ELECTRONIC DESIGN

SEPTEMBER 14, 1960

REPORT ON BIONICS p 38

COVER: Bionics, the subject of this issue's Staff Report, has been loosely defined as the imitation of nature by electronics. The cover painting is a stylized rendition of a neuron. Superimposed on it is the familiar pattern of a printed circuit to represent the electronics part of the new discipline.

Selected Topics In This Issue

Bionics—A New Discipline

As a general rule, our editors are from Missouri. With all the developments that pour across our desks every day, it is not too often that we get terribly excited about a story. But every once in a while, something comes along which makes us sit up, rub our eyes, and explode in a fit of superlatives.

Such was the case a few weeks ago with bionics. We had been sniffing around this new subject a bit, and the deeper we got into it, the more excited we got.

Opening up in front of designers is a whole new concept in electronics. The reasons why a dolphin has a better sonar than any available from man, why a bat's radar is more effective than man's, and why a frog jumps according to light patterns add not only to our knowledge of biology but to our knowledge of electronics. If we can duplicate these natural processes electronically, we shall have come a long way toward teaching machines to learn and to adapt themselves.

On p 38 of this issue, *ELECTRONIC DESIGN* presents the first report in depth on bionics. We are proud of it and hope you will find it helpful.

Hark, Hark, the Dogs Do Bark

A few days ago, a motley crew dragged into our editorial offices at 830 Third Ave. These were the blooded veterans of the WESCON campaign. For both *ED* and *ELECTRONIC DAILY*, they had labored hard and under the toughest possible conditions (see photo). *DAILY* Managing Editor Alan Corneretto and his staff had put together four issues of the magazine distributed at WESCON and each had returned to tell the tale, bloody but unbowed. The story in *ED* on p 14 of this issue and the one in the Aug. 31 issue are their work.

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Firms Seek Ultrareliability for Minuteman

13 Components Makers Join in Autonetics Program; May Lead to Complete Reliability Spec Revisions

SIGNIFICANT achievements in electronic-components reliability have already been recorded as a result of a bold new program launched late last year in preparation for the Minuteman missile system. The long-range result of this program, being directed by North American Aviation, Inc.'s Autonetics Div., could be a complete revamping of reliability specifications for vital military weapons systems.

The exacting procedures being followed to achieve the reliability requirements outlined in the table below should pinpoint weaknesses in present quality control programs and direct manufacturers to corrections of poor reliability results. Levels about 100 times over present reliability are sought.

The special nature of the inertial-guidance and flight-control systems for the Minuteman led to the North American program. Retaliatory solid-fuel missiles, stored in underground "hard" sites, must be ready to streak skyward with the first signs of enemy attack. Since components such as gyros require hours to warm up properly, many portions of the Minuteman electronic systems must be operating continuously in storage vaults. This could mean years of constant operation, with tests performed every few hours to assure the proper performance whenever it is needed.

To meet these severe conditions, Autonetics outlined an industrywide reliability-improvement program in a proposal to the Air Force for the guidance and control contract. This effort would be conducted at top component manufacturers' plants, with Autonetics coordinating the entire effort and issuing the specifications to be met by Minuteman parts. It is felt generally that this reliability program was the factor eventually winning the contract for Autonetics.

To arrive at initial reliability figures for the program an optimistic Mean Time Between Failures was set for the entire Minuteman system. From this total figure, MTBF's for subsystems were calculated, and from these the MTBF's for the components were derived. Although system's figures have not been disclosed, unofficial sources said that the system will operate at least for a year, perhaps for several years, 24 hours a day, without a malfunction due to electronic-component failure.

Reliability Compromises Necessary

In seeking component subcontractors for the Minuteman system, Autonetics asked for components with a reliability level that would assure unattended operation for a certain number of thousands of hours. Potential subcontractors submitted proposals in which they specified reliabil-

Careful records are kept for each part being stored by Autonetics—and each part is given an individual serial number. Parts are dip-soldered in place on printed boards in the storage trays used for stripping.

Contributions to Minuteman

Company	Product	Contract Amount (in millions)	Reliability Level Specified (per 1,000 hr)
Motorola Semiconductor Div.	germanium mesa transistors	$1	0.007%
Pacific Semiconductors, Inc.	silicon diodes	$1.2	0.002%
Fairchild Semiconductor Corp.	silicon transistors (2N697 and 2N1132)	$1.5	0.001% and 0.002%
General Electric Co., Syracuse, N. Y.	silicon transistors	$1.4	0.001%
Transitron Electronics Corp.	silicon transistors, and diodes	$2	0.001%
Delco Radio Div., General Motors Corp.	germanium power transistors	—	0.003%
Corning Glass Works	glass capacitors	over $0.5	0.0006%
John E. Fast Co.	paper capacitors	about $0.5	0.0006%
Sprague Electric Co.	soil and foil tantalum capacitors	$1.26	0.001%
General Electric Co., Irmo, S. Car.	solid tantalum capacitors foil tan. capacitors	$0.6 $1.8	0.001% 0.001%
International Resistance Corp.	metal film resistors	$1.7	0.004%
Dale Electronics, Inc.	wirewound resistors	$0.5	0.001%
Wheeler Electronics Corp., subsidiary of Sperry Rand Corp.	transformers	$0.43	0.001% at 60% confidence level

levels which they felt capable of achieving.

Because of the state-of-the-art in various component types, it was in some cases necessary to open reliability restrictions—but at the same time requirements were proportionately stiffened for components which were more susceptible to improvement.

Before awarding component subcontracts, Autonetics toured the plants of potential suppliers to evaluate reliability procedures and assist in coming to contracting decisions. During the program Autonetics specialists will be stationed at each component manufacturers' plant to keep a continuous check on procedures and provide liaison with the coordinating group.

In selecting components for use in the Minuteman system, all vacuum tubes and most moving parts have been eliminated—no potentiometers or relays are used, for example. The system is being designed so that it can not be repaired. If a malfunction occurs, it is assumed that the system will be scrapped.

Many of the concepts developed by Bell Telephone Laboratories in achieving estimated twenty-year reliability levels for the repeaters in undersea cables have been applied in the Autonetics effort. Long storage times are planned, following the example of the BTL program, and parameter shifts will be charted during this period to aid in prediction of parts which will fail or fall outside of tolerance before a specified time. To aid in this program automatic checking and tallying equipment has been built and installed, and every component in the program is being assigned a serial number and an IBM card carrying its complete history.

Elaborate record-keeping procedures and test-data requirements under the Autonetics plan will require considerable expense for special installations, hiring, and implementation of the program. So far, some $20 million has been subcontracted, directly for developmental efforts in achieving reliability.

At Pacific Semiconductors, Inc., for example, a 30,000 sq ft facility is being added for environmental testing equipment. Some 500,000 silicon wafers will be under test continually during the course of the Minuteman contract.

The elaborate checking procedures on each part in the production process—starting with incoming materials at the manufacturing plant right up to the placing of the part on a Minuteman circuit board—should isolate the major presumptive causes of poor reliability, program contributors agree.

At Wheeler Electronics Corp., Waterbury, Conn., subsidiary of Sperry Rand Corp., for instance, a reliability level 100 times greater than that for normal transformers is being sought.

(continued on page 6)

CIRCLE 6 ON READER-SERVICE CARD

NEWS

Various audio and power transformers, of open, vacuum-impregnated, epoxy encapsulated, and potted types contained in metal cans will be stored at the Wheeler plant for 2,000 to 5,000 hr —the exact figure has not yet been decided. Parameter shifts will be charted during this period, according to Frank Williams, engineering section head in electromechanical design at Sperry Gyroscope Co., and then the parts will be shipped to Autonetics. Another extended storage period will take place at the California plant and further parameter shifts will be plotted. This technique should give a good indication of the effects of shipping on deterioration of parts, according to Mr. Williams.

Information To Be Kept Under Wraps

The Air Force so far has not indicated that it will make the data gathered by component suppliers available to industry in general. Information on any reliability breakthroughs made during the program will be available to agencies of the Department of Defense and to those who can demonstrate "neeed to know," according to industry sources.

It appears, therefore, that the companies involved in the Minuteman program will gain a unique advantage in the pursuit of new reliability plateaus. Already some of the companies in the program are beginning to incorporate some of the know-how being gained into their standard product lines.

Dale Electronics, Inc., Columbus, Nebr., feels

Packaging of component boards with parts soldered in place for shipment is illustrated. This interior package is wrapped in six sides with rubberized hair and packed in a larger exterior container.

Parts are removed from individual component boards for attachment into actual Minuteman circuits.

that its efforts are already leading to improved reliability in its standard units. Dale is working on silicone-coated wire-wound power resistors—types RS5, RS2A, and RS10—to achieve reliability levels about 100 times greater than that of this type.

Corning Glass Works, Corning, N. Y., has already delivered about 100,000 of its fusion-sealed glass capacitors types CYF-10 and CYF-15 for prototype and development use, and is using the experience gained to boost reliability of conventional products.

The first is a complete Program Plan outlining in detail every step that will be made in producing components and advancing reliability levels. The initial, or Preliminary Program Plan, will be followed in 90 days from contract signing with a revised program including agreements made between the supplier and Autonetics during the first three month period. Tasks 2 and 3 involve documents on production control specifications.

A failure analysis aimed at steadily raising reliability levels is the fourth task, and 5 and 6 are the corrective action to be taken by the supplier on production processes and process controls. Task 7 is an evaluation of this corrective action.

Electrical parameters of the device being produced are tested under task 8 to provide the following data: the distribution of each critical device parameter; change in the distribution with respect to time; failure rates of devices at accelerated environment; and acceleration factor failure rate of the device.

The program organization showing names and job titles, responsibility and authority is the ninth task, followed by a requirement for a training program for all personnel associated with the program. Test equipment is specified under task 11, and technical direction and monitoring by Autonetics is task 12. The assigning of a serial number to each part is covered in task 13, and the special handling and packaging requirements are covered in task 14. Documentation for the entire program is covered by task 15. ■ ■

AF Seeks High-Sensitivity Accelerometers

Nuclear Gyros, Mossbauer Effect, Liquid Pressure Differences Studied

THE AIR FORCE is dusting off some old ideas, and at the same time turning to some of the latest concepts in developing instruments suitable for acceleration measurements during low thrust space flight.

