphragm is non-corrosive, and is secured by a welded seam around its circumference. Current rating is 2 amp at 28 v dc or 110 v ac. Device measures 1.5-in long and 0.75-in. wide, and weighs 2 oz.

Aero Mechanism, Inc., Dept. ED, 13918 Saticoy St., Van Nuys, Calif.

Price: \$40 to \$60, 10 to 1,000 components.

Availability: 45 days.

Grid Circuit Tester

566

For all TV tubes



The GCT-9 tester offers complete coverage of all TV tubes, including voltage amplifiers, power output and heater-type diodes. All tubes are checked with the dc testing process. The unit also provides for the cathode continuity check and complete inter-element short test. It makes up to 11 simultaneous tests.

Seco Electronics Inc., Dept. ED, 5015 Penn Ave. S., Minneapolis, Minn.

Price: \$32.95 to \$34.95, depending on case.

CIRCLE 72 ON READER-SERVICE CARD



Auto-Series* and Auto-Parallel* Operation



MODEL 865

*One-knob Master Control • Automatic Current Equalizing
Automatic Voltage Equalizing • Full Range Control From Any Selected Module

For the ultimate in Regulated Power Supplies, look to H-Lab Model 865, a standout in every detail. The compact 865 is suitable for either bench or relay rack operation. This trouble-free unit features automatic transition to a current-limiting mode of operation. The current-limit is adjustable by means of a front-panel knob. This power supply is short-circuit proof, as are all H-Lab transistor supplies. In addition, the current-limit circuit of the 865 can be set for exactly the value of current which will provide maximum protection to the load device.

H-Lab Regulated Power Supplies are preferred by major laboratory and O.E.M. consumers. H-Lab Model 865 is priced at **\$185** (with case)

SPECIFICATIONS

Output: 0-40 volts, 0-0.5 amps.
Input: 105-125 VAC
50-440 cps
Load and Line Regulation:
5 millivolts.
Size: 8" W x 5 1/4" H x 8" D
(with case)
Weight: 11 lbs. (with case)
Remote Programming

OTHER PRECISE, VERSATILE AND COMPACT POWER SUPPLIES INCLUDE:

Model	E Out	I Out	Bench Model	Rack Model	Continuously Variable	Special Comments	Price
400D	150-315	0-1.5		x	No	Vacuum Tube Type	\$595.00
520A	0-36	0-20		x	Yes	High Efficiency	575.00
900A-2	0-36	0-1.5	x	x	Yes	Dual Output	580.00
800B-2	0-36	0-2.5	x	x	Yes	Low Cost Medium Current Supply	339.00
802B	0-36	0-1.5		x	Yes	Dual Output Remote Sensing	580.00
806AM	0-20	0-2.0		x	Yes	Remote Sensing Remote Programming	350.00
808A	0-36	0-5		x	Yes	Constant E/Constant I	425.00
810A	0-50	0-7.5		x	Yes	Remote Sensing	895.00
812C	0-32	0-10		x	No	Remote Sensing	550.00
855	0-18	0-1.5	x	x	Yes	Can be connected in series or parallel	175.00
880	0-100	0-1.0	x	x	Yes	Wide Voltage Span	375.00

Write on your letterhead for new, illustrated catalog describing the complete H-Lab line.



HARRISON LABORATORIES, INC.
45 Industrial Road • Berkeley Heights, New Jersey

CIRCLE 73 ON READER-SERVICE CARD

NEW PRODUCTS

L-Band Transmitter

575

For airborne and ground use



Model 2701 transmitter has a frequency range of 1,650 to 1,680 mc, fm modulated with a minimum power output of 800 mw. It contains an integral power supply and operates from an input of 0.7 amp at 29 v from -55 to +72 C. Size is 5-1/2 in. long and 3-5/16 in. in diameter.

R S Electronics Corp., Dept. ED, 435 Portage Ave., Palo Alto, Calif.

Availability: Made on order for 30-day delivery.

Variable Delay Lines

572

Delay is 2 to 10,000 µsec



These continuously variable delay lines have bandwidths of up to 500 kc. Reproducibility and linearity of setting is 0.1%. Jitter is less than 1 nsec. Both military and commercial units can be furnished.

Ferranti Electric Inc., Dept. ED, 95 Madison Ave., Hempstead, L. I., N. Y.

Availability: 90- to 120-day delivery.

Trimmer Potentiometers

579

Measure 1/2 in. in diameter



Models 140 and 150 are designed for trimming, control and servo applications. Model 140 is 0.3-in. long, weighs 0.1-oz and has a standard resistance range from 50 to 10 K. Model 150 is 0.6-in. long, weighs 0.15-oz and has a resistance range of 20 to 70 K. These bushing mount units have a standard linearity tolerance of ±1% or ±0.5% on special order. Servo mount, ball-bearing

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GOOD-ALL ELECTRIC MFG. CO.

Distributors' Division

450 Narberth Ave. Narberth, Pa.

CIRCLE 74 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1968

low!

ing units, having a linearity of 0.5%, can also be furnished.

Spectrol Electronics Corp., Dept. ED, San Gabriel, Calif.

Price: Model 140, \$10; model 150, \$12 (in bushing mount design).

Availability: From stock.

Power Relay

577

Multi-pole type



This 115-v, 400-cps relay with self-wiping contacts continuously handles 10 amp loads at 28 v dc and 115 v ac. It is available with up to 3 pdt contacts, an octal plug and a clear polystyrene cover. Dimensions are 1-3/8 x 2-1/16 in. The dpdt type is for 8-pin mounting and the 3 pdt type, 11-pin.

Kurman Electric Co., Dept. ED, 191 Newel St., Brooklyn 22, N. Y.

Price: \$8.95 for spdt type; \$11.45 for 3 pdt type.

Availability: Six-week delivery.

Voltage Comparator

404

Has dynamic range of 0.1 mv to 1,000 v



Model 465 voltage comparator operates as a high-low limit alarm over a wide input range. It indicates whether an applied voltage is over, between or below preset tolerance limits. Its range of from ± 0.0001 to $\pm 1,000$ v makes it applicable to go/no-go type problems encountered in military and industrial systems. The unit can be used to operate lights, alarms, or relay closures for missile check-out systems, production line testing of resistors, transistors or other electronic components.

Cohu Electronics, Inc., Kin Tel Div., Dept. ED, 5725 Kearny Villa Road, San Diego 2, Calif



50-Volt

HERMETICALLY SEALED

METAL ENCLOSED

METAL BILLETIC

SOLVE SPACE PROBLEMS

TRANSISTOR COMPANIONS

Ideal transistor "companions" where hermetic sealing is required. Both types are smaller than comparable MIL-C-25A designs yet exceed all requirements of this specification. Their extremely miniature size saves space and weight with no sacrifice in reliability.

CAPACITY TOLERANCES TO $\pm 1\%$

Inherent stability of these designs leads to widespread use in tolerances of $\pm 5\%$, $\pm 2\%$ and $\pm 1\%$.

SUPERIOR STABILITY WITH LIFE

Exhibit excellent retrace following temperature cycling or accelerated life testing:

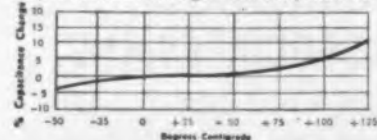
HIGH RELIABILITY CAPABILITY

These designs are capable of being produced to high reliability specifications comparable to MIL-C-14157 and MIL-C-26244 (USAF). Such customer applications are handled on a "project" basis, and the amount of premium cost varies depending on the level of performance required and on the lot acceptance testing specified.

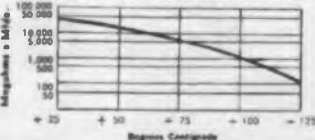
50-VOLT DIMENSIONS

Capacitance in Mfd.	626C*		627C		628C*		629C		616C*†		617C†	
	D	L	D	L	D	L	D	L	D	L	D	L
.001	.173 x $\frac{3}{32}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$
.0022	.173 x $\frac{3}{32}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$
.0047	.173 x $\frac{3}{32}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$
.01	.173 x $\frac{3}{32}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.173 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$
.022	.233 x $\frac{3}{32}$	.233 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.193 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.233 x $\frac{1}{16}$
.047	.312 x $\frac{3}{32}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.233 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$
.1	.312 x $\frac{1}{8}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.312 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$
.22	.400 x $\frac{1}{8}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.400 x $\frac{1}{16}$	.500 x $\frac{1}{16}$	.500 x $\frac{1}{16}$	.500 x $\frac{1}{16}$	.500 x $\frac{1}{16}$
.47	.500 x $\frac{1}{8}$.500 x $\frac{1}{16}$.500 x $\frac{1}{16}$.500 x $\frac{1}{16}$.500 x $\frac{1}{16}$.500 x $\frac{1}{16}$.500 x $\frac{1}{16}$.500 x $\frac{1}{16}$.562 x $\frac{1}{16}$.562 x $\frac{1}{16}$.562 x $\frac{1}{16}$.562 x $\frac{1}{16}$
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Capacitance Change vs. Temperature



Insulation Resistance vs. Temp.



HERMETICALLY SEALED

Types 626C - 627C (Extended foil)

Types 628C - 629C (Inserted tab)

Temperature Range—Full rating at 85° C—to 125° C with 50% derating.

Life Test—500 hours at 85° C and 125% of rated voltage.

Capacity Tolerance—All tolerances to $\pm 1\%$.

Insulation Resistance—40,000 meg. x mfd. at 25° C but need not exceed 70,000 megohms.

Case Styles—Available in all case style variations in MIL-C-25A.

FULL RATED TO 125° C

Type 616C (Extended foil)

Type 617C (Extended foil)

Temperature Range—Full rating to 125° C—to 150° C with 50% derating.

Life Test—500 hours at 125° C and 125% of rated voltage.

Capacity Tolerance—All tolerances to $\pm 1\%$.

Insulation Resistance—50,000 meg. x mfd. at 25° C but need not exceed 100,000 megohms.

Case Styles—Available in all case style variations in MIL-C-25A.

*These types have one lead grounded to the case. Others have both leads insulated. †Also available in 150V, 400V & 600V ranges.

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INDUSTRIAL DISTRIBUTORS

Write for detailed literature



GOOD-ALL ELECTRIC MFG. CO. • DALLAS, TEXAS
A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.

CIRCLE 75 ON READER-SERVICE CARD



Photo: Courtesy Westinghouse Air Arm Division

Congratulations!

to WESTINGHOUSE for an exciting breakthrough.

ARADAR RECEIVER NOISE FIGURE of 2.8 db at an X-band operating frequency has been achieved by engineers of the Westinghouse Air Arm Division. Dr. Robert Rampolla (left), and Mr. Thomas Hollis (right), using a true non-degenerate X-band parametric amplifier and a Microwave Associates "pill" varactor (MA-4253), achieved a 20 db gain with excellent stability and ample bandwidth.

This remarkable accomplishment in low-noise amplification at X-band resulted from research on a program sponsored jointly by Westinghouse and the U. S. Navy.

Sophisticated Varactor technology at Microwave Associates which made these results possible has produced the most complete line available of advanced varactors in standard, miniature "pill", and glass packages.

Write for detailed information and performance data on varactor techniques.

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NEW PRODUCTS

Modular Silicon Rectifier Columns

588

Deliver up to 1,000 w of power per cu. in.



These silicon rectifier columns deliver up to 1,000 w of power per cu in. of volume. They are available for voltages from 10,000 to 120,000 v, with current capacity ranges from 1 to 50 amp. Complete columns can be operated in air, or in gaseous or liquid coolants. Applications include long-range radar transmitters, high-voltage dc resistance welders, induction heaters and pulse modulators.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

Price: Dependent on requirements.

Availability: On request.

X-Y Recorder

592

High-speed type



Model 560-RX-Y digital plotter accepts data from all digital computers and can be driven by punched-paper tape and punched-card data processors. Applications include monitoring industrial processes, evaluation of processed flight test data, statistical surveys and analysis of time varying systems by digital differential analyzers. It provides up to 200 incremental steps per sec on each axis; Z-axis modulation can be maintained at up to 10 operations per sec. Input power is 125 w.

California Computer Products, Inc., Dept. ED, 8714 Cleta St., Downey, Calif.

Price: \$3,300.

CIRCLE 76 ON READER-SERVICE CARD

Transitron

introduces

an exciting new device for simpler, more reliable, more economical switching circuitry

BINISTOR

(BY-NIS-TOR)

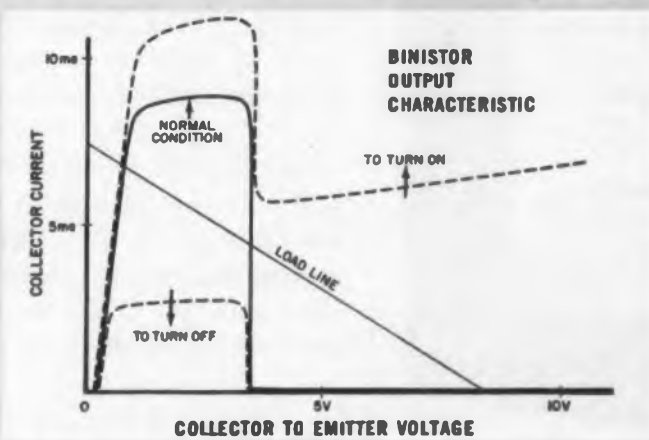
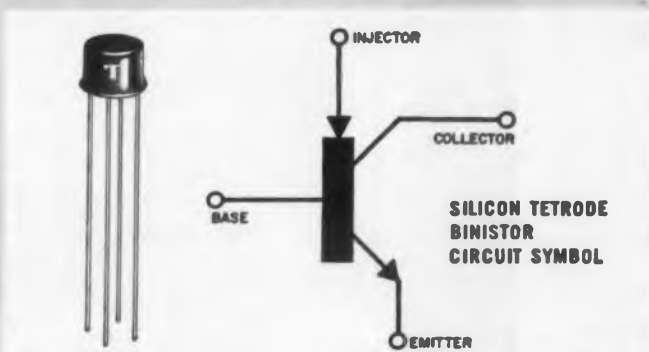
The Silicon NPN Tetrode binistor is a new component and a new concept for the circuit designer!

The key parameters of this bi-stable, negative resistance device are determined by external circuitry in contrast to existing devices. The significant reduction of peripheral circuitry results in outstanding savings in cost, space, weight and solder connections. For example, a typical flip-flop requires at least 13 components versus only 4 in an equivalent binistor stage. Very large current and voltage gains are realized in both on and off directions. Inputs and output are compatible in level with typical transistor and diode circuits. The tetrode binistor can operate from -80°C to $+200^{\circ}\text{C}$.

To learn more of this important new development — THE BINISTOR — and how it works — write for Bulletin No. TE-1360.

CONDENSED SPECIFICATIONS TRANSITRON BINISTOR

Typical Turn-off Current Gain	50 @ 15ma Collector Current
Operating Collector Current Range	50 μa to 15ma
I_{j} critical	0.5ma @ 5ma Collector Current
Operating Temperature Range without Temperature Compensation	-65°C to 150°C



Transitron



electronic corporation
wakefield, melrose, boston, mass.

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CIRCLE 77 ON READER-SERVICE CARD

← CIRCLE 78 ON READER-SERVICE CARD

There's News in an Editor's Work-Week

ELECTRONIC DESIGN

HAYDEN INTEROFFICE MEMO

Date: *Friday, 11, 1960*

TO: *Edward E. Graybe, Editor*
 FROM: *Manfred W. Meisels, News Department*
 SUBJECT: *Weekly Work Report*

MONDAY: *Completed article on design of A-Bomb detection system. Did background research for visit to Franklin Institute laboratories in Philadelphia.*

TUESDAY: *At Franklin. Discussed Air-Traffic Control, Medical Electronics, Automatic Joint Plotter, superconduct bolometers.*

WEDNESDAY: *Organized notes from Franklin. Wrote Joint Plotter and Bolometer articles. Contacted Bureau of Naval Weapons for additional details of a Design Requirement Study.*

THURSDAY: *Reviewed press releases. Checked by phone with people concerned. Wrote copy and pictures on the way. Examined latest technical journals and magazines. Conference with Art Director on A-Bomb story.*

FRIDAY: *Phoned John Hopkins for design data on Transit 2B. Planned for and did research on pay TV and type-writer articles. Arranged for plant visits for Wesson Corp. NBS in Boulder and Hughes Research visit sat.*

For Manfred Meisels, the above is a typical work-week as a News Editor on ELECTRONIC DESIGN.

In covering places where industry news occurs, Manfred concentrates on subjects of direct importance to electronic designers. He and his fellow News Editors know that engineers want news that applies to their work . . . news of research, development, technical trends.

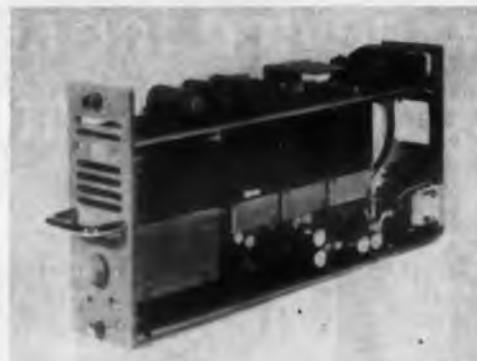
That's why you get practical news . . . exclusive design coverage—exclusively, in ELECTRONIC DESIGN.

NEW PRODUCTS

DC Amplifier

351

Common mode rejection is 180 db at dc



Type 1-104 floating differential dc amplifier offers common mode rejection of 180 db at dc and 130 db at 60 cps, with up to 1,000 ohms line unbalance. It is designed to amplify dc signals from strain gages, thermocouples, and bridge-type transducers. It provides complete isolation of input signal from amplifier output and chassis ground. Stability is 5 mv over a six-month period.

Neff Instrument Corp., Dept. ED, 2211 E. Foothill Blvd., Pasadena, Calif.

Price & Availability: \$800; 30-day delivery.

Linear Potentiometer

352

Life is better than 25,000,000 cycles



Model 34LP linear-motion potentiometer is made of conductive plastic material that provides the unit with a life in excess of 25,000,000 cycles. The unit has Teflon insulated leads. Terminals can be mounted on the case by special order. Resistance values of 50 ohms to 1 meg can be supplied. Case length is 1-3/4 in.

New England Instrument Co., Inc., Dept. ED, 1334 Main St., Waltham, Mass.

Availability: 60 days.

Liquid Cooling Unit

618

For radar transmitting tubes

Model D/SCU-1000 liquid cooling unit provides cooled, purified water to high-powered radar transmitting tubes. It has other applications in which the coolant is purified water. Packaged in a fully enclosed, drip-proof cabinet, the unit has a built-in meter for instantaneous



NEW
500°C

Therm-L INDUCTOR

A HIGH-Q FIXED INDUCTOR WITH EXTREME STABILITY UNDER TEMPERATURES FROM -55°C TO 375°C FOR CONTINUOUS AND 500°C INTERMITTENT OPERATION exhibiting excellent inductance and Q over this extreme range of temperature with excellent retrace characteristics.

These Essex Therm-L inductors cover a full range of inductances from 0.068 μ h to 3.9 μ h and are designed for Class C operation under MIL-C-1530-A.

- ENCAPSULATED
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CIRCLE 80 ON READER-SERVICE CARD

reading of resistivity of input and output water. The filter cartridge can be replaced without stopping the operation of the equipment.

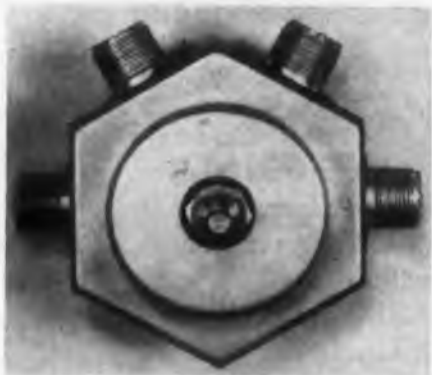
Budd Lewyt Electronics, Inc., Environmental Systems Section, Dept. ED, 43-22 Queens St., Long Island City 1, N.Y.

Price & Availability: Prices from \$4,000 to \$6,000; delivery 90 days after order received.

Coaxial Switches

353

For radio frequencies to 30 mc



These multi-position coaxial switches are designed for radio frequencies to 30 mc. Model 550A handles up to 1 kw of modulated power with a maximum of 45-db crosstalk. It selects any one of five transmitters, antennas, exciters or other devices. Model 551A two-pole, two position unit is for switching equipment in or out of series connections. Both switches can be used with 52- or 70-ohm coaxial lines.

Barker & Williamson, Inc., Dept. ED, Bristol, Pa.

Pressure Transducers

355

Have ranges up to 0 to 5,000 psi



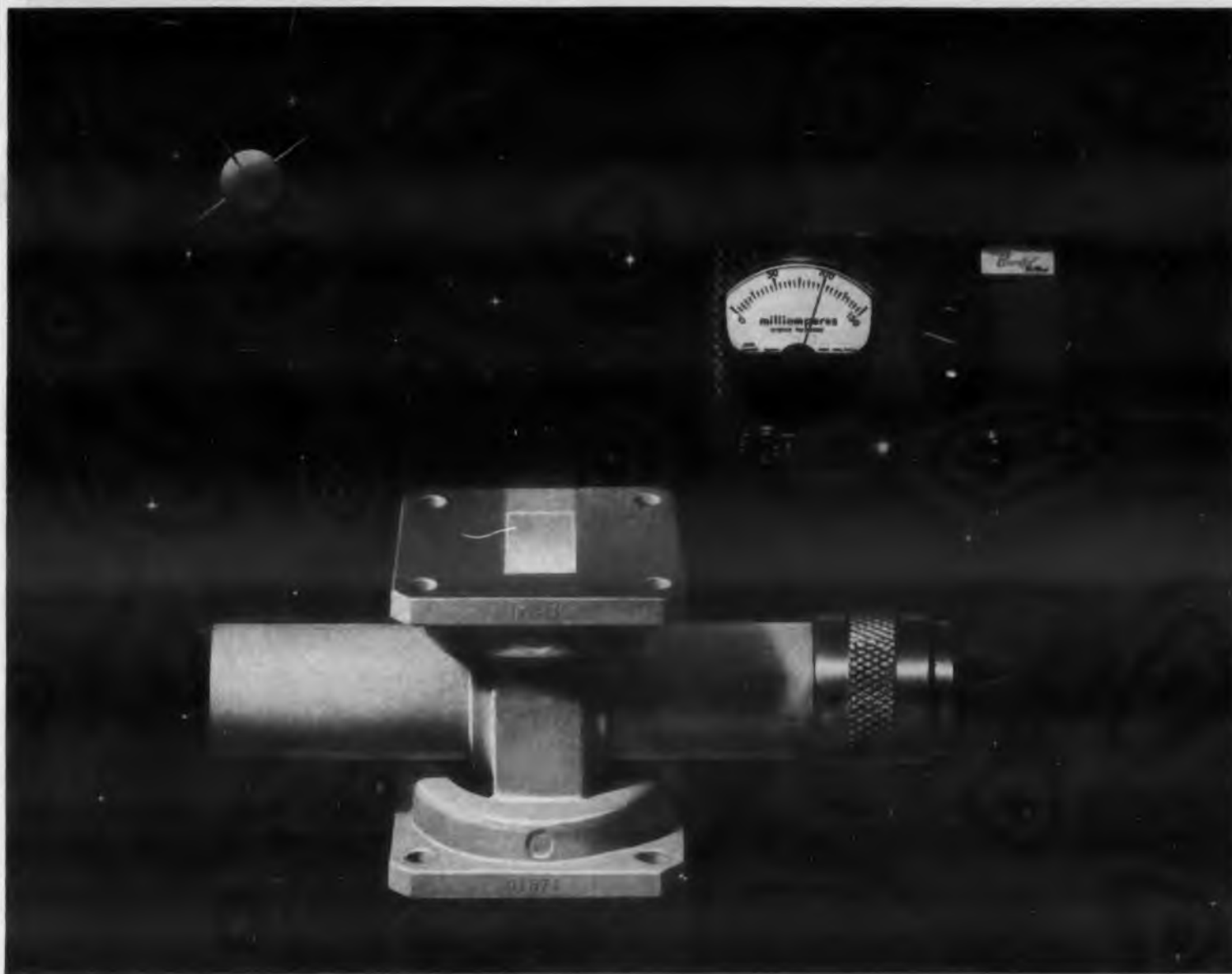
These industrial pressure transducers are available in full scale ranges of 0 to 0.05 psi through 0 to 5,000 psi. They operate from 115 v ac at 60 cps. Temperature range is -65 to +160 F. They weigh 9 lb, including housing, and measure 4-1/2 x 8-5/8 x 3-3/16 in.

Ultradyne, Inc., Dept. ED, P. O. Box 3308, Albuquerque, N.M.

Price & Availability: \$232 to \$314; 30-day delivery.



Bendix Craftsmanship at work for you



Shown in the background above is the Bendix TA-3 Power Supply

NEW BENDIX® 6-OUNCE NOISE GENERATOR meets need for fast, accurate noise measurement in miniaturized package. It has special value on noise monitoring applications—such as microwave and radar receivers—where size, weight, and power drain rank equally important with bandwidth. This Bendix model TN-1 is only 2.00" x 4.25" over-all, weighs a mere six ounces, features low power drain, and is ruggedly built for long, trouble-free service. Designed for transmission-type use over frequency range of 8500 to 9600 mc. For further information, write . . .

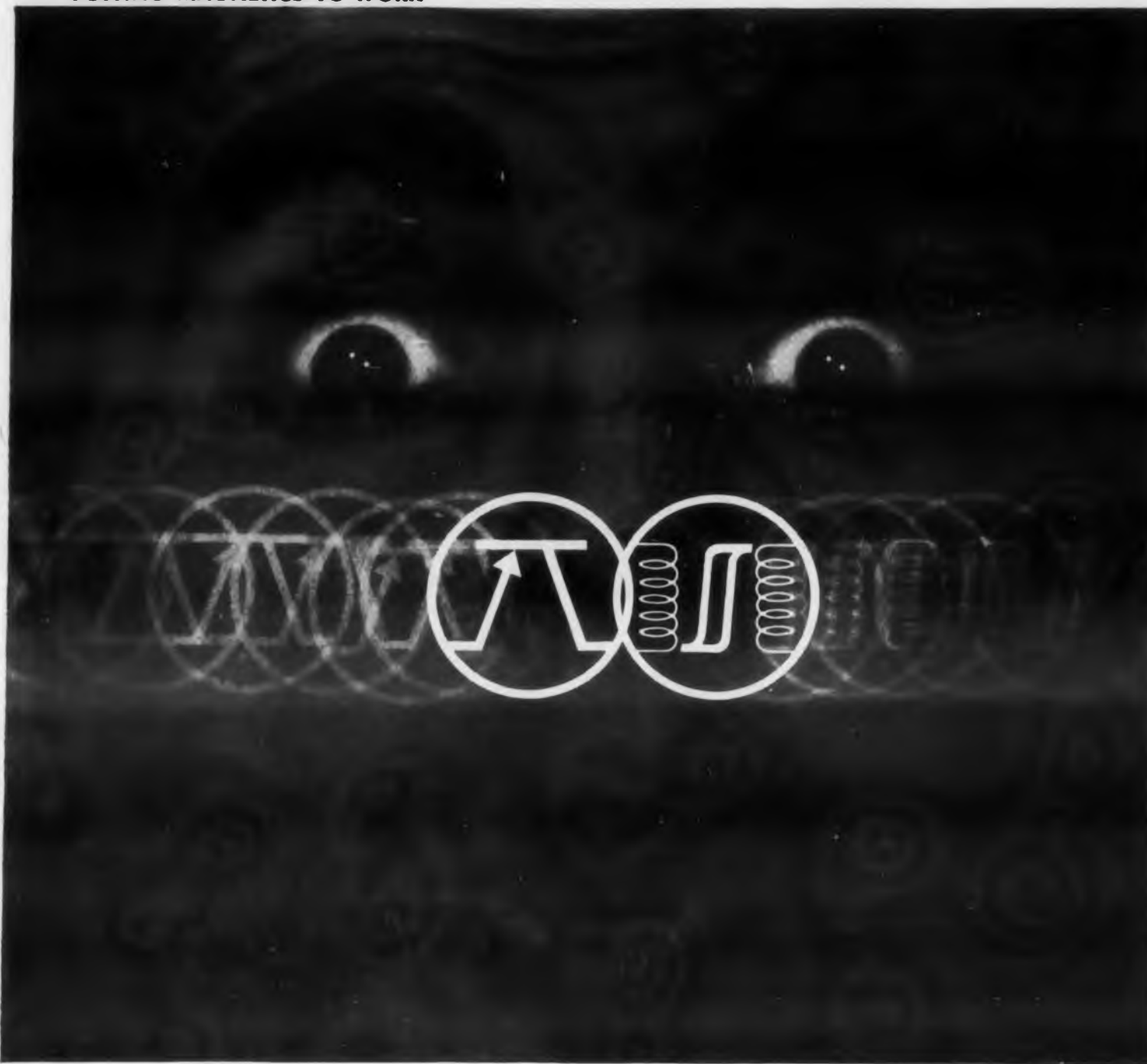
ELECTRON TUBE PRODUCTS

Red Bank Division

EATONTOWN, NEW JERSEY



CIRCLE 81 ON READER-SERVICE CARD



Open your eyes to new amplifier designs!

See how to combine tape wound cores and transistors for more versatile, lower-cost, smaller amplifiers

Tie tape wound cores and transistors into a magnetic-transistor amplifier, and open your eyes to new design opportunities.

To start with, these are static control elements—no moving parts, nothing to wear or burn out. Next thing you find is that you reduce components' size—your amplifier is smaller and costs less. That's because between them the core and the transistor perform just about every circuit function . . . and then some.

For instance? The core has multiple isolated windings. Thus you can feed many inputs to control the amplifier. The core also has a square hysteresis loop, and thus acts as a low loss transformer. That means you save power. In addition, the core can store and remember signals—so time delay becomes simple.

There's no need for temperature stabilization, either. The transistor acts only as a low loss, fast, static switch—and in this function it has no peer.

How do you want to use this superb combination? As a switching amplifier—or a linear one? In an oscillator? A power converter (d-c to d-c or d-c to a-c)? You'll have ideas of your own—and if they involve tape wound cores, why not write us? Ours are Performance-Guaranteed. *Magnetics Inc., Dept. ED-81, Butler, Pennsylvania.*



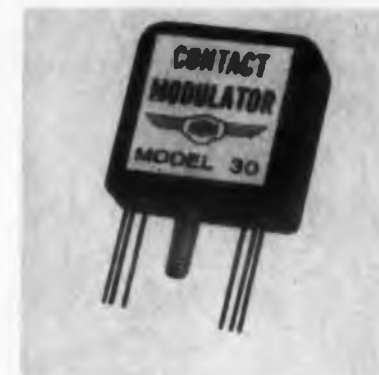
CIRCLE 82 ON READER-SERVICE CARD

NEW PRODUCTS

Miniature Chopper

747

Drive is 6.3 at 60 cps



Weighing 9 g, model 30 chopper is for printed circuit use. Characteristics are: drive, 6.3 v at 60 cps; dwell, 175 deg avg; phase, 25 ± 10 deg; and balance, within 15 deg. Jewel bearings are used.

Airpax Electronics, Inc., Cambridge Div., Dept. ED, Cambridge, Md.

Availability: 2 to 6 weeks.

Miniature Brakes, Clutches

619

Rated at 1.5 lb-in.

These miniature brakes and clutches, designed for power drives rated up to 1.5 lb-in., are less than 1 in. in diameter and 7/8 in. long. They are designed for aircraft components, data processing equipment, and similar equipment requiring rotary drives which cycle automatically or remotely. These units have stepless torque modulation and operate from a variety of actuating devices. They operate directly from 28 to 90 v dc.

Warner Electric Brake and Clutch Co., Dept. ED, Beloit, Wis.

Marker Generator

354

Provides pulses of 10 μ sec and 1 msec



Model LOO MG 1 marker generator uses crystal control to provide a 10- μ sec and a 1-msec pulse to accurately calibrate the sweep of an oscilloscope. Weighing 8 oz, the unit operates on its own 9-v battery. No warm up time is necessary.

Johnson Electronics, Inc., Electronics Div., P. O. Box 1675, Casselberry, Fla.

