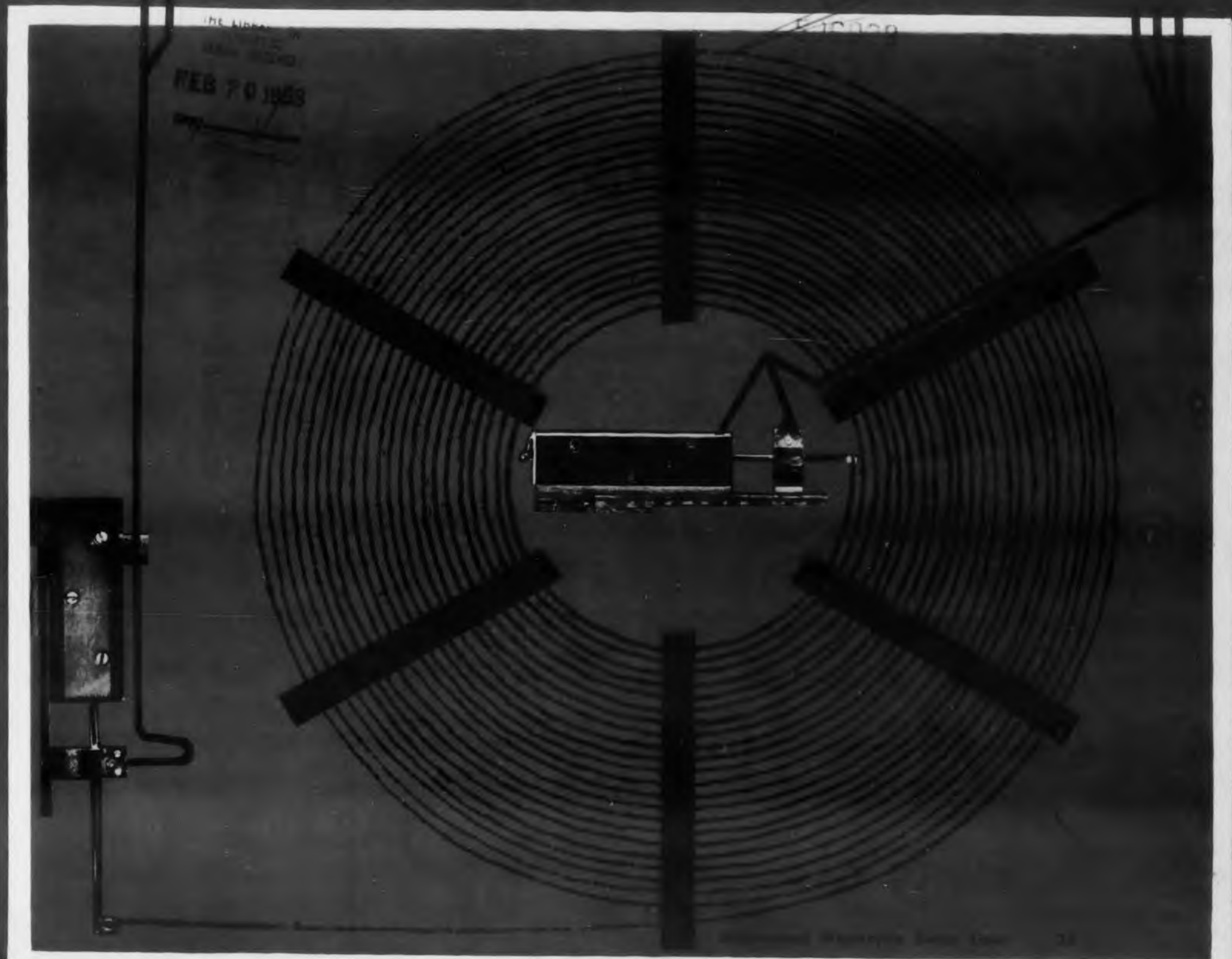
ELECTRONIC DESIGN

February 5, 1958



COVER STORY

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EDITORIAL

Double Work

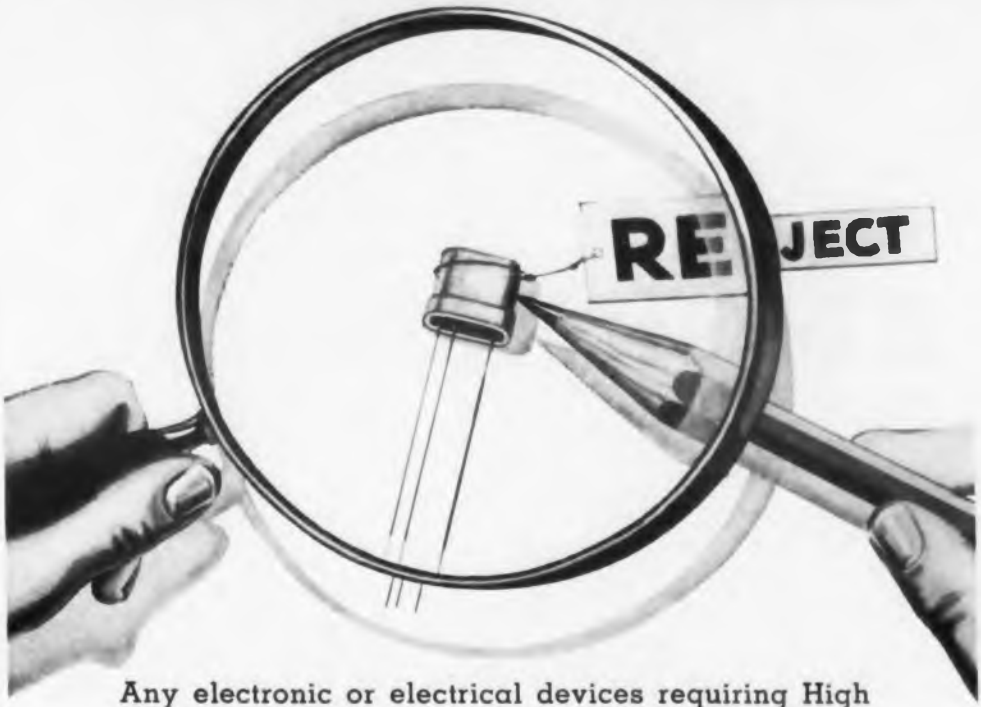
"Fantastic amounts of engineering manpower and test facilities are being devoted by components and equipment producers and agencies to component reliability studies *in complete duplication* of work done elsewhere. This must stop."

These are the words of Task Group Five of the Advisory Group on Reliability of Electronic Equipment. Hundreds of life tests on capacitors, resistors, tubes, switches, relays and other electronic parts have been run by as many companies—each working independently, virtually ignorant of the results obtained by the others. One of Task Group Five's solutions is to set up a central Government agency, to serve as a clearing house for all reliability information.

One approach to this solution has been made by an independent testing organization—the Inland Testing Laboratories' HELPR program, discussed in the staff report. This seems to be a step in the right direction. Owing to a certain apathy on the part of parts manufacturers, at whom the program is aimed, it has been slow in getting off the ground. We are informed, however, that recently the program has gained momentum and is on its way to being a success. We wish it well.

Another, more immediate solution might be for all companies to cooperate in disseminating all the quantitative reliability information they now have. Results of life tests on electronic parts should be made available to all engineers. We take great pleasure in congratulating RCA and Vitro Laboratories engineers for the efforts they have made in passing along this kind of information. The part reliability curves published in the staff report on reliability in this issue were taken from RCA and Vitro handbooks. These technical reports will soon be published by the Department of Commerce, and will be available to the designer at large.—TM

IN ELECTRONICS . . .
You Can't Clean It *AFTERWARDS*



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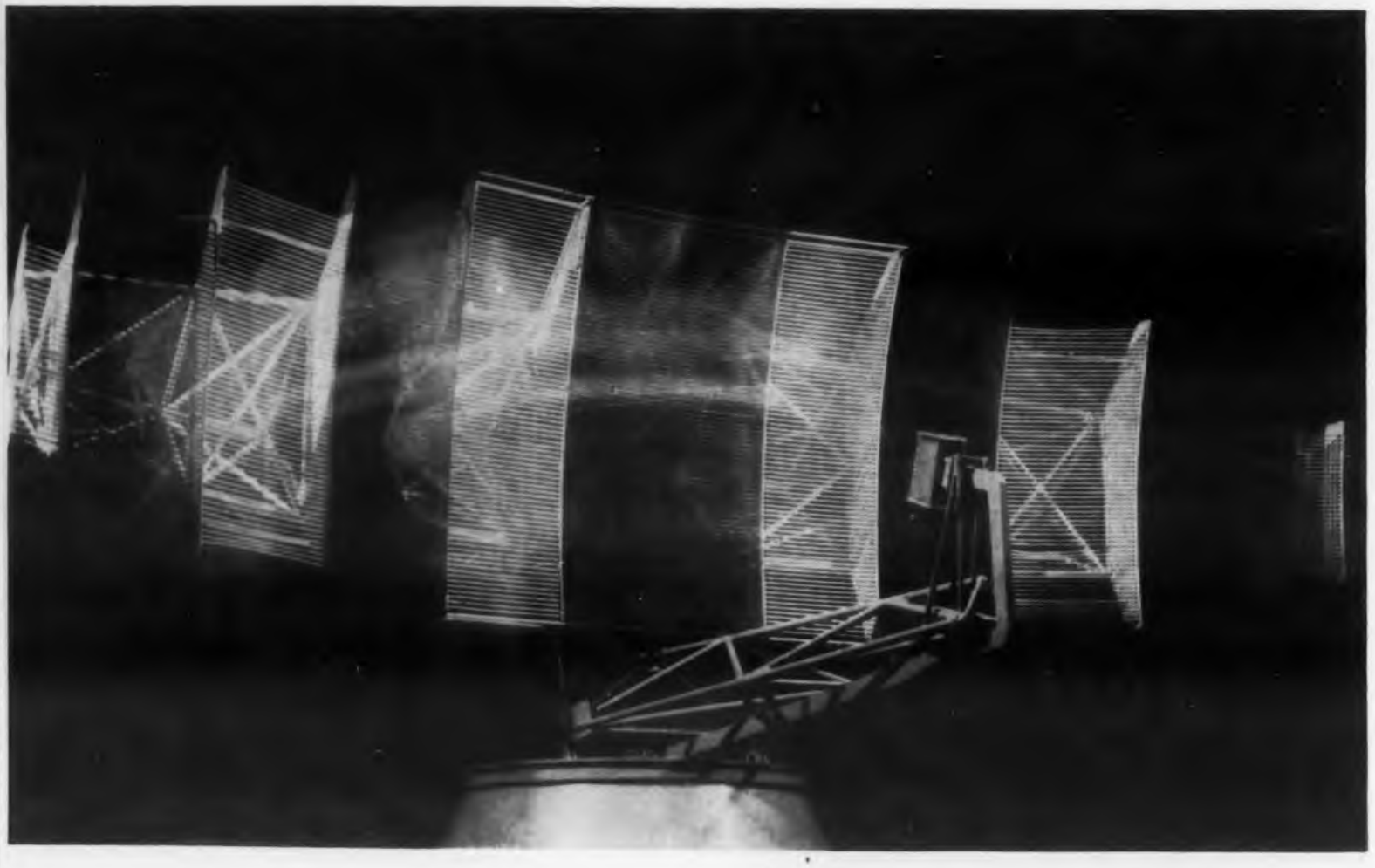
CIRCLE 4 ON READER-SERVICE CARD

ENGINEERING REVIEW

For more information on developments described in "Engineering Review," write directly to the address given in the individual item.

French Air Force Uses Diversity Principle to Improve Radar Reception



Single antenna used for three radar installations in the **French Diversity Radar System.**

By applying a common technique in communication systems to radar systems—"space" or "frequency" diversity—improvement in radar signal-to-noise ratio has been achieved by the French Air Force, according to findings of Intercontinental Electronics Corporation of Mineola, N.Y.

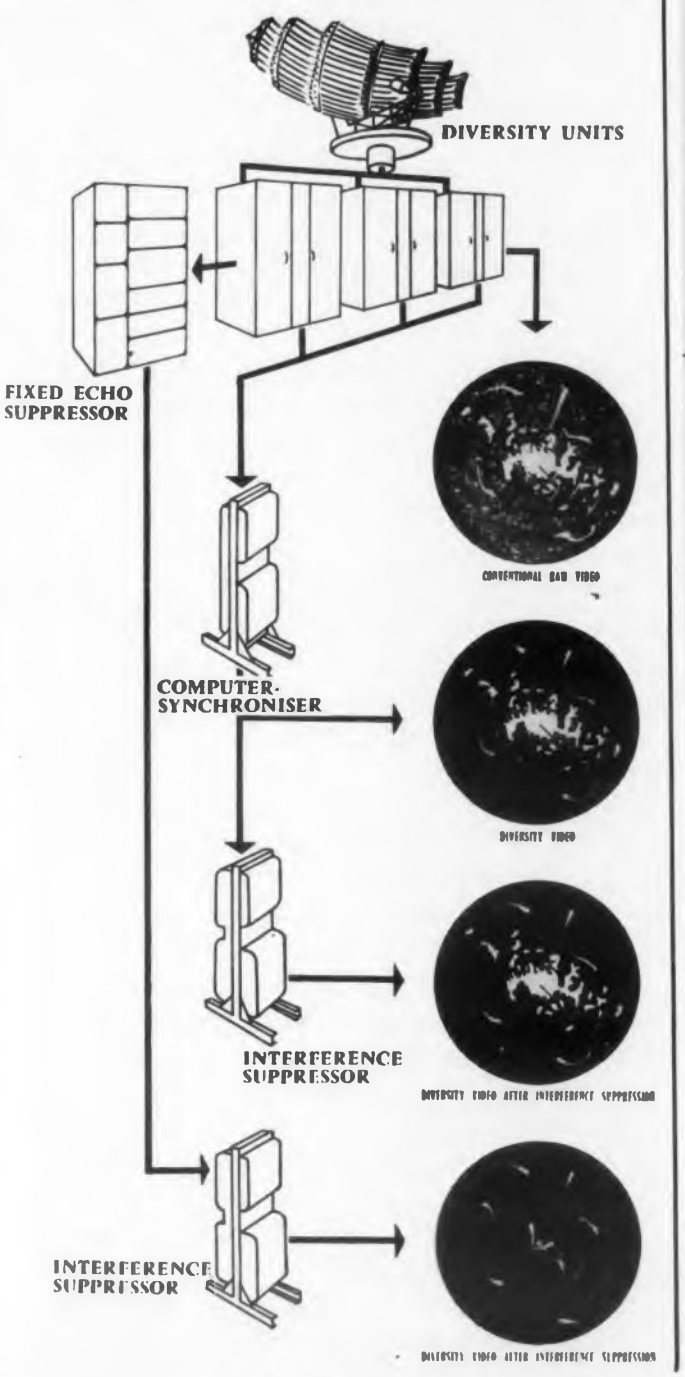
Results obtained are demonstrated in the PPI displays shown. The picture has high contrast on a completely dark background, and "noise" is almost entirely missing. Screen remanence is generally sufficient to ensure that the 4 or 5 preceding echoes produce a visible trace permitting evaluation of the course, and even of the approximate speed, of the aircraft. The device permits easy following of a situation which would otherwise be cluttered with interference.

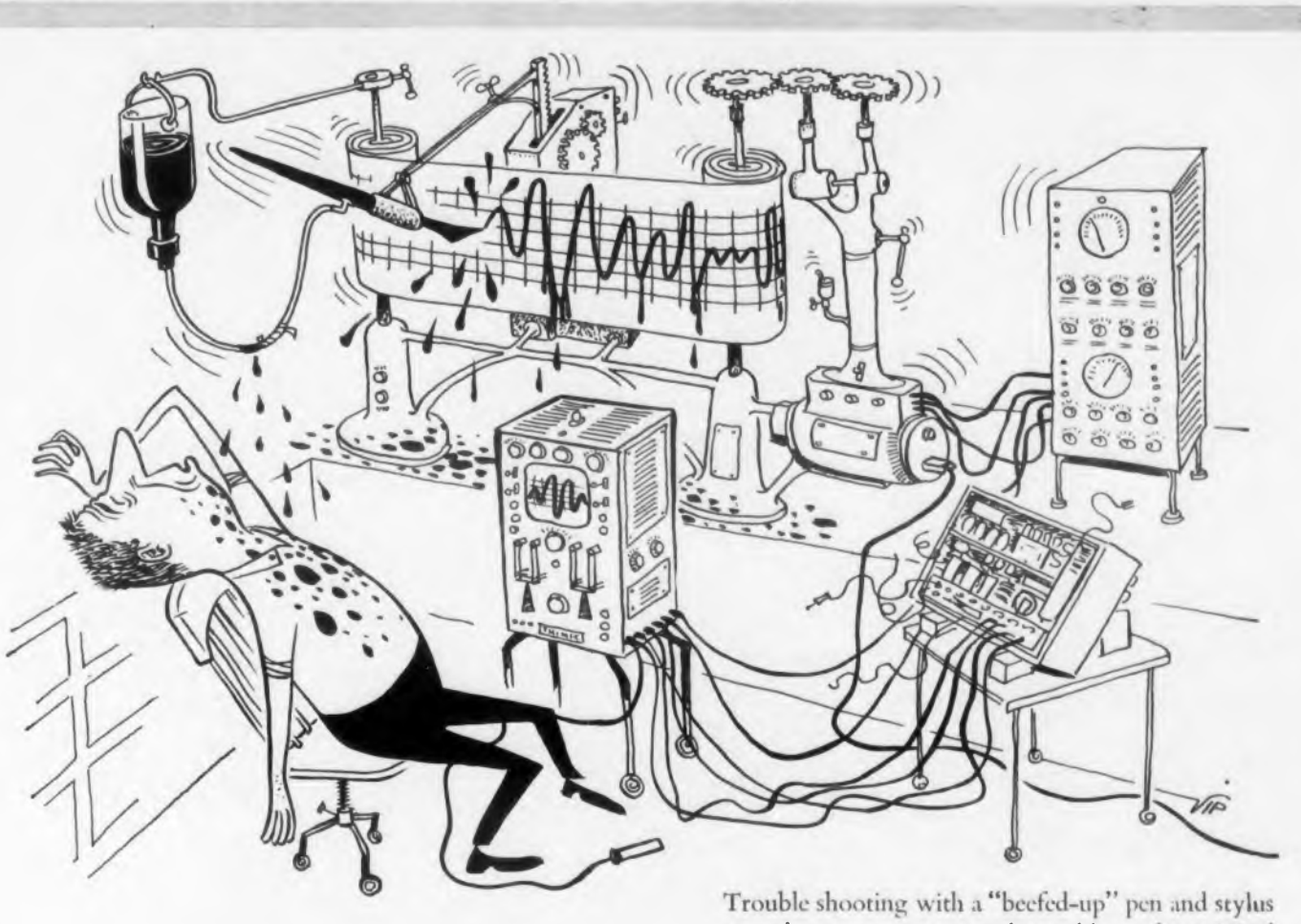
Range of the frequency diversity radar set is increased 30 to 35 per cent over the range of a single station having the same characteristics for 90 per cent detection; and there is a marked increase in the detection percentage at equal range. Apart from a weak zone at the edges of the reception lobe, the detection "blanks" completely disappear. In addition, fluctuations due to variations in the echo surface areas of a target are practically eliminated. A station equipped with three transmitters of power P, diversity coupled, is, from the point of view of an assured 90 per cent detection coverage, equivalent to a single radar transmitter of power 3P.

Almost 100 per cent reliability of operation is also secured by means of a twin transmitter-receiver installation.

In diversity communication work, the best signal available at any given instant is selected from two or three received signals by automatic

change-over switches. In applying the same principle to radar, space diversity, which requires more than one antenna, is found difficult in practice because of the necessity of maintaining synchronism of operation and especially of antenna rotation. But, frequency diversity is practical. In this instance, two or three transmitter-receivers operating on different frequencies use a common antenna, with a relative time delay of a few microseconds. A special hyper-frequency switch is used to feed the transmitter pulses to the common antenna and the echo pulses to the appropriate receiver. The pass band of this common antenna provides the same radiation characteristics for the several operating frequencies. On reception, the signals reaching the several receivers are re-synchronized by compensation of the relative delay introduced at the transmitter. To make the best possible use of the video signals thus synchronized, several alternatives are possible which utilize the combined power from all signals. (*Continued on following page*)





Trouble shooting with a "beefed-up" pen and stylus recorder can cause as much trouble as the original malady—thereby compounding the felony. Also, conventional recorders cannot capture high-frequency transients because of comparatively slow response.

PROBLEM: Trouble Shooting

SOLUTION: The Hughes **MEMO-SCOPE® Oscilloscope** can instantly "freeze" any number of selected traces. A storage type oscilloscope, it retains displays brilliantly *until intentionally erased*. Faithful reproduction of transients is assured always... for the electron beam has no appreciable weight, as opposed to the mass of mechanical recorder movement.

HUGHES MEMO-SCOPE OSCILLOSCOPE

STORAGE TUBE—5-inch diameter Memotron® Direct Display Cathode Ray Storage Tube. Writing speed for storage: 125,000 inches per second. The optional Speed Enhancement Feature multiplies writing speed approximately four times.

OPTIONAL PREAMPLIFIER EQUIPMENT—High Sensitivity, Differential Input, Type HS/6: 1 millivolt to 50 volts per division. Dual Trace Type WB/DI/11: 10 millivolts to 50 volts per division. Four independent positions may be selected for single or double channel performance and chopped or alternate sweeps.

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HUGHES PRODUCTS MEMO-SCOPE Oscilloscope
International Airport Station, Los Angeles 45, California

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CIRCLE 5 ON READER-SERVICE CARD

ENGINEERING REVIEW

Consider the case of three transmitter-receivers supplying video signals *a, b* and *c*. The three signals can be added directly; or, the video signals can be added in pairs and the partial sums multiplied to obtain a signal of the form $(a + b)(b + c)(c + a)$; or, partial products can be obtained and then added together to obtain a signal of the form $(ab + bc + ca)$.

The first solution is the simplest, yet gives the most marked improvement in the signal-to-noise ratio. This is because the echoes appear at the same instant on all three video stages, while noise peaks which are erratic and independent are only occasionally superimposed. This system has a disadvantage, however, in that the video sum is subject to interference occurring on any one of its three video stages. In this respect the latter two solutions are more satisfactory. If one of the three video stages is subject to interference, video *a* for instance, multiplication will remove that interference, in the absence of signals on video stages *b* and *c*. The simultaneous use of two or more frequencies is then an excellent anti-interference arrangement effective both against jamming and against interference originating from the transmissions of neighboring stations.

With any of these methods, a notable improvement in coverage is secured.

Suppression of Fixed Echoes

Another improvement in a radar display—elimination of echoes from fixed obstacles such as hills, overhead lines, etc.—is accomplished in the French Air Force equipment by use of a memory tube which replaces the more conventional delay-line elements. The advantage of this method are simplicity and stability of adjustments, and simple means for varying the radar repetition frequency—the tube's memory being available at any time and at any desired rate.

The memory tube is designed for adaptation to transmitter-receivers equipped with a stabilized local oscillator, with the possibility of adjusting it to the various intermediate frequencies of the radars. In installations not so equipped, an additional unit containing a stabilized oscillator can be substituted for the radar's local oscillator.

On the principle that noise is of a random nature while echoes appear over several consecutive radar cycles and at a practically constant distance (the distance changes from one rotation of the antenna to the next, but only slightly during the sweep of the beam over the target), it was theoretically possible to boost echoes with respect to noise. The memory element compares the video signals obtained during successive repetition cycles of the radar. It is a special tube of the "barrier-grid storage" type.

Known as "Coincidence Selector" or "Interference Suppressor," the device can be incorporated in any type of radar so long as its circuits and memory unit are suited to the characteristics of the main equipment. Use of the memory tube ensures the elimination of all non-recurrent signals, as well as of recurrent signals with a repetition frequency different from that of the particular radar set with which it is used. Practically complete cancellation of noise occurs as soon as the desired echo exceeds the noise level.

Pay TV May Fizzle

Lack of interest in Pay TV by businessmen may cause it to flop before it gets even a trial, according to testimony before the House Interstate Commerce Committee. Enthusiasm seems to be concentrated entirely among those who are advocating its adoption.

Main difficulty, according to FCC Chairman John C. Doerfer, is that only one application has been filed with the FCC so far for permission to conduct trials of toll TV allowed in a recent FCC decision. Applications can be submitted to the FCC until March 1, 1958, however, and the picture may change.

The limited trial allowed by the FCC could well discourage businessmen from investing in a temporary experiment. The FCC cannot run the tests because of costs involved. Those who propose some form of toll TV aren't in agreement as to the system that should be adopted.

The dilemma may spell doom for the idea.

Russian-English Electronics and Physics Glossary

The most up-to-date compilation of Russian terms and expressions culled from the pages of Soviet technical journals, including the most recent, has been published. This *Russian-English Glossary of Electronics and Physics* is the product of over thirty translators. A 20,000 word volume, it is among a series of glossaries being prepared to cover Russian terminology in all fields of modern physics. Many obsolete terms found in the Army manual, TM30-455, for example, have been omitted and the latest technical terms included.

A unique feature of the present volume is the addition of an appendix providing US equivalents for Soviet vacuum tubes, unit equivalents, circuit components, circuit notations, and abbreviations. Published by Consultants Bureau, Inc., 227 W. 17 St., N. Y., this glossary sells for ten dollars. The entire series may be purchased for fifty dollars.

ENGINEERING REVIEW

Pocket Receiver

Pocket-Radio Signaling

A small, pocket-radio receiver under development at Bell Telephone Labs., 463 West St., N.Y.C. may result in city-wide personal radio signaling. Reported in the current issue of *Bell Labs Record,* the new service is being tested in the Allentown-Bethlehem area of Pennsylvania.

Basically, the system serves to indicate to a particular customer—perhaps a doctor or a salesman—that his secretary or some other party is trying to reach him. The customer carries a small radio receiver slightly larger than a king size package of cigarettes in his pocket or clipped on his belt. On receiving a radio signal with the proper code the radio will emit an audible tone of sufficient loudness to inform the user that he is being called. He then goes to a telephone and calls his office or other pre-designated number where he is given the message.

To call a customer located somewhere within the coverage area, a person dials a particular telephone number and is connected with a personal-signaling operator. The operator responds with "signaling-service operator—number please." The calling party gives the operator a 4-digit number which corresponds to the code associated with the radio receiver assigned to the called party. With present experimental equipment, the operator then places this number into the system by setting a series of four rotary switches. A total of 24 such codes may be set up at any one time.

The codes are scanned at a rate of about 16 per minute and are translated into combinations of four out of nine audio frequencies. A total of about 3,500 codes can be assigned on a single radio channel. Each number in the code corresponds to a particular audio frequency—No. 1 is a frequency of about 160 cycles, No. 2 about 170

cycles, and so on up to No. 9 which is a frequency of about 300 cycles.

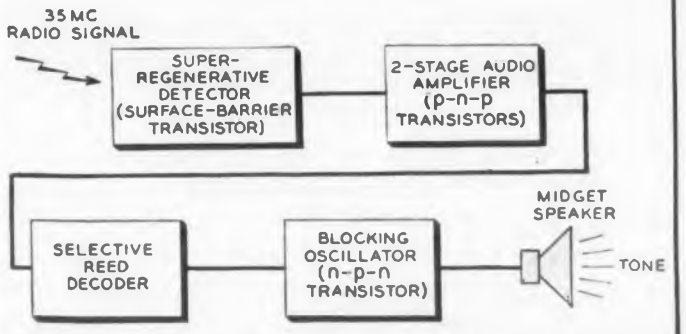
These audio frequencies sequentially modulate a 250-watt AM transmitter which operates on one of the common-carrier mobile telephone frequencies at about 35 mc. Each tone is sent for about four-tenths of a second—four tones (one code) requiring a total of 1.6 seconds. The spacing between code transmissions is approximately 2 seconds. Thus the total time per signal is about 3.6 seconds.

When the rf signal is picked up by the receiver, it is demodulated and the audio tones are recovered. These tones are amplified and used to energize a group of four highly selective vibrating reeds which will respond only if the proper frequencies are applied. If, during any coding interval, all reeds in a particular receiver are energized in the proper sequence, an audio oscillator is triggered, and an alerting tone informs the customer that he is being called. By depressing a small push button, the user can silence the oscillator and ready the receiver for the next call.

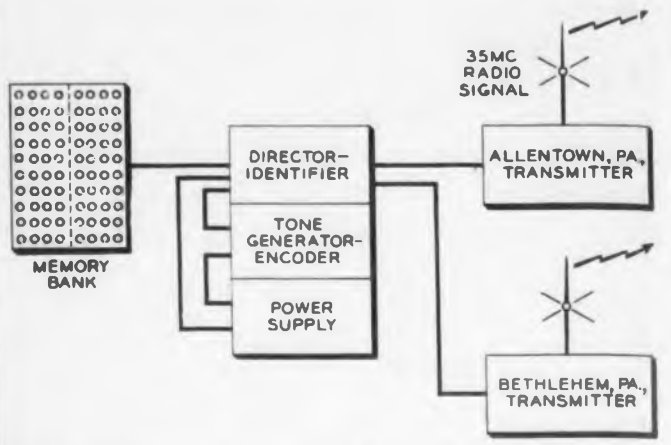
One of the major equipment problems associated with providing such a service is that of obtaining suitable radio receivers. These units must be small and light in weight if they are to be carried on the person. The model shown is now in use in Allentown. These receivers, manufactured by the Stromberg-Carlson Company, weigh approximately eight ounces and will fit conveniently into a coat pocket. They employ a single 4-volt battery having a life of about 900 hours. This is sufficient to provide about six months of service under normal conditions.

The block diagram of the receiver shows that the circuit employs four transistors—a surface-barrier transistor as a super-regenerative detector, two pnp junction transistors as audio amplifiers, and one npn junction transistor connected as a blocking oscillator, which is triggered when the proper code is received.

The transmitting station equipment used at Allentown (see block diagram) consists primarily of a memory bank, a tone generator and encoder, a director and identifier, and the radio transmitters. Except for the radio transmitter, the equip-



Block diagram of the receiving circuit employing four transistors.



Block diagram of central office arrangements as used in Allentown-Bethlehem trial.

ment in use at Allentown was manufactured by the Scantlin Electronics Company. The memory bank—which consists of 24 groups of rotary switches, four switches per group—is used for setting up the various codes. The tone generator supplies the nine precise audio frequencies for signaling. All are derived from a single crystal oscillator by using frequency-dividing circuits.

The encoder controls the scanning of the memory bank and the translation of the switch positions into a sequential code of the proper audio frequencies. To comply the FCC regulations, the identifier is used to send out the station call letters automatically at particular intervals. The director is used to route the coded audio signals to the various transmitters when more than one is necessary to obtain by a building or an automobile. It is estimated that ranges of about two to four miles from each transmitter will be experienced in the Allentown-Bethlehem area. This will be adequate to cover all of the business districts and the major portion of the surrounding suburbs. When larger areas are to be covered, it is expected that additional "satellite" transmitters will be employed.

Mergers Continue—Reduce Costs to Avoid Deficits

Mergers are continuing in our industry. These are taking on various forms, but it all amounts to the same thing—reduced cost of operation in the face of rising costs everywhere.

At General Dynamics Corporation, where the merger of a number of companies has resulted in noteworthy profitable operation, Earl D. Johnson, Executive Vice-President, recently told an American Management Association conference that one of the principal reasons for increased

mergers is the inflationary spiral that places a constantly increasing demand for cash on all businesses. Larger companies are in a stronger position to meet these requirements, he said.

Other reasons for mergers, according to Mr. Johnson, are the desire of companies to diversify their activities for greater sales, higher profit margins and increased stability; shortage of top administrative, scientific and engineering talent, which makes it almost impossible for the smaller companies to compete for these people; and the ever-increasing research costs making necessary a larger sales base to support it.

A recent example of consolidation to reduce administrative costs is the consolidation of nine affiliated companies of Engelhard Industries, Inc., fabricators of precious metals. Formerly with nine separate managements, Engelhard expects to improve efficiency, reduce overhead costs, and make greater profits in 1958 through centralized management.

The aluminum wire shown above is being disintegrated by an overvoltage pulse. On the left the action is virtually stopped at 20×10^{-9} sec, middle 30×10^{-9} sec, right 40×10^{-9} sec. Effective exposure time for each photograph was 5×10^{-9} sec, using a Kerr cell camera developed by Electro-Optical Systems, Inc. in Pasadena, California. Read bottom to top.

Punch Cards Run Steel Mill

A punch-card controlled reversing roughing mill has been placed in production at the Aliquippa Works of the Jones and Laughlin Steel Corp. Under the system designed and built by Westinghouse Electric Corp., Pittsburgh, Pa., the mill operator can press a single button to initiate the complete rolling sequence for a given slab. Speed and roll openings of the edger and main rolls are predetermined for a complete schedule up to nine passes by holes punched in one card.

Cards, prepared beforehand, will be available for nearly every slab and strip size and for each grade of steel. These cards are pre-punched to call for the optimum drafts and speeds that give uniform production at as high a production rate as possible.

A single IBM card includes all information required for a given schedule and controls mill screw-down opening, edger adjustment opening, mill speed, and edger speed. A notation is made on each card to indicate the last pass. By providing one standard punched card per rolling schedule it is possible to cover a wide range of metallurgical characteristics, temperature characteristics, and initial and final bar sizes.

To make mill operation completely automatic, a detector that responds to strip radiation is located on each side of the mill responding when the strip leaves the mill for fast repositioning of the rolls and re-entering for the next pass.

Weighty Examination: Scientists at the NBS Labs in Boulder, Colo., use this five-ton electromagnet to study man-made ferrite materials. A ferrite sample between the magnet's poles is subjected to a static magnetic field in a cross field of electromagnetic radiation (frequencies up to 10,000 mc). Minute details of its behavior are then recorded. Because they do not conduct electric currents, these highly magnetic ferrites can be used in transmitting super-high microwave frequencies.

Bell Laboratories researchers, Henry S. McDonald, Dr. Eng. and Max V. Mathews, Sc.D., examine magnetic tape used in a new research technique. Voice waves are converted into sequences of numbers by periodic sampling of amplitudes, 8000 samples per second. General purpose electronic computers act on these numbers to simulate proposed transmission systems.

Computer Simulates Transmission Medium

Recordings of real voices as modified by passing through a large digital computer or "electronic brain" were heard by engineers attending a recent meeting of the Northern New Jersey Section of the Institute of Radio Engineers.

Experiments at Bell Telephone Laboratories, Murray Hill, N.J., were described where ordinary speech is translated into machine "language," introduced into an IBM type 704 Computer processed by the computer, to simulate the effects of transmission through a transmission system, and then retranslated into speech sounds in the form of recordings on magnetic tape.

By this technique Bell Laboratories scientists can determine how the ear will respond to the product of a given transmission system without the expense and delay which would be involved in actually building and testing a proposed new system. Infinite variations may be tried by simple changes in the computer program. When not in use for this project, the computer is used for the solution of other scientific and accounting problems for the Laboratories.

The translating equipment which converts the speech sounds to a code for use in the computer was developed for Bell Laboratories by the Modac Department of the Airborne Instruments Laboratories, Inc.

Electronic Typing Calculator Developed by IBM

A new, low-cost computer—the IBM 632 Electronic Typing Calculator—consists of an electric typewriter, a 10-key companion keyboard, a magnetic core "memory" device within the computer unit, and a program reading device.

The computer embodies magnetic core "memory" and can be programmed to automatically retain and type out total gross sales, taxes, shipping charges, invoice totals, or other selected accumulations for management review.

According to IBM spokesmen, refinements and additions to the calculator show promise of extending its uses to many of the other important office applications now requiring separate calculating and typing operations. The new product will be manufactured at the company's new plant in Lexington, Kentucky with delivery scheduled for the second quarter of the year.

- A complete line of uniformly high-quality products—backed by the finest research and manufacturing facilities.
- Modern, up-to-date packaging designed specifically for easy handling and convenient use.
- Prompt customer service on deliveries and all inquiries.
- Application of vast engineering experience in helping select correct wire and insulation to meet requirements.
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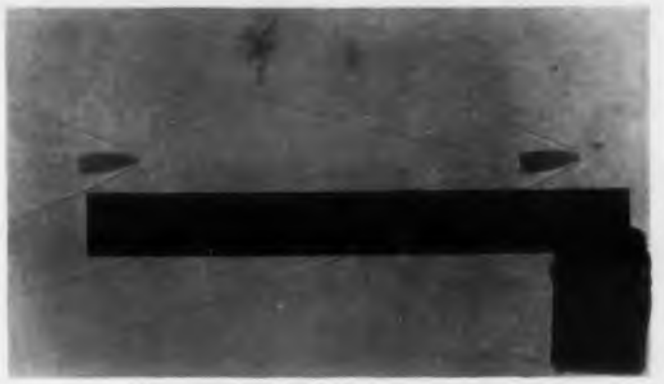
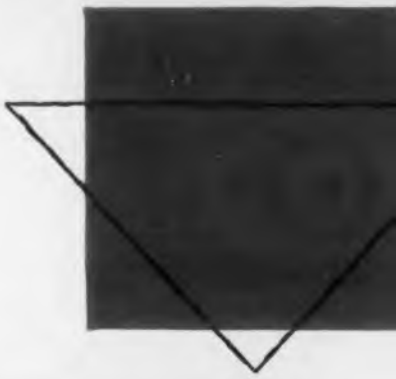
CIRCLE 14 ON READER-SERVICE CARD



Speed photography "stops" missile: A .220 calibre Swift—one of the world's fastest rifle bullets—is shown here in double exposure. To the left, it is crossing over the zero mark on an ordinary 6-inch ruler. To the right, it has reached the 5-inch mark. The exposures were made at one five-millionth of a second, with an interval of 100 microseconds between them. By simple calculation from the photo, the velocity of the bullet is found to be 4,050 ft. a second. The picture was taken with a double flash light source developed by Edgerton, Germeshausen and Grier, Inc. Shock waves, invisible by ordinary photographic methods, are clearly displayed by a silhouette technique. The indistinct pattern resembling a smoke trail is caused by the low pressure vortices or heated air filling in the "hole" left by the speeding bullet.

The Snark In Production

First photographs released by the Air Force of the production line for the world's first intercontinental guided missile—the USAF-Northrop Snark SM-62. Produced at Hawthorne, Calif., by the Northrop Division of Northrop Aircraft, Inc., the Snark is a 5000-mile range missile capable of carrying a nuclear warhead to a transoceanic target with extreme accuracy. The Snark missile has been assigned to operational duty with units of the Air Force's Strategic Air Command. The nation's first Snark intercontinental missile squadron will be based at Presque Isle, Maine.



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CIRCLE 15 ON READER-SERVICE CARD

Letters to the Editor

Seek Vendor's Advice

Dear Sir:

From our status as a supplier of components used in the production of electrical and electronic apparatus, I have the following message for your audience.

I would ask designers to please work out their wire and cable problem early in the design of the electronic equipment. All too often we find that a customer has completed the design of his gear, and has already completed much of his tooling by the time he has made his first inquiries concerning wire for internal connections and jacketed cables for power supply or other external use. His inquiry now comes to us specifying conductor sizes, etc., and also the outer diameters of the items desired.

We find, of course, that in trying to design cables with the proper conductor areas, current carrying capacities, and insulation thicknesses in conformity with the codes and standards to which we work, that we must exceed the designer's specified dimensions. The customer is faced with the unhappy choice between retooling to provide larger clearances and possibly discarding already purchased grommets, strain reliefs, terminals, etc., or accepting a cable design which has potential short-comings built in at the factory because of the undersize conductors, thin insulation walls, etc. which must be used to provide a small cable to squeeze through the inadequate holes and other clearances.

Considering the wiring as a component deserving the same attention as the more glamorized items of the electronic technique will truly result in lower cost and better quality. Unfortunately there are still too many design engineers doing a very creditable job except for the wiring design which is done as an afterthought and sometimes after production has already started.

J. W. Boughton, Chief Engineer
Western Insulated Wire Co.

► This letter points up a very important factor in good design—the timely use of vendors' knowledge as specialists in specific fields. The best designers are alert to the advantages of relying on specialists at a time during design when they can still make changes without scrapping related design effort.

MEETINGS

Mar. 24-27: IRE National Convention

Coliseum and Waldorf-Astoria, New York City. A comprehensive program of 275 papers, covering the most recent developments in the fields of all 27 IRE Professional groups, will be presented in 55 sessions. The high point of the program will be two special symposia on "Electronics in Space" and "Electronic Systems in Industry," to be held Tuesday Evening, March 25. The complete program will be announced sometime in January.

Mar. 27-29: Ninth Biennial Electrical Industry Show and Fifth Electrical Maintenance Conference

Shrine Exposition Hall, Los Angeles, Calif. Some of the topics to be discussed are maintenance to prevent breakdown, maintenance of electrical and electronic equipment, and maintenance of lighting to assure peak output. For more details write Paul H. Henrichs, Southern California Edison Co., P.O. Box 351, Los Angeles, Calif.

Mar. 31-Apr. 2: Instruments and Regulators Conference

University of Delaware, Newark, Del. Sponsored by the IRE, ASME, AIChE, and ISA. For details send to E. M. Grabbe, P.O. Box 45067, Airport Station, Los Angeles 45, Calif.

Apr. 2-4: ASME Conference on Automatic Optimization

University of Delaware, Wilmington, Del. AIEE, IRE, ISA, AIChE with professional groups analogous to the RE will participate in the conference by sponsoring technical paper centered around the theme, "Automatic Optimization." For details write W. E. Vannah, Control Engineering, 330 W. 42nd St., N. Y. 36, N. Y.

Apr. 8-10: Symposium on Electronic Waveguides

Auditorium of Engineering Societies Bldg., 33 W. 39th St., New York. Sponsored by IRE, PGED and PGMTT, and the Department of Defense Research Agencies. The symposium will deal with the interaction of electromagnetic fields and electron or plasma beams in general waveguide regions. The symposium covers the fields of electron beams, plasmas, and electromagnetics to

MEETINGS

compare the rather widely disparate theories and techniques employed to describe the wave phenomena encountered in the interaction of such fields. For further information contact the Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, New York.

Apr. 22-24: 1958 Electronic Components Conference

Ambassador Hotel, Los Angeles, Calif. Sponsored by the IRE, AIEE, EIA, and WCEMA. With "Reliable Application of Component Parts" as its main theme, the conference has been planned to cover the following general topics: resistors, capacitors, and dielectrics; transistors and solid state devices; component reliability; electron tubes and their application; and progress with materials. For complete information write to David M. Knox, Packard-Bell Electronics Corp., 12333 W. Olympic Blvd., Los Angeles 64, Calif.

Apr. 24-26: URSI Spring Meeting

Willard Hotel, Washington, D. C. Sponsored by the PGAP, PGMT&T, PGCT, PGIT, PGI, and URSI. For information, contact John P. Hagen, Naval Research Lab., Washington 25, D. C.

Apr. 30-May 1-2: 7th Region Technical Conference & Trade Show

Hobbies Bldg., State Fair Grounds, Sacramento, Calif. Write Ewald W. Berger, 3421 58th St., Sacramento 20, Calif. for information.

May 1-8: ASTE Tool Show

Convention Center, Philadelphia, Pa. A complete integrated technical program of papers, panels, seminars, plant tours, and related activities will be offered. For further information, write Richard Gebers, Public Relations Manager, 10700 Puritan, Detroit 38, Mich.

May 4-7: 4th National Flight Test Instrumentation Symposium

Park-Sheraton Hotel, New York City. Sponsored by the Instrument Society of America. Theme of the Symposium is "More Data Per Dollar." For details write P. O. Box 113, Bethpage, N. Y.

May 5-7: AIEE Great Lakes District Meeting

Michigan State University, East Lansing, Mich.

May 5-7: PGMT&T National Symposium

Stanford University, California. For details, write to Dr. K. Tomiyasu, GE Microwave Lab., 601 California Ave., Palo Alto, Calif.

May 6-9: Western Joint Computer Conference

Ambassador Hotel, Los Angeles, Calif. Cosponsored by IRE, ACM, and AIEE. Theme of the conference will be "Contrasts in Computers," with panel discussions on controversial aspects of modern computers. For more information write David Parry, 6363 Wilshire Blvd., Los Angeles 48, Calif.

May 13-15: Spring Assembly Meeting of the Radio Technical Commission for the Marine Services

Benjamin Franklin Hotel, Philadelphia, Pa. Write R. T. Brown, Radio Technical Commission for Marine Services, c/o Federal Communications Commission, Washington 25, D.C.

June 2-4: National Telemetering Conference

Lord Baltimore Hotel, Baltimore, Md. Sponsored by the AIEE, ARS, ISA, and IAS. The technical program will feature sessions in telemetering in the IGY program, telemetering overseas, rocket telemetering, industrial telemetering, and data reduction. In addition there will be the annual exhibit staged by manufacturers of telemetering equipment. For further details about the conference write W. J. Mayo-Wells, Program Chairman, 3830 Beecher St., N.W., Washington, D.C.

June 22-27: AIEE Summer General Meeting

Buffalo, N.Y.

June 23-27: ASTM 61st Annual Meeting

Hotel Statler, Boston, Mass. Highlighting the meeting will be the 12th Technical Photographic Exhibit of the ASTM. Entries will be accepted from members of ASTM, employees of company members, and engineering students. For further information, contact E. W. Walsh, Chairman, ASTM Photographic Exhibit, Narragansett Electric Co., 15 Westminster St., Providence, R.I.

Reliability-Sensitivity-Function Analysis

H. Elmore Blanton
Hycon Eastern, Inc.
Cambridge, Mass.

Now that the designer has made a paper prediction of reliability, he may want to change this reliability. Which component should he change? Which component should he *not* change? Sensitivity-function analysis provides an easy guide to determining the answer to these questions. Application of the principles described in the article will give the designer a quantitive evaluation of how sensitive the reliabilty of the system is to changes in the reliability of the system components.

Since this article refers to a hypothetical telemetering system described previously (reference 1) ELECTRONIC DESIGN here reconstructs salient elements of Mr. Blanton's reliability prediction technique, as a review for the reader. Turn the page for the start of the article.

Review

A block diagram like the one in Fig. 1 of a hypothetical telemetering system is drawn. Reliability numbers, based on test and experience are assigned to each block. In this example the *E′* and *D′* blocks have been added to show that there is a probability that transmitter *1* will fail if transmitter *2* does, and vice versa. A detailed diagram of the subcarrier oscillator-commutator-transducer boxes appears in Fig. 2.

Now a table is drawn up. Each path required for success is examined and tabulated as in Table 1. Note that signal transmission via any one of paths *1*, *2* or *3* will be successful. There is only one way in which information from variables *11* through *15*, *16*, and *17* can be transmitted, however. This is accordingly noted. Combinations of paths that can succeed are now listed. The probability of simultaneous success of two or more or all paths follow in order.

Weighting Factors

Preparatory to writing a reliability formula, the need for *exponent weighting factors* has to be looked at. These factors denote the relative importance of different kinds of success—in this case various telemetered variables. In the example under discussion variables *1* through *10* are considered the most important. Accordingly their exponents are listed as 1.0 in Table 2. The other variables are less important and are given exponents less than 1, roughly proportional to their relative importance. The nonunity exponent effectively increases the apparent reliability of the associated part . . . and causes the predicted reliability of the system to be higher.

Weighting factors, their use and derivation, are discussed at length in reference 2 by Mr. Blanton.

Reliability Formula

Having listed the paths necessary for success —and using the product rule to show the probability of success for (reliability of) each path, the reliability formula for the system can be written. The procedure is straightforward. System reliability is now equal to the algebraic sum of the probabilities that have been listed. Pay due attention to subtracting the equations for simultaneous success. The formula that results is

Line	Item	Probability of Success	Remarks
1	V_1-V_{10} to Output, Path 1	ABCDE′G	Path 1 or 2 or 3 req'd for success, weight = 1.0
2	V_1-V_{10} to Output, Path 2	ABCD′EFG	
3	V_1-V_{10} to Output, Path 3	ABCD′EH	
4	V_{11}-V_{15} to Output	ABCD′EJ	Req'd for success, weight = w_1
5	V_{16}, V_{17} to Output	ABCD′EK	Req'd for success, weight = w_2
6	Combination No. 1 for System Success (Lines 1, 4, & 5)	$ABCDEGJ^{w_1}K^{w_2}$	Any one of these combinations will give system success
7	Combination No. 2 for System Success (Lines 2, 4, & 5)	$ABCD'EFGJ^{w_1}K^{w_2}$	
8	Combination No. 3 for System Success (Lines 3, 4, & 5)	$ABCD'EHJ^{w_1}K^{w_2}$	
9	Simultaneous Success (Lines 6 & 7)	$ABCDEFGJ^{w_1}K^{w_2}$	
10	Simultaneous Success (Lines 6 & 8)	$ABCDEGHJ^{w_1}K^{w_2}$	
11	Simultaneous Success (Lines 7 & 8)	$ABCD'EFGHJ^{w_1}K^{w_2}$	
12	Simultaneous Success (Lines 6, 7 & 8)	$ABCDEFGHJ^{w_1}K^{w_2}$	
13	Reliability formula for P_1 (Line 6 + L. 7 + L. 8 — L. 9 — L. 10 — L. 11 + L. 12)	$ABCEJ^{w_1}K^{w_2}$ (DG + D′FG + D′H — DFG — DGH — D′FGH + DFGH)	

Table 1. Derivation of reliability formula for telemetering system.

Part	Symbol	Estimate
Atmospheric Propagation	A	0.98
Power Supply and Packaging	B	0.95
Diplexer and Antenna	C	0.99
Transmitter No. 1	D	0.95
Probability Xmtr No. 1 does not cause failure of Xmtr No. 2	D′	0.99
Transmitter No. 2	E	0.95
Probability Xmtr No. 2 does not cause failure of Xmtr No. 1	E′	0.99
Storage and Delay Device	F	0.95
Each Subcarrier Oscillator	a_1 - a_5	0.99
Each Commutator Output Section	b_1 - b_3	0.98
Each Commutator Input Section	c_1 - c_{25}	1.0*
Each Transducer	d_1 - d_{27}	0.98

*Estimated as greater than 0.995, hence use 1.0.

Table 2. Part reliability estimates for numerical computation of reliability formula. In practice these estimates would be derived from use of part reliability curves.

Situation	Formulas	Reliability
1. System-reliability prediction using proposed technique	Line 13, Table 1, and Eqs. (1)-(4)	0.786
2. Same as 1 except S. C. O. No. 2 and associated transducers not used	Same as 1 except H = 0	0.745
3. Same as 1 except storage-delay eliminated	Same as 1 except F = 0	0.785
4. Same as 1 except storage-delay replaced by straight-through transmission	Same as 1 except F = 1.0	0.786
5. System-reliability prediction using product rule	$Ps = R = ABCDEFa^5b^8c^{25}d^{27}$	0.410
6. Same as 5 except part unreliability reduced by factor of 4 (e.g., A is changed from 0.98 to 0.995, etc.)	Above equation with variables redefined	0.802
7. System-reliability prediction considering redundancy shown in Fig. 1 and all data required for success	$R = ABCEa^4b^2c^{15}d^{17}[D' + (1 - abc^{10}d^{10})(D + D'F - DF)]$	0.685

Table 3. Reliability predictions for hypothetical telemetering system. Substitution of figures from Table 2 in a variety of prediction methods gives widely differing results.

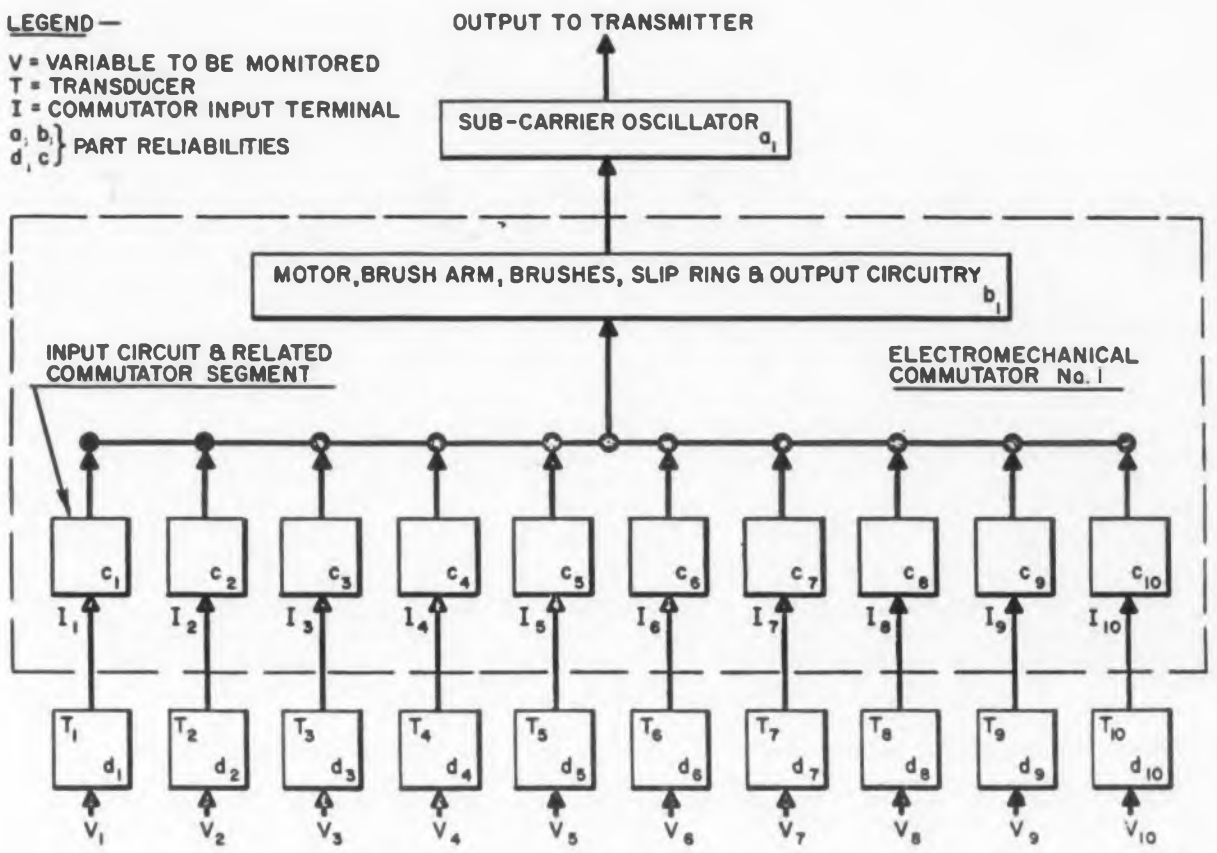

Fig. 1. Reliability diagram derived from engineering block diagram of a telemetering system. Arrows show signal (information) flow.