These highly sensitive instruments would be useful during orbital or interplanetary stages of flight when extremely minute accelerations must be sensed, according to sources at Wright Air Development Div., Dayton, Ohio.

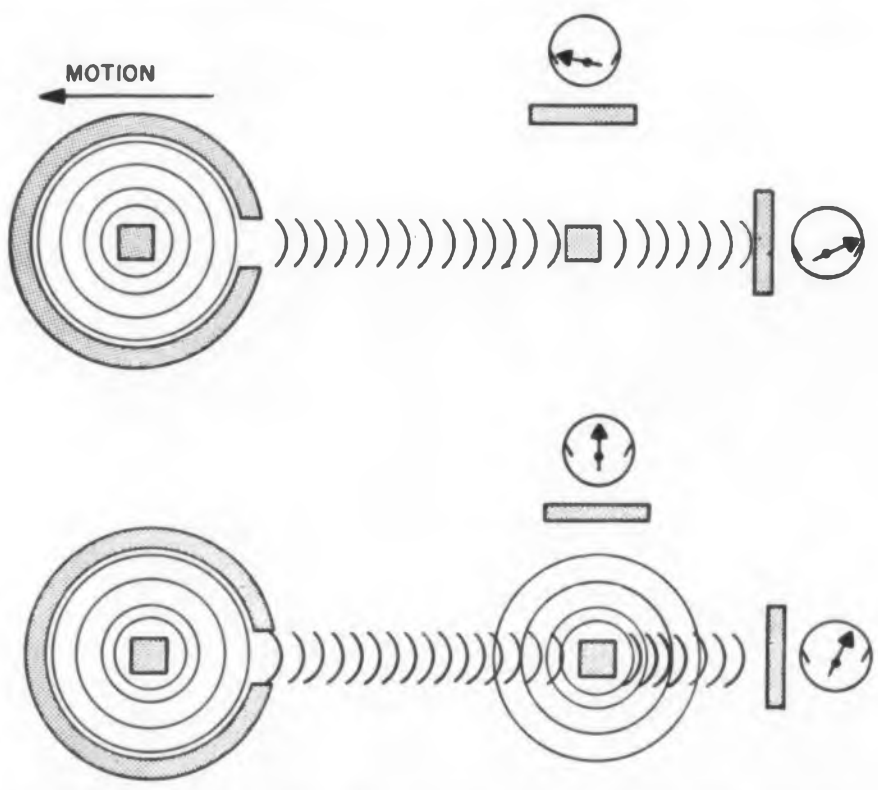
Reaching to the past, WADD's Navigation and Guidance Laboratory is studying the possibility of developing a precise pressure difference type accelerometer using liquid filled crossed U-tubes. Best configurations and liquids are currently studied at the laboratory under an in-house program.

Liquids of differing densities might be used in such a system, separated by an interface, so that accelerating forces would have differing effects on these liquids. Either optical measurement or physical sensing of fluid levels might be used for detecting level changes.

Nuclear Gyros May Eliminate Drift

Industry research laboratories have been studying possible nuclear gyroscopes for some time. These would theoretically eliminate many of the drift factors in conventional man-made gyros and would also be suitable for sensing minute accelerations.

Each atomic nucleus spins, creating an electric dipole. Various forces cause pre-



Instrumentation for observing nuclear resonance, with dials representing magnitude of readings on scintillation counters. When no resonance occurs because of relative motion between source and absorber, top, then the beam of photons from excited source causes a high reading on the counter behind the absorber and no indication on the counter to the side of the beam. When resonance occurs, bottom, much of the energy from the source is absorbed and reradiated, so that the counter behind the absorber has a lower reading and the counter to the side shows a reading.

ession of the direction of angular momentum of the nucleus in a fashion similar to the action of a conventional gyroscope, and the electric dipole is reoriented as a result of this precession. It is impossible theoretically to measure the orientation of a single nuclear dipole without disturbing this orientation. However, it is possible to measure statistically the orientation of a large number of nuclear dipoles.

The difficulty with this technique is that over a long period of time these orientations have a tendency to decay randomly. By choosing a material with an appropriately long time constant, and measuring for only short periods of time, an accurate short duration precession measurement is possible. In operation the measurement would switch back and forth between two statistical groups. Even though materials have been found which can be measured over several minutes without introducing meaningful errors, and switching times between two statistical groups have been reduced to a few microseconds, there is still a certain amount of noise entered into the system due to switching.

Another problem in the nuclear gyro is the presence of spurious torques—such as thermal agitation and interfering electromagnetic radiation. Even with operation near absolute zero and some form of shielding a certain amount of system noise is introduced by these factors. Extreme chemical purity is also required to reduce noise factors, another severe requirement on this approach.

Mössbauer Effect New Approach

The latest concept being investigated in the search for suitable orbital accelerometers is the Mössbauer effect, recently discovered by R. L. Mössbauer, a German physicist. If this effect can be instrumented for a space vehicle it may lead to an accelerometer of unparalleled sensitivity. Up to this point, however, only laboratory devices have been operated.

The principle of nuclear reso-

nance used in this approach has been known f several years, and a suitable measurement tec nique has also been available. A previously u controllable effect known as recoil has prevente the development of instruments however. Mö bauer's work has overcome the recoil proble opening the door to the development of ma ageable devices.

Experiments in this country have been pe formed primarily with a radioactive cobalt-5 source and an iron-57 absorber. As the cobalt-5 decays it produces excited atoms of iron-5 which oscillate at a frequency of about 3 x 10 cps with a half-life of about 10^{-7} sec. As the excited iron-57 atoms drop to a stable, or groun state they emit photons of a particular energ dependent on the energy difference between th two states, which is proportional to a particula frequency according to the principles of quan tum mechanics. When a beam of these photon is directed at the absorber material, containin stable iron-57 nuclei, and resonance occurs, the the absorber will be raised to an excited stat and the absorbed energy will be re-radiated in a directions.

Arrangement of Instruments

Instruments for detecting absorption can b arranged as illustrated in the diagram. On scintillation counter is placed in line with th photon beam from the source material, and th absorber is placed between the counter and th source. A second scintillation counter is place to one side of the absorber, at right angles to th photon beam.

When a nonresonant condition exists th counter in line with the beam shows a high read ing, and no reading is indicated at the other in strument. When resonance occurs there is a sharp drop in the reading of the counter in line with the beam due to the absorption, and a reading

Lathe was used at Argonne National Laboratory for Mössbauer effect experiments using iron-57.

will be indicated in addition on the counter at the side because of the reradiation of energy by the absorber.

Relative motion between the source and the absorber, even at extremely low velocity, will cause a slight doppler shift in the frequency reaching the absorber. Under ordinary conditions as a photon is emitted the nucleus simultaneously recoils—which introduces such a doppler effect. This recoil, therefore, prevented resonance from occurring in early experiments.

Mössbauer's approach to overcoming this difficulty was to freeze the excited atoms into a crystal lattice, so that the recoil energy is distributed over the lattice rather than causing recoil of an individual nucleus. This, in effect, locks the nucleus in place so that resonance can be much more easily achieved.

More Problems

Other problems face current researchers in instrumenting the effect—for example differences in the rate of change of temperature at the source and the absorber can cause enough relative motion to prevent resonance.

Moving such a sensitive instrument from the controlled environment of the laboratory to an operating space vehicle offers severe difficulties. Accelerative forces would probably be sensed by locking either the source or the absorber to the vehicle, and allowing the other unit freedom to shift with outside forces. Spurious signals, such as vehicle vibration, temperature variations, and other effects may prove too significant for high precision readings.

If adequate solutions can be found, however, designers will have a valuable new tool for acceleration measurements. By choosing a material with the appropriate nuclear oscillating frequency and half-life, a more or less sensitive instrument might conceivably be designed for particular applications. ■ ■

Personal to 'R.C.R.'

The editors of ELECTRONIC DESIGN would be more than happy to discuss further your proposed paper on analysis of transistor circuits. But is the contents of the paper so hush-hush that you couldn't include a return address with your letter? Let us know so we can let you know.

Accuracy Is Our Policy . . .

General Radio Company's Pulse Generator 1391-B has a 15-nsec rise time. The 50-nsec figure given in "Russian Test Equipment and Ours" (*ED*, Aug. 17, 1960, p 51) was erroneously supplied by General Radio.

NEWS

Space Meeting Stresses Electronics

IAF Stockholm Congress Hears Papers On Global Satellite Monitor System

ELECTRONICS and propulsion in space were the predominant themes of papers read by U.S. scientists at the International Astronautical Federation congress held recently in Stockholm.

A satellite traffic monitoring system, new techniques for re-entry communications, ion propulsion systems, nuclear rockets, space ecology and NASA's plans for higher thrust vehicles were included among the subjects discussed by Americans and the congress.

A worldwide satellite tracking and cataloging system to monitor the high-density satellite traffic expected to develop within the next few years was proposed by Peter R. Dax, radar engineer with Westinghouse's electronics division. Mr. Dax predicted that about 1,000 man-made objects may be in orbit by the end of the decade and that it will be necessary to build a monitoring system capable of handling this traffic. Detection of new satellites, cataloging of existing vehicles and measurement of atmosphere densities and earth shape by correlating orbit data from a large number of satellites would be among the objectives of such a system.

Seven Radar Sites Needed

The proposed system would include seven powerful radar installations located about a great circle of the earth. Each radar would be served by a local computer and linked to a central computing station which would further analyze the data collected at each station. The radar installations should be capable of searching between altitudes of 100 to 1,000 miles, where traffic is expected to be heaviest.

It was calculated that a satellite in this range of altitude will be within the sector of any one radar for an average of 5.5 min. This would give a typical radar ten opportunities to detect the vehicle during each pass.

Mr. Dax suggested that information should not be transmitted immediately to the central computer. Instead, position reports should be stored within the local computer to prevent transmittal of false indications caused by random noise, interference, meteor trails, and other irrelevant sources. A five-minute storage period would permit the examination of successive target returns to confirm the validity of a track.

Reentry Communications Held Possible

Radio waves directed along the lines of the earth's magnetic field could permit radio control and communication with vehicle reentering the atmosphere, according to Haeri Hodara, head of space communications for Hallicrafters. Mr. Hodara told the congress that these lines may constitute a window for low-frequency radio waves. Signals could be propagated along these lines with considerable reliability and set the pattern for an earth-space communications net, Mr. Hodara said.