WHEN YOU NEED



**TANTALYTIC®
CAPACITORS**

**FOR
IMMEDIATE
DELIVERY
AT
FACTORY
PRICES**

CALL

Schweber

ELECTRONICS

60 HERRICKS ROAD, MINEOLA, L. I., N. Y.
PIONEER 6-6520, TWX G-CY-NY-880U

NEW

General Electric High-voltage Tantalytic* Capacitors

RATINGS TO 300 VOLTS



General Electric announces a new high-voltage foil Tantalytic capacitor—rated to 300 volts at 85C and to 250 volts at 125C—in both polar and non-polar designs.

SMALLER IN SIZE than any previously available capacitor with similar voltage ratings, these new General Electric capacitors also provide size advantages over series arrangements of lower voltage units.

GREATER CAPACITANCE STABILITY, achieved over the entire temperature range, is provided by these new high-voltage Tantalytic capacitors. An 8 percent maximum capacitance increase at high temperatures and a 20 percent maximum capacitance loss at -55C are specified.

CLOSER CAPACITANCE TOLERANCE of ± 15 percent is standard. This represents a significant improvement over the ± 20 percent or -15 +75 percent initial tolerances characteristic of lower voltage capacitors.

SUPERIOR LIFE PERFORMANCE during 2000 hours under maximum rated conditions is realized, with a maximum capacitance change not exceeding 10 percent.

FOR COMPLETE INFORMATION on this significant breakthrough in Tantalytic capacitor design, contact your General Electric Sales Representative, or write Section 449-15, General Electric Co., Schenectady 5, N. Y.

*Registered trademark of General Electric Co.

TYPICAL OF THE WIDE RANGE OF RATINGS AVAILABLE WITH THE NEW G-E HIGH-VOLTAGE FOIL TANTALYTIC CAPACITORS

Cat. No.	Volts	Temp.	Capacitance (uf)	Polarity	Max. Leakage at Rated Temp. (ua)	Max. Imp. -55C 120 CPS (Ohms)	Diam.	Length
29F2200	200	85C	0.35	P	32	5715	1/8"	1 1/8"
29F2105	300	85C	25.0	P	500	82	1/4"	2 1/4"
29F2108	300	85C	2.0	NP	150	1010	3/8"	2 1/8"
29F2207	200	85C	0.15	NP	32	13330	1/8"	1 1/8"
29F2161	250	125C	2.5	P	100	830	3/8"	1 1/8"
29F2164	250	125C	13.0	P	325	160	1/4"	2 1/4"

These units are supplied in tubular form, in lightweight aluminum cases, with axial leads, and are available with insulating sleeve in 7 case sizes.

GENERAL  **ELECTRIC**

CIRCLE 84 ON READER-SERVICE CARD

CIRCLE 83 ON READER-SERVICE CARD
ELECTRONIC DESIGN • October 26, 1960

LAB ACCURACY IN A PANEL-MOUNTED METER? ... it's yours with **BECKMAN Expanded Scale Meters**. Your knowledge of power supplies... whether in the lab or on the launching pad... is only as accurate as the instruments you read.

Precision built by Helipot Division, **BECKMAN Expanded Scale Voltmeters** always tell the truth. The critical voltage range—the one you want to know the most about—is expanded across the entire arc of a fully linear scale, thus eliminating unnecessary and unusable calibrations.

Resolution of a typical 110–120v AC meter is one-tenth volt; combine that resolution with $\pm 0.3\%$ accuracy, and you have an instrument that will perform like a highly specialized bench model... yet is fully ruggedized and sealed, ready for the most demanding application. And this meter doesn't care what shape the waveform is in. Be it square, zig-zag, or what-have-you... this meter always reads direct rms. Nothing average here—not even the sensing device!

BECKMAN Expanded Scale Meters come in a variety of shapes, sizes, and ranges... including AC and DC voltmeters, frequency meters and linear scale ammeters. Each is available in both commercial and military models... and delivery is superb: 30 days on standard models, 60 days on specials.

For the whole truth about your power supply, use **BECKMAN Expanded Scale Meters**. For the whole truth about **BECKMAN Expanded Scale Meters**... send for Data File.



Beckman/Helipot

POTS : MOTORS : METERS
Helipot Division of
Beckman Instruments, Inc.
Fullerton, California



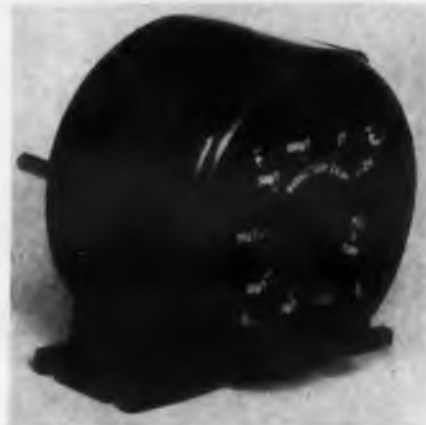
© 1960 B.I. 61009

CIRCLE 85 ON READER-SERVICE CARD

NEW PRODUCTS

Step-Function Speed Reducer 740

Torque capacity is to 50 oz-in.



This step-function speed reducer is available with either a single-gear reduction ratio or a continuously variable, friction-type speed change of limited ratio. Torque capacity is up to 50 oz-in.; speeds are to 1,500 rpm, continuous, and 3,000 rpm, intermittent; and size is 4.5 in. in diameter and 3 in. deep. Designated models 00140 through 00144, the units provide ratios of up to 1,000:1. They can be used in oscillators, tuning condensers and other devices.

Barry Controls Inc., Insko Co., Dept. ED, Hollis St., Groton, Mass.

Microwave Radio Equipment 748

Range is 11,000 to 15,000 mc



Model MW-601 microwave radio system provides terminal circuits for lower frequency systems entering congested areas. A temperature control chamber is provided for the klystron. Both the transmitter and receiver have ferrite devices to protect the transmitter klystron from effects of mismatch. Model 52A-1MW transmitter, shown, has an output of 100 mw, a frequency stability of $\pm 0.05\%$, and a nominal deviation of ± 3 mc. Model 54A-1MW receiver has a tangential threshold sensitivity of -117 dbw, a noise figure of 15 db max, an if of 70 mc, and an if bandwidth of 15 mc at 3 db points.

Collins Radio Co., Dept. ED, P.O. Box 1891, Dallas 21, Tex.

An important
**NEW GUIDE to
ELECTRONIC
CHEMICALS**
of high, defined purity



...may we send
you your
complimentary
copy? Mail
coupon below.

More than 40 electronic chemicals of exceptional purity appear in this handy new reference guide. You will find, for example, high purity 'Baker Analyzed' Reagents for semi-conductors...vacuum tubes...ferrites...thermistors.

Do you know that every 'Baker Analyzed' Reagent electronic chemical is labeled with an *Actual Lot Analysis* that defines the degree of purity to the decimal? And that many are labeled with an *Actual Lot Assay* as still a further proof of purity? Do you know that in many of these chemicals copper, nickel and other critical impurities are defined at levels of .1 and .2 parts per million? And that several important solvents are now controlled to meet *stringent resistivity specifications*?

SEND FOR YOUR FREE GUIDE TODAY.

It lists J. T. Baker electronic chemicals controlled to extremely low limits of critical impurities, and includes specification sheets that prove the superiority of 'Baker Analyzed' Reagents for electronic specifications. Fill in coupon now.



J. T. Baker Chemical Co.
Phillipsburg, New Jersey Dept. ED

Gentlemen: Please send me my copy of
"J. T. Baker Electronic Chemicals."

Name _____
Title _____
Company _____
Street Address _____
City _____ Zone _____ State _____

CIRCLE 86 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960

Rechargeable Battery 377

Capacity is 1,000 ma

The D style 2-v battery can be recharged 1,000 times. Although wet-cell construction is used, the unit is guaranteed not to leak if left in a radio or similar equipment for a year or longer. The two-cell charger, also offered, is equipped with indicator lights.

Beamco Associates Inc., Dept. ED, 8 E. Spring St., Ardmore, Pa.
Price & Availability: \$1.97 for battery in quantities of 48 and up; \$2.98 for charger. Delivery is from stock.

Ceramic Capacitors 378

Come in values of 47 pf to 0.01 μ f

These axial lead units are usable at a full rated voltage of 200 v to 150 C. Uses are in airborne and ground system equipment. The units are available in tolerances of 5%, 10%, 20% and GMV tolerances. Sizes are from 0.1 x 0.125 x 0.075 in.

King Electronics Inc., Dept. ED, 915 Meridian Ave., South Pasadena, Calif.

Availability: Immediate.

Tantalum Capacitors 381

For missile applications

These P-type tantalum capacitors are intended for missile, airborne, and similar applications up to 125 C. At maximum temperature and rated working voltage the units provide 2,000 hr of service. They are guaranteed to altitudes of 80,000 ft and will withstand 20-g acceleration from 50 to 2,000 cps. Capacitance values range from 1.75 to 330 μ f at dc working voltages of 85 v for operation to 125 C and 125 v at 85 C working temperature.

International Telephone and Telegraph Corp., Components Div., Dept. ED, 815 San Antonio Road, Palo Alto, Calif.

Price & Availability: From \$2 to \$7 in quantities of 1,000; available from stock.

exact duplication PRODUCES TOTAL RELIABILITY

Infinitesimal Mechanical Variation due to *Exclusive* Automation Processes

plus Exclusive Glass Alkyd Molded Permanence

plus Exclusive Full Silver Coverage on Contact Surface

equals NEW CTS NON-DRIFT COMPACT SELECTOR SWITCHES

Formerly manufactured by Trolex Corporation, now a part of CTS. 1/8" diameter 12-position indexed rotary switches are designed primarily for low power exacting military and commercial RF, VHF and UHF circuit applications. Series 212 surpasses MIL standards.



UNPRECEDENTED
SWITCH UNIFORMITY FROM
ENTIRELY NEW AUTOMATED
MANUFACTURING CONCEPT

- Drift virtually eliminated by molding terminals into exact, immovable, permanent position in stator, entirely by machine . . . making all switches identical in each production run. Machine exactitude replaces human error and variations, eliminating the wider tolerances characteristic of hand assembly.
- Delicate switch parts are not exposed to breakage; many parts are not even handled.
- Superior insulation due to repetitive exactness in terminal spacing and molded glass alkyd material.
- Heat from soldering cannot loosen terminals.
- Natural design barrier prevents solder from flowing into circuit elements during soldering.



SAFER, QUICKER,
EASIER HANDLING
IN YOUR PRODUCTION LINE

Molded glass alkyd stator won't break or crush during ordinary handling or if accidentally dropped. Terminals cannot be dislodged or moved. Both stationary and movable contacts are enclosed for additional safety and handling convenience.

LONGER LIFE CONTACTS

- After 1,000,000 index operations, life tests reveal virtually no change in rotor contact resistance.
- 1000% more silver than used by most commercial switches has been evenly applied at actual point of contact by exclusive process. (See Sketch). Optional solid sterling silver contacts and stator available for additional contact performance.
- Rotor contacts are double-wiping and self-cleaning.
- Stator contacts are integral with terminals.



NOW! NEWLY TOOLED CLUSTER AND 3-FINGER CONTACTS

Offered for numerous additional circuits not previously available. Transmitters range of military and commercial requirements without special tooling.



OTHER FEATURES

- Series 212 is available in numerous combinations with CTS variable resistors and power snap switches.
- Condensed assembly. Wafers can be stacked adjacent to each other. No spacers required.
- Non-toxic combustion fumes—an important advantage in submarine or similar closed space applications.
- Exclusive balanced detent mechanism has 2 dissimilar detent forms for definite feel and long pull in.
- New balanced lever arm and star wheel detent assembly free from end and side thrust for extremely long life and accurately controlled torque. Optional at extra cost.



CTS Corporation

4 FACTORIES TO SERVE YOU: CTS Corporation, Newark, Indiana; Chicago Telephone of Calif., Inc., St. Pasadena, California; CTS of Asheville, Inc., Shiloh, N.C.; CTS of Boring, Boring, Indiana; C. C. Meredith & Co., Ltd., Shilohville, Ontario, Canada.



just set it—
and forget it!

the voltage of this ultra-high
regulation power supply never varies
regardless of load or line fluctuations!

Now you can be assured of a constant voltage source over the *entire* operating range of 0 to 500 v, 0 to 200 ma, dc. Even if the load is varied — even if the line voltage fluctuates — you're *still* sure of load regulation to less than 0.001%, and line stabilization to less than 0.003%!

With this unusually high regulation over the entire range, the Model UHR-220 power supply lends itself to the most exacting applications, such as powering many high-gain stages in parallel. Ripple is less than 0.1 millivolts. Both the dc and ac impedances are unusually low — dc less than 0.01 ohms; ac less than 0.1 ohm up to 100 kc. Drift in 10 hours — 300 ppm.

So when you need a power supply you must depend on for constant voltage — a supply you can set and forget — investigate the UHR-220. The ultra-high regulation, extremely low ripple, and stability vs. line voltage free you to concentrate on the rest of your design work.

Krohn-Hite ultra-high regulation power supplies offer a total range coverage of 0 to 1200 v, 0 to 1000 ma, dc. *Other fine Krohn-Hite instruments include Amplifiers, Filters and Oscillators.* Write for full information.



KROHN-HITE CORPORATION
580 Massachusetts Avenue • Cambridge 39, Mass.
Pioneering in Quality Electronic Instruments

CIRCLE 88 ON READER-SERVICE CARD

NEW PRODUCTS

Trimming Potentiometer

434

Measures 1/3 in. in diameter



Measuring 1/3 in. in diameter and weighing 1 g, model 80 trimming potentiometer is a single-turn unit designed for printed circuits. It is sealed to meet requirements of MIL-STD-202A and MIL-E-5272C. Some specifications of the unit are: diameter, 0.345 in.; height, 0.28 in.; resistance range, 50 ohms to 10 K; tolerance $\pm 5\%$; noise, 100 ohms ENR per NAS-710; power rating, 1 w; shock, 50 g; vibration, 30 g to 2,000 cps; load life, 1,000 hr.

Spectrol Electronics Corp., Dept. ED, San Gabriel, Calif.

Price & Availability: \$6 ea for 1 to 9 units; from stock.

Variable Bandpass Filters

741

For af use



Designed for audio frequency use, type A103 continuously variable bandpass filters have no vacuum tubes, transistors or power supplies. Four major types are offered. Group 1 is step variable with a center frequency from 50 cps to 1,000 cps. Group 2 has a continuously variable center frequency from 50 to 2,000 cps. Group 3 has a center frequency continuously variable from 280 to 5,200 cps and group 4, center frequency continuously variable from 40 cps to 10 kc.

Ad-Yu Electronics Laboratory, Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N.J.

How
to get
very
precise
data...
anywhere



Ampex's new CP-100 ideally balances size and performance in a magnetic tape recorder. It meets laboratory standards in all the critical parameters—cumulative peak-to-peak flutter is well below 0.2% (60 ips, 300 cps cut-off); $\pm 0.25\%$ maximum tape-speed variation; frequency response from DC to over 200 kc. Yet it's compact enough (4.7 cu. ft.) to go virtually anywhere on land, sea or air where you need to recover critical data.

Like the rest of the facts? A full page in **ELECTRONIC DESIGN** for October 12 tells more, or write us and descriptive literature (plus a copy of the ad) is yours for the asking.

AMPEX

AMPEX DATA PRODUCTS COMPANY
Box 5000 Redwood City, California

CIRCLE 89 ON READER-SERVICE CARD

North Atlantic Series RB500 Ratio Boxes



Model RB-504
Bench mount

Measure A.C. Ratios
From -0.11111
To +1.11111...with
accuracy to 1 ppm

With any of North Atlantic's RB500 Ratio Boxes you can now measure voltage ratios about zero and unity—without disrupting test set-ups.

And—a complete range of models from low cost high-precision types to ultra-accurate ratio standards—in portable, bench, rack mount, binary and automatic stepping designs—lets you match the model to the job.

For example, characteristics covered by the RB500 Series include:

- Frequency: 25 cps to 10 kc.
- Accuracy: 10 ppm to 1.0 ppm
- Input voltage: 0.35f to 2.5f
- Input impedance: 60 k to 1 megohm
- Effective series impedance: 7.5 ohms to 0.5 ohms
- Long life, heavy duty switches

Name your ratio measurement and its probable there's a North Atlantic Ratio Box to meet them—precisely. Write for complete data in Bulletin 11R.

Also from North Atlantic...a complete line of complex voltage ratio-meters...ratio test sets...phase angle voltmeters

NORTH ATLANTIC
Industries, Inc.
Terminal One, Cambridge, Mass., U.S.A.

Adhesive Tape 460

Specially etched Permacele 423 Teflon-film adhesive tape accepts printing. It is compatible with epoxy resins and electrical varnishes, and adheres to itself. The material is suitable for continuous operation at temperatures from -150 to +500 F. Electrical strength is 8,500 v and insulation resistance is 2,000,000 meg.

R. S. Hughes Co., Inc., Dept. ED, 4515 Alger St., Los Angeles 39, Calif.

Price & Availability: \$21.97 for 36 yd of 1-in. tape; from stock.

IF Transformer 461

This miniature, bobbin-constructed unit has a dimension of 0.25 in. and a height of 29/64 in.

Radio Industries, Inc., Dept. ED, 666 Garland Pl., Des Plaines, Ill.

Crimping Tool 466

The CT-3050 is for insulated and non-insulated terminals and connectors. It cuts and strips wire, shears bolts and screws, and crimps all terminals in wire ranges 22 through 10.

Waldom Electronics, Inc., Dept. ED, 4625 W. 53rd St., Chicago 32, Ill.

Indium-Clad Aluminum 463

These preforms are for use in forming alloy junctions in germanium semiconductor devices. The indium cladding melts first at 400 C.

Accurate Specialties Co., Inc., Dept. ED, 340 Hudson St., Hackensack, N. J.

Harness Assemblies 464

These harness assemblies, for applications to 1,600 F, are available in a wide range of sizes and materials.

Harco Laboratories, Inc., Dept. ED, 77 Olive St., New Haven, Conn.

Indicator Lamps 491

The Tec-Lites, miniature neon transistor-driven indicator lamps, operate on low voltages and provide a minimum life of 25,000 hr. The units are shock-resistant.

Transistor Electronics Corp., Dept. ED, 3357 Republic Ave., Minneapolis 26, Minn.

Voltmeters and Ammeters 498

Type KX-251 100-deg indicating instruments have ranges of 20 μ a to 50 amp and 35 mv to 800 v. They can be used in magnetic fields of up to 500 gauss.

Westinghouse Electric Corp., Dept. ED, P. O. 2099, Pittsburgh 30, Pa.



... and 10 watts of power

with this direct-coupled amplifier!

New from Krohn-Hite: this unique combination of power and bandwidth! The Model DCA-10 direct-coupled amplifier allows you to increase power of all sources from dc to one megacycle, without the bother of changing amplifiers or bandswitching!

The DCA-10's low distortion (0.1%) makes it the perfect complement for low-distortion, quality oscillators — for unexcelled performance over the entire frequency range.

Output — to 300 volts peak to peak, to 600 milliamperes peak to peak. Frequency response is flat, within one db, from dc to 1 mc. Stability is excellent for both output DC level and gain.

The Model DCA-10 direct-coupled amplifier provides high, distortion-free power over the entire range, from sub-sonic into radio-frequencies. 20 watts of push-pull power can be obtained from two DCA-10's cascaded. If this high-quality, flexible amplifier can fill a need for you, write for full information.

Other Krohn-Hite amplifiers include the direct-coupled 50 watt DCA-50, and the ultra-low distortion (0.005%) 50 watt UF-101A. Also, Krohn-Hite Oscillators, Filters and Power Supplies.



KROHN-HITE CORPORATION

580 Massachusetts Avenue • Cambridge 39, Mass.
Pioneering in Quality Electronic Instruments

CIRCLE 91 ON READER-SERVICE CARD

CIRCLE 90 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960

103



Enlarged cross section of United Funnel Flange Eyelet showing greater soldered area which lends greater strength.



This Connection STAYS Connected

● **New United Funnel Flange design improves reliability of soldered connections**

● **Greater mechanical strength due to greater soldered area of funnel eyelet**

WHY UNITED FUNNEL FLANGE EYELETS ARE SUPERIOR . . . The funnel design permits easy insertion of leads. When soldering, the solder fills the funnels and flows around the outside of the eyelet on both sides of the etched circuit. This increases the soldered areas and seals the lead and the funnel eyelet tightly to the circuit. The unique design of the funnel eyelet permits entrapped gases to escape and makes it possible to achieve an unusually solid, dependable connection.

More uniform circuitry is also realized with United Funnel Flange Eyelets which are made from electrolytic copper. This material has a coefficient of expansion in the same order as that of the copper in the etched circuit.

United Funnel Flange Eyelets meet MIL Standard No. 202 for vibration, shock, thermal cycling, and humidity. Wide choice of sizes and lengths meet needs of hole sizes and board thicknesses. Also available in brass. Special plating, and packing to order.

Free: Send us a sample of your board for free insertion of funnel flange eyelets for your testing and evaluation or write for complete specifications of sizes available.



High speed automatic setting of Funnel Flange Eyelets with United Eyeletting Machine Model G.

United

UNITED SHOE MACHINERY CORPORATION
140 Federal Street, Boston, Mass.
Liberty 2-9100

NEW PRODUCTS

Linear-Motion Pot

417

Fits in hydraulic actuators



Model 159 tubular pot was designed for internal installation in hydraulic actuators and other telescoping assemblies. The 1/2-in. diameter case with concentric actuating shaft is O-ring sealed against contamination from hydraulic fluids and high-humidity conditions. Standard travel ranges are 1 to 5 in. Resolution is 0.001 in.

Bourns, Inc., Dept. ED, 6135 Magnolia Ave., Riverside, Calif.

Availability: Made to customer specs.

Miniature Toroidal Inductors

581

For printed-circuits

The firm has expanded its line of miniature toroidal inductors to include the following types: MM-5, 20 mh, 20 ma dc max; MM-6, 30 mh, 16 ma; MM-7, 60 mh, 11 ma; MM-8, 120 mh, 8 ma; MH-5, 10 mh, 22 ma; MH-6, 15 mh, 18 ma; MH-7, 25 mh, 14 ma; MH-8, 40 mh, 11 ma. Units are 7/16 in. OD and 1/4 in. high and weigh 0.07 oz. Hermetically sealed, they have a temperature range of -55 to +100 C. Terminal spacing is 21/64 in. MIL specs are met.

United Transformer Corp., Dept. ED, 150 Varick St., New York 13, N. Y.

Availability: From stock.

Half-Wave Rectifier

419

Piv is 1,000 v



This 10-amp, 1,000-piv rectifier is designed for control applications requiring a half-wave rectifier. Type 664L has a lug base; type 664P has bracket base and flying leads for panel mounting. Specifications are: filament voltage, 2.5 v; filament current, 25 amp; peak anode current, 120 amp; and condensed mercury temperature limits, -40 to +100 C.

National Electronics, Inc., Dept. ED, Geneva, Ill.

Price: \$26.

Availability: From stock.

dial any output



from 0-1000 volts



with 1% accuracy



Keithley Regulated High-voltage Supply gives you new speed and accuracy for a wide range of tests. Its many uses include calibration of meters and dc amplifiers, supplying voltages for photo-multiplier tubes and ion chambers, as well as furnishing potentials for high resistance measurements.

Three calibrated dials permit easy selection of the desired output in one volt steps, at up to 10 milliamperes. Polarity is selectable. Other features include:

- 1% accuracy above 10 volts.
- Line regulation 0.02%
- Load regulation 0.02%
- Ripple less than 3 mv RMS.
- Stability: within ± 0.02% per day.
- Protective relays disconnect output at 12 milliamperes.
- Price: \$325.00.

Send for details about the Model 240 Supply

KEITHLEY 
INSTRUMENTS, INC.
12415 Euclid Ave., Cleveland 6, Ohio

CIRCLE 93 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960

Integrating Motor Tachometer 716

Has high output-to-null voltage ratio

This size 15 integrating motor tachometer has high output-to-null voltage ratios and remains accurate from -55 to $+80$ C. No warm-up time is required at any temperature within the operating range. No heaters, mechanical thermostats, amplifiers or external heat sources are used, resulting in less weight and power drain on the over-all system.

United Aircraft Corp., Norden Div., Dept. ED, Jericho Turnpike, Commack, L.I., N.Y.

Silicon Varactor Diodes 699

Cut-off frequency is 120 kmc

Type MA-4297 silicon mesa varactor diodes have a cut-off frequency of 120 kmc. Shunt capacitance is about 0.4 pf and series lead inductance is about 2×10^{-9} h. Low-capacitance units used in 5,500-mc receivers that are equipped with parametric amplifiers achieve stable over-all receiver noise figures of 2.2 db for ± 10 mc bandwidth. Stable over-all receiver noise figure is under 1.8 db for 3,000-mc radar receivers using parametric amplifiers.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

Availability: Experimental quantities, immediate.

X-Band Isolator 388

Measures 1/2 in. long

This X-band isolation model XM2, is 1/2 in. long. It has a minimum isolation of 20 db and a maximum insertion loss of 0.3 db at 9375 ± 25 mc. VSWR is 1.2 max. The center frequency can be modified within the X-band.

E & M Laboratories, Dept. ED, P.O. Box 2427, Van Nuys Station, Van Nuys, Calif.

Price & Availability: \$65 to \$175 depending on quantity; units are made to order.



appearances are not deceiving THIS P & B 10-AMP RELAY IS AS RELIABLE AS IT LOOKS

Our AB relay looks rugged . . . and it is. You can specify it for 10 amp switching and confidently expect 100,000 cycles. Yet it is compact, easily mounted, and does not require special handling. Installation is simple, using your preference of screw terminals (adapters), quick connects, or dip soldering.



ABC Series—AB series can be supplied enclosed in sturdy metal dust cover, $1\frac{1}{4} \times 2\frac{1}{2} \times 2\frac{1}{2}$ in.

Designers specify the AB for air conditioners and other products where dependable, continual service is paramount.

These standard AB and ABC relays are listed by Underwriters' Laboratories and Canadian Standards Association:

Type	Arrangements	Type	Arrangements
AB7AY	DPST-NO	ABC7AY	DPST-NO
AB8AY	DPST-NC	ABC8AY	DPST-NC
AB11AY	DPDT	ABC11AY	DPDT

Coil voltages: 6, 12, 24, 115 and 230 volts AC, 50/60 cycle.
Contact rating 10 amps, 115 volts AC or 5 amps, 230 volts AC noninductive.

U/L File E-29244

CSA No. 15734

Write for complete data or contact your nearest P & B sales engineer.

AB AND ABC RELAYS ENGINEERING DATA

GENERAL:

Insulation Resistance: 100 megohms minimum.
Life: 3 million cycles (mechanical).
Breakdown Voltage: 1500 volts rms between all elements and ground.
Temperature Range: DC: -55 to $+45^\circ\text{C}$.
AC: -55 to $+45^\circ\text{C}$.

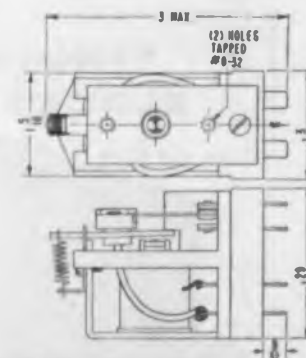
Weight: AB—5 ozs. ABC—7 ozs.
Terminals: Fit $\frac{1}{8}$ in. quick-connect terminals, or may be applied to printed circuits using dip soldering. Screw adapters furnished on request.
Enclosure: ABC: Heavy duty dust cover.
Dimensions: $1\frac{1}{4} \times 2\frac{1}{2} \times 2\frac{1}{2}$ in.

CONTACTS:

Arrangements: DPDT
Material: $\frac{1}{8}$ in. dia. silver. Other materials available.
Lead: 5 amps at 230 volts AC or 10 amps at 115 volts AC noninductive.
10 amps at 28 volts DC.

COIL:

Voltage: DC: 6 to 110 volts.
AC: 6 to 230 volts.



Power: DC: 2 watts nominal.
AC: 6.4 volt-amps.
Resistance: 35,000 ohms max.
Duty: Continuous: DC coils will withstand 6 watts at $+25^\circ\text{C}$.

MOUNTINGS:

AB: Two 8-32 tapped holes on $\frac{1}{4}$ in. centers.
ABC: One 8-32 stud $\frac{1}{4}$ in. long and locating tab.

P & B STANDARD RELAYS

ARE AVAILABLE AT YOUR LOCAL
ELECTRONIC PARTS DISTRIBUTOR



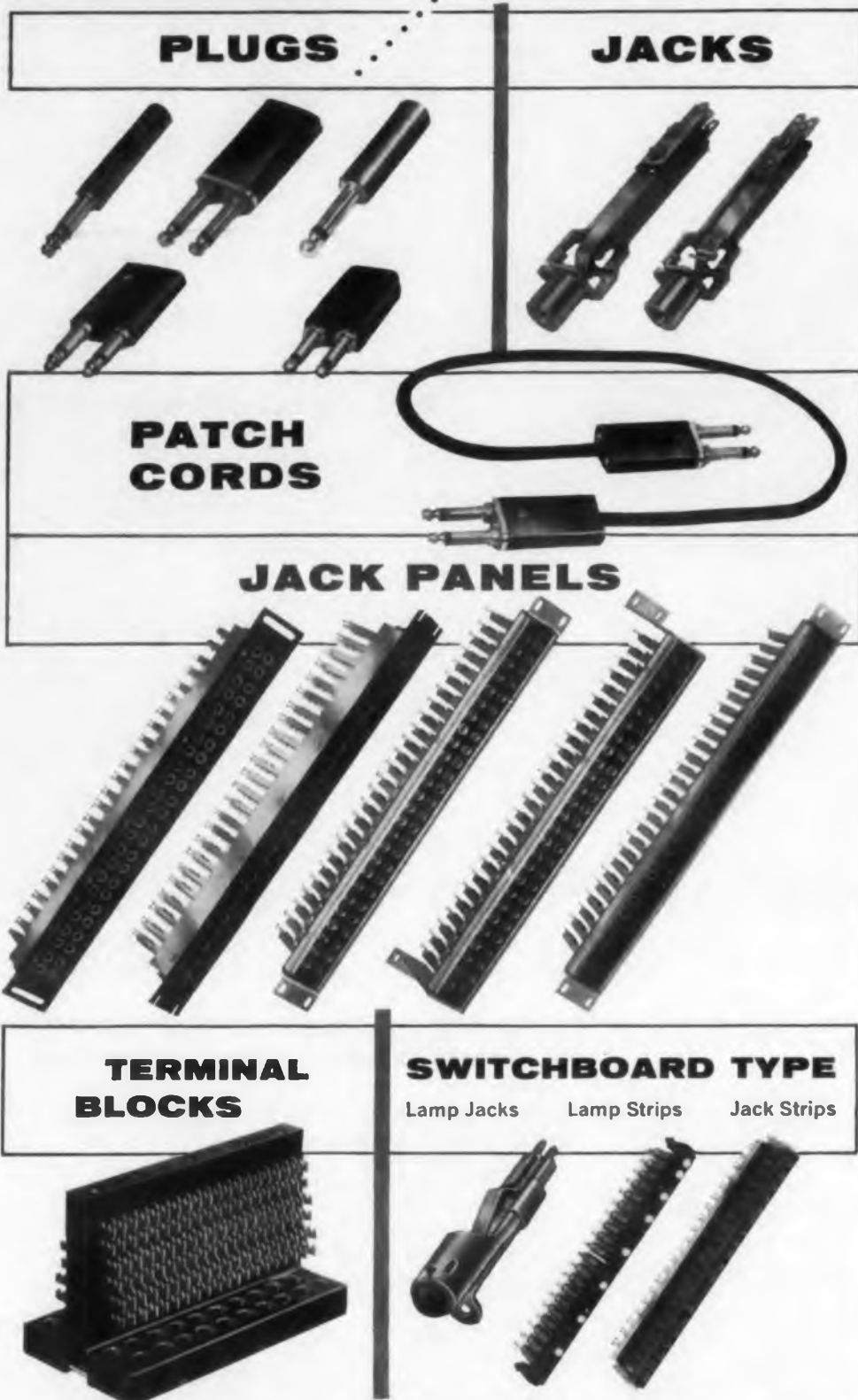
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For completeness of line, for quality and dependability, for availability from stock you'll like . . . ADC JACKS—First choice of the country's foremost manufacturers of communication equipment, unique one piece frame provides maximum strength . . . ADC JACK PANELS—One of the most complete assortments of jack panels available for use wherever audio signals are switched and distributed . . . ADC PLUGS AND PATCH CORDS—Standard in the communication industry! . . . ADC TERMINAL BLOCKS molded to your specifications; six popular sizes in stock.