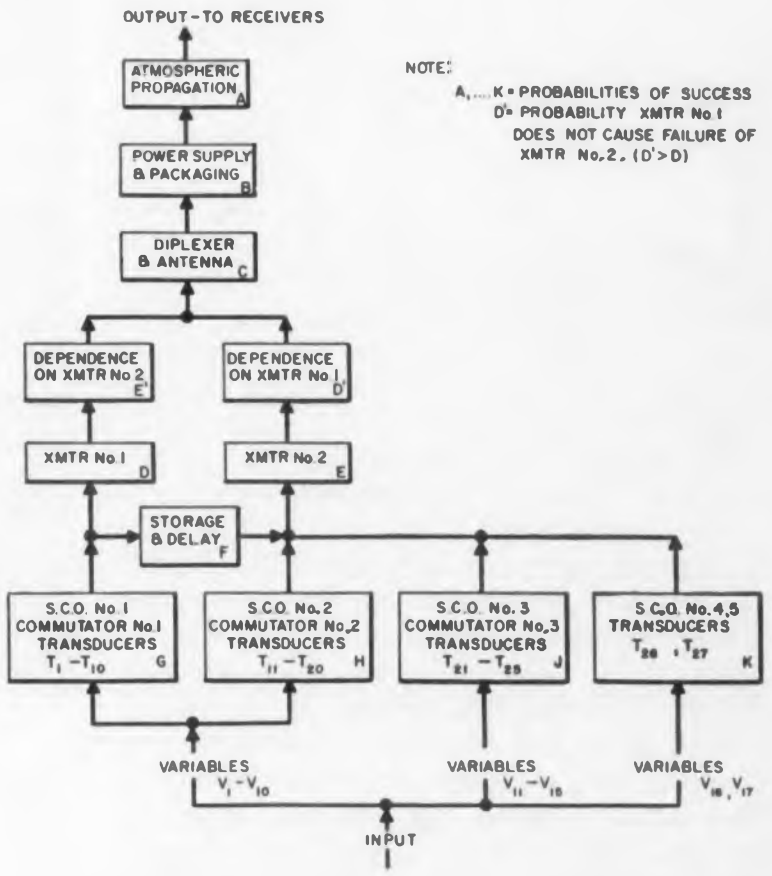

Fig. 2. Reliability detail of 10-input subcarrier oscillator-commutator-transducer boxes of Fig. 1.

$$R = P_1 = ABCEJ^{w_1}K^{w_2}\,(DG + D'FG + D'H - DFG - DGH - D'FGH + DFGH),$$

as in Table 3.

Let us recap the prediction procedure:

- Write the probability of success (use product rule) for transmission along each possible path of information transfer. Check to see if a path's success is necessary to system success or if there are alternative paths. Apply weighting factors.
- Calculate the probability of success for combinations of paths that result in system success. Again, use the product rule.
- If more than two combinations for system success exist, combine these and calculate their probabilities of success as above.
- Write the reliability of the system by adding the probabilities you got in the second step, subtracting those calculated in the third step, and alternately adding and subtracting those for groups of three, four, or more as computed in the last step.

Note that Line 6 of Table 4 does not include the factors D' and E'. This is because the probabilities D and E are more restrictive for the same parts in this example.

The four steps delineated above can be followed quickly and easily. The reliability number for the system being analyzed will be a much closer approximation to reality than a simple product rule estimate.

In point of fact the use of the product rule, without regard to the interdependence and redundancy of the system components, will lead to a reliability estimate very much lower than it should be. Consider Table 2. In this table some approximate part reliabilities are attributed to the system components. When these numbers are substituted in the equations derived above the system reliability is predicted in Table 3 as 0.786. Use of a simple product rule gives 0.410—half as much as the first method! This can be expensive if the designer takes his prediction seriously and designs more reliability into the system. Required reliability may be only 0.7.

But suppose it is higher. Suppose the required reliability is, say, 0.85. Which parts should be made more reliable to give the highest, most economical system reliability? The answer to this question will be found in the following article, where Mr. Blanton examines the sensitivity of system parts. In Reliability-Sensitivity-Function Analysis he shows how to evaluate the rate of change of system reliability with respect to changes in the reliability of the particular part. This article, together with reference 1 should give the design engineer a sound, fast technique for evaluating the reliability of his design before the prototype is built, and a good picture of how the system parameters can be varied to change that end reliability.

Table 4. Sensitivity function analysis of telemetering reliability.

Line	Sensitivity with respect to Changes in reliability of:	Symbol	Reliability — Sensitivity Function* (Partial derivative of P_1 with respect to symbol at left)	Sensitivity Factor based on Values in Table 2
1	Atmospheric Propagation	A	P_1/A	0.802
2	Power Supply and Packaging	B	P_1/B	0.828
3	Diplexer and Antenna	C	P_1/C	0.794
4	Transmitter No. 1	D	$MG\,(1-F)\,(1-H)$	0.0021
5	Dependence on Xmtr No. 1	D′	$M\,(FG + H - FGH)$	0.792
6	Transmitter No. 2	E	P_1/E	0.828
7	Dependence on Xmtr No. 2	E′	0	0
8	Storage and Delay	F	$MG\,(D'-D)\,(1-H)$	0.0017
9	S.C.O. No. 1, Commutator No. 1, Transducers T_1-T_{10}	G	$M\ [F\,(D'-D) + D]\,(1-H)$	0.0439
10	S.C.O. No. 2, Commutator No. 2, Transducers $T_{11}-T_{20}$	H	$M\,[D'\,(1-FG) - DG\,(1-F)]$	0.0455
11	S.C.O. No. 3, Commutator No. 3, Transducers $T_{21}-T_{25}$	J	$w_1\,P_1/J$	0.745
12	S.C.O. Nos. 4, 5, Transducers T_{26}, T_{27}	K	$w_2\,P_1/K$	0.668
13	Exponent Weighting Factor on J	w_1	$(\log_e J)\,P_1$	−0.0401
14	Exponent Weighting Factor on K	w_2	$(\log_e K)\,P_1$	−0.0487
15	Sub-Carrier Oscillator No. 1	a_1	$(G/a_1)\,(\partial P_1/\partial G)$	0.0419
16	Commutator No. 1	b_1	$(G/b_1)\,(\partial P_1/\partial G)$	0.0423
17	Each Transducer, T_1-T_{10}	$d_1 \ldots d_{10}$	$a_1b_1d_i^7\,(144 - 243d_i + 100d_i^2)\,(\partial P_1/\partial G)$ $[d_i = d_i$ for $i = 1, 2, \ldots,$ and 10$]$	0.0702
18	One Transducer, T_1, T_2, T_3, T_4, T_5 or T_6	d_1, d_2, ... or d_6	$a_1b_1d^7\,(15d_j - 25dd_j + 10d^2d_j + 3d - 2d^2)\,(\partial P_1/\partial G)$†	0.0038
19	Transducer T_{10}	d_{10}	$(G/d_{10})\,(\partial P_1/\partial G)$	0.0423
20	Sub-Carrier Oscillator No. 3	a_3	$(J/a_3)\,(\partial P_1/\partial J)$	0.715
21	Commutator No. 3	b_3	$(J/b_3)\,(\partial P_1/\partial J)$	0.722
22	Each Transducer, $T_{21}-T_{25}$	$d_{21} \ldots d_{25}$	$a_3b_3d_j\,(2d-d_j^2)^{w_3}\,[d_j + 2(2+w_3)\,(1-d_j)]\,(\partial P_1/\partial J)$ $[d_i$ $i = 21, 22,$ and 25$]$	0.770

* $P_1 = ABCE\,J^{w_1}K^{w_2}\,(DG + D'FG + D'H - DFG - DGH - D'FGH + DFGH)$
In several functions the simplified notation $M = ABCE\,J^{w_1}K^{w_2}$ is used.

† $d_j = d_i$ for $i = j = 1, 2, \ldots,$ or 6; $d_i = d$ for $i = 1, 2, \ldots, 27, \neq j$

Reliability-Sensitivity Function Analysis

THE RELIABILITY formula for a device provides a useful means for analyzing the sensitivity of the unit to changes in part reliability. If the formula is partially differentiated with respect to a particular part-reliability variable, the resulting function can be called the reliability-sensitivity function with respect to that part.

This function describes the way reliabilities of other parts affect the sensitivity of the system to changes in the reliability of the particular part. When the sensitivity function is evaluated with numbers, it gives a numerical value for the rate of change of system reliability with respect to changes in the reliability of the particular part.

Those parts that yield the highest rates of change of system reliability should be specified as high as possible and must be controlled closely within narrow tolerance limits.

Let us examine the telemetering system described in the review. The reliability formula for this system is given as

$$P_1 = ABCEJ^{w_1}K^{w_2}(DG + D'FG + D'H - DFG - DGH - D'FGH + DFGH). \quad (1)$$

The partial derivative of this formula with respect to A is

$$\partial P_1/\partial A = BCEJ^{w_1}K^{w_2}(DG+D'FG+D'H- DFG-DGH-D'FGH+DFGH) \quad (2)$$

$$= P_1/A \quad (3)$$

This reliability-sensitivity function shows that the sensitivity of P_1 to changes in A is a function of the reliability of each of the other parts in the system. Furthermore, when eq (3) is evaluated using the part-reliability estimates given in Table 2 of the review, the sensitivity factor with respect to A is found to be 0.802. Since the sensitivity factors with respect to variables such A, B, C, and E in eq (1) can never be greater than 1.0, a value of 0.802 indicates high sensitivity and the need for careful control of the reliability of the related part. For instance, a 5 per cent change in A produces slightly over a 4 per cent change in P_1.

Several reliability-sensitivity functions and related numerical sensitivity factors for the telemetering system are given in Table 4. The information on Lines *1-14* is obtained in a straightforward manner, as described in the preceding paragraph. Lines *15* and *16* give the sensitivity with respect to changes in the reliability of Subcarrier Oscillator No. 1 and Commutator No. 1, respectively. Refer to Fig. 2 of the review. These sensitivity functions, and those on Lines *17*, *18* and *19*, are based on the reliability formulae for the subcarrier oscillator-commutator-transducer combination, which may be derived as follows:

● The probability of the successful monitoring of any variable V_i is $a_1b_1c_id_i$ and of *all* variables is

$$a_1b_1\left[\prod_{i=1}^{6} c_id_i\right]\left[\prod_{i=7}^{9} c_id_i\right]\left[c_{10}d_{10}\right]. \quad (4)$$

● The pairs of brackets group the factors related to Class-*1*, -*2* and -*3* variables, respectively. Class *1* variables are V_1-V_6. The channel including Subcarrier Oscillator No. 1 is successful if five out of the six Class *1* variables are transmitted. Two out of the three Class 2 variables, V_7-V_9, and the Class 3 variable V_{10}, are necessary to success during each complete revolution of the commutator.

● Consequently eq (4) is rewritten to show the probability that the minimum number of variables in each class are monitored successfully subject to the condition that the monitoring of one variable in Class *1* and *2* is unsuccessful. The resulting formula for the probability of success, which is denoted by G in Fig. 1 of the review, is as follows:

$$G = a_1b_1\left[\prod_{i=1}^{6} c_id_i + \sum_{i=1}^{6}(1-c_id_i)\prod_{j=1}^{6,\neq i} c_jd_j\right]$$

$$\left[\prod_{i=7}^{9} c_id_i + \sum_{i=7}^{9}(1-c_id_i)\prod_{k=7}^{9,\neq i} c_kd_k\right]\left[c_{10}d_{10}\right]. \quad (5)$$

The same logic is followed to write the probability of success

$$H = a_2b_2\left[\prod_{i=11}^{16} c_id_i + \sum_{i=11}^{16}(1-c_id_i)\prod_{j=11}^{16,\neq i} c_jd_j\right]$$

$$\left[\prod_{i=17}^{19} c_id_i + \sum_{i=17}^{19}(1-c_id_i)\prod_{k=17}^{19,\neq i} c_kd_k\right]\left[c_{20}d_{20}\right]. \quad (6)$$

The sensitivity functions for reliabilities a_1 and b_1 are derived by forming the products

$(\partial G/\partial a_1)(\partial P_1/\partial G)$ and $(\partial G/\partial b_1)(\partial P_1/\partial G)$

respectively. We make the simplifying assumption that all c_i's are equal to c and all d_i's are equal to d, as implied by Table 1 of the review.

The sensitivity of the system with respect to equal changes in the reliability of each transducer (T_1-T_{10}) associated with SCO No. 1 is shown on Line *17* of Table 4 with respect to any one transducer in group T_1-T_6 on Line *18*, and with respect to T_{10} on Line *19*. Information similar to that given on Lines *15-17* for SCO No. 1 and associated parts is given on Lines *20-22* for SCO No. 3, commutator No. 3, and transducers T_{21}-T_{25}, respectively.

Following the usual mathematical rules, reliability-sensitivity factors may be used to estimate the effects of simultaneous changes of several part reliabilities, provided these changes are small (up to maybe 5 or 10 per cent of original values)—or of a large change in a particular part reliability. Acceptable estimates can be obtained, also, for the effect of simultaneous large changes in two or more reliabilities provided the sensitivity functions reveal negligible interaction between these several variables. Typical computations are illustrated by the following examples:

● Estimate the value of P_1 which results when SCO No. 2 and associated transducers are eliminated, that is, when H is changed from 0.944 to 0.

$$P_1 = 0.786 - 0.944 \times 0.0455 = 0.753 \quad (7)$$

The exact new value of P_1 is 0.745, as given as Situation 2, Table 3 of the review.

● Estimate the value of P_1 which results when Transmitter No. 1 is eliminated, that is, when D is changed from 0.95 to 0 and D' from 0.99 to 1.0.

$$P_1 = 0.786 - 0.95 \times 0.00210 + 0.01 \times 0.792 = 0.792. \quad (8)$$

The answer is correct to the three figures shown. This estimation is possible because the reliability-sensitivity functions for D and D', respectively, are not functions of the other variable. *This computation reveals that under the stated set of conditions Transmitter No. 1 contributes undesirable redundancy and should be removed from the system.*

● Estimate the value of P_1 which results when SCO Nos. 1 and 2 and the associated commutators and transducers are eliminated.

The situation implies that G and H are each changed from 0.944 to 0; hence, the computation

$$P_1 = 0.786 - 0.944 \times 0.0439 - 0.944 \times 0.045 \quad (9)$$

is suggested. This computation is incorrect because the reliability-sensitivity functions with respect to G and H are not independent. For instance, the sensitivity factor with respect to H when G is zero is

$$\frac{\partial}{\partial H}\left[P_1\Big|_{G=0}\right] = 0.789, \quad (9)$$

which is much greater than the sensitivity factor of 0.0455 given in Table 4. Further computations, of course, are not required since a glance at eq (1) shows that when G and H are both zero, P_1 is zero.[2]

● Estimate the value of P_1 which results when both G and H are decreased to 0.894.

$$P_1 = 0.786 - 0.05 \times 0.0439 - 0.05 \times 0.0455 = 0.782 \quad (10)$$

The correct answer is 0.780. For small variations in G and H, the effect of the interdependence in the sensitivity function is negligible.

The work in this paper, as well as in references 1 and 2 is based on the use of point estimates for the reliabilities of the various parts. A more realistic approach, where the computations are based on the assumption that the expected reliability for each type of part is normally distributed with a particular mean and standard deviation, is suggested. A first step in this direction is made by the sensitivity-function analysis—whereby the effects of various tolerances on the point estimates for part reliability can be approximated easily.

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1. Reliability-Design Technique for Complex Systems, H. Elmore Blanton, ELECTRONIC DESIGN, Sept. 1, 1957.
2. Reliability-Prediction Technique for Use in Design of Complex Systems, H. E. Blanton, *Technical Report AV7M*, Hycon-Eastern, Inc., Cambridge, Mass.

The Cost of Missile Unreliability

Dr. Joseph Tampico
Vice President-Director of Engineering
Associated Missile Products Corp.

Missile unreliability can be combatted in two ways—by providing more comprehensive field checkout, or by shooting more missiles. The author examines the case for both sides and concludes that real economic advantages may result from better checkout . . . though he notes in passing that too much checkout can impair a "good" missile's reliability.

GUIDED MISSILES are presumed perfect when they leave the factory. The malfunctioning of a missile in its mission, therefore, can be attributed to its field handling, its deterioration in storage, influences of its flight environment, or its impairment through constant checking. There is a variety of missiles whose combat mission has a duration of only a few minutes but whose operating time on the ground may exceed 100 hours. This kind of protracted usage of the internal equipment of the missile is making its own contribution to missile unreliability.

It makes no difference in the mathematical concept of missile flight performance reliability if the missile functions perfectly on its mission as the result of extensive checkout, parts replacement and systems adjustment, or as the result of its being simply a reliable missile. The combination of relatively poor missiles plus excellent checkout and repair may yield the same flight performance reliability as physically perfect missiles delivered from the factory.

The most advanced and accurate checkout equipment available is generally that in use in the missile manufacturer's plant. This equipment is costly and is operated by highly-skilled manpower. This level of checkout is not only economically unfeasible for use in the field but the acute shortage of trained technicians in uniform would render such equipment ineffective. Checkout equipment for use at the squadron level must be simple and economical. The check list is reduced, precision is relaxed, procedures are often oversimplified, and the time required for checkout is extended.

Each of these compromises in the theoretically ideal factory method produces obvious money savings . . . at a cost in missile flight performance reliability. The problem to be solved is to obtain the highest practical missile flight performance reliability with the optimum degree of checkout time and money expenditure. We require a frequent check on the probability of a successful mission for every missile in our arsenal with minimum ground operation of the missile, minimum expenditure of manhours, and minimum total operational cost for maintaining mission capability.

A study of these objectives begins with an attempt to isolate the proportion of expenditures involved in the several factors comprising an aborted missile mission. The missile itself is not the largest item of expenditure in an unsuccessful mission. The supporting elements of the complete weapons system, when allocated to each missile, prove many times the cost of the missile itself.

If a fixed percentage of the missiles assigned to a squadron will probably abort, then a proportionate number of additional missiles must be procured if the full squadron effectivity is to be assured. Mission reliability, however, is determined by a variety of factors, and the skill probability of a weapon system is the product of:

- Probability of kill, given a hit;
- Probability of hit, given a reliable missile;
- Reliability of launching support system;
- Reliability of the missile itself.

Arbitrarily assuming a value of 0.80 as the probability of the launch being made successfully, the missile hitting the target and the target

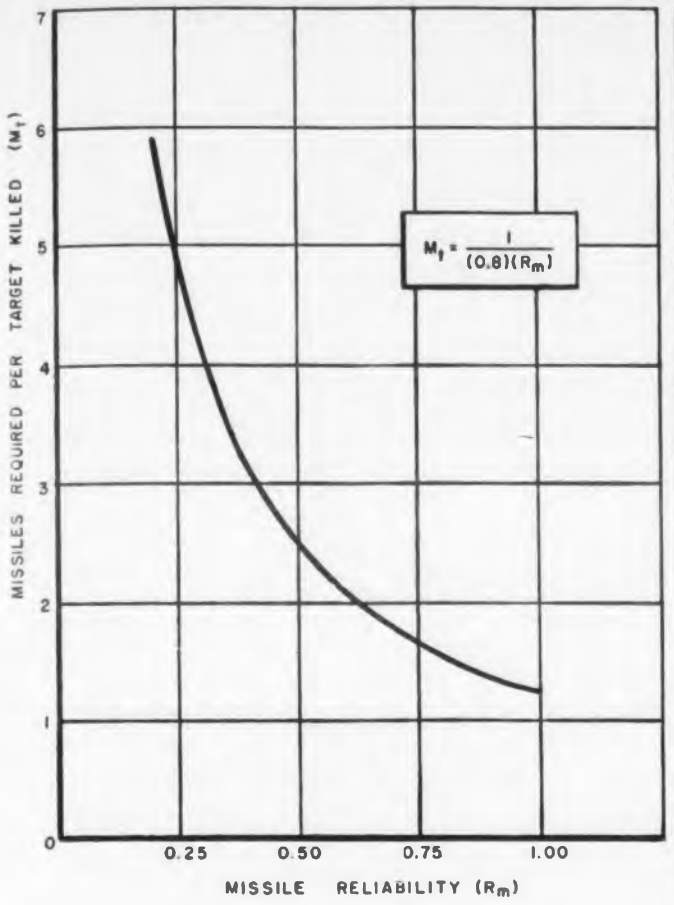


Fig. 1. Total of missiles necessary for a target kill is plotted against missile reliability. The probability of success of the launching, target hit and target kill is assumed to be 0.8, in this hypothetical example.

being destroyed, we may plot Fig. 1. In this way the total number of missiles required to provide squadron effectivity for varying degrees of missile reliability is determined. Study of the Figure reveals that as missile performance reliability falls below 100 per cent, the missile supply required to keep the squadron at full combat potential increases alarmingly.

The cost of the additional missiles required, however, is only a fraction of the total cost of unreliability. Each missile requires a shipping container, shipping, storage, ground handling, administrative records, repair, and overhaul. Additionally, it costs its proportional share of launching equipment, radar equipment, checkout and manpower expenditures at the squadron base. This total cost may vary from three to 15 times the cost of the missile alone.

It appears that missile checkout could offer a substantial economy as a primary means for improving missile flight performance reliability and, consequently, reducing the need for handling and launching excessive numbers of missiles. Measurement of the effect of additional checkout on missile flight performance reliability can be made by comparing this reliability before and after the use of such equipment. This effect can be illustrated analytically by assuming an

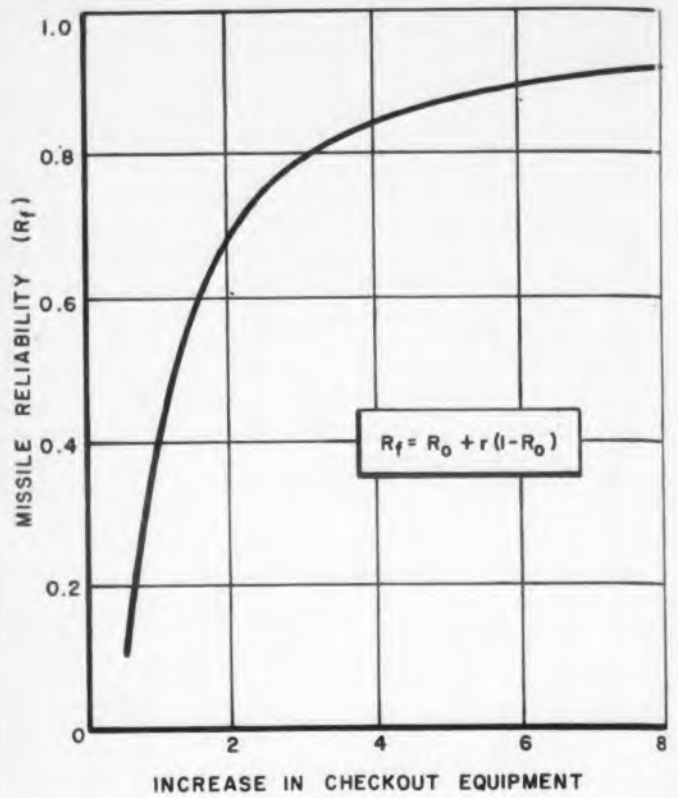


Fig. 2. If the effectiveness of increased checkout is equal to half the value of additional equipment it replaces (an arbitrary assumption), missile reliability increases as shown.

arbitrary "normal" amount of checkout, based on simplification of factory equipment. This amount of checkout is then increased, its effectiveness varying as a fraction of the effectiveness of the equipment to which it is added. This may be expressed

$$R_f = R_o + r(1 - R_o),$$

in which R_f = final missile reliability, R_o = original missile reliability, and r = effectiveness of additional checkout.

This relationship is shown in Fig. 2 for the assumption that the additional checkout is one-half as effective (arbitrary, constant) as the equipment to which it is added ($r = 1/2$). This plot reveals the sort of improvement in missile flight performance reliability which may be produced by more comprehensive ground checkout equipment and methods.

Cost of Checkout

This leads directly to examination of the cost of additional checkout equipment relative to its saving in aborted missions. Based on records to date, tactical missiles become obsolete and are withdrawn from service in a two-year cycle, due to wear and tear in constant checkout and continuous changes in design. The cost of checkout includes both the initial purchase of the equipment and its operating and maintenance costs. Available records show the latter is about equal

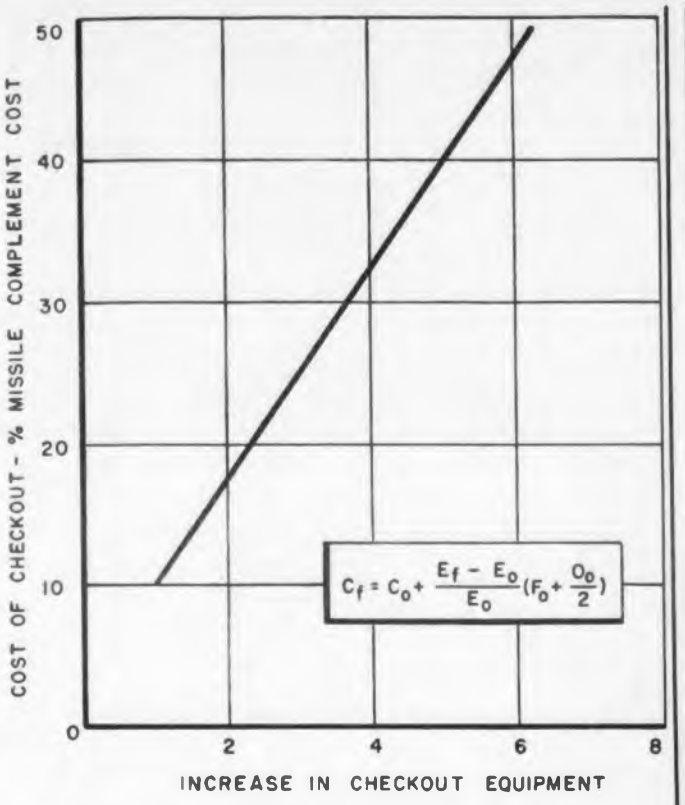


Fig. 3. The cost of buying more checkout equipment, maintaining and using it, may be less than buying and launching additional missiles to make up for their unreliability.

to the former over the two-year span of utilization. However, operating and maintenance costs for additional equipment within the two-year span should be approximately one-half equipment purchase price due to the economies realized from increasing equipment within a given shop area.

With these values, we write

$$C_f = C_o + \frac{E_f - E_o}{E_o}\left(F_o + \frac{O_o}{2}\right)$$

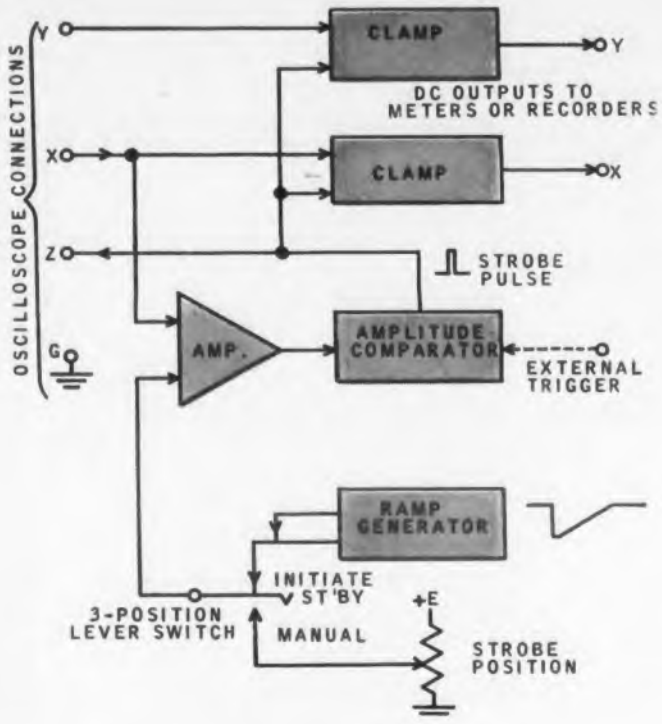
in which C_f is final cost for increased checkout, C_o is cost for "normal" checkout, E_f is final amount of equipment, E_o is original amount of equipment, F_o is cost for original equipment and O_o is the operating and maintenance cost for original equipment.

A plot of this equation is shown in Fig. 3 and it is seen that the cost of additional checkout equipment—including its operation and maintenance—may be less than a direct linear relationship with the percentage of cost of the squadron missile complement. Missile flight performance reliability may be improved by using additional checkout equipment at a cost below that of the expenditure of unreliable weapons.

A comprehensive report detailing the data and derivation of formulae presented is available from Associated Missile Products Corp., 2709 North Garey Ave., Pomona, Calif.

New Waveform Translator

Aids Quantitative Oscillograph Measurements



Waveform Translator Block Diagram.

QUANTITATIVE recording of repetitive waveforms from an oscilloscope trace has heretofore required the reading off of values visually point-by-point or by photographing them for subsequent reading. Recent development of a Waveform Translator removes the limitations imposed by direct-reading and photographic recording. The Translator, connected direct to CRT plates, converts waveform coordinates to static or slowly varying waveforms which can be read on conventional meters or recorded by servo-driven pen devices.

Operating Principle

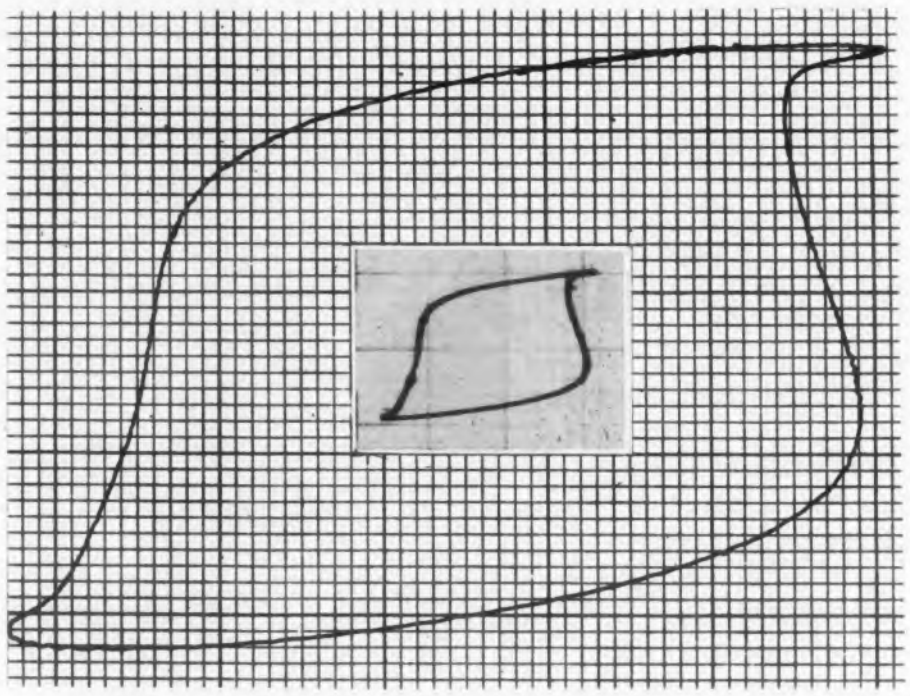
The Waveform Translator shown is a fully transistorized, battery operated device—developed by Transdata, 1844 Brigden Road, Pasadena, Calif. It operates on the principle of recurrent simultaneous sampling of both inputs (*X* and *Y*) at intervals equal to or very nearly equal to the waveform period. This operating principle will be evident from the block diagram. The oscilloscopic *X* and *Y* deflection signals resulting from normal oscilloscope function are applied to parallel sampling clamps. Sampling occurs when an amplitude comparator equates the *X* signal to a fixed or slowly varying reference voltage derived from a multi-turn potentiometer or a ramp generator. The strobe pulse produced by the amplitude comparator is used to drive the clamps and is also transmitted to the intensity or Z-axis of the oscilloscope to form a bright spot on the cathode-ray trace at the point being sampled.

Application

The waveform to be measured or recorded, which might typically be from a 18 kc astable multi-vibrator, is first adjusted for amplitude and synchronization on the oscilloscope. The sweep lever is depressed momentarily, displacing the strobe to the extreme left end of the trace. When the lever is allowed to spring back to center, the strobe slowly traverses the oscilloscope trace until it comes to rest on the extreme right end. Throughout this scanning interval, which is about 5 sec, the *X* and *Y* outputs of the Translator are accurate measures of the instantaneous coordinates of the scanning strobe point. This is the automatic sweep mode of operation.

Alternatively, a multi-turn potentiometer may be used to position the strobe along the trace or to move it at any desired rate over regions of particular interest. This is the manual mode.

If a continuous, periodic output waveform is



Typical "pen plot" from data converted by Translator. Inset photograph is recording from oscilloscope screen for comparison.

desired for recording on a strip chart, the oscilloscope "synch" is turned off and the trace is allowed to run slowly across the tube face; the strobe remains stationary in this mode.

Another use of the Translator is in the measurement or recording of *X-Y* figures in which time is parametric; magnetic hysteresis loops, voltampere characteristics, and Lissajous figures are representative functions. In such situations, the strobe is triggered by an external oscillator (which may be the unused oscilloscope sweep generator) at a frequency slightly different from that of the phenomena under examination. The result is that the strobe point traverses the loop slowly and recurrently; the pen of an associated *X-Y* plotter moves in accord with the apparent strobe motion (see figure).

The Translator provides all of the information available in the photograph but in an enlarged form suitable for immediate graphical design use or inclusion in reports. The versatility of scale, format, and arrangement afforded by servoed pen instruments enhances the utility of the resulting plots.

Also, where the photograph presents an instantaneous record of the entire curve, the Translator makes available the instantaneous coordinates of a point on a curve. Where quantitative measurement is required, coordinate output is to be preferred. In analog simulation, it is often desirable to tie together hardware operating at high frequency and dc analog computing equipment. The time-scale conversion coordinate output of the Translator permits its use as a "bridging" element in such simulation procedures.

General Characteristics

The Translator produces negligible loading of the oscilloscope (input impedance 500,000 ohms). Accuracy is essentially that of the oscilloscope used, since the sampling process introduces negligible error. The factor which limits the frequency of waveforms which the Translator can handle is the strobe pulse duration—about 2 μsec in present instruments. The waveforms translated are convolved by the sampling pulse in a manner corresponding approximately to a 500 kc bandwidth limitation. Allowing for some harmonic content in waveforms of average interest, estimated maximum repetition rate for allowable error is approximately 20 to 50 kc.

Output impedance of the Translator is about 0.25 μf capacitative in current models, and is intended for use with relatively high-impedance loads typifying vacuum-tube voltmeters and servo operated recorders. When used with inputs not derived from an oscilloscope, it is desirable that the peak-to-peak signal be in the 5-10 v range.

For additional information on the Waveform Translator, circle 21 on the Reader-Service Card.

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ELECTRONIC DESIGN presents here the first of a series devoted to saturable reactors in applications other than magnetic amplifiers. Dr. Storm, one of the world's leading authorities on magnetic devices, has written extensively on magnetic amplifiers and related subjects.

Applications of Non-Linear Magnetics

Herbert F. Storm
General Engineering Laboratory
General Electric Company
Schenectady, N. Y.

Part 1

1 Background

The saturable core device, which is the heart of the magnetic amplifier, will produce other important effects besides amplification. Such other effects find use in counters, timers, voltage and current references, frequency multipliers, firing circuits for thyratrons and ignitrons, pulse shaping circuits for magnetrons, rectifying circuits without conventional rectifiers, bistable flip-flops, frequency detectors, square wave oscillators, and many others.

In this paper, the saturable core device will be considered alone, and also in combination with other circuit elements. Only one component at a time will be introduced. The circuits described contain only one representative of each type of circuit element.

This method will permit discussing the fundamentals of most non-linear magnetic devices with a minimum number of components. For readers interested in a wider scope, many references have been added for further study.

The Saturable Reactor

In its simplest form, the saturable core device consists of a ferro-magnetic core with a single

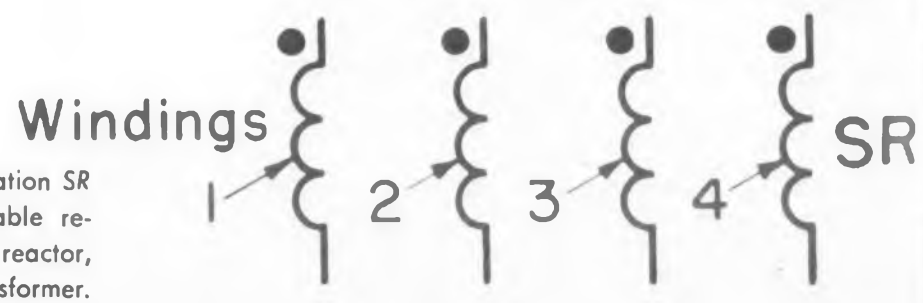

Fig. 1. The designation *SR* represents a saturable reactor, a saturating reactor, or a saturating transformer.

flux path, and one or several windings which are linked with essentially the same flux path (Fig. 1). This device will be designated by *SR* and no differentiation will be made between a saturable reactor, a saturating reactor, or a saturating transformer.

As a starting point, a toroidal core covered entirely by each winding is the preferred form. The ratio of outside to inside diameters of the core should not exceed 1.4. A suitable core material is anisotropic 50-50 nickel-iron, such as Orthonol or Deltamax.

The dots in Fig. 1 signify winding polarities. The voltage across each winding is defined as positive when the terminal with the dot is more positive than the other terminal. A current is called positive when it flows in the direction of the polarity arrow. The magnetomotive force, in all cases, is called positive when derived from a positive current

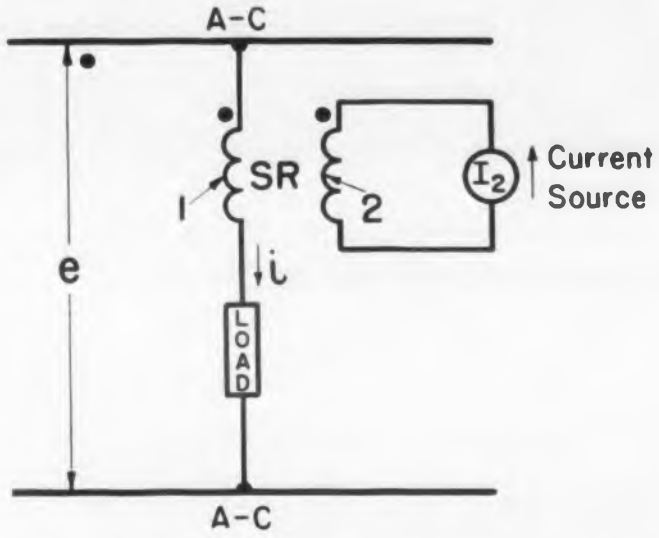

Fig. 2-2. Ordinary saturable reactor control.

2 The SR Alone

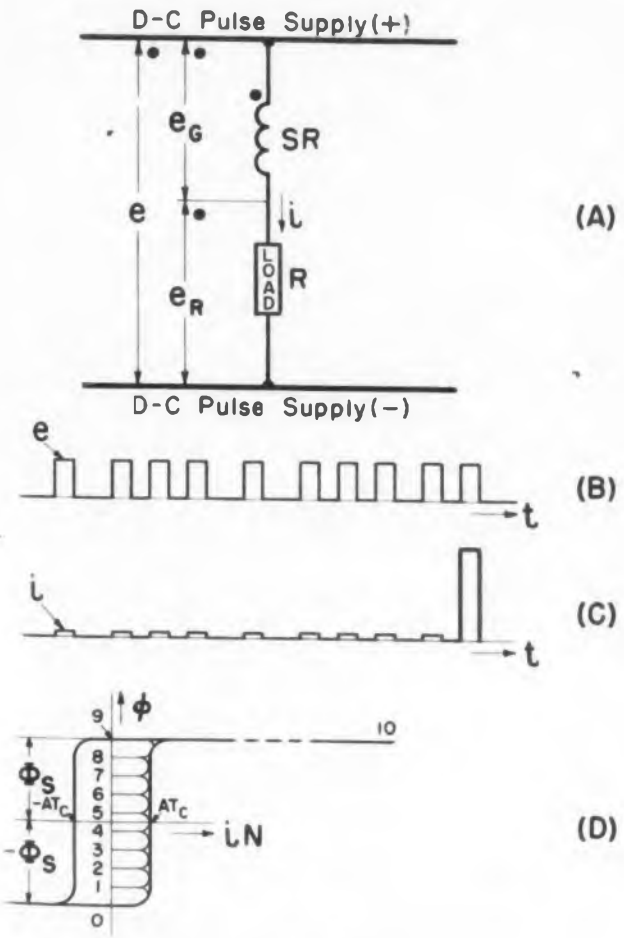

FIG 2 1

Fig. 2-1. Magnetic Counter: (A) Circuit diagram, (B) Counting pulses, (C) Current through load, (D) Flux-current loop of counting core.

Counters

The memory properties of a magnetic core can be used for counting. One form of counting device (Fig. 2-1A) consists of an *SR* which energizes the load after having received a predetermined number of pulses. The supply voltage *e* consists of pulses of constant volt-seconds (Fig. 2-1B) whose number represents the number to be counted. Fig. 2-1D shows the core properties.

Before the count starts, the core has been reset to negative residual flux as indicated by point *0* in Fig. 2-1D. The first counting pulse increases the core flux to a level indicated by *1*, and the flux will remain at this level until the next pulse arrives. As long as the core remains unsaturated, the supply voltage appears almost exclusively across the terminals of the *SR* and $e_G \approx e$. The flux $\Delta\Phi$ follows from

$$e_G = 10^{-8}\, N\, d\phi/dt \qquad (2\text{-}1)$$

$$\Delta\Phi \approx \frac{10^8}{N}\int e\, dt \qquad (2\text{-}2)$$

where e_G is the average value of the gate voltage, N is the number of turns, ϕ is the instantaneous flux, t is time in seconds, $\Delta\Phi$ is the flux change in maxwells, and e is the instantaneous value of supply voltage.

During the presence of the voltage, the load is traversed by a small magnetizing current (Fig. 2-1C) determined by the flux-current loop of Fig. 2-1D and

$$i = AT_c/N \quad \text{amps} \qquad (2\text{-}3)$$

where i is instantaneous current, and AT_c repre-

sents coercive ampere-turns.

Consecutive voltage pulses raise the flux level by equal amounts. At the end of the 9th pulse, in this particular case, the core will be at positive residual flux as indicated by point 9. When the next voltage pulse arrives, the core is driven into saturation (*10*, Fig. 2-1D). Then, the load current is no longer limited by eq 2-3; it increases substantially to

$$i = \frac{e}{R_L + R_G} \tag{2-4}$$

where R_L is the load resistance and R_G is the gate resistance.

The large current pulse indicates a completed count; thus we have a counter of 10. This large current pulse can be used, for instance, to actuate a relay, or to provide an input pulse for a second stage of a decade counter.

The memory properties of magnetic cores are also used for the storage of information in large scale computers (Ref. 2-1). For example, in a binary system, each digit can have only two values. By assigning one residual flux, say the negative one, to indicate *0*, and the positive residual flux to indicate *1*, the value of the digit can be stored. The time required to change the core from a *0* to a *1*, or vice versa (called flux reversal time) limits the computer's speed. To minimize the delay caused by eddy currents, the magnetically active part is often made of ferrite. Ultra-thin, vacuum deposited magnetic films promise further reduction of flux reversal time. (Ref. 2-2 to 2-4.)

Timers

If the counting pulses *e* (Fig. 2-1B) arrive at a constant rate, the counter becomes a timer. Such a device has been used as a weld control timer, counting up to 50 pulses per core (Ref. 2-5). A tap changing switch, connecting various numbers of active turns, permits different time settings. Suitable core materials for counting applications are those with rectangular flux-current loops such as Dynamax (Ref. 2-6), 65-Permalloy, 50-50 anisotropic nickel-iron, listed in sequence of preference. A pulse supply voltage of constant volt seconds can be obtained from circuit arrangements, such as described in sections 3 and 4 and shown in Figs. 3-1 and 4-1. A multi-stage decade counting device, which takes advantage of transistors, is described in Ref. 2-7.

Ordinary Saturable Reactor Control

By connecting one winding of the *SR* in series with the supply voltage and the load, and the other winding to a direct current source, the simplest form of magnetic amplifier results (Fig. 2-2). This circuit, particularly in its double core form, has found widespread attention in practice

and literature (Refs. 1-1 to 1-8, 2-8, 2-9), but it falls outside the scope of this paper.

The circuit of Fig. 2-2 is used not only as a power amplifier, but also as a constant current source, ac limiting reactor, phase shifter, frequency doubler, and measuring device for large direct currents and high direct voltages. While the single core arrangement also exhibits these properties to some extent, the higher efficiency of the double core arrangement makes it the preferred form for practical applications.

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From a paper presented at the AIEE Winter General Meeting in New York City, Feb. 2-7, 1958.

Even over the hill and far far away,
Beckman Expanded Scale Voltmeters read

RIGHT .*. AT A GLANCE

BECKMAN EXPANDED SCALE VOLTMETERS read sharp and clear: day or night, dark or light, near or far, up or down, fast or slow.

HOW'S IT POSSIBLE? We've simply expanded the useful portion of a conventional scale, completely eliminated the mass of non-essential, impossible-to-read divisions.

WHICH MEANS? Accuracy to 0.3% of center-scale value. And resolution of the highest order: 0.1 volt.

APPLICATIONS? Whether aground or aloft, there's a Beckman Expanded Scale AC or DC Voltmeter to meet your voltage measuring requirements. Eight basic models in 126 shapes, sizes and ranges for panel installations in ground systems, aircraft and test equipment.

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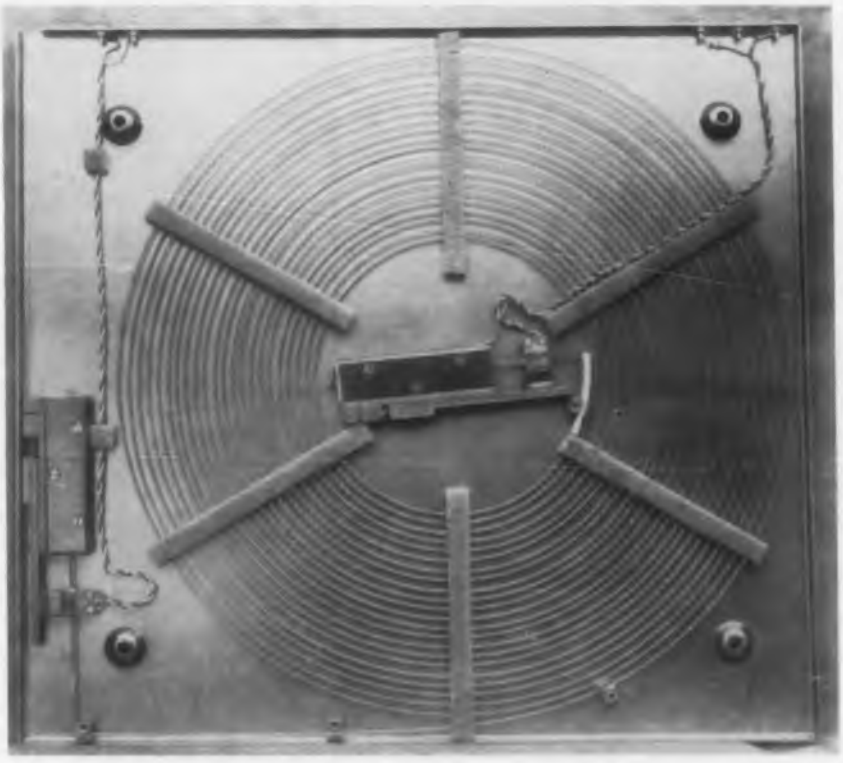
1174

CIRCLE 27 ON READER-SERVICE CARD

Millisecond Megacycle Delay Lines



The L40 is a 5 msec, 500 kc line. It can store 2500 bits.

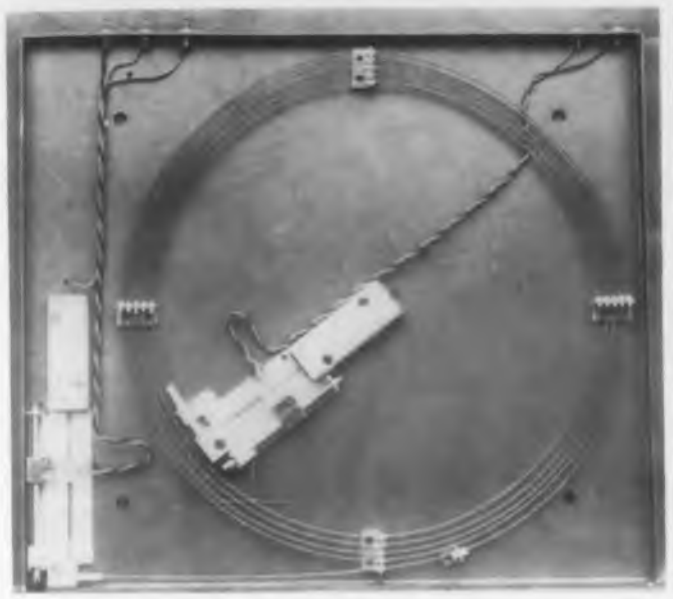
The L20 (100 μsec, 1 mc) operates in a longitudinal mode. Three taps are shown on the line.

TEMPERATURE stability and long delays at high frequencies are featured in these magnetostrictive delay lines. The new lines can operate with delays up to 5 milliseconds at a 500 kc digit rate or carrier frequency; or to one millisecond at a megacycle.

Designed by the Electronics Division of Ferranti Electric at 95 Madison Ave., Hempstead, L.I., N.Y., a typical package is only about 9 x 10 x 3/8 in. thick.

Limitations previously imposed by acoustic delays are removed by a special nickel-iron transmission medium with a very low temperature coefficient of delay, assuring a coefficient less than 5 ppm per deg C. As a result, ovens and temperature compensation are rarely required. This low coefficient is quite impressive when one recalls the coefficients for nickel and quartz, the usual delay line media, are, respectively, 140 and 75 ppm per deg C.

These packages can be supplied with



This is the L35, a one millisecond long, magnetostrictive delay line. It can operate at one megacycle digit rates in the torsional mode.

transistorized input and output amplifiers. Input amplifiers take a standard 5 v, 5 ma signal, while the output amplifiers provide 5 v at 10 ma.

When a line is used as a storage or memory device, one may use various digit rates and line lengths to obtain the required storage capacity. For example, the model L40, a 5 msec, 500 kc line can store 2500 bits; the L35, a 1 msec (±0.1 μsec), 1 mc line, can store 1000 bits of digital information.

Where the external bit rate is lower than the maximum for the line, the line can be time shared. Thus, where 500 kc pulses take the full capacity of a 5 millisecond line, one can use a 125 kc external clock to provide four recirculating paths and an effective bit rate of 500 kc.

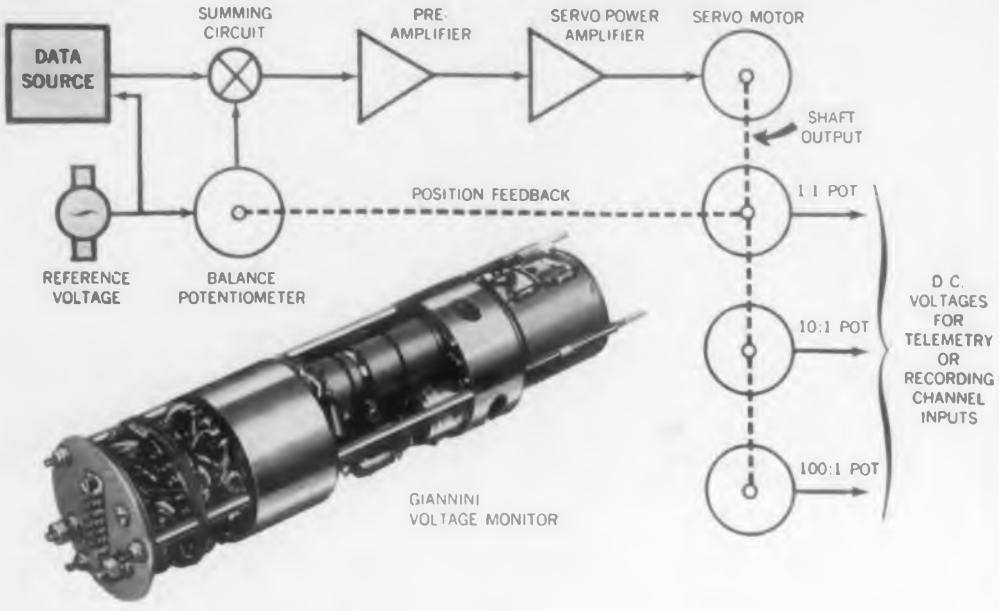
Lines are available which operate in a torsional mode, while others operate in a longitudinal mode. The latter can be tapped for shorter delays. On all lines, the overall delay can be adjusted through a range of 4 μsec by the user.

Though designed principally for digital storage (without requiring a carrier), these units can be used in analog applications where the required bandwidth does not exceed 50 per cent of the carrier or center frequency.

For more information on these new, temperature stable delay lines, turn to the Reader-Service Card and circle 28.

For 0.035% Accuracy
in your Airborne Data...

...Giannini
DATA REPEATERS



GIANNINI PRECISION VOLTAGE MONITORS are Data Repeaters which utilize the scale multiplying technique. They have an inherent accuracy of 0.035% under all conditions, and repeatability of one part in ten thousand. This is the first time that such accuracy has been possible in a small (2¼" x 9") unit capable of withstanding the extreme environments of airborne operation.

THE PRECISION VOLTAGE MONITOR alters a transducer or control system signal so that data relayed to the telemetering or recording system is less susceptible to system errors. A unit designed for incorporation in the airborne telemetering system of Chance Vought's Regulus II results in telemetered data with approximately 0.04% overall error. This figure is conservative, and includes the effects of all unit error sources such as hysteresis, linearity, temperature effects, and long term drift, as well as telemetering system error.

A VOLTAGE MONITOR CONVERTS AC output signals from an airborne data source into 3 DC voltages, representing the data to four or more significant figures. These three separate units of information are fed into the telemetering or recording system on three separate channels. The result is transmitted information with an accuracy of four or five significant figures.

WITHOUT CHANGING THE CIRCUITRY of the transmitting system in any way, errors incurred in transmittal are restricted to the fourth or higher order significant figures.

Designed to satisfy the extreme environmental demands of aircraft and missile data systems, Giannini Precision Voltage Monitors are also readily adaptable to other airborne or industrial applications requiring precise voltage monitoring, data repeating, or data multiplexing. They are available in voltage ranges from 0.0 to 0.8v to 0.0 to 100.0v, and sizes from 2¼" x 6" to 2¼" x 9".