Re-entry communications within the present state of the art are virtually impossible because of the ionized air that surrounds a reentering vehicle. This plasma blocks communications for several seconds at a time when the vehicle is extremely susceptible to loss of control.

Tracking systems accurate to within a few feet at 1,000 miles and able to measure velocity to a few hundredths of a foot per second were predicted by Calvin R. Woods and Earle B. Mullen of GE's defense systems department. "Rapid progress in space vehicle technology requires advances in tracking systems which emphasize accuracy and near-instantaneous data output," the authors said.

Phase-controlled coherent transponders were suggested as one means to achieve the precise timing needed for accurate

measurements. Uncertainties in the speed of light, deficiencies in present surveying methods, and atmospheric anomalities were cited as some of the obstacles to the achievement of tracking accuracy.

Space-Flight Costs to Be Cut

Electric space propulsion systems in the very near future were predicted by Dr. Ernest Stuhlinger, chief of the Research Projects Laboratory of NASA's Marshall Space flight center. Dr. Stuhlinger told the Stockholm parley that arc-heated and ionic propulsion systems are being developed rapidly enough to be flight-tested in 1962. "Space missions may be flown from arc-heated systems from about 1963 on, and with ion systems from 1964 on," Dr. Stuhlinger said. He also pointed out that such systems would prove very competitive with chemical propulsion on heavy freight missions in near space and particularly so on deep space flights.

Still another propulsion scheme described at the sessions involves a combination of nuclear, thermionic, and ionic principles. In this system, described by Dr. R. H. Olds of Lockheed's missiles and space division, several very small nuclear reactors would heat thermionic generators to supply electrical energy for ion-beam propulsion engines. On a trip to Jupiter, Dr. Olds said, 110 lb of cesium vapor expended as fuel could send a payload of equal weight.

Along more conventional lines, Dr. Wernher von Braun described plans for the Saturn vehicle now under development by NASA. Dr. von Braun indicated that a round trip to the moon by chemical rockets would require a vehicle with 12 million lb of thrust at lift off. However, this figure can be cut by refueling a smaller vehicle in flight. Orbiting tankers and cargo carriers now being designed for this purpose were described. ■ ■

40,076 Throng WESCON Exhibits

Most Products Subminiature; Parametric Transistor Shown

Lenkurt Electric's Vladimir Vodicka and Hughes Semiconducto Rainier Zuleeg (right) discussed new parametric transistor (see p 1

THE "new look" at the 1960 Western Electronic Show and Convention was characterized by the opening of the four-day meeting—there were no opening ceremonies.

Formal openings tie up hordes of engineers eager to get out onto the exhibit floor to check the thousands of products on display, so why not forget about the conventional formal show-opener, reasoned WESCON officials. To give the show maximum value to the industry several other precedent-setting policies were instituted by this year's WESCON managers.

Recruiting, for example, was banned by a gentleman's agreement initiated by a letter sent to several hundred companies prior to WESCON. Total registration at the show was kept continually up-to-date through the use of an automated "people-meter." Technical sessions were designed to stimulate spirited discussion of currently unresolved technical problem, and workshop sessions were built around topics that appeared to be worthy of extended discussion.

Results of these attempts at improving the show were not completely successful, but indications are that further improvements can be expected from some of these policies now that management has had a chance to see them in action during the Aug. 23-26 event.

The no-recruiting agreement was not followed to the letter. There were a few job-opening notices pushed under hotel doors, and a California Southland Career Center was operated at the Shrine Auditorium, not far from the Sports Arena. Show visitors agreed, however, that the little recruiting that took place didn't detract from the main business of the day—seeing the show and listening to technical presentations.

The people-meter, a registration counter with digital voltmeter readout prepared for the show by Non-Linear Systems, Inc., successfully automated the old fashioned painstaking hand tally method. The counter finished the show with a grand total of 40,076 registrants.

There were some outstanding exceptions to this general evaluation. One session that led to some lively debate was entitled Stereo Multiplex Broadcasting. Papers covering the major multiplexing techniques started off the session which then turned into a heated panel discussion.

Man-Machine Systems Top Topic

Man-machine systems gained more prominence at this year's WESCON than at any previous major convention—probably reflecting current man-in-space programs and military stress on bioinstrumentation and bionics. Six of forty technical sessions and four special workshops contr buted to the information exchange.

Dangerous tariff trends were threshed over a meeting of the Electronic Industries Associ tion's Tube and Semiconductor Div. Germaniu diodes have been placed on the "offer" list of t General Agreement on Tariff and Trade, speake pointed out. This means that the Governme can offer to lower tariffs on germanium diod in exchange for lower tariffs on other U. S. pro ucts shipped to the foreign country involved.

Transistors might be added to this tariff li at any time, the group was warned by Ma Shepard. Texas Instruments vice president.

On the Product Front

Few really new developments were shown WESCON. Several companies showed miniatu and microminiature components but most man facturers were content to exhibit "interimstag microelectronics.

Lots of action, plenty of customers were standard throughout the four days of the largest WESCON yet. A record total of 40,076 thronged through the exhibits, heard technical papers, and, more than occasionally, complained about a sprawling layout and sore feet. But all in all, it was judged a success.

Phasolver (see p 19) measures angles to fraction of a second of arc, said Telecomputing Corp. Project engineer Ray Dunwell.

Miniature transistors from Texas Instruments, Rheem Semiconductors, Sylvania, and Raytheon were a case in point. These transistors, while small and useful, are not in the "micro" class like the Pacific Semiconductors units announced in March or the Transistron and Hughes Aircraft development units. They were not designed for use with microcircuitry, but are aimed at the intermediate, subminiature stage.

To recap the small transistors shown:

- ***Texas Instruments,*** a high-speed, silicon mesa unit with 1.6-w power dissipation. The company calls these devices "micromesas." They were available in two types, TI450 and TI451, with guaranteed dc beta ranges of 20-60 and 40-120 respectively. The company also claimed 40 nsec turn-on switching time and 75 nsec turn-off. Micromesa case size is 0.050 in. thick and 0.190 in. across, about a tenth that of the TO-18 package.
- ***Rheem Semiconductor,*** silicon-mesa unit with 3-w power dissipation. According to Rheem, the RT697M Microbloc is a 50-per-cent higher-powered version of the 2N697. As the name implies, Microblocs are manufactured as virtually solid blocks: a silicon crystal is embedded in a gas-tight, hermetically sealed welded block. Rheem asserts the Microbloc is mechanically more stable than any previous transistor, will withstand minimum 1,500-g shock and 20,000-g acceleration.
- ***Sylvania Electric Products,*** a germanium alloy switching unit with a power dissipation of 0.1 w. The two "pancake" transistors, SYL1986 and SYL1987, were to be electrically similar to the 2N404 and 2N338. Case dimensions are 0.070 in.

thick and 0.230 across. Power dissipation of both units is about 0.1 w at 25 C.

■ ***Raytheon Manufacturing Co.,*** rf silicon-mesa units with case size a quarter that of the TO-18.

Several companies showed vacuum-deposited microcircuits and boasted an improvement in yield, but had not yet learned to vacuum-deposit active elements or diodes.

According to Dr. William B. Wright, Jr. of Electro Optical Systems, Pasadena, Calif., who chaired a panel session on microelectronics, the transistors, no matter how small, is still a standard component. It has leads that must be attached to the circuit.

Westinghouse Monoliths Sold

In line with Dr. Wright's comment, Westinghouse Electric joined Texas Instruments as suppliers of integrated functional blocks. Unlike the TI etched-circuit modules announced in March, however, the Westinghouse solid circuits are said to be true monolithic molecular electronics.

According to Westinghouse, five types of blocks, ranging from multi-level amplifiers two to three week delivery at prices from $300 to $400. Now available are:

■ ***Two-Stage Amplifiers.*** These have an asserted current gain of 500 and a power gain of about 45 db. Output current is from one to two amps.

■ ***Three-Stage Amplifiers.*** Specifications are similar to the two-stage; but current gain is increased to 10,000.

■ ***Bistable Multivibrators.*** Operating freguency is up to 500 kc for this cross-coupled type.

■ ***Trinistor Switches.*** These multiple transistor switches are 10-position, three-terminal pnpn units. Acceptable operating conditions are 100 v and 50 ma.

■ ***Pulse Generators.*** Operate in the 100-kc range, with pulse widths said to be less than 1 usec.

Other functional blocks still in development by Westinghouse include high-impedance and very-high-impedance low-level amplifiers, a notch filter, and a broadcast-band tuned amplifier. Computer blocks in development include a tunnel-diode bistable multi-vibrator, cross-coupled analog and pnpn type astable multivibrators, and an analog multiplier. A ten-position switch fabricated by dendritic techniques will also be offered in future.

Four-Kmc Transistor in Prototype

One of the most startling revelations at WESCON was the announcement of a transistor developed at Hughes Semiconductor Div., designed to operate in the parametric mode at

All solid-state components, available from Philco, make up this 5-mw, 2.2-kmc generator, shown at WESCON booth by Philco engineer Charles S. McCarthy.

4 kmc. Hughes showed it working at 10-per-cent efficiency in a mixer-oscillator circuit.

According to Hughes physicist Rainier Zuleeg, the transistor now being readied for production, may soon produce 10 kmc with a minimum of 10 per cent efficiency. The Hughes transistor is reportedly the first ever designed to operate in the parametric mode at such high frequencies—two to five times higher than those heretofore considered the limit for commercial transistors.

Significance of the development: it could replace parametric amplifiers, which are now costly and tricky to operate.

Key to the success of the parametric transistor is a circuit designed last fall by Dr. Vladmir W. Vodicka of Lenkurt Electric Co.'s Advanced Development Group. The mixer-oscillator circuit is said to extend the performance of transistors so they develop useful gain well beyond their normal cut-off. It also reduces inherent noise to low levels.

"Even with mesa transistors," Dr. Vodicka told ELECTRONIC DESIGN, "frequency response is limited by the geometry. Major limitations are the capacitances inherent to pn junctions. These are proportional to the junction area—reduction in size helps, but on the other hand militates against power dissipation.

"Up to now the practical limit of commercially available transistors has been a maximum oscilla-

tion frequency of about 1 kmc and 30-to-50-mw power dissipation. These were the 2N700 and 2N502 transistors."