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CIRCLE 95 ON READER-SERVICE CARD

NEW PRODUCTS

NPN Power Transistors

706

Rated at 60 w



These four diffused-silicon, npn power transistors, types 2N1487 through 2N1490, dissipate 60 w at a mounting-flange temperature of 25 C. Temperature range is -65 to +175 C. Types 2N1489 and 2N1490 transistors have beta ratings from 25 to 75 with saturation resistance of 0.67 ohms max measured at 1.5 amp. Units are hermetically sealed in welded cases conforming to the JEDEC TO-3 outline. The collector is in electrical contact with the case. Applications are in power converters, power-supply regulators, relay replacements and controls, and dc and servo amplifiers.

Silicon Transistor Corp., Dept. ED, 150 Glen Cove Road, Carle Place, L.I., N.Y.

Price & Availability: \$50 to \$75; three week delivery.

Plug-In Sweep Generator

713

For alignment applications



This plug-in sweep generator is designed for alignment of if stages and wide-band amplifiers. No power cables or batteries are required. The device has separate center-frequency and sweep-width controls. Marker input, synchronization and blanking, variable sweep rate and 10^4 short-term stability in center frequency are provided.

Teltronics, Inc., Dept. ED, 277 Main St., Nashua, N.H.

Price & Availability: \$98.90; delivery from stock in small quantities.

CLEAN

Electronic, Electrical,
Mechanical Components
and Contacts with
NO Film or Residue

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SPRAY-CLEAN TECHNIQUE



APPLICATIONS

Electronic Components & Assemblies: Diodes, Transistors, Slip-Ring Commutators, Crystals, Vacuum Tube Components, Sub-Miniature Assemblies.

Meter & Instrument Components: Instrument Bearings, Jewel Bearings & Pivots, Gear Trains, Lapped Surfaces.

Electrical Contacts: Relays, Vibrators, Voltage Regulators, Sensitive Switches.

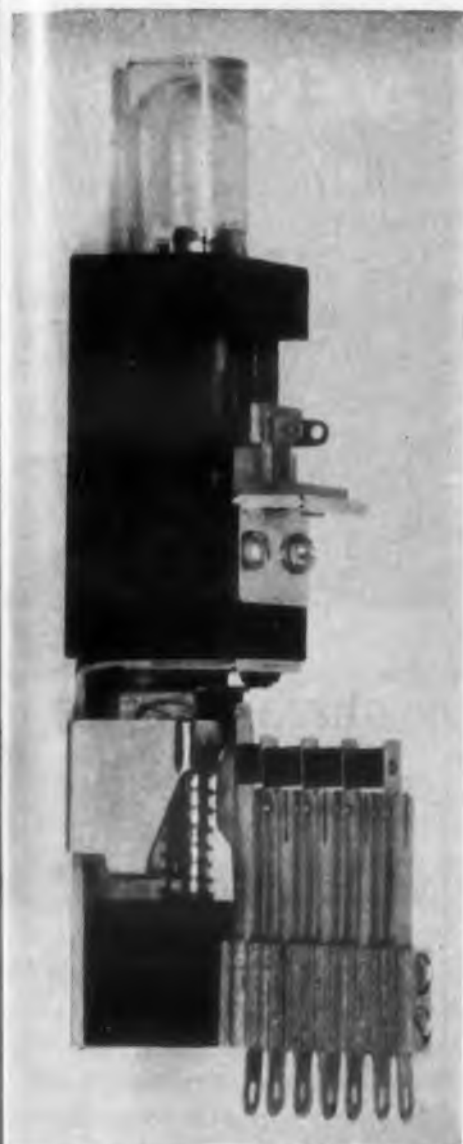
FEATURES

No film, residue, or corrosive effect to damage surface, fire and explosion hazard nil, non-polar, non-ionic, an all around safe operation.

For specific information about your critical cleaning problems, send product information and production requirements.

Cobehn Inc.
226 Passaic Avenue
Caldwell, N. J. Capital 6-6675

CIRCLE 96 ON READER-SERVICE CARD



MODEL PLS-IA (Actual Size)

ILLUMINATED SINGLE POSITION PUSH BUTTON SWITCHES

Latest Design of Illuminated Push To
Lock Push To Release Switch

The Capitol Model PLS-IA switch accommodates a single contact midget flanged type lamp. A unique bayonet lamp base adapter is provided so that the lamp can be easily inserted or removed. Eliminates need of pressure spring to hold lamp in place.

Lamp terminals are designed so that they can be wired to an external current source for continuous duty or wired to the switch contact springs for duty only when the switch is engaged.

Accommodates either straight or right angle terminals on contact springs. Total depth behind panels is 4". 3 Amp rating 110 Volt AC non-inductive.

Buttons can be supplied in various transparent colors and or sand blasted (frosted) for identification purposes. Engravings on buttons are also available.

Write for complete catalog.

CAPITOL SWITCHES

The Capitol Machine Co.

16 Elmforth Avenue, Danbury, Connecticut

CIRCLE 97 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960

Insulated Jack 467

No. 4351 insulated jack is for use in quick and tight patchwork panels. It mates with the firm's plugs having pin diameters of 0.045 in.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

Inertial Dampers 468

Model 1D-15-100, size 15, inertial damper can be used in high-performance instrument servo loops. The units, also available for sizes 11 and 18, work equally well with 60- or 400-cps servo motors.

Industrial Control Co., Inc., Dept. ED, Central Ave. at Pinelawn, Farmingdale, N. Y.

Plastic Instrument Cases 469

The interior compartments of these ABS thermo-plastic, custom-designed instrument cases are specially formed to hold various shapes and sizes of electronic instruments.

Hollywood Plastics, Inc., Dept. ED, 4560 Worth St., Los Angeles 63, Calif.

Decade Scaler 470

Model N-240 3.5-in. scaler is for use in analytical scintillation and proportional counting systems. Pulse-pair resolution is 1 μ sec, with a continuous repetition rate of up to 250,000 cps.

Hamner Electronics Co., Inc., Dept. ED, P.O. Box 531, Princeton, N. J.

Rosin Flux 471

The RU series activated rosin flux is for electronic use where non-conductive, non-corrosive flux residues are required.

Fusion Engineering, Dept. ED, 17921 Roseland Ave., Cleveland 12, Ohio.

Wire Stripper 473

The Glo-Melt stripper is for on-the-job or bench work; a foot control is optional. Stripping of all plastic wire including Teflon is accomplished. A Ni-chrome cutting element is used.

American Electrical Heater Co., Dept. ED, 6110 Cass Ave., Detroit 2, Mich.

Thyratron Trigger System 476

Type SP-504 is for triggering the 1237, 1754, and the SGR-2 thyratrons. It is small in size and is mechanically rugged.

Axel Electronics, Inc., Dept. ED, 134-20 Jamaica Ave., Jamaica 18, N. Y.

Series Motor 496

Type TW, for special purpose applications where fractional-horsepower motors are required, has removable brushes for quick, easy replacement.

Redmond Co., Inc., Dept. ED, Owosso, Mich.

Sealectro **PRESS-FIT**[®]

TEFLON* TERMINALS

improve
dependability



ELECTRICAL

The Teflon dielectric used in Sealectro "Press-Fit" terminals provides a power factor less than .0005 from 60 cps to 30,000 mcs. Dielectric constant is 2.0. Volume resistivity even after water immersion is better than 10^{15} ohm/cm. 1000 to 2000 volts per mil dielectric strength.

MECHANICAL

Sealectro "Press-Fit" terminals are consistently manufactured to the closest tolerances in the industry assuring greater resistance to torque and pullout. Resilient over wide temperature range. No cracking or breaking in transit or assembly. No water absorption. Unaffected by soft-soldering operations.

THE RIGHT TERMINAL FOR EVERY PURPOSE

Sealectro's unparalleled experience, know-how and complete customer services assure you the right terminal for every purpose. Sealectro offers you a choice of over 1000 standard "Press-Fit" terminals, plus virtually unlimited talents in the design, development and manufacture of any terminal for any purpose. Write for Catalog.

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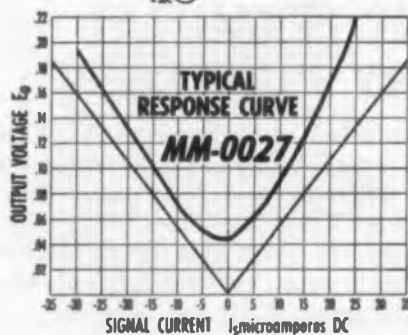
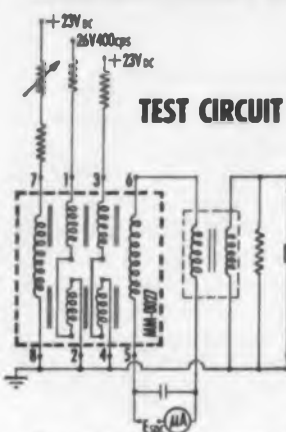


CIRCLE 98 ON READER-SERVICE CARD



HST MAGNETIC MODULATOR furnishes stable signal amplification

THEORY & APPLICATION: Since certain control and instrumentation systems require amplification of DC signals, it is desirable to employ a static signal converter. Magnitude of these available DC signals is so small that instability of DC amplifying systems results when signal is brought to usable level. Therefore a stable AC amplifier is required to convert low level DC to AC. A magnetic modulator serves this function with the added advantage that a "polarity reversible" DC input is converted to a "phase reversible" output. The output can be rectified to a "polarity reversible" pulsating DC or can be applied to a phase sensitive indicating device. Input impedance is relatively high while the output impedance is inherently low.



DC input is converted to a "phase reversible" output. The output can be rectified to a "polarity reversible" pulsating DC or can be applied to a phase sensitive indicating device. Input impedance is relatively high while the output impedance is inherently low.

SPECIFICATIONS: Model MM-0027

ELECTRICAL CHARACTERISTICS:

Maximum Output	>.4 V _{RMS} @ I _s 100μa
Minimum Output	<.05 V _{RMS} @ I _s 0μa
Voltage Unbalance	< 35%
DC Resistance 1-2	7.3Ω ±20%
3-4	500Ω ±20%
5-6	1200Ω ±20%
7-8	60Ω ±20%

Frequency 400 cycles

MECHANICAL CHARACTERISTICS:

Diameter	1.13" maximum
Height	.68" maximum
Lead Length	2.00" minimum
Mounting	.125" clearance hole

ENVIRONMENT CONDITIONS:

Storage Temperature	-85° to +100°C
Operating Temperature	-40° to +70°C
Vibration	.060" total excursion 10-5cps
Shock	15 g's
Altitude	50,000 feet
Humidity	95% relative

Prices on request. Quotations without obligation on your other special components.

Hermetic Seal
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MAGNETIC IRON-CORE COMPONENTS
ENVIRONMENTAL TESTING
POWER SUPPLIES—SERVO AMPLIFIERS



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CIRCLE 99 ON READER-SERVICE CARD

NEW PRODUCTS

Mercury Plunger Relay

714

Will handle 100 amp at 115 v



The type 100 mercury plunger relay will handle 100 amp at 115 v ac. Mercury-to-mercury contacts are hermetically sealed; an inert-gas atmosphere quenches arcs to provide cool operation. The relay is suitable for motor and lighting control, heating power and other high-current applications.

Ebert Electronics Corp., Dept. ED, 212-26 Jamaica Ave., Queens Village, N.Y.

Price & Availability: From \$32.50 to \$21.20, depending on quantity; delivery is 1 to 2 weeks.

Printing Scalar

711

For high-speed counting systems



The type N-276 scalar is designed especially for use in systems where high speed and automatic operation are needed. It is intended for use in conjunction with the firm's type N-803 printing timer. Preset counts from 10 to 500,000 are provided. At the end of the preset count or time, an optional printer prints the scalar display and the instrument automatically starts counting again. The device has a pulse-pair resolution of better than 1 μsec, a repetition rate of 1 mc, and a display of six electronic decades. Sensitivity is ±4 v min. Dimensions are 3-1/2 x 19 x 13-1/2 in.

Hamner Electronics Co., Inc., Dept. ED, P. O. Box 531, Princeton, N.J.

NEW!

Engraved
Deep-Kut*
Perma-Grip
Peg Stamps
give you
fully
aligned
printing
impressions
every time!



*VINYLITE
Acid-Resistant
Stamps

characters are
locked into
wooden pegs
...can't come off!

Made only by Kregel Mfg.
Co., Inc., Perma-Grip Peg Stamps
with DEEP-KUT dies
give you clear, clean,
sharp markings every time.

Each set of peg stamps
contains all the letters in
the alphabet plus all the
numbers 0 to 9.

1/16	ABC123
3/32	ABC123
1/8	ABC123
5/32	ABC123
3/16	ABC12
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Complete set
of alphabet and
figures in any of
the 6 sizes shown. **\$15⁹⁵**

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CIRCLE 100 ON READER-SERVICE CARD

High-Voltage Test Set 379

Produces 5 ma continuously at 50 kv

Designed for dielectric testing and leakage-current measurement at high voltage, the model S50-5DC test set provides 5 ma continuously at 50 kc. The high-voltage tank is oil-filled, weighs 90 lb and occupies less than 1 cu ft.

Peschel Electronics, Inc., Dept. ED, Towners, Patterson, N.Y.

Price & Availability: \$1,200; delivery is 10 days.

High-Gain Power Transistors 389

For high-frequency applications

These npn diffused-silicon power transistors, types 2N1661 and 2N1662, have high gain and are designed for high-frequency power handling. Collector-to-emitter voltages are 80 and 100 v, respectively. Collector current is 2 amp max; beta frequency, 25 mc min; power output, 85 w. The units have applications in regulated power supplies, power switching, amplifiers, oscillators, core drivers and servo amplifiers.

Raytheon Co., Semiconductor Div., Dept. ED, 215 First Ave., Needham, Mass.

Price & Availability: 2N1661, \$67.50; 2N1662, \$90; delivery from stock.

Extension-Plunger Slide Switches 382

For unconventional mountings

These extension-plunger slide switches are designed for applications where conventional panel mounting is inconvenient. Model SW-726X switch is a dpdt device with detent and a contact rating of 0.5 amp at 125 v, ac or dc. Also available are spst, spdt and dpst switches with detent, and spst and spdt switches with spring return.

Continental - Wirt Electronics Corp., 26 W. Queen Lane, Philadelphia 44, Pa.

Availability: Immediate.

GEE DAD-IT'S A WHOPPER!



SPERRY

**SPERRY SEMICONDUCTOR
DIVISION**

OF

**SPERRY RAND CORPORATION
NORWALK, CONNECTICUT**

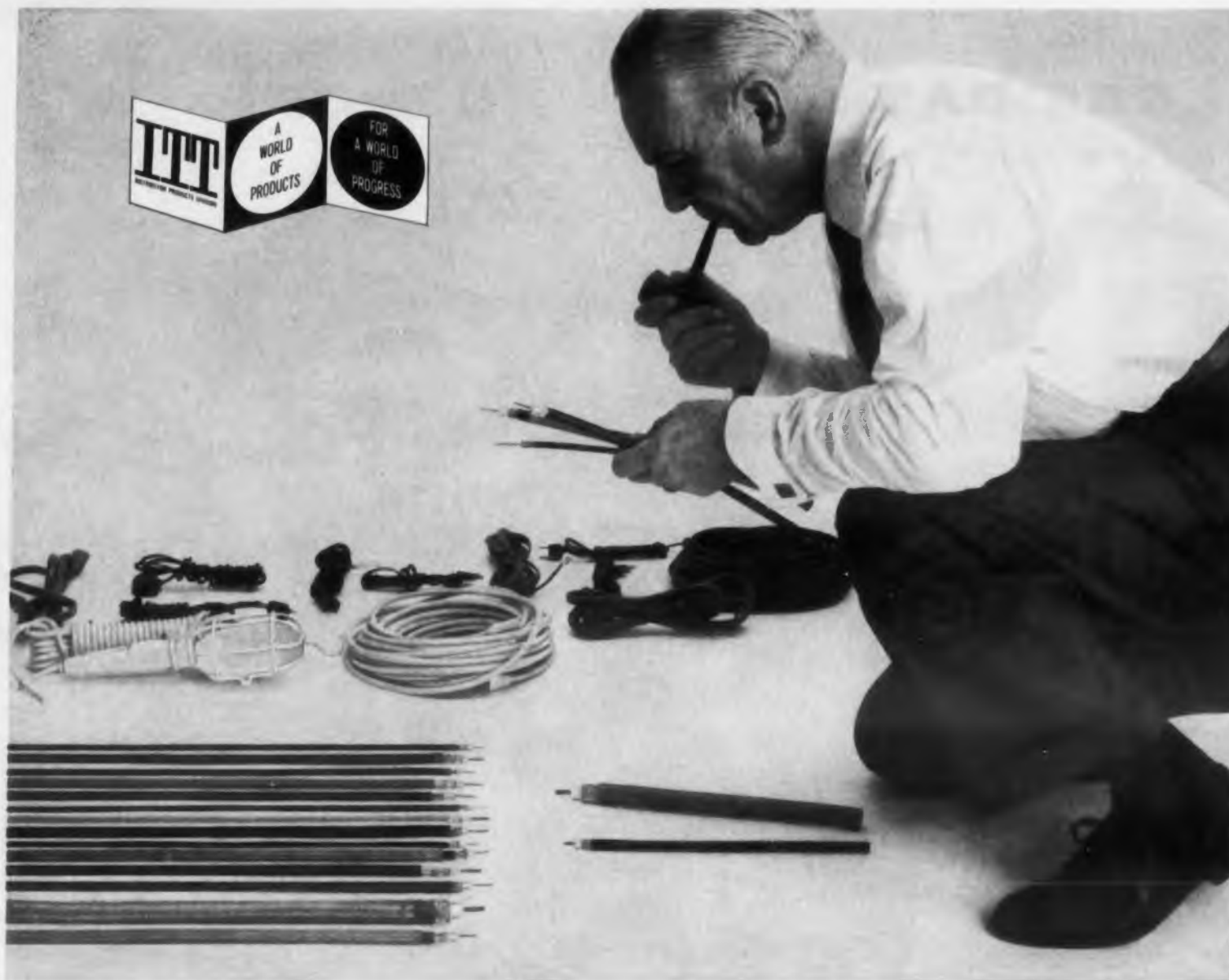
Whether it's fishing or designing equipment, you're proud when you've accomplished what you set out to do. You feel a sense of security . . . of satisfaction . . . whether the job be big or small.

As engineers, we have more opportunities than the average man to concentrate, solve problems and experience satisfaction.

A constant source of pride is the product reliability accomplished through control of quality during mechanized manufacture. For example, the new low voltage series of PNP Silicon Alloy Transistors enables many engineers working on choppers, modulators demodulators, etc., to achieve performance of which they can be proud. Evidence: Sperry's new Technical Application Bulletin #2107.

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* Trade Mark, Sperry Rand Corporation



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Power Supply Cords and Cord Sets: Heavy duty extensions; air conditioner, range and dryer cords; cube

ITT's thousands of experience-tested and quality-proven wire and cable products include:

	O. D. Inch	Impedance (Ohms)
Coaxial Cable:		
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Single Shield	.475	50
Single Shield	.195	50
Single Shield in air-spaced polyethylene dielectric	.242	93
Double Shield	.420	51
Solid Conductor—		
Single Shield	.870	52
Single Shield	.945	50
Single Shield	.195	53.5
Single Shield	.242	73 and 75
Single Shield in air-spaced polyethylene dielectric	.242	93
Double Shield	.216	50
Double Shield in air-spaced polyethylene dielectric	.250	93

tap and extension, special purpose cord sets; power supply replacement cords; trouble lights.

Electrical Wire: Rubber and plastic parallel lamp cord; rubber portable cord.

TV Lead-in Wire: Heavy duty, 2 conductors — 7 strands #28 — 70 mil.

Wiring Devices: Modern in design and modern in construction . . . combine exceptional utility features with durability, strength, safety . . . and ease of installation and use.



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CIRCLE 102 ON READER-SERVICE CARD

NEW PRODUCTS

Regulated Power Supplies

707

Rated 300 to 500 v, 0 to 500 ma, dc



The output for model RR 550 dc power supply is 300 to 500 v at 0 to 500 ma. Line and load regulation is 0.1%. Filament output is 6.3 v, 15 amp. Input is 105 to 125 v, 55 to 400 cps. The device is rack mounted; panel height is 5-1/4 in., and depth is 14-1/4 in.

Trans Electronics, Inc., Dept. ED, 7349 Canoga Ave., Canoga Park, Calif.

Price & Availability: \$310 without meters; \$350 with meters. Delivery is from stock.

Transistorized Power Supplies

710

Provide 12 v at 5 amp



Model PS111M transistorized power supply, one of a series, has the following specifications: output, 12 v dc at 0 to 5 amp; transient response, 50 mv or less for 50 μsec or less square-wave load; no line transients; line regulation, 0.1%; load regulation, 0.25%; stability, 0.5% or 50 mv for 24 hr; ripple, 1 mv rms. Device measures 19 x 5-1/4 x 10 in., weighs 15 lb. Input is 105 to 125 v, 60 to 400 cps.

Valor Instruments, Inc., Dept. ED, 13214 Crenshaw Blvd., Gardena, Calif.

Price & Availability: \$395; two weeks.

Film Resistors

422

Are rated at 1 and 1/2 w



Types C-20 and C-32 resistors have resistance ranges of 56 ohms to 150 K and 56 ohms to 470

... respectively. Other specifications are: derating, full load at 70 C ambient to zero at 150 C; load life, change in resistance of 1% and 1.5% after 1,000 hr operation at 70 C; temperature coefficient, ± 150 ppm per deg C from -55 to $+150$ C; and noise level, 0.1 mv per v of applied signal.

Corning Glass Works, Dept. ED, Bradford, Pa.
Price: Type C-32 with 5% tolerance, 6.1 cents in quantities of 5,000; type C-20 with 5% tolerance, 5.9 cents.

High-Gain Amplifier

362

Bandwidth is 0.1 to 320,000 cps



Model 72 amplifier is a low-noise, high-gain, wide-band unit useful in research and development work, both as an amplifier and a noise source. Nominal bandwidth is 0.1 cycle to 320 kc. Gain is adjustable in 3 db steps from 100 to 10,000. Noise is less than $3 \mu\text{v}$; distortion, less than 0.5%. With an auxiliary input, gain is 500,000.

Shapiro and Edwards, Dept. ED, 1130 Mission St., South Pasadena, Calif.

Price & Availability: \$1950; stock to 45-day delivery.

Solid-State Switches

418

For airborne and missile uses



These solid-state switches are designed for airborne and ground-control missile applications and aircraft uses. Model EA 154, for example, operates from an input of 110 v ac at 400 cps and is rated at 2 amp at 28 v dc. It stands temperatures from -40 to $+160$ F, 25 g shock for 10 msec, 10 g vibration from 5 to 500 cps, and humidity, salt spray and fungus. It meets MIL-E-4790.

Thermador Electronics, Dept. ED, 715 S. Raymond Ave., Alhambra, Calif.

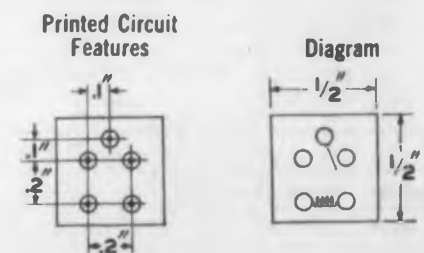


INTRODUCING the NEW Hi-G *“dice cube” relay

(Created Specifically for
Printed Circuit Applications)

Volume — $\frac{1}{8}$ cubic inch max.
 Package Density — 8 per cubic inch,
 13,824 per cubic foot.

- Type:** Model C Relay.
- Contacts:** SPDT, dry circuit to 1 amp resistive.
- Temperature:** -65°C to $+125^{\circ}\text{C}$.
- Insulation Resistance:** 1000 megohms @ 125°C .
- Dielectric Strength:** 1000 VRMS @ Sea Level.
- Convenient Size:** $\frac{1}{2}$ " Cube, allowing best compatibility in size to other printed circuit components.
- Optional Terminals:** Long or short leads for printed circuit applications, or hook type for standard wiring.
- Construction:** Balanced armature construction, proven the best approach available for resistance to extremes of vibration and shock, exceeding all present military specifications.
- Environmental Characteristics:** To meet all military relay specifications for components of this size.



*Trade Mark of Hi-G, Inc.



THE ONLY COMPLETE LINE OF BALANCED ROTARY RELAYS

Hi-G INC.

BRADLEY FIELD, WINDSOR LOCKS, CONN.

CIRCLE 103 ON READER-SERVICE CARD

FOR PRECISION MEASUREMENTS

RESISTANCE DECADES—MODEL DR

Available in a wide variety of standard models. Accuracy at 1.0 and 0.1 ohm steps is $\pm 0.25\%$. Accuracy of all other resistors is $\pm 0.1\%$ of indicated value. Self-cleaning, molded nylon and silver plated brass switch mounted below panel. Zero resistance is less than .003 ohms per dial. Hardwood case. Models DR-1D to DR-4D, 8" x 5½" x 4½" h. Weight 4 lbs. net, 6 lbs. shipping. Models DR-50D to DR-52D, 9" x 6" x 4½" h. Weight 5 lbs. net, 7 lbs. shipping. Models DR-70D and DR-71D, 17¼" x 5" x 4½" h. Weight 6 lbs. net, 8 lbs. shipping.



ELECTRICAL SPECIFICATIONS

Model No.	Total Res. Ohms	Decade Steps	Accuracy
DR-1D	1,110,000	10x(1,000+10,000+100,000)	$\pm 0.1\%$
DR-2D	111,000	10x(100+1,000+10,000)	$\pm 0.1\%$
DR-3D	11,100	10x(10+100+1,000)	+0.1%
DR-4D	1,100	10x(1.+10+100)	$\pm 0.25\%$ & $\pm 0.1\%$
DR-50D	11,111	10x(.1+1+10+100+1,000)	$\pm 0.25\%$ & $\pm 0.1\%$
DR-51D	111,110	10x(1+10+100+1,000+10,000)	$\pm 0.25\%$ & $\pm 0.1\%$
DR-52D	1,111,100	10x(10+100+1,000+10,000+100,000)	$\pm 0.1\%$
DR-70D	1,111,111	10x(.1+1+10+100+1,000+10,000+100,000)	$\pm 0.25\%$ & $\pm 0.1\%$
DR-71D	11,111,110	10x(1+10+100+1,000+10,000+100,000+1,000,000)	$\pm 0.25\%$ & $\pm 0.1\%$



WHEATSTONE BRIDGES—MODEL RN

Universally used for the measurement of all types of resistance devices and circuits where high accuracy is required. Models available for performing Murray-Varley Loop tests.

ELECTRICAL SPECIFICATIONS

Model	Total Res. of Decade	Ratio Dial Settings	Circuits	Dimensions
RN-1	9X(1+10+100+1000)	.001, .01, .1, 1.0, 10, 100, 1000	.....	9"x8"x6½"
RN-2	9X(1+10+100+1000)	.001, .01, .1, 1.0, 10, 1000, M10, M100, M1000	Murray & Varley	9½"x8"x6½"
RN-3	10X(1+10+100)+9(1000)	1/1000, 1/100, 1/10, 1/9, 1/4, 1/1, 10/1, 100/1, M10, M100, M1000	Murray & Varley	9½"x8"x6½"

CAPACITANCE DECADES—MODEL DK

These are 3-dial units with the sum of the dial setting indicating total capacity in microfarads. Mylar and silver-mica capacitors are used for high stability, low-loss characteristics. Polished hardwood case, engraved dial graduations.



ELECTRICAL SPECIFICATIONS

Model	Decade Steps (MFD)	Accuracy	Dielectric	Power Factor	Peak Volts
DK-2A	0.001, 0.01, 0.1	$\pm 1\%$, $\pm 1\%$, $\pm 1\%$	Silver Mica	0.2%, 0.2%, 0.2%	700, 700, 500
DK-4	0.001, 0.01, 0.1	$\pm 1\%$, $\pm 1\%$, $\pm 3\%$	Silver Mica, Mica & Foil, Mylar	0.2%, 0.2%, 1%	700, 700, 400
DK-5A	0.01, 0.1, 1.0	$\pm 1\%$, $\pm 3\%$, $\pm 3\%$	Mica & Foil, Mylar, Mylar	0.2%, 1%, 1%	700, 400, 400
DK-11A	0.01, 0.1, 1.0	$\pm 0.5\%$, $\pm 0.5\%$, $\pm 2.0\%$	Silver Mica, Silver Mica, Mylar	0.2%, 0.2%, 1.0%	700, 500, 400
DK-10	0.0001, 0.001, 0.01	$\pm 0.5\%$ in 10 mmf	Silver Mica	2.0%, .2%, .2%	700, 700, 700

PHYSICAL SPECIFICATIONS

Model	Over-all Dimensions	Weight (Lbs.)	
		Net	Shipping
DK-2A, DK-4, DK-10	8 x 5½ x 7½	8	10
DK-5A, DK-11A	10¾ x 7¾ x 7½	10	12



Industrial Instruments

89 COMMERCE ROAD, CEDAR GROVE, N. J.

CIRCLE 104 ON READER-SERVICE CARD

NEW PRODUCTS

Subminiature RF Tubes

359



Have high transconductance with low heater power

Two subminiature rf-amplifier tubes, types CK6611 and CK6612, have mutual conductances of 1,000 and 3,000 μ mhos at filament powers of 25 and 100 mw, respectively. Plate voltage is 30 v max. Operating life-time is over 5,000 hr. Units are designed to stand shock, vibration and fatigue conditions.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton, Mass.

Price & Availability: CK6611, \$9.95; CK6612, \$12.45. Delivery from stock.

Parametric Amplifiers

408

For all microwave frequency applications



These reactance diode parametric amplifiers are designed for applications at all microwave frequencies. The heart of the line is the gallium arsenide, variable reactance diode which gives improved noise performance over a wide range of temperatures. Typical models include: model S-21, S-band tunable from 2.7 to 2.9 gigacycles, has ratings of 3 db over-all noise figure (double sideband) with 15 db gain over a 15 mc bandwidth; model C-11, C-band tunable from 4.4 to 5 gigacycles, has a 3 db over-all noise figure (double sideband) with 15 db gain over a 20 mc bandwidth; model L-11, tunable from 0.9 to 1.2 gigacycles, has a noise figure of 1 db (double sideband) with 16 db gain over a 50 mc bandwidth.

Texas Instruments Inc., Dept. ED, 6000 Lemmon Ave., Dallas 9, Tex.



for your

TOUGHEST PROBLEMS
ON

Laboratory Constructions

Special Apparatus

Instruments

PF Teflon furnishes near-miraculous solutions to difficult application problems because of its unique chemical, electrical and mechanical advantages. Wherever tubing has a critical job to perform in electrical, electronic, chemical, food, laboratory, mechanical and other applications, PF Instrument Tubing is the best answer because it:

1. Has an extreme service temperature range from -320° to 500° F
2. Has excellent dielectric properties and zero moisture absorption
3. Resists almost all chemicals and solvents
4. Is easy to clean or sterilize
5. Is translucent, tough and flexible
6. Will not contaminate a stream

PF extrudes this tubing in all popular sizes from .012" to .330" I.D., thin and standard wall, in a full range of colors.

The combination of Teflon's outstanding properties and PF's outstanding engineering and manufacturing techniques can help solve your difficult application problems.



Write, wire or phone for information and advice on your specific applications

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Philadelphia 4, Pa.

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*De Pont Reg. T.M.

CIRCLE 105 ON READER-SERVICE CARD

AUGAT

COMPLETE LINE OF SOCKET ASSEMBLIES FOR MICRO-MINIATURE RELAYS

Combining Holding Clip And
Built-In Socket For Unmatched
Reliability Under Severe Condi-
tions Of Shock And Vibration.