Giannini measures & controls:

ϖ	β	θ	ψ	τ	v	ϕ
δ	Ω_r	α_t	h	P	ΔP	T
Ts	P_s	Qc	M	T_a	P_T	TAS

PRECISION INSTRUMENTS SYSTEMS & CONTROLS

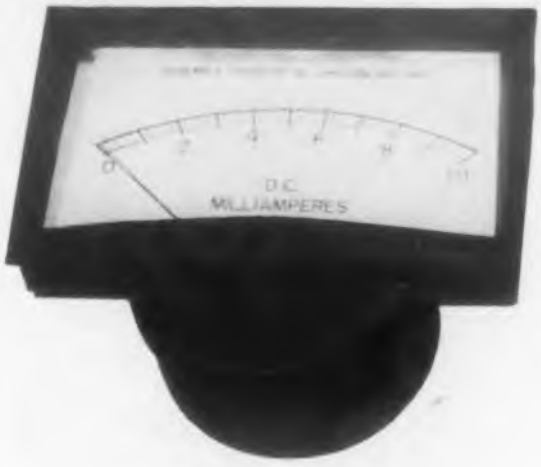
Giannini

G. M. GIANNINI & CO., INC., 918 EAST GREEN STREET, PASADENA, CALIF.

CIRCLE 30 ON READER-SERVICE CARD

Receding Chin Meter

Something missing? Where is the meter movement?



The non-display parts of this meter are recessed, giving the meter a "receding chin" effect.

A FIRST look at this meter on a panel gives one the uneasy feeling that something is missing. The works don't show! Only the indicating area is exposed to view.

Not only does this new meter improve the appearance of original equipment, it also improves the accuracy. With the magnet pole pieces well behind the panel, rather than in the same plane, magnetic error is reduced from the usual 5 per cent to only 1 per cent.

The new meter, model 561, was developed by Chesterland, Ohio's Assembly Products, Inc. Viewed in profile, it has a "receding chin" effect. About a third of the round barrel, which houses the meter movement, extends behind and below the rectangular dial section. The

High Speed

No cams—no contacts in this high speed rotary switch

RESOLUTION is improved while cam wear, switch wear, and contact bounce are eliminated in this new rotary switch. It provides pulses corresponding to angular positions of a rotating shaft. The voltage change, negative or positive, can be from 2 to 10 vdc at a 10 K impedance level depending on the external wiring and supply voltage.

Departing from cam follower actuated switch contacts, this product of Automation, Inc., of Wellesley Hills, Mass., employs an optical shutter on the shaft to gate light from an internal lamp to a variable resistance phototransistor. The transistor, a Texas Instrument type 800 npn grown junction germanium, has a 200 kc response, so that even at 5000 rpm the electrical response time is substantially independent of speed.

Phase alignment is adjusted easily, even when the shaft is driven at full speed, simply by rotating the dust-tight cover assembly. The optical shutter can be cut for any angular limits from 0.1 to 358 degrees.

The rugged assembly, including sealed ball bearings for a 1/2 in. shaft, has an OD of 4-3/8 in. and is 4-5/8 in. long. It weighs about 3-1/2 lb.

For more information, circle 32 on the Reader's Service Card .

Shows Face Only

Brackets hold the meter in place, so no positioning holes need be drilled in the panel. Note the plastic strip above the dial section.

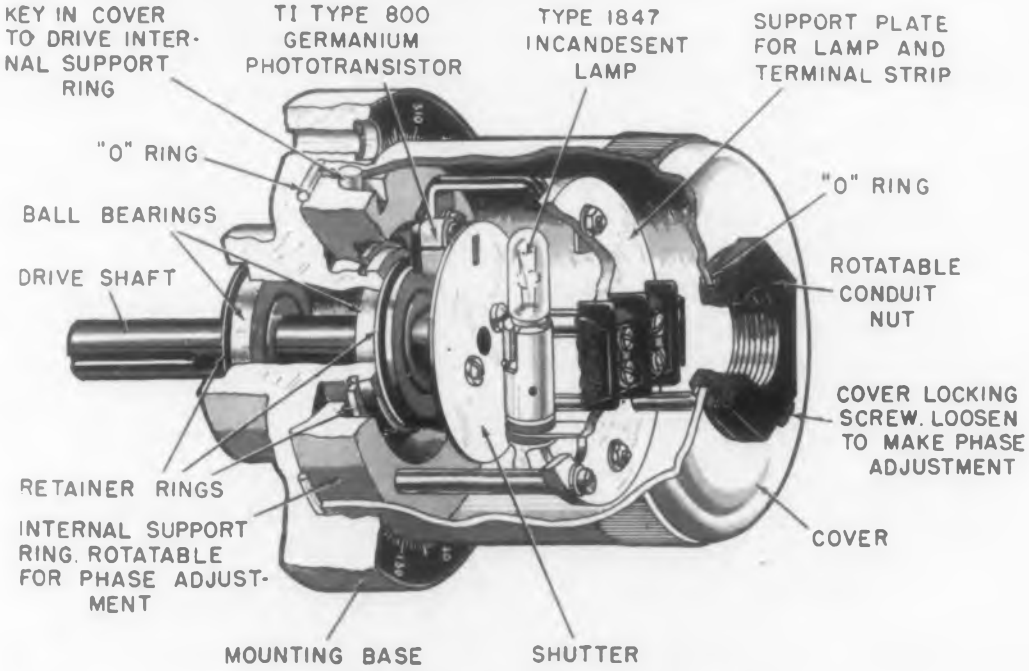
movement, face, and pointer tilt back about six degrees from the vertical front of the meter. This makes reading easier and reflects glare upward. A strip of plastic above the dial section transmits light to the dial, if desired.

In a panel, the meter rests against a flange behind the edges of the dial section. The housing has screw holes for attaching brackets that hold the meter in place from behind the panel. No panel holes need be drilled.

The dial section is 5 in. wide by 2-7/8 high, while the depth from the flange to the end of the barrel is 2-1/3 in. Sensitivities are available from 5 microamperes to 50 amps full scale.

For more information, circle 31 on the Reader's Service Card.

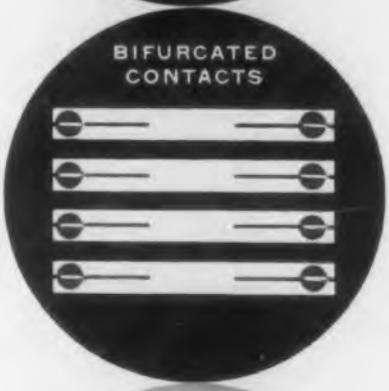
Rotary Photoswitch



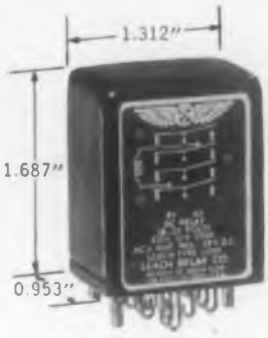
Photoswitch cutaway view. Slots may be cut in the shutter to suit individual requirements.

LEACH

balanced armature relays help you solve electronic circuit problems



First proven in all types of advanced aircraft, Leach *Balanced Armature* relays are now solving the most exacting problems for systems designers. Exclusive balanced armature design eliminates faulty operation of contacts due to vibration and shock forces. Bifurcated contacts assure high reliability in contact-making circuits. You'll find that these unique relays outperform all other types in resistance to shock, acceleration and vibration.



9220. . . Balanced Armature relay. Rectangular configuration. . . with a variety of mountings and terminals available. Hermetic sealing is 100% tested by mass spectrometer.

Typical Ratings

Normal operating voltages—6-115 vdc, 115 vac (400 cycle), 4 PDT.
Contact ratings @ 28 vdc or 115 vac single-phase
Resistive – 3 amp @ 120°C
– 5 amp @ 85°C (dc only)
Inductive – 1.5 amp @ 85°-120°C
Motor Load – 1.5 amp @ 85°-120°C
Rated duty – continuous
Minimum operating cycles – 100,000
Weight – 0.25 to 0.30 lbs.
Shock – 50 G's
Vibration – 10 G's, 0-500 cps
Applicable specifications – MIL-R-6106B, MIL-R-5757C
Also available in units to meet the minimum current requirements of MIL-R-6106C
We invite other special requirements such as microamp switching, high vibration and special mountings.

See for yourself

Write today for your copy of the Leach *Balanced Armature* Catalog describing relays for electronic and missile applications.

LEACH

CORPORATION

Leach Relay Division

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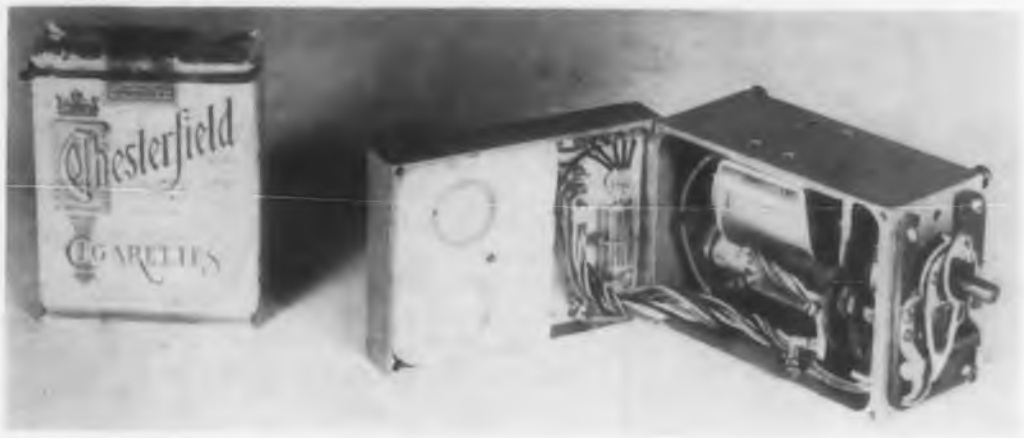
CIRCLE 33 ON READER-SERVICE CARD

NEW PRODUCTS

To provide a complete coverage of ALL new products generally specified when designing electronic original equipment, the New Product section has been extended. To include the larger number of items, products which are best suited to a brief description have been noted at the end of the section.

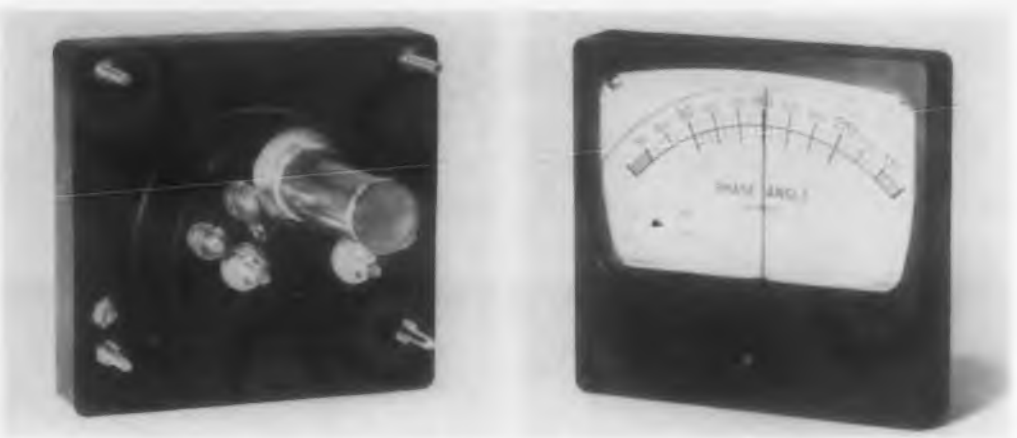


SERVO UNIT

High speed and torque characteristics in a small package are featured in this dc servo unit. Model 2, shown, has an output torque of 2 ft-lb and a free running speed of approximately 250 deg per sec. Resolution is better than ±0.45 per cent. Power input is 28 v dc center tapped, and input impedance is 1 meg. Transistors are used throughout except for a tube at the input stage. Besides the model 2, both 10 and 25 ft-lb units of comparable characteristics have been developed.

Advanced Research Assoc. Inc., Dept. ED, 4128-B Howard Ave., Kensington, Md.

CIRCLE 34 ON READER-SERVICE CARD



MEMORY METER

Holding a reading for as long as desired makes this meter particularly applicable wherever readings cannot be noted immediately. The unit consists of a sensitive panel meter with a rear-mounted solenoid that is normally energized so that its plunger is retracted. When a reading is desired, the solenoid is de-energized, holding the pointer fast between the face plate and a clamper plate mounted over the top arc of the face plate. The meter is available in almost any sensitivity range, from a few μa up to 50 amp or 500 v, either dc or ac.

Assembly Products Inc., Dept. ED, Chesterland, Ohio.

CIRCLE 35 ON READER-SERVICE CARD

COMMUTATOR SWITCHES

Long life, rated at 500 hr minimum, and small size are qualities of this line of commutator switches. The switches are available in a wide selection of poles and positions, and in speeds from 1/8 to 30 rps. Circuits include two independent switch sections per commutator on the model TSC-50, and three independent swich sections on the model TSC-51. Rated performance is achieved at temperatures to 85 C and vibration of 25 g to 2000 cps. Weight is less than 2 lb.

Bendix Aviation Corp., Pacific Div., Dept. ED, 11600 Sherman Way, N. Hollywood, Calif.

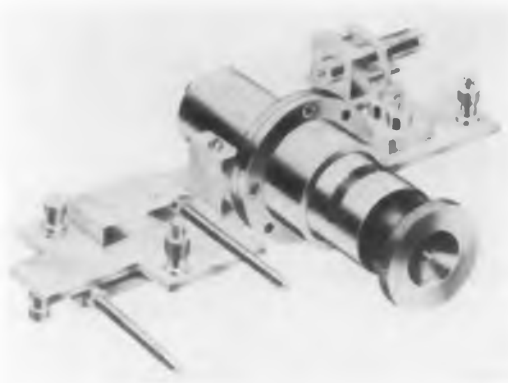
CIRCLE 36 ON READER-SERVICE CARD

DIGITAL READOUT

Large Numeral In-Line Readout is provided with the model 401A, which due to its modular construction, allows the relay trees and lamp assemblies to be used separately or with other equipment. The typical small numbers of the average counter are presented as 2-1/2 in. numerals in correct reading sequence. The numerals are formed by a number of small high intensity neon bulbs, which are set well back in a honey-comb formation to provide a precise easy-to-read image. For simultaneous, multiple or remote use, two or more readouts may be activated by one digital counter.

Computer-Measurements Corp., Dept. ED, 5528 Vineland Ave., North Hollywood, Calif.

CIRCLE 37 ON READER-SERVICE CARD



MICROWAVE TRANSMISSION LINE

Reduction in Size and Weight for microwave transmission systems is made possible by this Strip-Line assembly package. Utilizing a sandwich type of construction, printed circuitry has been adapted to permit microwave energy transmission over the frequency bands between 500 mc and 12,000 mc. Electrical characteristics, in general, can be compared with co-axial cable.

Kearfott Co., Inc., Western Div., Dept. ED, 1544 Oxnard St., Van Nuys, Calif.

CIRCLE 38 ON READER-SERVICE CARD

NEW PRODUCTS

Microwave Power Divider

20 Db Isolation

A rat race microwave hybrid for use in the 68 to 73 kmc band, the MA-606 has an isolation in excess of 20 db over the specified bandwidth. The unit is useful wherever exact power division with negligible cross talk is required. When used in conjunction with two mixer crystals, such as the MA-412, the assembly will perform as a balanced mixer. Balance is 1/2 db, and vswr is 1.25 max. Mating surfaces connect with flange type UG-385/U used with RG-98/U waveguide.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 41 ON READER-SERVICE CARD

Switching Reactors

Standard line of eight offered in four ratings

The switching action of these eight reactors is based on impedance changes, and enable them to translate inputs to plain logic operations using normal control voltages. Inherent power switching ratios are 10,000 to 1 for off to on states, with nominal supply voltage, and windings are provided for logic inputs. The windings permit zero to maximum output with 20 ma of control, but each winding can withstand 80 ma. The eight models are offered in four nominal volt-ampere ratins of 15, 75, 150 and 300 for switching either ac or dc loads. One group of four with the above va ratins operates directly from nominal supply voltages, whereas the other delivers standard load voltages.

Control, Div. of Magnetics, Inc., Dept. ED, Butler, Pa.

CIRCLE 42 ON READER-SERVICE CARD

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Circulation Manager

Thermal Relay

Features high sensitivity

Various power requirements of the TR-103 thermal relay range from 0.05 w to 0.004 w dc ac or rf. Actuating voltage is 0.4 to 0.5 v. Component parts will withstand 1.5 v without failure. Operational differential voltage is 0.02 v. With proper arc suppression (0.01 μf) this relay will accommodate a 100 w tungsten lamp load. The TR-103 is hermetically sealed in a glass vial to eliminate contamination or oxidation of parts and to provide for visual inspection of contacts.

Hamlin, Inc., Dept. ED, 1316 Sherman Ave., Evanston, Ill.

CIRCLE 66 ON READER-SERVICE CARD

VTVM

Tilting meter provides accurate readings

Model 904 vtvm permits the user to tilt the meter movement to eye level from any angle for more accurate readings. Another feature is a switch provided to short or open test leads for zero and infinite ohms adjustment. The meter reads peak-to-peak and rms voltages. Frequency range is up to 250 mc when used with the 912 probe, and voltage range goes up to 30,000 v with the 999 hv probe. A true zero alignment scale for fm and tv discriminators is provided. Input impedance for dc is 11 meg.

Precise Development Corp., Dept. ED, 2 Neil Ct., Oceanside, N.Y.

CIRCLE 67 ON READER-SERVICE CARD

CIRCLE 68 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Wiring Harness

Shielded zipper-type acts as uhf ground

This laminated type of Zippertubing consists of plastic saturated fiberglass backing laminated to aluminum, lead or magnetic foil. The laminated metal foil provides a method of grounding rf and uhf less expensively than conventional tin or copper shielding with outer jacket. The tubing weighs much less than conventional shielded harness, and is available with an overlap construction which offers full coverage. The shielding material is available in sizes 3/8-in. id and larger in wall thicknesses of 20, 40, and 60 gauge.

Zippertubing Co., Dept. ED, 750 S. San Pedro, Los Angeles, Calif.

CIRCLE 47 ON READER-SERVICE CARD

Power Supply

Operates most travelling wave tubes

Model 4998 power supply is a compact unit for operation of most low level and intermediate level permanent magnet traveling wave tubes. The unit is completely metered for quick determination of all important voltages and currents.

Wave/Particle Corp., Dept. ED, Box 252, Menlo Park, Calif.

CIRCLE 48 ON READER-SERVICE CARD

◀ CIRCLE 46 ON READER-SERVICE CARD

Silicon Diode

Power dissipation of 200 mw

This silicon diode will handle an average rectified current of 200 ma and has a power dissipation rating of 200 mw. Designated 1N658, the unit will operate from −65 to 175 C. Forward voltage drop is under 1 v at 100 ma, with a 0.3 μsec reverse recovery. Peak inverse voltage is 120 v, with a reverse leakage of 0.05 μa at −50 v and 25 C, and 25 μa at −50 v at 150 C.

Radio Receptor Co., Inc., Dept. ED, 240 Wythe Ave., Brooklyn, N.Y.

CIRCLE 49 ON READER-SERVICE CARD

Strain Gage Indicator

Digital readout in true units of measure

This digital strain gage indicator converts analog signals to digital readout in true units of measurement. For example, if the instrument is used for load cell measurement, the readout is in actual pounds. A panel permits adjustment of controls to accommodate full or half bridge transducers with 1, 2, or 4 active legs, and to select the proper polarity. Other controls regulate amplifier gain and balance and permit transducer calibration with built in calibrated precision resistors of various ranges. A choice of visual or automatic digital readout is available for recording.

Datran Electronics, Dept. ED, 3015 Aviation Blvd., Manhattan Beach, Calif.

CIRCLE 50 ON READER-SERVICE CARD

CIRCLE 51 ON READER-SERVICE CARD ➤

Transitron

Silicon Transistors

DESIGNED FOR HIGH RELIABILITY MILITARY SYSTEMS

A new family of Silicon Transistors, the 2N471A, 2N474A and 2N479A are now available for use in the most critical military applications. Complete specifications in MIL-T-19500A format include rigid life, environmental, electrical and mechanical tests to assure high performance reliability.

Through close process control, these units have exceptionally low I_{co} up to their maximum voltage and temperature ratings. They can be used with confidence even with the simultaneous application of maximum ratings.

Type	Common Emitter Current Gain, β	Maximum Collector Cut-off Current At V_c Max (u a)	Maximum Collector Voltage V_c Max (Volts)
2N479A	40 to 100	0.5	30
2N474A	20 to 50	0.5	30
2N471A	10 to 25	0.5	30

ENVIRONMENTAL TESTS INCLUDE

Operating Life Test	Temperature Cycling
Storage Life Test	Vibration Fatigue
Moisture Resistance	Vibration Noise
Lead Fatigue	Shock
Soldering	Centrifuge

Features:

- Low I_{co} up to Rated V_c maximum.
- Operation to 175° C
- 200 mw power rating
- JETEC 30 Package
- Excellent high temperature stability
- Welded Hermetic seal

Send for Bulletin TE-1353

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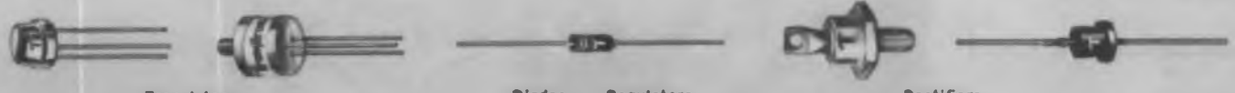


Transistors Diodes Regulators Rectifiers

NEW PRODUCTS

Backward-Wave Oscillator

Signal source for 49-59 kmc use

Type TE-57 backward wave oscillator has applications where low power, voltage tuned millimeter wavelength r-f energy is required. Weighing 5 oz without magnet, and measuring 8 in. long, the tube has an average output of 5 mw over the range from 49 to 59 kmc anode voltage ranges from 1000 to 3000 v. Beam current is 10 ma, and magnetic field strength is 1300 gauss minimum.

The tube has application in advanced types of multichannel telephone and television systems using circular waveguide for transmission, high definition short range radar, highly directive communications, and microwave spectroscopy.

Bendix Aviation Corp., Red Bank Div., Dept. ED, Eatontown, N.J.

CIRCLE 52 ON READER-SERVICE CARD

Preamplifier

High input impedance achieved without tubes

Model 110 Amplifier is completely transistorized and self-powered from ordinary C cells. It features an input impedance of over 1 meg, continuously adjustable gain to 50 db, response from 10 cps to 500,000 cps, 0.5 per cent maximum distortion, 750 hr battery life.

Burr-Brown Research Corp., Dept. ED, Box 6444, Tuscon, Ariz.

CIRCLE 53 ON READER-SERVICE CARD

CIRCLE 54 ON READER-SERVICE CARD ➤

Ferrite Isolator

Covers entire useful X-band

The BX 812 I load isolator is constructed with RG-52/U waveguide and covers the entire useful X-band frequency range from 8.2 to 12.4 kmc. The unit is 3.5 in. long, lightweight, rugged, and has a typical isolation of 20 db with an insertion loss of 1 db.

Rantec Corp., Dept. ED, P. O. Box 18, Calabas, Calif.

CIRCLE 55 ON READER-SERVICE CARD

Power Supplies

Provide highly regulated 60-v output

Model 6-IMB and Model D.6-300B are closely regulated dc power supplies designed for use in transistor circuit development. Both models are continuously variable from 0 to 60 v, but differ as to load ratings, which are 1 amp and 300 ma. Model D.6-300B provides two independent floating outputs.

Regulation for both models is 20 mv change, no load to full load, and for line change of 105 to 125 v ac. Ripple and internal noise are below 1.5 mv rms. Units are designed for very low output impedance and fast recovery time. One per cent meters are provided.

Dressen-Barnes Corp., Dept. ED, 250 N. Vinedo Ave., Pasadena, Calif.

CIRCLE 56 ON READER-SERVICE CARD

NEW PRODUCTS

Wirewound Resistor

Hermetically sealed, ceramic type enclosure

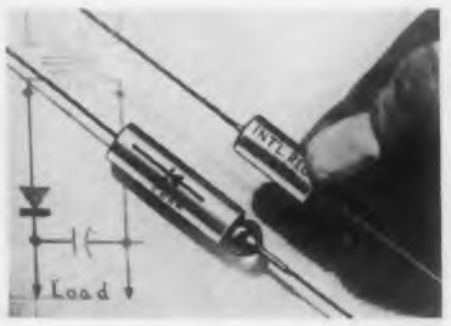
This ceramic enclosed wirewound resistor passes temperature, humidity, salt water, and thermal shock tests as per MIL R-93A specifications. Stability is achieved through the absense of any material which would constrict outer windings. The resistor has particular application wherever there are gamma or neutron fields.

Dmeter Mfg. Co., Inc., Dept. ED, 22-24 Larkin Plaza, Yonkers 2, N.Y.

CIRCLE 58 ON READER-SERVICE CARD

Silicon Power Diodes

Ratings extended to 2400 v piv



This series of silicon cartridge type rectifiers has ratings up to 2400 v piv, which provides a complete range from 600 to 2400 volts piv now available in this company's cartridge type. Designation is IN1410, IN1411, IN1412 and IN1413, with ratings of 1500, 1800, 2000 and 2400 v respectively, all at 100 ma. The operating temperature range for these diodes is —55 to 150 C ambient.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 59 ON READER-SERVICE CARD

◀ CIRCLE 57 ON READER-SERVICE CARD

Toggle Switch

Provides double-pole 3-position operation

Type 2050 toggle switch provides three circuit arrangements: single throw on-off, double throw on-on, or double throw on-off-on. A flush panel-mounting type, the switch has ratings of 15 amp, 125 v, 7-1/2 amp, 250 v ac.

Ark-les Switch Corp., Dept. ED, 51 Water St., Watertown 72, Mass.

CIRCLE 60 ON READER-SERVICE CARD

Computing Galvanometer

Will add, subtract, multiply, and record resultant

This computing galvanometer, model 7-370, will add, subtract, and multiply two signals and record the resultant. According to the manufacturers, previous computing galvanometers could be applied only to utility power measurements, and no galvanometer could perform all three of these basic computations. Designed for low-level measurements, the unit will record instantaneous power. Its phase sensitivity also enables the user to determine power factor.

Three galvanometer bodies are used in the construction of the 7-370. The center body houses the moving-coil suspension and mirror, and two outside bodies house the stationary field coils. A static reference mirror is fixed to one outside body for marking zero. In the power-measurement application, the static reference is used to mark zero watts. The 7-370 will add by using the two stationary field coils and applying a constant dc potential to the moving coil suspension. This effectively adds the ampere turns in the field coils. Reversing one of the field coils will cause subtraction. In multiplication, the sum of the field effect (magnetic flux density) times the moving-coil current result in a deflection proportional to the product of the two input signals.

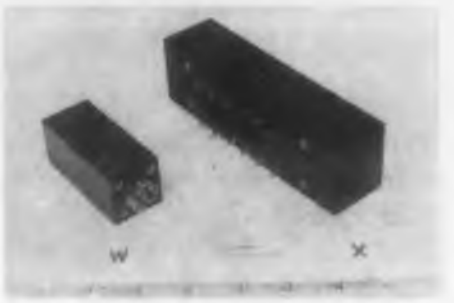
Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 61 ON READER-SERVICE CARD

NEW PRODUCTS

Delay Lines

A magnetic core type providing a wide bandwidth in a compact size



Two series of these delay lines, designated WM and XM, are available. Lines are available with delays ranging from 1 to 10 μsec, and with characteristic impedances from 200 to 2000 ohms. The feature of these delay lines are given in terms of the following figures: the bandwidth-delay product per unit volume is 7.3 (mc-μsec)/in³ for the WM series, and 7.1/in³ for the XM series; for pulses of conventional length, delay-time-to-rise-time ratios of 30:1 are attainable with the WM series, and ratios of 80:1 to 100:1 are attainable with the XM series. When these lines are designed for very short pulses appreciably better ratios are attainable.

Jacobs Instrument Co., Dept. ED, Bethesda, Md.

CIRCLE 64 ON READER-SERVICE CARD

Rotary Joints

Peak power ratings over 10 megawatts

A line of high power, broad band, single and dual channel rotary joints for high power, vhf and uhf applications has been announced. The rotary joints are capable of withstanding peak power loads in excess of 10 megawatts and average power in the 500 kw to one megawatt range. These stock designs are available for radar, radio telescope, and high power tracking requirements. Modification of some of these stock designs is possible for peak power applications as high as 45 megawatts.

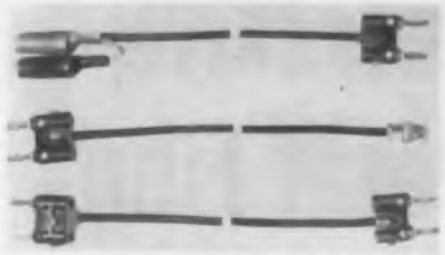
General Bronze Corp., Dept. ED, Stewart Ave., Garden City, N.Y.

CIRCLE 65 ON READER-SERVICE CARD

◀ CIRCLE 63 ON READER-SERVICE CARD

Patch Cord

Permits parallel multiple stacking



These patch cords come with a choice of three different cables: two conductor twisted 18 gauge wire with Vinyl insulation and a nominal capacity of 30 μμf per ft shielded microphone cable with a nominal capacity of 25 μμf per ft., and coaxial shielded cable with a nominal capacity of 28.5 μμf per ft. The molded polyethylene plug body is fully insulated, and permits parallel multiple stacking.

Pomona Electronics Co., Inc., Dept. ED, 1126 W. Fifth Ave., Pomona, Calif.

CIRCLE 43 ON READER-SERVICE CARD

Traveling Wave Amplifier

Provides peak pulsed output of 10 w over 2 to 4 kmc band.

This broadband traveling wave tube amplifier, model PA-3, operates from 2 to 4 kmc without the necessity of electrical or mechanical adjustments. Specifications over this bandwidth include a signal gain of 36 db min, saturation gain of 30 db min, peak power output of 10 w, capsule length of 13-1/2 in. and net weight of 1 lb. Provision is made for anode modulation in such a way that any electrode may be operated at ground potential.

Huggins Labs., Inc. Dept. ED, 711 Hamilton Ave., Menlo Park, Calif.

CIRCLE 44 ON READER-SERVICE CARD

CIRCLE 45 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Connector

Has removable wire lanyard

Model DM9714-3S connector provides three contacts and is equipped with a special coupling ring that permits use of a removable lanyard. It can be installed without the lanyard, which may be attached later. A cable grommet is used on the end of the connector.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 69 ON READER-SERVICE CARD

Parts Counter

Counts non-magnetic pieces

Designed to satisfy automation needs where accurate counting of non-magnetic parts is required, this unit is essentially a proximity coil with unbalanced fields. Zinc and lead parts passing through the coil actuate a control relay by producing a phase shift. The winding consists of two aiding primaries and two bucking secondaries. Sensitivity is controlled by adjusting a screw which distorts the field of one primary and one secondary winding to unbalance the system. A non-magnetic material passing through the coil balances the system and actuates the relay.

Automatic Timing & Controls, Inc., Dept. ED, King of Prussia, Pa.

CIRCLE 70 ON READER-SERVICE CARD

Flexible Couplings

Transmit up to 45 in.-lb at high speed

Made in 2 stock models and in 2 sizes for each model, these couplings range from 15/16 in. to 1-5/16 in. od for shaft diameters from 1/8 to 1/2 in. They are rated to transmit from 30 to 45 in.-lb. torque at high speeds, and are torsionally rigid with no backlash. The couplings absorb angular misalignment up to 7-1/2 deg, lateral misalignment up to 0.015 in., and axial movement up to 0.06 in. in a single unit.

Dial Products Co., Dept. ED, 9 Avenue E, Bayonne, N.J.

CIRCLE 72 ON READER-SERVICE CARD

Nickel Cadmium Batteries

General purpose types with ratings to 160 amp-hr

Designated the VO-series for general purpose use, this rechargeable line includes nickel cadmium batteries with nominal voltages in multiples of 1.2 v with rated capacities from 0.1 to 160 amp-hr. The sintered plates used make possible the construction of cells with extremely low internal resistance, capable of delivering peak currents up to 20 times normal rated capacity. The non-gassing batteries can be recharged easily using constant potential or constant current system. Other characteristics include flat discharge, dependable performance from −20 to +165 F, with special units available for −40 F operation.

Gulton Industries, Inc., Alkaline Battery Div., Dept. ED, 212 Durham Ave., Metuchen, N.J.

CIRCLE 73 ON READER-SERVICE CARD

NEW PRODUCTS

Carrier Voltage Attenuators

Pushbutton operation

Called the Alectra 40 series, the first two of these instruments (models 40A and 41A), operate in the frequency range from dc to 600 kc. Pushbutton switches are used to select values of attenuation from 0 to 82 db in 1-db steps. Both models are calibrated for operation into 600-ohm circuits. The attenuator configuration is unbalanced in the 40A and balanced in the 41A.

Consolidated Electrodynamics Corp., Alectra Div., Dept. ED, 326 N. Altadena Dr., Pasadena, Calif.

CIRCLE 75 ON READER-SERVICE CARD

Power Supplies

Hermetically sealed

Model RPS-5K power supply has an output voltage of 5000 v dc, regulated to within 3 per cent over its range of 0 to 150 μa. Output remains within 3 per cent when input voltage varies from 95 to 130 v ac. Model RPS-5K is potted with epoxy resin and hermetically sealed. Other similar models are available having input voltages from 24 to 550 v, with outputs from 600 to 5000 v dc.

American-Monarch Corp., American Electronics Div., Dept. ED, 81 N. E. Lowry, Minneapolis, Minn.

CIRCLE 76 ON READER-SERVICE CARD

◀ CIRCLE 74 ON READER-SERVICE CARD

Standard Signal Generator

Accuracy of ±0.005 Per Cent

Having an accuracy of ±0.005 per cent, type 209 supplies 400 cps with an output of 0 to 10 v continuously variable. Output impedance is 2500 ohms, and distortion is less than 0.5 per cent. The instrument has a tuning fork oscillator, with negative feedback for amplitude stabilization.

Advance Electronics Lab., Inc., Dept. ED, 249-259 Terhune Ave., Passaic, N.J.

CIRCLE 78 ON READER-SERVICE CARD

Silicon Diode

120 PIV, 200 Ma

The 1N658 silicon junction diode is designed for computer, communications, and general moderate power applications. Forward voltage drop is under 1 v at 100 ma, with a 0.3 μsec reverse recovery. Peak inverse voltage is 120 v, with a reverse leakage of 0.50 μa at −50 v and 25 C, and 25 μa at −50 v at 150 C. Operating temperature of the diode is from −65 to 175 C. It will handle an average rectified current of 200 ma and has a power dissipation rating of 200 mw.

Radio Receptor Co., Inc., Germanium & Silicon Div., Dept. ED, 240 Wythe Ave., Brooklyn, N.Y.

CIRCLE 79 ON READER-SERVICE CARD

Hysteresis Motor

1-In. Diam

This 115 v, 400 cps hysteresis synchronous motor measures 1 in. od by 1-13/64 in. long. Weight is 1-1/2 oz, speed 3000 rpm, torque 10 oz-in. at 1 rpm, input 2-1/2 w, and rotation is reversible. In addition to the motor, a gear train is available, giving an overall package measuring 1-53/64 in. long by 1 in. diam.

Advanced Products Co., Dept. ED, 59 Broadway, North Haven, Conn.

CIRCLE 80 ON READER-SERVICE CARD

New!.....

actual size

SILICON POWER RECTIFIERS

53 TYPES including military 1N253, 1N254, 1N255 and 1N256

- **200 ma to 1 amp current capability.**
- **Voltage ratings from 50 to 1000 vd-c.**
- **Reliable operation at 150°C.**

Send for bulletin 58R . . .

MICROWAVE ASSOCIATES INC.

Burlington, Massachusetts • BRowning 2-3000

CIRCLE 81 ON READER-SERVICE CARD

NEW PRODUCTS

Thyratron Grid Drive

A push-pull type for servo application

This full wave, medium gain thyratron grid drive, incorporating a fast response magnetic amplifier, provides a complete servo amplifier for power levels up to 15 kw when used with appropriate thyratrons. In typical push-pull applications, a polarity reversible dc input signal controls two sets of two thyratrons each in full wave or back to back connection. Either set fires smoothly from off to full on, depending on polarity of input signal. The unit provides a 6 msec response time for rapid reversing in high performance servo systems. An external resistor provides complete adjustment of null point crossover. The unit measures 2-3/8 x 2-3/4 x 3-3/4 in.

Fairfield Engineering Corp., Dept. ED, 934 Hope St., Springdale, Conn.

CIRCLE 82 ON READER-SERVICE CARD

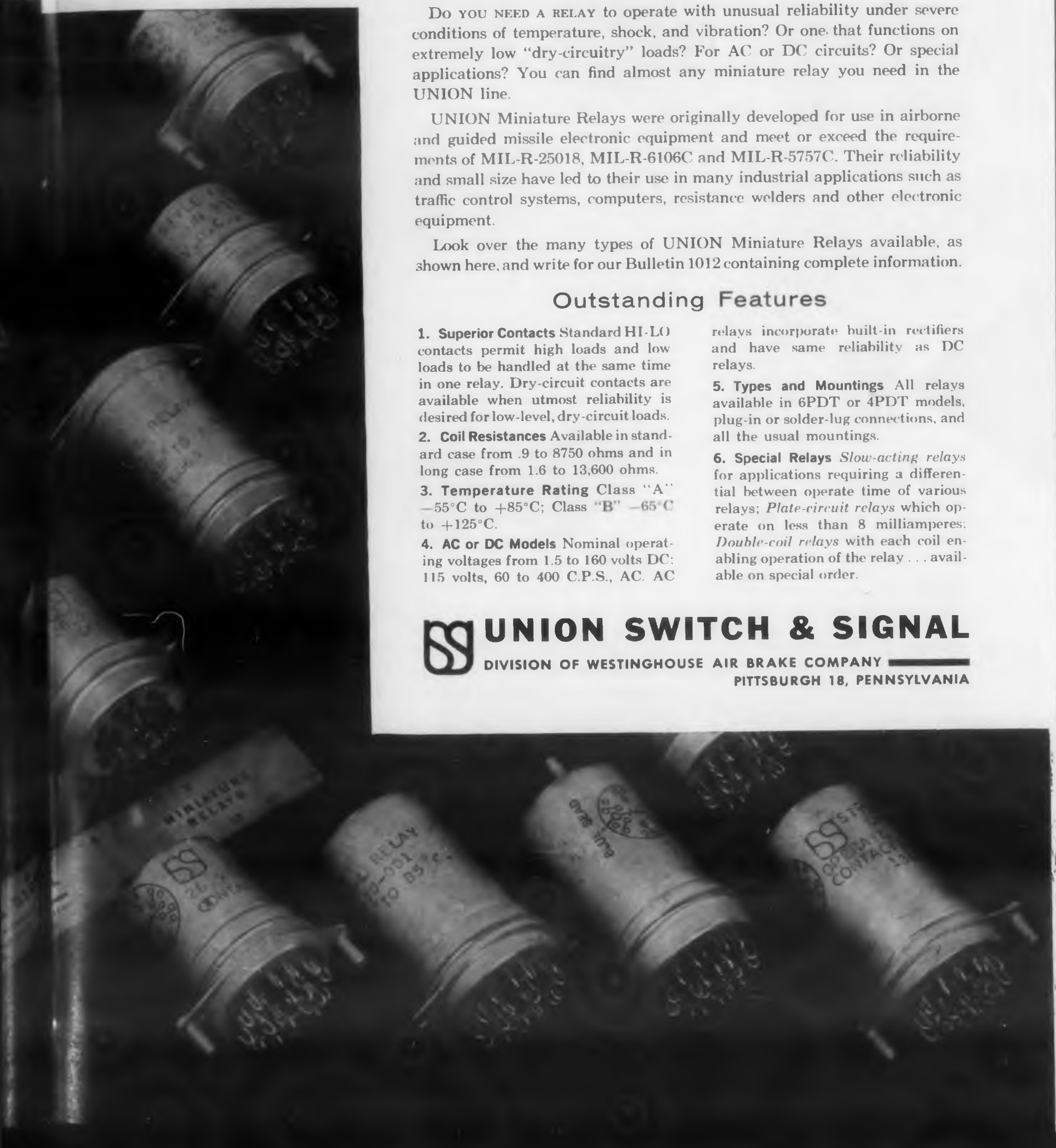
Analog Computer

Fast operation, quick patching

Centralized control and scanning and print-out system with a speed of 200 points per min are some of the features of the 231-R analog computer. To facilitate patching, a pre-patch panel with 3450 holes is so designed that bottle plugs and shorter patch cords may be used. The board is capa-

CIRCLE 83 ON READER-SERVICE CARD ➤

Miniature Relays is designed in guided missile environments



Do YOU NEED A RELAY to operate with unusual reliability under severe conditions of temperature, shock, and vibration? Or one that functions on extremely low "dry-circuitry" loads? For AC or DC circuits? Or special applications? You can find almost any miniature relay you need in the UNION line.

UNION Miniature Relays were originally developed for use in airborne and guided missile electronic equipment and meet or exceed the requirements of MIL-R-25018, MIL-R-6106C and MIL-R-5757C. Their reliability and small size have led to their use in many industrial applications such as traffic control systems, computers, resistance welders and other electronic equipment.

Look over the many types of UNION Miniature Relays available, as shown here, and write for our Bulletin 1012 containing complete information.

Outstanding Features

1. Superior Contacts Standard HI-LO contacts permit high loads and low loads to be handled at the same time in one relay. Dry-circuit contacts are available when utmost reliability is desired for low-level, dry-circuit loads.

2. Coil Resistances Available in standard case from .9 to 8750 ohms and in long case from 1.6 to 13,600 ohms.

3. Temperature Rating Class "A" —55°C to +85°C; Class "B" —65°C to +125°C.

4. AC or DC Models Nominal operating voltages from 1.5 to 160 volts DC; 115 volts, 60 to 400 C.P.S., AC. AC relays incorporate built-in rectifiers and have same reliability as DC relays.

5. Types and Mountings All relays available in 6PDT or 4PDT models, plug-in or solder-lug connections, and all the usual mountings.

6. Special Relays *Slow-acting relays* for applications requiring a differential between operate time of various relays; *Plate-circuit relays* which operate on less than 8 milliamperes; *Double-coil relays* with each coil enabling operation of the relay . . . available on special order.

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

ble of terminating 100 operational amplifiers and associated non-linear equipment, with complete read-out of all linear and non-linear equipment. It provides for individual operational control of all integrators, and shows 30 combination summing integrating amplifiers, 45 summing amplifiers, 25 inverters, 200 trunks, 150 co-efficient potentiometers, 10 multipliers (convertible to dividers by bottle plug), 10 five-channel servo multipliers, 5 servo resolvers, 5 functions of two variable generators, 3 eight-channel recorders for X-Y plotters, 10 comparators, 20 function switches, 15 limiters, 20 passive elements. The patch panel also has 225 jacks available for miscellaneous expansion. A digital, input-output system is available to permit complete control of the computer from prepared punched tape.

Electronic Associates, Inc., Dept. ED, Long Branch, N.J.

CIRCLE 84 ON READER-SERVICE CARD

Regulated Power Supply

Current, voltage regulation

Model HCVS-106-A constant current and constant voltage automatic switchover power supply, is designed for the controlled application of Faraday's law where quantitative coulomb or electric charge transfer or material deposition or removal is to be effected.

A principal characteristic is the automatic switchover feature. On constant current operation, the supply automatically switches to constant voltage operation when the output voltage reaches a selected predetermined value due to buildup of load resistance. The output current range is adjustable from 0-20 amp and the output voltage range is adjustable from 0-100 v.

Matthew Labs., Dept. ED, 146 Riverdale Ave., Yonkers, N.Y.

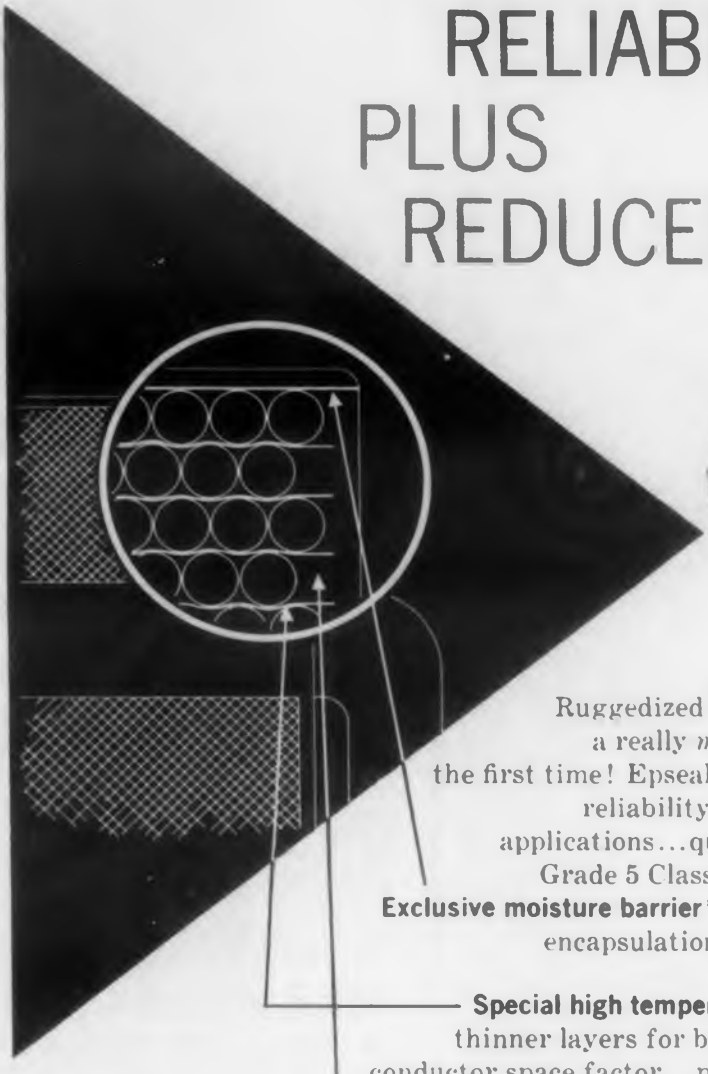
CIRCLE 85 ON READER-SERVICE CARD

◀ CIRCLE 83 ON READER-SERVICE CARD

EPSEAL

Encapsulated power transformers

GREATER RELIABILITY PLUS REDUCED SIZE



Ruggedized Grade 5 construction in a really *minified* transformer for the first time! Epseal units are proving their reliability in missile and airborne applications...qualifying to MIL-T-27A Grade 5 Class T Life X specifications.

Exclusive moisture barrier* eliminates bulky outer encapsulation, helps cut temperature rise as much as 50%.

Special high temperature insulations permit thinner layers for better cooling and higher conductor space factor...permit reliable operation in 125°C to 175°C ambients!

Unique encapsulation process saturates and fuses coil insulations into one mass ...eliminates heat-retaining *microscopic boundaries* usually found in high temperature coils...permits additional size reductions.

Result is a solid, rugged unit that combines extreme reliability with extreme miniaturization! Epseal transformers are designed to meet your requirements. Write today for the whole story.

LOOK TO **ELECTRO**

*Patent Pending

Precision transformers for electronics...miniature to 300 kva

ELECTRO ENGINEERING WORKS inc. / 401 PREDA STREET, SAN LEANDRO, CALIF.

CIRCLE 86 ON READER-SERVICE CARD

NEW PRODUCTS

Strain Gage Plotter

Records 4 Channels Per Sec

Model 220 high speed strain gage plotter is furnished as a 48 or 96 channel unit. It records 48 channels in 12 sec and 96 channels in 24 sec. One or two 60 to 500 ohm resistance strain gage inputs can be employed per channel. Ranges of 2000; 5000; 10,000 μin. for 5-1/2 in. graph available with a gage factor adjustment of 1.6 to 2.2.

Gilmore Industries, Inc., Dept. ED, 5713 Euclid Ave., Cleveland 3, Ohio.

CIRCLE 87 ON READER-SERVICE CARD

400 CPS Frequency Meter

Accuracy of 0.1 Per Cent

Model 650B dual scale frequency measuring device for 400 cps power sources provides a center scale accuracy of 0.1 per cent and full scale accuracy of 1 per cent on the 360 to 440 cps scale and 0.1 per cent on the 396 to 404 cps scale. Accuracy is achieved by utilizing a tuning fork frequency standard as a calibration reference standard.

Varo Mfg. Co., Dept. ED, 2201 Walnut St., Garland, Texas.

CIRCLE 88 ON READER-SERVICE CARD

Counter-Controller

Low Power Input

Model WE-360 six-decade preset counter and controller uses decade glow-transfer tubes to

provide reliability along with low power requirements and small size. The unit counts from 0 to 5000 pulses per sec, and provides a 50 v, 50 μsec pulse or relay operation (5 amp) at a pre-selected number of counts. Input requirements are 50 mv pulse of 20 μsec minimum duration. Maximum input frequency for re-cycling with no loss of count is 2 kc.

Westport Electric, Dept. ED, 149 Lomita St., El Segundo, Calif.

CIRCLE 91 ON READER-SERVICE CARD

Mechanical Differentials

Smooth direction change through zero rpm

Featuring high torque characteristics and smooth speed variation through zero rpm, each of these differentials contains two ac or dc motors and a precision gearing unit. Typical performance is from 5 rpm clockwise to 5 rpm counterclockwise with 300 oz-in. of torque. Speed range is from 10 to 100 rpm in either direction; torques to 2500 oz-in. are possible with smooth changes through zero at full torque. Applications are in antenna drives, tracking devices, or digital-to-analog mechanisms.

Globe Industries, Inc., Dept. ED, 1784 Stanley Ave., Dayton 4, Ohio.

CIRCLE 92 ON READER-SERVICE CARD

Time Mark Generator

1 to 10,000 μSec Marks

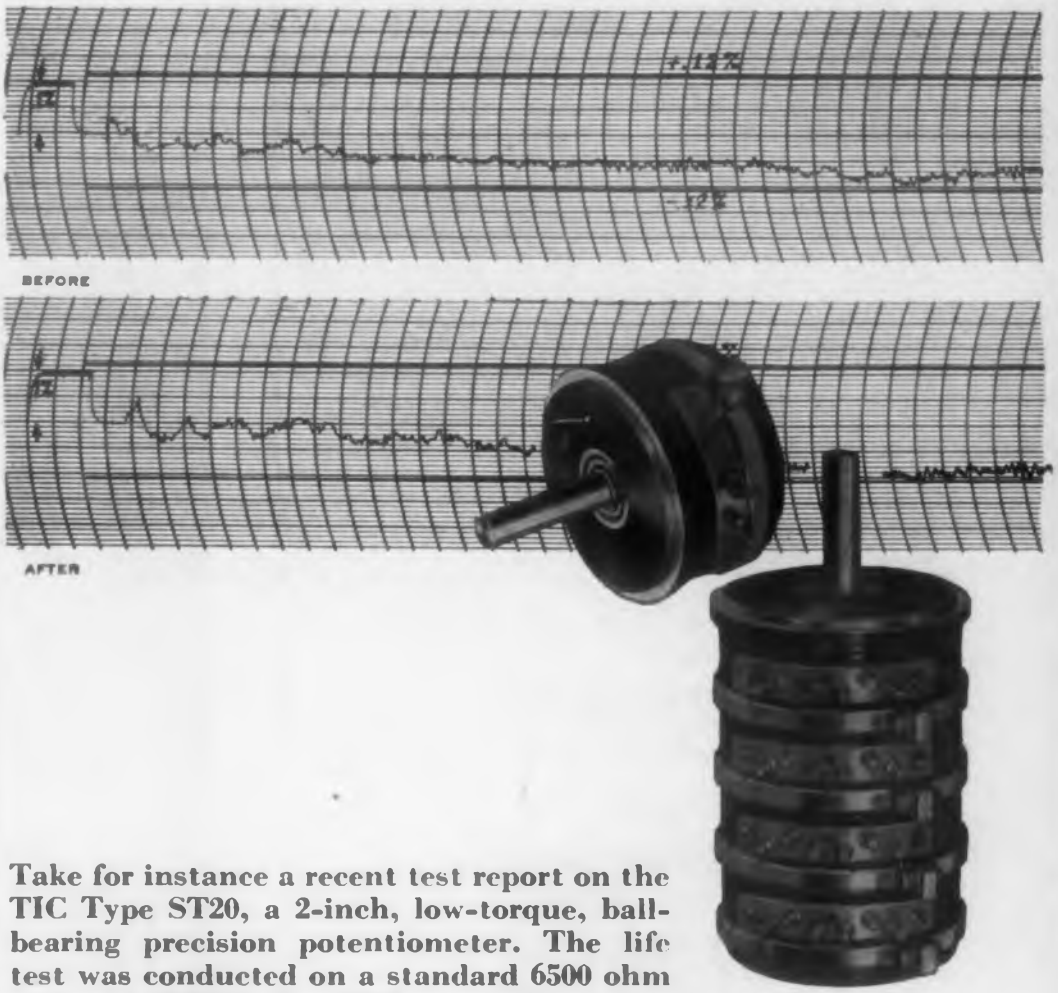
Type RM181 time mark generator produces five time markers 1, 10, 100, 1000, and 10,000 μsec, and a 10-mc sine wave. Output amplitude is about 2 v. The markers and sine wave are derived from a 1 mc crystal-controlled oscillator with a frequency tolerance of about 0.03 per cent and a short-time stability, after initial warmup, of about 0.005 per cent per hour. Dimensions are 5-1/4 in. high, 9-1/4 in. deep standard rods.

Tektronix, Inc., Dept. ED, P. O. Box 831, Portland 7, Ore.

CIRCLE 93 ON READER-SERVICE CARD

LIFE IS NO PROBLEM

WITH TIC PRECISION POTENTIOMETERS



Take for instance a recent test report on the TIC Type ST20, a 2-inch, low-torque, ball-bearing precision potentiometer. The life test was conducted on a standard 6500 ohm unit. At 30RPM the ST20 was subjected to 700,000 cycles, reversing direction every 30 minutes. The linearity graphs shown above show the before and after of the ST20's independent linearity. *As can be seen, the linearity change is imperceptible.*

Some of the change in linearity after the life cycling can be attributed to change in effective resolution due to contact wear. Other results from the life test indicate less than 100 ohm equivalent noise resistance except for one spot, where it was less than 1000 ohms. The 1000 ohm spot was of such short duration that the linearity recording did not pick it up. **Test Summary: The ST20 will perform with only infinitesimal degradation for over 700,000 cycles.** If it's long life *at full precision performance*, that you want, specify precision potentiometers by TIC.