The basic Vodicka circuit is an oscillator. Input and output are 180 deg out of phase and loop gain is unity or greater. Feedback to accomplish this is applied through C_f in the circuit drawing. This loop reflects the input impedance back into the output, the tuned circuit effectively sees a negative impedance in the region of operation. Input Z is negative and equivalent to a capacitive reactance.

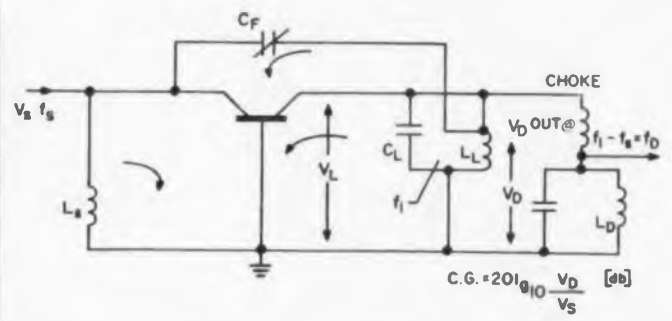
An inductance, L_S in the schematic, replaces the usual input blocking resistance in the converter circuit and a second resonance circuit with L_D and C_D was added in the collector.

The transistor is oscillating at a frequency F_L—smaller than F_{max} of the transistor—which is determined by tuning the tank L_L and C_L. Transistor input is then current-tuned, according to Dr. Vodicka, to give maximum conversion gain for the frequency F_S, of amplitude V_S. The amount of feedback—therefore conversion gain—is controlled by C_F.

Stringent requirements are imposed on the transistor in the Vodicka circuit: during current-tuning of the input, the oscillation must be maintained. "These oscillations are met by only a very few existing high-frequency transistor types," Dr. Vodicka said.

Dr. Vodicka and Hughes Semiconductor's Mr. Zuleeg have been working together since Feb-

Westinghouse functional blocks are (left to right): multiple trinsistor switch, high-level two-stage amplifier, high-level three-stage amplifier, pulse generator, and bistable multivibrator.



Circuit designed by Dr. Vodicka varies entire input impedance of parametric transistor for high-efficiency amplification.

ruary to increase the performance of the circuit and have tested a number of microalloy diffused transistors. The new Hughes transistor modified to favor parametric operation, "has consistently produced excellent uhf and microwave operation," said Mr. Zuleeg.

Solid Microwave Sources Unveiled

Two semiconductor microwave power generators were on display at the Sports Arena. First, a solid-state 1000-mc generator that reportedly delivered 11 w of rf power was described at a technical session by G. Luettgenau, M. V. Duffin, and P. H. Dirnbach of Pacific Semiconductors, Inc. ELECTRONIC DESIGN learned that the circuit described in this paper had been improved (see circuit diagram). The solid-state devices used in this circuit, all immediately available from PSI are two vhf power transistors, and four high-Q voltage variable capacitors.

Second power source was Philco Corp.'s Lansdale Div. S P-801 unit, said to deliver 5 to 10 mw at 2,200 mc. It consists of three sections: a transistorized oscillator–amplifier followed by fourth and fifth harmonic amplifier stages. Two transistors and two varactor diodes available from Philco are used.

A pair of printed-circuit disks 9 in. in outside diameter measured angles with 6 sec accuracy and ±0.324 sec resolution at Telecomputing Corp.'s exhibit.

The Phasolver (see picture, p 15) a product of Telecomputing's Electronic Systems Div. converts small mechanical motions to large electrical phase shifts with such accuracy that Société Genevoise d'Instruments de Physique's Precision Rotary Table for Angular Measurements couldn't identify any error.

According to Telecomputing's Ray Dunwell, a 30-in. disk phasolver currently under development will measure angles with an accuracy of a fraction of a second of arc—something even the National Bureau of Standards cannot do, using optical techniques. One second is 1.296 millionths of a circle. ■ ■

NEWS

Navy Data System egi

Prototype in Operation Univac Unit at Center

Automatic collection, processing and display of tactical data along with recommended courses of action are provided by a Naval Tactical Data System which has just reached operational status.

Central unit of the system is a Univac Advanced Navy Computer which operates in real time. Methods used to feed radar, sonar and other data directly into the computer are classified, a Remington Rand spokesman told ELECTRONIC DESIGN. Communication ierrs, submarines, or atomic ships in a task force can be accomplished using a data transmission system developed by Collins Radio Co., Cedar Rapids, Iowa. Tactical data is displayed for unit commanders using special tubes and other devices developed by Hughes Aircraft Co.

Several prototype systems are now in operation, and the Navy hopes to install the system on all future combatant vessels, and to provide existing ships with retrofit systems, according to a Remington Rand source.

The data systems can be used on cruisers, destroyers, aircraft car-

Computer designed by Remington Rand Univac's Military Div. for Naval Tactical Data System.

tem egins Sea Duty

riers, submarines, or atomic ships of the future.

The Univac computer, which is packed into a case measuring 3 x 3 x 6 ft has a 1 million bit memory with a 2.5 μsec average access time. Germanium transistors and magnetic cores are used in the unit. Germanium transistors are used despite the high ambient temperatures sometimes experienced aboard ship because of the high reliability experienced with the Athena computer used with the Titan missile, according to a Remington Rand spokesman.

The ruggedized shipboard machine will be cooled, and parts are being hermetically sealed and potted in epoxy, it was added.

Remington Rand Univac's Military Div., St. Paul, systems contractor for the Tactical Data System, has been working on the shipboard computer since 1955. ■ ■

Radar Under Test for Zeus

Eerie view at Sperry Gyroscope's Great Neck plant shows radar transmitter for the Army's Zeus anti-missile system under test. In the foreground is the high-power klystron; transmitter cabinets are in the background. Prior to shipment, the equipment is checked for output, stability and fidelity. The Army Ordnance Missile Command directs the development of Zeus, with Western Electric Co. as prime contractor.

CIRCLE 19 ON READER-SERVICE CARD ➤

WASHINGTON REPORT

Ephraim Kahn

ANTI-KICKBACK LAW has been extended to all negotiated contracts. The original anti-kickback act was passed in 1946. Since then, according to the General Accounting Office, "new types of negotiated contracts have been devised to meet the specialized and complex procurement problems of the government." Penalty for violation of the law is a fine of up to $10,000 or imprisonment for not more than two years, or both.

ECONOMY SHOULD BE THE WATCHWORD of defense contractors, says Cecil P. Milne, the navy's Assistant Secretary for Materiel. He says that Congress and the public at large have "a general feeling of apprehension" that the military has "not been doing an adequate job of management." Saying that the military services are constantly trying to tighten buying procedures and obtain tougher competition, he asks whether industry is doing all that it can. He warns that changing conditions in different industries may alter the "reasonableness" of a cost, and urges that "questionable or unnecessary fringe expenses" be pared to the bone.

SMALL BUSINESS SET-ASIDES will be increased by the Army, though some complaints have been received from medium-sized firms that the set-aside program is keeping them from getting business. In fiscal 1960, the Defense Department figured on a set-aside program of $974 million, and actually awarded $781 million worth of contracts to little companies. The Army's technical services have been told to take the initiative in setting aside contracts for small companies without waiting for intervention by representatives of the Small Business Administration. They are also to continue to make future set-asides for items which have been handled under this procedure in the past.

CHANGES IN MILITARY BUYING RULES have been urged by the Senate Armed Services Committee. One major suggestion — that formal advertising be used whenever practicable — is believed to have been satisfied by recent changes in the Armed Services Procurement Regulation. The committee also would like the military to change its regulations governing incentive contracts to exclude from the target cost any excess amounts that can be attributed to inaccurate cost data.

IMPACT OF IMPORTS on American producers should be cushioned by government aid, according to the Senate Small Business Committee. The electronics industry has been one of those that has complained to the government that it is suffering from extensive import competition.

Among other things, the group suggests that the government should continue efforts to secure international cooperation to prevent exploitation of pirated American designs and ideas. As direct help to injured industries, the group would institute specific federal programs for firms and communities hard-hit by imports.

TIGHTER CONTROLS OVER ARMY R&D has been given to Lt. Gen. Arthur G. Trudeau, its Chief of Research and Development. His control will be exercised through the chiefs of the Army's technical Services. Objective of the change is speedier decisions. Trudeau, "under the functional policy supervision" of Richard S. Morse, Director of R&D, will be responsible for "planning, coordinating, directing, and supervising" all the Army's research, development, test and evaluation, including control over disposition of funds. Army Secretary Wilver M. Brucker says this will "greatly strengthen authoritative direction of research and development matters."

DIMINISH PATENT PROTECTION is implied in a recent change to the Armed Services Procurement Regulation. It reflects adoption by the Defense Department — after considerable protest—of a position taken by the General Accounting Office. The GAO had held that the mere fact that an item is patented does not justify buying it through negotiation instead of by formal advertising. Now, the ASPR has been changed to caution that awards cannot be negotiated "merely because the item to be bought is patented." Under formal advertising a standard patent indemnity clause is put in the final contract. This is supported to provide recourse for the owner of the patent. As a result, contracting officers are advised that the low bidder must get the contract "even though not the patent owner of Licensee, if otherwise responsive."

QUALITY-CONTROL REQUIREMENTS for "complex supplies" have been noted in the Armed Services Procurement Regulation. With some exceptions, future pacts for such items will require the contractor to provide "a quality control system acceptable to the government." In general, military specifications MIL-Q-9858 will satisfy the need for such control. Standard commercial items are exempt from this quality control system requirement, as are products which are being purchased under such stringent specifications as to insure that necessary quality control standards and inspections be observed.

LISTS OF FIRMS interested in doing R&D for the Defense Department are being mechanized as a part of the military's efforts to throw more business to little companies. The Signal Corps' Research and Development Laboratory expects to have its mechanized list of R&D sources ready very soon. In about five months, the Bureau of Naval Weapons (which places about 70 per cent of the Navy's R&D contracts by dollar value) hopes to have a comparable project completed. The Air Research and Development Command will have its headquarters list mechanized by mid-October. All ARDC purchasing branches should have a similar set-up by the end of the current fiscal year.

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NEWS

Instrument-Automation Meetings Slated for N.Y.C., Sept. 26-30

The Fall Instrument-Automation Conference and Exhibit of the Instrument Society of America will be held in New York during the week of September 26-30. Don G. Mitchell, president of General Telephone and Electronics Corp., has been named general chairman.