HORIZONTAL MOUNTING
(Solder Cup Contacts)



HORIZONTAL PRINTED
CIRCUIT MOUNTING



VERTICAL MOUNTING
(Solder Cup Contacts)



VERTICAL PRINTED
CIRCUIT MOUNTING



SOCKET ONLY WITH
MOUNTING SADDLE
(Solder Cup Contacts or
Printed Circuit Pins)

Patent Pending

These assemblies will accomodate
Micro-Miniature relays as manufac-
tured by G. E., Elgin, Sigma, Allied,
Patter & Brumfield, Clare, Iron Fire-
man, Babcock and many others.

For additional information
write for catalog RS-160

AUGAT BROS., INC.

31 Perry Avenue
Attleboro, Massachusetts

Miniature Lights 465

Series MCL indicators are for commercial data processing and industrial control system applications. Six different types offered are neon or incandescent lamps, pin or wire lead terminals, and square or round lenses.

Transistor Electronics Corp., Dept. ED, 3357 Re-
public Ave., Minneapolis 26, Minn.

Metal Film Resistors 484

This is a flat sided version of the firm's cylindrical, axial-lead resistor. Three of the units fit into an area that would ordinarily accommodate two cylindrical units. Temperature coefficient of resistance is 25 ppm per deg C.

Ohmite Manufacturing Co., Dept. ED, 3645 W.
Howard St., Skokie, Ill.

Fastener 474

Series 12F 1/4-turn fastener is for light covers, small sub-assemblies, and miniature black boxes. They use rivets 0.062 in. in diameter; rivet spacing is 1/2 in.

Camloc Fastener Corp., Dept. ED, 61 Spring
Valley Road, Paramus, N. J.

Terminals 485

The Tabon terminals for quick connect-disconnect applications are available in chain form for rapid machine crimping. Offered in a wide range of wire and insulation sizes, the terminals are self-wiping and self-cleaning.

Malco Mfg. Co., Dept. ED, 4025 W. Lake St.,
Chicago 24, Ill.

Radio Filters 472

Designed for installation in aircraft these units are light and compact. They come in hermetically sealed drawn-steel containers, have high Q inductors, and use low power factor capacitors.

Aerovox Corp., Cinema Engineering Div., Dept.
ED, 1100 Chestnut St., Burbank, Calif.

Instrument Ball Bearings 505

Made in R2, R3 and R4 sizes, the MPB R series uses a stainless steel retainer. They are suitable for use in servos, generators, small motors, synchros and gyros.

Precision Bearings, Inc., Dept. ED, Keene, N. H.

Capacitor Package 504

The Vu-Paks are clear plastic tubes packed with electrolytic twistmount capacitors. They are re-us-
able.

Pyramid Electric Co., Dept. ED, Darlington, S. C.

**HELIPOT SINGLE-TURN
POTENTIOMETERS...a line
you can hang your toughest
specs on! Don't worry, they can
take it...environmentally, elec-
trically, and mechanically!
And you pay only for what you
need, because Helipot offers
85°, 125°, and 150°C models!
Standard linearity: ±0.5%,
with ±0.10% available for most.**

The Helipot line is simply
stacked with stand-out single-
turns, linear or non-linear, from
1/8" to 3" diameters. Numerous
modifications are available for
any of them—things like flatted
or slotted shafts, rear shaft ex-
tension, shaft lock, anti-fungus
treatment, color coding or
center tap. And most models
allow 8 cups to be ganged!

All these significant single-
turns are precision built by
Helipot...as are surprisingly
large numbers of multi-turns,
trimmers, A-C pots, dials, delay
lines and in-line packages.

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Beckman/Helipot

POTS : MOTORS : METERS

Helipot Division of
Beckman Instruments, Inc.
Fullerton, California



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WIDE-RANGE TRANSISTORIZED POWER SUPPLIES:

available for immediate
off-the-shelf delivery



Here is a complete line of transistorized power supplies. Exacting performance of the unique differential DC amplifier assures extremely tight static and dynamic regulation; ultrafast response . . . less than 20 μ sec; very low output impedance and a high degree of drift stability with temperature — plus complete protection from short circuits and overload.

CHECK THE FOLLOWING CHART FOR YOUR REQUIREMENTS:

	Output Voltage DC	Output Amps DC	Static Regulation		Output Impedance Ohms	Ripple Millivolts Peak-to-peak	Panel Height
			Load	Line			
T-200-C	0-10	0-3	.03%	.03%	.040	2.0	3½
T-205-C	0-10	0-10	.03%	.03%	.012	2.0	3½
T-210-C	0-10	0-30	.03%	.03%	.004	2.0	5¼
T-215-C	0-32	0-1	.02%	.02%	.240	2.0	3½
T-220-C	0-32	0-3	.02%	.02%	.080	2.0	3½
T-225-C	0-32	0-10	.02%	.02%	.024	2.0	5¼
T-221-C	0-50	0-2	.02%	.03%	.200	4.5	3½
T-230-C	0-150	0-0.75	.02%	.05%	1.000	6.0	3½
T-235-C	0-150	0-2	.02%	.05%	.500	6.0	5¼

These transistorized supplies, contained in compact light-weight consoles, have front and rear terminals, permitting either rack or cabinet installation for such applications as laboratory, computer power (digital or analog), production testing, and ground support equipment.

Write for the Armour Stablvolt catalog describing the complete line of transistorized and magnetically regulated power supplies for your application.



as

ARMOUR/STABLVOLT

division of Magnetic Research Corp.
3160 W. EL SEGUNDO BLVD., HAWTHORNE, CALIF.

CIRCLE 108 ON READER-SERVICE CARD

NEW PRODUCTS

Refrigeration Unit

420

Dissipates 65.3 w



This Peltier cooling device dissipates 65.3 w of heat to the ambient air at 140 F at sea level. In so doing, temperatures are maintained below 110 F. The Peltier modules require 20 amp at 5.5 v dc for cooling. When used with the firm's temperature controller, this device can also be used to heat by reversing the current.

The Garret Corp., AiResearch Manufacturing Div. of Los Angeles, Dept. ED, 9851 Sepulveda Blvd., Los Angeles, Calif.

Environmental Test Fixture

407

Is resonant-free below 2,000 cycles



An environmental test fixture that is resonant-free below 2,000 cycles has been designed for testing specimens in three mutually perpendicular axes, simultaneously. It may be used for vibration, shock and acceleration testing. The transmissibility factor does not exceed 1.10 up to 2,000 cps, giving accurate transmission of input with no amplification. Available in two sizes, the smaller size has a capacity of 6 x 6 x 4-1/2 in. with a weight capacity of up to 6 lb; the larger type has a capacity of 12 x 12 x 9-1/2 in. and a weight capacity up to 25 lb. The T-type fixture is made of cast magnesium.

Avco Research and Advanced Development Div., Dept. ED, 201 Lowell St., Wilmington, Mass.

SEMICONDUCTOR TEST EQUIPMENT

COMPLETE LINE OF
STANDARD INSTRUMENTS...



*MODEL 1803
TRANSISTOR PARAMETER TEST SET
Measures the small signal "h" parameters and wide range of I_{co} .



*MODEL 1811
MILLIMICROAMMETER
Measures low level dc currents from less than 1 μ ma to 3 ma. Chopper stabilized. No zero adj.



*MODEL 1802
RF TRANSISTOR TEST SET
Measures F_a , F_t to 50 mc, $r_b C_c$, and C_{ob} —Direct reading.

*All above instruments are complete and require no accessories — line operated — no batteries.
ALSO: MODEL 1816—TUNNEL DIODE TEST SET — MODEL 1808 — WIDE RANGE DIODE TEST SET

...and CUSTOM DESIGNED
MANUAL AND AUTOMATIC
SEMI-CONDUCTOR TEST
EQUIPMENT.

DYNATRAN
electronics corporation

178 HERRICKS ROAD
MINEOLA, NEW YORK

Pioneer 1-4141

CIRCLE 109 ON READER-SERVICE CARD

Push-Button Switches 387

Momentary-contact type

This line of 400-1 miniature, momentary-contact, push-button type switches are rated at 1/2 amp and 115 v ac. It stands a dielectric test of 1,000 v. Nipple mounting is standard. Terminals are solder type. The switch is suitable for control of electronic equipment, television sets, audio equipment, computers and relays.

Alcor Manufacturing Co., Dept. ED, 4444 W. Roosevelt Road, Chicago 24, Ill.

Price & Availability: \$0.40 in quantities of 5,000; delivery is 15 days.

Beam Pentode 383

For high-voltage applications

This beam pentode is designed for use in high-voltage pulse amplifiers and high-voltage shunt regulator applications. Designated type 7239, the tube has a type 9KH base. The nine-pin miniature device has a plate dissipation of 4 w and a peak cathode current of 85 ma. Maximum plate voltage is 2200 v and screen voltage is 200 v.

General Electric Co., Dept. ED, Schenectady 5, N.Y.

Price & Availability: \$8.75; from stock.

Plug-In Relay 386

Has indicating lamp

The series 1210-N plug-in relay has an indicating neon lamp that lights when the coil is energized. Failure to light is an indication of a fault. The unit is applicable in relay banks, mass relay installations and at intermediate switching points. The device has an eight-pin octal plug for dpdt and an 11-pin plug for 3 pdt. Contacts are rated at 8 amp, 115 v ac. The unit measures 2-22/32 x 1-3/8 x 1-3/8 in.

Guardian Electric Manufacturing Co., Dept. ED, 1550 W. Carrol Ave. Chicago 7, Ill.

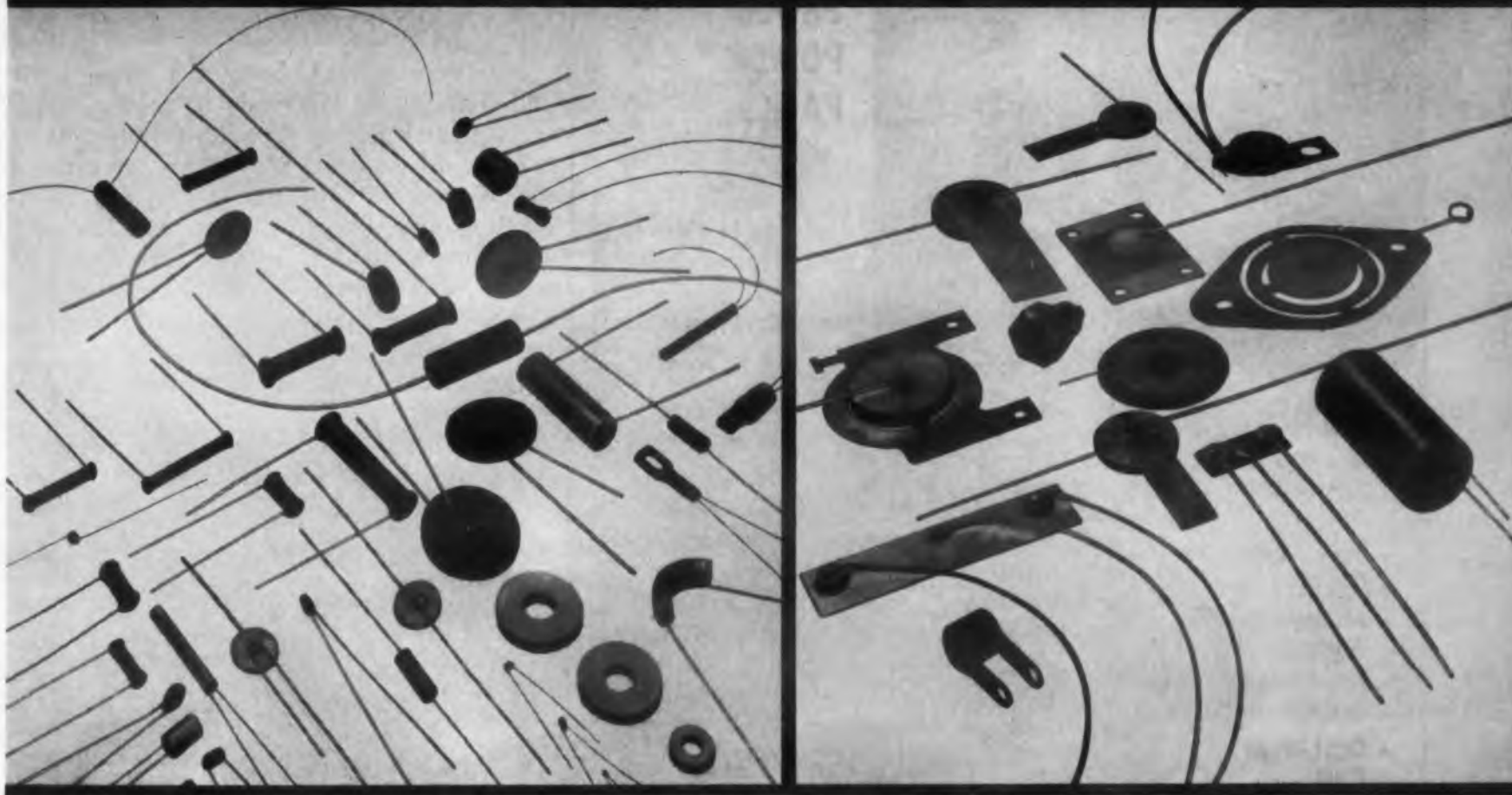
Price & Availability: DPDT, \$6.30; 3PDT, \$7.70; available from stock.

IN THERMISTORS

...the key name is **Keystone**

... whether you need **10** or **10,000,000** pieces—

STANDARD PARTS ... or SPECIAL ASSEMBLIES



Versatility Plus . . .

A partial list of small discs and rods, all with identical characteristics

Temperature Coefficient (25°C) -3.8% / °C
Beta Value (37.8°C / 104.4°C) 3500°K
Ratio (37.8°C / 104.4°C) 7.3

Resistance 25° C	Keystone Type Number	Diameter (Inches)	Thickness (Inches)
500	L0503-312-73	0.050	0.030
160	L0903-100-73	0.100	0.030
500	L0903-312-73	0.100	0.030
1000	L0909-623-73	0.100	0.100
100	L2003-62-73	0.200	0.030
180	L2006-112-73	0.200	0.060
200	L2006-125-73	0.200	0.060
230	L2006-143-73	0.200	0.060
270	L2008-168-73	0.200	0.080
300	L2008-187-73	0.200	0.080
100	L3006-62-73	0.300	0.060
200	L3008-125-73	0.300	0.080
250	L3008-156-73	0.300	0.080
300	L3018-187-73	0.300	0.180
270	L060637-168-73°	*Rod, 0.060" square, 3/8" Length.	
5000	L060637-3120-73°		
10000	L060437-6234-73°		

Special Mounting Requirements

Thermistor applications often dictate special mounting requirements. As a result, Keystone units are supplied with many types of special lead assemblies, mounting tabs, heat dissipating fins. Units are mounted in probes and transistor type cans, attached to plates and metal parts of wide variety.

Keystone has the experience (over almost a quarter of a century), the knowledge and production capability to handle your thermistor requirements in any quantity—of any type and size.

Because of unsurpassed quality control, your tolerance specifications are acceptable to $\pm 2\%$ on resistance value and Beta value (in fact, we maintain a $\pm 2\%$ production tolerance on the material constant of all Keystone thermistors regardless of resistance tolerance). All parts can be supplied in pairs or sets matched closely in resistance-temperature or voltage drop characteristics.

We can supply discs, washers, rods, beads and special shapes including washer segments, square rods, rectangular wafers, square wafers, etc. Our experienced sales staff and engineering and research and development organizations are available for consultation. Write us or call today.

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CARBON COMPANY
RESISTOR DIVISION • St. Marys, Pa.
Telephone: Terminal 4-1591

NEW HIGH CURRENT Miniaturized TRANSPAC®



**NEW
SOLID
STATE
SHORT-
CIRCUIT
AND
TRANSIENT
PROOF
POWER
PACKS**

Featuring ERA's
New "Thermo-guide"®
principle
for minimum heat rise,
size and weight.

FEATURES:

- New High Current Solid-State Designs
- Battery Voltage Outputs
- Advanced Thermal Design
- Low Ripple Content
- Short-Circuit Proof . . . Automatic Recovery
- Thermal Transistor Stud Temperature Monitor and Automatic Cut-Off
- All Components Accessible
- Minimum Size and Weight
- Moderately Priced

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SAVE SPACE, WEIGHT and WIRING

ERA's new high current transistorized Transpacs are miniaturized self-contained AC operated units which provide regulated DC outputs at all standard battery voltages. These units may be used to replace battery sources for laboratory and test purposes or wired into equipment to supply a rugged reliable source of DC power for miniature or standard size electronic devices.

SPECIFICATIONS

Input 105-125 VAC, 60-400 cps. Line or load regulation better than 0.05% or 5 millivolts. Ripple less than 2 millivolts. Models listed are specified for operating temperatures up to 35°C, but may be derated for extended temperatures. Extremely high temperature and military designs also available on order. Units include provision for ±1 volt output adjustment.

Model No.	Output Volts	Current Amps.	Case Size (WxDxH — inches)	Net Price*
YR2R	5-7	0-2	4 3/4 x 4 x 5 1/4	\$165.
YR12R	11-13	0-2	4 3/4 x 4 x 5 1/4	165.
YR16R	17-19	0-2	5 x 4 1/4 x 6 1/4	170.
YR24R	23-25	0-2	5 x 4 1/4 x 6 1/4	170.
YR28R	27-29	0-2	5 x 4 1/4 x 6 1/4	175.
YR32R	31-33	0-2	5 x 4 1/4 x 6 1/4	175.
YR32R	6-32**	0-2	5 x 4 1/4 x 6 1/4	195.

*Prices FOB Cedar Grove, Subject to change without notice.
**Selectable Voltages at 6, 12, 24, 28 or 32 VDC.

In addition to models listed, units can be supplied to meet special military or commercial requirements. Write for quotations on special types. For further details request Technical Bulletin 20-1096.

For further details send for catalogue #116.

ELECTRONIC RESEARCH ASSOCIATES, INC.

67 Factory Pl., Cedar Grove, N. J. CEnter 9-3000

SUBSIDIARIES

Era Electric Corp • Era Pacific Inc • Era Dynamics Corporation • Advanced Acoustics Corp

NEW PRODUCTS

Null Voltmeter

427

Range is 300 mv to 300 v



This transistorized, battery or line-operated null voltmeter has full-scale ranges of 300, 30, and 3 v, and 300 mv. The device measures the in-phase fundamental components of small ac signals, particularly the null or error signals common to suppressed-carrier control systems, with an accuracy of 1-1/2% of full scale. Reference, input, and power-input circuits are isolated from each other and chassis ground to eliminate ground-loop effects.

Hydel, Inc., Dept. ED, 223 Crescent St., Waltham, Mass.

Price: \$1100.

Availability: 8 to 10 weeks.

Beam Power Pentode

425

Rated at 400 w



The type PL-175A beam pentode, rated at 400 w, is directly interchangeable with the type 4-400A tetrode. A specially designed vane-type suppressor grid is said to provide increased efficiency, lower distortion and greater output. In class AB₁ operation, the tube delivers 790-w usable power. In class-C service, the tube provides 960-w power with 1.4 w driving power.

Penta Laboratories, Inc., Dept. ED, 312 Nopal St., Santa Barbara, Calif.

Price: \$50 ea for 1 to 25 units; \$35 ea for 25 or more.

Availability: From stock in small quantities.

“ Say,
what's this
I hear
about LFE
making
read/write
heads for
magnetic drums
and
tape?”

“They have been
making them
for years
for their own
systems!
Now they're
available
to the industry.
Why don't you
write for
further info?”

LFE

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BOSTON 15, MASS. DEPT. 1026-E

Please send me complete data on
your magnetic read/write heads.

Name _____

Title _____

Company _____

Division _____

Address _____

CIRCLE 112 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960

High-Voltage Relays 743

Weigh 1 oz

Able to switch 3,000 v, the Mini-
c R-5 relay weighs 1 oz and
measures 2 in. long and 3/4 in. in
diameter. It handles up to 750 va
with a maximum contact rating of
1 amp. Contacts are sealed in a
high vacuum. The relay stands
shock, vibration, and temperature
extremes and meets Mil specs.

Resistron Laboratories, Inc., Dept.
D, 2908 Nebraska Ave., Santa
Monica, Calif.

Availability: From stock in sample
production quantities.

X-Band Detector 724

For systems monitoring

This miniature X-Band detector
mount, model 1046, is intended for
systems monitoring and has a mini-
mum dc output of 0.5 v across 10 K
for 1 mw rf, 7500 to 8500 mc, into
the sub-miniature connector. The
total unit is enclosed by 1 x 1 x
1/2 in. Weight is 3.5 oz.

Radar Design Corp., Dept. ED,
P.O. Box 38, Syracuse 11, N.Y.

Price & Availability: Prices are: 1
to 9, \$82 ea; 10 to 49, \$74 ea; 50 to
99, \$64 ea; prices include the
N23C crystal. Available 30 days
after receipt of order.

Shaft Encoders 728

Analog to digital

These analog-to-digital shaft en-
coders have passed life tests in ex-
cess of 10,000 hours at average slew
speeds of 500 rpm and maximum
slew speeds of 3,000 rpm. They are
available in 6, 7, 8, 9, 10, 13, 15, 17
and 19 bit models. This line of shaft
encoders has a constant thickness
design for the brushes, single
brush contacts for each bit, and
low friction, low surface wear cod-
ing discs. Readout accuracies of
 $\pm 1/2$ a digit are maintained in ex-
cess of 10,000 hours.

Guidance Controls Corp., Dept.
ED, 110 Duffy Ave., Hicksville,
L.I., N.Y.



Advancing the Science of Communications through Electronic R & D at Lockheed



The extent of the science of communications is as vast as the universe itself will allow. Fresh areas in this science are being explored at Lockheed. Our pursuits cover the spectrum of communications problems—on and under the water to tracking missiles and satellites—from components to complete systems. ■ One essential phase in the electronics communications R & D program is the development of antennas and supporting equipment to receive telemetered, tracking and relay data—each uniquely designed to answer a particular need.

This program is vital to support our sophisticated spacecraft projects—now and in the future. ■ Areas under investigation in electronics and other fields

excite the creative mind: Design and development of data processing equipment; V/STOL design and development; electromagnetic research in corona and high-altitude breakdown studies, surface wave generation, antenna vehicle interaction, millimeter wave radiometry; electrical instrumentation; infrared and solid state physics; biophysics research (on radiation hazards coincident with space flight); solid state electronics; underwater sound propagation and oceanography studies; aerothermodynamics; dynamics; autocontrols; and servosystems are but a few of them. ■ Scientists and Engineers: The challenges and rewards of our current and future programs are unlimited. If you are experienced in any of the areas mentioned above you are invited to investigate opportunities offered by a company that always looks far into the future. Write today to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1310, 2407 No. Hollywood Way, Burbank, California.

LOCKHEED / CALIFORNIA DIVISION



COUCH ROTARY RELAYS

Start with a unique and simple design — manufacture within a narrow range of tolerances — specify performance on the *conservative* side — this is how Couch solves the problem of supplying relays that meet the present and future needs of our aircraft and missile programs.

The record shows that this technique is successful: many thousands of Couch CVE type rotary relays are providing consistent flight insurance in complex systems under the most severe environmental conditions.

IMPORTANT SPECIFICATIONS

Contacts: 4PDT (dry circuit to 10 amps)

Size: 1 3/32" D x 1 1/2" H

Weight: 3.2 oz. max.

Pull-in power: 1/2 watt

Ambient temperature: -65° to +125°C

Vibration resistance: 20G's, 5 to 2000 cps

Shock resistance: 75G's operating, 200G's non-operating

Write for complete specifications.



COUCH ORDNANCE, INC.

A Subsidiary of S. H. Couch Company, Inc.

3 Arlington St., North Quincy 71, Mass. Tel.: (Boston) BLuehills 8-4147

CIRCLE 114 ON READER-SERVICE CARD

NEW PRODUCTS

Mica Capacitors

360

Measure 5/16 x 1/4 x 1/8 in.



The series DM-10 silvered mica capacitors measure 5/16 x 1/4 x 1/8 in. They are available in values from 1 to 360 pf, rated from 100 to 500 wvdc. Operating temperature is up to 150 C. Units are encased in phenolic and are suitable for printed-circuit applications.

Electro-Motive Manufacturing Co., Inc., Dept. ED, Willimantic, Conn.

Availability: Large quantities, made to order, are delivered in 30 days; limited quantities from stock.

Laboratory DC Power Supply

429

Provides 0 to 20 v at 5 amp



This laboratory power supply, model PS-1235, provides 0 to 20 v, continuously adjustable, at a rated current of 5 amp. Load current can be limited to a maximum of either 1 or 5.5 amp to protect components in the load circuit. Ripple is less than 2 mv. Voltage regulation is better than ±0.1% or ±5 mv, whichever is greater, for full load or rated line change. Input is 105 to 125 v, 60 cps. The device has low internal impedance and fast recovery time. It measures 7 x 9.5 x 10.6 in., and weighs 19 lb.

Power Instruments Corp., Dept. ED, 235 Oregon St., El Segundo, Calif.

Price: \$280.

Availability: 3 to 4 weeks.



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FAST, CONVENIENT, NO PAPERWORK. ANY NUMBER OF REASONS FOR USING ELECTRONIC DESIGN'S READER SERVICE CARD.

Test Point Jacks 497

The Kwik-Term line includes both lug and turret styles. Standard contact and terminal material is gold flash over silver-plated beryllium copper. Probe diameters range from 0.041 to 0.09 in.

Cannon Electric Co., Dept. ED, 3208 Humbolt St., Los Angeles 31, Calif.

Terminal and Pull Box Enclosures 486

JIC enclosures with factory installed terminal blocks are for use as full boxes and junction boxes on all types of OEM machinery and signal systems. They are suitable for use where wiring must be protected from dust, dirt, oil, water and coolants.

Keystone Manufacturing Co., Dept. ED, 23328 Sherwood Road, Warren, Mich.

Transistor Holder 488

This three-pin holder is designed to eliminate holding failures of transistors undergoing shock, vibration and environmental tests. Made of heat resistant materials, it can be used to hold transistors undergoing tests at 260 C.

Jupiter Electronics, Inc., Dept. ED, 225 E. 144th St., New York 51, N. Y.

Hot-Junction Thermocouples 494

These single-wire thermocouples have unbroken mineral oxide insulation and sheath continuity for use under extremes of pressure and temperature, corrosive conditions and physical stresses.

Conax Corp., Dept. ED, 2300 Walden Ave., Buffalo 25, N. Y.

Accelerometer Switches 508

These units make accurate measurements of the shocks that critical missile components and other sensitive parts receive in shipping. The units are multi-range. A typical device has three sets of contacts, closing at 1, 2 and 3 g.

Humphrey, Inc., Dept. ED, 2805 Canon St., San Diego 6, Calif.

Resin Mixer 502

The Multi-Rez-Processor proportions, dispenses and mixes epoxy and polyurethane compounds. The Teflon is the only part of the unit to enter the reactive resin mix.

CPM Special Machinery Corp., Dept. ED, 324 Butler St., Brooklyn 17, N. Y.

Overtravel Switch 509

Type 14-324 heavy-duty, snap-action switch is rated at 20 mp and has a mechanical life of over 10,000,000 cycles. Standard type is spdt with double 0.02-in. contact gaps.

Illinois Tool Works, Licon Div., Dept. ED, 6606 S. Dakin St., Chicago 34, Ill.

ELECTRONIC DESIGN • October 26, 1960



NEW Corning wafer capacitors run from 1 to 10,000 uuf

Uuf for uuf the smallest, most stable capacitors you can get for printed circuits and high reliability components.

Never has so much capacitance been crammed into so little space with so much ruggedness and reliability.

The smallest gives from 1 to 560 uuf while resting in a space only 0.00204 cubic inch in volume.

The largest runs from 4301 to 10,000 uuf and takes up only 0.02106 cubic inch.

You sacrifice nothing for size. The flat shape gives you more options in mounting, e.g., slot or flat mounting in printed circuits.

When you need leads we can provide those too, in 3/16-inch lengths, in the WL series.

These capacitors are rugged and reliable. The dielectric and conductor layers are fused at high temperatures and need no encasement. You'd almost have to smash one completely to stop its operation. Meets or exceeds the performance requirements of MIL-C-11272A.

For complete specs write for a new 4-page bulletin to Corning Glass Works, Dept. 540, Bradford, Pa.

Capacitor	Capacitance (uuf)	Volume (approx.)
W, WL-5	1 to 560	0.00204 in. ³
W, WL-4	561 to 1000	0.00327
W, WL-3	1001 to 2700	0.00702
W, WL-2	2701 to 4300	0.01951
W, WL-1	4301 to 10,000	0.02106



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CORNING GLASS WORKS, BRADFORD, PA.

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Advanced component application of electroluminescent display instrument at Honeywell-Aero

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There are a variety of professional positions that offer challenges and opportunities for self-starters with imagination and drive to push the state of the art. Experience with military programs is valued. Specific openings include:

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BSEE from an accredited university or college. MSEE desirable. BS and MS in engineering physics acceptable if followed by suitable experience; e.g., several years of experience in design of audio frequency or servo mechanism circuits; utilizing such components as transistors, semi-conductor diodes, transformers, and magnetic amplifiers.

ELECTRONIC PACKAGING ENGINEER

BSEE or MSEE. Degree in other field such as physics or chemistry if experience is applicable. It is desirable to have experience in basic development of micro-miniature devices.

RADIO FREQUENCY SUPPRESSION ENGINEER

BSEE or MSEE experienced in communications and radio frequency propagation. Ham radio experience desirable. Must have firm grasp of RF knowledge.

MECHANICAL DESIGN SPECIALIST IN VIBRATION AND STRESS ANALYSIS

BSME or MSME with several years' experience in design or equivalent capacity in field of mechanics and materials, particularly stress analysis and vibration. Able to apply mechanical analysis to mechanical and vibratory stress problems.

To discuss these or other openings, write Mr. James H. Burg, Technical Director, Dept. 825, Aeronautical Division, 2600 Ridgeway Road, Minneapolis 40, Minn.

Honeywell

H Military Products Group

To explore professional opportunities in other Honeywell operations, coast to coast, send your application in confidence to H. T. Eckstrom, Honeywell, Minneapolis 8, Minn.

NEW PRODUCTS

Transistor Tester

415

Beta calibration accuracy is $\pm 1\%$



Model 200 transistor tester provides for measuring beta at different collector-current reference levels and incorporates an I_{co} test leakage reading on a 200- μ a meter. The instrument has separate sockets for npn and pnp transistors. Beta calibration accuracy is $\pm 1\%$ and current meter accuracy is $\pm 2\%$.

Westmore, Inc., Dept. ED, Fanwood, N. J.
Price: \$67.50.

Availability: One week.

Telemetry Pulse Separator

409

For PAM decommutation systems



The TPS-100-B telemetrics system, capable of decoding a 100% non-return to zero commutated wave train into a standard IRIG return to zero wave train, has a high degree of stability and synchronization. Frame rates are from 20 to 7200 pps. It is designed to operate where bit channels total 30, 45, 60 or 90 per frame. Decommutation rate variations of $\pm 20\%$ do not affect system synchronization. After 20 min warm-up, the system is stable within 0.20% over an 8 hr period.

Telemetrics, Inc., Dept. ED, 12927 Budlong Ave., Gardena, Calif.

Transistorized Crystal Oscillator

411

Output amplitude is 8 v peak-to-peak



The T-311 crystal oscillator has an output amplitude of 8 v peak-to-peak, from -11 v to +11 v. Frequency stability is $\pm 0.001\%$ max under the maximum combined variations of temperature

supply voltage and load with crystal in oven. The unit contains four germanium pnp transistors, two as a Butler crystal oscillator circuit, one for squaring and one as an emitter follower. A type H-160 crystal acts as a coupling impedance between the two stages of the Butler circuit. The T-311 covers the frequency range of 250 kc to 1 mc.

Engineered Electronics Co., Dept. ED, 1441 E. Chestnut Ave., Santa Ana, Calif.