TECHNOLOGY INSTRUMENT CORP.

555 Main Street, Acton, Mass. COlonial 3-7711
West Coast Mail Address, Box 3941, No. Hollywood, Calif. POplar 5-8620

CIRCLE 94 ON READER-SERVICE CARD

NEW PRODUCTS

DC Overpotential Tester

0-50 Kv at 0-5 Ma

The 3050-5, an addition to the series 3000 dc overpotential testers, has an output range of 0-50 kv at 0-5 ma, 0-5/20/50 kv voltmeter ranges, 0-50/200/500/2000/5000 μamp meter ranges, 105 to 125 v–50 to 60 cps–single phase input, reversible polarity, and less than 2 per cent ripple at full resistive load.

Sorensen & Co., Inc., Beta Electric Div., Dept. ED, 333 E. 103 St., New York 29, N.Y.

CIRCLE 95 ON READER-SERVICE CARD

Field Strength Meter

Covers 54-216 Mc

The battery operated FSM-1 field strength meter tunes continuously through the frequency range from 54 to 216 mc to supply accurate, direct voltage readings. The meter includes db and percentage a-m modulation scales, and a model MB balun to handle 300 ohm inputs. Total weight, less batteries, is 14 lb.

Blonder-Tongue Laboratories, Inc., Dept. ED, 9-25 Alling St., Newark 2, N.J.

CIRCLE 96 ON READER-SERVICE CARD

Broadband Klystron

Delivers 10 kw cw over a 10 mc bandwidth

Designed for use in the 720 to 980 mc range, this six-cavity water-cooled amplifier klystron

"INCUBATOR BABIES"

delivers 10 kw cw power over a 10 mc bandwidth with a driving power of 5 w and an efficiency of 40 per cent. At 25 per cent efficiency the unit is effective over a 20 mc bandwidth. Designed model 6K50,000LQ, the klystron was formerly the developmental model X631.

Eitel-McCullough, Inc., Dept. ED, San Bruno, Calif.

CIRCLE 98 ON READER-SERVICE CARD

Miniature Clutches

2 to 32 In.-Oz

Available in four sizes, model CF clutch offers fast response, zero backlash, and a high efficiency per unit weight. The clutch is normally engaged and is designed for dc operation. Sizes with torque ratings are as follows: CF-4 with 0.5 in. diam servo mounting flange has 2 in.-oz min torque; CF-6, 0.75 in. diam with 8 in.-oz torque; CF-8, 1 in. diam with 16 in.-oz min torque; CF-10, 1.25 in. diam with 32 in.-oz min torque.

Autotronics, Inc., Dept. ED, Rt. 1, Box 812, Florissant, Mo.

CIRCLE 99 ON READER-SERVICE CARD

Log N and Period Amplifier

Serves as a combined indicator of reactor period and power level

Model 420 combines a logarithmic micro-microameter and a reactor period meter. It measures current from 10^{-13} to 10^{-6} ampere and positive or negative reactor period from 3 to 30 sec. After warmup, drift of the log circuit is within 0.05 decade in 24 hrs. The period meter has 5-sec recovery time from overload and adjustable response time over a 10-to-1 range. Other features include large full scale outputs to drive remote meters; 50-mv outputs for recorders; regulated 225 v polarizing potential for ion chambers.

Keithley Instruments, Inc., Dept. ED, 12415 Euclid Ave., Cleveland, Ohio.

CIRCLE 100 ON READER-SERVICE CARD

Electrolytic Capacitors

Automatic Upright Insertion

Upright aluminum electrolytic capacitors have been developed with up to three individual electrode elements each. Ratings range from 1/2 to 680 μf, and 4 to 150 v. Operating temperature range is −20 to +85 C. Can heights range from 1/2 to 1-1/4 and diameters from 1/4 to 5/8 in. The connector pins are positioned to permit automatic insertion in printed circuit boards.

The Magnavox Co., Dept. ED, Fort Wayne 4, Ind.

CIRCLE 101 ON READER-SERVICE CARD

AC Breakdown Testers

Cover range from 50 to 100 kv

Series 4000 ac breakdown testers cover ranges from 50 to 100 kv ac at capacities of 2 and 5 k va. Each of the models features continuously variable output voltage control, accurate measurement of applied test voltage, as well as safety to test personnel.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago 18, Ill.

CIRCLE 102 ON READER-SERVICE CARD

Frequency Meter

Detects Error Over Preset Limits

A combined expanded-scale frequency meter and frequency error detector has been made

Is it possible to build a **MAN?**

"Theoretically, yes," said the scientist. "Or a reasonably remarkable imitation—a kind of mechanical analogue. Call it a habit machine, a mechanism operating according to the laws of the conditioned reflex."

You mean that you could actually build a mechanical mind? One that would exhibit emotions —such as love, fear, anger, loyalty?

"We're doing something like that now in advanced missile development," the scientist replied. "In a limited, highly specialized way, of course."

"Take the 'pilot' that is being developed for the big long-range missile. *He* has a wonderful memory, and can solve many complex navigational problems in a flash. *He* loves perfection, and actually becomes highly excited when *he* gets off course. *He's* a tough-skinned character, impervious to the cold at several hundred miles altitude and the incredible heat at re-entry. And *his* loyalty is heroic. *His* life is a single mission, the mission *his* whole life . . . and maybe ours, too. *He's* a pretty important *fellow*."

What about the complete man-made Man? What would that entail?

"A mechanism the size of the capitol in Washington, and the best scientific resources in the world. But it could be done. You see, it's only a question of how physical matter is organized. As a great biophysicist explained, 'If material is organized in a certain way, it will walk like a man. If it is organized in another way, it will fly like a missile.'"

Still, wouldn't there be something missing in the complete man-made Man—something very important?

"Yes," said the scientist. "A soul."

MARTIN

BALTIMORE·DENVER·ORLANDO

available. Any band of frequencies within the meter scale, which is ±5 to ±50 cps with a center frequency of 400 cps, may be selected by means of two simple external adjustments. Deviation of the measured frequency from this band is indicated by lamps and closure of relay contacts within an accuracy of 0.1 per cent. The unit is available with a vibrating reed meter for field use.

Aerojet-General Corp., Turbo-Machinery Div., Dept. ED, Azusa, Calif.

CIRCLE 103 ON READER-SERVICE CARD

Linear Force Meter

Accurate Proportional Output

A moving coil device, the Dynastroke linear force motor is available with strokes to 0.1 in. and force outputs to 2 lb. Standard coil resistances are from 200 to 4000 ohms with resonant frequencies from 10 to 100 cps. Applications include wherever a linear motion or force accurately proportional to exciting current is required. The unit is 2-in. long and has an accuracy of 0.1 per cent.

Mandrel Industrial Instruments, Dept. ED, P.O. Box 13243, Houston, Texas.

CIRCLE 104 ON READER-SERVICE CARD

Oscilloscope

Continuously Calibrated Vertical Control

Model LA-259D is a ruggedized wide range oscilloscope, conforming to MIL-T-945. The vertical attenuator and gain control are direct reading and continuously calibrated. The vertical amplitude has a sensitivity of 10 mv per cm, is flat from dc to beyond 15 mc and has a rise time of less than 0.02 μsec. The oscilloscope features an intensified marker system and a high frequency sweep synchronization system.

Lavoie Laboratories, Dept. ED, Morganville, N. J.

CIRCLE 105 ON READER-SERVICE CARD

NEW PRODUCTS

Switch

1/4 In. Overtravel

The 6132 switch basically consists of two standard hermetically sealed miniature switches in a dust and moisture-proof case, and a plunger type actuator. Featuring 1/4 in. overtravel, the switch meets standard shock and vibration tests, dielectric test of 1250 v rms for 1 sec, acceleration test of 10 g, and standard atmospheric tests.

Haydon Switch, Inc., Dept. ED, Waterbury, Conn.

CIRCLE 107 ON READER-SERVICE CARD

Power Supply

Six outputs with up to 0.01 per cent regulation

Especially designed to operate and test backward wave oscillators, this equipment produces six independent voltages, 600 to 6000 v dc negative, 300 to 2000 v dc negative, 0 to 2500 v dc positive and negative, filament supplies, and a magnet supply of 0 to 250 v dc. Power supplies nos. 1 through 4 can be modulated at 60 or 400 cps. Regulation of the supplies ranges from 0.01 to 1 per cent.

Manson Labs., Inc., Dept. ED, P. O. Box 594, 207 Greenwich Ave., Stamford, Conn.

CIRCLE 108 ON READER-SERVICE CARD

Potentiometers

These 0.1 per cent assemblies have moisture seals between sections

Each section of a standard series 300 potentiometer has been ganged by a stainless steel clamp ring, allowing a moisture seal to be inserted be-

SPECIFICATIONS

	TYPE	Resistance Min. Max.	Wattage Rating	Size	Temperature Coefficient	Standard Tolerances
Permanent resistance change after standard 5-second overload of 6.25 × rated power averages less than 0.2% Impervious to moisture Available with ±150 ppm/°C temperature coefficient	N20 N25 N30	10 500K 10 1.5 Meg. 30 4.2 Meg.	(@ 40°C) ½ 1 2	13/32 x 1 1/64 1 5/16 x 1 3/64 2 1/16 x 1 3/64	±.03% per °C from −55 to +105°C referenced to 25°C	1% 2% 5%
Overload—standard 5 second overload of 6.25 × rated power causes permanent resistance change of less than 0.5% Available with ±150 ppm/°C temperature coefficient	S20 S25 S30	10 500K 10 1.5 Meg. 30 4.2 Meg.	40°C 120°C 1 ½ 2 1 4 2	13/32 x 1 1/64 1 5/16 x 1 3/64 2 1/16 x 1 3/64	±.03% per °C from −55 to +235°C referenced to 25°C	1% 2% 5%
Low-cost Easily installed	LPI-3 LPI-4 LPI-5 LPI-7 LPI-10	200 20K 200 50K 200 60K 200 40K 200 70K	3 @ 40°C 4 @ 40°C 5 @ 40°C 7 @ 25°C 10 @ 40°C	1 5/16 x 2 1/64 1 1/16 x 2 1/64 1¾ x 2 1/64 2 1/16 x 2 1/64 1¾ x 1 5/32	±.025% per °C @ 105°C referenced to 25°C	5% 10%
Average change of resistance after 500 hrs. at max. dissipation at 25°C ambient is less than 3% Standard 5-second overload of 6.25 × rated power causes permanent resistance change of less than 0.5%	R31 R33 R35 R37 R39	10 70K 30 150K 20 300K 20 500K 40 1 Meg.	(@ 25°C) 7 13 25 55 115	1½ x 9/16 3 x 9/16 4 x ⅞ 6 x 1¼ 12 x 1¼	±.03% per °C from −55 to +235°C referenced to 25°C	1% 2% 5% 10%
Stability—average resistance change after 500 hours at max. dissipation at 40°C ambient is 3% Standard 5-second overload of 6.25 × rated power causes less than 0.5% permanent resistance change Power ratings may be increased by forced air cooling, or liquid cooling	H31 H33 H35 H37 H39	10 70K 30 150K 20 300K 20 500K 40 1 Meg.	(@ 40°C) DC AC 5 7 10 15 20 30 50 70 100 140	1½ x 1 7/32 3 x 1 7/32 4 x 1 3/16 6 x 1⅛ 12 x 1⅛	±.03% per °C from −55 to +235°C referenced to 25°C	1% 2% 5% 10%
Skin effect is negligible Resistance elements are interchangeable	WC5	35 300	5KW			5% 10% 15%

Roundup

The rest is on the chart. There is a greater collection of particulars, including performance graphs, in separate bulletins on the resistors. Send the coupon for copies.

For any of the following resistor bulletins write Electronic Components Sales Department:

☐ Type N ☐ Type S ☐ Type LPI ☐ Type R ☐ Type H ☐ Type WC5

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

CORNING GLASS WORKS

97-2 Crystal Street, Corning, New York

Corning means research in Glass

CIRCLE 109 ON READER-SERVICE CARD

tween sections, yet permitting easy phasing of individual sections. The units can be obtained with an independent linearity of 0.1 per cent and with a total resistance up to 100 k. Non-linear windings are also available. The 300 series are provided with low torque sleeve type bearings. Torque can be reduced to 0.5 oz-in. per section and up to 9 sections can be mounted on a common shaft.

Maurey Instrument Corp., Dept. ED, 7924 S. Exchange Ave., Chicago 17, Ill.

CIRCLE 110 ON READER-SERVICE CARD

Connectors

Solderless Pins and Sockets

This solderless AN-type plug-in-receptacle connector is especially suited for computer applications. Single-stroke manual or high-speed automatic tools crimp wire ends in the pins and sockets which are snap-locked into the Hyfen connector. Both pins and sockets may be inserted in the same plug and receptacle, and as many, or as few, may be inserted into the connector positions as desired. They may be removed individually for circuit changes or field servicing.

Burndy Corp., Dept. ED, Norwalk, Conn.

CIRCLE 111 ON READER-SERVICE CARD

VHF System

Provides 360 communication channels and weighs 22 Lb

Primary unit of the model 210 vhf communication system is the RT-11A transceiver shown above. The system has a frequency coverage of 118 to 135.95 mc on 360 channels and a transmitter output of 15 w. Total weight of the system, including transceiver, mountings, control panel and power supply, is exactly 22 lb. The unit has true 50 kc channel spacing, and a transmitter with low spurious output and a reciever sensitivity of 2 μv. The system can be operated either as a single-channel simplex or double-channel simplex with 6 mc separation.

Aircraft Radio Corp., Dept. ED, Boonton, N.J.

CIRCLE 112 ON READER-SERVICE CARD

ACEPOT®

SUB-MINIATURE, PRECISION, WIRE-WOUND

LINEAR POTENTIOMETERS

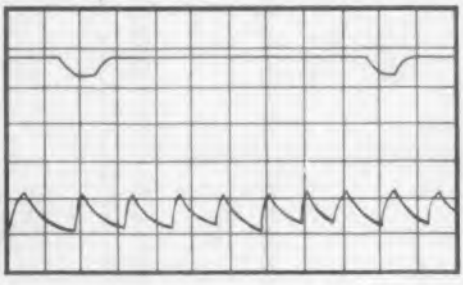
500 Series ACEPOT actual size

Small pot size — Big pot performance

Only ½" in diameter, the ACEPOT excels in a combination of all around top performance characteristics comparable to larger units. For example, these precision units feature ± 2% resistance tolerance and ± 0.3% independent linearity. Every potentiometer is completely sealed against sand, dust and foreign matter to avoid abrasive action between moving parts. All materials and metals are treated for maximum resistance to salt spray, corrosion, humidity and conform to shock and vibration tests. ACEPOTS are designed and assembled MIL-A-8625A, QQ-M-1512, JAN-T-152, MIL-E-5272A, MIL-R-19A, NAS-710 and MIL-R-19518 (ships).

ACEPOT LINEARITY TEST

Plot of voltage ratio error versus rotation illustrates linearity to better than ± 0.3%.



ACEPOT RESOLUTION TEST

Section of oscillograph trace of electrical resolution shows voltage change for each turn of wire.

ACE offers a wide variety of linear and nonlinear precision, wirewound potentiometers in standard, special and AIA sizes. Custom designs to meet special requirements can be made available on short lead time. Call, write or teletype Dept. G, ACE ELECTRONICS ASSOCIATES, INC., 99 Dover Street, Somerville, Mass., SOmerset 6-5130, TWX SMVL 181.

ACEPOT®
ACETRIM®
ACESET®
ACEOHM®

ACE ELECTRONICS ASSOCIATES, INC.

CIRCLE 113 ON READER-SERVICE CARD

NEW PRODUCTS

Solenoid Valves

General purpose lightweight units

The SV-4900 series of 2-way normally closed valves features a unique plunger seal design of soft rubber which assures bubble-tight sealing. The valves have full operation in any position and offer stainless steel internal construction and brass body. They measure 2.35 in. high by 1.5 in. wide, and are available with a 7/64 orifice rated at 130 psi or 5/32 rated at 60 psi max. These valves are designed for general usage with semi-corrosive media.

Valcor Engineering Corp., Dept. ED, Carnegie Ave., Kenilworth, N.J.

CIRCLE 135 ON READER-SERVICE CARD

Voltage Regulator

Controls Warm-Up

Design of the Stabline voltage regulator type EM10018 is based on a combination of adjustable voltage control and automatic voltage regulation functions. When the equipment is energized, the voltage is run-up gradually to minimize the surge strain on filaments. A control cricuit automatically actuates at the proper time to maintain a stabilized output. As an additional precaution, the equipment is protected from being reenergized at other than zero voltage after a power failure of more than 5 sec duration. Voltage run-up takes 5 to 14 sec depending upon the output setting. Input: 208 v ±10 per cent, single phase, 57-63 cps. Output: 208 v nominal, 0-163 v unregulated, 163-208 v adjustable regulated, 45 amp at 40 C ambient. Accuracy ±1.0 per cent for rated line and load changes.

Superior Electric Co., Dept. ED, Bristol, Conn.

CIRCLE 136 ON READER-SERVICE CARD

Design for Reliability

This staff report on the status of reliability was intended to be a simple roundup of the work done in the field to date. In the course of the work's progress several factors came to light that changed the character of the report.

The Editors found trenchant shortcomings in the field. There is a great deal of lip service being done to the question of reliability. Like virtue, everybody is for it. The government demands it. Reputable organizations work very hard to achieve a "reliable" product. Large sums are spent on life testing and analysis of equipment failure. In the past years hundreds of thousands of words have been written in technical journals and spoken at conferences, in an effort to add to the fund of knowledge available to the engineer who wants to design a reliable piece of equipment.

With this background, progress has been surprisingly slow.

WHY?

It is generally agreed that the lack of *part reliability numbers* is an important cause. These numbers, or curves, would permit the designer to estimate a device's reliability before putting it into production.

Without them, the engineer must rely strictly on his own experience and judgment when asked to design equipment. Design becomes an art rather than a science. Clearly there is no substitute for solid experience and insight in engineering. Designs created by a careful engineer are often very good—but they can be bad, too. They are bad often enough to make the problem of reliability one of the most important in electronics today.

At some point engineering judgment must be supplanted by statistics and quantitative measurement. ELECTRONIC DESIGN has therefore given over a large part of this report to printing PART RELIABILITY CURVES obtained from Vitro Laboratories and RCA. These curves were compiled from empirical data and give practical information that can be put to immediate use by the equipment designer.

As a further aid to reliable design four methods of PREDICTING EQUIPMENT RELIABILITY are exposed to the reader. Used with care and common sense, any one of these methods will help the designer to save time and money, and to produce an electronic device with the reliability required of it. They will also enable the manufacturer to present the buyer with a quantitative rating of equipment reliability.

Guides for CIRCUIT and EQUIPMENT DESIGN are also included in the report, as well as an examination of the recommendations of the government in the matter of specifying reliability in a contract proposal.—T. E. Mount

For a free reprint of this special report on Reliability, circle 115 on Reader-Service Card.

What the Government Is Doing

Greatly concerned with the problem of reliability in military equipment, the Department of Defense has been insisting that equipment purchased be dependable. Unreliable equipment is expensive equipment. The Rand Corporation has established that the *annual* cost of equipment maintenance and repair is *twice* that of the original equipment cost. The AGREE committee generally concurs that the problem must be attacked at the parts level, and that part reliability must be specified by the equipment manufacturer.

The AGREE Report

The Advisory Group on Reliability of Electronic Equipment was established by the Research and Development Board in 1952 and continued under the Assistant Secretary of Defense when the RDB was abolished. Its purpose is to monitor and stimulate interest in reliability matters and recommend measures which would result in more reliable electronic equipment.

Nine task groups, composed of people from industry and the military were assigned to investigate numerical reliability requirements, tests, design procedures, components, procurement, packaging and transportation, storage and operation, and maintenance. Their report, the AGREE report on Reliability of Military Electronic Equipment of June 4, 1957, was the result.

It is a compilation and distillation of reliability information. Recommendations are given in essence as follows:

Task Group 1 recommends that certain minimum acceptable reliability figures for equipment presented by them be adopted by AGREE, and that these figures be studied and modified as more information is obtained.

Task Group 2 recommends that independent evaluation groups supervise reliability test programs in accordance with the procedures set forth in the report.

Task Group 3 recommends that the detailed test procedures included in its report be referred to the Office of the Assistant Secretary of Defense for trial with selected contracts for pilot production and production electronic equipment for a prescribed time, and mandatory implementation on a wholesale basis for following contract. Further, Task Group 3 recommends that OASD select, at the earliest practical date, independently of the above recommendation, a limited group of pilot production and production contracts for whom the procedures will be made mandatory. OASD should make reliability index evaluation of all pilot production and production military electronic equipment mandatory.

Task Group 4 recommends that when the design, construction, and evaluation of a prototype electronic equipment is finished, the contractor prepare a report to the government agency concerned. The report should contain a description of parts selection and circuit design procedures and a calculation of the predicted reliability of the equipment, as well as information on conditions that seem weak, to the contractor, from the reliability standpoint, and suggestions on how to increase the reliability.

Task Group 5 points out that present practices used in most military component inspection are ineffective. It recommends that, as a temporary measure, these practices be revised and improved. It also recommends that *part reliability curves* be developed for each part produced, and that the government procurement procedure and the system of military inspection and approval of supplier be revised. The development of military component specifications and the testing of components for design capability should be coordinated by one controlling group at the Department of Defense level.

Task Group 6 recommends no basic change in the existing laws and procurement regulations.

Task Group 7 recommends that packing and packaging of electronic procedures be reviewed and improved.

Task Group 8 recommends that test and inspection requirements be amended to provide the data necessary for reliability studies, and that a centralized working group within the Department of Defense be established to coordinate and evaluate reliability data from all sources.

Task Group 9 reviewed the problem of maintainability of electronic equipment.

WASHINGTON MEMO

Memo to: Managing Editor
From: Herbert H. Rosen Washington office
Subject: Your reliability issue

I'll give this to you just about as I got it from Dick DeWitt, Jim Bridges' [of ASOD] right arm on reliability. This is in reference to your observation that lots has been said about reliability — but very little done.

At the Defense Department level, there is great doubt that the recommendations of Task Group 5 will be implemented — that anything will be put into military specifications reflecting their views. However, there is a need for a committee to establish the criteria outlined by Task Group 5. Unfortunately, the press of higher priority causes have precluded the setting up of this committee. It is still Bridges' intention to move ahead . . . as soon as he can.

But in other areas . . . there are a few definite things being done. For instance, you will recall the last Bridges statement we had concerning equipment [Jan. 8, ED, page 18]. Here's how that's going to work. Two equipments from each service that are just about to be designed are being offered as guinea pigs. They will fall under the areas reported on by Task Groups 1, 2, and 4. Two other equipments from each service just going into production have likewise been chosen for the cause. They will fall into the categories set up by Task Groups 1 and 3. Here's how it is supposed to work. The services have named people with whom DeWitt and his people can be in contact. Soon they will all get together and be told how the DOD expects the equipment to be evaluated in terms of reliability. The basis for this will be the numbers cited by Task Group 1. If numbers do not exist for the equipments to be evaluated, other numbers will have to be developed by using the techniques Task Group 1 used to arrive at what they reported. The people will use the techniques of Task Group 4 during

What Industry Is Doing

Industry is as concerned with reliability as the Government. Responsible manufacturers are poignantly aware of the need for reliable military equipment, and in some cases have set up extensive programs to ensure its attainment. But so far little has been done relative to what must be done. Those corporations with foresight have established programs which are corporate-wide (see box below) and are headed by high company officials. The majority have not.

A spot check of the more important parts manufacturers was conducted in early January by ELECTRONIC DESIGN. The question was asked, "Will your company tag its components with reliability numbers during 1958, as a result of the recommendations in the AGREE report?" It was explained that reliability numbers expressed the probability that a part would not fail over a given period of time; and that Task Group 5 in particular recommended that all parts be rated with these numbers.

Few companies, at the management and sales level, had even heard of the AGREE report. Fewer had any concrete plans for tagging reliability numbers or curves to their parts.

There was considerable skepticism about the program. Reasons given were that other projects for achieving reliability had been recommended in the past and had faded; and that prime contractors were equipment manufacturers, not parts suppliers. Reliability testing takes time and money, said the parts manufacturers, and the equipment manufacturers were at present not willing to pay for it.

Part Reliability Numbers

These "numbers" are usually expressed as the reciprocal of the mean time between failures (MTBF). For the greatest usefulness, they take the form of curves, where reliability is plotted against a stress condition. They may show the change in reliability over a range of temperature, voltage or other operational stress.

There are two fundamental ways of obtaining these curves: by life testing of parts, components or equipment; or by gathering failure data from the field and compiling empirical evidence about which parts fail under what circumstances.

Two outstanding examples of the latter technique is the work done by Vitro Laboratories, Silver Spring, Md. BuShips failure report data and field observation data on fifteen pieces of shipboard equipment were analyzed. Incidence of equipment failure due to resistors, tubes, capacitors, etc., was tabulated and curves derived, like the ones shown in curves 1-28.

To test the validity of these curves, they were used to predict the reliability of five other equip-

the equipment development and apply the test methods from Task Group 2 when that stage is reached.

Still to be decided are what equipment parameters are to be set up. Moreover, they must also determine what constitutes a failure in terms of reliability. Behind all of this activity is the desire to put reliability requirements into all specifications for electronic equipment. They must be written so that they will not be subject for renegotiation later on. In other words, no ambiguities.

But no one really knows how reliable are the conclusions of the various task groups. Therefore, the need for this extensive testing program on 12 service equipments . . . 6 about to be designed, and 6 getting ready for production.

While this is going on, the DOD has asked each of the services to make a detailed analysis of the reliability program and to report on how implementation of the recommendations contained in the reports will affect their programs . . . technically and fiscally. Also, what they will have to do to get their program off the ground.

DOD people feel that the report has been in the hinterlands for too short a time for any comments to be received. They are still harboring the hope that the wisdom in its pages will be picked up voluntarily by industry and adopted as its own. They think the reports are pretty thorough and tell the reliability story in solid terms. However, they have not yet decided that some kind of Defense Department axe will have to fall on the industry's head before it will start on the reliability kick. In fact, they think they detect evidence that some manufacturers are already making strides in the reliability programs for their own equipment. It would be possible for us to cite at least twenty seven examples.

So as for action . . . it is sketchy. No concerted program except in isolated instances. But even this is progress. DOD, because of its size and complexity, is forced to move slowly. It doesn't want to be the great white father and scalp all those who don't obey. Yet, if nothing is done, they may be forced to strengthen their specifications to reflect their own findings. . . .

EIA Reliability Spec Issued

Covering low-loss fixed ceramic capacitor of voltage ratings up to 500 v, EIA SMC-1 of November 1957 asks for an in-service failure rate less than 0.01 per cent per 1000 hr. This is the first reliability spec issued by the Electronic Industries Association. Next to be issued is SMC-2, still in the proposal stage, for insulated high temperature wire. The EIA, in cooperation with the military, hopes eventually to specify quantitative reliability for all electronic parts.

In the field . . .

In addition to the extensive reliability programs being pushed by Aeronautical Radio, Inc., Washington, IRE, EIA, ASQC, and AIEE, ELECTRONIC DESIGN wishes to call attention to ARMA, Bendix Aviation and Radio, General Electric, Hoffman Labs, Hughes Aircraft, Inland Testing Labs, Martin, Philco, RCA, Raytheon, Sperry Rand, and Vitro, who all have outstanding programs. ARMA, Bendix, Hughes, Martin and Raytheon's programs are corporate-wide.

ments. They proved successful.[2] Meantime between failures for a navigational aid was predicted to be 131—measurement by BuShips failure reports showed it to be 135, and field observation by Vitro personnel resulted in an MTBF of 131 ± 23.

According to Ralph Stokes of Vitro, these curves are applicable to any equipment that is to be used in environmental conditions of a severity that is comparable to shipboard equipment. Each graph contains a number of curves, representative of different stress levels as in Curve 2 later in this report to approximate the change in reliability with severity of application.

The HELPR program, initiated by Inland Testing Laboratories in Morton Grove, Ill., proposes to test components and rate them according to their reliability. Curves like the ones shown in Figs. 1 and 2 would be drawn up for each set of parts. A detailed, systematic approach has been prepared and a description of it is available. Briefly the purpose of the HELPR—Handbook of Electronic Parts Reliability—program is to generate data on component parts which will allow the equipment designer to choose the parts realistically. Test procedures will reflect as closely as possible the conditions to which the final equipment will be subjected. No panacea for all the

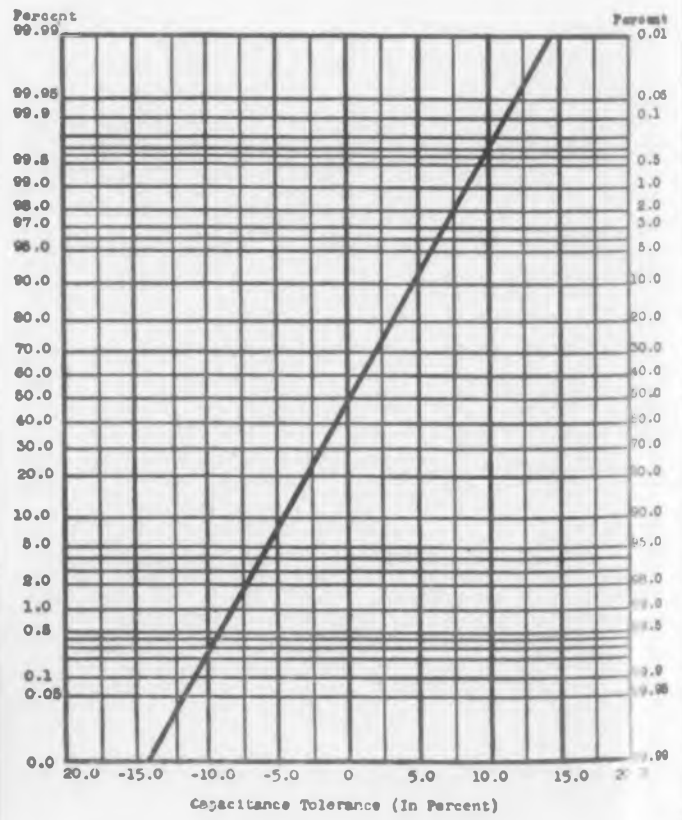


Fig. 1. Manufacturer *A:* capacitance out-of-tolerance rate at *1000 hours.*

test problems that exist, the program is intended to provide basic reliability information that will serve as a starting point for more explicit studies. It is not meant to replace the individual manufacturer's test capability. It will supplement it by providing a fund of basic data as a starting point, and the individual company can then concentrate its own facilities to product data relating to its specific applications. The cost of the program will be borne by companies subscribing to it, generally the equipment manufacturers, says George Brown of Inland Testing Labs. Parts manufacturers will be given the results of test on their components, to provide them with information that could be of use in improving their product. As the program is set up, engineers of companies *not* subscribing will not get data.

Experience Does Pay Off

RCA's reliability program is corporate-wide, headed by an executive vice president of the corporation. Reliability techniques developed during five years of experience with the program have proven to save about 60 per cent of re-engineering costs—after paying for the program. Many military proposals have been pulled out of the fire by reliability-conscious design engineers.

Design reviews play an important part in the process. The design engineer must justify his design after paper design, bread-board layout and after the prototype is complete. In this way the buyer is assured of a reliable product.

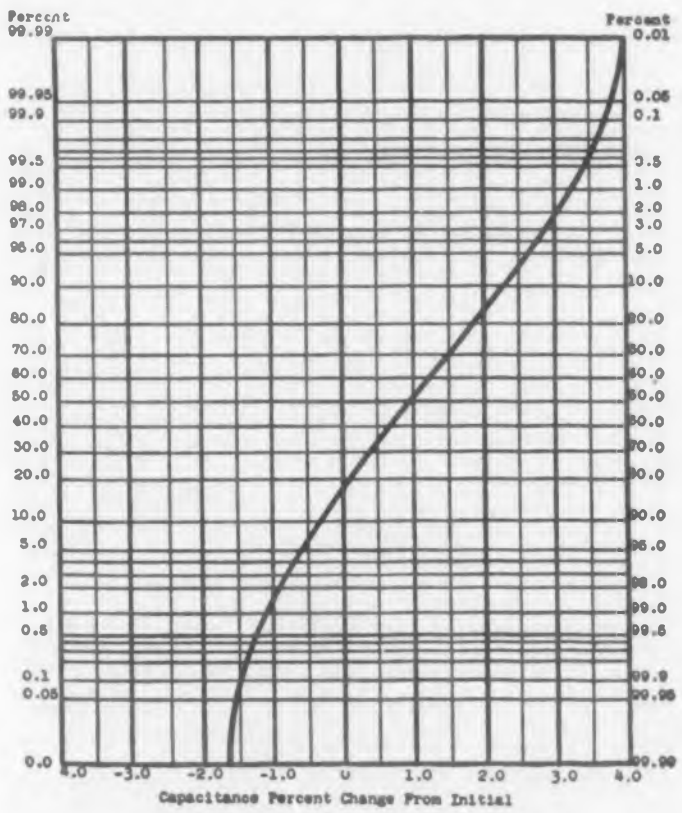


Fig. 2. Manufacturer *A*: per cent of units *vs* percentage capacitance change.

Guides to Design

The importance of part reliability curves described above can be pointed up by a look at the procedure for designing and producing a reliable piece of equipment.

Paper design is the first step. Circuits are laid out on paper, breadboarded to see whether they will operate at the worst tolerances of their specified components and combined on paper to form the equipment or system schematic.

A paper prediction of system reliability then follows. The engineer examines the schematic or block diagram and estimates the reliability of his system. If the estimate falls short of the number required by the buyer, he can then juggle circuits, components and voltages to upgrade the reliability or downgrade it, for purposes of economy. *Note that this step absolutely requires component part reliability numbers.*

Prototype testing—Now a prototype is built, by the designer himself, by his technicians, or by a special department within the company. Prototype testing is used to find out if the equipment works according to specifications—it is not a test for reliability.

Production testing of equipment samples as they are taken off the production line follows pilot production testing and process control techniques. This step should be an empirical determination of reliability. The experienced engineer should find that this empirical reliability number agrees closely with his original paper prediction. Control of the production processes are important to him—the reliability attributed to each process obviously has a direct bearing on the reliability of his equipment. But this is usually under the direct control of the production and quality control departments—and only informal coordination between the designer and these departments is practicable.

Paper design, paper reliability prediction, prototype testing and production testing. These are the discrete steps of a practical process of design. And integral to the first two steps—the basic steps in a reliable-design procedure—are part reliability numbers. Without these paper prediction is impossible and the whole design process is hit-or-miss with regard to the final equipment reliability.

Use Your Judgment

Part reliability numbers are not yet generally available. So the engineer uses his judgment, which is often very good. He has had experience with the components he specifies in his design, he knows their ratings and knows that in previous designs they have held up adequately. If he is enjoined to build a very reliable equipment, he uses the best components he knows of and derates them as much as he can. He may test them, or his components department may test them. He makes a careful paper design, predicated upon his own experience. These precautions lead to a "good"—and in many cases "reliable"—piece of equipment.

This approach may prove expensive. The equipment may be overreliabilized, and like an overdesigned equipment, prove an economic loss to the company. It may not have enough reliability due to some factor overlooked by the designer, in which case it will prove unacceptable to the buyer and must be redesigned.

The only sure solution is the use of valid reliability numbers. Components must be rated and given some reliability index. Curves should be drawn to show this reliability number changes with variation in stress. If a given capacitor has a probability of success of 0.99 over 1000 hours at normal temperature, what is the reliability at a higher temperature? Curves providing this kind of information should be supplied with every component.

(Continued on next page)

Components contributing to equipment failure

(listed in order of failure frequency)

1. **Tubes**
2. **Relays**
3. **Composition fixed resistors**
4. **Paper fixed capacitors**
5. **Film fixed resistors**
6. **Mica fixed capacitors**
7. **Wire wound fixed resistors**
8. **Diodes and transistors**
9. **Connectors**
10. **Wire wound variable resistors**
11. **Composition variable resistors**
12. **Switches**
13. **Wire wound precision fixed resistors**
14. **Ceramic fixed capacitors**
15. **Tantalum electrolytic fixed capacitors**
16. **Electrolytic fixed capacitors**

Guides to D

Circuit Design

A system or equipment is composed of basic circuits. If the system is to be reliable, it is plain that the building blocks of the system must be reliable. A sharp awareness of this logic is shown by engineers of Stromberg-Carlson, for example, who divide engineering design into *components*, *basic circuits*, *systems* and *materials*. The basic circuit division works in close coordination with the components people. If the basic circuit is such that it will not work if the worst possible variation of its components occurs, or if the component specified has been found to be unreliable, the design is changed.

Let us examine the problems confronting the engineer who is asked to design a circuit. He must make a configuration of electronic components perform a specific function. He may be given performance specifications, and must adhere to them. But it is not enough to draw lines, resistors, capacitors, transistors on paper, and devise equations to delineate their values. The circuit designer cannot make unrealistic demands on the component engineers, specify close tolerances and one per cent resistors. He must know about component stability and variation and design his circuit around them.

The splendid paper, "Designing for Reliability," by Lincoln Labs' Norman H. Taylor[3] reveals that in designing a circuit for maximum reliability the following criteria should be followed.

- The circuit must meet its performance specifications with all components and voltages at their worst initial tolerances, and with any component at its worst end-of-life tolerance.
- The circuit must be able to withstand the loss of any one of the supply voltages in itself or in any circuit connected to its input or output without component damage.
- Since all components (especially vacuum tubes) degenerate with life, circuit design should include means for detecting significant changes in component values during use of the circuit, and soon enough to insure replacement of the component before failure occurs.

Circuit Components

Due regard must be paid to the choice of components in any design. Does the circuit configuration require that the component have an inherently high reliability? Just how stable is the capacitor, resistor, vacuum tube under examination? The circuit engineer must know and consider the component tolerances before specifying

them for any given application. As a matter of record, how close can the transistor manufacturers come to reproducing the same values for each transistor supplied to the equipment producer? The circuit engineer has to know these things about the components he specifies in a design: What is the component's behavior in a given environment, what is its expected life, what stability can be demanded of it, and how nearly identical in characteristics are components from different production runs?

Component modes of failure should be recognized by the designer: deterioration, catastrophic failure, and intermittent failure. Intelligent design and selection should obviate the last two, leaving only normal degradation of performance to be contended with.

The circuit designer must know the conditions at which his components are rated, and he must pay attention to what stresses are anticipated. The size, weight and cost of the component may be very important. H. L. Garbarino of the Armour Research Foundation[6] points out that stress often has an inverse relation to life. In a capacitor, for instance, as voltage stress is reduced life will normally increase. He shows that for a given capacitor halving the voltage will increase the capacitor life 32 times.

Severity of operation curves will give the designer guides. Always the operational environment of the final equipment must be considered.

Conversely the same effect can be accomplished by doubling the thickness of the dielectric and—to keep the same capacitance value—doubling the electrode area. Making both these changes would increase the capacitor size three times and make it twice as expensive. But added advantages *vis a vis* reliability may make such a course desirable.

Accelerated Life Testing

Earl Peacox of Stromberg-Carlson notes[7] that Time is the ultimate environment, that equipment or components that survive in the environment of time are reliable.

Good engineering judgment is required in testing components to failure—failure being defined as operation outside assigned tolerances. The exponential model of failure rate has generally been accepted by the industry and has particularly been recommended by the government.[1] According to this model, which is admittedly an approximation, the hours to failure of a component may be characterized by a probability density function of the form

$$f(t;\theta) = e^{-t/\theta}/\theta, t >> 0, \theta > 0$$

where t is the life in hours and θ is the mean of life of the component. A constant failure rate is then defined: λ = number of failures divided by the unit of time.

For a detailed discussion of statistical techniques for accelerated life testing, the reader is particularly referred to the excellent work done by B. Epstein of Wayne University[8, 9, 10] and G. R. Herd.[11, 12]

All samples under test are subjected to as nearly identical stresses as possible. In this way time to failure becomes the important random variable. Quantities of the component in question are subjected to increasingly severe stresses until failure occurs. The trouble is that a program like this is expensive—and extreme conditions may cause a change in the mode of failure, leading to wrong conclusions. You can heat a component to the point where it fails because it has melted; you still don't know much about its long-time electrical characteristics at some temperature short of melting.

Many tests for determining component failure rate are given in the literature, and are beyond the scope of this report. We can only say "brute force" techniques, involving large sample sizes and long periods of time to get statistically significant data, are expensive and some times not practicable. The newer transistors, for example, have not been around long enough to predict with great accuracy what their mean life to failure under a variety of conditions is. Better methods must be found.

One step along the way is the analysis of failure mechanism. The determination of the critical modes of failure, investigation of the underlying mechanisms which bring the failure about, will help to bring about better methods for failure rate estimation with smaller sample sizes—and will help in developing better components.

Brute force testing is illustrated with an example from "Component Part Reliability Studies for Complex Military Equipment" by J. W. Gruol of the Signal Corps Engineering Labs. Fig. 3 shows the result of life tests on 1000 paper capacitors conducted at highly accelerated conditions. In Fig. 4 this data is translated into a failure rate curve. The high initial rate is due to "quick death" failure, attributable to manufacturing defects.

(Continued on next page)

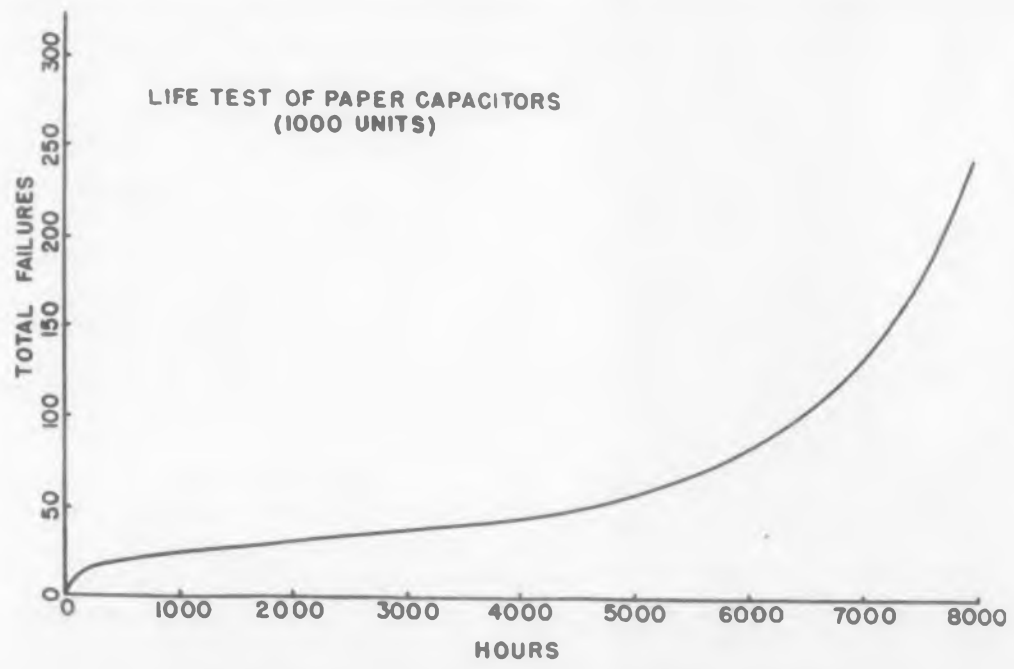


Fig. 3. Per cent of resistors that changed by more than the per cents shown, in life tests.

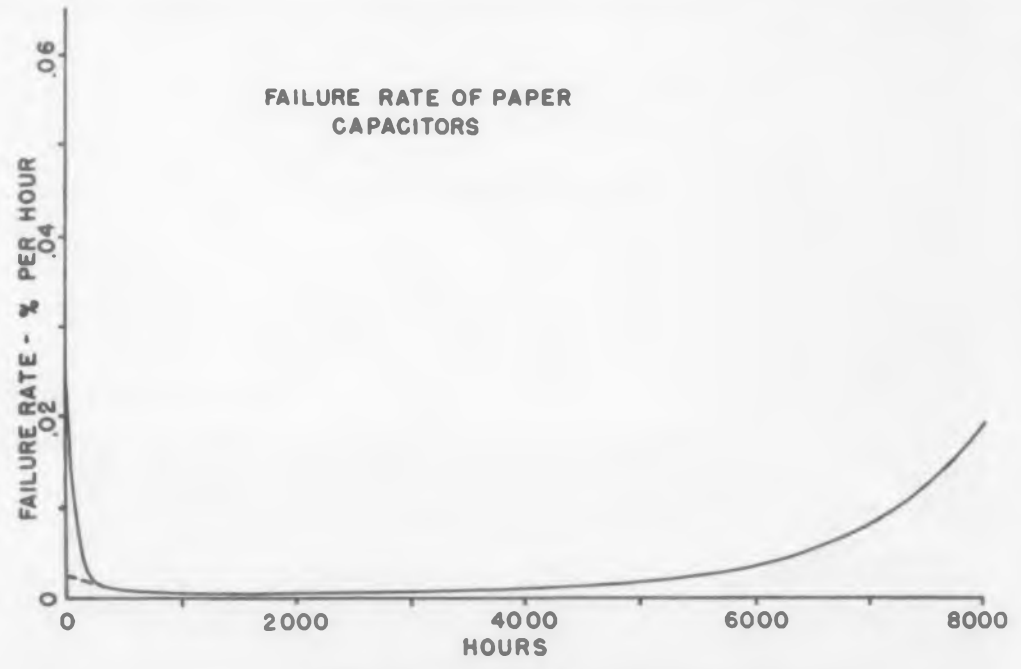


Fig. 4. Difference in performance between different manufacturers.

Marginal Checking

Evaluation of the reliability of a given circuit should make quantitatively clear what tolerance a circuit has to component variation. This is done, in general terms, by determining what excursion of component performance is allowable, as a function of a selected circuit parameter. The tolerance of any of the components in the circuit is plotted against the variation in this marginal checking parameter. If the circuit contains a great many components, this can be a tedious job—particularly since the effect of two or more component variations may be additive to result in a circuit operating out of tolerance. There are as yet, however, few short cuts in this procedure. References 5 and 13 examine the marginal checking procedure in some detail, and offer the engineer sound information of a general nature on component variations.

Production Testing

When the prototype equipment is constructed it must be tested to see if it works. This is not reliability testing. It is a confirmation of the designer's ability to create piece of equipment to perform a given function. Tests given to the prototype are operational—they determine whether it will work under different conditions and in different environments.

There is no great virtue in testing the prototype equipment for reliability. Even accelerated life testing takes time, and at this point time is usually at a premium. The idea is to get the equipment into production as soon as possible. In addition a statistical sample of one piece of equipment—which is not a duplicate of those that will finally come off the production line—will not provide a very accurate representation of what reliability to expect in the field.

Just as with life testing of components, equipment testing reveals three phases of failure: *early*, *normal operating* and *wear-out*.

The *early* period is when marginal parts, initially defective but unrecognized, are causing premature equipment failure. Equipment should be kept on life test until this period is over. During the *normal operating* period the failure rate is essentially constant, and should have a duration somewhat longer than the specified equipment longevity. The *wear-out* period is sometimes a function of the total equipment age, and sometimes it is a function of the user's environment and maintenance technique. When this last is the case reliability evaluation may perforce differ from the time of wearout later observed in the field.

Paper Prediction

IF A fairly close prediction of equipment reliability can be made before a prototype is constructed, a good deal of work may be saved the design engineer. Redesigning a piece of equipment to have greater or less reliability can be expensive and time consuming.

Several methods of prediction have been compiled here for the engineer's guidance. The product rule method—$P = p_1p_2 \ldots p_n$—is recommended by AGREE Task Group 4. This method has gained favor among engineers. It is simple. But it is crude. The reliability estimates obtained using it are generally lower than they should be—this is one reason it is safe to use. On the other hand an estimate like this can be expensive—the final equipment tends to be over reliabilized. This is an easy way to lose a contract bid.[14]

Other experts feel that better estimates can be obtained with other techniques. The Blanton method described in references 15 and 16 and later in this issue is very little more difficult to use than the product method, and may give more accurate results. If a simple series system is analyzed, the Blanton technique rapidly turns into the product rule—simplicity is not sacrificed.

Systems presently in use are the Vitro and RCA methods.

Product Rule Method

Subject to the limitations outlined in the AGREE report, which are stringent enough to reduce the value of the method substantially, the procedure for estimating reliability by the product rule is

- Define the equipment explicitly and uniquely in terms of its functions and boundary points. When this is done "failure" for the equipment will have been defined.
- Specify the components within the system. They must be uniquely identifiable. Select them in such a way as to take into account and eliminate the effect of system redundancy.
- Select the parts which affect system unreliability. Within each component some parts have a very small effect and can be neglected. Other parts, due to large number or high failure rate, have a dominant effect.
- Determine a failure rate for each part or class of parts used in each component of the system. Some parts can be grouped according to failure rate—tubes with high operating temperature, tubes with low temperature, capacitors with high voltage applied, resistors with high power rating, etc.
- Determine a preliminary figure for the failure rate of each component within the equipment. Add the failure rate for all parts in each component to get preliminary figures for component failure rates.
- Determine the correction factors to be used to modify the preliminary figures for the failure rate of each component. Some effects of dependence between part and component can be accounted for by a single correction factor in the component failure rate.
- Determine the failure rate for each component. Multiply the preliminary figure by the correction factor.

The above steps are an elementary way of obtaining a failure rate estimate for each component. Only partial corrections to the product rule have been considered. The interaction between components and operating conditions must be evaluated with more sophisticated techniques not described in the AGREE report.

- Determine a preliminary figure for the failure rate of the equipment. Add the failure rates for all independent components within the equipment to obtain the preliminary figure for the equipment failure rate.
- Determine the correction factors to modify the preliminary failure rate obtained above. Special stresses not accounted for in the above steps should be accounted for at this point.
- Determine the failure rate of the equipment. Multiply the preliminary estimate by any correction factors that apply.
- Determine the predicted reliability function for the equipment. This function is given by

$$R(t) = e^{-t(\textit{equipment failure rate})}$$

- Determine the predicted mean number of hours between equipment malfunctions. This number, ξ, is given by

$$\xi = 1/\textit{equipment failure rate}$$

The procedure listed above is described by Task Group 4 in reference 1. It is plain that for an estimate of reliability that is not intolerably rough, some rather involved mathematics (in the derivation of correction factors) is needed. This is to some extent unavoidable with any method. At the same time other techniques can be used which reduce the problem to manageable proportions.

Vitro Method

The failure rate curves compiled by Vitro Laboratories, Silver Spring, Md., are used in this paper prediction technique. The curves are useful for any equipment designed to be used under conditions comparable to those experienced by shipboard equipment. The procedure is as follows.

Paper Prediction (Cont.)

- Calculate the *receiving tube* plate, screen grid and cathode currents, and the plate and screen grid power dissipations. These are to be working values. Compare the values with the tube manufacturer's design center values to determine the per cent of rated values. Determine the application severity level—U, V, W, X, Y or Z of Curve 2 to be assigned to each tube. In the case of a dual triode or diode the application severity level is that of the more severely applied half tube. The number of tubes used for prediction is equal to the number of tube sockets.
- The wattage dissipations of *fixed carbon composition resistors* are calculated and compared with rated capabilities, and a severity of application number is assigned as shown in the Vitro curves.
- The above step is repeated for *fixed wire wound resistor* severity level determination.
- Maximum voltage appearing across the terminals of *capacitors* is determined and compared with rated capabilities, and an application severity number assigned. With multiple section paper capacitor unit the container counts as one capacitor with a severity level equal to the highest level in the container. Each electrolytic capacitor section in a container counts separately, however.
- Because of lack of operational data, application severity levels sometimes cannot be assigned to a few parts in the above categories. When they are few they should arbitrarily be assigned *level 2* for parts and *V* for tubes.
- The number of *transmitting tubes* are counted. This class includes rectifiers with output ratings greater than 1500 v dc, tubes with ratings greater than the *807*, klystrons and duplexing tubes. Magnetrons are excluded.
- The remaining electrical parts are divided into three groups and counted. *Group 1* includes circuit breakers, synchro motors and generators, indicator lamps, jacks, plugs, etc.; *Group 2* includes magnetic amplifiers, blower and instrument motors, crystal rectifiers, fuses, etc.; *Group 3* includes relays and switches with a high cyclic rate such as keying relays and heading flash microswitches.
- After all the preceding steps have been executed, a tabulation like the one shown in Table 1 can be made. Using the appropriate guideline for each category, find the failure rates per 5000 operating hours.
- Sum the above rates, multiply by 1.2 to com-

pensate for adjustments and mechanical failures. To find MTBF, divide 5000 by the product.

The resulting MTBF does not take account of the effect of failures due to film resistors, magnetrons and potentiometers, for which no guide lines were developed. As these populations are usually small, however, the effect of the omitted parts may be neglected. In the case where failure rates of excluded parts can be approximated, these parts may be included in the calculation.

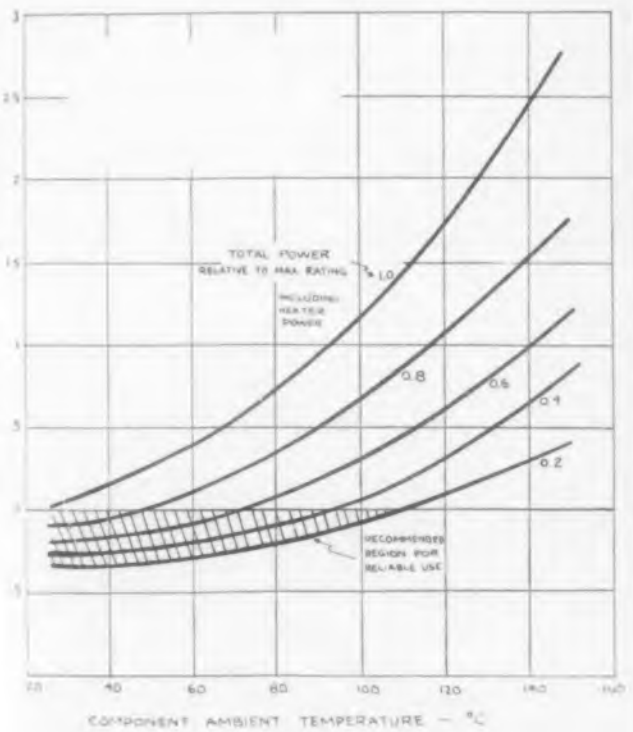
Blanton Method

A complete review of this prediction technique is exposed to the reader in Mr. Blanton's article "Reliability-Sensitivity Function Analysis" on page 22 of this issue. For a more complete description of the method the reader is referred to references 14 and 15.