Three sessions dealing with meteorological instrumentation will also be held. The programs for these are being developed jointly by ISA and the American Meteorological Society. The sessions deal with modern instrumentation in radiation meteorology, stratospheric meteorological measurement, and instrumentation for airborne weather-reconnaissance systems.

6th RFI Autumn Conference Is Scheduled for Oct. 4-6

Electromagnetic interference problems will be the topic of discussion again this year at the Sixth Conference on Radio-Interference Reduction and Electronic Compatibility. The conference will be held at the Museum of Science and Industry October 4-6 in Chicago.

Jointly sponsored by the three military services the conference is conducted by Armour Research Foundation in cooperation with the Institute of Radio Engineers professional group on radio frequency interference. Included in the program will be sessions on design and measurement techniques and problems of civilian and military alike.

Stanley I. Cohn, assistant director of electronic research at Armour Research Foundation, is conference chairman. Inquiries concerning the conference should be addressed to Robert Brausch, conference secretary, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

NEC October Meeting in Chicago Will Feature Exhibit, 100 Papers

The 1960 National Electronics Conference will be held at the Hotel Sherman in Chicago on October 10-12.

Approximately 100 papers will be presented covering these typical areas: instrumentation and telemetry, masers, parametric amplifiers, plasma research, radar and radio navigation, radio astronomy, space electronics, and communications and navigation.

New Materials Science Center Being Organized at Cornell

Cornell University, the University of Pennsylvania, and Northwestern University have been selected to set up enlarged programs for the expansion of basic research in the science of materials.

Under a $6.1 million contract, from the Advanced Research Projects Agency, Department of Defense, Cornell will organize a Materials Science Center.

The work of the Laboratory of Atomic and Solid State Physics will comprise the largest part of the Center. A second area of emphasis in the Center will be chemistry—concerned with electron and X-ray diffraction, inorganic polymers, solid-vapor reactions, electronic processes in oxides, diffusion in polymers, polymers under high pressure, catalysis, photoconductivity, and theoretical physical chemistry.

The third area will be concerned with metallurgy and the fourth with mechanics and materials.

NBS Attempting to Find Cause Of Severe Radio Blackout

Members of the solar research group of the Radio Warning Services Section of the National Bureal of Standards', Boulder, Colo., Laboratories have been appraising a recent unusual solar event.

A severe radio blackout of long duration, and large radio noise outbursts on a number of wavelengths, began at 1630 hours, UT. No solar flare could be seen on the sun's disk, although a prominent flare would normally be apparent at the time of the radio disturbance. It now appears that the reason for this anomaly can only be conjectured until solar behavior is known in much greater detail than at present.

Complete blackout of the Bureau's radio station, WWV, occurred at a number of receiving locations. Cosmic noise absorption of an outstanding nature was evidenced by the great drop-off in received signal strength, and also by the unusually slow onset of the absorption.

Another unusual feature of the occurrence was the exceptionally low velocity of the radio emission source. The velocity was deduced from observations at two separate low frequencies. Slow drift bursts on dynamic spectrum records normally show velocities of the order of 1,000 km per sec at metric wavelengths. By comparison, velocities derived from 18-, 38-, and 200-mc fixed-frequency observations during the blackout average about 250 km per sec.

Commercial Use of Space Bringing New Problems

New Equipment, Adequate Frequencies Needed for Global Satellite Links; Public Begins to Move into Area Previously Used Only by Government

Robert Haavind
News Editor

POTENTIAL commercial uses of space have catapulted to public attention in recent weeks, sparked by Projects Echo and Courier and a controversy over the re-allocation of spectrum for possible space requirements (*ED*, Aug. 3, p. 4).

The push toward public rather than government use of space opens new problem areas and casts a different light on the direction of satellite and ground system design.

The most pressing problem, now being faced by the FCC, lies in adequate frequency allocation. Up to now the use of frequencies in space has been restricted to the government—through the military, National Aeronautics and Space Administration, and Advanced Research Projects Agency. These frequencies have for the most part been drawn from the large portions of the spectrum assigned to government use. They are not controlled by the FCC, but are assigned by the Interdepartment Radio Advisory Committee under the Office of Civil and Defense Mobilization. Many of these government space bands are already internationally protected under agreements reached during the International Telecommunications Union meeting in Geneva last year. Potential commercial applications, however, are not yet covered by international agreements.

The testimony presented before the FCC by commercial interests at recent space frequency allocations hearings indicated that telephone, television, and teletype users are all seriously considering the use of satellite links to serve international markets. Intercontinental exchange of digital computer data was suggested as another potential use of space systems.

Intercontinental television is an important factor in the allocations issue, since broadband systems like those required for TV transmission can not presently be provided by overseas cable technology. Current two-wire transatlantic cable systems have capacity for about 80 voice channels, and planned single wire cables will carry about 230 channels—still short of the requirement for broadband television transmission. Coaxial cables can carry TV signals over land because repeaters can be used frequently and adequate power can be obtained from sources in the vicinity of each repeater, permitting wide bandwidth transmission. Repeaters on undersea cables, however, are widely spaced and powered from the shore ends, restricting possible bandwidth.

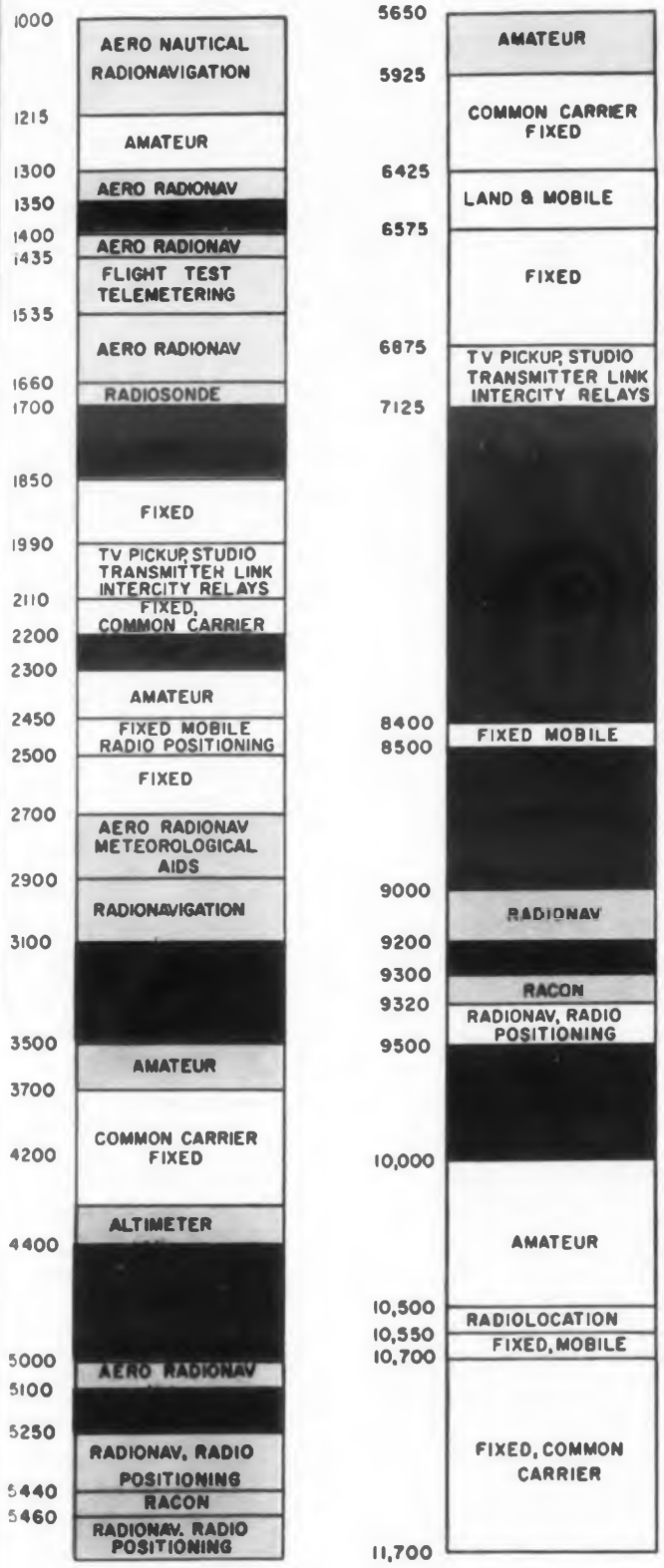
A significant increase in overseas cable bandwith capability is expected with the use of transistor rather than currently used tube repeaters. Transistor repeaters will require less power so that they can be placed closer together, thus operating at higher frequencies and providing wider bands. This progress must wait, however, until high frequency transistors of the required reliability are available.

Meanwhile, the satellite overseas link offers the broadband capability needed for TV.

In making its request for space frequency allocations AT&T indicated that 500 mc would be required for a TV channel or 600 voice channels. The most desirable frequency range for these requirements lies between 1 and 10 kmc—bounded on the low end by galactic noise and already existing heavy usage of the lower frequencies, and on the high end by atmospheric attenuation due to rainstorms, heavy clouds or fog. At least four, and preferably more, of these 500 mc frequency units are required for currently envisioned telephone and TV traffic via satellites.

(text continued on p 29)

Project Echo receiver uses this maser, giving low noise reception considered virtually impossible to achieve a short five years ago. Other breakthroughs like this should permit much more efficient bandwidth utilization than can presently be foreseen.



Current Allocations in 1 to 11.7 Kmc Band

Government bands.

Bands shared by government and non-government services.