Microwave Fault Alarm System 421

Reports 11 or 17 fault conditions



This transistorized fault alarm for microwave systems reports 11 or 17 different fault conditions from as many as 30 remote stations. Tones can be set within one of five ranges from 1 to 30 kc. Indication is by means of lights on the front panel. Each unit is housed in a plug-in module measuring 1.5 x 7 x 18 in. and requiring 20 w of power.

Collins Radio Co., Texas Division Sales, Dept. ED, 1930 Hi-Line Drive, Dallas 7, Tex.
Availability: 90 days.

Three-turn Potentiometer 406

Over-all length is 1-31/64 in.



The three-turn design of this potentiometer results in a housing length of 1-31/64 in. The basic design for the 205 series was developed originally for the military, but is now available commercially as well. Major specifications of the 205-3T potentiometer are: resistance range, 10 to 50,000 ohms; linearity, zero biased or independent; linearity accuracy, $\pm 0.5\%$ to 0.1% ; weight, 3.2 oz; mechanical rotation, 1080 deg $+15 -0$ deg; electrical rotation, 1080 deg $+14.4 -0$ deg.

Amphenol-Borg Electronics Corp., Borg Equipment Div., Dept. ED, 120 S. Main St., Janesville, Wis.

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ELECTRONIC DESIGN • October 26, 1960



MINIATURE MOTOR PROTOTYPES

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Understandably we can't guarantee to meet every requirement that fast: the Globe line is the broadest available today with literally millions of combinations—stocks change day to day. But we are almost sure our inventory contains a motor that comes close to your prototype requirements—to tide you over until we can furnish the exact motor you need. (Most unstocked prototypes normally can be built and delivered in 4 weeks or less.)

Your Globe engineering representative has the latest stock lists. Contact us when you need a miniature motor immediately. For details about 24-hour prototypes, write for Bulletin 24. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio, or telephone direct: BAldwin 2-3741.

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TELEFLIGHT[®]

NEW Model 181

AIRBORNE PRESSURE TRANSDUCER

Now a NEW Taber TELEFLIGHT, weighing less than 12 ounces has been designed with an adapter that permits an amplifier to be built in to increase output signal to five volts as used in telemetering systems. BONDED STRAIN GAGE construction makes it relatively insensitive to vibration or shock. Resolution is INFINITE. Handles extremely corrosive media, including fuming NITRIC ACID. Features Pressure Cavity clean-out and standard built in pressure overload protection. Pressure ranges: 0-250, 0-300, 0-350, 0-500, 0-750, 0-1000 PSIA or PSIG. Linearity 0.25%, Hysteresis 0.25% of F.S. at any given point, Ambient temperature -150° F. to +275° F.

Taber also produces a complete line of Miniature Transistor Amplifiers. Voltage, Power, Servo & Audio Amplifiers also available.

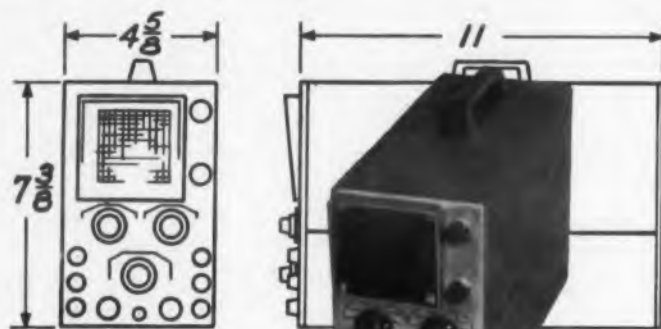
Write or telephone for literature and prices.

TABER INSTRUMENT CORPORATION
 Section 161 107 Goundry St.
 North Tonawanda, N. Y.
 Phone: NX 3-8900 • TWX-TON 277



Model 2075 Transistor Amplifier Model 2145-12 Transistor Amplifier

CIRCLE 120 ON READER-SERVICE CARD



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Model IO-10 **\$79.95**

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The Gurley Model 7530 test stand is a precision shaft-positioning device, consisting of an optical coincidence reading system with ± 2 second accuracy, a rack and gear for precise shaft positioning, and an adaptor plate and coupling.

For an illustrated bulletin, write on your letterhead to Industrial Division, W. & L. E. Gurley, 525 Fulton Street, Troy, N. Y.

W. & L. E. GURLEY
 TROY, N. Y.

NEW PRODUCTS

Recentring Magnetic Clutch 415

Over-all length is less than 5/8 in.



This re-centering magnetic clutch has an over-all length of less than 5/8 in. It has a cavity for potentiometer winding, synchro winding or switches to facilitate marriage of clutching with the function to be performed. Recentring spring torque is not applied until the clutch is disengaged, keeping operational torque to a minimum. Dual winding coil permits 12 or 24 v operation.

Magnetec Corp., Dept. ED, 7232 Eton Ave., Canoga Park, Calif.

Solid-State Counter-Timer 412

For dc to 20 mc applications

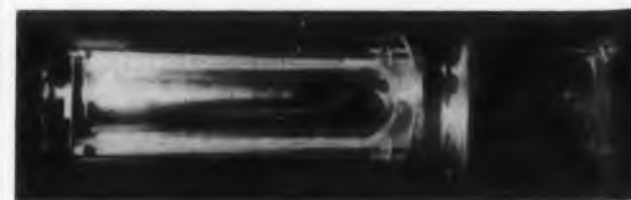


This dc to 20 mc counter-timer is completely transistorized, direct reading and combines the functions of a counter, time interval meter and frequency period meter. Heterodyning techniques are not used. It is available with either the standard vertical decade number panels or inline Nixie readout. Power consumption is 50 w and weight is 27 lb. Sensitivity is 0.25 v rms, input impedance is 25 K per v. Output information from each DCU will operate digital printers, punches and other data processing equipment.

Computer-Measurements Co., Dept. ED, 12970 Bradley Ave., Sylmar, Calif.

Photovoltaic IR Detectors 435

Have military and industrial applications



Minimum detectivity for types ISC-301, A, B, C, and D IR detectors is 3, 6, 9, 12 and 15 bil

lion cm per w, respectively. Minimum impedance for the units is 500, 1,000, 2,000, 3,000 and 4,000 ohms. They operate in excess of 30 min with one filling of liquid nitrogen. Cryostats are available for operations with gaseous nitrogen. Applications include search, track, guidance, reconnaissance and spectroscopy.

Philco Corp., Lansdale Div., Dept. ED, Lansdale, Pa.

Price & Availability: Ranges from \$500 for ISC-301 to \$1,700 for ISC-301D; 60 to 90 days.

Transistorized Relay

426

Input impedance is 250 K



This transistorized relay, model T-681, is said to have high input sensitivity through 250 K impedance. Device operates to 120 F. Device measures 3 x 4 x 5 in., and weighs 30 oz. Power requirements are 110 v ac; contact load is 1,500 w max.

Precision Thermometer and Instrument Co. Dept. ED, 1434 Brandywine St., Philadelphia 30, Pa.

Price: \$75.

Availability: From stock.

Digital Comparator

433

Provides 100,000 operations per sec



This programable, solid-state, unit is capable of comparing measurement numbers at rates as high as 100,000 per sec. Intended for use as part of a checkout system, the device accepts digital information from an analog-to-digital converter, as an example, and compares it with preset high and low tolerance limits. It then gives the correct answers in terms of Go, No Go Hi, or No Go Lo. Circuitry is laid out in the form of etched-card modules that fit into a standard 19-in. rack-mounted chassis with a 5.5-in. panel height.

Leach Corp., Dept. ED, Compton, Calif.

Price & Availability: About \$2,000; immediate.

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TYPE	DESCRIPTION	GRADE	DIELECTRIC STRENGTH V/MIL	TEMP. RATING	LOW TEMP. FLEX.	OIL RESISTANCE	SIZES & COLORS
PVC-105 PLASTIC TUBING	High resistance to heat, oil, chemicals, corrosion, fungi; no loss in tensile strength or flexibility. Protects irregular objects and snakes well.		800	105°C	-30°C	remains flexible indefinitely	#24-#12 A-I #11-#2 A, B, C, D, G, H #2 1/2-#1 A, B
PVC-744 PLAST. TUBING	Specifically designed for sub-zero temperatures.		850	70°C	-67°C	Good	#24-#0 A
PIF-130 PLASTIC IMPREGNATED FIBERGLASS SLEEVING	Class B insulation for continuous operation to 130°C. Excellent color retention even on prolonged baking at high altitudes.	A-1 B-1 C-1	8000 4500 2800	130°C 130°C 130°C	-30°C -30°C -30°C	Good Good Good	#24-#2 B, C, D, G #1 and larger C, D
VTS-135 VARNISH IMPREGNATED TUBING & SLEEVING	Class B insulation for general use; high tensile strength, good flexibility, non-peeling cracking, low moisture absorption, acid oil resistant.	A-1 B-1 C-1	7000 4000 2500	135°C 135°C 135°C		Good Good Good	#24-#2 B, C, D, G #2 1/2-#1 B, C
TFT-200 TEFLON EXTRUDED TUBING	Unmatched for electrical application at high temperature frequencies. Thin, flexible, permits miniaturization and compactness.		500-1000	250°C	-90°C	Excellent	#30-#15 B-K #14-#8 B, C, D, F, G, H, I, J #7-#0 J
SRT-250 SILICONE RUBBER EXTRUDED TUBING	Excellent tensile strength, elongation, and tear strength, low water absorption and good oil resistance.		400	200°C	-85°C	Good	#28-#10 H
PVC-80 EXTRUDED PEASTIC TUBING	Excellent snaking, expands to irregular shapes. Dilates under certain conditions and resumes its size if it is the polyvinylchloride type.		800		-30°C	stiffens slightly	#24-#12 A-I #11-#2 A, B, C, D, G, H #2 1/2-#1 A, B
PLE-70	(Same as PVC-80)		1200	80°C	-70°C	swells slightly	#24-#7 J
SRF-200 SILICONE RUBBER FIBERGLASS TUBING	Class H insulation, excellent for shock resistance, extreme flexibility and freedom from cracking and crazing at extreme temperatures.	A-1 B-1 C-1	7000 4000 2500	200°C 200°C 200°C	-67°C -67°C -67°C	Good Good Good	#24-#15 B-K #14-#2 B, C, D, G, H, J #1-# 1/2 B, C, H, J
HTF-1200 HI-TEMPERATURE FIBERGLASS SLEEVING	Class H insulation. Tightly braided sleeving for use up to 650°C. Can be colored for coding. Special constructions up to 1/16" wall thickness and double wall thickness available.		Determined by space factor	650°C	-55°C	Good	#24-# 1/2 B, J
SFS-400 SILICONE IMPREGNATED FIBERGLASS TUBING	Class H insulation for high temperature use. Remains flexible and retains its electrical properties to 205°C.	C-1 C-2 C-3	2500 1500 Space factor	205°C 205°C 205°C	-39°C -39°C -39°C	Good Good Good	#24-# 1/2 J

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speeds up,
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applications



This photo sensitive resist ends time-consuming handwork, allows close-limit accuracy in deep-etch weight reduction and parts manufacture. Also reproduces fine-line detail as in plating, dial and nameplate making. Withstands acids, alkalis, electrolytic fluids . . . adheres well to aluminum, titanium, magnesium, stainless and other alloy steels. Makes volume production possible because of its high stability, strict uniformity. Send for detailed brochure: *Etching, Chemical Milling & Plating with Kodak Metal-Etch Resist.*

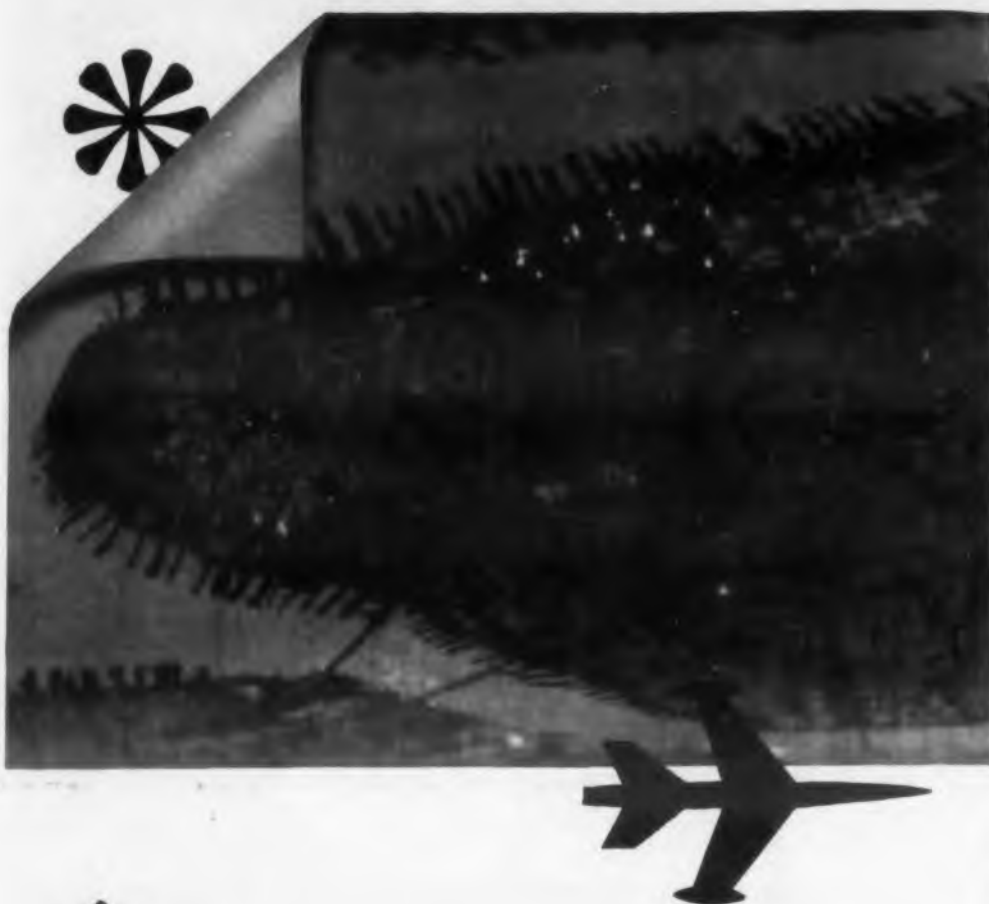
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At long last HRB is permitted to admit openly their relationship to the revolutionary "Manhattan Strip," taken with IR equipment developed at HRB-SINGER. The map-like image was photographed under conditions of complete darkness. Amazingly clear, accurate and continuous data of the Manhattan terrain resulted.

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NEW PRODUCTS

Constant-Power Tubes

424

Plate dissipation rating is 20,000 w



The 7806 high-vacuum triode is for use as an oscillator at frequencies up to 30 mc in industrial, dielectric and induction heating applications. Type 7807 is a water-cooled version of the 7806 forced-air cooled tube. Some specifications are: dc plate voltage, 12,000 v; dc plate current (loaded), 4.5 amp; dc grid current (loaded), 0.9 amp; power input, 54,000 w; and plate power output, 39,000 w.

Amperex Electronic Corp., Power Tube Div., Dept. ED, 230 Duffy Ave., Hicksville, L.I., N.Y.
Price: Type 7806, \$795; Type 7807, \$584.

Availability: From stock.

Oscillographic Recording System

744



Has a response of 0 to
5,000 cps

Combining model 650 recorder and model 658-3400 amplifier, this recording system provides direct readout of events in the range of 0 to 5,000 cps within 3 db. Mirror galvanometer inserts may be added to the recorder to provide it with up to 24 channels. Chart width is 8 in. The amplifier, consisting of 8 channels of identical circuitry, has a maximum sensitivity of 7.2 ma per mv input, an input resistance of 100,000 ohms. Common mode performance tolerance is ± 500 v max and rejection is at least 140 db for dc.

Sanborn Co., Industrial Div., Dept. ED, 175 Wyman St., Waltham 54, Mass.

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for every application*



Model 350 P
Clear Plastic
3 1/2 Inch

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CIRCLE 127 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960



What!!
a universal
counter-
timer with
in-line
NIXIE
readout

for only \$895⁰⁰?

Yes, sir! It's true. And the new Erie Model 725 has all the quality features usually found in instruments costing up to 50% more.



Model 725

Model 725 accurately counts cyclic or random electrical events and precisely measures frequency, period and time intervals. NIXIE readout is available in 5 or 6 decades. Major components are independent modules for easy maintenance. An internal SELF-TEST automatically checks counter operation.

Incorporating quality, flexibility, performance and PRICE, the Model 725 is your best instrument for production or laboratory use. Why not send for complete technical literature today?

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ERIE-PACIFIC DIVISION • ERIE RESISTOR CORPORATION
12932 S. Weber Way, Hawthorne, California
Phone: ORegon 8-5418

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Pin and Socket Contacts 500

These contacts are offered in both crimp and solder type for a variety of wire sizes. Typical specs for size 16 type are: 5 amp, 5 mv drop; 10 amp, 15 mv drop; socket contacts machined from grade A phosphor bronze; pin contacts machined from high-conductivity commercial bronze; gold-alloy plating over silver.

General Products Corp., Dept. ED, Union Springs, N. Y.

Availability: Immediate.

Tape Connectors 501

These units provide for electrical continuity, positive gripping and strain relief by means of one cam adjustment. Multiple barbed contacts are forced through the conductive metal.

Digital Sensors, Inc., Dept. ED, 6443 N. Figueroa St., Los Angeles 42, Calif.

Molded Knobs 506

This series includes four standard sizes: 5/8 in. high and 23/32 in. in diameter, 21/32 in. high and 29/32 in. in diameter, 11/16 in. high and 1-1/4 in. in diameter, and 3/4 in. high and 1-3/4 in. in diameter. They may be equipped with special shaft holes.

Rogan Brothers, Dept. ED, 8025 N. Monticello Ave., Skokie, Ill.

Pulse Tube 503

Type XD-5 forced-air cooled triode switches 30 amp at 40,000 v with a duty of 0.03. Anode voltage is 35 kv, grid voltage is -5,000 v dc, pulse width is 90 μsec, and peak power output is 1.2 mw.

Nuclear Corp. of America, Central Electronics Manufacturing Div., Dept. ED, 2 Richwood Place, Denville, N. J.

Availability: Immediate.

Jacks 475

Series J6 is smaller, lighter and claimed more reliable than conventional telephone and short-frame jacks. It uses only a few parts which are locked in place to a rigid molded body.

Carter Parts Co., Dept. ED, 3401 Madison St., Skokie, Ill.

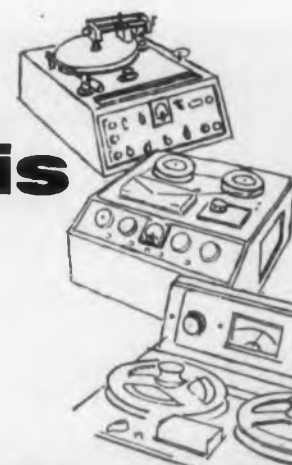
Stepping Switch 478

Type 200 is available with up to 8 cams providing 30, 32, or 36 tooth ratchets. Operating speed is up to 60 steps per sec, self-interrupted, or 30 steps per sec, remote-impulsed. It can be used as a memory device, as a replacement for interlock relays or in applications where control of a sequence of operations is necessary.

C. P. Clare & Co., Dept. ED, 3101 Pratt Blvd., Chicago 11, Ill.

NOW
rapid analysis
of recorder
frequency
response

20 cps-
200 kc



**PANORAMIC
SWEEP
GENERATOR
MODEL SG-1R**

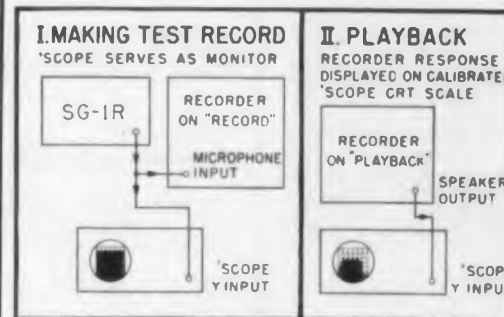
- Ideal for tape, wire, and disc recorders.
- Much faster than point-by-point methods.
- One cps repetition rate permits easy synchronization with many oscilloscopes, e.g. H-P #150A, DuMont #304 and #401. We will supply oscilloscope if desired.
- Internal frequency markers speed set-up and insure accuracy.
- Precise enough for lab use.
- Simple enough for production test.

SG-1R features include

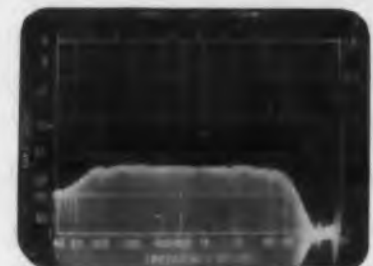
1. Separately adjustable swept signal pulse outputs. 1 volt rms signal with 75 db attenuation. 4 volt peak pulse reducible to zero.
2. Two log sweeps: 40 cps-20 kc and 400 cps-200 kc. Linear sweeps: Any linear segment adjustable within 20 cps to 200 kc range may be selected.
3. SG-1R log amplifier provides 40 db calibration in addition to linear amplitude calibration.
4. SG-1R may be used as normal SG-1 sweep generator for tests of filters, amplifiers, etc. Sawtooth output drives oscilloscope H axis in such applications.

Plots recorder's relative amplitude response vs. frequency on oscilloscope screen. Trace repeats each second.

An optional version of the versatile Model SG-1, this new Panoramic Sweep Generator combines the swept signal with a synchronizing pulse. Sweep frequency test records are made using SG-1R. Calibrated CRT screen furnished.



Block diagram shows recorder test setup with oscilloscope and SG-1R



Visual plot shows frequency response of tape recorder upon playback of test record using SG-1R Log sweep; 40 cps to 20 kc.

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data

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PANORAMIC RADIO PRODUCTS, INC.
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TWX—MT.-V.-N.Y.-5229 • Cables: Panoramic, Mt. Vernon, N.Y. State

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to monitor the performance of
components or assemblies
for final acceptance tests*



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PORTABLE
ROTOCON SPOTS
ASSEMBLY DEFECTS
IN ELECTRICAL
AND ELECTRONIC
COMPONENTS OR
SUB ASSEMBLIES.
MOST PRACTICAL
QUALITY CONTROL
COMPLEX WAVE
VIBRATION MACHINE
AVAILABLE TODAY.
EASY TO OPERATE.**

DESIGNED BY CONVAIR— *manufactured and sold under exclusive license by Rototest. **AUTOMATIC**—easily operated by any production personnel. Low maintenance cost. **DUAL PURPOSE**—prevents cumulative error at each assembly stage, plus final check on any item up to 120 lbs. **RELIABLE**—built-in capability to 20,000 cps. Damped to 50–2000 cps. No special power or cooling requirements. **QUIET**—only 75 db six feet from machine. **WRITE J. K. Davidson** for complete data.*

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price \$3850

NEW PRODUCTS

Excess Temperature Cut-Out 490

The Pyrotac, an instrument that automatically protects against excess temperature and provides continuous temperature indication, is offered in two types. Model N-30 does not shut off upon line voltage failure and model N-34 does shut off in this condition.

Illinois Testing Laboratories, Inc., Alnor Instrument Co., Dept. ED, 420 N. LaSalle St., Chicago 10, Ill.

Component Holders 489

Series II holders use a stainless-steel, type 302 spring for jaw movement and tension. Only finger pressure is needed to open the jaws for insertion of leads as large as banana plugs. Applications include: prototype-circuit design, Wheatstone and other null-balance bridge instruments; capacitance, resistance and other measuring equipment.

Jupiter Electronics, Dept. ED, 225 E. 144th St., New York 51, N. Y.

Stand-Off Terminals 510

A complete line of terminals set in molded phenolic, melamine, or ceramic is offered. Ceramic types are gold over silver plate; others are silver-plated with cadmium-plated bases. Miniature, insulated stand-offs can also be furnished.

Goe Engineering Co., Dept. ED, 219 S. Mednik Ave., Los Angeles 22, Calif.

Gold-Bonded Contacts 493

The use of gold in these contacts eliminates surface formation of various sulphides and oxides, which create circuit resistance. A break-through process, rather than plating, is employed.

Contacts Inc., Dept. 1100 Silas Deane Highway, Wethersfield, Conn.
Availability: Some types in stock; others can be made to customer specs.

Print-Punch Equipment 480

Designed for use with the firm's Recomp digital computer, this equipment consists of two table-top units, a 10-key input keyboard and the paper-tape punch.

North American Aviation, Inc., Autonetics, Dept. ED, 9150 E. Imperial Highway, Downey, Calif.

Kits of Silicon and Germanium Slices 499

This kit consists of five slices of material in each of the ten most commonly-used resistivity ranges. All slices are 0.02 in. thick and measure from 3/4 to 1 in. in diameter.

Tang Industries, Inc., Dept. ED, 49 Jones Road, Waltham, Mass.

MINIATURE VOLTAGE REFERENCE STANDARDS



by C. L. Wallace, Electronics Division Mgr.
Viking Industries, Inc.



There is a squeeze imposed today on electronic designers. They are expected to deliver more and more precision with greater stability in smaller packages at higher and higher temperatures. Viking Industries, Inc., new Electronics Division functions to provide you with ultra stable subminiaturized voltage reference standards to solve such design problems.

Typical of the line is the unit pictured above, our Series 260. This unit, which measures 7/8 x 25/32 x 3/8 inches, is intended primarily for high temperature military applications. Viking Series 260 is regulated to $\pm .005\%$ over a $\pm 10\%$ line voltage variation. A temperature coefficient of $\pm .001\%/^{\circ}\text{C}$ is guaranteed over a temperature range of -55°C to $+150^{\circ}\text{C}$. For additional information, please write Viking Industries, Inc., Dept. C, 21343 Roscoe Blvd., Canoga Park, California.

CIRCLE 131 ON READER-SERVICE CARD

Lepel

HIGH FREQUENCY INDUCTION HEATING EQUIPMENT

For **Hardening • Annealing • Soldering
Brazing • Zone Refining • Crystal Growing**

ELECTRONIC TUBE GENERATORS:
1 kw; 2½ kw; 5 kw; 10 kw;
20 kw; 30 kw; 50 kw;
75 kw; 100 kw.

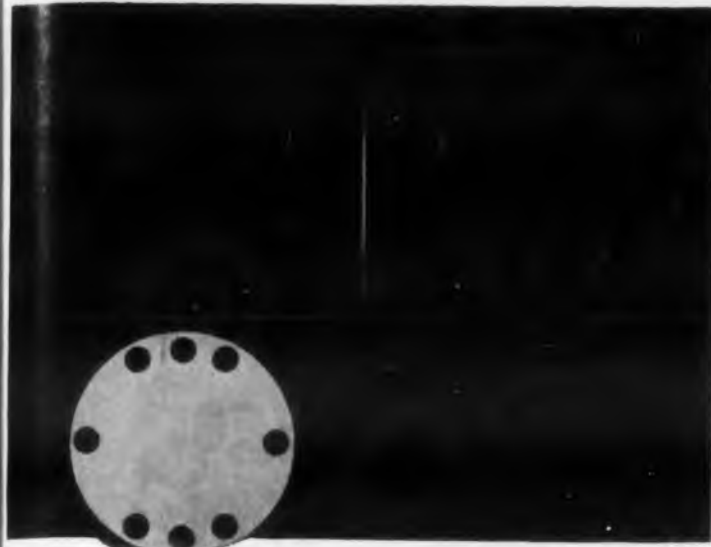
SPARK GAP CONVERTERS:
2 kw; 4 kw; 7½ kw;
15 kw; 30 kw.

WRITE FOR THE NEW LEPEL
CATALOG 36 illustrated pages
of valuable information.

**Lepel HIGH FREQUENCY
LABORATORIES, INC.**

55th ST. & 37th AVE., WOODSIDE 77, N. Y.

CIRCLE 132 ON READER-SERVICE CARD
ELECTRONIC DESIGN • October 26, 1966



New Transducer Package

... WITH ONLY ONE MOVING PART

The stiff metal diaphragm shown above is the only moving part in the new Ultradyne DCS-4 DC/DC pressure transducer package. It has a stable DC output to $\pm 1\%$ despite supply changes from 25 to 30 volts DC. Weighs only 9 ounces. Eliminates amplifiers and drift problems. Write, wire or phone for complete specifications.



ULTRADYNE
INCORPORATED

P.O. BOX 3308 ALBUQUERQUE, NEW MEXICO

CIRCLE 133 ON READER-SERVICE CARD



New ESNA miniatures flush mount in thin stock



← ACTUAL SIZE →
New Clinch Nuts

When space requirements are tight, one of these two new ESNA miniature clinch nuts may be just what you're looking for! They are easily flush mounted in sheet as thin as .030".

Type NCFM clinch nut for temperatures up to 350°F, has special nylon locking insert which will not gall screws or create the cadmium flaking so damaging to electrical circuitry. Type LHCFM is an all-metal nut with an elliptical crown locking device capable of withstanding up to 550°F.

Detailed dimensional drawings on these two new miniature nuts, plus full data covering necessary installation tools are now available. Write Elastic Stop Nut Corporation of America, Dept. S8-1057, 2330 Vauxhall Road, Union, N. J.

**ELASTIC STOP NUT CORPORATION
OF AMERICA**

CIRCLE 134 ON READER-SERVICE CARD

Power Supply

479

Model P-1 is for high-intensity gas-discharge tubes such as are used in high-speed photography. The unit is housed in an encapsulated container and is suitable for use in aircraft, missiles and satellites. Dimensions are 2-3/8 x 3 x 5-3/4 in.

Cubic Corp., Dept. ED, 5575 Kearny Villa Road, San Diego 11, Calif.

Slip Ring Assembly

483

This assembly is of concentric-ring type construction and for switching from positive to negative for sine and cosine functions in radar antenna mounts. Switching is accomplished within 20 min. of arc. Phasing accuracy is 0.2 min, electrical, and 0.005 sec, mechanical.

Breeze Corp., Inc., Dept. ED, 700 Liberty Ave., Union, N. J.

Metal Cabinets

481

Single or sectionalized units can be furnished for communications equipment, computers, electronic testing units, production control units and other devices. Shelving, roll shelves, racks and other constructions can be furnished. Cabinets are made of cold rolled steel.

Anetsberger Brothers, Inc., Dept. ED, 110 N., Anets Drive, Northbrook, Ill.

Power Supply

507

Model F1002A contains four isolated supplies that may be connected in many combinations for computers or transistorized equipment. Voltages range from 1 to 15 v dc for each output with currents of 2, 4 and 8 amp. Regulation is better than 0.1% for lone and load.

Anders Electric Products Inc., Dept. ED, Brook Road, Needham Heights 94, Mass.

Insulating Tape

477

Type CDF Level-Wrap tapes, made of silicone rubber, come in widths from 1 to 1.5-in. and in thickness from 0.02 to 0.08 in. at the apex and 0.007 to 0.008 in. at the edges. It offers: good thermal stability, Corona resistance, moisture resistance and high resiliency.

Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

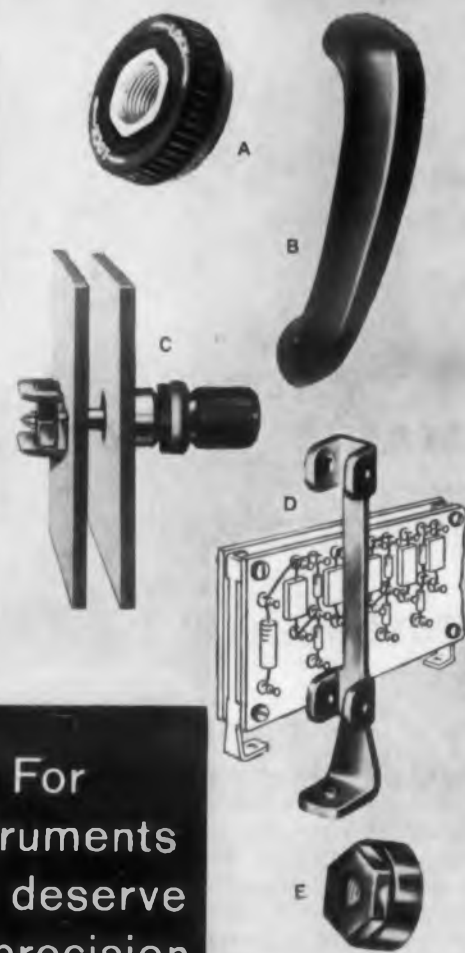
Toggle Switches

487

Meeting MIL-S-3950A and MIL-S-6745, this line of toggle switches incorporates a barrier configuration between terminals. This design increases leakage paths and provides a safety factor in case of a loose connection. Models for all common circuit characteristics can be furnished.