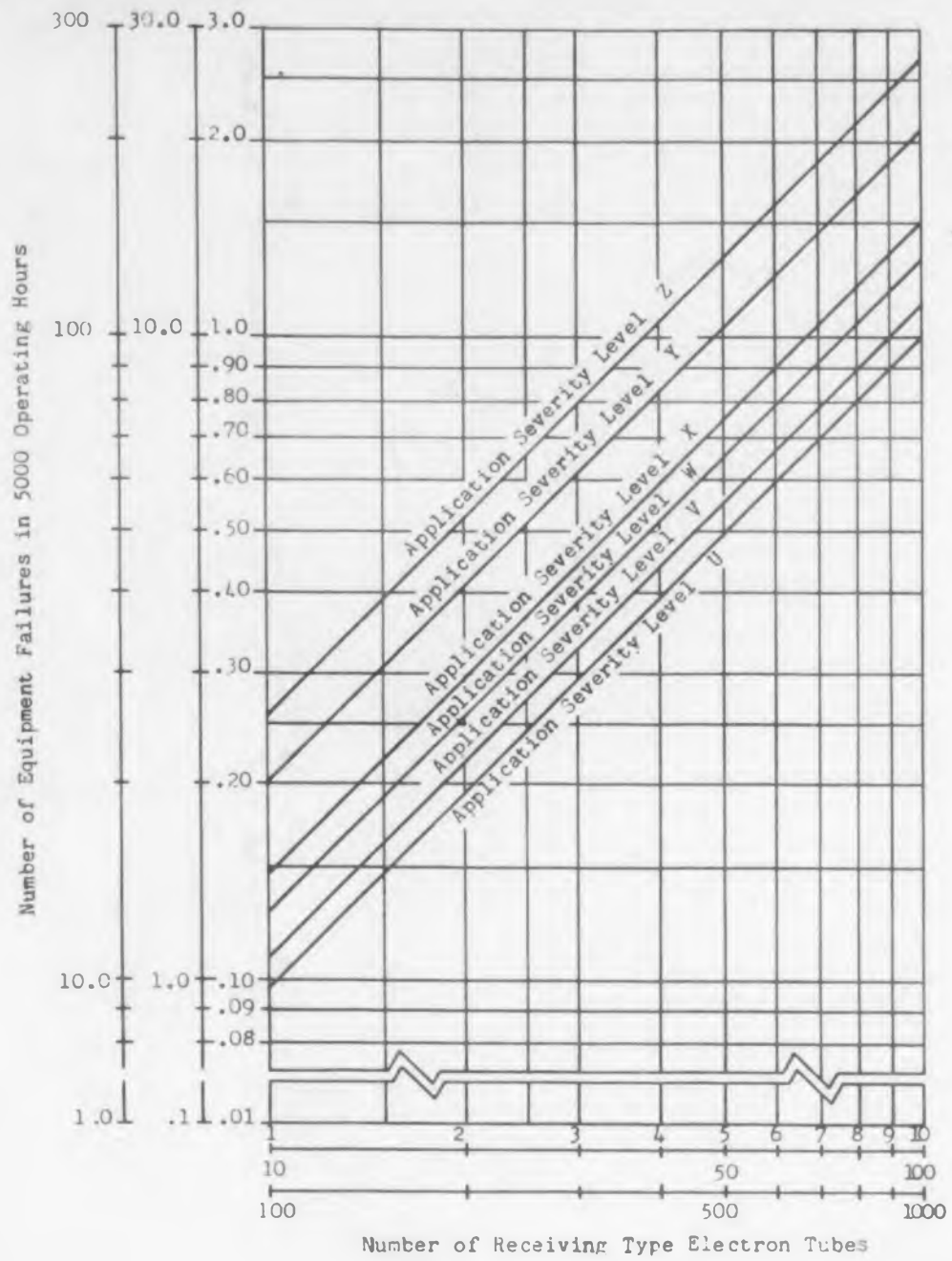
RCA Method

A demonstration of this technique will be found following the part reliability curves. A multivibrator circuit is analyzed and its reliability predicted. For further details the reader is referred to reference 4, which treats this prediction method extensively, and has additional curves.

Part Reliability Curves



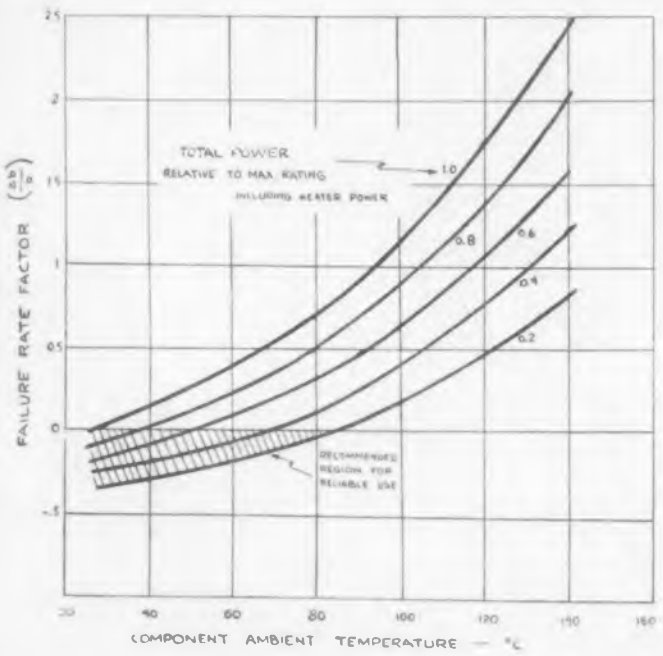
Curve 1. Electron tubes, predicted failure rate factor ($\Delta b/b$) referenced to rated power dissipation at 25 C. Miniature and subminiature, except with JETEC 3-1 bulb or equal. *RCA.*



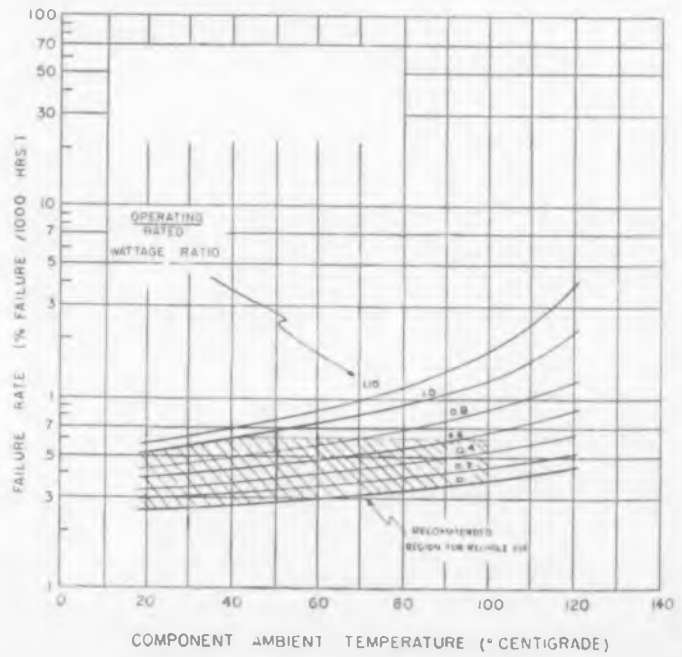
Definitions of Severity of Application

Application Severity Level	Voltage, Current, and Power Levels for Tube Elements (Lowest level possible is assigned)
U	All voltages and currents less than 50% of rated values, and power dissipation of all elements less than 25% of rated dissipation.
V	All voltages and currents less than 75% of rated values and power dissipation less than 50% of rated value, or, all voltages and currents less than 90% of rated values and power dissipation less than 25% of rated value. All VR tubes are to be included in this level.
W	All voltages and currents less than 90% of rated value and power dissipation less than 75% of rated value, or, all voltages or current less than 100% of rated value and power dissipation less than 25% of rated value.
X	Any voltage or current and power dissipation less than 50% of rated value, or, all voltages less than 90% of rated value and power dissipation less than 90% of rated value. All Receiving Type thyratrons are included in this level.
Y	All voltages, currents, and power dissipations less than 100% of rated value, or any voltage or current and power dissipation less than 90% of rated value.
Z	Any value of voltage and current and the power dissipation greater than 90% of rated value.

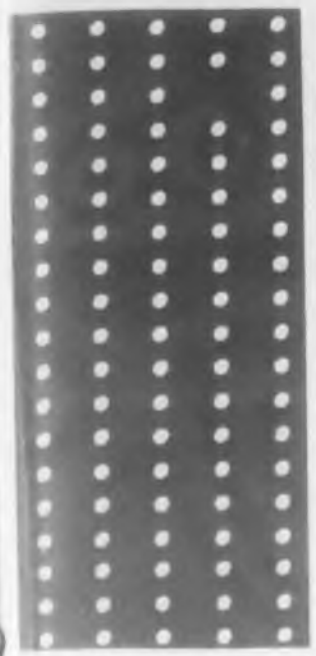
Curve 2. Receiving tubes, number of equipment failures as a function of application severity. *Vitro.*

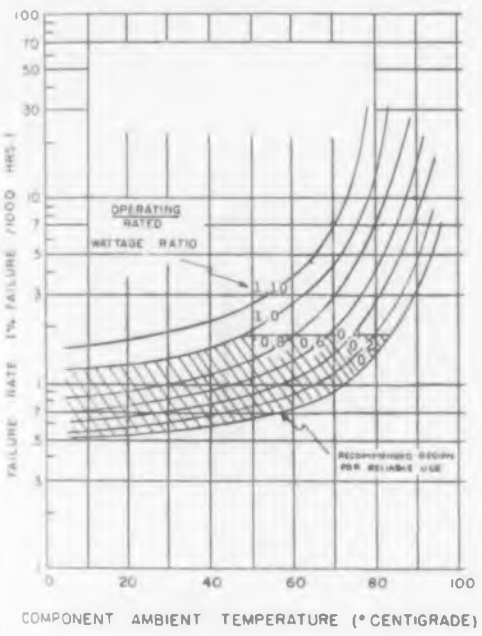


Curve 3. Electron tubes, predicted failure rate ($\Delta b/b$), referenced to rated power dissipation at 25 C. Applicable to subminiature tubes with JETEC 3-1 bulb or equal. *RCA.*

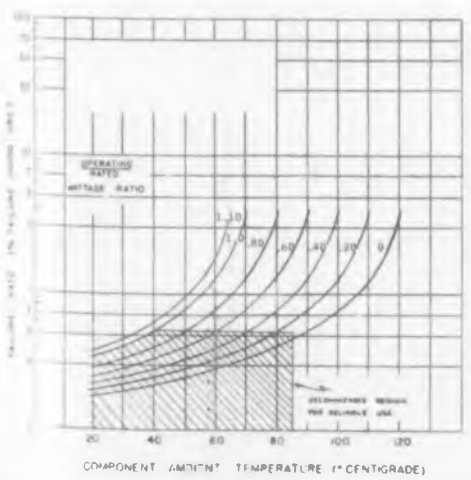


Curve 4. Silicon diodes, predicted failure rates. *RCA.*





Curve 5. Germanium diodes, predicted failure rates. *RCA.*



Curve 6. Selenium rectifiers, predicted failure rates. *RCA.*

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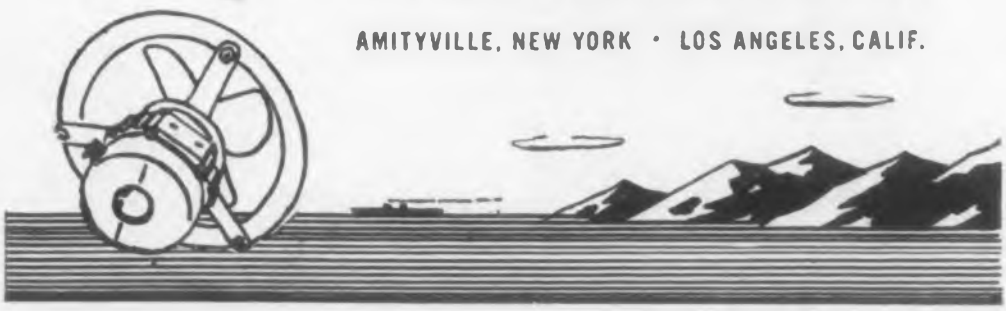

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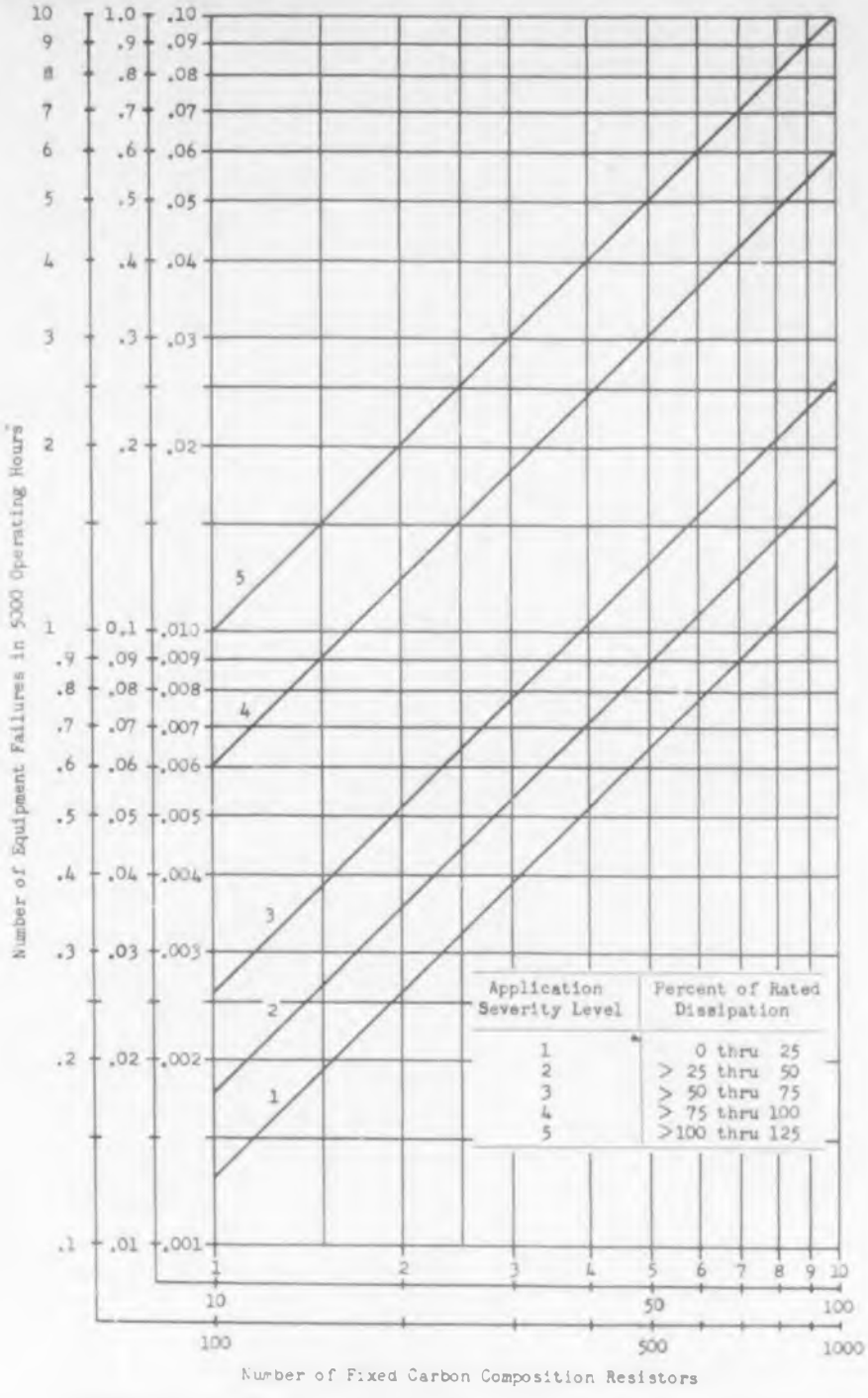
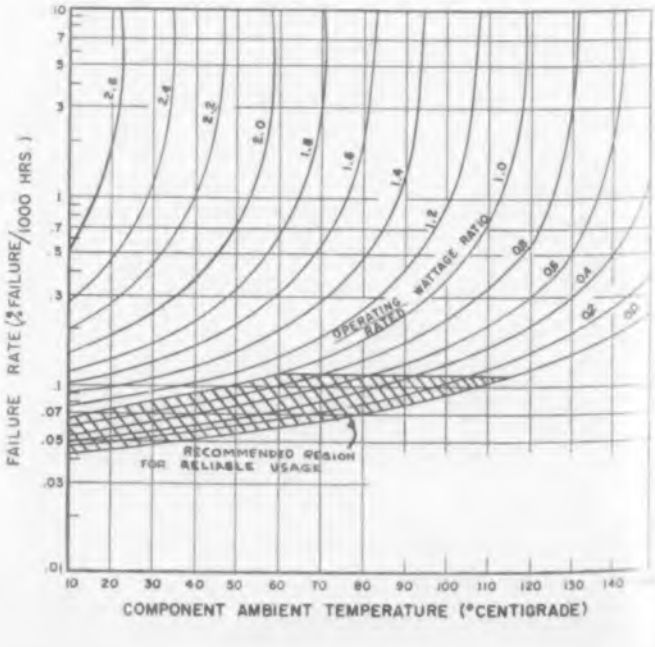
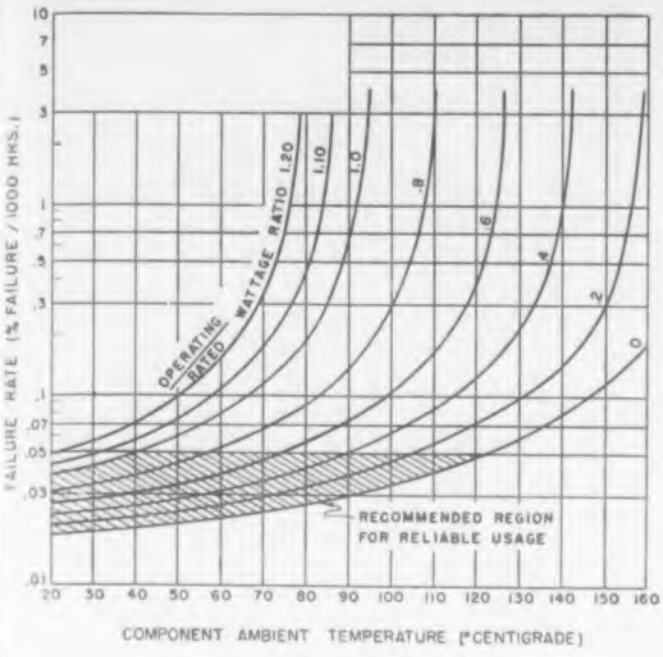


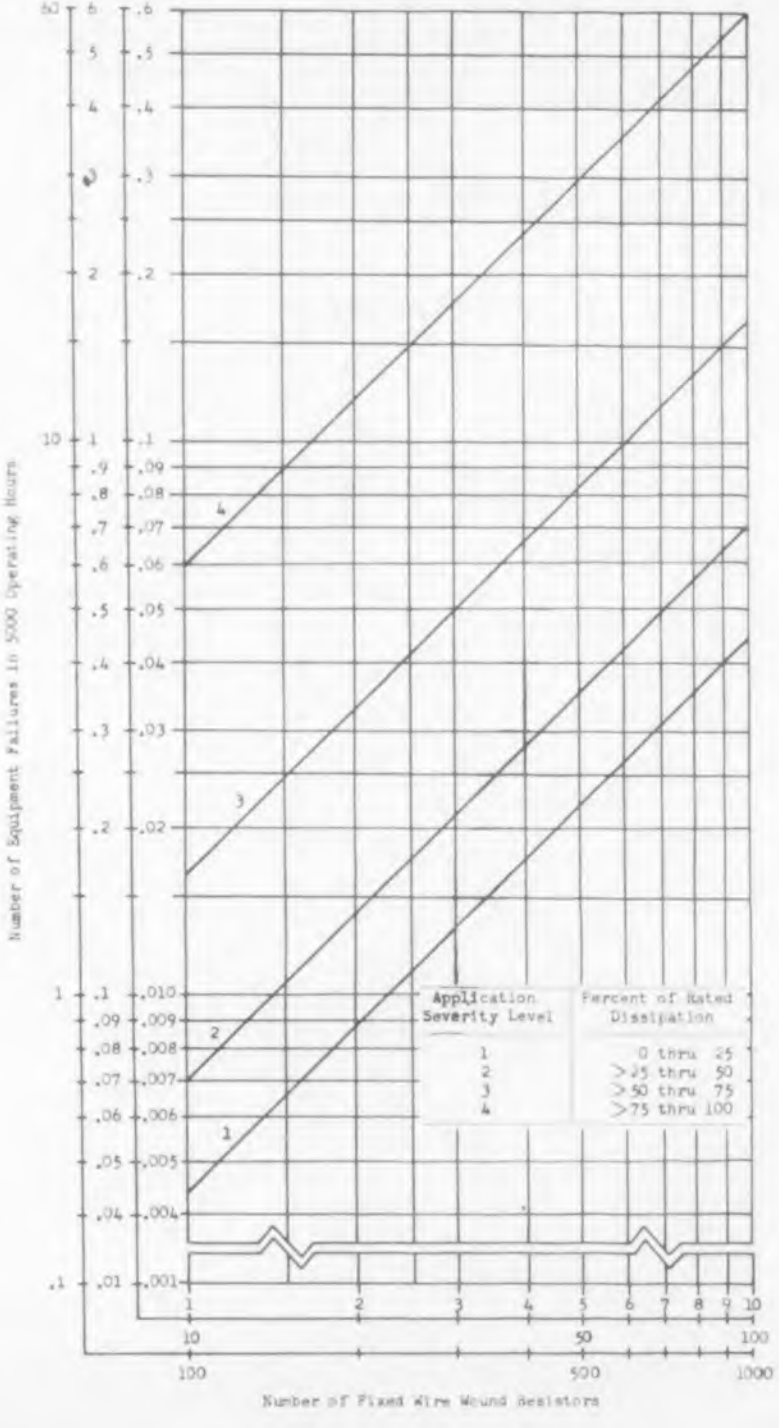
Curve 7. Carbon compostion resistors, number of equipment failures as a function of application severity. *Vitro.*



Curve 8. Carbon composition resistors, MIL-R-11A, GF, predicted failure rates. *RCA.*



Curve 9. Film resistors, MIL-R-10509A, predicted failure rates. *RCA.*



Curve 10. Fixed wire wound resistors, equipment failures as a function of applications severity. *Vitro.*

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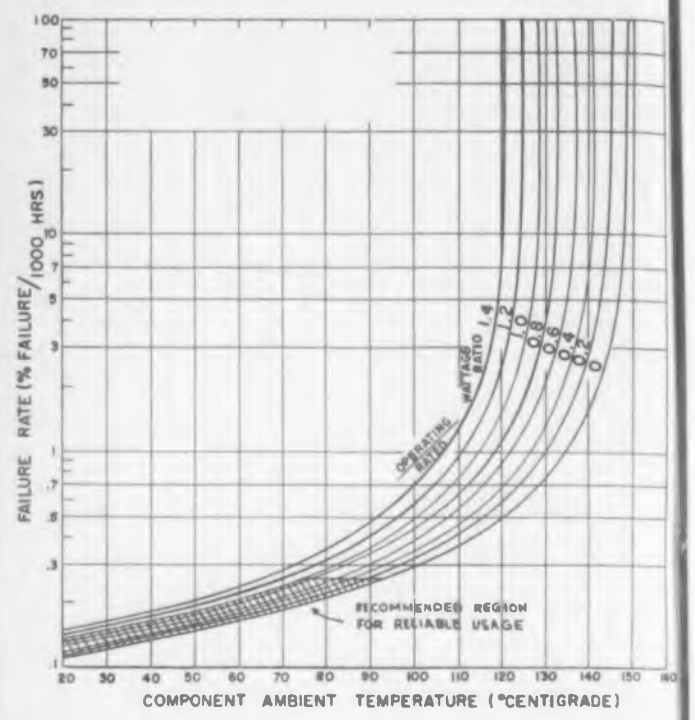
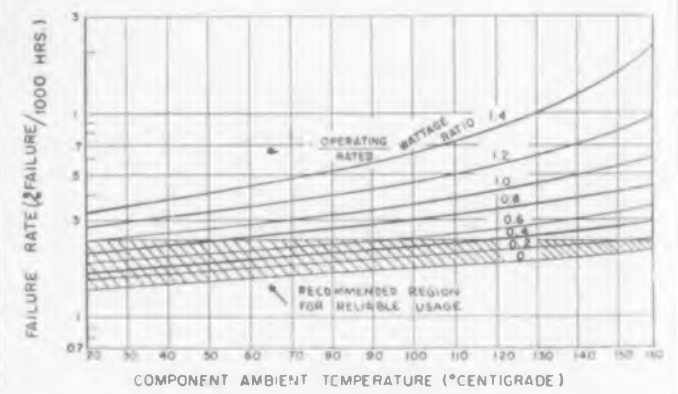
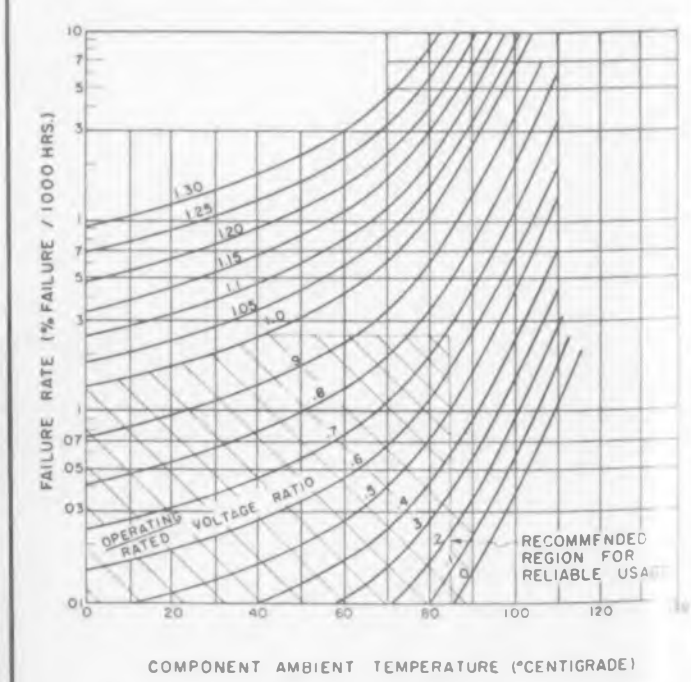


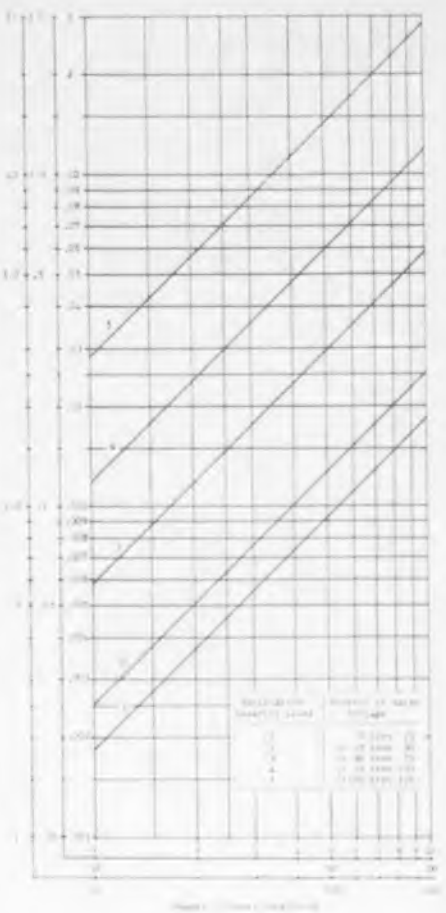
Curve 11. Accurate wire wound resistors, MIL-R-93A, predicted failure rates. *RCA.*



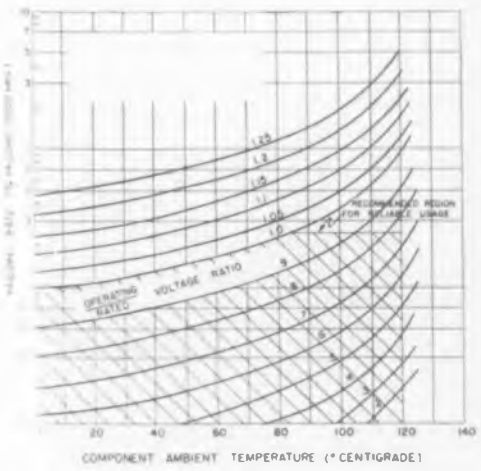
Curve 12. Power wire wound resistors, MIL-R-26B; F, G + V, predicted failure rates. *RCA.*



Curve 14. Paper capacitors, MIL-C-25A, ch-E predicted failure rates. *RCA.*



Curve 13. Paper capacitors, equipment failures as a function of application severity. *Vitro.*



Curve 15. Paper capacitors, MIL-C-25[illegible], ch K, predicted failure rates. *RCA.*

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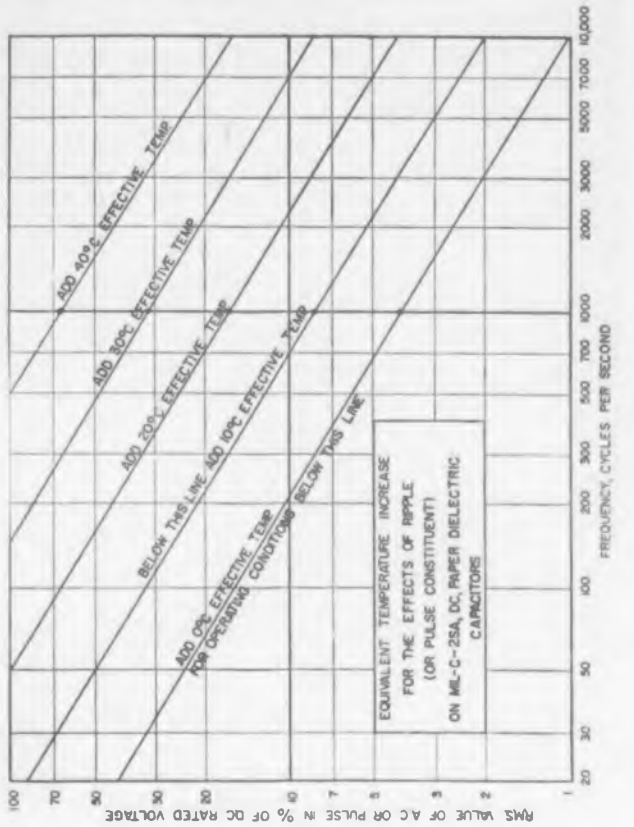
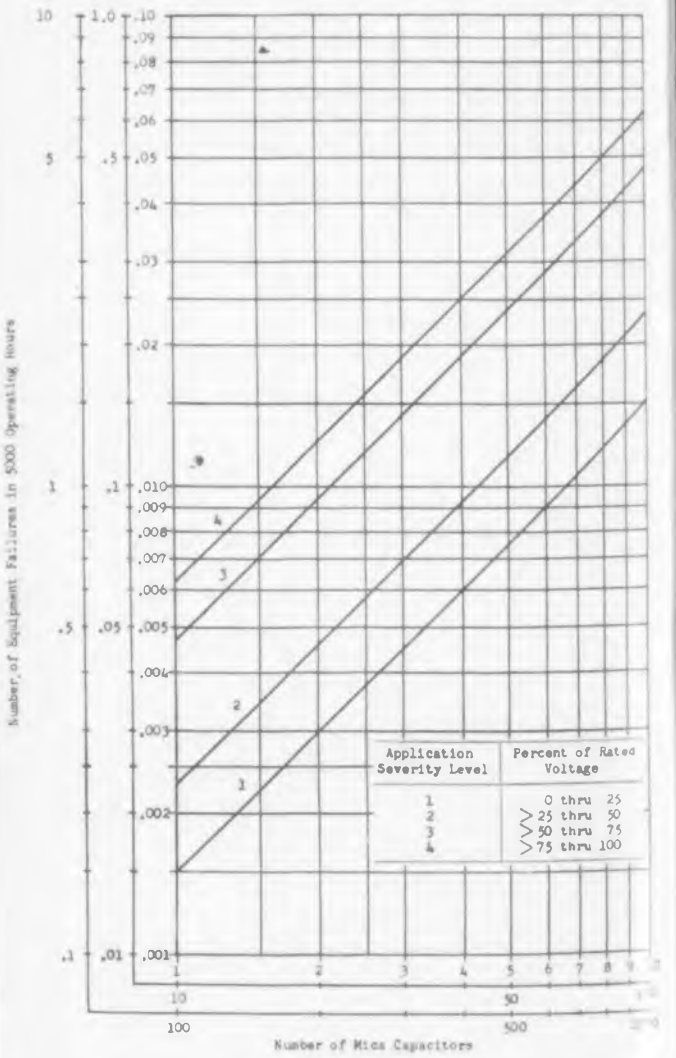
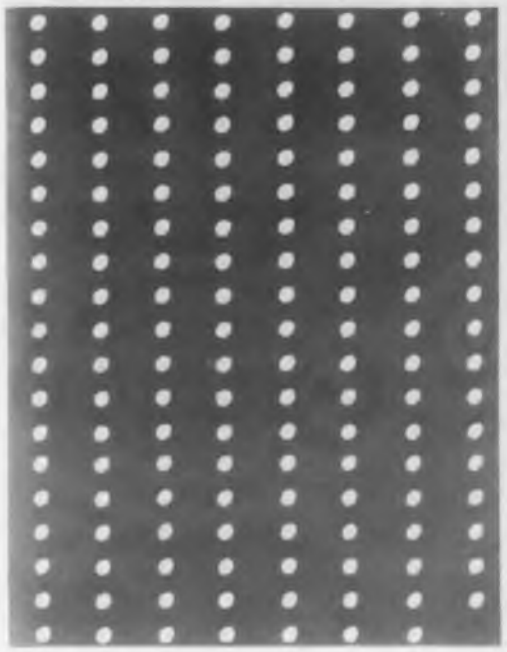
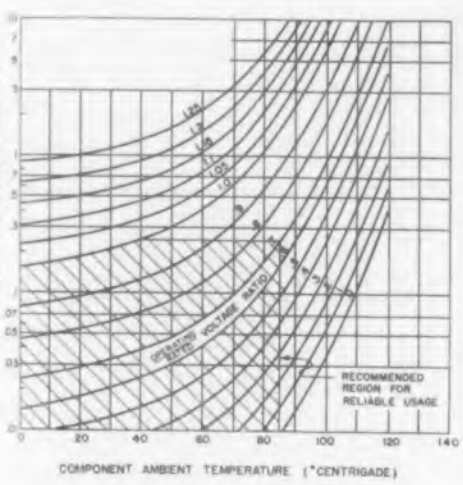


Curve 16. Paper capacitors, MIL-C-25A, equivalent temperature increase for the effects of ripple. *RCA.*

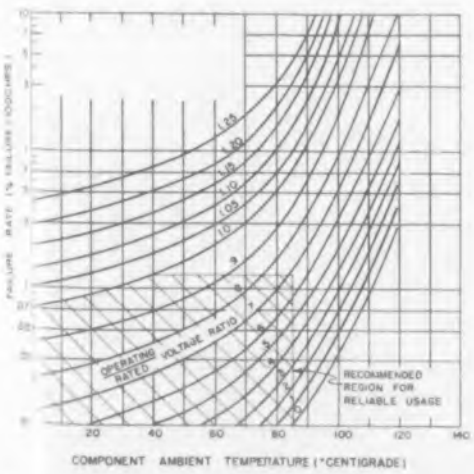


Curve 17. Mica capacitors, equipment failure as a function of application severity. *Vitro.*



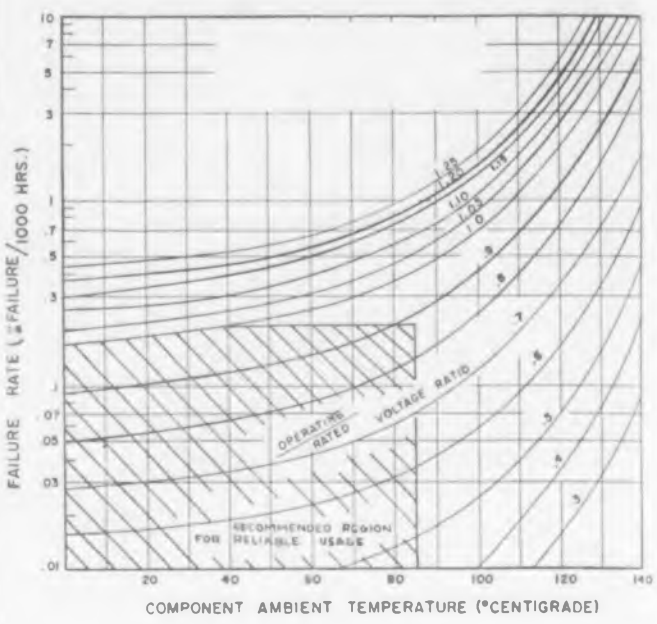


Curve 18. **Mica capacitors,** silvered, MIL-C-5A, predicted failure rates. *RCA.*

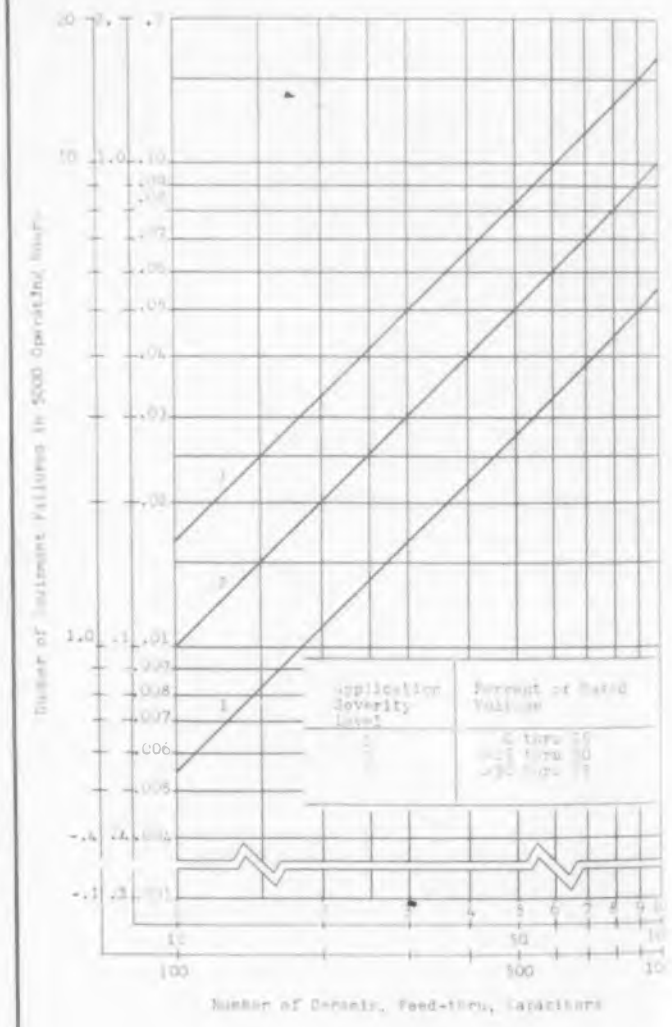


Curve 19. **Mica capacitors,** foil, MIL-C-5A, predicted failure rates. *RCA.*

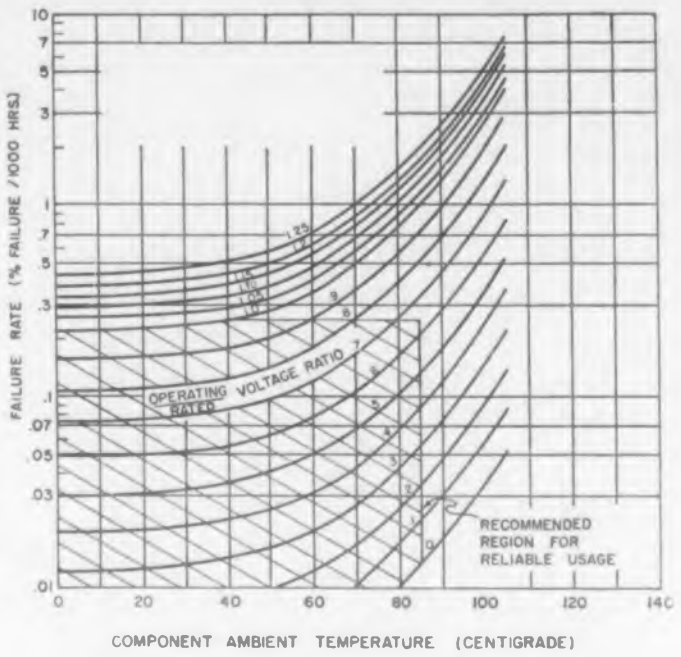
CIRCLE 127 ON READER SERVICE CARD →



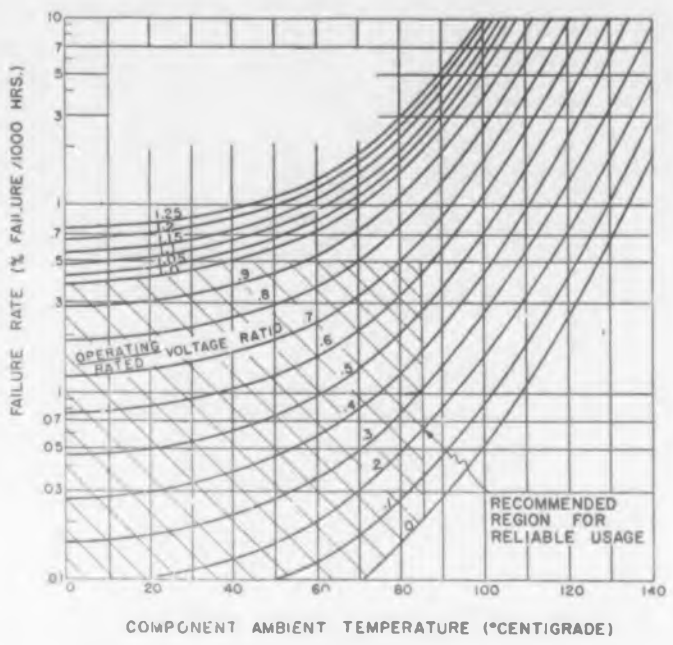
Curve 20. Mica capacitors, button, MIL-C-10950, predicted failure rates. *RCA.*



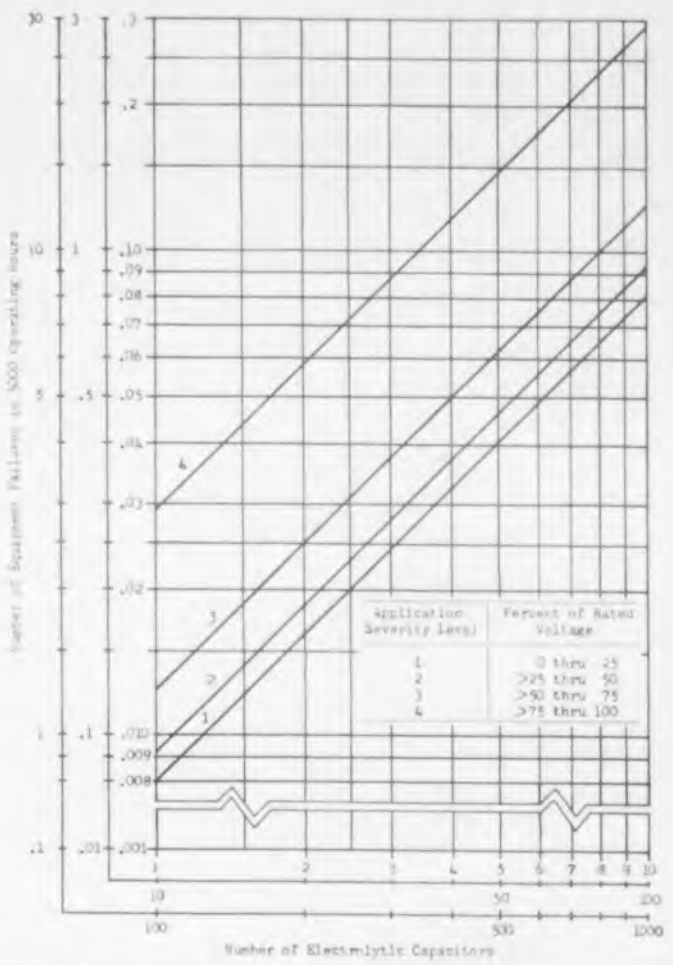
Curve 21. Ceramic feed-thru capacitors, number of equipment failures as a function of application severity. *Vitro.*



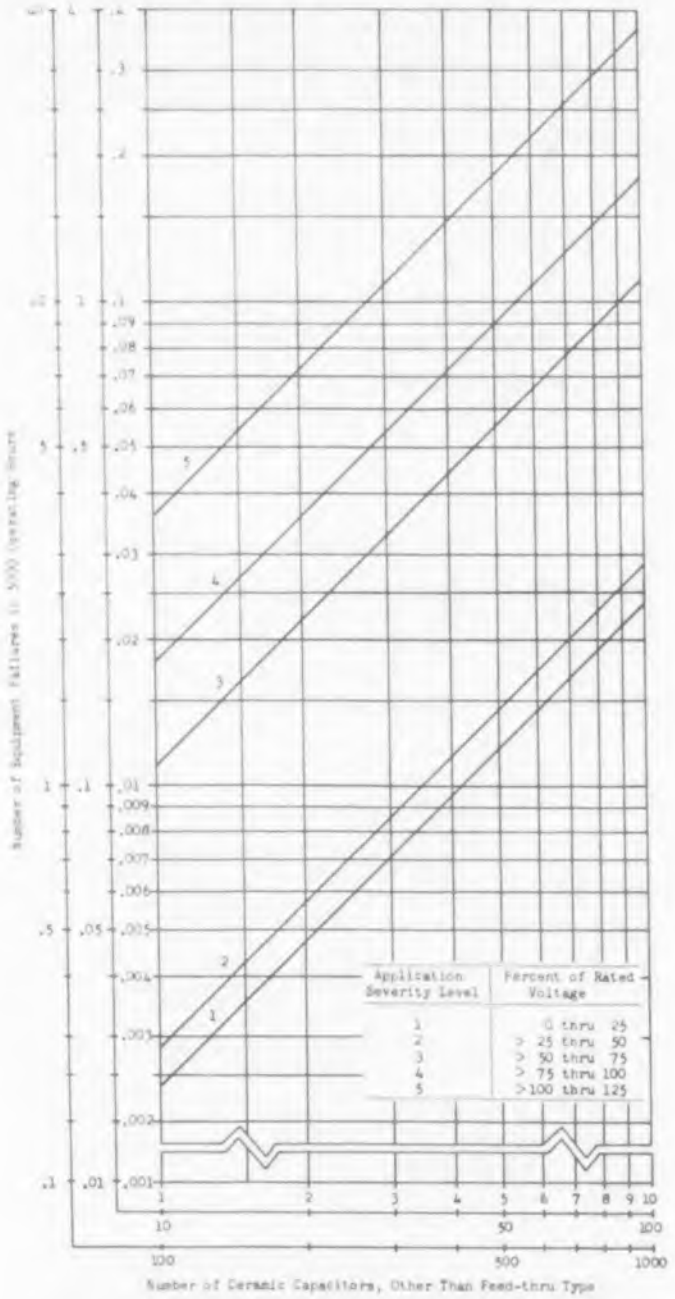
Curve 22. Ceramic capacitors, JAN-C-20A, predicted failure rates. *RCA.*



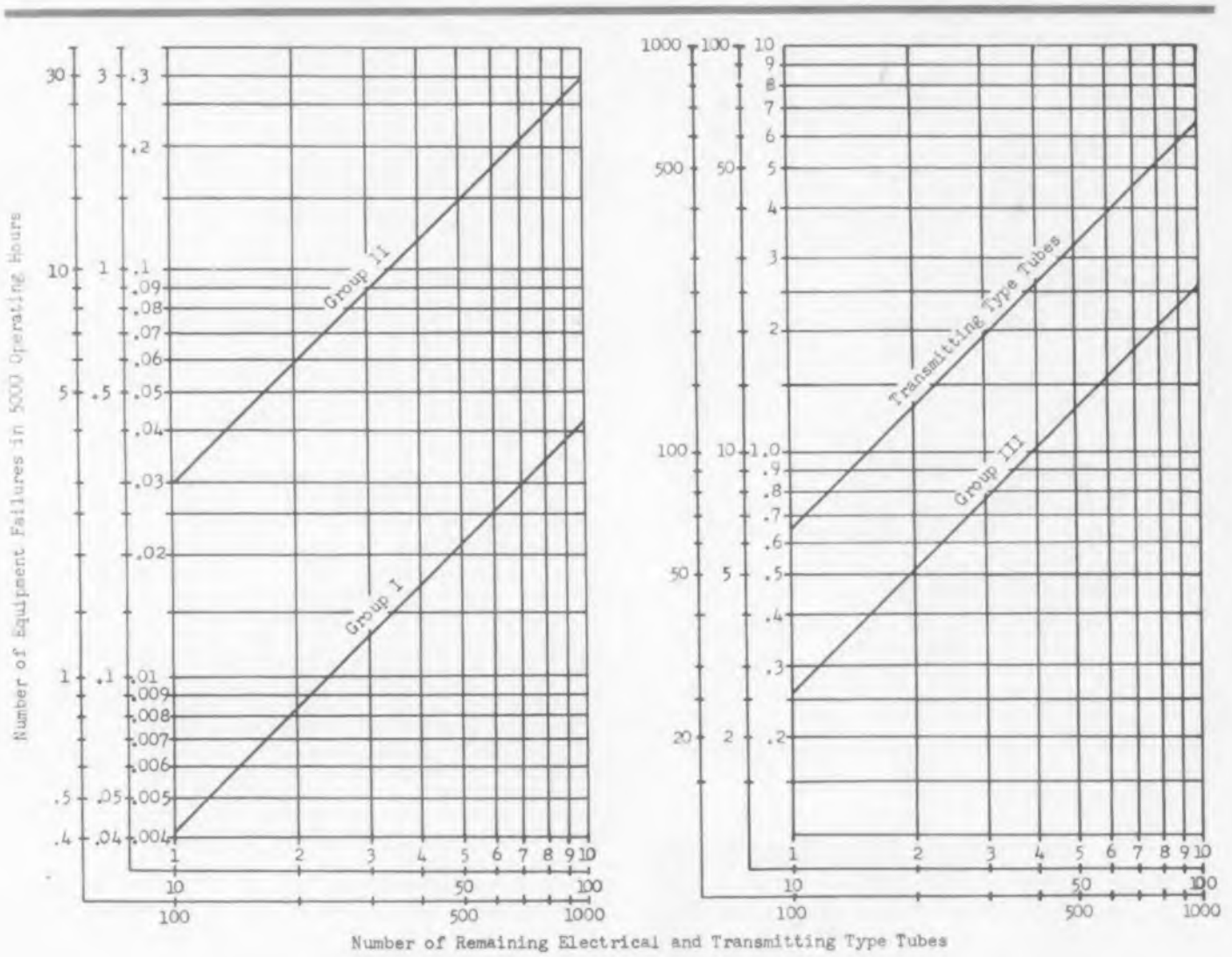
Curve 24. Ceramic capacitors, MIL-C-11015, predicted failure rates. *RCA.*



Curve 25. (right). **Electrolytic capacitors,** number of equipment failures as a function of application severity. *Vitro.*



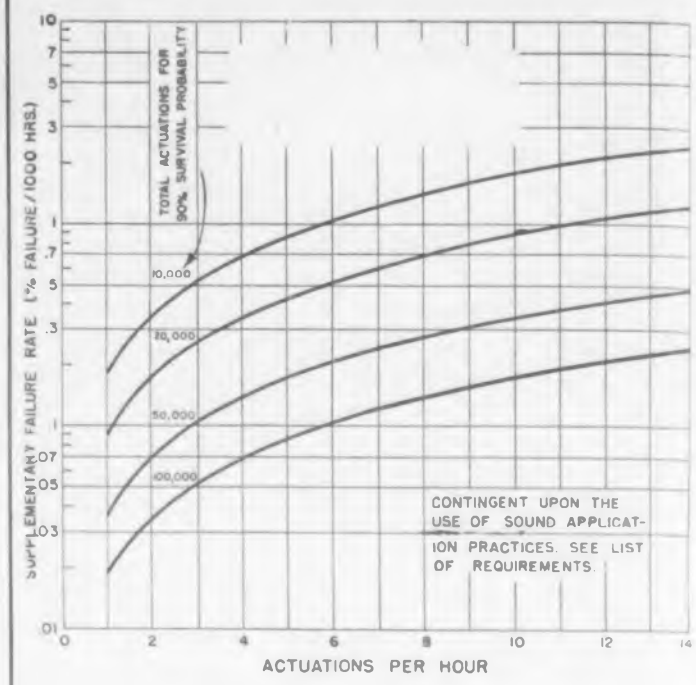
Curve 23. Ceramic capacitors, other than feed-thru equipment failure as a function of application severity. *Vitro.*



(See legend on facing page)

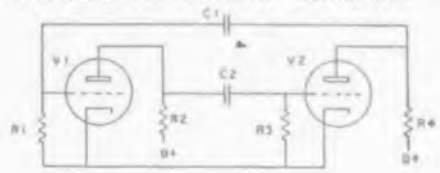
Curve 26. Remaining electrical parts and transmitting tubes (see text), number of equipment failures. *Vitro.*

Design for Reliability



Curve 27. Switches and relays, predicted failure rates per contact set. Coverage can be extended by multiplying axes by 10 or 100. Not valid for greater than x 100. *RCA.*

RISK COMPUTATION FOR AN EXAMPLE MULTIVIBRATOR CIRCUIT



(1) CIRCUIT SYMBOL	(2) BASE FAILURE RATE %/1000 HRS	(3) ELECTRICAL STRESS (ACTUAL/RATED* VOLTAGE OR WATTAGE)	(4) TEMPERATURE STRESS °C	(5) STRESS FAILURE RATE %/1000 HRS	(6) TOTAL FAILURE RATE %/1000 HRS
C1	0.130	0.5*	50	+0.117	0.013
C2	0.130	0.5*	50	+0.117	0.013
R1	0.090	0.1	50	+0.032	0.058
R2	0.090	0.4	50	0.022	0.068
R3	0.090	0.1	50	+0.032	0.058
R4	0.090	0.4	50	+0.022	0.068
V1	2.0	0.5	65	+0.2	1.8
V2	2.0	0.5	65	+0.2	1.8
	GRAND TOTAL (FAILURE RATE FOR COMPLETE CIRCUIT)				3.878

* after considering fan B+

USUAL SOURCE FOR DATA TABULATED ABOVE

COLUMN (1) - PARTS LISTED AND/OR CIRCUIT DIAGRAMS
COLUMN (2) - FAILURE RATE CHARTS OR CURVES FOR SPECIFIC COMPONENT FAMILIES
COLUMN (3) - CIRCUIT ANALYSIS OR DIRECT CIRCUIT MEASUREMENT
COLUMN (4) - ANALYSIS OF PACKAGING ENVIRONMENT, AND TOTAL POWER DISSIPATION AND/OR DIRECT MEASUREMENTS ON PROTOTYPE.
COLUMN (5) - SPECIFIC FAILURE-RATE CHARTS OR CURVES WHICH ARE A COMPOSITE FUNCTION OF ELECTRICAL STRESS (3) AND TEMPERATURE STRESS (4)
COLUMN (6) - ALGEBRAIC SUM OF BASE RATE (2) AND STRESS RATE (5)

RCA prediction technique. The failure rate for a multivibrator circuit, such as might be mounted on a plug-in assembly, is calculated. Environmental operating temperature for all components except tubes is 50 C. Tube temperature is 60 C. Electrical stress for each part is estimated, and the applicable curves are consulted. Information from failure-rate curves for specific component families and from specific failure-rate curves which are a composite of electrical stress and temperature stress are summed algebraically.