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Table 1. International Allocations and Past Space Frequency Usage

Freq., mc*	Present U. S. Assignments	Present or Future Uses
10.003-10.007	Standard freq. guard band	Space research
19.99-20.01	Standard freq. guard band	Ionospheric research beacon
39.986-40.002	Fixed-mobile, safety	Ionospheric research beacon
54	*Amateur*	*Transit I-B, II-A*
70.2	*TV Channel 4*	*Lunik I*
108-108.09	*Radionavigation (present Minitrack freq.)*	*U. S. satellites*
136-137	Govt. (aviation, being withdrawn)	New Minitrack freq.
162	*Govt.*	*Transit I-B, II-A*
183.1-184.1	TV Channel 8	Russian satellites
212	*TV Channel 13*	*Lunik I*
216	*TV Channel 13*	*Transit I-B, II-A*
235	*Aeronautical radionavigation*	*Tiros I TV*
324	*Govt.*	*Transit I-B, II-A*
378	*Govt.*	*Vanguard I, Pioneer V*
400-401	Meteorological aids	Telemetering, particularly for meteorological satellites
960.05	*Aeronautical radionavigation*	*Pioneer III, V*
1427-1429	Aeronautical radionavigation	Deep space probes, precision Minitrack
1700-1710	Govt. (communications)	Project Nimbus, meteorological satellite, for wide-band TV
2290-2300	Govt. (communications)	Deep-space probes
5250-5255	Govt. (high-power radar)	Requested by Britain. No U. S. plans because of interference problem
8400-8500	Fixed-Mobile	Planned for communications satellite
15,150-15,250	Govt.	Space research, primary assignment
31,500-31,800	Fixed-Mobile (secondary)	Space research, primary assignment

*Italics denote frequencies used in space but not allocated to space research at 1959 Geneva Conference.

(continued from p 26)

Where Will Spectrum Come From?

Finding 2 to 3 kmc in the 1 to 10 kmc region is not an easy job, as can be seen from the table showing present allocations in that region. Currently common carrier fixed services are assigned 1 kmc in the region—used by AT&T for its present TD-2 and now-being-constructed TH microwave relay link systems. Another 730 mc of the region is allotted to operational fixed services.

The possibility of sharing these frequencies with space systems has been pointed out by the Electronic Industries Association. A TH system antenna radiates 5 w with 40 db antenna gain, compared to a satellite system ground terminal feeding a kilowatt into a 57 db antenna, the EIA said at FCC hearings, using active satellite repeater parameters specified by Dr. John R. Pierce, director of research, communications principles, Bell Telephone Laboratories. In this case the only serious interference problem might be encountered if the ground terminal transmitter was directed at a TH receiver—and this problem is minimized by the directivity of the ground to satellite transmitter except when it is directly pointed at a TH receiver antenna. Physical separation of the stations could overcome this problem because of the line-of-sight nature of microwave transmission, and in addition the ground-to-satellite antenna could be limited to about 10 deg in elevation.

Isolated locations for ground terminals will probably be required anyway to avoid interference from aircraft and other sources in areas of dense population, the EIA said, so that compatibility will not be a severe problem.

During AT&T testimony this view was countered by Brockway McMillan, Bell Labs director of military research, who commented that space communications systems must be engineered for the greatest economy of signal power. No margins can be afforded against possible interference because of the low-level signals that must be received from a satellite transmitter. Fundamental physical facts such as thermal noise and path loss set these limits, he said.

If the FCC decides that the AT&T argument is valid, and that additional frequencies must be re-allocated to potential space uses, it will be difficult to find the frequencies for the shift. The government is sole user of 3.825 kmc of this band, and another 2.32 kmc is shared by government and non-government services. With past history as a precedent it is extremely unlikely that any of this spectrum will be taken away from the government, according to an FCC source.

Thus with the present common carrier, operational fixed, government and shared services re-

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moved from the band only about 2 kmc remains, sprinkled lightly over amateur, television relay and studio link, fixed and mobile, and radionavigation services. Although little equipment is yet being used at these high microwave frequencies, it would appear to be unfair to private users to deprive them of these small tokens of hard-fought-for spectrum.

There is a possibility that the FCC may feel that some of the frequencies a little over the 10 kmc band might be easier to re-allocate. Another common carrier allocation at 10.7 to 11.7 kmc might be usable as one of the 500 mc links requested.

Alternate Modulation Technique Possible

AT&T frequency requests were made on the basis of a wide-deviation FM modulation technique using FM demodulation feedback receivers. This technique, based on a feedback receiver conceived by J. G. Chaffee of Bell Labs in the early 1930's, permits a significant reduction in noise levels. Shannon's information theory work indicates that a broader band permits an increase in signal to noise ratio without increasing transmitter power—a vital consideration in space systems. Using FM accomplishes this, but if the band is made too wide noise increases until a break point is reached, and only a hiss can be heard. The Chaffee FM receiver responds to only a narrow band of frequencies at any instant, but a feedback loop enables the narrow band tuning to continuously track the incoming modulated signal. Noise can be reduced by a factor of about 100 over a conventional wide band FM system by using this technique.

AT&T plans call for a 5-mc baseband and a 100-mc total band. Different frequencies are required by the receiver and the transmitter in an active repeater type satellite so that retransmission does not affect the satellite receiver. With 25 mc guard bands for each frequency a total of 250 mc is therefore required for a one-way transmission link. Two-way transmission for telephone service leads to the 500 mc figure.

This calculation is used to show what might be accomplished with equipment that is now available or in the laboratory. It does not assume future technical breakthroughs, such as the maser, which might make much more efficient modulation techniques feasible, greatly reducing bandwidth requirements. As AT&T points out, breakthroughs can not be assumed because no one knows when they will happen or what direction they will take.

Table 2. Frequency Usage for Planned Ranger Moon Vehicle

Service	Purpose	Freq. Area, mc
Guidance	Rate beacon, interrogation	7125-8400
Guidance	Pulse beacon, reply	7125-8400
Guidance	Interrogation	8400-8500
Guidance	Reply (two freq.)	9200-9500
Control	Ground to second stage	335.4-400
Control	Air to ground (two freq.)	335.4-400
Control	Synch link	335.4-400
Data	Ground microwave link (four freq.)	7125-8400
Guidance	Ground to air	335.4-400
Guidance	Air to ground	225-260
Telemetry	Function indication (two freq.)	225-260
Telemetry	Function indication	335.4-400
Range Safety	Primary	335.4-400
Range Safety	Alternate	335.4-400
Impact prediction	(two freq.)	4400-5650
Tracking Radar	(Four frequency bands)	400-9000

General Telephone & Telegraph Corp., although agreeing with the importance of setting aside frequencies for potential space uses, stated that it did not feel that the ultimate form of such systems was yet clearly defined. It suggested the setting aside of "hopefully" two 500 mc channels for possible space uses, and urged that this requirement be given international consideration at the Extraordinary Administrative Radio Conference of the ITU scheduled for 1963.

Although the direction required for reducing bandwidth requirements can not be ascertained with certainty, some current research programs might lead to important improvements. Just looking at the figures used for calculating a space system's parameters indicates certain directions, one communications engineer commented to ELECTRONIC DESIGN.

As satellite technology improves, he said, directional antennas should be possible from a stabilized satellite. Larger launch vehicles should permit greater weight and consequently more powerful satellite transmitters. Larger antennas could be used on the ground, and larger ground transmitters might also be used.

On the other hand, this engineer pointed out, AT&T has been one of the most efficient users of

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spectrum space, and if frequencies were allotted to the common carriers they would certainly not be wasted. As technology improves and more efficient modulation schemes can be used, other public services would be added to the intercontinental satellite links and existing services would be expanded in order to meet increasing traffic requirements.

Digital Speech Promising Approach

One research program which could lead to highly efficient bandwidth utilization is current work in digitalizing speech. At one time this approach did not appear too promising because of the difficulty encountered in mechanizing a faithful reconstruction of the human voice. Recent progress in this field, however, has been promising. The use of cross-correlation and other techniques is leading to greatly improved synthetic speech.

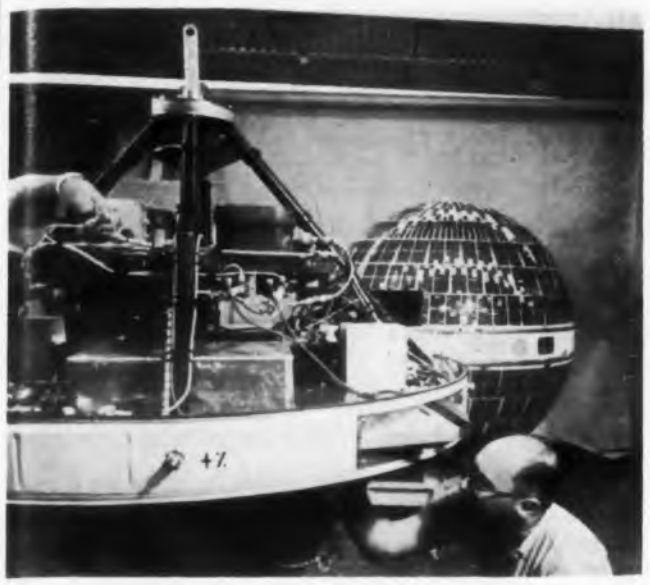
Once digital speech is possible, narrow band modulation schemes such as PCM could be used for transmission. This form of modulation using matched orthogonal filters leads to transmission efficiency approaching the theoretical limit, it was pointed out in American Rocket Society testimony to the FCC.

The wide band TV problem still remains, of course, but here again progress toward digitalizing is encouraging. A research program at Massachusetts Institute of Technology, for example, has produced fairly good quality pictures using various digital coding approaches.

Development of bandwidth compression techniques is being spurred by space requirements already foreseen by the government. Reconnaissance and weather satellites will require extensive TV transmission, and as resolution requirements stiffen even greater bandwith will be needed unless improved modulation methods can be discovered.

End to Microwave Reserve In Sight

Despite the wide bands assigned to the Government, the end to its present microwave reserve already seems to be in sight. Heavy radar and communications usage is in effect throughout the microwave region. Provisions for the man-in-space program—a single project—have dug deeply into the reserve frequency supply, testimony before the FCC indicated. Thirteen land stations and two ships, located around the world, will monitor the astronauts, the capsule, and flight progress over a myriad of transmission



Courier satellite, weighing 500 lb, carries four microwave transmitters, four microwave receivers, four VHF transmitters and two VHF receivers. Improvements in the satellite art should permit even heavier, higher powered equipment to be reliably orbited for commercial systems.

links. The spectrum requirement for a single Ranger vehicle moon shot next year, illustrated in table 2, shows the heavy requirements that can be expected for future space missions. An example of what can be done when bandwidth problems become extreme is illustrated by AT&T's success in tucking color television into the same 4-1/2 mc channel used for black-and-white, one communications engineer commented. Information on the black-and-white system occurs in bunches, related to the 60 field per second frequency and the 262-1/2 line per field distribution occurring in TV transmission. The extra carriers required for color transmission were, in effect, slid into the cracks between the lines in the black-and-white frames through careful application of information theory.