Kulka Electric Corp., Dept. ED, 633-643 S. Fulton Ave., Mount Vernon, N. Y.

SPECIFY RAYTHEON PANEL HARDWARE



For
instruments
that deserve
the precision
engineered
look

A. non-slip knob locks
B. contour-grip pull handles
C. convenient captive hardware
D. printed-circuit terminal board brackets
E. one-piece nylon shaft locks

FREE FOLDER IS YOURS

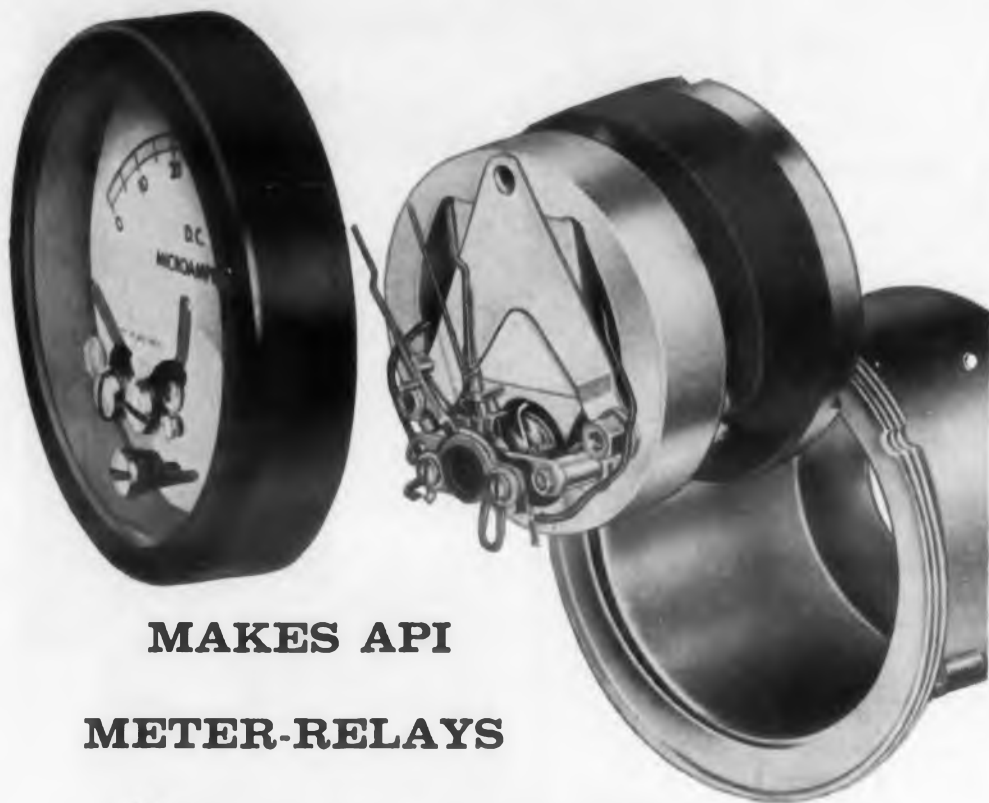
for the asking. Tells more about panel hardware and gives specifications on control knobs, test jacks, binding posts, fuse clips. Write Raytheon Company, 55 Chapel St., Newton, Mass.



RAYTHEON COMPANY
Industrial Components Division
55 Chapel Street, Newton, Mass.

CIRCLE 135 ON READER-SERVICE CARD

NEW SHIELDED BAR-RING METER MOVEMENT



**MAKES API
METER-RELAYS
"MIL-SPEC" RUGGED**

Designed to meet applicable provisions of MIL-M-10304, API's new meter-relays are far more rugged than conventional core-magnet types. Reason: the greater magnetic efficiency of the bar-ring movement.* It puts more magnetic "horsepower" in the works . . . allows use of more substantial components at a better torque-to-weight ratio. Result: improved resistance to shock, vibration and other environmental factors.

Nicely enough, the bar-ring also provides shielding from external magnetic fields. This means that you can mount the new meter-relays in *any* kind of panel—magnetic or non-magnetic—without worrying about effects on calibration.

As simple to incorporate into a design as a D'Arsonval panel meter (which it is—with control contacts added), the new API meter-relay might well be your best answer to a knotty engineering problem. It can monitor and control almost any electrically measurable variable. It's small and compact. It's reasonably low in cost. And it's reliable—models *without* the benefit of the sturdier bar-ring movement were tested to more than 10,000,000 operations! Have a look at Bulletin 4H, and see if the API meter-relay can't do a job for you.

*To be used in all models ordered after Nov. 1, 1960.



ASSEMBLY PRODUCTS, INC.*
Chesterland 17, Ohio

CIRCLE 136 ON READER-SERVICE CARD

DESIGN DECISIONS

Featuring the clever and unusual in packaging, appearance design, and circuitry in electronic equipment.

Pulser Uses 50-V Trigger To Short Four 200-V Diodes

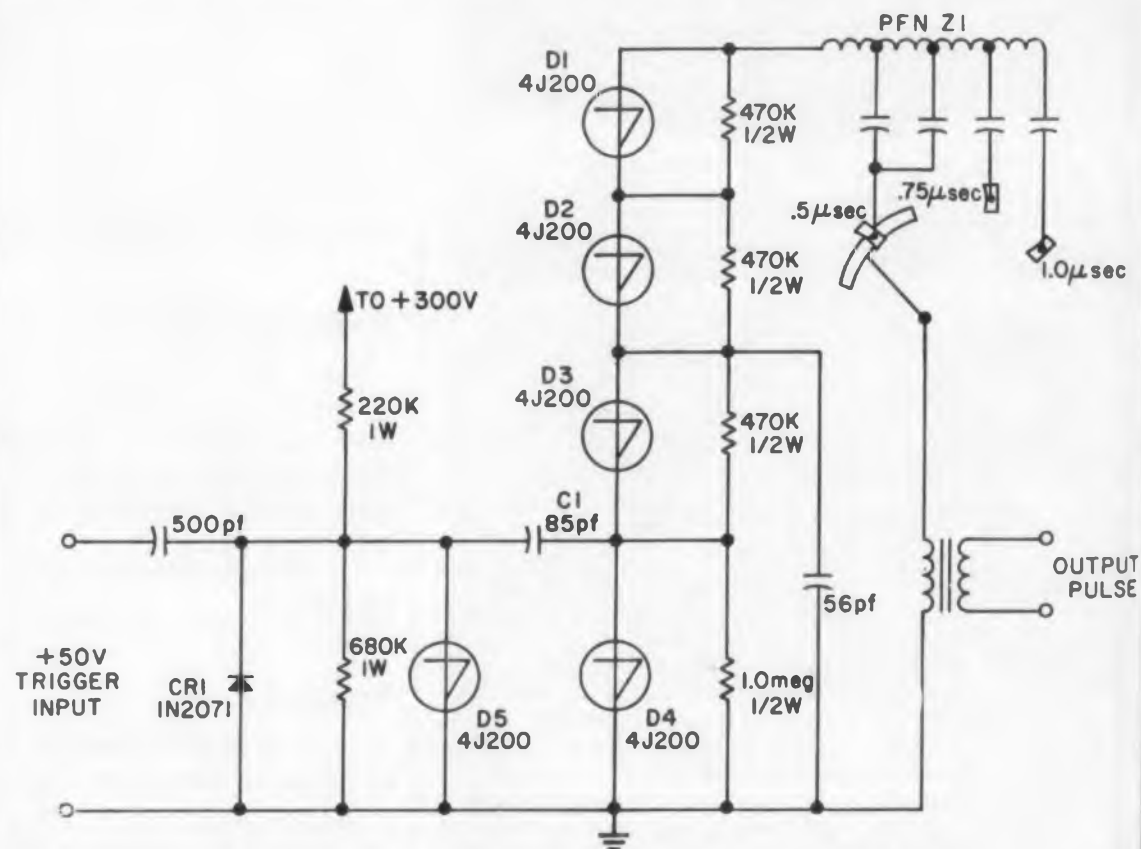
SWITCHING diodes in a pulser manufactured by Burmac Electronics Co., Inc. of Rockville Center, L.I., N.Y., posed an interesting problem. The solution, developed by Burmac's president Steve Delligatti, proved even more interesting.

The switch, shown in the schematic, consists of four 200-v, four-layer diodes, D1, D2, D3, and D4 in series. Due to resonant charging of the capacitors in the pulse-forming network Z1, the maximum voltage on the four-diode switch is

almost twice the power supply voltage, or 600 v.

To allow for variations in charging voltage and shorting voltage of the diodes, four 200-v, four-layer diodes were used in series. Attempts to use only three resulted in a tendency of the switch to "free-run" at a rather high frequency; it acted as a relaxation oscillator.

Now, here lies the problem. Under quiescent conditions, with no trigger pulses applied to the switch, the voltage



A 50-v pulse can short four-layer diode D5. This shorts the 680-K resistor across it. Voltage across this resistor drops suddenly to zero, resulting in a large negative pulse transmitted through C1. The negative-going pulse shorts D3, and the remaining four-layer diodes in the string quickly break down.

NEW FIFTH EDITION OF AN INDUSTRY CLASSIC:



GENERAL ELECTRIC TRANSISTOR MANUAL

Featuring two new chapters on the **tunnel diode**. This is one book in the transistor field you can't afford to be without... because it's the one reference that is constantly being revised and brought up to date to serve your needs.

The greatly expanded new Fifth Edition has 93 more pages... new material on tunnel diode theory and switching circuits... tunnel diode

amplifiers... feedback and servo amplifiers. Sections on the silicon controlled rectifier, power supplies, transistor and rectifier specifications have been expanded.

Here is a work you'll find yourself turning to time and again. Get your copy from your G-E Semiconductor Distributor or by mailing one dollar with the coupon below.

GENERAL  ELECTRIC

General Electric Company, Semiconductor Products Dept.,
Section S23100, Electronics Park, Syracuse, N. Y.

Send me the enlarged new 5th Edition (320 pages) of the General
Electric Transistor Manual. I enclose \$1.00. (No stamps, please.)

Name _____

Address _____

City _____ Zone _____ State _____

across it stabilizes at 300 v. A 50-v trigger could not short the switch. It would have been necessary to interrupt the supply voltage, then reapply it while the trigger pulses were present. The transient double voltage on the switch would then permit its being shorted.

But it was desired that the supply voltage be applied continuously, if at all possible, and the switch be ready to respond to random triggers of all spacings down to considerably less than 100 μ sec. To meet this objective it was necessary to short the switch with only 300 v across it.

The normal shorting voltage of these four-layer diodes is 200 v. However, the literature cautions that with high rates of voltage rise, the diodes can short at reduced voltage. Thus, if a large trigger were applied—one large enough to short one of the diodes in the string—the sudden voltage increase across the others should cause an avalanche.

To supply this large trigger, another four-layer diode, *D5*, is used. Tied by a voltage divider to the regulated 300-v supply, this diode is easily shorted by a 50-v positive pulse. When it shorts, the voltage across it is suddenly pulled down to zero, causing a negative pulse of about 200 v to be coupled through *C1* to the junction of *D3* and *D4*. Hence, *D3* (not *D4*), is the first diode shorted by the trigger pulse, followed, probably, by *D1* and *D2*, then finally *D4*.

Unfortunately, negative transients fed back through *C1*, tended to cause failure of *D5*. To preclude this, silicon diode *CR1* was added. It removes any negative spikes which might appear. ■ ■

CIRCLE 137 ON READER-SERVICE CARD



75th HONEYWELL
PIONEERING THE FUTURE
YEAR



(ACTUAL SIZE)

NEW "BOUNCE-FREE" SWITCH

**Eliminates Contact
Bounce in High-Speed
Electronic
Applications**

A new compact switch device has been developed by MICRO SWITCH to eliminate the effects of contact bounce in applications which involve high speed electronic tubes that operate in less than a microsecond.

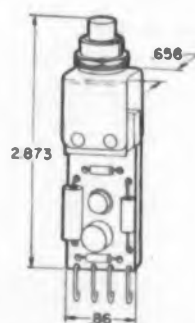
This new "Bounce-Free" Switch makes it possible for designers to save valuable engineering time otherwise required to develop special circuits to eliminate spurious voltage pulses caused by contact bounce. And, its compactness makes it possible to save valuable cabinet space in control consoles.

The new circuit may be actuated by any switch that has a normally open and normally closed position. It is an electronic switch triggered by a mechanical switch.

Write for Data Sheet 177 which describes the new "1PB2000."

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell

In Canada: Honeywell Controls Limited, Toronto 17, Ontario



OPERATING CHARACTERISTICS

There are four circuit types available. One produces a positive output to accommodate resistive loads of 100 to 500 ohms, another produces a positive output for resistive loads of 500 ohms or greater, and two produce

a negative output voltage at these loads. All circuit types have a voltage range of from 5 volts to 25 volts.

The circuits are designed to produce an output voltage which has a maximum rise time of 1/2 microsecond.



Honeywell
MICRO SWITCH Precision Switches

DESIGN DECISIONS

'Flat' and Eccentric-Magnet Speakers Conserve Space in TV, Portable Radio

Minimizing the space requirements of loud speakers was the problem solved by these two designs.

The 4-in. speaker for portable radios, Fig. 1, has an over-all thickness of 3/4 in. The eccentric permanent-magnet speaker, Fig. 2, conserves space at the front of a TV cabinet, as shown in Fig. 3. The magnet is mounted at the rim of the speaker. Both speakers are made by Audax.



Fig. 1. "Flat" speaker for portable radios has over-all thickness of 3/4 in.



Fig. 2. Eccentric-permanent-magnet speaker has magnet mounted near rim.

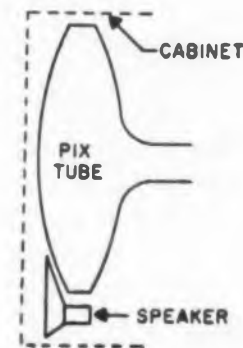


Fig. 3. Eccentric-permanent magnet speaker conserves space at front of TV cabinet.

Computer Logic Cards Shaped To Fit Curved Missile-Contour

Logic cards for a missile-borne computer were shaped so the computer could fit into a 60-degree sector of the missile's circumference. The plane of the cards was normal to missile's axis. Hence, mounting-leads of components within the sandwich were parallel to direction of missile's thrust.



Acceleration and high shock

testing before trigger time, are critical to the quality control of bomb rack components at Singer-Bridgeport. Today high capability in engineering, precision machining and electro-mechanical assembly make Singer-Bridgeport a prime supplier to the military and sub-contractors.

Test facilities provide the range of equipment needed to check out components and systems to close specifications: acceleration, vibration and shock, temperature, altitude, humidity, salt spray conditions. Military and industrial procurement alike find both quality control and quality production at Singer-Bridgeport.

A comprehensive brochure describing these engineering and production capabilities is available to you on request.



SINGER-BRIDGEPORT

A DIVISION OF THE SINGER MANUFACTURING COMPANY
915 Pembroke Street Bridgeport 8, Conn.



*A Trademark of the SINGER MANUFACTURING COMPANY

CIRCLE 139 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960



Estimation of External Surface Case Temperature Rise For Closed Electronic Equipment

J. R. Baum
Senior Staff Member
Mechanical Engineering Laboratory
Military Electronics Div.
Motorola, Inc.
Scottsdale, Ariz.

IN MILITARY equipment packaging, it is often desirable to house electronic devices in closed cases for protection against dust, humidity and low pressure. Since the initial analysis of anticipated case heat dissipation, required during the initial packaging study, can be tedious and lengthy, a nomogram is presented to provide a preliminary estimation tool.

Only the ambient altitude and unit surface power dissipation density need be known to determine the anticipated surface temperature rise over ambient. The assumptions and approximations required to simplify the complex relationships include:

1. Case is closed and unlouvered.
2. Air is the surrounding medium.
3. Average electronic "black box" configuration and dimension are known.
4. External surface of the package and surroundings are painted.
5. Free convection and radiation take place only from the case surface.

When preliminary estimates are completed, a more detailed study can then be undertaken to establish accurate thermal analysis information for final design considerations.

The procedure for use of the nomogram is as follows:

1. Determine amount of heat (in watts) to be dissipated by the case. For a closed unit with no special external cooling provisions, this would be the total unit power input.
2. Determine surface power density in watts per square inch by dividing the heat dissipated by the total exposed external surface dissipation area (including ribs, etc.).
3. Enter the nomogram with this value and the

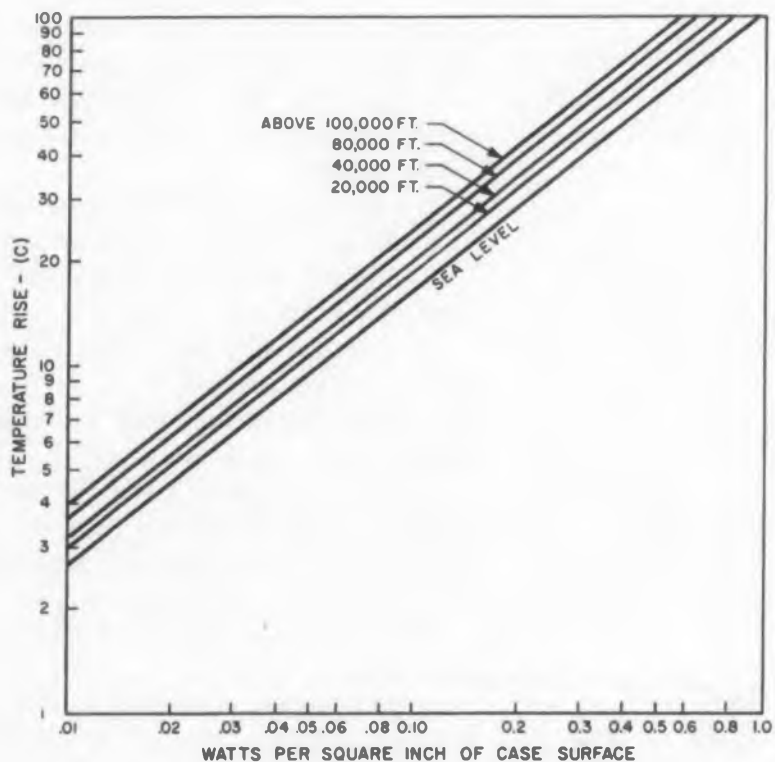
ENGINEERING DATA

(Continued from p. 131)

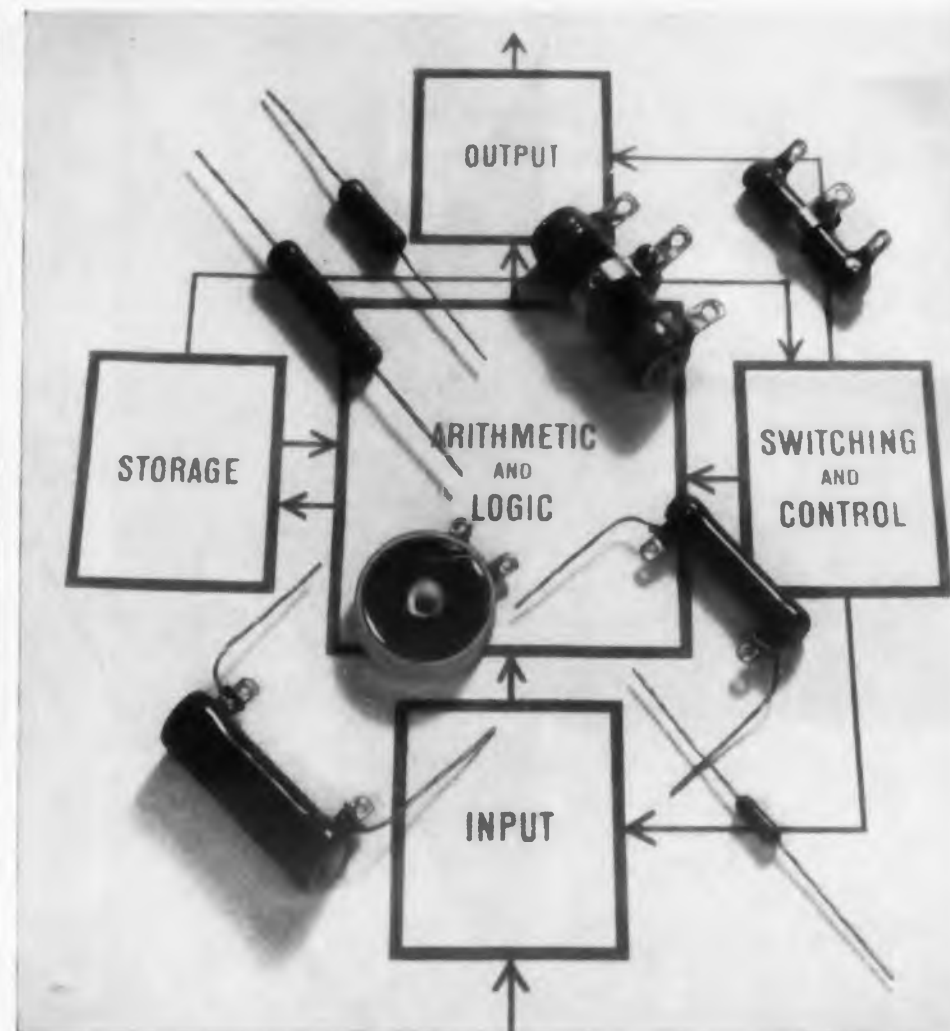
appropriate altitude and read the resultant temperature rise of unit case surface over the ambient.

4. The reverse procedure can be used to determine the allowable power density for a given temperature rise.

A rough estimate of the unit internal ambient can be made by doubling the temperature rise obtained above and applying it to the external ambient. The result would be conservative where the components have a good conductive path to the case and would be realistic for the typical situation where they are thermally isolated from the case with no special internal cooling provisions. ■ ■



Estimated surface temperature rise for closed electronic equipment with no external cooling provisions.



In modern digital computers

PERFORMANCE IS THE PAY-OFF

A big, modern digital computer may cost as much as \$10-million to buy outright. Even rental may run as high as \$50,000 a month.

With money like that involved, computer-makers can't take a chance on substandard components. They want, and get, the best components... the best resistors. Where wire-wound power resistors are required, they frequently specify Ward Leonard VITROHMS.

There's another reason, too, why computer manufacturers want only the best: They're shooting for 99.99...% statistical reliability of components, and the more "9's" the better. Computer components—say, resistors—are numbered in the tens of thousands, and they have to have this kind of performance to get 99.8% reliability in their final product. For this reason, computer makers insist on, and get, performance—as continuous and reliable as the state of the art permits. And again, where wire-wounds are required, they are likely to specify Ward Leonard VITROHMS.

If you want maximum quality and maximum reliability in your product, follow the lead of outstanding digital computer manufacturers—like IBM, Remington Rand, and Burroughs—and specify W/L VITROHMS. You'll find full information in catalog D130. Write for your copy, and the name of your nearest VITROHM distributor, today. Ward Leonard Electric Co., 77 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)



RESULT-ENGINEERED CONTROLS SINCE 1892

WARD LEONARD
ELECTRIC CO. MOUNT VERNON
NEW YORK

RESISTORS • RHEOSTATS • RELAYS • CONTROLS • DIMMERS
CIRCLE 140 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960

NEW LITERATURE

Waveguide Stand 261

This two-page bulletin describes the 370 universal waveguide stand which accommodates all waveguide sizes in the frequency range of 2.6 to 40 kmc. All waveguide sizes are listed in their respective frequency ranges and the proper RG waveguide type numbers are given. PRD Electronics, Inc., 202 Tillary St., Brooklyn 1, N.Y.

Power Supplies 262

The company's ME series of transistorized power supplies are listed and briefly described in this two-page data sheet. Included are performance specifications, data on trouble-shooting instructions, and data on pre-tested plug-in modules for simplified maintenance and parts stocking. Mid-Eastern Electronics, Inc., 32 Commerce St., Springfield, N.J.

Diodes and Rectifiers 263

Listed in this 18-page booklet are diodes and rectifiers made by Texas Instruments, Inc. Available from off-the-shelf are: a photo device; silicon rectifiers; high conductance general purpose silicon diodes; silicon controlled rectifiers; silicon computer diodes; voltage regulator diodes; and power regulators and double anode clippers. Lafayette Radio, 165-08 Liberty Ave., Jamaica 33, N.Y.

IR Detector Measurement 264

Model ISL 302 infrared detector measurement console is described in this six-page booklet. The illustrated booklet covers uses of the equipment including: photoconductive, photovoltaic, photoelectromagnetic and pyroelectric detector measurements, in addition to measurement of thermistor bolometers and ac thermocouples. A block diagram of the equipment is included. Infrared Industries, Inc., Box 42, Waltham 54, Mass.

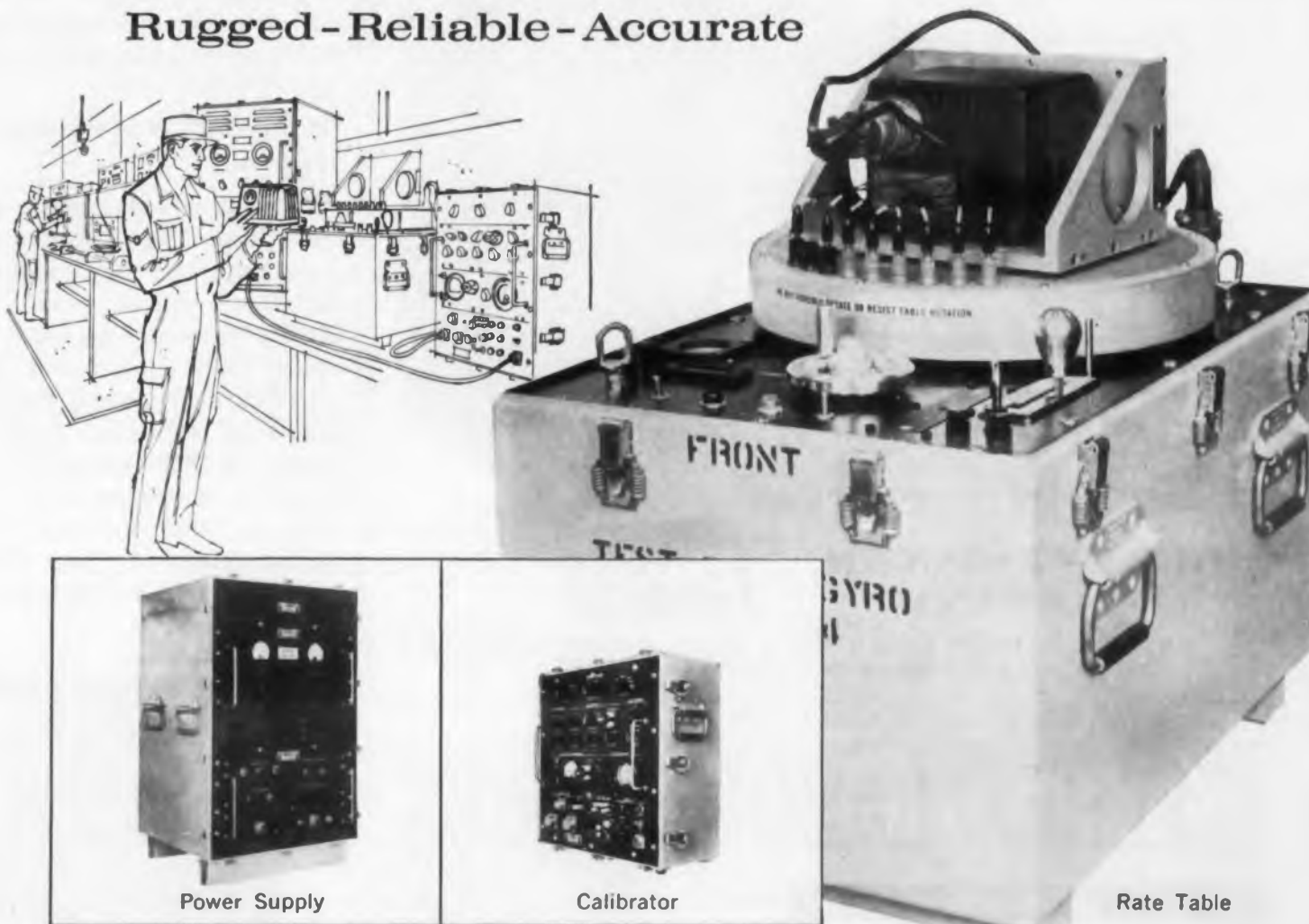
Photovoltaic Cells 265

Called "Photovoltaic Cells For the Precise Measurement of Light," bulletin No. GEZ-3005, eight pages, offers a complete description of these sensors for applications where light is used to perform a control function. It includes graphic data on spectral sensitivity, exposure effect, temperature characteristics, current output, internal resistance and other factors. Dimensions for all available cells, and typical circuits for single and multiple cell applications are given. General Electric Co., Schenectady 5, N.Y.

Use the Gyro Tester approved for
USAF Air Defense Squadrons -

HONEYWELL RATE GYRO TEST SET

Rugged - Reliable - Accurate



Now you can eliminate rejection of inertial components and sub-systems by USAF Service Squadrons because of differences in test results. If you perform your quality control tests on the same type of gyro tester as that used by USAF, such discrepancies can be avoided.

The Honeywell Rate Gyro Test Set No. 32589 (FSN 4920-705-7536) has been accepted by the Air Force. Over eighty have been purchased for use at squadron level. This equipment combines the ruggedness to withstand the abuse of field service, the reliability associated with the environmental specifications of MIL-E-4970, and the accuracy of a laboratory instrument. Highly trained technical personnel are not required to operate this equipment.

This Gyro Test Set consists of a Rate Table, Calibrator, and precision Power Supply. *Rate Table*,* with holding fixture for instrument under test, is turned at a variable angular rate up to 120 degrees per second. The Table is self-calibrating at 5 deg/sec. increments by means of a built-in stroboscope. Input rates are continuously variable. *Calibrator* permits checking pick-off voltage outputs for many other devices such as accelerometers and rate-of-turn indicators. AC pick-off output voltages can also be measured. *Power Supply* is 400 cps but other frequencies for pick-off or motor may be used. Write for Technical Bulletin BM-SGT-1 to Minneapolis-Honeywell, Boston Division, 40 Life Street, Dept. 10, Boston 35, Massachusetts.

*Available separately

CUSTOM DESIGN

For ranges up to 1200 deg/sec., and accuracies and tolerances other than described above, Honeywell can custom design and manufacture specialized Gyro Test Equipment to requirements.

75th
PIONEERING THE FUTURE
YEAR

Honeywell

H Military Products Group
SINCE 1885

CIRCLE 141 ON READER-SERVICE CARD

New 100 kc PLUG-IN CRYSTAL OSCILLATOR

This 100 kc plug-in package, Model CCO-7G, combines a high precision sealed-in-glass quartz crystal with integral temperature control and transistorized circuitry.

Designed to deliver 100 kc output with stability of 2 parts in 10 million over ambient temperatures from 0°C. to 50°C. With fixed ambient conditions and voltage regulation, stability of one part in 10 million can be realized. The standard unit requires 27 volts dc, 12 ma for the oscillator and 27 volts, ac or dc, 10 watts for the crystal oven. Package size, excluding octal base, is 2" x 2" x 4 $\frac{1}{16}$ ".

BULLETIN NO. 520 AVAILABLE

BLILEY ELECTRIC COMPANY

UNION STATION BUILDING • ERIE, PENNSYLVANIA
CIRCLE 142 ON READER-SERVICE CARD



BLILEY
CCO-7G

Bliley

TELREX LABORATORIES

Designers and Manufacturers of

COMMERCIAL SERVICE "BEAMED-POWER" ARRAYS AND TWO-WAY SYSTEMS

Model illustrates a wide-spaced, 12 element circular polarized optimum-tuned skewed dipole "SPIRALRAY" antenna. Provides unusually high gain, even response, in all polarization planes, vertical, horizontal or oblique with unusually high signal-to-noise ratio.