Part	Application Severity Level	Number of Applications		Predicted Failures per 5000 Operating Hours	
Electron Tubes, Receiving Type	U	19		1.9	
	V	44		5.0	
	W	12		1.6	
	X	8		1.2	
	Y	12		2.4	
	Z	17		4.6	
Summation			112		16.7
Electron Tubes, Transmitting Type			15		9.85
Resistors, Fixed Carbon Composition	1	387		.50	
	2	92		.17	
	3	6		.02	
	4	7		.04	
Summation			492		.73
Resistors, Fixed Wire Wound	1	8		.04	
	2	6		.04	
	3	6		.1	
Summation			20		.18
Capacitors, Fixed Paper	1	32		.06	
	2	37		.09	
	3	28		.16	
	4	23		.27	
Summation			120		.58
Capacitors, Fixed Mica	1	64		.10	
	2	104		.24	
	3	40		.19	
	4	7		.04	
Summation			215		.57
Capacitors, Ceramic Feed-thru	1	47		.25	
	2	26		.26	
	3	5		.081	
	4	2		No rate	
Summation			80		.591
Capacitors, Ceramic other than feed-thru	1	8		.02	
	2	7		.02	
	3	1		.01	
Summation			16		.05
Capacitors, Electrolytic	1	0		—	
	2	3		.03	
	3	10		.12	
	4	6		.17	
Summation			19		.32
	Group				
Remaining Electrical Parts	1	440		1.9	
	2	187		5.61	
	3	4		1.04	
Summation			631		8.55

Equipment Summation

Multiplied by 1.2 to compensate for adjustments and mechanical failures · 38.1 × 1.2 = 45.7

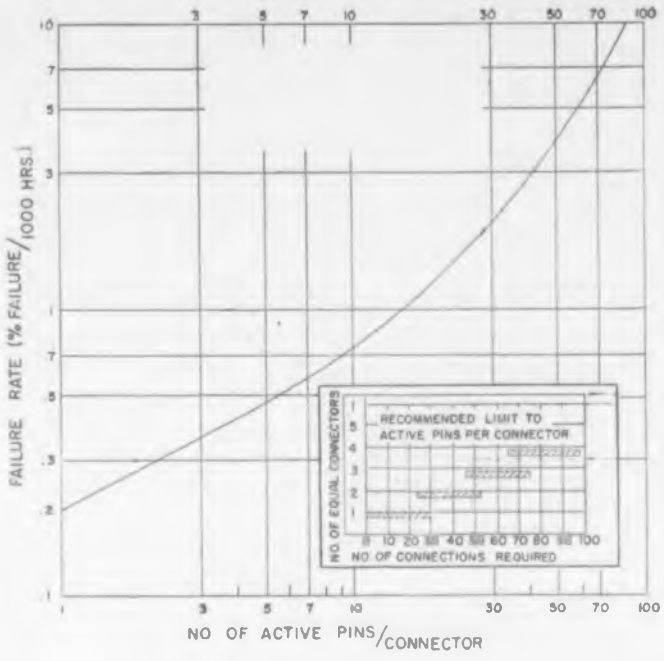
MTBF 5000/45.7 = 109 HOURS

NOTES ON NAVIGATIONAL AID A PREDICTION

1. Excluded from the calculation are the following parts for which no guidelines have as yet been developed:

Potentiometers 31
Film Resistors 36

Vitro prediction technique. Use of guidelines established in the Vitro curves is shown by the table. The correction factor, *1.2*, is to compensate for adjustments and mechanical failure. It is empirical.



Curve 28. Connectors, predicted failure rate. *RCA.*

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absolute maximum ratings @ 25°C (case temperature)

		type 2N497	type 2N498	unit
BV_{EBO}	(I_E = 250 μA)	8	8	V
BV_{CEO}	(I_C = 250 μA)	60	100	V
BV_{CBO}	(I_C = 100 μA)	60	100	V

design characteristics @ 25°C (case temperature)

		min.	des. cen.	max.	unit
R_{CS}	(I_B = 40 mA; I_C = 200 mA)	—	20	40	Ohm
h_{FE}	(V_C = 10 V; I_C = 200 mA)	12	20	36	—

Just as all TI semiconductors . . . your new 2N497's and 2N498's are fully guaranteed for one year from the date of delivery.

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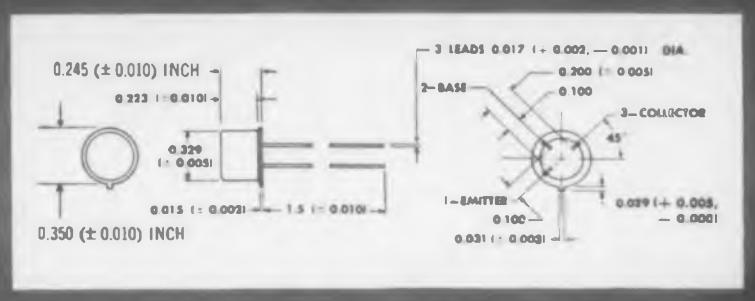

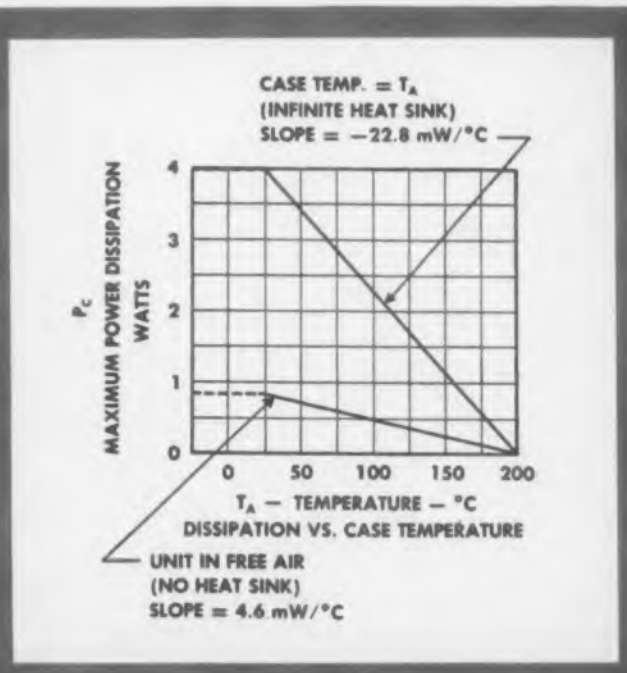

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Designed for 1/16, 1/8 or 1/4 in. printed circuits, series UPCC-SLH screw-lock connectors have anodized aluminum hoods, and high-compression, asbestos-filled melamine moldings within trapezoidal-polarized die cast aluminum shells. Voltage breakdown between contacts at sea level is 1800 v rms, and insulation resistance is over 5000 meg. Available with 7, 11, 15, 19, or 23 contacts rated 7.5 amp.

U. S. Components, Inc., Dept. ED, 454 E. 148th St., New York 55, N.Y.

CIRCLE 139 ON READER-SERVICE CARD

24 V DC Motor

Totally Enclosed

This 24-v dc explosion-proof, totally enclosed motor measures 7/8 in. diam by 1-1/2 in. length. Model 6A5 is rated at 0.01 hp at 12,000 rpm, and model 6A2 is rated at 0.001 hp at 4000 rpm. Model 6A2 is designed for continuous duty and requires a 0.22 amp maximum current, while model 6A5 is for intermittent service and requires a 0.9 amp maximum current.

Western Gear Corp., Dept. ED, P. O. Box 182, Lynwood, Calif.

CIRCLE 140 ON READER-SERVICE CARD

Radar Recorder

Films airborne scopes

Designed for filming both sector scan and ppi presentation, this radar recorder employs a modified indicator whose trace is photographed by a servo-driven, non-intermittent 35 mm camera. The unit includes provisions for monitoring the recording trace brightness. The recorder is self-contained in two portable cases each measuring approximately 20 x 26 x 15 in.

Alto Scientific Co., Dept. ED, 855 Commercial St., Palo Alto, Calif.

CIRCLE 141 ON READER-SERVICE CARD

NEW PRODUCTS

Motor-Reversing Switch

Provides three speeds forward and reverse

This totally-enclosed, motor-reversing switch type 1910, provides low, medium and high speeds in both forward and reverse, with an off position in the center. It is also available in single-speed and two-speed reversing types. It can be furnished for use with split-phase capacitor or shaded-pole motors; also as a seven-position tap switch with one off position. Electrical rating is 6 amp 125 v ac.

Ark-les Switch Corp., Dept. ED, 51 Water St., Watertown 72, Mass.

CIRCLE 144 ON READER-SERVICE CARD

Power Supplies

150-225 and 225-325 V DC

Models RS-217A and RS-317 power supplies are similar except for output voltage ranges, and are both designed with demountable construction for quick substitution. Output for models RS-317 is 225-325 v dc at 175 ma continuous duty, and for model RS-217A it is 150-225 v dc at 175 ma. Input for both models is 105-125 v, 60 cps; line regulation 0.1 per cent; load regulation 0.1 per cent; ripple and noise less than 7 mv peak to peak; recovery time less than 25 μsec; and internal impedance is less than 1 ohm.

Trans Electronics, Inc., Dept. ED, 7349 Canoga Ave., Canoga Park, Calif.

CIRCLE 145 ON READER-SERVICE CARD

Counter

Storage readout enables reading without stopping count

Called the Optimeter (Occurrences Per Time Interval Meter), this four-decade instrument counts, samples, stores, and provides a working

output without the need to stop the count in order to sample, and with no loss of time between samples. Information is transferred from the counter to a storage output in less than 50 μsec, while the counter resets automatically to accept the next sample. The storage output continuously displays the last count sampled.

Provisions have been made for relays, Nixie numerical indicators, and printers. The instrument is in a standard rack mount and has a maximum counting rate of 100 kc, with a 5 v input signal. A 40-v, 2-μsec transfer pulse is required for sampling.

Burroughs Corp., Electronic Tube Div., Dept. ED, Plainfield, N. J.

CIRCLE 148 ON READER-SERVICE CARD

Transistorized Power Supply

Converts 28 to 225 V DC

Designated TPS-5, this power supply operates in ambient temperatures from —40 to +70 C, and converts 28 v dc at 3 amp to 225 v dc at 300 ma for operating mobile electronic systems or devices. Package dimensions are 2-1/2 x 3-1/2 x 4-1/2 in. including mounting flanges. The unit weighs 1.5 lb.

Aerophysics Development Corp., Dept. ED, P. O. Box 689, Santa Barbara, Calif.

CIRCLE 149 ON READER-SERVICE CARD

Sum and Difference Amplifier

Flat Response 1 to 100,000 CPS

This sum and difference amplifier, model SND, is for use in correlating output signals from transducers such as strain gages, hot wire anemometers, sound and vibration pickups. Frequency response of each channel is flat from 1 cps to 100,000 cps; gain is 0.4; sum is correct to ±2 per cent and output difference signal, for identical inputs, is down 40 db. The maximum input signal for undistorted output is 40 v peak to peak.

Flow Corp., Dept. ED, 85 Mystic St., Arlington 74, Mass.

CIRCLE 150 ON READER-SERVICE CARD

NEW PRODUCTS

Reference Power Supply

Non-Exhaustible

This 3-lb reference supply will replace up to four reference cells, is hermetically sealed, non microphonic, and has instant operation.

A control permits adjustment to exact voltage between 1 and 6 v at 0 to 5 ma. Applications include transistor and vacuum tube bias supplies, or the replacement of batteries, since the unit does not run down, wear out, or leak corrosive chemicals.

Transistor Devices, Inc., Dept. ED, 730 Boulevard, Kenilworth, N. J.

CIRCLE 153 ON READER-SERVICE CARD

PM Motor-Tach Generator

380 to 1760 CPS

Type 15-MTG-6276-02 is a 28 v dc pm motor driving a tach generator. The tach generator has a frequency range from 380 to 1760 cps at 115 v ac input; output of 1.65 v min at 11,000 rpm min with 25,000 ohm load; linearity 5 per cent min up to 5000 rpm, and phase shift output within 15 deg of input at 400 and 1600 cps. Motor input is 28 v dc, rated torque 0.3 oz-in. and brush life 1000 hr.

John Oster Mfg. Co., Avionic Div., Dept. ED, 1 Main St., Racine, Wis.

CIRCLE 154 ON READER-SERVICE CARD

Vibration Pickup

Output of 1 V/In./Sec.

Available in a wide range of stock sizes, the Dynavolt vibration pickup is a moving-coil de-

vice to convert motion into voltage. Resonant frequencies from 7 to 80 cps result in possible use of this vibration pickup as a displacement, velocity or acceleration transducer. Outputs as high as 1 v/in./sec may be had under critically damped operation. Rugged construction is provided by a spring suspension system and limit stops engineered to eliminate stress concentration points. Overall case sizes vary from 2-1/4 in. diam by 3 in. high down to 1-5 8 in. diam by 1-3/4 in. high.

Mandrel Industrial Instruments, Dept. ED. P.O. Box 13243, Houston 19, Texas.

CIRCLE 157 ON READER-SERVICE CARD

Silicon Power Rectifier

Rated at 35 amp, 100 piv

Designed to meet MIL-E-1 and MIL-T-19500-A, the IN412B silicon power rectifier is rated at 35 amp rectified dc output current with a piv rating of 100 v. Also available, but not covered by individual military specifications are the IN411B and the IN413B rated at 35 amp with piv ratings of 50 and 200 v respectively.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 158 ON READER-SERVICE CARD

Phase Sensitive Null Detector

Both X and Y Output

Model ND-101, 400 cps phase sensitive null detector is an error measuring instrument having two output meters, simultaneously reading X and Y components of input voltage with respect to the line reference. With almost complete rejection of all harmonic frequencies, the unit's sensitivity is 1 mv full-scale for both X and Y components. Overall accuracy as a voltmeter is ±5 per cent. Available in portable or rack-mount models.

Dynamic Development Co., Dept. ED, 59 New York Ave., Westbury, N.Y.

CIRCLE 159 ON READER-SERVICE CARD

NEW PRODUCTS

Log-Linear Recorder

Dynamic range of 40 db ±0.1 db

Designed primarily to record antenna radiation patterns, the HSR-1 log-linear recorder plots the logarithm of voltage input level as the abscissa. When used with a square-law detector, the recorder has a dynamic range of 40 db with an accuracy of ±0.1 db. This corresponds to an 80 db voltage range. The instrument has a writing speed of 30 in. per sec and records in ink on standard reproducible paper.

Rantec Corp., Dept. ED, P. O. Box 18, Calabasas, Calif.

CIRCLE 161 ON READER-SERVICE CARD

Klystron Power Supply

High Voltage Stability

Model 701-B klystron power supply accommodates reflex klystrons requiring up to 600 v of beam voltage. Basic features include a unique clamping circuit which allows cw or square wave operation without readjustment of the reflector voltage, and a high voltage stability due to the use of a shunt regulated reflector supply. Low fm modulation results from the use of a square fm modulation results from use of square wave modulation with minimized rise and decay time.

Cubic Corp., Dept. ED, 5575 Kearny Villa Rd., San Diego, Calif.

CIRCLE 162 ON READER-SERVICE CARD

Trimming Potentiometer

Two-in-One Unit

Model 062 WS Vari-Trim contains two trimming potentiometers, two variable resistors, or one of each, plus a fixed resistor in a case measur-

ing 1/4 x 5/8 x 1-1/4-in. Each wire-wound element is offered in resistances ranging from 1 to 125,000 ohms. By use of an overwind, up to 250,000 ohms can be furnished. In addition, series resistances are available at one end of either or both elements, or symetrically at both ends, to provide a maximum of 500,000 ohms. Power rating is 0.4 w at 50 C derating to zero at 105 C. Each unit has a mechanical range of 45 turns.

Con-Elco, Dept. ED, P. O. Box 307, 1711 S. Mountain Ave., Monrovia, Calif.

CIRCLE 166 ON READER-SERVICE CARD

Video Transformer

Wide bandwidth of 50 cps to 8 mc in a miniature size.

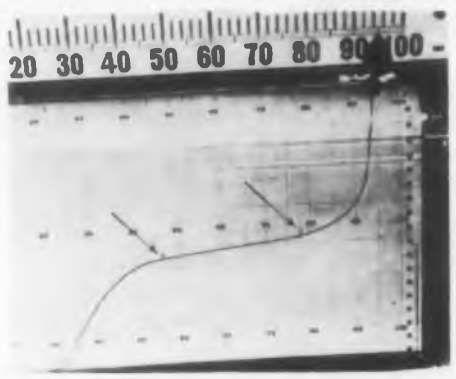
These subminiature wide band video transformers have a bandwidth of 50 cps to 8 mc and expected to be used to replace bulkier and more costly components. Transformers are supplied with solder terminals, and meet all applicable mil-specs. Each transformer prototype is accompanied by a comprehensive laboratory report, which includes submitted electrical requirements, photo-oscillograms, the test equipment used, and evaluation of the electrical characteristics of the prototype.

ESC Corp, Components Div., Dept. ED, 534 Bergen Blvd., Palisades Pk., N.J.

CIRCLE 167 ON READER-SERVICE CARD

Strip Chart Devices

Make Recorders Versatile



A three-position pen, a pen jogger, an events marker pen, a curve follower pen, and an access door are all designed for the fuller utilization of strip chart recorders. The three-position pen is particularly useful for recording the output of an integrator. The jogger is useful in testing-machine work to identify the knee of the curve.

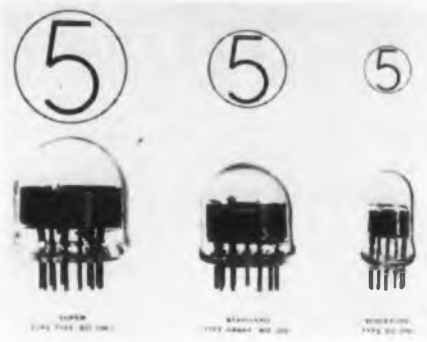
Royson Engineering, Dept. ED, Hatboro, Pa.

CIRCLE 168 ON READER-SERVICE CARD

NEW PRODUCTS

Digital Readout Tubes

Two additions to the Nixie line provide longer life and improved readability



Two ten-digit, direct read-out tubes with considerable increase in life expectancy have been added to the Nixie line. These tubes have a new cup design providing a non-reflecting background and feature improved uniformity and shelf life characteristics. Type 7153 Super Nixie has a bulb diameter of 1-1/4 in. with increased viewing distance of 60 to 75 ft. Type 6844 A is a improved version of the standard Nixie type 6844, with a bulb diameter of 1 in., and a viewing distance of approximately 35 ft.

Burroughs Corp., Electronic Tube Div., Dept. ED, Plainfield, N.J.

CIRCLE 171 ON READER-SERVICE CARD

Impedance and Inductance Bridge

Applies high ac voltage along with large dc current

Type 277 impedance and inductance bridge is offered as a standard system for measuring inductances with high voltage ac applied simultaneously with large dc currents. Type 277 provides for inductance measurements from 1 μh to 1000 h with superimposed dc currents as high as 4 amp and ac voltages up to 250 v from 20 cps to 20 kc. A bridge oscillator, power amplifier and dc power supply is included as well as a null indicator which will indicate independently the real and quadrature components of the bridge balance points. The bridge ratio arms will dissipate 500 w ac and/or dc and remain 0.1 per cent accurate. Effective resistance within a billion to one range is measurable as well as inductance.

Pennsylvania Testing Lab., Inc., Dept. ED, Doylestown, Pa.

CIRCLE 172 ON READER-SERVICE CARD

Solenoid Valves

A two-way normally closed type

The first model of the L series has been announced. The valve is a two-way, normally closed, pilot-operated type weighing 1-3/4 lb and measuring 3-31/32 in. high. A full 1/2 in. orifice with either 3/8 or 1/2 in. taps is provided.

Skinner Electric Valve Div., Dept. ED, 105 Edgewood Ave., New Britain, Conn.

CIRCLE 175 ON READER-SERVICE CARD

Telemetering Amplifier

100 w output from a 2 w drive

A miniature unit providing 100 w with only 2 w drive, model 1466 r-f amplifier covers the range from 215 to 260 mc. The unit it ruggedized for vibration, acceleration and heat conditions. A built in blower allows operation at temperatures up to 125 C. The amplifier can be used with such 2-w transmitters as the model 1472-A fm/fm or pdm, fm telemetering transmitters.

Telechrome Mfg. Corp., Dept. ED, 28 Ranick Dr., Amityville, N.Y.

CIRCLE 176 ON READER-SERVICE CARD

DC VTVM

Reads lower than 200 μv

Model 110-1 dc vtvm, designed especially for integration into test consoles, is capable of reading lower than 200 μv on its 3 mv range. The instrument is practically insensitive to line voltage variations from 80 to 125 v and undamaged by occasional overloads of 100 times full scale setting. With an input impedance of 10 meg, model 110-1 has an accuracy of 2 per cent of full scale on all ranges.

Trio Labs., Inc., Dept. ED, 4025 Merrick Rd., Seaford, N.Y.

CIRCLE 177 ON READRE-SERVICE CARD

NEW Development!

HICKOK

250° Arc

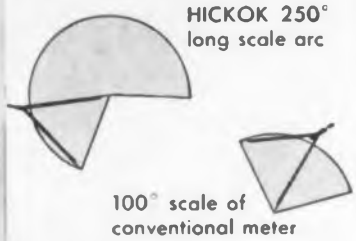
LONG SCALE METERS

Save Valuable Panel Space

The scale in these new instruments is 2½ times as long as conventional meters. A 3½" HICKOK 250° meter has a scale length equal to a conventional 6" instrument.

These exclusive panel style 250° meters fit a smaller space though still provide easier, more accurate readings.

Available in all popular AC or DC ranges. Square, semi-flush or round flush cases. 2½" thru 5½" sizes.



HICKOK 250° long scale arc

100° scale of conventional meter

UNIFORM SCALE
Evenly Spaced Scale Divisions

RUGGEDIZED and SEALED

AC rectifier or DC types

The highly efficient HICKOK shock mount construction permits pointer and scale divisions to be easily read when meter is under vibration. The DC movement is a precise and rugged type. The AC movement is of the AC rectifier type with unusually efficient magnetic damping for ruggedized purposes. Case is permanently sealed at the factory, however, may be opened and resealed.

These instruments meet military specifications and are in volume production. Your inquiry is invited. Kindly list details of your requirements or request Catalog No. 37

THE HICKOK ELECTRICAL INSTRUMENT CO.

10535 DuPont Avenue • Cleveland 8, Ohio

CIRCLE 179 ON READER-SERVICE CARD

NEW PRODUCTS

Multimeters

Imported line with ratings to 30,000 ohms/v dc

The first two of a series of Japanese-import instruments recently announced are the model M70 and SC Multimeters. The Model M70 offers a sensitivity of 30,000 ohms per v dc, and 15,000 ohms per v ac on all normal scales. It has 60 ranges with accuracy of 2 per cent and dc and 3 per cent ac of full scale deflection, with a 21 μa basic movement. There are two internal batteries, 1.5 and 45 v, for resistance measurements. The ranges offered include ac and dc v, r-f v, rms and peak to peak, dc and ac current, ohms, audio frequency of 20,000 to 20 cps, audio distortion, mutual conductance, direct reading capacitance and inductance, and signal strength. Weight is 3 lb 7 oz.

Dyna-Vac Co., Dept. ED, P.O. Box 12146, Atlanta, Ga.

CIRCLE 180 ON READER-SERVICE CARD

Ferrite Isolator

Operates from 8.2 to 12.4 kmc and handles 100 w average

Model W177-5C-1 transverse field ferrite isolator operates over the frequency range of 8.2 to 12.4 kmc, and is capable of handling an average power of 100 w. Isolation is indicated at 20 db min and insertion loss is 1.3 db max over the entire range. Other features include: input vswr of 1.15 max; peak power at 5 kw and ambient from −55 to +100 C. Dimensions are: 5-1/4 x 1-7/8 x 2-5/32 in. with weight at 2.4 lb.

As with other of the company's isolators, this unit consists of rectangular waveguide with permanent magnetic transverse field and ferrite sections built into the unit.

Kearfott Co., Inc., Western Div., Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

CIRCLE 181 ON READER-SERVICE CARD

Time Delay Relay

Uses a magnetic amplifier for high sensitivity

This time delay relay provides precise time delays without the use of thermal or motor element by incorporating a highly sensitive magnetic amplifier with the company's standard relay. Time delays up to 30 sec or greater can be provided depending on actuation voltage. Normal sensitivity is 10 mw. dc. The device can be provided with an instant resetting feature.

These relay feature absence of contact chatter at pick-up and drop-out points, allowing the unit to operate with high reliability in a 40 g shock, 20 g vibration environment. Excitation required is 115 v rms, 400 cps, with other ratings available. Power consumption is a few mw. Contacts are rated at 2 amps resistive and in configurations up to dpdt. Operating temperature range is −55 to +100 C.

Torwico Electronics, Inc., Dept. ED, 1090 Morris Ave., Union, N.J.

CIRCLE 184 ON READER-SERVICE CARD

Electrolytic Capacitors

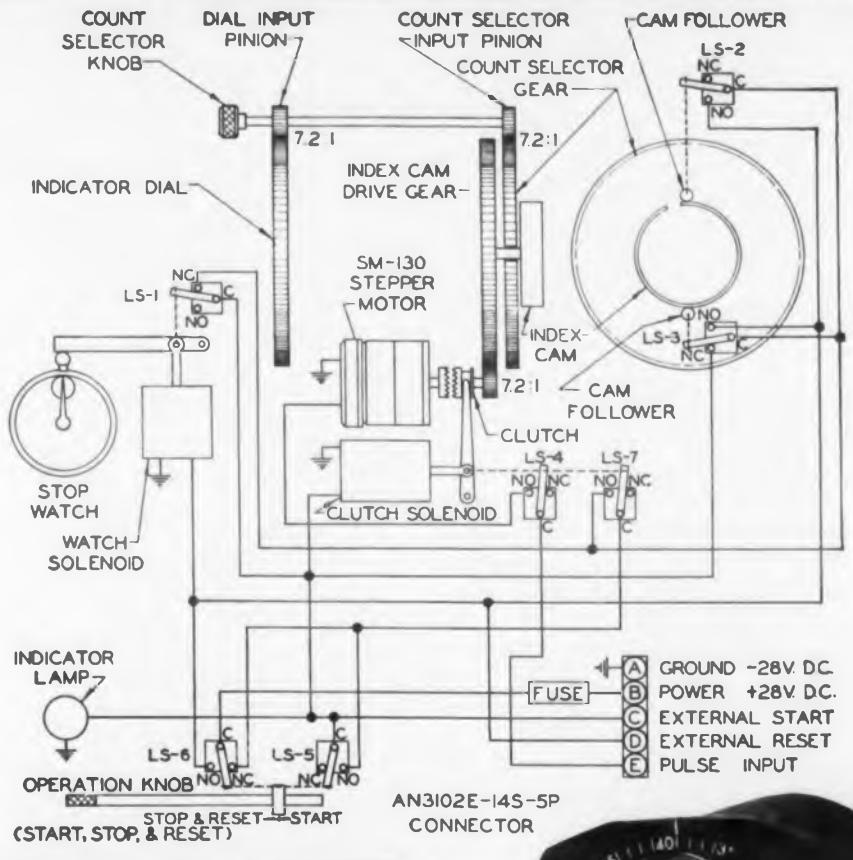
Designed for long-life applications

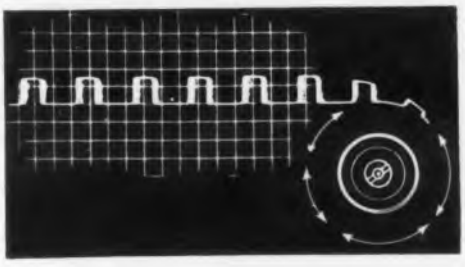
The operating life expectancy of type UPB aluminum-can electrolytic capacitors is stated as in excess of ten years, provided operation is within ratings for dc working voltage, surge voltage, ripple current and ambient temperature conditions. Shelf life expectancy is over two years with satisfactory maintenance of leakage current, capacitance and dissipation factor characteristics provided storage temperatures do not exceed 40 C. Intended primarily for bypass and low-frequency filter applications, the units are available in single sections with dc voltage ratings from 6 to 450 v, and in capacity values from 20 to 2000 μfd.

Cornell-Dubilier Electric Corp., Dept. ED, S. Plainfield, N.J.

CIRCLE 185 ON READER-SERVICE CARD

STEPPER AUTOMATIC PULSE TIMER





Model K-165

This Automatic Pulse Timer mounts in a standard 3⅛" mounting. The initial usage of the Automatic Pulse Timer was for a difficult instrumentation problem encountered on test aircraft—timing the pulses from a fuel flow transducer and thus determining specific fuel consumption. It successfully replaced a complex and unreliable method.

The Automatic Pulse Timer incorporates an uni-directional Stepper Motor along with complimentary gears, cams, solenoids, switches, an indicator light and—for an accurate independent time base—a stop watch. It is designed to visually record the lapsed time of an occurance of a specific number of electrical impulses. The Pulse Timer can count pre-selected quantity of 2 to 60 pulses, having a uniform or variable rate up to 25 pulses per second.

In this application the combined accuracy of the fuel flow transmitter and the automatic pulse timer is better than 1%, and of this the timer contributes essentially no error. When the broad input requirements are available, the unit can be used for timing pulses regardless of the source from which they may originate.

DETAILED OPERATIONAL SEQUENCE IS AVAILABLE UPON REQUEST.

STEPPER MOTORS CORPORATION

Subsidiary of California Eastern Aviation, Inc.

7445 West Wilson Avenue • Chicago 31, Illinois

• WEST COAST FACILITY . . . 11879 W. FLORENCE AVE. . . . CULVER CITY, CALIF.

CIRCLE 186 ON READER-SERVICE CARD

NEW... SPEER P.A.C.

This new Speer Packaged Assembly Circuit offers you a wide variety of custom, preassembled units of high-quality components for use in conjunction with printed board applications.

P.A.C. permits the insertion, *as a group*, of a full range of capacitors and resistors in simple or complex circuitry. Each P.A.C. is based on components of uniform dimensions, ⅛" diameter and ⅝" long. Component availability includes Jeffers tubular ceramic capacitors and Speer fixed composition resistors, providing wide circuit flexibility in a single P.A.C. unit.

ADVANTAGES OF SPEER P.A.C.

- *Simplifies chassis design and assembly*
- *Reduces printed circuit board area and insertion operations*
- *Permits easy and low-cost component change-over to accommodate circuit revisions*
- *Broad choice of characteristics—low capacitance temperature compensating units and high capacitance bypass capacitors mounted in same P.A.C. unit*
- *Isolation of individually mounted units provides low shunt capacitance across resistors*
- *Pretested components achieve unusually close tolerance assembly*

Learn more about the new Speer P.A.C.
For information write to:

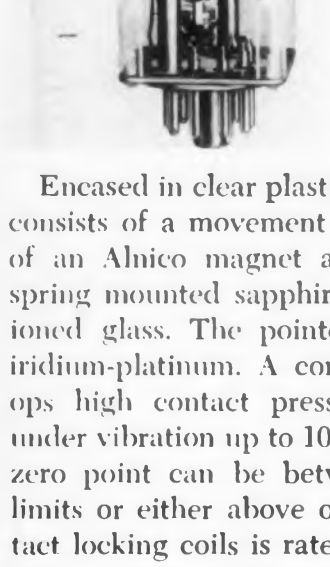
JEFFERS ELECTRONICS DIV.

Speer Carbon Co. Du Bois, Pennsylvania

JEFFERS ELECTRONICS

CIRCLE 187 ON READER-SERVICE CARD

NEW PRODUCTS



Meter Relay

With sensitivities down to 0.2 μa

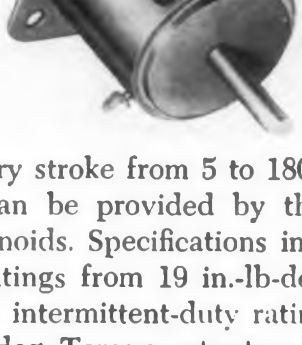
Encased in clear plastic, model 137 meter relay consists of a movement rotating in the flux gap of an Alnico magnet and riding on jewels of spring mounted sapphire or sapphire and cushioned glass. The pointer is a contact of solid iridium-platinum. A contact locking coil develops high contact pressure enabling operation under vibration up to 10 g from 5 to 200 cps. The zero point can be between the high and low limits or either above or below them. The contact locking coils is rated at 5 to 25 ma dc with open circuit contact voltage of 75 to 125 v. Higher ratings are available. Sensitivity or trip points range from 0.2 μa to 10 amp or 0.1 mv to 500 v. Accuracy of the trip point is within 3 per cent except on some of the lowest sensitivities.

Assembly Products, Inc., San Gorcinto Div., Dept. ED, P. O. Box xx, Palm Springs, Calif.

CIRCLE 188 ON READER-SERVICE CARD

Rotary Torque Solenoid

Torques to 1050 in.-lb-deg



Any rotary stroke from 5 to 180 deg in either direction can be provided by these dc rotary torque solenoids. Specifications include continuous-duty ratings from 19 in.-lb-deg to 1050 in.-lb-deg, and intermittent-duty ratings from 35 to 1750 in.-lb-deg. Torque output can duplicate any torque curve. Power range is from 7 to 350 w. The units measure from 1 to 4 in. diam and weigh from 1 oz to 5 lb.

Powerdex Co., Dept. ED, 2501 E. 68th St., Long Beach, Calif.

CIRCLE 189 ON READER-SERVICE CARD

Analyzer Computer

Pulse-height analyzer and scaler

Model 132 analyzer computer is designed for use with all gamma-sensitive scintillation counters. Versatility and compact design have been accomplished by combining a well-regulated high voltage supply, single channel pulse-height analyzer, binary scaler, and a push-button computing circuit, all in one chassis. The instrument's single channel analyzer section materially reduces background and scatter radiation through the rejection of gamma or other radiation below or above the desired level. Regulated high voltage to the external scintillation counter is variable from 500 to 1500 v.

Nuclear-Chicago Corp., Dept. ED, 229 W. Erie St., Chicago 10, Ill.

CIRCLE 191 ON READER-SERVICE CARD

Servo Coupling

Accommodates misalignment

Designed specifically for precision coupling requirements in servo and instrument applications, the Maxflex coupling accommodates radial, axial and angular misalignment in connecting shafts, motors, and components without backlash or error. The coupling utilizes universal joints of balanced construction with no springs, pivots, or point contacts. The unit accommodates radial error up to ±1/16 in., axial error to ±1/16 in., angular error to ±15 deg in 1/4 in. diam, 1-1/8 in. long coupling.

Parametrics, Dept. ED, P. O. Box 629 Costa Mesa, Calif.

CIRCLE 192 ON READER-SERVICE CARD

CIRCLE 193 ON READER-SERVICE CARD ➤

LOOK FOR YOUR COPY EVERY OTHER WEDNESDAY

Beginning January 8th, *Electronic Design* will reach your desk 26 times a year. This increase in publishing frequency from 24 to 26 issues may not seem important at first glance, but here are some of the advantages to the reader:

- More timely presentation of new products, materials, and processes.
- Better coverage of important electronic events, conventions, meetings, etc.
- More balanced editorial—some departments will be expanded.
- Improved delivery schedules, more efficient production and handling—copies will reach you faster.

Studies conducted among *Electronic Design* readers have shown an unusually heavy "habit readership". 26 time scheduling should help to regularize this reading routine even more. Next year you can expect *Electronic Design*—more timely and more complete than ever before—on a regular basis, *every other Wednesday.*

ELECTRONIC DESIGN

New York · Chicago · Los Angeles

NEW PRODUCTS

High Power Load

Low vswr of 1.25 in 300-350 mc range

This waveguide load, model WR2100 is capable of absorbing average powers of one megawatt and peak powers of ten megawatts. The vswr of this load is less than 1.25 in the 300 to 530 mc range and less than 1.10 between 350 and 530 mc. Type 525A Mega-Sorber utilizes a water wedge for the dissipative element. Water flow rate of 175 gpm through the load as required for maximum rated dissipation. Dimensions of the load are 11 x 2 x 3 ft.

Continental Electronics Mfg. Co., Dept. ED, 4212 S. Buckner Blvd., Dallas 27, Texas.

CIRCLE 195 ON READER-SERVICE CARD

Power Converters

Have ac and multiple dc outputs

Model PS-2000 and PS-2001 regulated multiple output power converters are designed to operate from 28 v dc ±5 per cent and differ only in the current ratings of their outputs. The PS-2000 supplies 6.3 v dc at 3 amp, 150 v dc at 260 ma, 250 v dc at 120 ma, and 115 v, 400 cps at 125 ma. The PS-2001 supplies 6.3 v dc at 600 ma, 150 v dc at 120 ma, 250 v dc at 120 ma, and 115 v, 400 cps at 1.5 amp. Regulation over the complete range of line variation, and load variation will not exceed 5 per cent for the 6.3 v output, 1 per cent for the 150 v output and 6.5 per cent for the 250 v output. Frequency tolerance on the 400 cps output is ±2 per cent.

Power Sources, Inc., Dept. ED, Burlington, Mass.

CIRCLE 196 ON READER-SERVICE CARD

Momentary Contact Switch

Several types in 3 or 10 amp ratings

This line of straight frame, push button switches is available in 3 amp standard rating—in single make single break spdt, two make two break dpdt, and 3pdt types. Ratings may be increased up to 10 amp at 110 v ac non-inductive load by using special materials.

Richards Electrocraft, Inc., Dept. ED, 4432 N. Kedzie Ave., Chicago, Ill.

CIRCLE 199 ON READER-SERVICE CARD

Digital Data Recorder

Provides 450 traces

Using wide range electrolytic paper, the RX-48 digital recorder produces 450 immediately visible traces across a 14-in. spread. Applications are in telemetry output recording, spectrum analysis work, and general off-on event displays. Ten discrete speeds up to 12 in. per sec are provided.

Hogan Labs., Inc., Dept. ED, 155 Perry St., New York 14, N.Y.

CIRCLE 200 ON READER-SERVICE CARD

R-F Coil Form

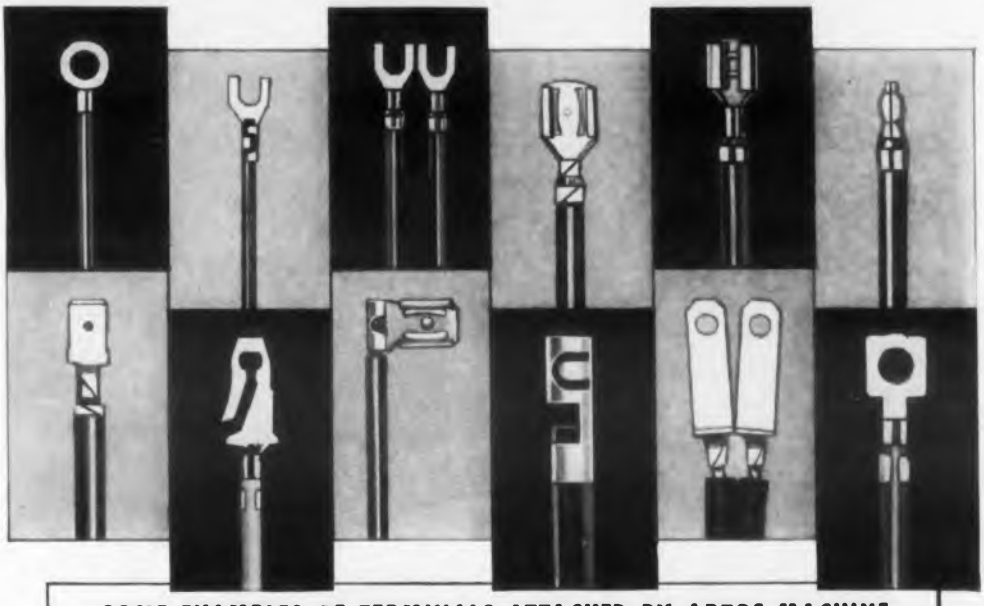
Completely shielded

This completely shielded coil form assembly, using powdered iron components, is designed for i-f strip work where ease of tuning, compactness, and dependability are required. The assembly can be chassis mounted screws, or pin mounted for printed wiring. The mounted assembly measures 1/2 in. wide by 1/2 in. high. A positive compression-type tuning core lock is provided.

Cambridge Thermionic Corp., Dept. ED, 445 Concord Ave., Cambridge 38, Mass.

CIRCLE 201 ON READER-SERVICE CARD

DO YOU NEED *Automation* FOR FINISHING WIRE LEADS WITH TERMINALS ATTACHED?



SOME EXAMPLES OF TERMINALS ATTACHED BY ARTOS MACHINE

NEW ARTOS TA-20-S Performs 4 Operations *Automatically!*

Artos TA-20-S with guard raised

1. Measures and cuts solid or stranded wire 2" to 250" in length.
2. Strips one or both ends of wire from 1/8" to 1".
3. Attaches any prefabricated terminal in strip form to one end of wire. (Artos Model CS-9 attaches terminals to BOTH ENDS OF WIRE simultaneously.)
4. Marks finished wire leads with code numbers and letters. (Available as optional attachment.)

PRODUCTION SPEEDS up to 3,000 finished pieces per hour. Can be operated by unskilled labor. Easily set up and adjusted to different lengths of wire and stripping—die units for different types of terminals simply and quickly changed.

ENGINEERING CONSULTATION . . . recommendations without obligation. Special adaptations made to fit requirements of your product. Machines for all types of wire lead finishing.

VISIT US AT THE I.R.E. SHOW BOOTH No. 4228

WRITE for FREE Bulletin No. 655 on Artos TA-20-S

World Leaders in Automatic Machines for Finishing Wire Leads

ARTOS ENGINEERING CO.

2777 South 28th Street • Milwaukee 46, Wisconsin

CIRCLE 202 ON READER-SERVICE CARD

How stable? How small?
What temperature range?
How shock resistant?

FANSTEEL

HP TYPE

HIGH TEMPERATURE Tantalum Capacitors

... Just off the press. Latest technical bulletin with details, specifications, ratings, application information, performance curves, and ordering references on Fansteel High Temperature Tantalum Capacitors. Write for your copy today.

CAPACITORS
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RECTIFIERS

FANSTEEL METALLURGICAL CORPORATION
North Chicago, Illinois, U.S.A.

C581A

RELIABLE TANTALUM CAPACITORS SINCE 1930

CIRCLE 203 ON READER-SERVICE CARD

NEW PRODUCTS

Power Transistors.—Two pup power transistors are supplied in matched pairs for low distortion in audio and servo push-pull power amplifier applications. The 2N399 and the 2N401 can readily dissipate up to 25 w. Typical Class B undistorted output power for both types is 8 w.

Bendix Aviation Corp., Red Bank Div., 201 Westwood Ave., Long Branch, N.J.

CIRCLE 204 ON READER-SERVICE CARD

Toggle Switches.—Four types of the 2000 series are available in spst and dpdt, with solder or screw terminals nominally rated at 10 amp 250 v ac and 1/2 hp 125-250 v ac or 3/4 hp 125-250 v ac.

Sargent Electric Corp., Dept. ED, 630 Merrick Rd., Lynbrook, N.Y.

CIRCLE 205 ON READER-SERVICE CARD

Power Supplies.—These additions to the Transpac transistorized line permit full input voltage to be repeatedly applied and abruptly disconnected without deterioration of performance. The units may also be short-circuited. Regulation is 0.1 and ripple is 0.02 per cent.

Electronic Research Assoc., Inc., Dept. ED, 67 Factory Pl., Cedar Grove, N.J.

CIRCLE 206 ON READER-SERVICE CARD

Magnetic Shielding.—Available as an insert in the company's heat dissipating tube shields, this Netic and Co-Netic foil is particularly effective in attenuating low level magnetic fields for high gain input circuits.

International Electronic Research Corp., Dept. ED, 145 W. Magnolia Blvd., Burbank, Calif.

CIRCLE 207 ON READER-SERVICE CARD

Pressure Control.—Type H95 has been added to the company's line of calibrated, explosion-proof controls. Models are available with adjustable range spans between 0 and 500 psi, and maximum pressures to 600 psi.

United Electric Controls Co., Dept. ED, 79 School St., Watertown, Mass.

CIRCLE 208 ON READER-SERVICE CARD

Coupling Ring.—Available on all the company's miniature connector sizes, a heavily-knurled coupling ring, model DM9718-19S, permits easier connection and disconnection.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles 3, Calif.

CIRCLE 209 ON READER-SERVICE CARD

Sealed Switch.—Consists of a Unimax USM5 Switch completely sealed against dust, oil, and water. The new version is designated Unimax Type EA 1.

W. L. Maxson Corp., Unimax Switch Div., Dept. ED, Ives Rd., Wallingford, Conn.

CIRCLE 210 ON READER-SERVICE CARD

Junction Transistors.—Three types have been added to the company's line. The 2N404 is a p-n-p type designed for low-level, medium-speed switching. The 2N407 and its flexible-lead version, the 2N408, are intended for class A and class B audio service. Maximum dc collector cutoff is −14 μa, emitter cutoff −14 μa, and current transfer ratio is 65.

Radio Corp. of America, Semiconductor Div., Dept. ED, Somerville, N.J.

CIRCLE 471 ON READER-SERVICE CARD

Actuator.—Capable of operating three miniature switches at the same time. This assembly, including the switches, measures 1 x 1-1/4 x 3/4 in.

Robertshaw-Fulton Controls Co., Aero Div., Dept. ED, P. O. Box 449, Columbus 16, Ohio.

CIRCLE 213 ON READER-SERVICE CARD

Servomotor.—Featuring high stall torque and low rotor inertia, model 18 SM 490 has been added to the company's line. Weight is 12 oz, and length slightly over 2-1/2 in.

Beckman/Helipot Corp., Dept. ED, Newport Beach, Calif.

CIRCLE 214 ON READER-SERVICE CARD

Audio Transistors.—The 2N405 and its flexible-lead version, the 2N406, are germanium p-n-p types for use in class A a-f driver service. Both feature long-term stability in low-power audio applications.

Radio Corp. of America, Semiconductor Div., Dept. ED, Somerville, N.J.

CIRCLE 472 ON READER-SERVICE CARD

Micro-Microammeter.—Model 413 lately added to the 400 series, is intended primarily for monitoring rapidly varying currents. High stability measurments can be made from 10^{-11} to 10^{-5} amp.

Keithley Instruments, Inc., Dept. ED, 12415 Euclid Ave., Cleveland 6, Ohio.

CIRCLE 215 ON READER-SERVICE CARD

Servosystem Worksheets.—Provide an easy and permanent method of dynamic analysis by recording and plotting the phase and amplitude characteristics of any servo component or system as indicated by the Servoscope servosystems analyzer. Each of the four worksheets is an Ozalid master copy.

Servo Corp. of America, Dept. ED, 20-20 Jericho Turnpike, New Hyde Park, N.Y.

CIRCLE 216 ON READER-SERVICE CARD

5000-W Triodes.—Primarily for industrial application, the 3W5000A1 and the 3W5000F1 are water-cooled versions of the previously announced 3X3000-A1 and 3X3000F1, and except for higher plate dissipation they have the same ratings as the air-cooled versions.

Eitel-McCullough, Inc., Dept. ED, San Bruno, Calif.

CIRCLE 217 ON READER-SERVICE CARD

FANSTEEL

SELENIUM RECTIFIERS

To meet any of your specific requirements, there are over 400,000 different rectifier stack combinations available from standard Fansteel selenium cells. No matter what your specifications for size or output, Fansteel Selenium Rectifiers are obtainable in a wide range of sizes and ratings, from a few milliamperes to power loads of many kilowatts.

Write for Bulletin 6.400

OVER 100,000 TYPES OF HIGH TEMPERATURE SELENIUM RECTIFIERS

Operating at 100°C (212°F) Ambient High Temperature Rectifiers assure full rated power output continuously with no derating. All have current ratings at 100°C (212°F) only moderately derated at temperatures available to all standard cell sizes and types and special arrangements exist with all standard assembly factories.

Write for Bulletin 6.101

CAPACITORS

FANSTEEL®

RECTIFIERS

FANSTEEL METALLURGICAL CORPORATION

North Chicago, Illinois, U.S.A.

DEPENDABLE RECTIFIERS SINCE 1924

CIRCLE 218 ON READER-SERVICE CARD

NEW PRODUCTS

Transistor Chassis Kit.—Designed primarily for experimental or prototype design, type 22X has special clips provided to fasten transistor sockets using the regular holes of a prepunched board.

Vector Electronic Co., Dept. ED, 1100 Flower St., Glendale 1, Calif.

CIRCLE 220 ON READER-SERVICE CARD

Parbolic Antennas.—A series of 19-ft parabolic types are available in various combinations of mounts and feed systems. The reflector is made up of four pie-shaped sections to facilitate transportation.

Technical Appliance Corp., Dept. ED, Sherburne, N.Y.

CIRCLE 221 ON READER-SERVICE CARD

Tube Lead Insulators.—Made of Teflon, these insulators withstand shock, vibration, heat to 500 F, and have moisture absorption and low-loss characteristics of less than 0.0005.

United States Gasket Co., Fluorocarbon Products, Inc., Dept. ED, Camden, N.J.

CIRCLE 222 ON READER-SERVICE CARD

Potential Transformers.—Replacing four older types of potential transformers, two types in the butyl-molded line have been announced for 5-kv indoor and outdoor use. Thermal capacity has been increased to 600 va at 30 C ambient.

General Electric, Instrument Dept., Dept. ED, Schenectady 5, N.Y.

CIRCLE 223 ON READER-SERVICE CARD

Delay Lines.—Models F118 and F119 are inexpensive units with 5 and 2 μsec delays respectively. Both lines are tapped every 0.1 μsec and have a rise time of less than 10 per cent of the delay of any tap point.

Control Electronics Co., Inc., Dept. ED, 1925 New York Ave., Huntington Station, N.Y.

CIRCLE 224 ON READER-SERVICE CARD

Ultraviolet-Visible Microscope.—For research purposes in structure microchemistry, absorption spectrum, and other fields, model ME-401 has a monochromator adjustable from 2300 A to 6000 A. Resolution is of the order of 0.2 microns.

Neutronics Research Co., Dept. ED, 165 Lake St., Waltham, Mass.

CIRCLE 225 ON READER-SERVICE CARD

Analog-Digital Converter.—Closely related to the model B, model K Datrac permits increased digital computer utilization. Operates under the programmed direction of virtually any digital computer.

Epsco, Inc., Dept. ED, 588 Commonwealth Ave., Boston 15, Mass.

CIRCLE 226 ON READER-SERVICE CARD

Metal Film Resistors.—Besides a 1/2-w size now being produced, this company has announced its intention of going into mass production of a complete line by March, 1958. The line will include 1/8, 1/4, 1/2, 1, and 2 w sizes. The film resistors offer high stability with low and controllable temperature coefficients, and will withstand full load at 125 C ambient.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

CIRCLE 229 ON READER-SERVICE CARD

Relay Dust Covers.—Removable enclosures for the class 22 relay line have been announced.

Magnecraft Electric Co., Dept. ED, W. Grand Ave., Chicago 51, Ill.

CIRCLE 230 ON READER-SERVICE CARD

Strain Gage Cells.—These hermetically sealed cells are designed in nine capacities from 500 to 200,000 lb. Construction permits 225 per cent overload without affecting calibration.

Revere Corp. of America, Dept. ED, Wallingford, Conn.

CIRCLE 231 ON READER-SERVICE CARD

Component Enclosures.—Precision drawn closures of Mu Metal are available in round, rectangular, or square shapes.

Hudson Tool and Die Co., Inc., Dept. ED, 18 Malvern St., Newark, N.J.

CIRCLE 232 ON READER-SERVICE CARD

Photorelay.—Comprised of a printed-circuit board held in a sheet-steel cradle which fits into a small conventional conduit box of the l-gang type. Control is provided by 10 foot-candles.

Photobell Co., Inc., Dept. ED, 43 Vesey St., New York 7, N.Y.

CIRCLE 233 ON READER-SERVICE CARD

TV Tubes.—Types 17CMP4 and 17CNP4 are 17-in. 90-deg types permitting increased bandwidth. The tubes are designed with a low 50-v grid no. 2 voltage.

Sylvania Electric Products, Inc., Dept. ED, Seneca Falls, N.Y.

CIRCLE 234 ON READER-SERVICE CARD

Capacitor.—Recently added to the company's line is type BAM for use up to 150,000 vdc. The capacitor has a Bakelite case and employs a film dielectric with high volts per mil rating.

Chicago Condenser Corp., Dept. ED, 3255 W. Armitage Ave., Chicago 47, Ill.

CIRCLE 235 ON READER-SERVICE CARD

Instrument Trunk.—Designed to carry and ship delicate instruments, this trunk has separate compartments blocked and padded with sponge rubber to absorb shock.

William Bal Corp., Dept. ED, 947 Newark Ave., Elizabeth, N.J.