New Design Factors in Commercial Systems

In addition to the severe frequency allocation problem, many design considerations enter into public space systems that have not been a serious problem with previous government experiments.

Cost, for example, becomes an overriding factor in deciding to initiate a space communications system. Already some figures indicate that channel for channel a space communications system is more economical than an underseas cable link.

The difficulty here is that certain assumptions about reliability must be made in order to reach this favorable cost comparison, and the equipment with this required reliability has not yet been developed for the 1 to 10 kmc band. AT&T in its testimony specified ten years reliability as a reasonable goal in order to reach a favorable cost comparison with cable links. Two possible satellite repeater systems were suggested

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by Dr. Pierce in FCC testimony.

One of these systems uses a 1-w traveling wave tube in an oscillator circuit in the satellite. The use of a 1-w tube is made possible by assuming a broadband modulation method, such as wide deviation FM, Dr. Pierce pointed out. He said that the 1-w TWT was assumed because of Bell Labs experience in building four 5-w travelling wave tubes which have been operating without a failure for four years.

The other possibility is the use of tunnel diodes or transistor harmonic generators as local oscillators to accomplish the offset frequency transponder function. He did not comment on the reliability that might be expected from this configuration.

Higher power output from the satellite transmitter could be accomplished if components of the necessary 10-year reliability were available. As power goes up, however, higher cathode current densities in tubes are required, naturally leading to shorter life. Solid-state components designed to operate at higher power levels also suffer from a reliability standpoint. Further development in both the microwave tube and solid-velopments in both the microwave tube and solid-state fields must be undertaken to overcome these deficiencies.

Stationary Orbit Appears Best

From a cost analysis all studies seem to agree on the active stationary orbit satellite as the best prospect for a commercial intercontinental link. The active type seems best because of the better S/N compared to the passive satellite, such as Project Echo's inflated balloon. With active satellites in lower orbits many more satellites will be required to assure the line-of-sight presence of one of them between any two ground terminals at all times. Another vital requirement for such a low-orbit active system is that two transmitters and receivers are necessary at any ground terminal so that one can be picking up the next satellite while the other tracks the one presently in view, providing continuous service. Interference would be a problem with this scheme, even if different channels were used by the two transmitters, because of their close proximity to each other.

A stationary system, on the other hand, could provide complete world coverage with three satellites, kept on station by systems now under development for government satellites. Only one transmitter and receiver would be needed at each ground station, and the interference problem of the low-orbit system would be eliminated.

A stationary system, on the other hand, could provide complete world coverage with three satellites, kept on station by systems now under development for government satellites. Only one transmitter and receiver would be needed at each ground station, and the interference problem of the low-orbit system would be eliminated.

Interference would be much easier to avoid between ground and space systems using a fixed orbit satellite, the EIA pointed out during FCC testimony.

Delay Is a Difficulty

The major difficulty with the stationary scheme, aside from the increased path loss caused by the greater transmission distance, is in the delay of some 0.6 sec encountered in telephone conversations over such a distance.

Current-telephone transmission systems use the same transmission path for conversations each way in a two way system. Because of this, an annoying echo would be heard unless some means is provided for preventing it. Present systems use an echo suppressor to cut off reception at the end of the transmission line where signals are being transmitted, thus eliminating echos. Tests of echo suppressors with a half second delay, however, indicate that at times part of a conversation can be cut off because of this suppression. Further research is necesary to see if there is some method of overcoming this difficulty, but meanwhile AT&T feels it represents a serious flaw in the stationary satellite scheme.

Commercial Use of Satellites Assured

In any event the eventual commercial use of satellites for global transmission appears to be assured. Industrialization is increasing rapidly all over the world, and existing communications links are becoming overcrowded at an ever increasing rate.

The technical solutions to satellite transmission problems appear to be well within reach. Lockheed Aircraft Corp., for example, told the FCC that if given the go-ahead it could have an international link in operation within three years. Lockheed has been prime contractor for the Discoverer, Midas, and Samos programs, and has coordinated the construction of an elaborate ground tracking network for controlling and communicating with these satellites.

Meanwhile the stationary satellite scheme is planned under ARPA's Project Advent, to be carried out over the next three to four years. Military global communications needs are already spurring development of equipment suitable for systems such as this, and once reliable equipment is available it will undoubtedly be pressed into public service. ■ ■

New Pay-TV System Being Readied for Field Tests

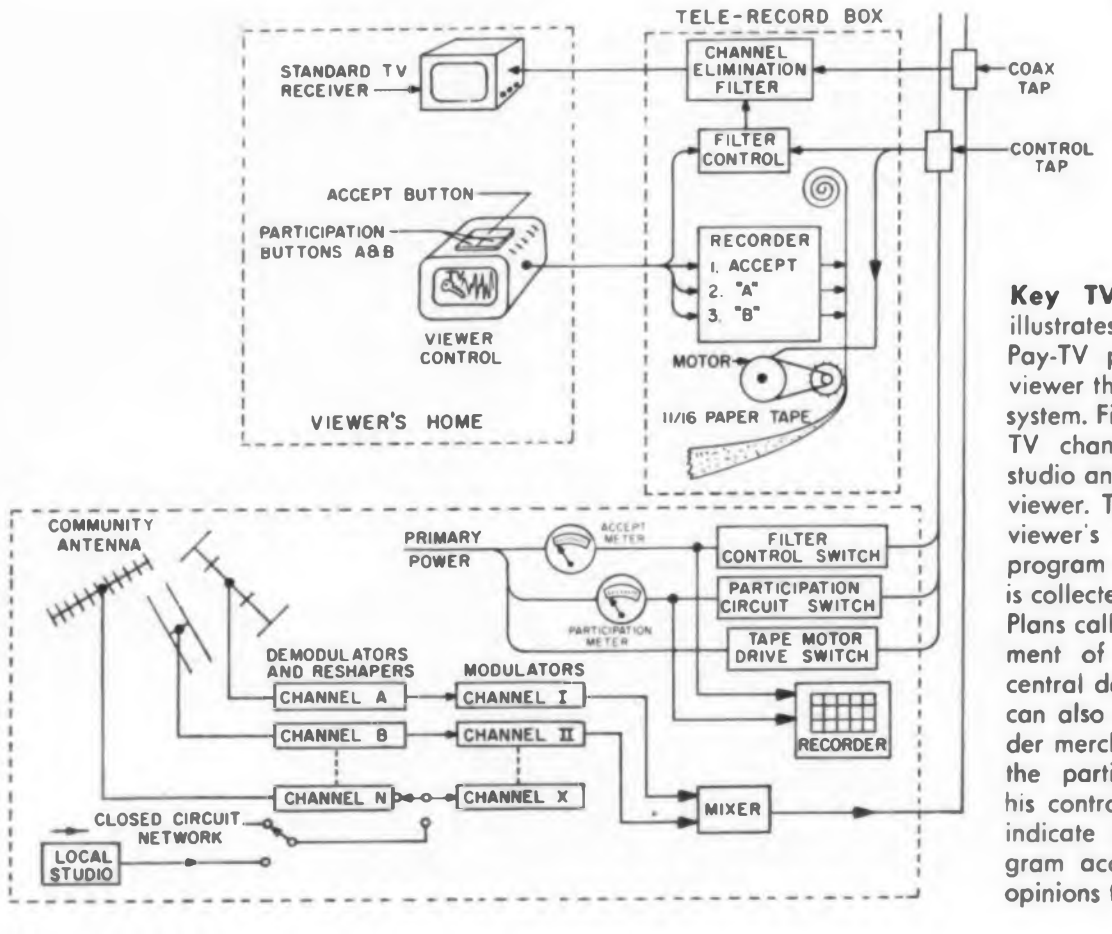
TelePrompTer's 'Key TV' Uses Coaxial Cables, Costs Little; Field Still Wide Open for New Concepts in Equipment Design

PAY-TV, which not too long ago was dismissed as a dead issue, is back again for another try. Two systems, one brand new, the other not so new, are being readied for field tests in the near future. One system uses expensive coaxial cables but is otherwise low in cost and embodies a unique "talk-back" feature. The other operates over existing TV channels, thereby requiring FCC approval, and employs a considerable amount of electronic gear. Since it is unlikely that either system will in its present form prove convenient for nation-wide Pay-TV (if and when it becomes a reality), the field remains wide open for new design concepts.

A cable-distributed Pay-TV scheme that falls into the "Why didn't I think of it" category will be field-tested before the end of the year by the TelePrompTer Corp. of New York. Dubbed Key TV, the system also enables the viewer to order merchandise, participate in surveys, and answer questions—all by means of a push-button control box in his living room.

Key TV is designed for use in cities already wired for Community Antenna TV systems (CATV). It rides piggy-back over the existing cables and requires little additional equipment in home or studio. Two components, a viewer control box and a tele-record box, are installed at the home; switching and recording equipment are installed at the studio.

The tele-record box contains a band elimination filter for the Pay-TV channel which is inserted into the circuit upon command from the studio. It is switched out, and the Pay-TV program received, when the viewer pushes an "Accept" button on his control box. This action also inscribes a paper tape inside the tele-record box. The tape is collected at regular intervals and the viewer billed accordingly.



Key TV system diagram illustrates how regular and Pay-TV programs are fed to viewer through an CATV cable system. Filters to attenuate Pay-TV channel are inserted by studio and can be removed by viewer. Tele-record box marks viewer's acceptance of pay program on paper tape which is collected at regular intervals. Plans call for eventual replacement of tele-record box by central data processor. Viewer can also answer questions, order merchandise, etc. by using the participation buttons on his control box. Studio meters indicate percentages of program acceptance and viewer opinions to survey questions.

The Viewer Talks Back

The viewer control box also includes "A" and "B" participation buttons which enable the viewer to "talk back" by expressing preferences, ordering merchandise, etc. Depressing these buttons inscribes a mark on the paper tape in the tele-record box. In addition, studio meters indicate the percentage of viewers depressing a button at any given time and the percentage of viewers who are receiving a Pay-TV program.