NO OTHER CIRCULAR POLARIZED ARRAY known to the art today can provide the linear high gain and signal-to-noise ratio in all radiation planes.

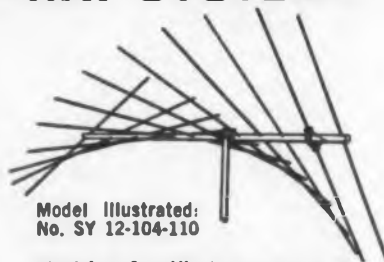
The ideal antenna for missile tracking, telemetering and no-fade response to mobile (or moving) stations.

Models available to extend the practical range of 2-Way Communication Systems.

Model SY-12-104-11
\$265.00

Model MSY-104-110
\$390.00

(f.o.b. Asbury
Park, N. J.)



Model Illustrated:
No. SY 12-104-110

Electrical Specifications—Model No. SY-12-104-110: Polarization, circular, linear within 1/2 db. Gain 13 db. F/B-Ratio 30 db. V/S/W/R (50 ohm cable) 1.1/1. Beamwidth at half power points 33 degrees. Max. power input 300 w, with "Balun" supplied.

Mechanical Specifications: Boom diameter 2" O.D. x 25 ft. All aluminum boom and elements. Weight approx 25 lbs. Rated wind-load 90 mph. No ice load. Available for 120 mph wind load. (Model No. MSY-104-110).

- Telrex is equipped to design and supply to our specifications or yours, Broad-band or single frequency, fixed or rotary arrays for communications, FM, TV, scatter-propagation, etc.

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CIRCLE 143 ON READER-SERVICE CARD

NEW LITERATURE

Instrument Bearings 266

A series of technical data sheets contains dimensional specifications and load factors for the firm's type R2, R3, and R4 instrument bearings made to ABEC class 7 tolerances. Miniature Precision Bearings, Inc., Keene, N.H.

Timing and Data-Processing Systems 267

These three data sheets describe: the firm's model 26211 airborne time code generator which is a compact, transistorized unit with an accuracy of one part in 10⁵; the model ZA-23833 search and control system for Ampex FR-100 tape recorders for searching PAFB or EGTR time-code reference tapes; and the model ZA-25159 computer format converter for converting AN/FPS-16 radar data into IBM 704 magnetic tape or NRZ format. Electronic Engineering Co. of California, 1601 E. Chestnut Ave., Santa Ana, Calif.

Heat-Shrunk Tubing 263

Thermofit tubing, an irradiated modified-polyolefin insulation sleeving which shrinks to a preselected diameter when exposed to heat, is described in these two brochures. Brochure No. 203-4 lists properties, test data, weights, sizes, and various applications. Brochure No. RT-2000 describes applications in harnessing and splicing, and outlines fabrication techniques. Raychem Corp., Oakside at Northside, Redwood City, Calif.

Electronic Cables 269

Bulletin No. DM-S-6015, six pages, describes and illustrates a line of electronic cables suitable for high-temperature and radiation applications. Included are control cables, instrument probe cables, airframe, missile, and satellite cables, instrumentation cables, communication cables, TV camera cables, and computer cables. Anaconda Wire & Cable Co., 2201 Bay Road, Redwood City, Calif.

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Thermocouples 270

This six-page bulletin, No. P1281A, describes Armorox thermocouples. The metal-sheathed, ceramic-insulated construction of the thermocouples is explained, and typical applications are cited. Physical specifications are tabulated. The Bristol Co., Waterbury 20, Conn.

Terminal Strips 271

This 12-page brochure, "Guide Book to Thermal Strips," contains drawings and tables on standard terminal strips made up from universal, external "T", Wire-Grip, tear-drop, Wrap-A-Wire, and subminiature lugs. Mandex Manufacturing Co., Inc., 2614 W. 48th St., Chicago 32, Ill.

Test and Sensing Components 272

This vest-pocket guide and wall chart is intended to help the design engineer choose test and sensing component. The chart contains complete specs on panel

lights, switches, fuseholders, test prods and jacks, and molding materials. Alden Products Co., 117 N. Main St., Brockton 64, Mass.

High-Current Power Supplies 273

High-current power supplies and variable-voltage transformers are described and illustrated in this four-page brochure. Electronic applications include capacitor forming, electrolytic refining, magnet powering, tube testing and aging, and supply for computers and check-out systems. Glenn Pacific Power Supply Corp., 703 37th Ave., Oakland 1, Calif.

Pulse Generators 274

A series of 9-kw solid-state pulse generators is described in this two-page bulletin. Circuit-design information, tabulated specifications, and dimensional drawings are included. Magnetic Research Corp., 3160 W. El Segundo Blvd., Hawthorne, Calif.

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CIRCLE 912 ON CAREER INQUIRY FORM, PAGE 149

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CIRCLE 149 ON READER-SERVICE CARD

NEW LITERATURE

Permanent Magnet Alloy 275

This four-page, illustrated brochure describes properties and applications of a copper-nickel-iron ductile permanent-magnet alloy of the generic Cunife type. Applications include timer motors for appliances, speedometers, aircraft instruments, and various electronic equipment and control systems. Watkins-Rogers, Inc., 685 Pallister, Detroit 2, Mich.

Plastic Materials 276

A line of plastic materials, including molding and extruding materials and resins applicable in the electronics field is described in this 12-page booklet. Applications of the plastics are indicated, and properties are listed or tabulated. Monsanto Chemical Co., Springfield 2, Mass.

Servo Motor 277

The firm's type 5752-03 inertially damped servo motor for high-temperature applications is described and illus-

trated in this two-page data sheet. Electrical, mechanical, and physical characteristics, outline drawings, and performance curves are included. John Oster Mfg. Co., Avionic Div., Racine, Wis.

Resonant Modes 278

This two-page bulletin, No. 5A, describes a method of obtaining crisp photographs of vibrations. The method enables a still camera to photograph resonant modes detected in a frequency sweep. Full instructions and examples are provided. Chadwick-Helmuth Co., 427 E. Duarte Rd., Monrovia, Calif.

Special-Purpose Capacitors 279

Feed-thru, trimmer, transmitting, flat-plate, discoidal, precision, high-voltage, disk, and tubular capacitors are described and illustrated in this 20-page catalog, No. 42-407. Electrical specifications and dimensional drawings are given for each type. Centralab, 900 E. Keefe Ave., Milwaukee 1, Wis.



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CIRCLE 913 ON CAREER INQUIRY FORM, PAGE 149

Tubing Connectors 280

Connectors for plastic tubing intended to conduct compressed air, fluids, and gases are described and illustrated in this two-page bulletin, No. 125. Male and female end connectors and panel-mount connectors are included. Devices quickly connect and disconnect manually. Breco Div., Perfecting Service Co., 332 Atando Ave., Charlotte 6, N.C.

RF Coaxial Plugs 281

The firm's series BNC rf coaxial plugs are described in this 16-page booklet. The plugs, designed for small coaxial cables, are lightweight and weather proof. The catalog includes nomenclature, a mating functional diagram, assembly instruction, and drawings and specifications. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Stepping Switches 282

Forty-page, two-color catalog, No. 202, contains data on construction features, circuitry, and performance characteris-

tics of spring-given, cam-operated, and direct-drive stepping switches. Mounting accessories, sealed and dust-cover enclosures are pictured and described. C. P. Clare, 3101 Pratt Blvd., Chicago 45, Ill.

Heavy Tungsten Alloys 283

This eight-page bulletin describes heavy tungsten alloys with densities of 17 to 18.5 g per cu cm. Properties, applications, fabrication methods, and available sizes and shapes of three grades are given. The firm's engineering services and facilities for applying the materials are also outlined. Kennametal Inc., Latrobe, Pa.

Snap Action Switches 284

A line of snap action switches is described in this 12-page folder. Heavy-duty limit switches, compact sealed switches, explosion-proof switches, precision snap-action basic switches, and manually operated, door interlock, mercury, and proximity switches are illustrated and briefly described. Micro Switch, Freeport, Ill.

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V_{CB}	40	60	60	80	80
V_{EBO}	20	20	20	40	40
V_{CEO}	30	40	40	60	60
I_C	1.5 A	1.5 A	1.5 A	1.5 A	1.5 A
I_{CO}	200 μ a	100 μ a	100 μ a	100 μ a	100 μ a
H_{FE}	30/90	30/75	50/125	30/75	50/125
V_{Sat}	1.0 V	1.0 V	0.6 V	1.0 V	0.6 V

These four new Delco transistors, plus the 2N1172 40-volt model, offer highly reliable operation in a new range of applications where space and weight are restricting factors.

Designed primarily for driver applications, Delco's versatile new transistors are also excellent for amplifiers, voltage regulators, servo amplifiers, miniature power supplies, ultra-low frequency communications, citizens' radio equipment and other uses where substantial power output in a small package (TO 37) is required.

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CIRCLE 153 ON READER-SERVICE CARD

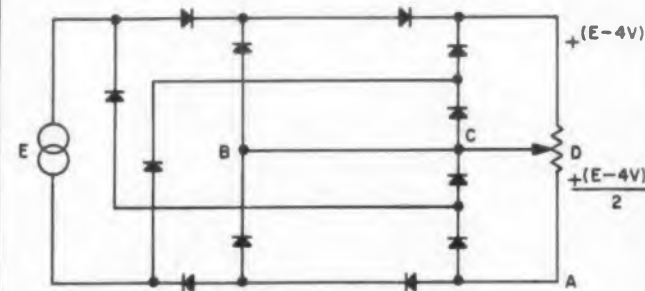
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Equal load sharing between series rectifiers in high voltage, full wave bridge circuits can be easily attained by using only four extra diodes. When connected as shown, the extra diodes eliminate the need for complex RLC matching circuits in any of the legs. Such matching is especially necessary when high frequencies, in the tens or hundreds of kilocycles are applied to the bridge. At these frequencies the junction switching and peak inverse loads depend on



Four diodes at B and C provide equal load sharing between series rectifiers in each leg of the bridge.

matched resistance, capacitance, and leakage characteristics of each diode.

Referring to the figure, if points B and C, and if necessary a third equipotential point D bisecting the load are joined, each diode will switch at precisely the same moment. Also, the two diodes in each leg will share inverse and forward peak voltages.

Considering one end A of the load as zero reference potential, and each diode as having a forward voltage drop 'V', it can be shown that the potentials

$$V_{AB} = V_{AC} = V_{AD} = 1/2(E - 4v)$$

As an economy measure, resistors can be substituted for the four extra diodes at B and C.

Patrick F. Howden, Systems Engineer, Consolidated Systems Corp., Monrovia, Calif.

Dual Frequency Oscillator Built With 6EZ8 Tube

A dual frequency, low impedance source was required for upper and lower sideband carrier re-insertion. The frequency selector switch had

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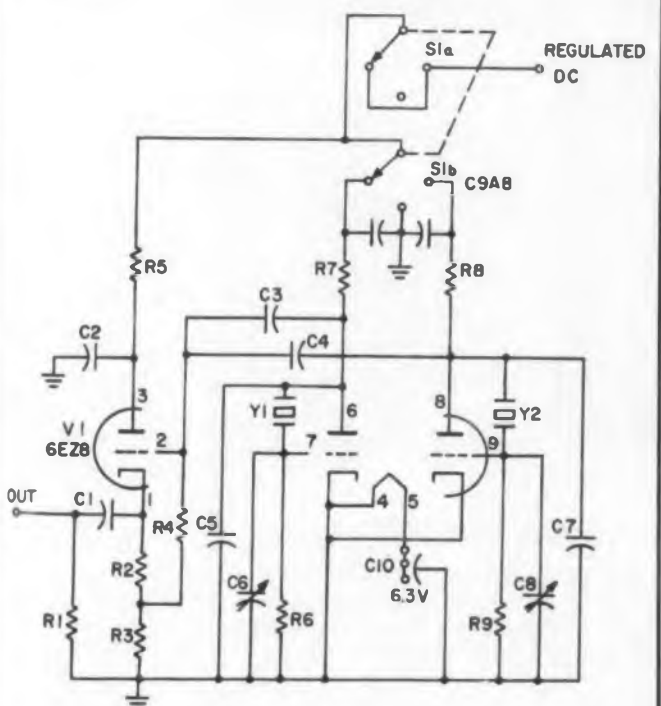
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to be remote, stray radiation and leakage were not permissible and the printed circuit usable space was 2-3/4 sq in. Selection of a crystal within an oscillator circuit was not possible; the required long rf shielded leads interfered with the oscillator operation in different ways, depending on the type of oscillator circuit. Since the usable space and economy rejected the use of several tubes, a rather new comer among the electron tubes, the 6EZ8 was selected.

The 6EZ8 is very similar in characteristics to the 12AT7 and is well suited to low power oscillator circuitry. Since low impedance output was required, one section is used as a cathode follower stage and the two other sections as individual oscillators. Selection of the operating oscillator is determined by switching the dc plate supply. This eliminates all rf leads. The coupling between each oscillator and common cathode follower is assumed constant. The fact that the rf plate impedances are coupled through E3 - C4 required a circuit having a minimum of such impedance to avoid shunting effect or interaction. A modified Pierce oscillator was selected. Grounded cathode operation was necessary because of the common cathode and filament connections.



Dual frequency, low source impedance oscillator uses 6EZ8 tube in modified Pierce circuit.

Georges M. Cnudde, Engineer, Sierra Electronic Corp., Div. of Philco Corp., Menlo Park, Calif.

EXTRA QUALITY AT NO EXTRA COST WITH BENDIX TRANSISTORS

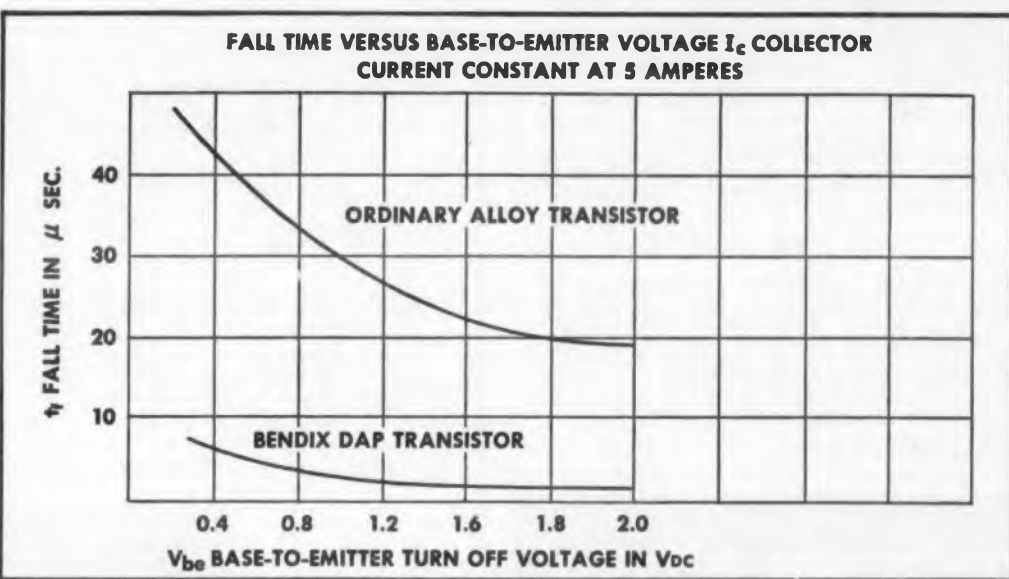


Bendix Bulletin



Up-to-the-minute news about transistors

NEW DAP TRANSISTORS SWITCH 5 TIMES FASTER



Higher breakdown than ordinary transistors also a DAP feature.

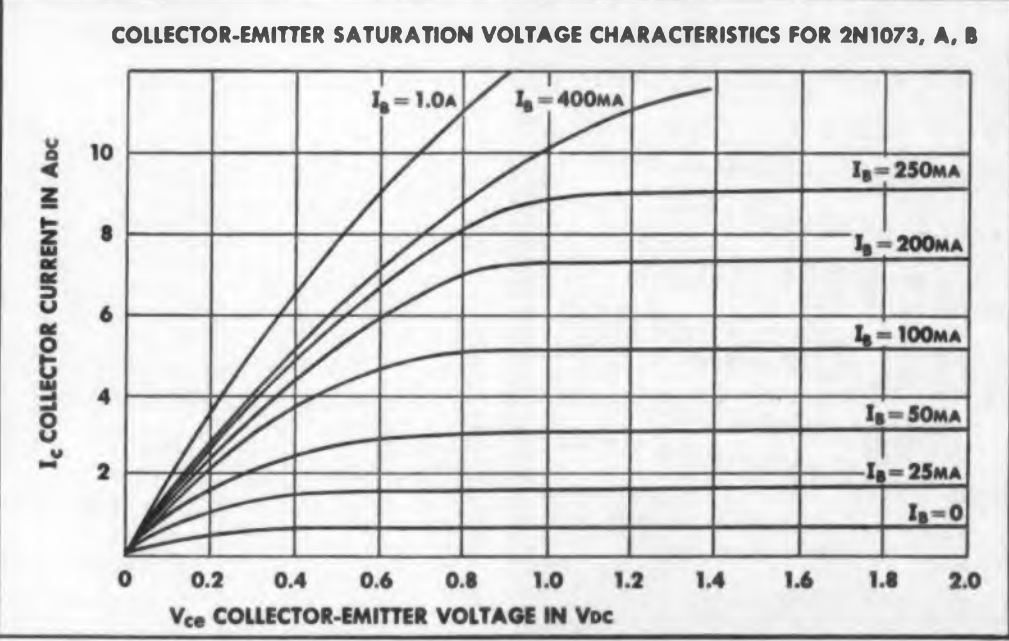
Now design engineers are freed from many of the limitations imposed by ordinary germanium alloy transistors. Bendix* germanium PNP Diffused-Alloy-Power DAP* transistors can switch up to 10 amperes with typical speeds of a microsecond.

While maintaining high collector-to-emitter breakdown voltage—up to 120 volts—the new transistors provide lower input resistance, controlled current gain, and higher cut-off frequency. Particularly suited to high current, high frequency switching, the DAP transistor's exclusive features will suggest to the design engineer many new applications which, until now, have not been feasible.

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2N1073A	- 80	- 80					
2N1073B	-120	-120					

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PATENTS

Benjamin Bernstein

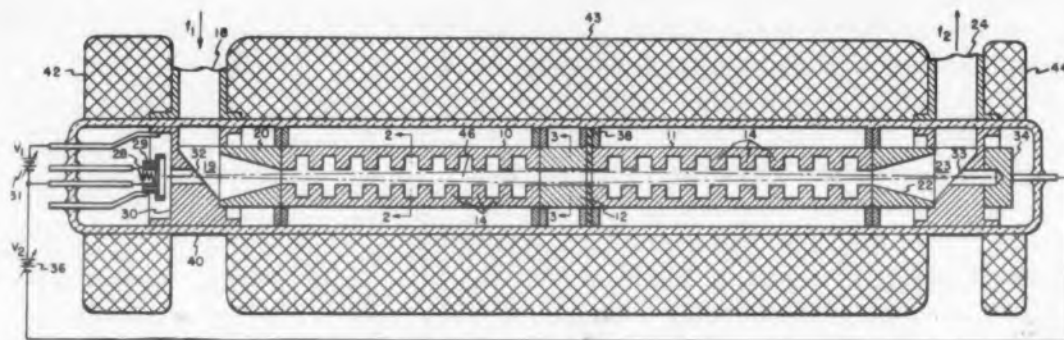
Frequency Shifting Apparatus

Patent No. 2,933,639. P. M. Lally. (Assigned to Sperry Rand.)

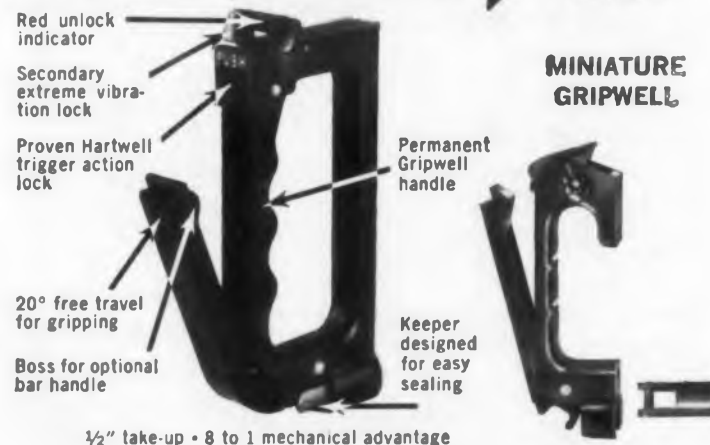
Frequency is changed in a cyclotron TWT by causing interaction of the electron beam and the wave at separate axial velocities of the beam.

The electron beam, originating at cathode 28, accelerates through the slow wave structure 14, and propagates a

transverse electric field at the first frequency. Due to the axial-magnetic field generated by solenoid 43, the beam orbits in a helical path at cyclotron frequency. Drift space 12 isolates slow wave structure 11. The beam is then accelerated at a second potential to induce a wave at a second frequency in the slow wave structure. This signal is coupled out through waveguide 24.



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CIRCLE 157 ON READER-SERVICE CARD

ELECTRONIC DESIGN • October 26, 1960

Transmitter-Receiver for Radio Location
 Patent No. 2,943,188. L. George, W. Knott and D. Kerr. (Assigned to Ultra Electric, Inc.)

Designed for use in a homing-type radio locating system, the transmitter-receiver uses a one-tube squegging oscillator, that generates bursts of rf energy that can be pulse modulated.

Variable Artificial Transmission Lines
 Patent No. 2,943,276. E. Lovick. (Assigned to Lockheed Aircraft Corp.)

The device consists of tubular dielectric members, a conductive core and a helical winding around the outer wall of the dielectric members. The inductance and capacitance of the circuit are varied by rotating the conductive cores.

Folded Dipole Having a Direct Current Output

Patent No. 2,943,189. L. R. Crump. (One half assigned to G. T. Morris.)

The two wires of the folded dipole

are connected at their ends to one another, so that the distance between wires is small compared to the shortest wavelength used. One wire is broken at its midpoint and diodes are inserted in the wire back to back. A capacitor is connected from a point between the diodes to the midpoint of the other wire. The signal is taken from across the capacitor.

Instrument Linearizer
 Patent No. 2,943,207. N. W. Burlis and M. J. Reinert. (Assigned to Custom Engineering and Development Co.)

This system improves the linearity of voltages proportional to data derived from nonlinear measuring instruments. Input data are displayed on an oscilloscope. The display falls onto a photo tube. The photo tube voltage is fed back negatively to the input. A transparent calibration curve on an opaque background is mounted between the photo tube and the oscilloscope face. This curve is the reference that the input voltage is made to align itself with.



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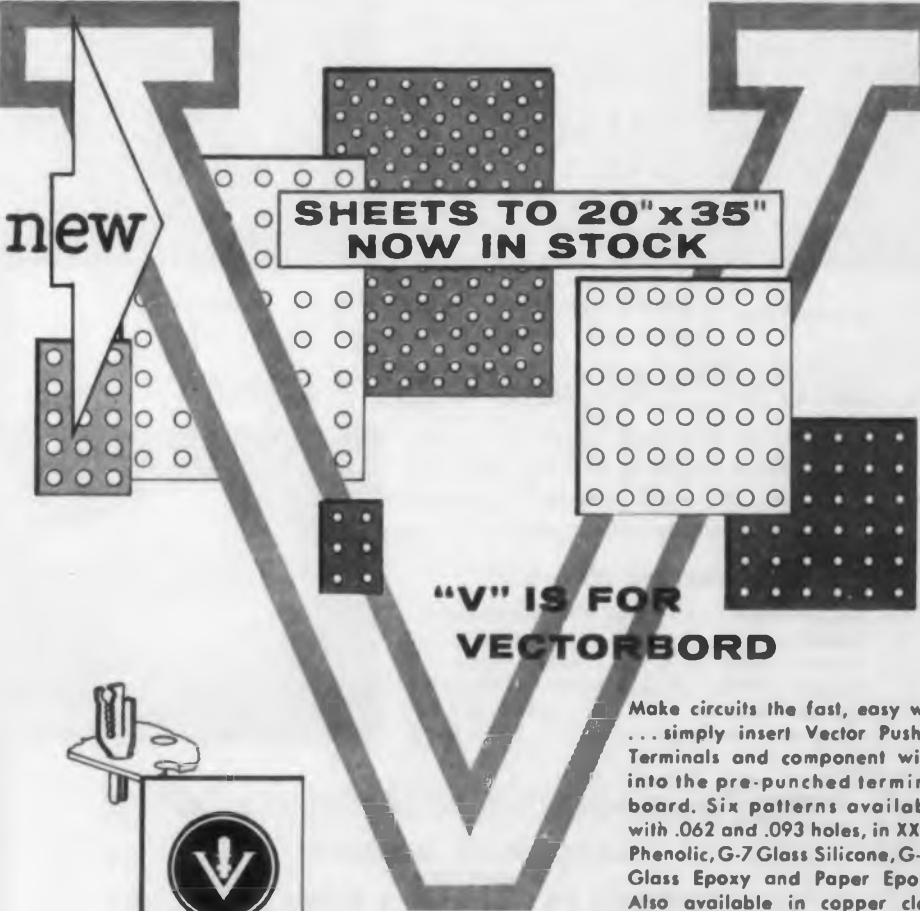


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RUSSIAN TRANSLATIONS

J. George Adashko

Limiting Values Of Active Resistances In RC Phase-Shift Generators

IN ANALYZING RC phase shift generators it is usually assumed that the input resistance of the phase shift network is considerably greater than the output resistance of the amplifying stage. Consequently, formulas for the frequency and for the self-excitation conditions usually disregard the effect of the internal resistance of the vacuum tube and the resistance of the plate load.

Townsend (*Electronic Engineering*, Vol. 22, No. 265, pp 116-117, March, 1950) did derive formulas for the frequency and for the attenuation with allowance for the amplifier parameters. In the present article we will derive formulas for the limiting values of the active resistances of the phase-shifting network below which the RC generator cannot become excited.

Self-Excitation Conditions of RC Phase Shift Generators

The RC phase shift generator can be represented as a cascade connection, for which the a -matrix is known, of an amplifier and a phase shifting network, Fig. 1. With the feedback loop open, the self-excitation condition can be determined by assuming the attenuation of the overall network to be less than unity.

The amplifier matrix is

$$[a'] = \begin{bmatrix} -\frac{1}{SR_a} & -\frac{1}{S} \\ 0 & 0 \end{bmatrix} \quad (1)$$

where S is the transconductance, and

$$R_a = \frac{R'_a R_i}{R'_a + R_i} \quad (2)$$

By multiplying the matrix of the amplifier and the matrix of the phasing network, still specified in general form, we obtain

$$[a] = \begin{bmatrix} -\frac{a_{11}}{SR_a} - \frac{a_{21}}{S} & -\frac{a_{12}}{SR_a} - \frac{a_{22}}{S} \\ 0 & 0 \end{bmatrix} \quad (3)$$

Assuming that the element a_{11} of matrix (3) is less than unity, we obtain, after transformation, a general formula for self-excitation.

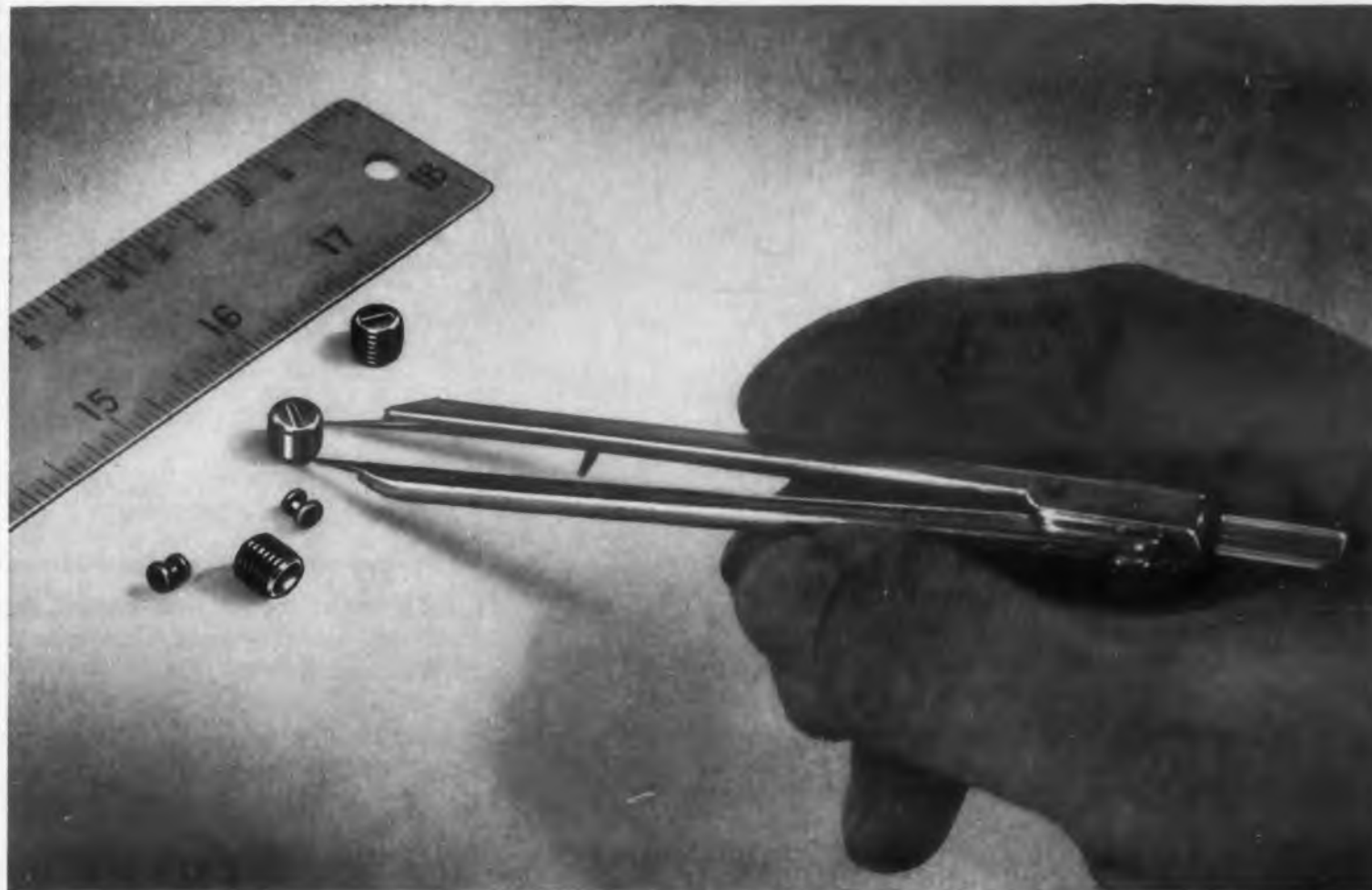
$$-a_{11} - a_{21}R_a < SR_a \quad (4)$$

Three-Element RC Phase Shift Generator

For a three-element phase-shifting network, Fig. 2, the a -matrix can be determined by mul-

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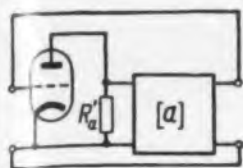


Fig. 1. RC phase-shift generator can be represented by an amplifier and a phase-shifting network.