CIRCLE 236 ON READER-SERVICE CARD

CAMLOC *low cost/light weight*

5F series

Camloc's new small, lightweight 5F Series features high strength-weight ratio plus the quick-operating advantages of a ¼-turn fastener...in a size and weight that offers new design possibilities to original equipment manufacturers! Particularly adaptable to thin materials and miniaturized equipment like airborne electronics, small electro-mechanical and computing devices and communications components. Ideal for attaching lightweight components in "packaged" equipment or for holding access panels on everything from washing machines to radar units.

Offered in many different head styles. Complete specifications will be sent to you on request.

CAMLOC®

See Camloc products at the I.R.E. Show March 24-27, Booths 4306 & 4308

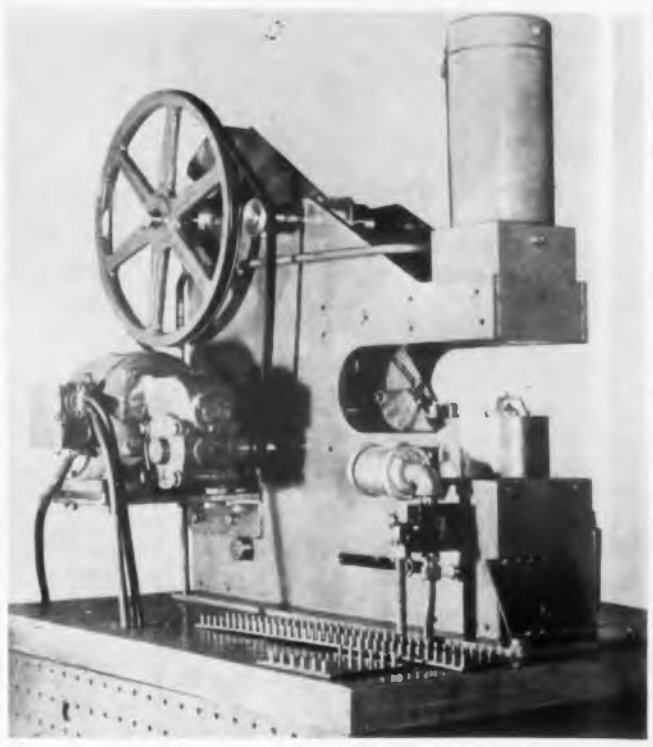
FASTENER CORPORATION
61 Spring Valley Road, Paramus, N. J.

WEST COAST OFFICE: 5410 WILSHIRE BLVD., LOS ANGELES, CAL.
FORT WORTH OFFICE: 2509 W. BERRY ST., FORT WORTH, TEXAS

CIRCLE 237 ON READER-SERVICE CARD

PRODUCTION PRODUCTS

Terminal Setting Machine
Has Bottom Feed



A compact production machine that sets turret terminals and tube pins, model LSD features bottom feed. Hydraulically or air-operated, the machine compensates for variations in board thickness, preventing part breakage.

The machine achieves between 40 to 50 settings per minute depending upon type of assembly. The machine is not limited to setting turret terminals and tube pins. Other similar components including double end rivets can be set on it. The machine is designed with bottom feed, which permits work to be loaded directly on the component before the machine is tripped. The prepunched board is located on top of the part which is automatically fed from the bottom into a pair of jaws. These machines can be supplied with pressure regulated up to 1400 psi with greater pressure possible if necessary.

Edward Segal, Dept. ED, 72 Spring St., New York 12, N.Y.

CIRCLE 319 ON READER-SERVICE CARD

Sheet Metal Punch
For Heavy Chassis

High speed piercing of heavy electronic chassis, panels, side plates and other sheet metal or plate parts, in low to medium production quantities can be done at 60 to 90 per cent savings with the RA-61 Turret Punch Press.

This 40-ton capacity press, equipped with the Wiedemann High Speed Follower Gauge

(Paragraph), eliminates setup and work layout. Flat sheet metal or plate up to 33 x 40 in. is pierced in one handling at the rate of 30 or more holes per minute. Its rotating turrets house 20 to 25 tools which can be brought into piercing position in three to five sec. The heavy duty press with a throat depth of 33 in. will punch holes up to 6 in. diam. in 1/8 in. mild steel or up to 1-1/2 in. diam. in 3/8 in. mild steel.

Wiedemann Machine Co., Dept. ED, 4272 Wissahickon Ave., Philadelphia, Pa.

CIRCLE 320 ON READER-SERVICE CARD

Germanium Slicing Machine

Cuts Smooth Wafers

A new type of slicing machine makes it possible to increase production of germanium transistor crystals. A slicing machine designed specifically for hard, brittle, friable materials, called Microtom-atic slices germanium bars into usable crystals wafers, uniform and accurate in thickness and parallelism. The finish, approaching a lapped surface is adequate for transistor applications as it comes from the machine. The machines are virtually unattended once they have been loaded and the automatic cycle started. Other materials for which these machines are used are silicon, quartz, ceramics, ferrites and carbides. They are widely used also for the preparation of metallographic test sections.

Production is increased by slicing a number of germanium bars in a single pass. Cutter is a diamond wheel 4 in. in diam and .021 in. thick revolving at 5000 rpm. Smooth, fracture-free cuts are the result of steady chatter-free table movement at speeds from 1/16 in. per minute up to 50 ft. per minute. Parallelism is held to .0002 in.

The DoAll Co., Dept. ED, 254 N. Laurel Ave., Des Plaines, Illinois.

CIRCLE 321 ON READER-SERVICE CARD

NEW!

chassis-trak®

roller slides for cabinet or rack mounted electronic equipment...

. . . give you complete accessibility and faster servicing. The Chassis-Trak "Detent" is easy to install, with eight different slide lengths, from 10" to 24". It fits a standard 17" chassis into a standard 19" panel rack, enabling you to *cut your engineering costs in half by using standard stock racks and chassis.*

With Chassis-Trak slides, the chassis locks in seven different tilt positions (45°-90°-105°) with the touch of a finger . . . a spring mechanism releases the chassis from the cabinet for removal. Consider these features when you make a slide selection for your equipment.

There is a CHASSIS-TRAK in the right size and model for your application. Write today for complete specifications and prices.

chassis Trak inc.

525 South Webster
Indianapolis, Indiana

CIRCLE 241 ON READER-SERVICE CARD

NEW MATERIALS

Rigidized Teflon

High Tensile Strength

This filled Teflon, called Enflon, has superior mechanical properties over Teflon yet retains many of the electrical properties. The improved mechanical characteristics include greater compressive strength, lower coefficient of thermal expansion, lower heat distortion, and less bothered by cold flow. The additives reinforce the Teflon, resulting in a higher tensile strength. Enflon is available in tape, rod, tubing and slugs.

Enflo Corp., Dept. ED, Route 38 at Airport Circle, Pennsauken, N. J.

CIRCLE 242 ON READER-SERVICE CARD

Solenoid Coil Forms

Laminated Plastic Tubing

This Grade G-5-96A tubing is made from continuous-filament glass cloth bonded with melamine resin. Used as a solenoid coil form, the material has an axial compressive strength of 15,000 psi, a tensile strength of 25,000 psi, and water absorption of less than .01 after immersion for 24 hrs. Heat resistance is rated at 300 F continuous. The material's dielectric strength is rated at 225 v per mil.

National Vulcanized Fibre Co., Dept. ED, Wilmington, Del.

CIRCLE 243 ON READER-SERVICE CARD

Ultra-Sonic Solvent

Safe, Fast Drying

For use in ultra-sonic cleaners, Sonic-Solve no. 113 has the power to remove contaminants without affecting plastics, decals, numbers, magnet wire, insulating varnishes, etc. The non-ionic, non-hydroscopic liquid has selective solvency, and is completely stable and safe. The solvent dries rapidly in open air, and no rinsing or neutralizing are necessary. Low unit cost is achieved through short immersion time, elimination of rinsing, and rapid drying.

London Chemical Co., Inc., Dept. ED, 1535 N. 31st Ave., Melrose Park, Ill.

CIRCLE 244 ON READER-SERVICE CARD

Solid Film Lubricant

Withstands Salt Spray

Type 66-C solid film lubricant meets the requirements of Mil Spec L-25504 without sacrificing the long wear life or frictional properties inherent in solid film lubricants. Coefficient of friction is less than .04 and the lubricant withstands 1300 hours salt spray test over anodized aluminum. The coating is a good built-in dry film lubricant for operation from −65 to +600 F.

Electrofilm, Inc., Dept. ED, North Hollywood, Calif.

CIRCLE 247 ON READER-SERVICE CARD

Epoxy Casting Powder

Liquefies and Hardens When Heated

Epoxy E-Form casting powder is a stable, dry blend of epoxy resin and hardener in an easily handled, non-toxic powder form. The powder offers the advantage of liquefying and then hardening when heated. When placed into an oven at 250 to 300 F, the powder liquefies. Continued heating will gel and then cure the epoxy.

Epoxy Products, Inc., Dept. ED, 137 Coit St., Irvington, N.J.

CIRCLE 248 ON READER-SERVICE CARD

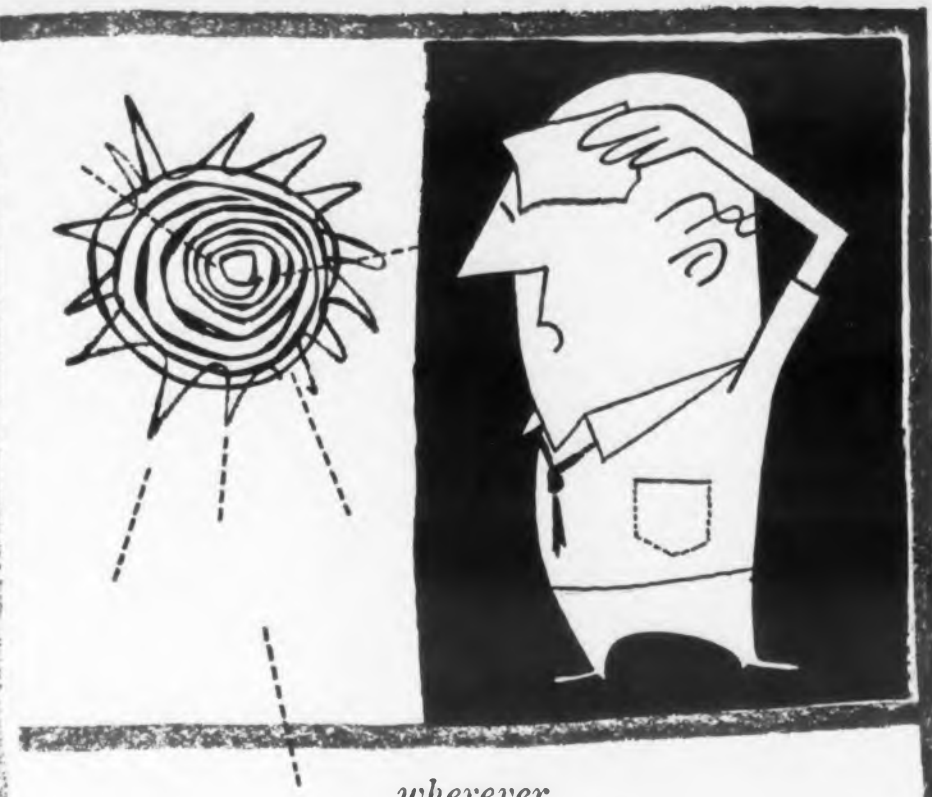
Ceramic Boats and Jigs

For Transistor Production

Ceramic boats and jigging buttons for alloying indium and germanium in transistor production are available. Called Sur-Braze M120-F the Ceramic combines the wear resistance of stainless steel fixtures with the purity of graphite boats. M120-F is not wet by indium at 900 C, nor will it contaminate the transistor components. The alloying jigs used in transistor production do not oxidize and change size the way stainless steel jigs do, nor do they wear out of tolerance as graphite jigs. The ceramic is available either in raw forms, such as rods, bars and flats, or as precision fabricated parts. The material is easily machined and then fired. Using carbide tooling, or ultra-sonics, the material can be machined after firing to tolerances as close as ±0.0001 in.

Duramic Products Div., Technion Design & Mfg. Co., Dept. ED, 262-72 Mott Street, New York 12, N.Y.

CIRCLE 249 ON READER-SERVICE CARD



wherever

HIGH OPERATING TEMPERATURES

are a matter of fact

Then it's time to face the facts. Just any insulated wire or cable won't meet the test. But you can be sure that there's a Continental heat-resistant wire or cable that will. And when you meet high operating temperatures combined with moisture and corrosive vapor problems, the fact of the matter is ONE Continental wire that offers insulated advantages to meet your requirements all ways.

ELECTRONIC INSTRUMENT INSULATED WIRE

600-3000 volt service. Sizes: 32 AWG to 6 AWG inclusive.
CONSTRUCTION: stranded tinned copper, polyvinyl insulation with or without nylon jacket. Maximum operating temperature: 100°C.
CONFORMS TO: MIL-W-16878B
COLOR CODED: 1, 2, or 3 spiral stripes over polyvinyl insulation.

FACT-FILLED CATALOG

NEW, COMPLETE CATALOG OF CONTINENTAL INSULATED WIRE AND CABLE AVAILABLE ON REQUEST. WRITE TODAY.

Continental

WIRE CORPORATION

WALLINGFORD, CONNECTICUT • YORK, PENNSYLVANIA

CIRCLE 250 ON READER-SERVICE CARD

NEW MATERIALS

Precious Metal Wire

For Resistance Windings

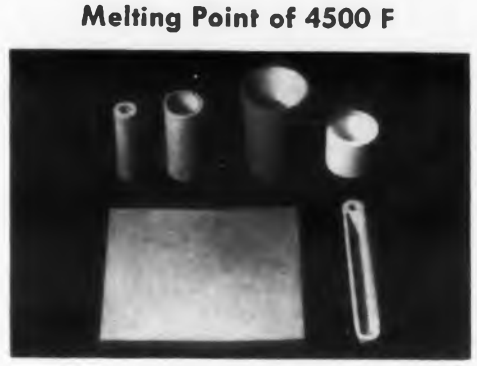
Precious metal wires for resistance windings are being manufactured down to diameters of 0.0005. The two wires are Ney-Oro G, a gold, platinum, silver, copper alloy having a resistivity of 80 ohms per cmf, and Paliney No. 7, a palladium, platinum, gold, silver, copper alloy, having a resistivity of 200 ohms per CMF. Both alloys have high tensile strength and are resistant to tarnish and corrosion under extreme conditions. Furnished either bare or enameled, and are also available as sliding contacts or wipers in standard wire forms.

J. M. Ney Co., Dept. ED, P.O. Drawer 990, Hartford 1, Conn.

CIRCLE 252 ON READER-SERVICE CARD

Stabilized Zirconia Ware

Melting Point of 4500 F



This stabilized Zirconia ware can be easily formed into rods, discs, tubes, combustion boats, or crucibles and other special shapes. The material is erosion resistant and has a melting point of approximately 4500 F. Being very inert chemically, the ware will not react when firing titanates or sintering metals, and most other materials.

Saxonburg Ceramics, Dept. 55 ZW, Dept. ED, Saxonburg, Pa.

CIRCLE 253 ON READER-SERVICE CARD

Insulation Tubing

Heat Resistant

Heat resistant silicone is featured in this silicone varnish tubing. Made from braided, filament glass fibers, with anti-fray treatment, the tubing is impregnated and completely coated with unmodified silicone varnish. The tubing can be bent to twice its diameter without cracking the coating and meets the revised MIL-I-3190B specifications and Class H requirements.

Bentley, Harris Manufacturing Co., Dept. ED, Conshohocken, Pa.

CIRCLE 254 ON READER-SERVICE CARD

Mica Paper

Cured With Silicone Resin

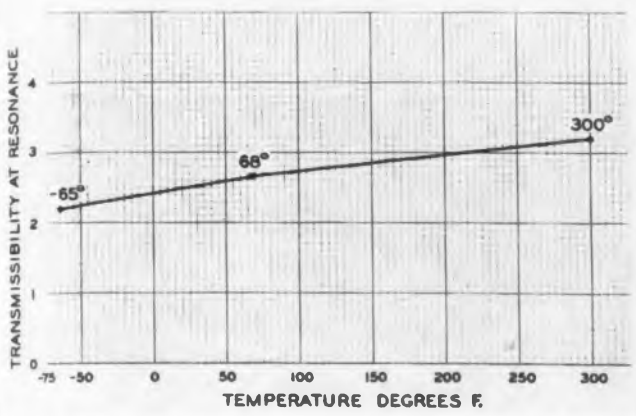
Fully impregnated and cured with silicone resin rather than surface coated, Flexi-Mica is a mica paper available in thicknesses of 0.002 to 0.01 in. A low cost class H insulator, it has dielectric strength of 500-800 vpm and a tensile strength (unsupported) of 10,000 lb per sq. in. depending on type of impregnation.

Spruce Pine Mica Co., Flexi-Mica Div., Dept. ED, Spruce Pine, N.C.

CIRCLE 255 ON READER-SERVICE CARD

Vibration Mountings

Withstand Temperature Extremes



Bonded rubber vibration and shock control mountings are being produced to operate efficiently from −65 to +300 F. Transmissability at resonance is less than 3 at 68 F, and less than 3.5 at 300 F. The broad temperature range elastomer used in the mounting is resistant to oil and ozone, and has high tensile strength, high tear resistance, and good flex life. The hysteresis characteristic of the material eliminates the need for auxiliary dampers which generate harmonics destructive to mounted equipment.

Lord Mfg. Co., Dept. ED, 1635 W. 12th St., Erie, Pa.

CIRCLE 256 ON READER-SERVICE CARD

Printed Circuit Coating

Speeds Production

Called Printed Circuit Resist, this liquid photo sensitive coating employed to cover the copper surface of a circuit board before the image is transferred from a negative to the copper. A presensitized solution, it is ready for immediate use without mixing or other preparation. The coating keeps well in solution form and will remain stable for six months. Available in gallon quantities.

LePage's, Inc., Dept. ED, Gloucester, Mass.

CIRCLE 257 ON READER-SERVICE CARD

SERVICES FOR DESIGNERS

R & D Laboratory

A research and development organization, Westgate Laboratory, has a staff of 15 scientists and engineers engaged in work in electronics, mechanics, and photo-optics. Personnel are recognized in the fields of radar interpretation, prediction, and simulation. Equipment recently designed and constructed is in use in a current missile program. Facilities and personnel are available on contract to industry to help solve development or design problem in the physical sciences. Members of the staff will go to clients' plants and offices for consultation.

Westgate Lab., Dept. ED, P.O. Box 63, Yellow Springs, Ohio.

Swiss Ruling Engines

Two Swiss ruling engines, in the metric and the English system, will be available for precise drafting on contract. The large-size coordinate plotter can meet all practical demands in plotting of control and grids. The engines are expected to have wide use in special mapping and chart-making, in artwork for Ronchi test gradings, and for examination of lines for cross-section lenses.

Industrial Division, W. & L. E. Gurley, Dept. ED, Troy, N.Y.

Low-Cost Metal Stamping

A new method of low-cost metal stamping known as "Rapid-Tooling" has been announced by the Insuline Corporation of America. This unique stamping process produces small, medium, or large runs at savings up to 80 per cent of conventional tooling costs, and permits a large range of shapes, forms and sizes of parts. Complex dies can be turned out in a matter of days and delivery time is cut to a minimum. "Rapid-Tooling" is permanent tooling with complete

uniformity of production. Any part over 2" square can be blanked, pierced, sheared, punched, formed and notched. Aluminum and magnesium up to 1/4" thick, and steel or special steel alloys up to 3/16" thick can be stamped. Stamping tolerances down to .003 inches are practical at both high and low production rates. The new process insures tool availability for reruns. Relocation or resizing of holes and other changes, which would ordinarily mean scrapping conventional dies, can be quickly and economically made. "Rapid-Tooling" is ideal for Chassis, brackets and panel work.

Insuline Corp. of America, Dept. ED, Manchester, N.H.

Precision Potentiometers

A 10-day delivery of non-standard potentiometers at no extra cost is available from Helipot Corp. of Newport Beach, Calif. A special group, POCO TIEMPO, has been set up to supply prototype quantities of specially modified precision potentiometers. Both single and multi-turn potentiometers in a wide range of diameters and resistance values are produced by the group. Modifications available include special resistance values, tolerances, linearities, taps, shafts, lids, bushings, ganged assemblies, torque, bearings and rotation. The group has its own coil-winding, machining, and assembly facilities, its own sales, engineering, purchasing, inspection, and shipping activities.

Beckman-Helipot Corp., Dept. ED, Newport Beach, Calif.

Quality Test Facilities

The Government Div. of Webcor, Inc., plans to make available its environmental and general test facilities to serve the testing needs of industry. At present, these laboratories are being utilized to test timers, signal generators, data recorders, guidance systems, direction finders, keyers, and classified military equipment, as well as commercial products, such as tape recorders, phonographs, and record changers. The laboratory will furnish facilities for testing commercial items in addition to performing tests on qualification acceptance, inspection and quality assurance tests to fulfill requirements of Military specifications. All phases of mechanical, pneumatic, hydraulic, electrical, electronic, and environmental testing will be stressed.

Webcor, Inc., Dept. ED, 5610 Bloomingdale Ave., Chicago 39, Ill.

IDEAS FOR DESIGN—*ENTRY BLANK*

To the *Ideas-For-Design* Editor of ELECTRONIC DESIGN —
830 3rd Ave., New York 22, N.Y. • TEmpleton 8-1940

Here is my design idea for possible publications in your *Ideas For Design* department. I can expect $10 for this idea if accepted for publication.

(Ideas suitable include: *1.* new circuits or circuit modifications, *2.* new design techniques, *3.* designs for new production methods, *4.* clever use of new materials or new components in design, *5.* design or drafting aids, *6.* new methods of packaging, *7.* design short cuts, or *8.* cost saving tips)

STATEMENT OF THE PROBLEM—

MY SOLUTION. AND WHY—(Please be explicit. Include sketches or photos that will help the idea across)

Signed _____

Title _____

Company _____

Address _____

(Place illustrations on separate sheet if necessary)

SERVICES FOR DESIGNERS

IBM 704 Computer

The Computer Services Division of Council for Economic and Industry Research, Inc. offers its IBM 704 Data Processing System at substantially reduced rates. In addition, discounts for large blocks of time, or for continued repetitive work, are now increased to give clients quantity discounts of off the standard rate.

The IBM 704 includes 8,192 words of magnetic core memory and 8,192 words of magnetic drum memory. Up to six tape units are available. The use of all peripheral equipment necessary for getting data into the 704, or for obtaining the output from the 704 in desired form, is offered as a free courtesy service to clients using the 704. Also offered are complete programmer-training courses for companies building up staffs for 704 installations. These courses are designed to produce fully experienced programmers, and to contribute programs for immediate use in the customer's future installation.

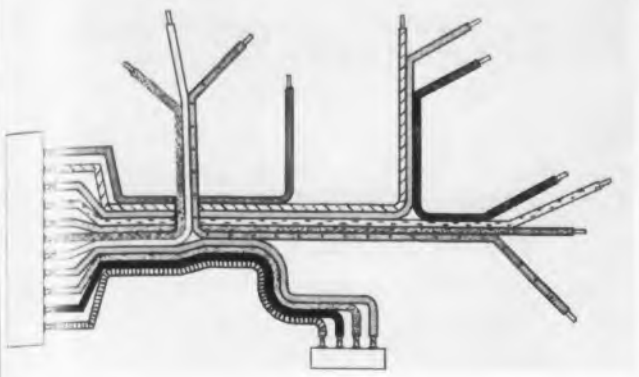
Council For Economic and Industry Research, Inc., Dept. ED, 1200 Jefferson Davis Highway, Arlington 2, Va.

Thread Metrology Labs

A coast-to-coast network of screw-thread measuring laboratories will be available to industries with fastener fit and gaging problems. This service for industry to be set up by Standard Pressed Steel Co., Jenkintown, Pa., early in 1958, will include screw metrology labs at company plants in Jenkintown (in suburban Philadelphia), Cleveland and Los Angeles.

Basic services of the metrology labs will be the analysis of fastener fit problems; the checking and setting of screw-thread inspection gages with highly accurate equipment; and the setting up of reliable inspection gaging system in conformance with recognized thread standards. Each lab will have complete equipment for precision measurement of all screw thread elements, such as diameters, angles, lead, radii and others, for gage setting; and for inspecting the thread-forming tools, themselves, if necessary. Equipment will include precision machines for direct measurement of thread dimensions to the nearest one hundred thousandth (0.00001) of an inch and primary reference standards for calibrating the machines.

Standard Pressed Steel Co., Dept. ED, Jenkintown, Pa.



Flat Cable Wiring

Organic Development Corporation, Spectra-Strip Division, using the flat cable technique, is prepared to fabricate wiring assemblies to the customer's requirements. Tests have shown a remarkable uniformity between individual harnesses made by this method, especially in relation to inter-wire capacitance. Neatness, ease of handling, greater speed of installation, and substantial savings in cost over the conventional method of strip typing are claimed for the new method. Harnesses are made with either Military Spec of U.L. approved vinyl insulated wires.

Organic Development Corp., Dept. ED, 10052 Larson Ave., Garden Grove, Calif.

Ceramic Design Course

To meet the demands of their customers in the electrical, electronic, instrument, aircraft and automotive industries, for information on the best methods for using high temperature ceramic tooling, the Duramic Products Div. of Technion Design & Mfg. Co., has set up a training school for production personnel.

The training course is offered to production engineers and manufacturing personnel at no charge in New York City. The course covers such topics as: how to correctly design ceramic tooling, how to machine ceramic tooling, how to make low-cost cast ceramic tools, how to correctly fasten ceramics.

In addition to these general topics, the students are encouraged to bring with them review by the company's engineers. Also on exhibition at the class, are many applications in which high temperature ceramic fixtures have been successfully applied.

Those wishing to take this course, should contact Mr. Herbert Schwartz of Technion Design & Mfg. Co. in New York City; or write to his attention on company letterhead, specifying at least two convenient dates. Classes take place on Tuesday and Wednesday of each week, and the course is completed in one day.

Duramic Products Div., Technion Design & Mfg. Co., Inc., Dept. ED, 262-72 Mott Street, New York 12, N.Y.

NEW LITERATURE

Servo-Mechanical Parts 264

A 32-page catalog describing a complete line of miniature and standard parts for prototype and production servos is now available.

Included are descriptions and specifications for precision gears, mounting plates, shaft hangers, dial assemblies, couplings, and many other parts for assembling servo systems. Reeves Instrument Corp., 207 E. 91st St., New York City, N.Y.

Specifying DC Supplies 265

"Specifying Regulated Direct Current Power Supplies" is a notebook page defining the terms frequently used in power supply work. Its purpose is to facilitate the selection of power sources by summarizing their basic characteristics. Transistor Devices, Inc., 730 Boulevard, Kenilworth, N.J.

Hermetic Sealed Thermostat 266

Revised data on the fixed temperature, hermetically sealed Klixon C4344 Series Thermostat has been released. This model, described in technical bulletin THSN-4A, gives information on aircraft and guided missile controls, electronic and radar equipment, high limit heater controls, aerial cameras, fuel pumps, gyroscopes, refrigeration, motor winding over heat protection and similar applications. The bulletin shows major configurations and dimensions, and up-dates the prior edition throughout. Metals & Controls Corp., Spencer Thermostat Div., Attleboro, Mass.

Electronic Hardware

A 20-page catalog featuring a line of electrical and electronic connectors, Varicon connectors, tube sockets, and shields, has recently been published.

The catalog contains photos, description, and pertinent information relating to Varicon connectors and Varicon sub-miniature connectors; 7 and 9 pin JAN, ventilated and snap-in pins; corrugated JAN shield insert; 7 and 9 pin JAN, RMA, Miniature and radiation type socket; 14 pin saddle and miniature socket; 20 pin socket and crystal socket.

Printed circuit sockets included are: 7 and 9 pin; 7 and 9 pin shield base type; 7 and 9 pin right angle; and octal. Subminiature transistor sockets; flat in line 3, 4, 5, 6, and 7 pin; round octal; and combination subminiature socket. Printed circuit subminiature transistor sockets 3, 4, 5, 6, and 7 pin. A binding post assembly; and 7 and 9 pin strap nuts rounds out this catalog. *For a copy, write on company letterhead to Elco Corp., Philadelphia, Pa.*

Electrical Vacuum Gages 268

A line of electrical vacuum gages for continuous and consistently accurate measurement of very low absolute pressure is described in data sheet no. 560. Specifications, including dimensions, are given in the sheet for the three models available covering the following pressure ranges: model TP-5, 1 to 100 microns; model TP-3, 1 to 1000 microns; model TP-4, 1 to 20,000 microns. F. J. Stokes Corp., 5500 Tabor Rd., Philadelphia 20, Pa.

Stainless Steel Strip 269

Highlight of the data sheet now available is a section tabulating the more important properties of the recently developed hardenable types of a line of ultra-thin, precision tolerance stainless steel strip. These types may be hardened by sub-zero as well as by conventional precipitation hardening processes. Up to the time of their development, alloys of the 300 series were regarded as non-hardenable except by cold-working. The data sheet supplies complete physical data for the most-used types of the chromium-martensitic group, The chromium ferritic group and the chromium-nickel austenitic group. Mechanical properties, heat-resistance characteristics, and chemical analyses are given in tabular form. American Silver Co., 36-07 Prince St., Flushing 54, N.Y.

NEW LITERATURE

Power Supplies 274

This file drawer folder contains catalog sheets on standard line of electronically regulated laboratory power supplies giving specifications, dimensions and other characteristics. The 12-page folder also contains power supply requirement sheets to facilitate setting down on paper information in ordering special power supply units. The text briefly covers the company's facilities and personnel. Trans Electronics, Inc., 7349 Canoga Ave., Canoga Park, Calif.

Holding Magnet Design 275

A 16-page guide and reference book is now available. The guide presents pictorially twenty-four basic designs for holding-magnets which can be used to drive holding assemblies with any required pull force. Complex equations are eliminated, and high school algebra is used to obtain the magnet dimensions. The Indiana Steel Products Co., Valparaiso, Ind.

Information, Memory Systems 276

Bulletins 103 and 104 describe information and memory systems. Bulletin 103 describes a reliable, solid-state digital computer with magnetic core memory designed specifically for industrial data processing and "on stream" computation. The memory system used in these computers is further described in bulletin 104. This memory system combines transistor with magnetics to provide a reliable information storage system. Daystrom Systems, 5640 La Jolla Blvd., La Jolla, Calif.

Digital Clock 277

Bulletin sheet 2500 gives specifications for the manufacturer's digital clock. The illustrated bulletin shows engineering data and typical application schematics for serial and parallel readouts and program control. Chrono-log Corp., P. O. Box 4587, Philadelphia 31, Pa.

Preforms 278

Bulletin 114, a 2-page technical report on 100 preforms for production joining of metals, plastics, ceramics, glass and quartz is now available. The bulletin offers such information as melting point, curing temperatures, curing cycles, clearances required, and a photo of typical preforms. Technion Design & Mfg. Co., Inc., Duramic Products Div., 262-72 Mott St., New York 12, N.Y.

Transistorized Power Supplies 279

A line of both regulated and unregulated transistorized power supplies is described in a four page folder covering ac to dc, dc to dc and dc to ac equipment. Hyperion, Inc., 1449 Washington St., West Newton, Mass.

Meter Relays 280

A 12-page Bulletin 106 describes all purpose controls, known as Versatrols and suitable for use with virtually any detectable variable. The bulletin explains applications of the most common Versatrol circuits, both automatic and limit, including the load sentry overload control. Bulletin 106 also contains complete ordering information. Assembly Products, Inc., Chesterland, Ohio.

Transistorized Equipment 281

A 10-page, multi-color, folder type catalog, is now available. This catalog covers technical descriptions, specifications, application notes, model numbers, and prices, of transistorized inverters and converters, transistorized high current power supplies, transistor test equipment, miniaturized power packs, transistor regulated dc power supplies, and transistor application power supplies. Electronic Research Assoc., Inc., 67 Factory Place, Cedar Grove, New Jersey.

Wire Markers 282

A 12-page brochure describes self-adhering wire markers. The markers are permanent and may be used on miniature electronic components, cables, harnesses, and wires of any size. The booklet describes cloth markers for fungus resistance and aluminum-foil markers for high temperature use. It lists thousands of markers in numerals, letters, sequence, and combinations. It also lists NEMA color codes, machine tool markers, electrical symbols, and voltage markers. Samples come free with the booklet. Westline Products Div., Western Lithograph Co., 665 E. 2nd St., Los Angeles 54, Calif.

Power Supplies 283

A collection of data sheets on transistor power supply dc to ac inverters is offered as a 13-page booklet. Each sheet has complete specifications, an illustration, and details on operation theory. Covered, too, are some ac to ac transistor frequency changers. A complete engineering discussion takes up various design approaches. Varo Mfg. Co., Inc., 2201 Walnut St., Garland, Tex.

NEW LITERATURE

Microwave Facilities 286

This manufacturer of precision components and tubes for the microwave industry has published a 16-page facilities brochure. The brochure describes the semiconductor, switching devices, magnetron, and waveguide component operation. Also discussed are the company's skills and facilities, production, administrative functions and philosophy as applied to weapon or commercial systems. A full page map is included which pinpoints the location of the company's new plant. Microwave Associates, Inc., Rt. 128, Burlington, Mass.

Thermostat Metals 287

TRU-6 is a 4-page technical bulletin of test results on thermostat metals exposed to corrosive environments. The illustrated brochure has a relative cost chart, a comparative thermal deflection graph, and a listing of mechanical and physical properties for eight corrosion-resistant thermostat metals. Metals & Controls Corp., General Plate Div., Attleboro, Mass.

Gears and Reducers 288

A 6-page brochure covers precision and commercial gears, and speed and motorized reducers. It outlines many of the ranges, sizes, and types of gears available. It also illustrates manufacturing processes. Grant Gear Works, Inc., 154 W. 2nd St., Boston 27, Mass.

Time Delay Relays 289

Bulletin AWH TD-502 describes a line of miniature hermetically sealed time delay relays. The two illustrated pages show tolerances on time delay, approximate weights, and dimensional and wiring diagrams. They also list basic military specifications which the relays will meet. Discussed are time delay settings, switch ratings, motors used, and other pertinent points. The A. W. Haydon Co., Waterbury, Conn.

Teflon Hook-Up Wire 290

A 2-page bulletin covers Teflon insulated hook-up wire. The silver-plated copper wire may be used in aircraft, rockets, missiles, transformers, and motors. It is available in sizes 10 to 30. Haveg Industries, Inc., 900 Greenbank Rd., Wilmington 8, Del.

High-Frequency Capacitors 291

Bulletin GEC-1482 discusses water-cooled, high-frequency parallel-plate capacitors for use in induction heaters. The 2-page leaflet contains performance data on 12 separate ratings, dimensional drawings, a characteristics curve, and pertinent water cooling data. General Electric Co., Schenectady 5, N.Y.

Continuous Resistance Winder 292

All technical details on a fully automatic continuous resistance winder are given in an illustrated catalog page. Included are dimensions, weights, winding types, maximum coil length, wire size, and other data. Geo. Stevens Mfg. Co., Pulaski Rd. at Peterson, Chicago 30, Ill.

Transformer Chart 293

Equivalent data on types and output amperage of Adjust-A-Volt, Powerstat, and Variac variable transformers is given in a 4-page interchangeability chart. The chart covers both manually operated and motorized variable transformers. It provides an accurate cross reference by current ratings between equivalent units of the three major manufacturers. Standard Electrical Products Co., 2240 E. 3rd St., Dayton, Ohio.

Power Relay 294

A 4-page data folder reports on a general purpose power relay. Details about characteristics and features are supported by technical data. The folder has dimensional drawings and standard stock and contact lists. It comes with other data sheets in a permanent binder. Phillips Control Corp., 59 Washington St., Joliet, Ill.

Lab and Production Equipment 295

Electronic equipment for laboratory and production is described in an 8-page catalog. Meter calibrators, voltage regulators, digital readout meters, and dc power supplies are some of the units mentioned. The booklet gives complete information and operating data for all models. It is illustrated with photographs. Davenport Mfg. Co., 1713 N. Ashland Ave., Chicago 2, Ill.

Fastener Fact File

Complete design and buying information on rivets and riveting machines is contained in a "Fastener Fact File." The 42 illustrated pages are bound by a plastic sleeve. The book has an evaluation questionnaire and a rivets standards chart. *Request the "Fastener Fact File" on company letterhead from Judson L. Thomson Mfg. Co. Dept. ED, Waltham 54, Mass.*

IDEAS FOR DESIGN

Fig. 1. Probe circuits for extending range and usefulness of conventional vacuum-tube voltmeters.

Probes for Vacuum-Tube Voltmeters

VOLT-OHMMETERS, whether of the electronic or non-electronic type, find vastly expanded fields of application when supplemented by suitable probes. Schematics of three probes for different applications are shown in Fig. 1.

High-Ohms Probe

At *a* in Fig. 1 is a vtvm high-ohms probe that can be used to measure the leakage resistance of a fixed capacitor. This type of probe is used in place of the conventional test lead for the vtvm, and is designed to operate with any vtvm having an Rx1-meg range, an input resistance of 10 meg, and an internal ohmmeter battery of 1.5 v. The probe uses a 15 v transistor-type battery and a 1.5 v cell, plus a 90 meg multiplier resistor. When the probe is used in place of the conventional test lead for the vtvm, the center-scale indication becomes 100 meg (instead of 10 meg), and the top resistance value which can be measured becomes 10,000 meg (instead of 1,000 meg).

Use of the vtvm high-ohms probe not only makes possible the measurement of unusually high values of resistance, but also provides more accurate measurement of resistance values in lower ranges, e.g., from 100 to 1000 meg. This is because the pointer then falls on the expanded portion of the meter scale where observational error is minimized.

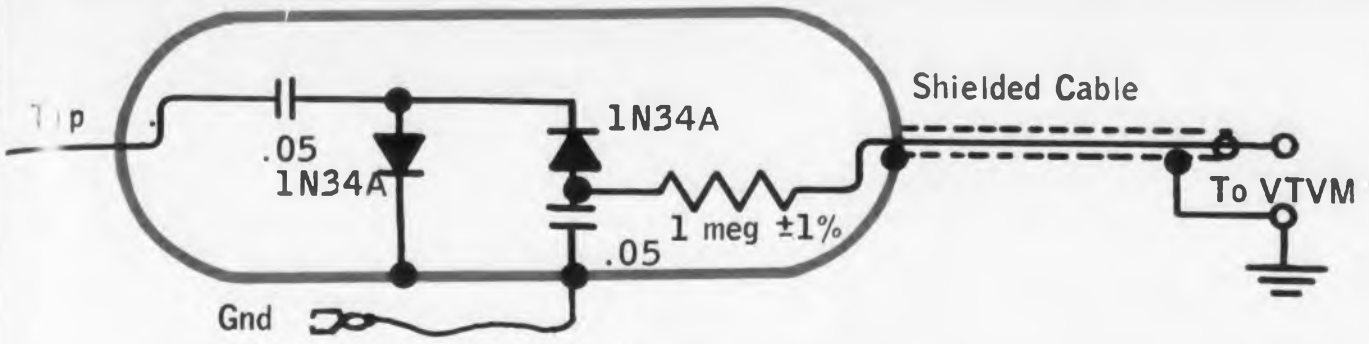
Signal-Tracing Probe

A peak-to-peak vtvm signal-tracing probe, illustrated in Fig. 1b and shown in operation in Fig. 2, works on the dc voltage ranges of a vtvm. When used with an instrument having an input resistance of 10 meg, the probe provides measurement of peak-to-peak voltage values at frequencies from 60 cps to 150 mc. Accordingly, the probe permits checking of TV receiver waveform amplitudes, and the indication obtained on the meter can be checked against the peak-to-peak voltage values published in receiver service manuals.

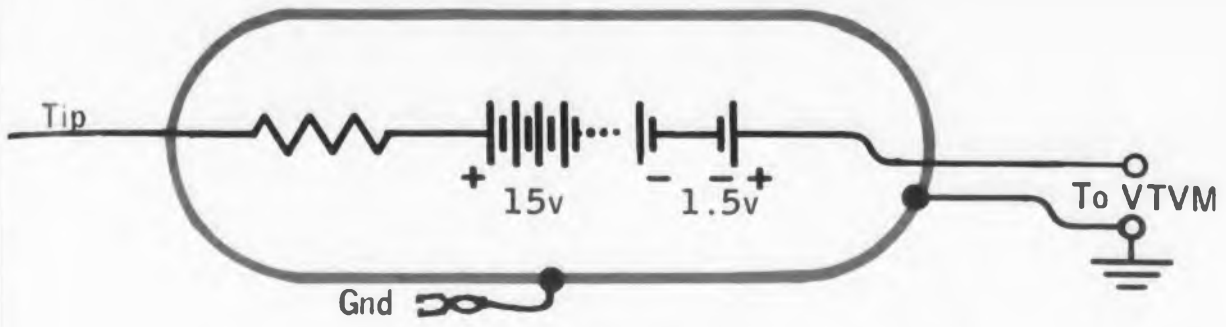
The probe circuit shown has an input voltage limitation of approximately 65 peak volts due to the characteristics of the diode rectifiers utilized in the probe. However, a capacitance divider can be used to permit higher input voltages. When the divider manufactured by Futuramic Co. is utilized, tests are restricted to frequencies above about 15,000 cps, since the divider is an uncompensated series-capacitor arrangement. Divider construction is designed to withstand 15,000 peak-to-peak v for protection of the probe and meter.

Special Considerations

When using high-ohms probes and signal-trac-



a. Circuit of high-ohms probe for vtvm.



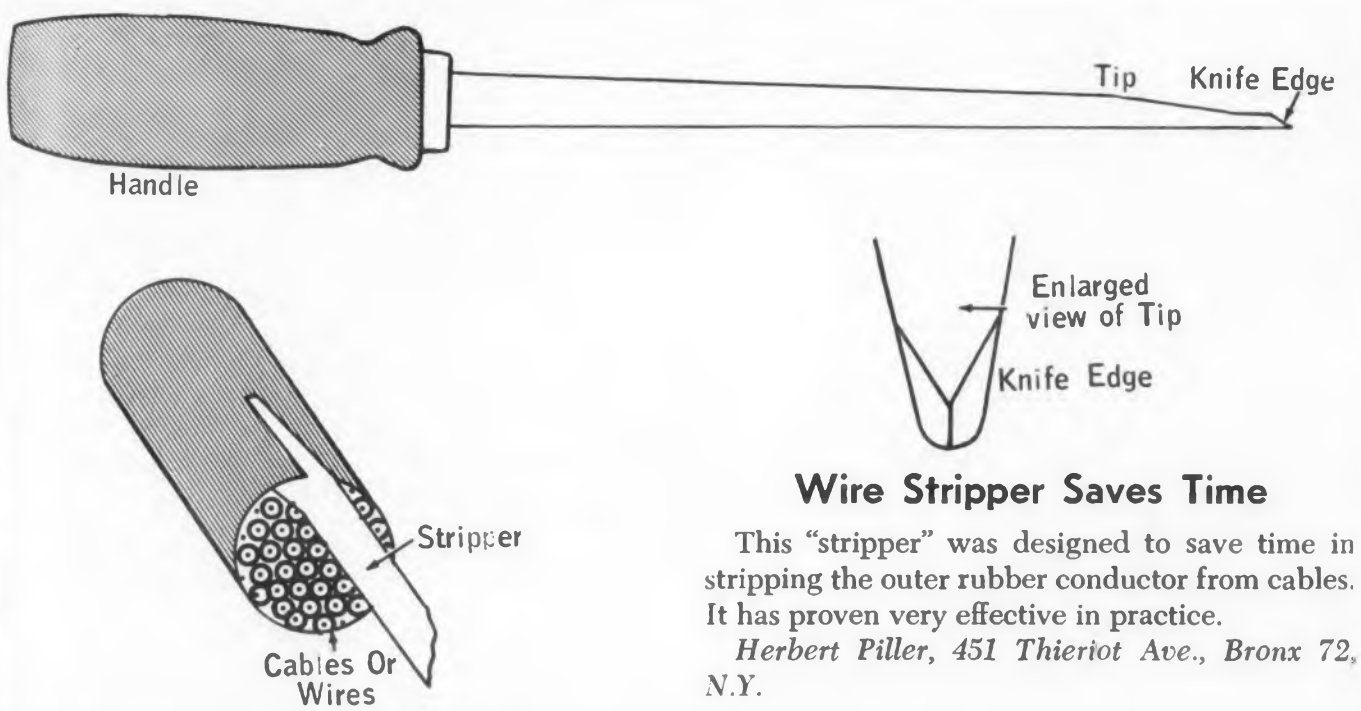
b. Circuit configuration of peak-to-peak signal-tracing probe.

Fig. 2. Peak-to-peak vtvm signal-tracing probe used in checking waveform amplitude at sync-separator stage of t-v receiver.

ıng probes with high-sensitivity volt-ohmmeters, it may be found that sources of error due to circulating ground currents and 60-cycle hum fields must be eliminated. For example, when a signal-tracing probe is "grounded" to a receiver chassis which operates above ground (such as an ac-dc radio or TV receiver), a large error may be encountered with some vtvms.

To avoid error, due to circulating ground currents, a line-isolating transformer can be used to energize the receiver under test, and a ground lead run from the receiver chassis to a cold-water pipe or other good ground. This arrangement stabilizes the test set-up, and permits accurate measurement of signal-voltage values. Likewise, it will sometimes be necessary to stabilize the vtvm by running wire from the instrument to a good ground. When the input circuit of the vtvm is inadequately filtered, it may also be necessary to keep hands away from the component under test to avoid entry of strong ac fields in to the instrument circuitry. Such fields can over-drive the grids of the bridge tubes and introduce an error into the measurement.

Robert G. Middleton, Consultant, Futuramic Co., 915 S. Broadway, Park Ridge, Ill.



Wire Stripper Saves Time

This "stripper" was designed to save time in stripping the outer rubber conductor from cables. It has proven very effective in practice.

Herbert Piller, 451 Thieriot Ave., Bronx 72, N.Y.

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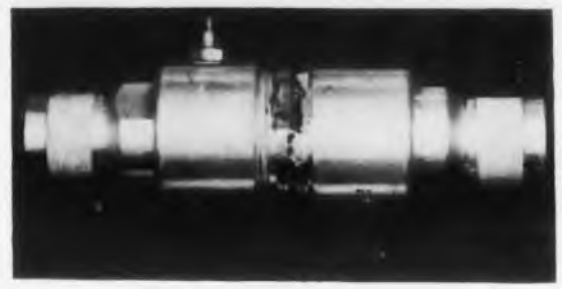

A typical coaxial coupler with impedance matching network enclosed.

Circuit Elements Are Incorporated in RF Couplers

When setting up equipment for laboratory tests it is often necessary to modify existing equipment units or improvise a hasty breadboard circuit in order to couple these units or utilize them in the desired manner. In order to avoid construction of crude breadboards or undesired alterations of existing equipment, a technique has been developed to house complete circuit elements within standard coaxial fittings.

RF instruments used for laboratory measurements are often designed for 50-ohm termination. Occasionally a requirement exists for use of a higher impedance instrument with the conventional 50-ohm gear. Specifically, it was desired to utilize the General Radio 874-MR mixer and 1216A Unit IF amplifier with 50-ohm units. The mixer was designed to supply a 400-ohm termination and the amplifier was designed for operation from a 400-ohm source. To use either of these devices in an unconventional manner requires an impedance transformation or modification of existing equipment. A coaxial fitting type of adapter was devised as follows: Two type UG-167D/U, coax connectors were used to house a slug-tuned matching transformer. The locking nuts from each connector were soldered back to back so that when they were screwed to the connector one solid coax adapter resulted. The coil form is a 1/4 in. diameter slug-tuned type. The coil was tuned to 30 megacycles in order to operate from the mixer or into the IF amplifier. To achieve a close match with minimum reactance some cut-and-try was resorted to, changing the calculated turns ratio. Final design was as

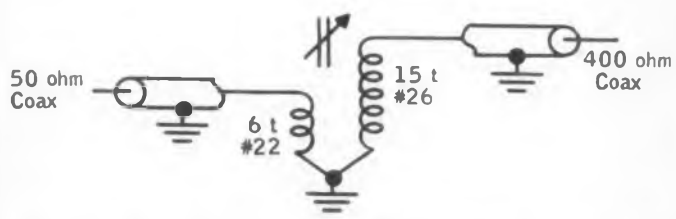

Fig. 1. Impedance-matching circuit in a coaxial coupler.

shown in Fig. 1. The 50-ohm side was close wound over the 400-ohm side and the common end connected to a ground lug fitted to the coil mounting stud (inside the adapter).

Another impedance matcher was constructed by mounting a T matching circuit inside a pair of UG-167D/U coax fittings as shown in Fig. 2. The capacitors are glass-mica units.

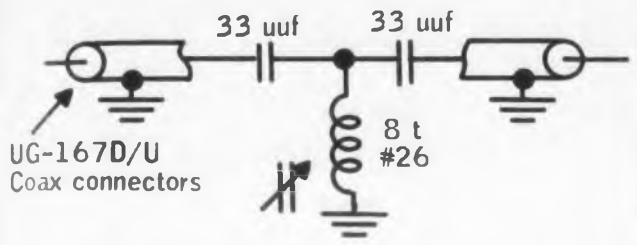

Fig. 2. "T" match in a coaxial coupler.

The same technique was applied to the construction of a coaxial crystal detector termination, Fig. 3. RF or IF is coupled through one end of the unit, and the demodulated signal is coupled through the other end to the oscilloscope. UG-204A/U coax connectors were used. Circuit

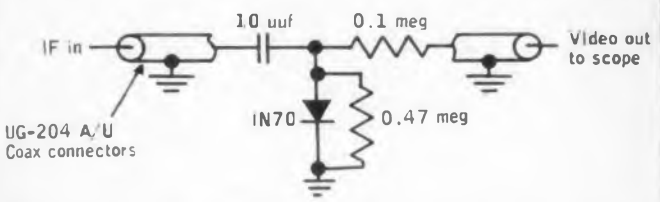

Fig. 3. Crystal detector circuit encased in a coaxial coupler.

values were chosen to fit a particular application.

The SWR bridge described in the 1957 edition of the Radio Amateur's Handbook was incorporated into a similar coax adapter.

The same technique described can be used to make an entire line of such totally enclosed coaxial adapters and circuit elements.

J. Metz, D. Herzog, and M. Shar, U. S. Army Signal Engineering Laboratories.

Avoiding Cross-Talk in Multi-Channel High Impedance Circuits

Connection of multiconductor flat cable to avoid interchannel cross-talk.

In a multi-channel audio mixing amplifier, it was necessary to cable a group of high impedance leads to the various channels. This resulted

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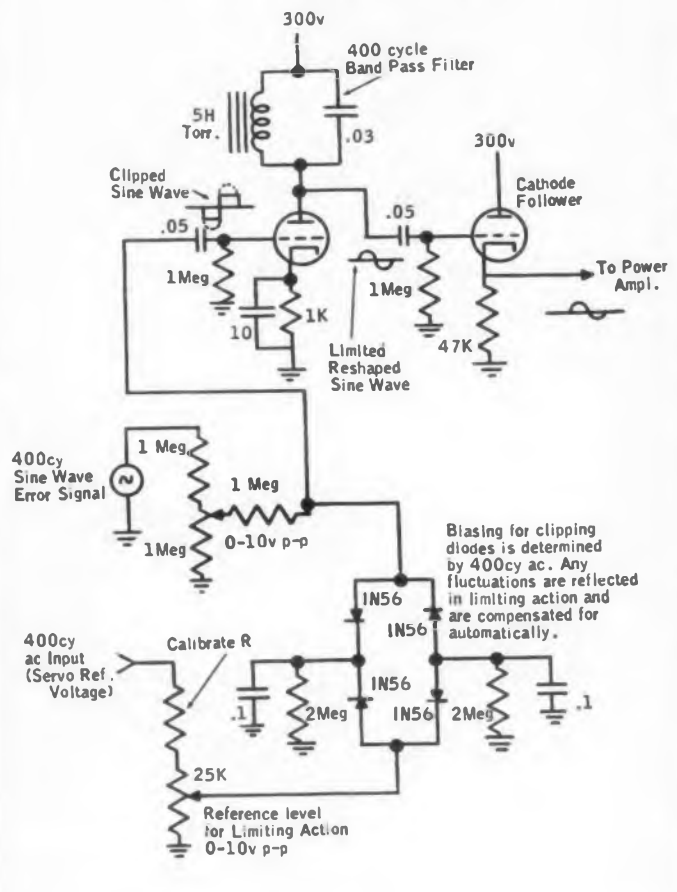
is cross-talk due to capacitance between leads. The leads could not be shielded, because this decreased the high-frequency response.

A solution was found by using a flat multiconductor color-coded cable called "Spectra-Strip," and manufactured by The Organic Development Co., Anaheim, Calif. By using alternate leads of this cable as signal leads and grounding the other alternate leads, electrostatic shielding was provided between the signal leads without adding an objectional amount of shunting to ground.

Charles Defir, Project Engineer, Hallamore Electronics, 8352 Brookhurst, Anaheim, Calif.

Automatic Flight Control

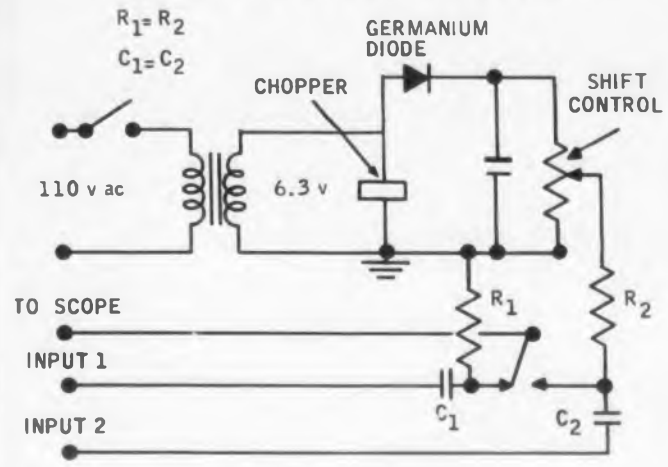
Servo System



A 400 cps servo limiting amplifier was desired in that it should prevent too much power being delivered to the motor (under large error signal conditions). The limiting amplifier should maintain sine wave and good response. Gain and limiting action should be adjustable and compensate for ac reference fluctuations. The circuit developed to accomplish the desired aims is shown.

James L. Halcomb, Electronic Engineer, Forney Mfg. Co., Fort Collins, Colo.

Obtaining Dual Trace on Single Trace Pulse 'Scope



Dual Trace Switch

It was required to provide a simple dual trace facility on a pulse oscilloscope to show relative pulse positions. The switch is a chopper relay and the ac drive supply is rectified and applied to the trace shift control. This control enables the trace separation to be adjusted. If a greater trace separation is required, voltage doubling can be used from the coil supply.

In operation the lack of synchronism between the pulse repetition frequency and the supply frequency causes only a faint background trace.

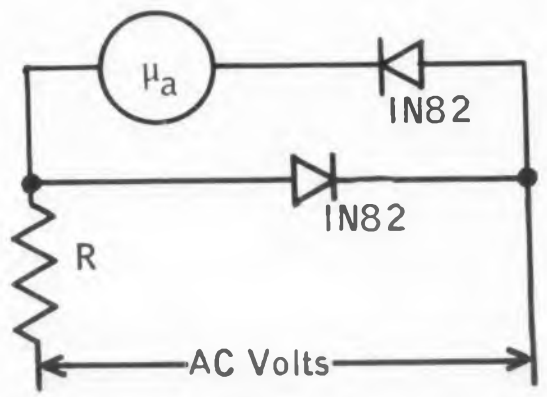
K. E. Wood, Senior Engineer, Electronics Division, Westinghouse Electric Corp., Baltimore 3, Md.

Meter Rectifier for Hi-Temp Operation

Shown here is a solution to the problem of a low cost hermetically sealed high temperature meter rectifier. High reverse-silicon diodes normally used, are expensive. The 1N82 is a low-cost silicon diode but unfortunately has low reverse-voltage characteristics.

Solution to the problem was found in the use of two 1N82 diodes connected as shown in the accompanying schematic.

R. G. Swain, Supervisor, Field Engineering, CBS-Hytron., 32 Green St., Newark, N.J.



Low-cost high-temperature meter rectifier circuit.

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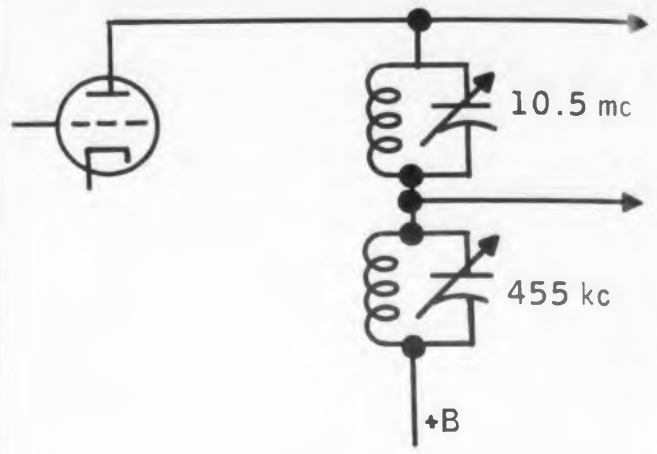
Improved Dual-Frequency Amplifier Circuit

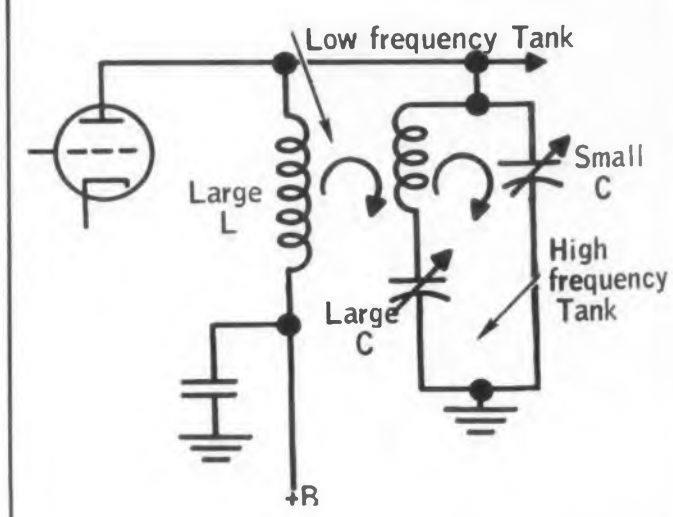


Usual circuit has DC on capacitor rotors.

In an amplifier which requires peaking at two frequencies, such as an i-f amplifier for an fm-am radio, one of the circuits is ordinarily in tandem with the other. This poses a problem of physically isolating the tuned-circuit components (tuning capacitors), as shown in the illustration of the "usual circuit."

By connecting as shown in the "suggested circuit," the plate tank circuit will still resonate at the two frequencies; but, each tank will have no significant effect on the other. Also, each capacitor is grounded, avoiding stray capacitance problems when aligning.

James L. Halcomb, Electronics Eng., Forney Mfg. Co., Fort Collins, Colo.



Suggested Circuit has rotors grounded. No hand switching is required; both low and high frequency circuits can be resonated independently; and stray-capacitance problems are avoided.

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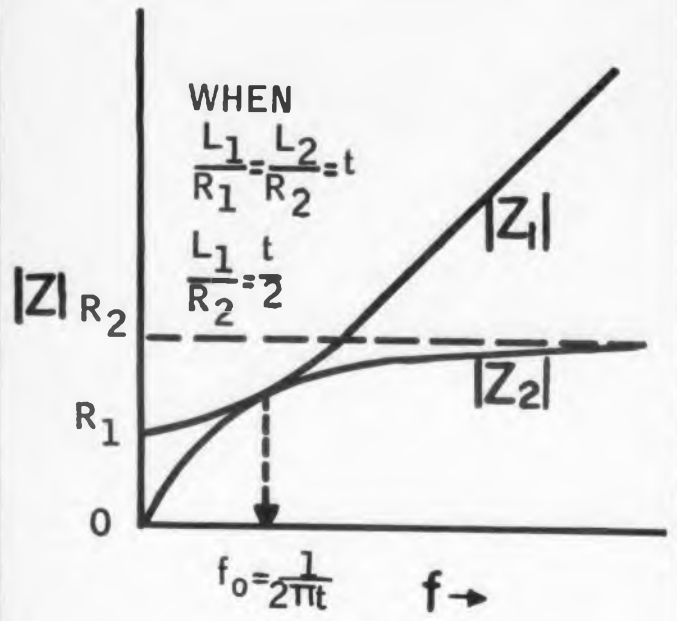
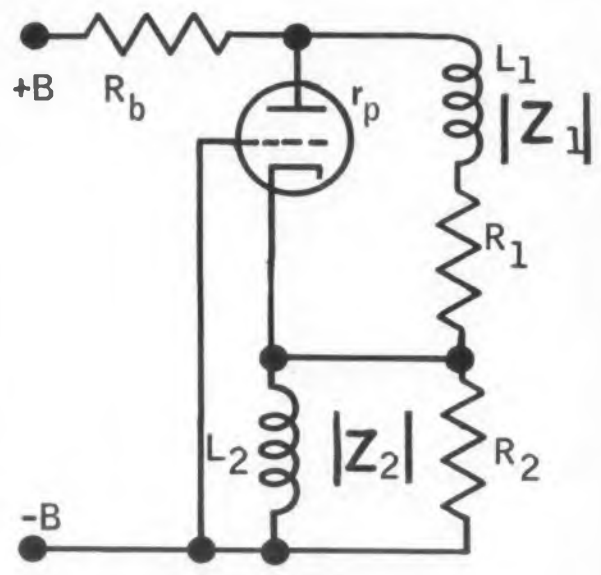
Low Cost "Wien Bridge" Oscillator



Impedance-frequency characteristic curves.

As the result of a study to determine whether the component parts required for a Wien-Bridge type oscillator could be reduced without a loss in operational performance, the circuit shown evolved.

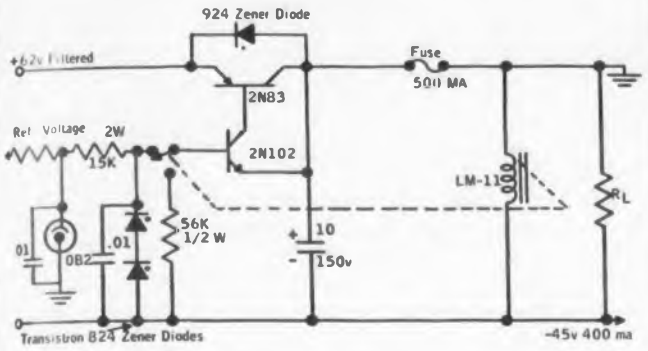
The new circuitry substitutes two R-L networks for the normal R-C elements found in the Wien-Bridge oscillator. It also eliminates the need for combining a phase-reversal amplifier and automatic feedback regulation, since voltage regeneration is now conveniently and directly coupled between the tube plate and cathode. The same frequency range of oscillation can be selected (as in the case of the R-C Wien-Bridge circuit) by the proper choice in R-L time con-



R-L "Wien-Bridge" ciruit.

states, and provided $Z_1 + Z_2$ is less than r_p. An absolute R-L impedance-vs-frequency characteristics curve is shown with relative operational values and limits for the optimum oscillator applications.

John Nicolosi, Defense Projects Eng., Western Electric Co., 220 Church St., New York 13, N.Y.



Typical Transistor Regulator Circuit with Zener Diode Transistor-Overload Protector.

Transistor-Overvoltage Protection

In using transistors as regulating devices in power supply circuits, a problem which presented itself was that accidental shorts would cause excessive voltage across the regulating transistors.

The solution was to connect a ten-watt "Zener" diode having a breakdown voltage five or six volts lower than the maximum permitted transistor voltage across the regulating transistor. See circuit.

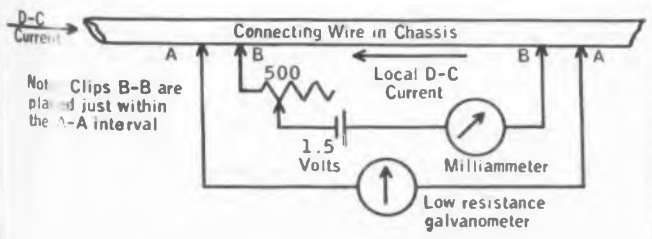
John J. Robinson, 600 Elmira St., S.E., Washington 20, D.C.

Current Measurement Without Breaking Into Circuit

A problem arose where it was necessary to measure the dc current flowing in a wire without cutting the wire.

The solution was to clip a galvanometer across a 6-inch exposed length of the wire, as shown. A reverse current from a dry cell was introduced to bring the galvanometer deflection to zero. The milliammeter then read the current flowing in the wire.

R. G. Middleton, Futuramic Co., 915 S. Broadway, Park Ridge, Ill.



IDEAS FOR DESIGN

Short Pulse Operation of Low-Frequency High-Powered Transmitters

A problem developed recently, in connection with a research project at Rome Air Development Center, Griffiss Air Force Base, Rome, N.Y., of modifying a high-powered low-frequency loran transmitter for short pulse operation. This transmitter had a peak power output for loran purposes of one megawatt at a carrier frequency of 100 kc, and the pulse length was intended to be several hundred microseconds. It was desired to operate the transmitter and antenna to radiate pulses of 50 μsec or shorter. One of the severe problems in such a case is the antenna, and the solution to this problem depends on antenna design as well as the allowable loss loading. Only the transmitter will be dealt with here.

As originally constituted, the transmitter consists of an exciter unit, a grid modulated driver unit, and a class B push-pull bias to produce the required output pulse, the modulation being obtained from the discharge of a lumped constant line. The first thing done was to install a pulse-forming line to get the proper pulse duration. After this, it was found that an excessively long train of oscillations existed after the modulating pulse was over. This situation was cured by a combination of three techniques.

The first improvement consisted of removing the more or less conventional coupling circuit between driver and final amplifier, and replacing it with low-Q transformers with powdered iron cores. This delivered a reasonably short pulse to the final amplifier stage. Next, a low-Q tank was used in the final amplifier. It did not seem feasible to utilize extremely low-Q from the standpoint of efficiency, so a third and more unusual feature was added.

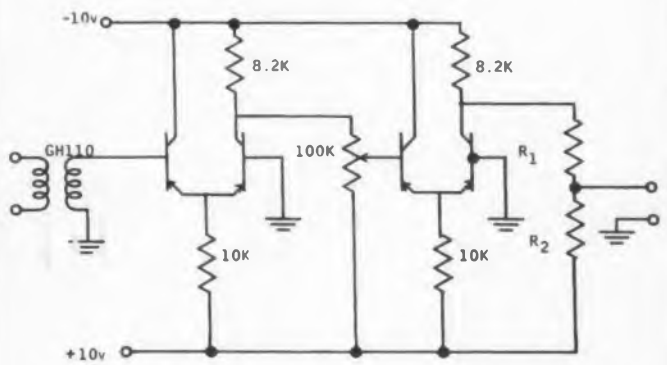
A second line pulser was constructed to deliver a positive pulse of approximately 50 μsecs (not at all critical) to the grids of the final amplifier tubes. However, this was delayed until after the actual modulating pulse was completed. After the excitation was removed, a large positive voltage was supplied to all final amplifier grids. The object was to reduce the plate resistance of the tubes to its minimum value,

and consequently to lower the Q of the output circuit after the pulse was supposed to be completed, thus discharging the remaining energy from the output circuit.

It is necessary to consider the plate dissipation of the final amplifier tubes when determining the length of the applied pulse and the feasibility of the entire method. However, in the case at hand, this was no problem. Operation proved satisfactorily; and with a resistive load, an output pulse of nearly rectangular shape resulted with a duration of four cycles.

Charles R. Ammerman, Haller, Raymond and Brown, Inc., State College, Pa.

Precision Clipper



All Transistors are GE 2N192.

The clipping circuit shown produces a square wave from a sine wave with precision. The requirement was for a square wave that would pass through zero volts within 10 millivolts of the dc level of the sine wave, under a wide range of temperature conditions.

The circuit is a balanced clipper, and consists of two differential amplifier circuits with a balancing potentiometer between them. The balanced differential amplifiers provide the temperature stability feature. The function of the balancing potentiometer is to compensate for unbalance in the transistors. It is adjusted so that the output voltage is zero volts when there is no input signal. Test made on the circuit indicate that it has enough sensitivity to detect the dc level of the sine wave within a few millivolts.

Robert W. Cope, Project Engineer, Bendix Radio, Joppa Road, Towson 4, Md.

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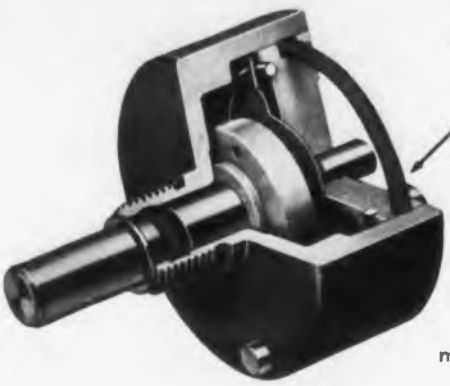

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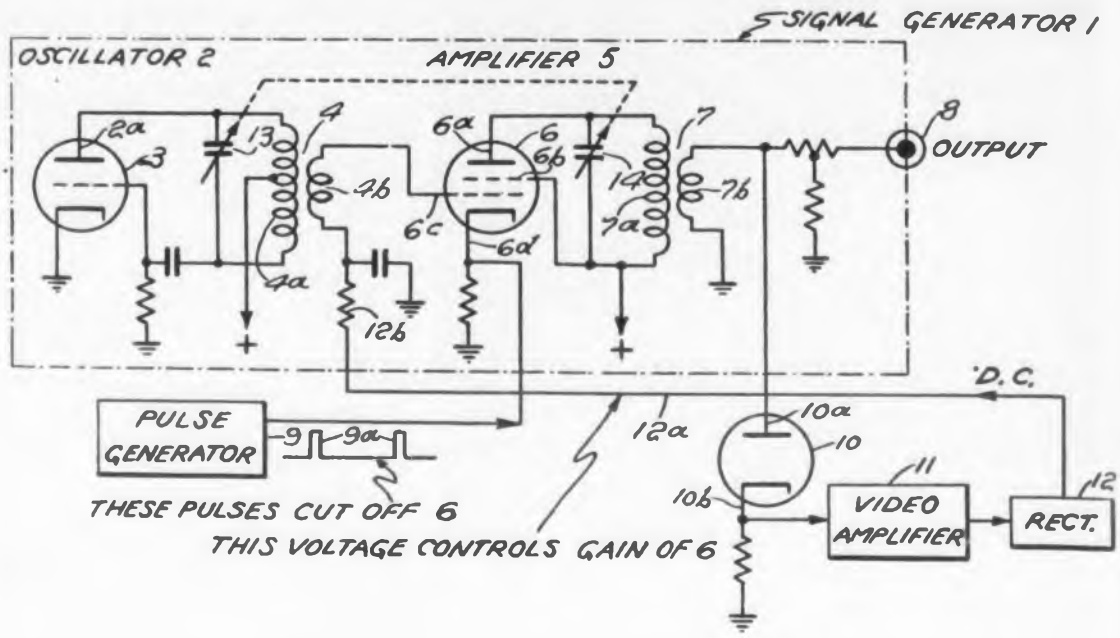

Automatic Level Control Of Local Oscillation In Superheterodyne Receiver

Patent No. 2,798,947. Sven H. M. Dodington. (Assigned to International Telephone and Telegraph Corp.)

A simple form of automatic level control for the output of the local oscillator which can be used with various types of electronic equipment such as a continuous wave signal generator, local oscillators of a general character and radio receivers. Continuous wave generators which operate over a wide frequency range have had difficulties because the output level will vary appreciably as the output frequency is changed. Sometimes this occurred also when the load impedance changed although the frequency remained constant. If such a generator is used occasionally then manual adjustment could be made when the circuit was not in operation to control the output level. If, however, this generator was in continuous use this manual adjustment was unsatisfactory. In some cases, manual adjustment is impossbile. Automatic level control has been sought, however, in such circuitry the rectifier output was too feeble to satisfactorily amplify and feedback to adjust the output level. In addition drift and variations in the dc amplifier circuit resulted when this signal was amplified. This circuit overcomes these difficulties and produces a satisfactory automatic level control.

The circuit shown in the figure uses a local oscillator which is coupled through the transformer *4* to an amplifier tube *6*. The amplifier is coupled to the output *8* through a transformer *7*. The amplifier tube has cut-off pulses supplied to the cathode of the amplifier tube from a pulse generator *9*. In a typical circuit these pulses may be at a rate of 200 per second with a pulse duration of one microsecond so that the count down in the received signal is insignificant. If this local oscillator for a radar receiver is synchronized so that pulses are applied when there is no reception there would be no loss of signal energy. From the output of the amplifier or particularly from the secondary *7b* of the coupling transformer *7* there is connected a detector diode *10*, the signal from which is amplified at *11* and rectified at *12* and fed back as a dc signal through a resistor *12b* and secondary winding *46* to control grid of the amplifier tube *6*. This dc signal controls the bias on the control grid of the amplifier to stabilize output.

The patent shows a particular application of the automatic control circuit in a crystal controlled superheterodyne receiver such as designed to be used in the 1000 megacycle frequency range. In this type of receiver tests have shown that there is an output variation of 50 to 1 upon changes of frequency of the local oscillator. Other variations are introduced when line voltage changes or when the tubes of the circuit age. With the automatic control circuit disclosed variation in the output is reduced.

W e Generating Circuits

Pa nt No. 2,808,454. Benjamin S. Vilkerson. (Assigned to Radio Corporation of America)

The circuit is for a television receiver which has horizontal and vertical deflection circuits operating at frequencies fractionally related to one another so as to produce line interlaced television images. The vertical deflection circuit is of the squedging oscillator variety. A synchronizing signal input is supplied with vertical synchronizing signal information. A control wave is generated from the horizontal deflection circuit which wave is harmonically related to the horizontal deflection circuit operating frequency. This control wave is superimposed upon the vertical synchronizing information applied to the synchronizing signal input to produce a composite synchronizing wave. The composite wave is applied to the vertical deflection circuit for controlling of this circuit.

Gated Pulse Generator

Patent No. 2,806,949. Raymond H. Smith. (Assigned to the United States of America)

The generator comprises an electronic signal amplifier which is biased beyond cutoff and rendered conductive by a gating pulse. The amplifier includes a plate load having an output terminal at the plate end of the plate load. A normally conductive means is connected to the plate load intermediate of its ends so that current flows through a portion of the plate load to the conductive means. In addition this conductive means normally conducts one level of current and is adapted to be rendered momentarily nonconductive. Gating pulses are coupled to the amplifier. A gating pulse is produced when the normally conductive means is rendered momentarily nonconductive. The portions of the plate load are selected of such relative values that the amplifier transmits the signal and does not transmit the gating pulse.

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CIRCLE 340 ON READER-SERVICE CARD

REPORT BRIEFS

Cockpit Design

A symposium was held in October, 1956 for exchange of information between psychologists and engineers involved in Air Force and Navy programs to improve flight instrumentation. Seven papers were presented which describe military and contractor work with integrated display panels, instrument evaluation, and cockpit research. In addition, a panel discussion was held on each of three subjects: "Problems and Methods in Cockpit Research," Problems and Methods of Whole-Panel Flight Evaluation," and "Whole-Panel Design Objectives to Be Met in Future Aircraft." *Psychological Aspects of Cockpit Design—A Symposium Report, Wright Air Development Center, Apr., 1957, 144 pp, $3.75. Order PB 131189 from OTS, U. S. Department of Commerce, Washington 25, D.C.*

Dial Display Data Check

An indicator display was designed to eliminate the frequent human error accompanying the manual setting of information into a machine. The dial display incorporates both a data reference check and a discrete go-no-go error indicator. Proximity of printed data to information on the dial display provides for an accurate visual reference comparison of the input settings. An additional go-no-go display in the form of a red-dot error signal furnishes the operator with a means for spot checking his input settings by visually scanning the dial display. A series of the displays placed in horizontal alignment permits use of a single tape to present a combination of group input settings simultaneously. *A Dial Display Incorporating a Data Reference Check and a Discrete Go-No-Go Error Indicator, A. W. Baldwin, Naval Research Laboratory, Aug., 1957, 4 pp, $.50. Order PB 131173 from OTS, U. S. Department of Commerce, Washington 25, D.C.*

Retention of Air Frame Control Bearings

This volume describes the data-gathering and testing program leading to the standardization of retentions for air frame control bearings in aircraft structural housings. Based on more than 8500 preliminary tests and subsequent race-out tests, it was concluded that press type retentions meet more requirements of the aircraft industry for standard retention. Twenty-one retentions were tested in ten materials and grouped as press, roller swaged, spun, sleeve restraining shoulder,

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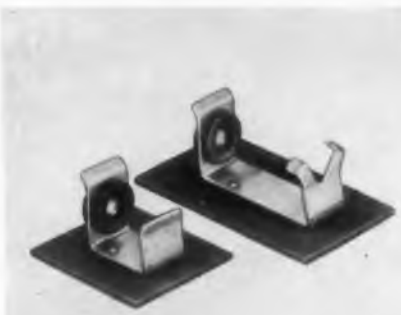

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CIRCLE 344 ON READER-SERVICE CARD

and retaining ring types. A method of rating the retentions based on press-out and fatigue tests is discussed in the report. Extension of the results to other sizes of bearings is also considered. *Investigation of Methods for the Retention of Air Frame Control Bearings in Structural Housings, A. B. Asch, Asch Equipment Co., Jan. 1957, 274 pp., $4.75. Order PB 131068 from OTS, U. S. Dept. of Commerce, Washington, D. C.*

Flake Cores for Low Frequency Application

High permeability toroidal cores for low frequency applications have been prepared from flakes made by rolling Alfenol and 2-81 Molybdenum Permalloy powders. These cores exhibited a two-fold increase in permeability over the corresponding powder cores, with approximately the same total loss factors, but only at the expense of some of the stability to varying flux levels and dc shock. The temperature coefficient of permeability for an Alfenol flake core was made quite small in the low temperature region by selection of insulation. No attempts were made to stabilize the Mo-Permalloy flake cores against temperature changes. The techniques used for processing these cores are described along with representative magnetic properties. *New Magnetic Flake Cores for Low Frequency Application, William M. Hubbard and Edmond Adams, U. S. Naval Ordnance Lab., July 1956, 13 pp., microfilm $2.40, photocopy $3.30. Order PB 128092 from Library of Congress, Washington, D. C.*

Current-Pulse Testing of Magnetic Cores

A discussion of the principles and procedures of testing magnetic cores to be used in digital computer magnetic circuits is presented. Physical quantities to be tested are defined and the necessary pulse patterns to test these physical quantities are given. Resulting typical output waveforms and methods of plotting data are given. A description of the circuits used to generate the test pulse patterns, and descriptions of the current pulse generators, calibrating device, core handling equipment, procedures for processing the cores to avoid damage, and testing the cores are given with suggestions for the physical handling of the equipment. Switching characteristic data is given for three different metallic core materials along with reproductions of typical core output waveforms. *Current-Pulse Testing of Magnetic Cores for Digital Computers, LeRoy F. Silva, Ballistic Research Lab., July 1956, 40 pp., microfilm $3.00, photocopy $6.30. Order PB 125193 from Library of Congress, Washington, D. C.*

REPORT BRIEFS

Electrostatically Focused Velocity-Jump Amplifiers

Small light focusing systems are needed for high current density beams in beam-type electron tubes. This research approached the problem with tests of periodic electrostatic focusing and its application to traveling-wave tubes. It dealt mainly with the results of experiments with two velocity-jump amplifiers consisting of a helix input, drift tubes, and a helix output. Electrostatic lenses existing between the various electrodes were used for focusing. It was established that instead of the confined flow plasma frequency reduction factors, those for ion neutralized flow were more correct for electrostatically focused flow. Because of the long plasma wavelengths corresponding to the reduction factors, construction of this type of tube seemed impossible. Suggestions are made for development of tubes consisting of short sections of helix operating at different potentials. These could be practical for low current densities. *Experiments with Electrostatically Focused Velocity-Jump Amplifiers, W. M. Mueller, University of California, Mar. 1957, 66 pp., $1.75. Order PB 131031 from OTS, U. S. Dept. of Commerce, Washington, D. C.*

Small Pulse Connectors

Miniaturized pulse connectors able to withstand the severest climatic and environmental conditions yet operate satisfactorily at working voltages of 7500 v peak were developed. The connectors, which are said to be the smallest developed to the date of the research, were intended to replace larger pulse connectors then used in airborne electronic equipment. The connectors met or exceeded all electrical and mechanical requirements of the associated cable and were capable of operation over the temperature range minus 65 to 150 C at altitudes up to 70,000 feet. They measured approximately one in. diam. and three in. length, or five in. for plug and mated receptacle. Development of semiconducting silicone rubber for high temperature operation is discussed in the report. Tests for performance characteristics of connector assemblies and components are reviewed in detail. *Miniaturized Pulse Connectors, J. H. Gesell, Federal Telecommunications Labs. for Wright Air Development Center, U. S. Air Force, Dec. 1956, 49 pp, $1.25. Order PB 131048 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Reactor Safety Conference

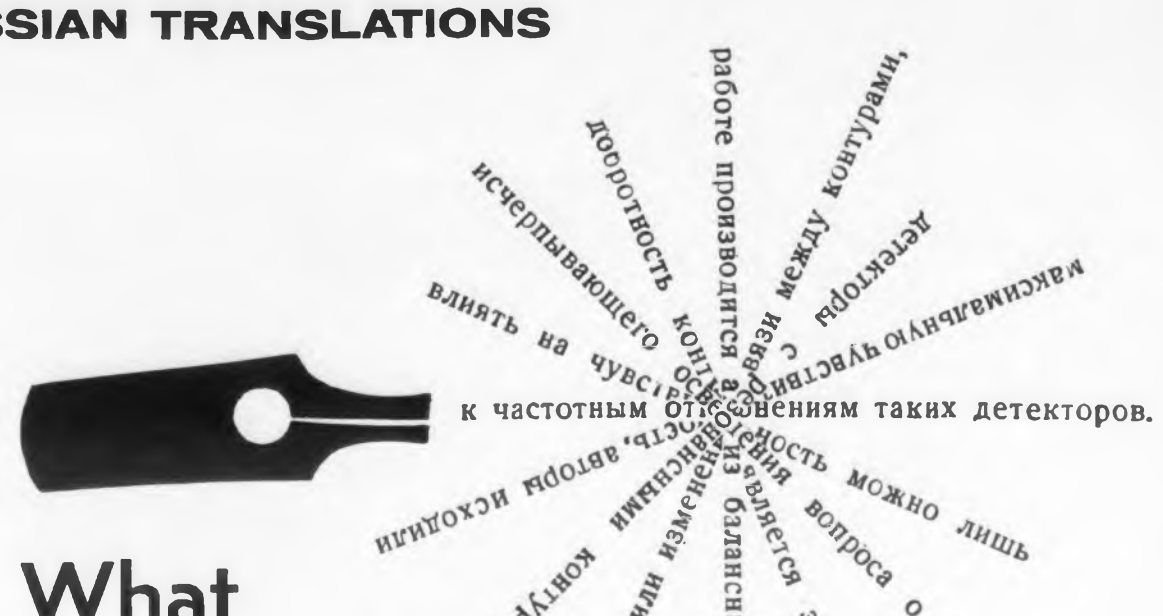
Four papers presented at an industry-Government conference on nuclear reactor safety held in October have just been published by the U. S. Atomic Energy Commission for sale by the Office of Technical Services, U. S. Dept. of Commerce.

The two-session conference was held in New York City under sponsorship of the American Nuclear Society, the Atomic Industrial Forum, and the U. S. Atomic Energy Commission. Four of the five papers read at the first session are contained in the publication. The remaining documents are expected to be available by mid-February 1958.

Two of the published papers, "AEC Licensing Policies and Procedures with Regard to Reactor Safety" and "Technical Requirements for an AEC Safeguards Report," deal with what an applicant must do in order to get a permit to build and operate a reactor.

The third, "AEC Reactor Safety Experimental Program," describes the AEC's continuing work toward solving safety problems. The fourth paper discusses the role of the Advisory Committee on Reactor Safeguards, which is charged with evaluation of reactor hazards and review of proposed standards of reactor safety. *Part I—Reactor Safety Conference, 44 pp, $.75. Order TID-7549, from OTS, U. S. Department of Commerce, Washington 25, D. C.*

RUSSIAN TRANSLATIONS



What the Russians Are Writing and Saying

J. George Adashko

THE DAY OF RADIO

In the January 22nd and February 5th issues of ELECTRONIC DESIGN we reported on the All-Union Scientific Session of the A. S. Popov Scientific-Technical Society for Radio Engineering and Electric Communication. This conference took place in Moscow during May, 1957. It attracted some 2000 scientists and engineers from Bulgaria, Hungary, East Germany, China, Poland, and Czechoslovakia, and from Russia's largest cities, as well as representatives of the IRE.

In this issue we are concluding our presentation of the highlights of papers of principal interest to electronic design engineers.

SESSION ON RADIO BROADCASTING, ELECTROACOUSTICS, AND SOUND RECORDING

V. A. Niurenberg described a setup for automatic control of operation of broadcast installations. The paper gave the results of tests of such a device.

In a paper "Use of White Noise for the Measurement of Electroacoustic Parameters of Microphones and Loud Speakers" R. V. Dombrovski indicated that the white-noise method makes it possible to obtain a picture that is from the physical point of view considerably closer to the real transmission than the pure-tone method. The method proposed reflects well the specific features of physiological sound perception and gives a more correct estimate of the electroacoustic parameters of the apparatus.

In a paper "Method of Improving Loudspeaker Quality" S. T. Ter-Osipiants indicated that the analysis of typical general shortcomings of reproduction by modern dynamic loudspeakers shows that it is necessary to employ the "active load mode" as a means for reducing the distortion in actual loud speakers. Experimental units, built of ordinary components, but using a special acoustic loading, give a substantial improvement in the sound-reproduction quality.

A. G. Kul'gachev showed the applicability of magnetic recording for infrasonic frequencies, formulated the requirements that such recording and reproduction systems must satisfy, and also indicated the important factors that prevent the fulfillment of these requirements.

M. G. Arutiunov considered the fundamental

relationships in magnetic recording by boundary displacement and the existing types of recording heads. It was shown that the linearity of recording depends exclusively on the construction of the heads.

I. R. Arnol'd dwelled on two trends which have been receiving extensive use in recent times, in magnetic recording and reproduction at short wavelengths, namely the recording of sound frequencies at lower tape speeds and the recording of frequencies up to 5 mc at increased tape speeds. He considered the fundamental parameters of magnetic recording heads, magnetic tapes and tape advancing mechanisms used for each of the above applications.

L. A. Pusset considered the effect of the irregular motion of the tape carrier on the geometric construction of the television image. It was shown that it is impossible to obtain a satisfactory image without recording the line pulses. This gives an idea of the accuracy required for the tape mechanism for video recording.

V. A. Vatsenko reported the results of his investigations on the use of magnetic recording for relaying of facsimile telegrams and for producing visual images in the final facsimile apparatus.

S. F. Savrin described apparatus for automatic relaying of telegrams with magnetic recording, based on a method developed by the Scientific Research Institute of the Ministry of Communication.

In a paper "Principles of Engineering Planning of Television and UHF Broadcasting Networks" N. M. Sankin considered the fundamental indices of the television and fm broadcasting equipment planned for production during the current five-year plan.

TELEVISION SESSION

A paper by M. N. Tovbin "Use of Single-Projector Tubes for Reproduction of Color Images in Simultaneous Color-Television Systems" contained a comparative analysis of various types of tubes from the point of view of the possibilities of improving and simplifying the receivers.

Ch. G. Postarnak considered the problem of modulation-phase control of the colors of single-beam receiving tubes with line screens.

A. P. Angaforov, in a comparative analysis of modern receiving tubes for color television, noted that from the point of view of reducing the cost of the receiver, the greatest promises were offered by a single-beam tube with a line screen and bipotential grid.

A. D. Galinski gave a brief description of superopticon apparatus developed for television studio broadcasts.

A paper by I. K. Malakhov pointed out the need for solving the problem of simultaneous reception of three color signals to insure compatible

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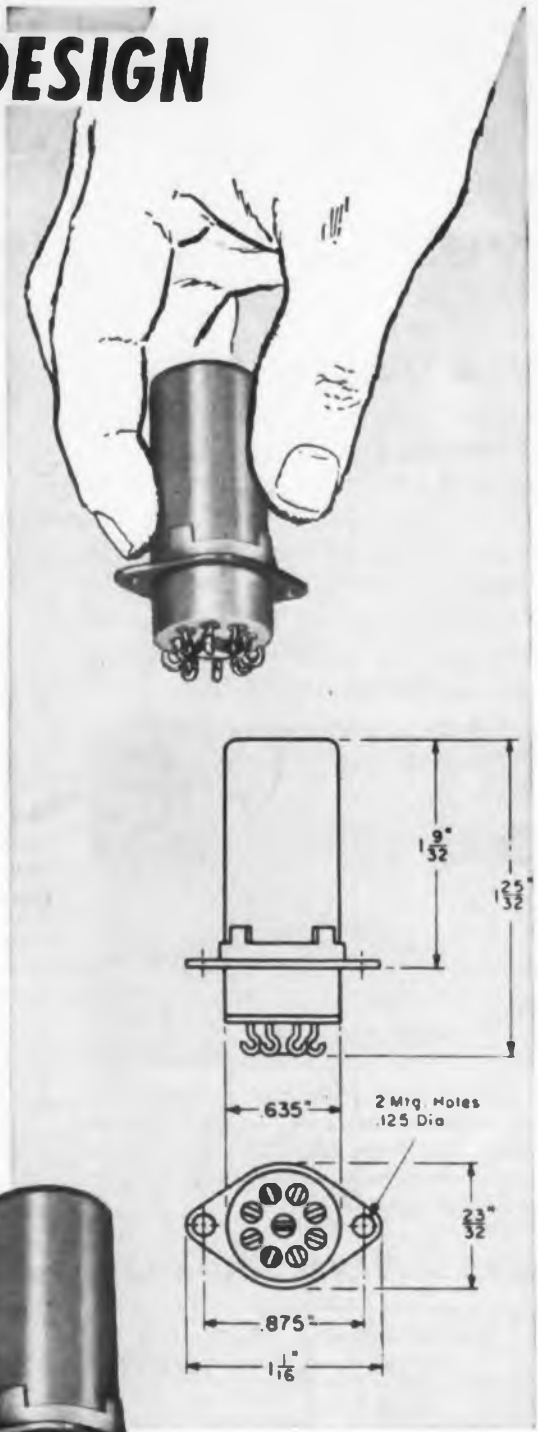

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CIRCLE 355 ON READER-SERVICE CARD

color-television systems and to consider the modifications of three-, two-, and single-tube transmitters.

A. N. Basov and V. V. Odnol'ko considered the urgency of creating a one- or two-tube color-television camera capable of transmitting black and white television.

In the discussions following these lectures, it was recommended that a system with quadrature modulation of the color subcarrier be promoted, and that a search be intensified for a new compatible color television system.

V. I. Efimkin considered the problem of the influence of the detuning of the balanced-modulator circuit on the color reproduction. The tolerances for the stability of the phase of the color subcarrier were discussed.

V. S. Polonik considered the problems involved in organizing the production of various industrial television apparatus, breadboards of which have already been tested in various branches of the national economy. The section recommended that a special design bureau be organized at one of the existing plants to develop apparatus for industrial television.

V. V. Arbuzov in his paper "Television System with Line Splitting" considered the possibility of using quadruple shifting scanning.

In a paper by L. M. Seliakov he considered the resolving power of a kinescope along the line from the point of view of the transient characteristic. The size of the zone in which the aperture characteristic becomes blurred is determined theoretically and experimentally. It is shown that for large-diameter kinescopes the aperture correction is not essential, for their resolving power exceeds the resolving power of the eye.

M. G. Garb devoted his paper to a system of centralized synchronization and reported on the results of an experimental investigation of such a system.

V. M. Sigalov reported on a new synchronizing generator, which provides the television apparatus with standard signals and permits connecting the apparatus to a centralized synchronization system.

In a paper "Statistical Measurements of Interlaced Scanning," B. I. Lytkin noted that his measurements show that selection of the synchronization pulses for the frames by means of combined integration and differentiation offers the highest noise rejection.

A. I. Shchipkov formulated the requirements that must be satisfied by a color-television transmitter in order that the electric signals produced by it reflect correctly, from the colorimetric point of view, the information concerning the color of the radiation acting on the transmitter.

V. M. Zusmanovich discussed the problem of

th choice of the equivalent white color television signal and of the peak to peak amplitude of the compressed color signal.

I. Tsukerman and V. D. Glezer noted that a comparative analysis of certain features of information transmission in television and in the human vision can be of interest both for television engineering as well as for a study of the physiology of vision. The section recommended after this lecture that joint work be performed by physiologists and television specialists to produce an objective procedure for estimating the quality of a television image.

I. Ja. Butlitski considered the principle of operation of a transmitter with a traveling beam and showed that the distortion due to afterglow of the phosphor of the projection tube can be compensated for by electrical means, but at the expense of reducing the signal to noise ratio.

A paper by G. V. Lur'e, A. D. Tumul'kan and V. A. Ianushevski showed the possibility of employing a radioactive method for automatization of the transfer from one motion picture projector to another in motion picture theaters.

SESSION ON ELECTRONICS

(Editor's Note.—the Russians use "electronics" where we would normally use "electron dynamics" or "electron ballistics," i.e., the behavior of electron beams, traveling wave tubes, klystrons, etc.).

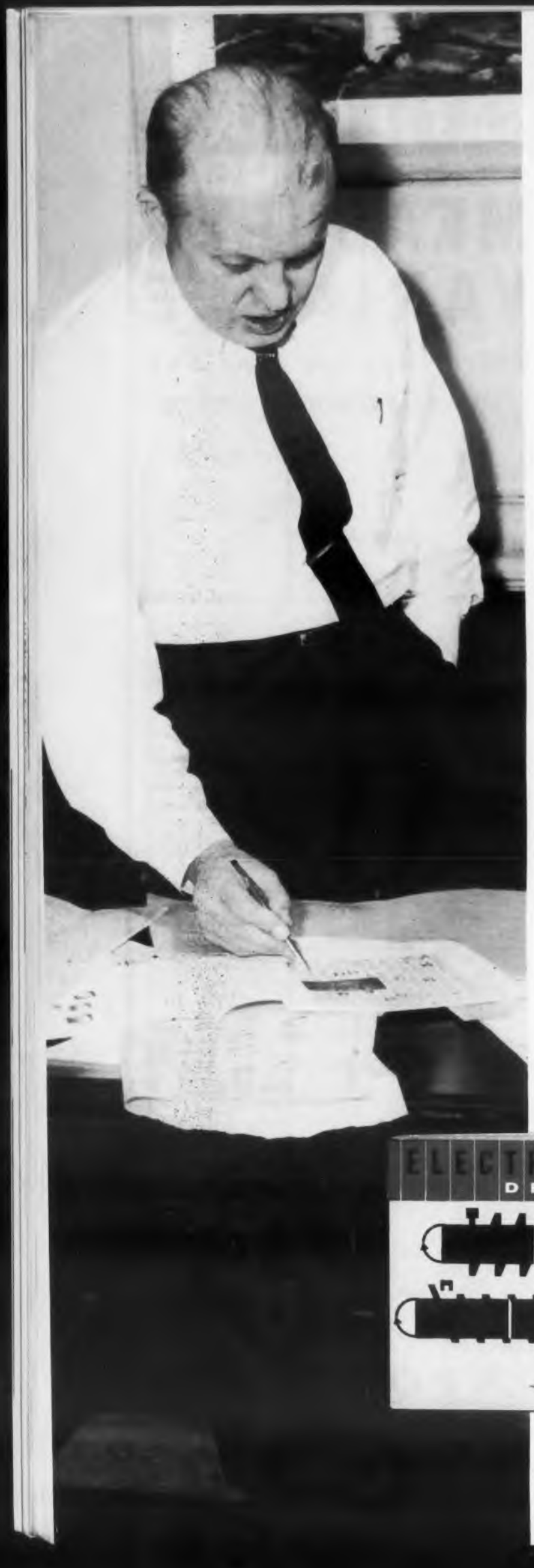
In a paper by S. I. Tetel'baum, "Generation of a Backward Wave without using a Decelerating Waveguide Systems" he derived nonlinear equations for the operation of the generator at large oscillation amplitudes, and solved the equations by an approximate method, analogous to the quasi-linear one. The article describes also the method of slowly-varying amplitudes. The analysis is carried out all the way to the design formulas. The results of the experimental investigations of a model generator are in good agreement with the calculations.

E. N. Bazarov and M. E. Zhabotinski indicated the possibility of realizing frequency division and multiplication with reflex klystrons.

Iu. A. Katsman discussed in his paper the fundamental space charge oscillations that take place in an electron beam of a transit-time klystron of finite diameter with good focusing.

S. M. Afanasov considered problems related to the use of the reactive properties of plane diode gaps, formed by the grid-anode gap in superhigh frequency triodes for electronic retuning of the frequency of cavity resonators. Results of an experimental investigation of various oscillating systems have been given.

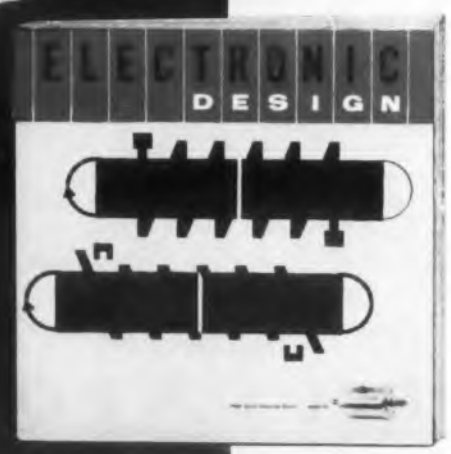
I. M. Iablonski described the construction and the operating principle of the 10 SG-1 decatron, which is a Russian multi-electrode glow dis-



Meet Your Editor

It requires a special combination of talents to be the editor of a publication like *Electronic Design*. Experience in the electronic field, is, of course, the prime requisite—but so are a number of less tangible achievements. Such an editor must have a keen sense of progress . . . of change, and innovation. He must have enthusiasm for the new, yet patience and discernment to establish which of the new is of value to the reader. He must have the knowledge, not only of your own design activities, but the activities and informational needs of thousands of readers. Most important of all, he must have a singleness of purpose to keep ELECTRONIC DESIGN firmly on its course as a 100% design publication.

In December, Edward E. Grazda began his sixth year as Editor of *Electronic Design*. His influence has been responsible in large measure for *Electronic Design's* achievement of highest readership, highest reader response, and greatest advertising page gain in business paper publishing history.



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charge device. He also gave a survey of various types of multi-electrode counting tubes, described in the foreign literature.

A paper "Problems of Reliability and Service Life of Electron Tubes" by N. V. Cherepnin considered faults in tubes that caused their failure in operation. The causes of these faults and measures for the localization were discussed.

Iu. I. Dnestrovski and D. P. Kostomarov treated the general problem of the radiation of charged particles passing through vacuum near ideally-conducting bodies. Equations were derived for the energy and the radiation spectrum. The section recommended that this work be extended to include relativistic electron velocities.

I. M. Bleivas delivered a paper on "Installation for Automatic Calculation and Plotting of Trajectories of Charged Particles in Electric and Magnetic Fields in the Presence of Space Charge." The automatic computer was intended in general for solving a system of two nonlinear differential equations of second order with constant and variable coefficients. The section recommended that several such computers be produced for use in scientific research organizations.

A. M. Chernushenko discussed an instrument that permits the variation of the slope of the electron-tuning characteristic of broadband oscillators to be observed directly on the screen of a cathode ray tube.

The results of tests on a system with a reticulate electrode and its principal parameters were treated in a paper by I. F. Pes'iatski and D. N. Khorozh "Post-Accelerating System in Cathode Ray Tubes, Permitting Retention of Deflection Sensitivity at high First and Second Anode Supply-Voltage Ratios."

SESSION ON RADIO MEASUREMENTS

M. V. Fomin reported on the development of a thermistor power meter intended for the 700-1000, 1600-2000 and 3400-4400 mc band. Each range calls for a different set of thermistor heads and attenuators, but the constructions of the elements are the same for all ranges.

L. A. Birger considered the block diagram of a superheterodyne setup with a measurement limit of 100 db/mw for the measurement of the attenuation of uhf attenuators, and analyzed the principal sources of measurement errors.

V. I. Ermakov pointed out in his paper "Problems of Metrology in Radio Measurements" that a characteristic feature of rf instrumentation is the exceedingly wide frequency range (from 0.1 cycle to 400 mc) covered, and that it is therefore necessary to develop instruments particularly intended for the purpose.

V. R. Lopan' considered the results of a theoretical and experimental investigation of an electrodynamic ammeter for the measurement of

high frequency current, and reported that a meter with an accuracy of 1 per cent over a wide frequency band is feasible. The section recommended that this be pursued further to develop a commercial meter of this type.

I. M. Furmanov reported on measurement of radio interference in accordance with the specifications of the International Special Committee on Radio Interference. The requirements imposed on the apparatus by this committee differ substantially from those satisfied by the Russian apparatus.

A. I. Tereshchenko discussed an instrument for the measurement of the dielectric constant at uhf.

V. I. Teverski reported on the development of a portable broadband spectrum analyzer for the 30-10,000 mc band, intended principally for the investigation of spectra of periodically repeating signals.

P. I. Morozov defined the functions of measuring receivers and meters for field-intensity determination, operating from 12 kc to 1000 mc, and gave the characteristics of the instruments already developed.

A. A. Semenov and G. A. Karpeev described an instrument for the measurement of antenna impedance, and reported on test results performed on board a helicopter.

E. N. Dolbnev considered a series of radio-measurement apparatus employing semiconductor diodes and transistors. Most instruments are inferior to those employing vacuum tubes, but are much smaller and consume ten times less power. Such instruments are therefore recommended for use for field measurements.

GERMAN ABSTRACTS

Diode Measurements in the X-Band

ONE OF the most important components in radars is the mixing diode in the receiver. It is possible to determine the most important characteristics of such diodes by means of comparatively simple measurements. The type of diode which is discussed here is a silicon diode such as the 1N23A or the 1N23B. These diodes are of the cartridge type; they are inserted directly into the waveguide and matched to it if their characteristics are appropriate.

Conventionally the standing wave ratio is determined by means of the slotted section and the location of a minimum and a maximum. Alternatively direct reading meters employ directional couplers for the measurement of incident and reflected energy. A "Magic Tee" is used to advantage as shown in the figure. The source feeds the H arm, the "1" arm is matched and the "2" arm in which the diode under test is placed is also matched, then the E arm is completely decoupled and no energy flows into it so that the position of the variable short in the E arm has no influence at all. The bridge type equivalent circuit for the magic tee (shown in the figure) justifies this statement. The indication obtained from the detector in the E arm allows a direct determination of the mismatch (due to the diode under test) if the E and H arms as well as arm "1" of the magic tee are matched to the guide and if the power delivered to the tee is kept constant.

To determine how "broadband" the diode is it is necessary to determine the extent to which the diode impedance depends on the frequency. A point by point determination of this relationship is time-consuming because the frequency of the source must be changed continuously so that many adjustments must be made. This point by point method can be avoided if the diode is visualized through its equivalent (damped oscillatory) circuit. It is then possible to deduce the

A Silicon Rectifier

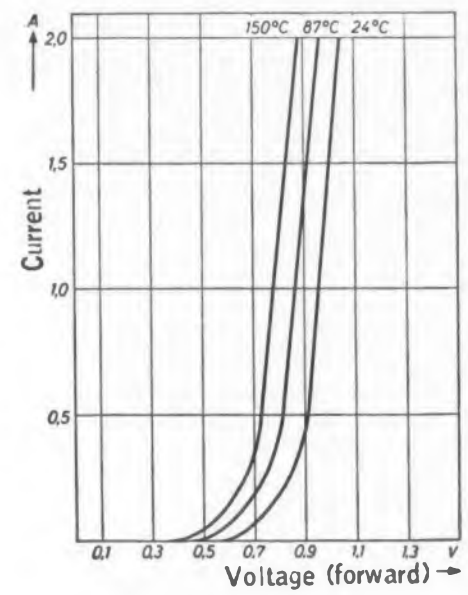


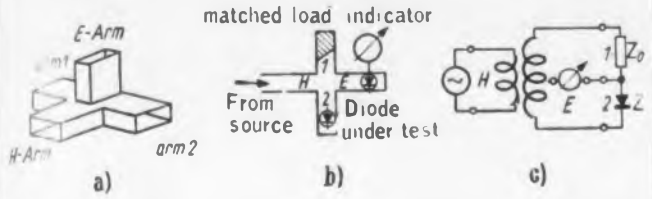
Fig. 1. Forward characteristics of the experimental silicon diode for three temperatures.

SILICON as a semiconductor rectifier material has two advantages over germanium, namely higher operating temperatures and higher peak inverse voltage ratings are possible. This abstract is concerned with a 0.5 (dc) ampere 650 (peak inverse) volt experimental rectifier.

The unit in question has a 3 sq.mm. rectifying surface and is hermetically sealed in a metallic case of 0.7 cm. diameter. The weight of the assembly is so small that it can be introduced in circuits without mechanical support.

When used with capacitance filtered loads a five ohm resistance is series connected to limit the current to about 400 ma when the line voltage is 220 volts.

In Fig. 1 the slight temperature dependence of the volt ampere relationship in the forward direction is illustrated. For the reverse direction the temperature dependence is more pronounced (See Fig. 2) but the resulting currents remain



"Magic Tee": a. Pictorial, b. Principal connections, c. Equivalent circuit.

frequency characteristics of the diode not by changes of frequency but by variation of the termination which follows the diode. A variable short is placed in back of the diode and the location of the short relative to the diode is a measure of the broadband property of the crystal. The more the location of the short for optimum match differs from 10 mm, the more selective is the diode.

The original paper also treats the problem of quickly matching diodes in pairs, measurement of mixing efficiency and the related problem of local-oscillator Klystron measurements. (*Abstracted from an article by W. Otto*, Nachrichtentechnik, *Vol. 7, No. 10, Oct. 1957, pp454-460.*)

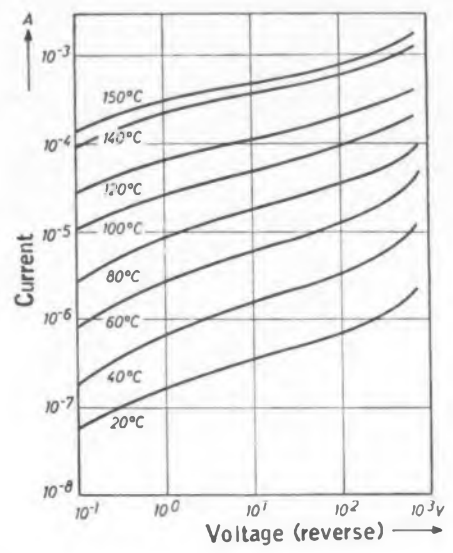


Fig. 2. Characteristics of the silicon diode in the reverse direction at various temperatures.

satisfactorily small even at moderately high temperatures.

A bridge type rectifier in which these silicon units are used has markedly smaller output resistance than a comparable selenium unit. This characteristic together with the higher resistance in the reverse direction suggests the eventual use of silicon diodes in magnetic rectifier applications. (*Abstracted from an article by E. Nitsche* Elektronische Rundschau, *Vol. 11, No. 7, July 1957, pp 197-199.*)

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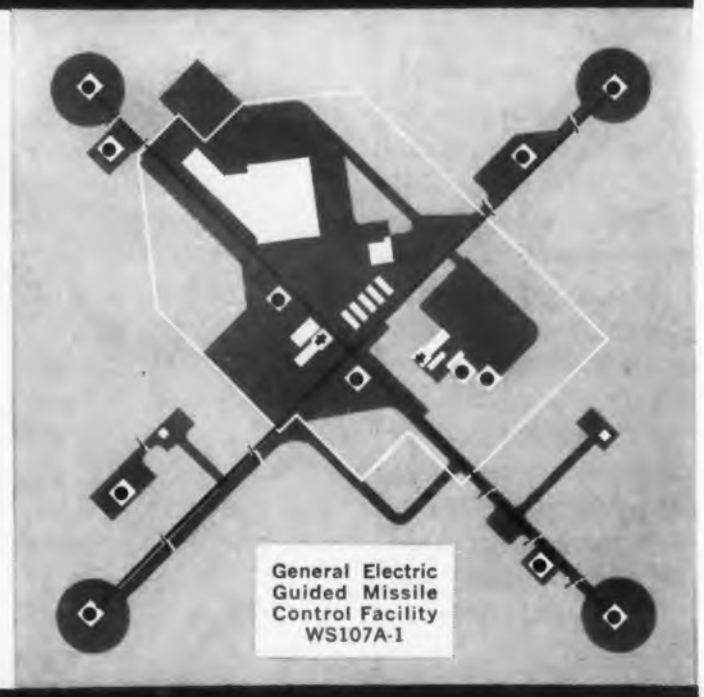

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SPECIFICATIONS

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