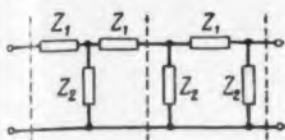


Fig. 2. Dotted lines separate individual units in this three-element phase shifting network.

multiplying the matrices of the separate four-terminal network. That is,

$$[a] = \begin{bmatrix} 1 + Z_1 Y_2 & 2Z_1 + Z_1^2 Y_2 \\ Y_2 & 1 + Z_1 Y_2 \end{bmatrix} \begin{bmatrix} 1 + Z_1 Y_2 & Z_1 \\ 2Y_2 + Z_1 Y_2^2 & 1 + Z_1 Y_2 \end{bmatrix}$$

After multiplication we get

$$[a] = \begin{bmatrix} 1 + 6Z_1 Y_2 + 5Z_1^2 Y_2^2 + Z_1^3 Y_2^3 & 3Z_1 + 4Z_1^2 Y_2 + Z_1^3 Y_2^2 \\ 3Y_2 + 4Z_1 Y_2^2 + Z_1^2 Y_2^3 & 1 + 3Z_1 Y_2 + Z_1^2 Y_2^2 \end{bmatrix} \quad (5)$$

Substituting the elements of the matrix (5) into the general formula (4) for the self-excitation condition, yields

$$-(1 + 6Z_1 Y_2 + 5Z_1^2 Y_2^2 + Z_1^3 Y_2^3) - (3Y_2 + 4Z_1 Y_2^2 + Z_1^2 Y_2^3) R_a < S R_a. \quad (6)$$

For a phase-shifting network with R in the parallel legs, the impedances of the network of Fig. 2 are

$$Z_1 = \frac{1}{i\omega C}; Z_2 = R. \quad (7)$$

After substituting Eq. 7 in Eq. 6, separating real and imaginary parts, and setting the latter equal to zero, we obtain

$$\omega_0 = \frac{1}{RC \sqrt{6 + 4 \frac{R_a}{R}}} \quad (8)$$

$$(S R_a - 29) \left(\frac{R}{R_a}\right)^2 - 23 \frac{R}{R_a} - 4 > 0. \quad (9)$$

Eq. 9 yields the condition for the gain

$$S R_a > 29, \quad (10)$$

since for positive values of R/R_a , inequality (9) can be satisfied only if Eq. 10 is satisfied.

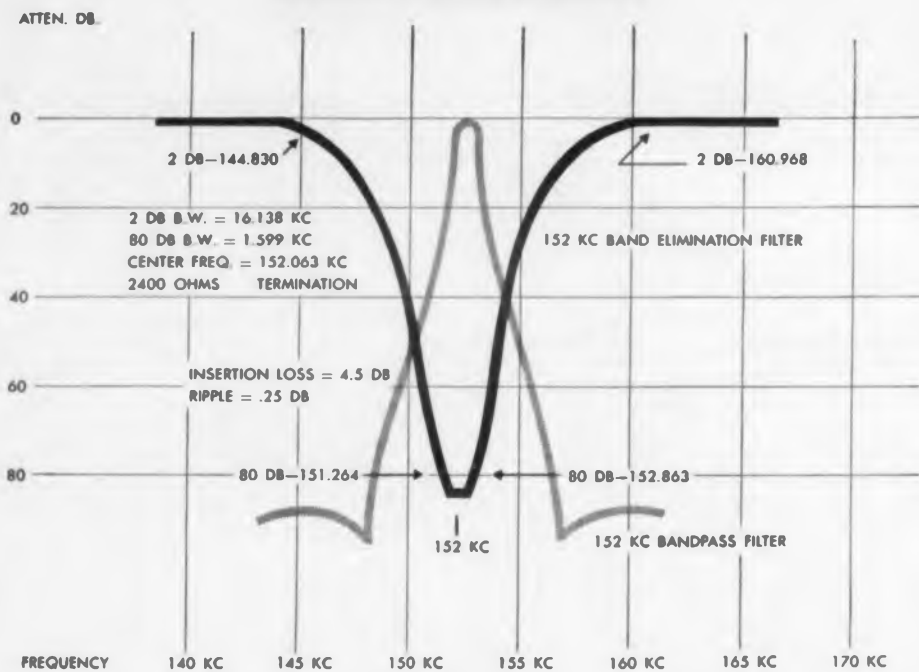
The positive root R_{min}/R_a of Eq. 9 determines the limiting value of the resistance of the phasing network, below which the generator will not be excited. In designing an RC generator, when the gain and the resistance R_a (Eq. 2) are specified, the resistances of the phase-shifting network must be chosen to satisfy the condition

$$\frac{R}{R_a} > \frac{R_{min}}{R_a} = \frac{23 + \sqrt{65 + 165 S R_a}}{2 (S R_a - 29)}. \quad (11)$$

Fig. 3 (curve 1) plots a curve of R_{min}/R_a as a

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They contain details and specifications concerning the filters described above.



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RUSSIAN TRANSLATIONS

function of the gain product SR_a .

For a phase-shifting network with the capacitance in the parallel leg, the impedances of the circuit of Fig. 2 are

$$Z_1 = R; Y_2 = i\omega C. \quad (12)$$

After suitable transformations we obtain

$$\omega_0 = \frac{1}{RC} \sqrt{\frac{6 \frac{R}{R_a} + 3}{\frac{R}{R_a} + 1}}; \quad (13)$$

$$(SR_a - 29) \left(\frac{R}{R_a}\right)^2 + (SR_a - 38) \frac{R}{R_a} - 12 \geq 0; \quad (14)$$

$$\frac{R}{R_a} > \frac{R_{min}}{R_a} = \frac{38 - SR_a + \sqrt{(SR_a)^2 - 28SR_a + 52}}{2(SR_a - 29)} \quad (15)$$

Fig. 3 (curve 2) plots R_{min}/R_a versus the gain.

Four-Element RC Phase Shift Generator

The matrix of the four-element phase-shifting network, using the same notation as in Fig. 2, has the following form

$$[a] = \begin{bmatrix} 1 + 10Z_1Y_2 + 15Z_1^2Y_2^2 + 7Z_1^3Y_2^3 + Z_1^4Y_2^4 & 4Y_2 + 10Z_1Y_2^2 + 6Z_1^2Y_2^3 + Z_1^3Y_2^4 \\ 4Z_1 + 10Z_1^2Y_2 + 6Z_1^3Y_2^2 + Z_1^4Y_2^3 & 1 + 6Z_1Y_2 + 5Z_1^2Y_2^2 + Z_1^3Y_2^3 \end{bmatrix}, \quad (16)$$

The self-excitation condition becomes

$$-(1 + 10Z_1Y_2 + 15Z_1^2Y_2^2 + 7Z_1^3Y_2^3 + Z_1^4Y_2^4) - (4Y_2 + 10Z_1Y_2^2 + 6Z_1^2Y_2^3 + Z_1^3Y_2^4) R_a \leq SR_a \quad (17)$$

For a phase-shifting network with the resistance in the parallel leg, Eq. 7, we obtain

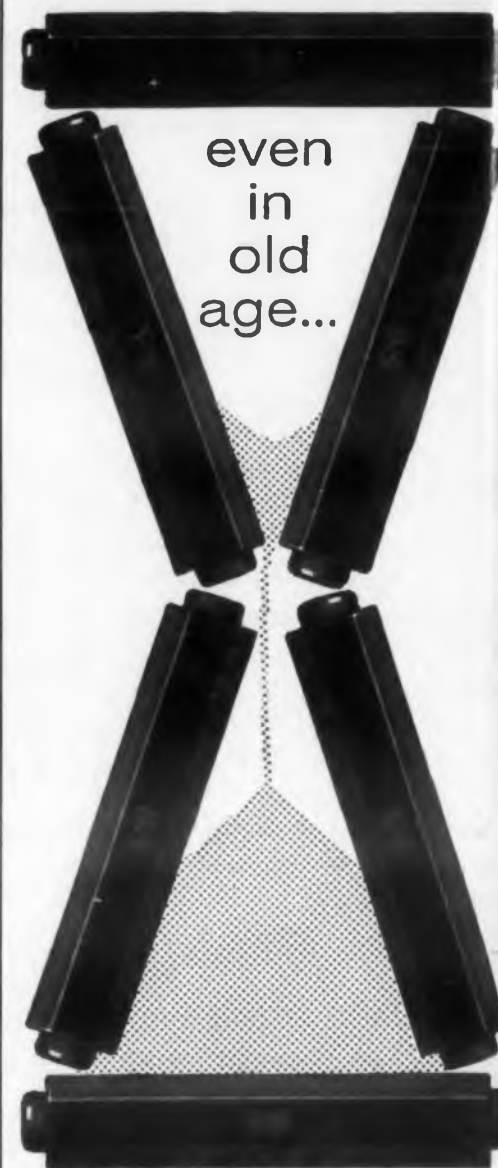
$$\omega_0 = \frac{1}{RC} \sqrt{\frac{7 \frac{R}{R_a} + 1}{10 \left(\frac{R}{R_a} + 1\right)}}; \quad (18)$$

$$(49SR_a - 901) \left(\frac{R}{R_a}\right)^3 + (14SR_a - 1210) \quad (19)$$

$$\times \left(\frac{R}{R_a}\right)^2 + (SR_a - 470) \frac{R}{R_a} - 56 \geq 0,$$

For a capacitance in the parallel leg, Eq. 12, we obtain

$$\omega_0 = \frac{1}{RC} \sqrt{\frac{10 \frac{R}{R_a} + 4}{7 \frac{R}{R_a} + 6}}. \quad (20)$$



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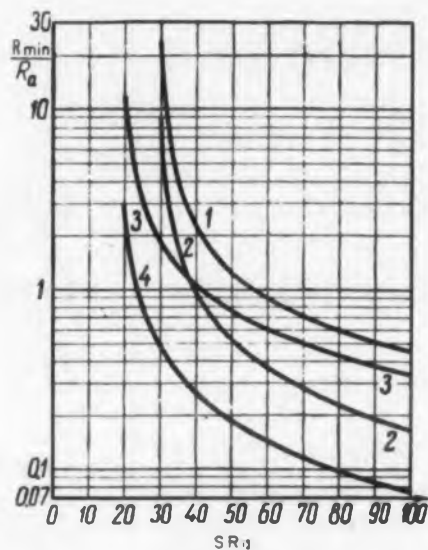


Fig. 3. The ratio R_{min}/R_a as a function of gain, SR_a .

$$(49SR_a - 901) \left(\frac{R}{R_a}\right)^3 + (84SR_a - 1.756) \left(\frac{R}{R_a}\right)^2 + (36SR_a - 1.108) \frac{R}{R_a} - 224 \geq 0. \quad (21)$$

From Eqs. 19 and 21 we obtain the well known condition for the selection of the gain

$$SR_a > 18.4 \quad (22)$$

Here the polynomials (Eqs. 19 or 21) have one positive root, which determines the minimum value of the ratio R/R_a . Fig. 3 shows a plot of R_{min}/R_a (parallel R—curve 3, parallel C—curve 4) versus the gain, obtained by solving cubic Eqs. 19 and 21 by one of the standard methods.

Conclusions

1. From a comparison of the curves of Fig. 3 for parallel R and parallel C networks one can see that, other conditions being equal, the parallel RC generator is excited at lower values of R/R_a .

2. Starting with a gain of 38 and greater, the RC generator with a four-element parallel R phase-shifting network is excited at larger values of R/R_a than the RC generator with a three-element parallel C network.

3. When the gain exceeds a definite value (differing with the type of network), the resistance of the phase-shifting network can be smaller than R_a .

4. In the design of RC generators one must choose such a value of R, that the ratio R/R_a , for a chosen gain, be greater than the minimum R_{min}/R_a , as given in Fig. 3.

5. The formulas for frequency agree with those given by Townsend.

Translated from "Limiting Values of Active Resistances of Phase Shift Generators," Garmash, *Elektrosvyaz*, No. 6, June, 1960, pp 24-27.

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STANDARDS AND SPECS

Sherman H. Hubelbank

Adjustable Wirewound Resistors: Styles Modified in MIL-R-19365

Resistor styles have been modified by the C amendment of MIL-R-19365 to correspond to the fixed resistor styles in spec MIL-R-28C. The resistance tolerance has been reduced from +10% to +5%. The 24-number decade for standard resistance values has been adopted. The quality assurance provisions have been revised to incorporate standard paragraphs on responsibility for inspection. Latest packaging information has been incorporated. Adjustable wirewound power resistors, MIL-R-19365C, 18 March 1960.

Electrolytic Capacitors: New Voltage Rating Substituted In MIL-C-3965B

Amendment 1 to spec MIL-C-3965B has deleted the 18-v rating and substituted a 20-v rating. A requirement for visual examination has been added after life test. The insulating sleeve requirements for testing have been revised. Requirements for brackets have been added for the bathtub styles. The appendix has been changed to match the addition of new styles and the changed number of specimens necessary. MIL-C-3965B, Amendment 1, Fixed Electrolytic (Tantalum) Capacitors, 16 April 1960.

Mil Spec Covers Five New Plastic Sheets for Printed Wiring

Five new types of plastic sheets have been added to MIL-P-1394 by the "B" revision. Rigid tolerance classes have also been established for thickness, and warp or twist, in addition to normal tolerances. The quality assurance sections have been modified to incorporate the latest paragraphs on responsibility for inspection. MIL-P-1394B, Plastic Sheet, Laminated, Copper Clad (For printed wiring).

Feed-Through Capacitor Spec Is Completely Revised

MIL-C-11693 has been completely recast. The "B" issue also supersedes MIL-C-19080 (SHIPS). The military standard format has been changed to the detail format. The type designation has been changed to delete the identification of terminals. Current rating is now identified by a letter

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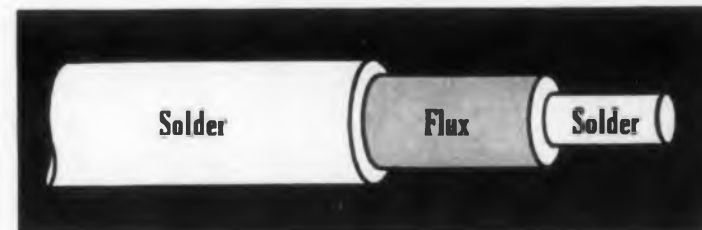
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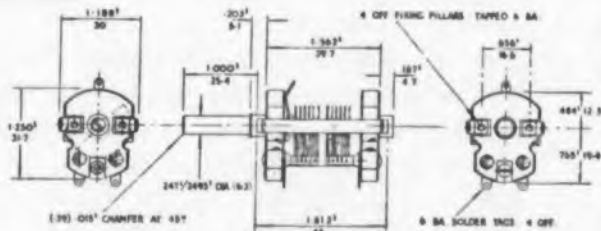
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symbol instead of a number symbol. The scope of the spec has been broadened to cover additional dielectric materials, such as paper-plastic, metalized paper, and metalized plastic. Fifteen new-style capacitors have been added. MIL-C-11693B, Capacitors, Feed Through, Radio-Interference Reduction, AC and DC (Hermetically sealed in metallic cases).

**Air Force Issues
Materials and Processes Specs**

Issued monthly by the Air Force, USAF Specification Bulletin 23, provides a list of material and process specs, and other closely related specs. These specs are approved for use in the construction and maintenance of Air Force equipment and accessories. The primary purpose of the bulletin is to provide a check-list to insure that correct issues of applicable publications and specs are being used in manufacture. Copies can be obtained from: Commander, Wright-Patterson Air Force Base, USAF Engineering Specifications and Drawings Branch, Administrative Services Office, Attn: EWBF, Wright-Patterson Air Force Base, Ohio. Be sure to reference the contract number or bid.

**RF Filters: Eight New
Types Added To MIL-F-15733**

The most significant change to MIL-F-15733 has been the deletion of all six types of filters listed in MIL-F-15733C and the addition of eight new styles. Two of the new styles are tubular; the other six are bathtub type. The tubular types have current ranges from 1 to 30 amp at 100 v dc, and 1 to 50 amp at 400 v dc (125 v ac). The bathtub types have ranges from 1 to 50 amp at 100 v dc, 400 v dc (125 v ac), and 600 v dc (250 v ac). The type designation has been expanded to include symbols for current rating, insertion loss characteristic, terminal identification, operating temperature range, and vibration grade. This spec also supersedes MIL-F-18344A (SHIPS). Radio Interference Filters, MIL-F-15733D.

**Coax Connector Adapters: General
Requirements Listed In MIL-A-27434**

MIL-A-27434 is a new spec covering the general requirements for weatherproof, between series, rf, coaxial connector adapters having a nominal impedance of 50 ohms. These connectors are intended for use in rf applications up to 10,000 mc. Adapter connector types established by this spec are: UG-564/U, UG-565/U, UG-635/U, UG-636A/U, and UG-637/U. MIL-A-27434, Adapters, Connector, Coaxial, Radio Frequency, Between Series, General Specifications For, May 10, 1960.

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CIRCLE 172 ON READER-SERVICE CARD

YOUR CAREER NEWS AND NOTES

Electrical engineers received the highest starting salaries of 1960 graduates from Lehigh University.

The electrical engineers averaged \$540 per month, a 7-per-cent increase over the 1959 average starting salary. However, according to the University's placement office, the greatest demand by employers was for mechanical engineers.

The 48 electrical engineers who were graduated had a total of 717 interviews with prospective employers, the placement office said.

The National Science Foundation has awarded 500 summer fellowships to secondary-school teachers of science and mathematics.

The recipients will work on individually planned summer programs of graduate study and research for six to 12 weeks. The Foundation will pay tuition, fees, travel expenses, and dependency allowances.

The recipients come from 45 states and the District of Columbia. A total of 226 awards went to mathematics instructors, 173 to teachers of the biological sciences, 55 to physical-science instructors and 46 to general-science instructors.

The Datex Corp., Monrovia, Calif., has found that engineers' writing problems were in organization and planning. The company's engineers, however, disagree.

The engineers, according to Datex, listed their major writing problems as deficiencies in vocabulary, grammar, composition, spelling, and sentence structure.

The engineers surveyed spent an average of 7 per cent of their time writing, according to the company. The company said studies have shown that "most engineers write grammatically. Despite their feeling to the contrary, their college training and experience (plus the usual reading) have given them vocabularies more than adequate to handle any engineering writing job."

The Engineering Manpower Commission is trying to find out again what engineers are earning.

The commission's fourth survey of earnings is expected to cover more than 200,000 engineers employed in private industry, the government and education.

The last survey, conducted in 1958, indicated that engineers' salaries jumped an average of 6.5 per cent annually between 1953 and 1958.

Electronics men in the Chicago area often seek career advice from a woman.

She is Barbara Ann Seibert, an employment counselor with Drake Personnel, Inc., who specializes in helping electronics engineers and executives find better jobs in the industry.

"Those first months weren't easy," Miss Seibert said. "Many employers at first refused to deal with me when they found that B. A. didn't stand for Bart or Bert."

Although she now is well established in the personnel guidance field, she still uses only her initials in correspondence with men she hasn't met.

Her advice to job seekers: first pick the geographic area in which you are interested. Then decide on the size and type of company you want to work for. In addition, she said, consider whether you prefer to work with components or systems.

By 1970, technical and professional employment will rise by 40 per cent, the largest change of any working group, according to a pamphlet compiled by the Labor Department.

The pamphlet, "Manpower—Challenge of the 60's," deals with expected changes in the nation's population and labor force in the next decade. It may be obtained from the U.S. Government Printing Office, Washington, D.C.

ENGINEER-IMPROVEMENT COURSES AND SEMINARS

Below are courses and seminars intended to provide the engineer with a better knowledge of various specialties. Our grouping includes several different types of meetings: National Courses—those held on consecutive days and intended to draw attendees from all geographical areas; One-Day Seminars—one-day intensive seminars which move from city to city; and Regional Lectures—regional symposia or lecture series which generally run one night a week for several weeks.

Linear Metrology Course

An intensive 70-hour, four-week course in Linear Metrology is being offered to qualified personnel by MetroLronics, Inc. The course, beginning Oct. 3 will utilize the complete facilities of MetroLronics. Subjects to be covered include Necessity for Standards, Derivation of Standards, Human Factors in Precision Measurement, Type of Instruments, such as Comparative and Absolute Instruments and Sources of Error. Instructors will be MetroLronics' experts headed by John A. Harrington, vice president for technical operations and an internationally recognized

metrologist. For further information write: MetroLronics, Inc., 2201 N. Hollywood Way, Burbank, Calif.

Cyrogenic Engineering Course

An intensive two-week short course on Cyrogenic Engineering will be held Oct. 31-Nov. 11, 1960 sponsored by Engineering Extension and Physical Science Extension, University of California, Los Angeles. This course is an introduction to cyrogenic engineering. It is intended for the engineer unfamiliar with low-temperature techniques, who finds that he must employ some of these techniques in his design and research work. A prerequisite for the course is a bachelor's degree in engineering or physical science, including a course in elementary thermodynamics. For further information write: Engineering Extension, Room 6266, Engineering Building Unit II, University of California, Los Angeles, Calif.

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

Oct. 1: Deadline for complete manuscripts for the Fifth Midwest Symposium on Circuit Theory to be held May 7 and 8, 1961, at Allerton Park and the Urbana campus of the University of Illinois. Send manuscripts to: Prof. M. E. Van Valkenburg, Guest Editor, Dept. of Electrical Engineering, University of Illinois, Urbana, Ill.

Oct. 10: Deadline for titles and abstracts (100 to 200 words) of papers, in duplicate, for the URSI-IRE fall meeting to be held Dec. 12-14 at the Boulder Laboratories of the National Bureau of Standards, Boulder, Colo. The following commissions are planning to hold one or more technical sessions in addition to their business meetings. Commission 2—Tropospheric Radio Propagation, Irwin H. Gerks, Chairman; Commission 3—Ionospheric Radio Propagation, L. A. Manning, Chairman; Commission 4—Radio Noise of Terrestrial Origin, William Q. Crichlow, Chairman; Commission 6—Radio Waves and Circuits, John I. Bohnert, Chairman. At the top of each abstract, give your name in the form you prefer, your affiliation, and your complete address. Send abstracts to: Chairman, Commission ———(Appropriate one from above), c/o A. H. Shapley, CRPL, National Bureau of Standards, Boulder, Colo.

Nov. 15: Deadline for 100-word abstracts and 500-word summaries for the Winter Convention on Military Electronics, sponsored by the Institute of Radio Engineers on Military Electronics, Feb. 1, 2 and 3, 1961 in Los Angeles. Send abstracts and summaries to: Dr. John J. Myers, Hoffman Electronics Corp., Military Products Div., 3717 S. Grand Ave., Los Angeles 7, Calif.

After completing, mail career form to *ELECTRONIC DESIGN*, 830 Third Avenue, New York, N. Y. Our Reader Service Department will forward copies to the companies you select below.

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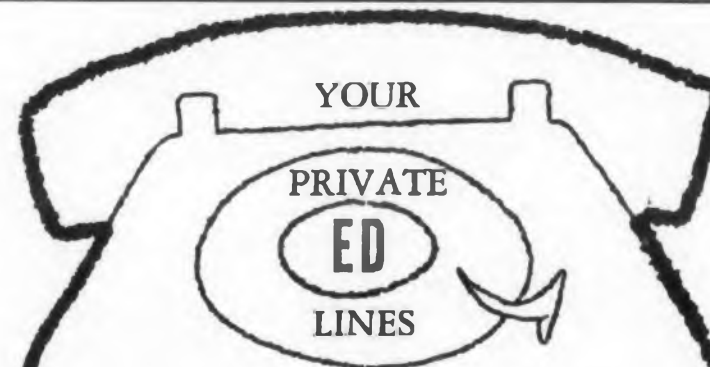
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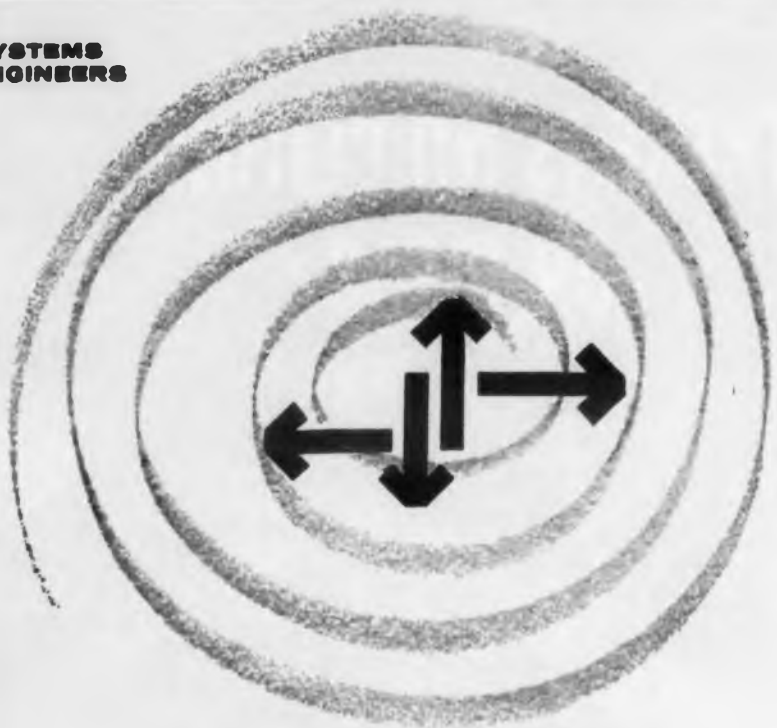
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CIRCLE 905 ON CAREER INQUIRY FORM

ADVERTISERS' INDEX

Advertiser	Page
A C Spark Plug, The Electronics Div. of General Motors, Inc.	35
A D C, Inc.	106
AMP, Inc.	77
Airpax Electronics	153
Alfred Electronics	68
Allen-Bradley Co.	16
Alpha Metals, Inc.	146
Alpha Wire Corp.	123
Amperex Electronic Corp.	19
Ampex Data Products Co.	102
Anaconda Wire & Cable Co.	24, A-B
Applied Electronics Corp.	84
Arnold Engineering Co., The	39
Assembly Products, Inc.	128
Augat Brothers, Inc.	113
Avnet, System, The	61
Babcock Relays, Inc.	23
Baker, J. T. Chemical Co.	100
Beattie-Coleman, Inc.	141
Beckman/Helipot	100, 113
Bell Aerosystems Co.	155
Bendix Corp., The Red Bank Div., Semiconductors	139
Bendix Corp., The Red Bank Div. Tubes ...	97
Bliley Electric Company	134
Bryant Computer Products	29
Bulova Electronics Div.	7
CBS Electronics	17, 87
C T S Corp.	101
Cadillao Associates, Inc.	150
Cannon Electric Co.	21
Canoga Corp.	3
Capitol Machine Co.	107
Celco Constantine Engineering Labs., Co. ...	88
Centralab, The Electronics Div. of Globe-Union, Inc.	14
Chance Vought Electronics Div.	49
Chassis-Trak Corp.	25
Cherry Electrical Products Corp.	84
Clevite Transistor	96 A-B
Clifton Precision Products Co., Inc. ...	Cover II
Cobehn, Inc.	106
Conrad, Inc.	140
Convair/Pomona	48 A-B
Corning Glass Works	119
Couch Ordnance, Inc.	118
Curtiss-Wright Corp.	142
Daystrom, Inc., Weston Instruments Div. ...	79
Daystrom Inc. Transcoil Div.	18
Delco Radio, Div. of General Motors Corp.	138
Dialight Corp.	136
Digitronics Corp.	145
DuMont, Allen B. Labs., Inc.	20
Dynatron Electronics Corp.	114
ESC Electronics Corporation	83
Eastman Kodak Co.	123
Edison, Thomas A., Industries	85
Elastic Stop Nut Corp. of Amer.	127
Electrical Industries	63
Electronic Design	96, 108
Electronic Measurements Co. of Red Bank ...	65
Electronic Research Associates, Inc.	116
Engineered Electronics Company	12
Epsco, Inc.	82
Erie Resistor Corp.	45, 125
Essex Electronics Div.	96
Fairchild Semiconductor Corp.	13
Fastex Div., Illinois Tool Works	146
Fluke, John Mfg., Co., Inc.	6
G-V Controls, Inc.	89
Garrett Corp., The	151
General Cable	56
General Ceramics Corp.	143
General Electric Co., Ordnance Dept.	152



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Advertiser	Page
General Electric Co., Silicone Products Dept.	66
General Electric Co., Semiconductor Products Dept.	129
General Electric Co., Specialty Control Dept.	28
General Electric Co., Tantalum Capacitors	99
General Motors Corp., AC Spark Plug Div.	35
Globe Industries, Inc.	121
Good-All Electric Mfg. Co.	92, 93
Goodyear Aircraft Corp.	37
Greiner Mfg. Co. Inc.	146
Gurley, W & L. E.	122
H & H Machine Company	141
HRB Singer	124
Harrison Laboratories, Inc.	92
Hartwell Corp., The	140
Heath Co.	122
Helipot Div. of Beckman Instruments 100,	113
Hermetic Seal Transformer Corp.	108
Hewlett-Packard Company 15, 156 ,Cover III	
Hi-G, Inc.	111
Hill Electronics, Inc.	144
Hughes Aircraft Co.	24, 153
I T & T Distributor Products Div.	110
Ideal Precision Products, Inc.	124
Industrial Instruments, Inc.	112
Inland Motor Corp. of Virginia	67
International Nickel Co., Inc.	34
J F D Electronics Corp.	81
Jackson Bros.	147
Kay Electric Co.	2
Keithley Instruments, Inc.	104
Kester Soeder Co.	135
Keystone Carbon Co.	115
Kintel, A Div. of Cohu Electronics	5
Kneights Co., The James	134
Kollsmorgen Corp.	67
Krengel Mfg. Co., Inc.	108
Krohn-Hite Corp.	102, 103
Laboratory for Electronics	116, 135
Lepel High Frequency Laboratories, Inc. .	126
Librascope, Div. of General Precision, Inc.	41
Lockheed California Div.	117
M. Ten Bosch, Inc.	147
Magnetic Research Corp.	114
Magnetics Inc.	98
Mallory, P. R. Co., Inc.	55
Micro Switch, Div. of Honeywell	130
Microwave Assocs., Inc.	94
Minneapolis-Honeywell Co., Aeronautical Div.	120
Minneapolis-Honeywell Co., Boston Div. .	133
Minnesota Mining & Mfg. Co., Chemical Products Div.	154
Motorola, Inc.	151
Mycalex Corp. of America	62
Mystic Adhesive Products, Inc.	123
Nems-Clarke Co.	22
North Atlantic Industries, Inc.	103
Ohmite Mfg. Co.	27
Panoramic Radio Products, Inc.	125
Pennsylvania Fluorocarbon Co., Inc.	112
Philco Corp., Western Development Laboratories	150
Philco, Lansdale Div.	9
Post Co., Frederick	76
Potter & Brumfield	105
Radio Corp. of America, Electron Tube Div.	Cover IV
Radio Cores Inc.	136
Raytheon Co., Semiconductor Div.	53

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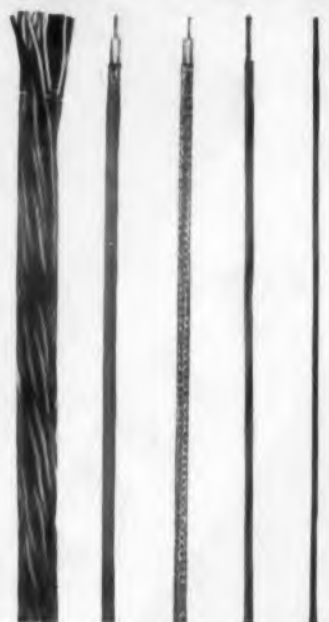
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CIRCLE 175 ON READER-SERVICE CARD

Advertiser	Page
Raytheon Co., Industrial Components	1, 127
Reeves-Hoffman	140
Remington Rand Univac	152
Rototest Laboratories Inc.	126
Rotron Mfg. Co., Inc.	78
Rutherford Electronics Co.	8
Schweber Electronics	99
Sealectro Corp.	107
Shockley Transistor	10
Sierra Electronics Corp.	51
Simpson Electric Co.	90, 91
Singer-Bridgeport	131
Spencer Products	54
Sperry Electronic Tube Div.	86
Sperry Semiconductor Div. of Sperry Rand Corp.	109
Sprague Electric Co.	11
Stanpat Co.	137
Sylvania Electric Products, Inc., Electronic Tube Div.	72 A-B
Sylvania Electric Products, Inc. Special Tubes Operations	59
Taber Instrument Corp.	122
Technology Instrument Corp.	26
Telrex Laboratories	134
Texas Instrument, Inc.	136
Tinnerman Products, Inc.	69
Transitron Electronic Corp.	95
Tung-Sol Electric, Inc.	52
Ultek Corp.	145
Ucinite Co., The	137
Ultradyn Inc.	127
United Shoe Machinery Corp.	104
Universal Mfg. Co., Inc.	137
Varian Associates	47
Vector Electronics Co.	141
Viking Industries, Inc.	126
Ward Leonard Electric Co.	132
Westinghouse Electric Corp.	57
White Industrial Div., S. S.	144
Xytan	153
Zero Mfg., Co.	147

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