Typical operation of the system would be as follows: A few minutes before a Pay-TV program is scheduled to begin, an amber light is turned on in the window of the viewer control boxes. This is accomplished by command from the studio and the light is visible in all boxes regardless of whether the set is tuned to the Pay-TV channel or turned on at all. The viewer may then turn to the Pay-TV channel where a sales pitch for the program is being telecast. Immediately before the program is to begin, 40 db band elimination filters for the Pay-TV channel are activated in all the tele-record boxes by studio command. If the viewer wants to receive the program he depresses the accept button on his control box. The filter is deactivated, a green light appears in the window of the control box and the recording tape is inscribed.

The participation buttons can be used in a variety of ways. After a commercial the announcer might say, "If you want to order this vacuum cleaner, press button 'A', now." When the viewer pushes the button, the recording tape is inscribed and a red light appears under the button in the window of the control box. For educational TV, multiple choice tests could be answered by pressing the buttons singly or in combination. Pollsters could run their surveys merely by asking viewers to press the participation buttons in response to certain questions.

Since the recording tape is generally advanced by studio command after each question, viewer anonymity for "sensitive" questions can be pre-

Viewer control box for Key TV. This is the only additional component required in the home for receiving the pay programs. The box contains switches for accepting pay programs, ordering merchandise and answering questions. Lights of different colors appear on the screen to indicate the status of the system to the viewer. A key is provided to lock the control box against unauthorized use.

served by not advancing the tape. Viewers may be asked to express their choice for president by pressing the same button, but at different times. If the tape is not advanced from one time to the next, it will be marked in the same place regardless of how the viewer voted. Preference would be expressed in percentage terms by the participation meter in the studio.

In designing the control box, TelePrompTer relied on a number of psychological tricks. "This business of colored lights inside a little TV screen isn't really necessary, but it gives the viewer the idea he's doing something," H. J. Schlafly, TelePrompTer vice-president, told ELECTRONIC DESIGN. The TV-like shape of the control box is another instance of customer psychology, as is the key supplied to lock the box against unauthorized use. "Just as Junior must have the keys to use the family car, he must have the key to the control box to see the special programs," Mr. Schlafly points out.

The present system of inscribing marks on a paper tape to be subsequently collected by route men is of course practical only on a small scale. Teleprompter is experimenting with data processing systems which can be tied into Key TV to record customer acceptances and participation at a central station. TelePrompTer claims to have six different data systems in development but is not commenting on them at this time.

First tests of Key TV are scheduled to begin this fall over channel 5 in Liberal, Kans. TelePrompTer already operates a CATV system in Liberal with 2,000 homes wired to the studio by coax cable. These tests will be devoted primarily to entertainment and sports programs. Some months later, a second test at Farmington, N.M., will be the pilot for educational and merchandising aspects of Key TV. ■■

REPORT ON BIONICS

Electronics Learns from Biology

Devices Patterned After Nature's Processes Solving Some Problems; New Horizons Beckon to Designers; First Symposium Under Way

Alan Corneretto
News Editor

IN DEVELOPMENT at Stanford Research Institute is a completely new computer logic element based on network theory believed operative in the human brain. At General Electric, researchers are building an array of thin-film electroluminescent elements that they hope will behave like a neuron. At the University of Illinois, a "retina" of photocells sees differences in quantities of objects placed in its visual field —it senses "n-ness."

These projects, with many others under development, probably represent the first substantial work in a new kind of electronics: bionics—the science of applying knowledge of biology and biological techniques to the design of electronic devices and equipment. Each of the projects described in this report was inspired at least in part by the way nature solves problems that face electronic designers.

Nature's know-how is now finally being tapped by investigators throughout electronics, who hope to adapt for their own uses the methods nature has developed over the countless centuries that her creatures have been detecting, transmitting, integrating and otherwise processing information. Together, the research programs under way mark the start of what can be considered the era of bionics.

Many organizations conducting bionics R&D have already built hardware, and some, like RCA, the University of Illinois, GE, and others, have formed special departments for such work. The first symposium completely devoted to the subject is being held this week in Dayton, Ohio. And the era may even be said to have an official beginning—the start of the 1960-61 fiscal year, when the Air Force made more than $1 million available to Wright Air Development Division expressly for bionics research and development. The corresponding Air Force figure for the previous year was about $40,000.

Growing Pains Hinder Bionics Progress

But though bionics is a going concept it has not gone far. There are three connected problems which are limiting its growth:

- To apply a knowledge of biological systems to the design of electronic systems requires a substantial knowledge of those systems. But not nearly enough is known of the way living things work. Particularly lacking is a sufficiently thorough knowledge of human processes. Neurology, physiology, and many other of the biological specialties are only now changing from descriptive to analytical sciences.
- There are not enough researchers who know both electronics and the biological sciences. The most highly rated work in bionics to date has been done by a few scattered researchers with training in both electronics or physics and one or more of biological specialties. It is believed that only at MIT, Cal Tech, and the University of Minnesota is biophysics taught at a theoretical level.
- Bionics as a concept is young and only beginning to earn acceptance. The very shallow base of useful knowledge of living systems appears to be inhibiting systematic exploitation of bionics as a concept. And at another extreme, some sci-

What Is Bionics?

In this report, the word "bionics" is used to mean the science of applying knowledge of biology and biological techniques to the design of electronic devices and systems. This is a special use of the "official" definition, that given by Maj. J. E. Steele, who coined the word at Wright Air Development Division. His definition is: "The science of systems which function, after the manner of, or in a manner characteristic of or resembling living systems." This meaning is based on the Greek root and suffixes, *bion*, *ic* and *ics*, which were used in coining the term.

Bionics, then, is different from medical electronics or bio-electronics, which is the specialty in which electronics is used for biological purposes. Bionics is also different from the discipline of studying electronics for help in acquiring knowledge of biology.

Some work in adaptive or self-organizing mechanisms is proceeding under biological inspiration. These machines are bionic systems. Other adaptive mechanisms, however, are not related directly to biological operations and are not, therefore, considered bionic, at least within the context of this report. The dividing line between the two is admittedly dim, if, indeed, it actually exists.

The Universe of Bionics

Major classifications of bionics	Areas of Applied Research	Electronic and Other Significance
Biological systems	Perception mechanisms Normal, abnormal psychology Perception parameters Analysis of time series	Reduced disorientation accidents Diagnostic data reduction Channel conservation Psychotherapy
Biological components	Analysis by receptors Neuronal processes Transfer functions Transducer mechanisms Organic structural properties	Optimum use of sensory channels Improved prosthetic units Effective warning devices
Analysis, theory and logic	Theory of automata Stochastic processes Theory of invariants Topology Information theory	Advanced problem formulation Iterative solutions New symbolism Reliable diagnostic tests Brain function analysis
Neoteric techniques	Non-synchronous multiplexing Concept formation Auto. focusing and tracking Automatic programing Error elimination	Secure communication Channel conservation Diagnostic potential Automatic photo reading Self-adaptive reliability
Synthesized components	Logical transducers Synthetic neurons Non-resonant freq. analyzers Nonlinear elements Polymer & solid-state units	Voice-controlled switching Automatic speech recognition Novel instrumentation Signal/noise enhancement Bionic sensors, transducers
Systems synthesis	Self-adaptive control Pattern recognition Association systems Logical machinery	Retrieval of information Target identification Learning machines Discrimination machines Decision formulators

entists believe that designing from nature has always existed and will continue, whether or not the practice is glamorized by a title.

Though these problems are slowing progress in bionics, a surprising amount of work is going on—probably scores of projects. An exact count cannot be made because of the difficulty of classifying many programs. Most projects involving both electronics and biology, apart from those in medical electronics, are not purely bionic, though they may serve bionics purposes.

Prime mover in bionics is the Air Force—specifically two close-working groups in the Directorate of Advance Systems Technology in the Wright Air Development Division: the Bio-Acoustics Branch of the Aero-Space Medical Div., and the Bionics and Computer Branch of the Avionics Div. Both groups are at Wright-Patterson Air Force Base, Ohio.

The Air Force's Office of Scientific Research is supporting many basic-research programs, which though not primarily bionic, are potentially important to the bionics effort, and are considered so by OSR. Rome Air Development Center has directed at least one bionics project.

The Navy, through the Office of Naval Research is also supporting much bionics research.

WADD, in contrast to other organizations, believes that bionics as a concept is not premature. The WADD group cites three reasons why such R&D should be pursued now:

- Modern electronics technology is permitting the consideration and construction of devices with the high parts-densities, low-power requirements and other characteristics that appear to be needed by bionics systems. Electron-beam-etched microminiature elements, thin-film devices, and ferrites are already proving useful in bionics developments.
- The availability of computers and newly developed mathematical techniques is permitting construction of models of complicated processes, and these in turn help the direct analysis of biological data.
- The need for information-handling devices of enormous capability and probably of great complexity is increasing, and this is forcing researchers to examine novel approaches to processing information.

First Step: Neuron Simulations

Because of the pressing requirements for vastly improved information handling, most bionics research is on computer elements. These generally take the form of simulations of neurons, transducing cells that are the basic elements of nerve networks. In biological systems, neurons permit cortex or brain tissue to receive, transfer, process, and store information to permit system operations in order to adapt to changed environments.

Among the organizations in the United States that have built electronic analogs of neurons are Rockefeller Institute, Bell Telephone Laboratories, Stanford Research Institute, Applied Physics Laboratories, GE, the University of Illinois, Aeronutronic Div. of the Ford Motor Co., Lockheed Electronics, RCA, MIT, and Litton Industries.

Much of the work of these organizations and others, like Melpar, Inc., and Raytheon, which are planning to build neuron simulations, is being pursued in the hopes that single neuron analogs could be constructed and be arranged in networks that could process information with some of the facility of living organisms. Such networks would have high reliability, high speeds and, most important would be made self-organiz-

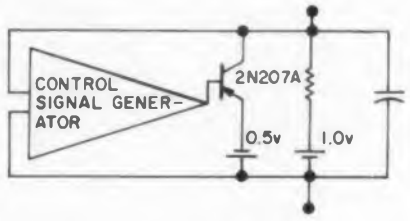
Electronic Neurons

Or four practical approaches to designing the basic element of bionic information-processing systems.

This early simulation built at Rockefeller Institute is based on the classic Hodgkins-Huxley model of neuron behavior, which describes cell activity in terms of membrane potential, sodium-ion conductance and polarization.

The voltage and time-dependent sodium resistance of the neuron's membrane is simulated by a 2N207A transistor. In the saturation region of this transistor the collector-current - collector - voltage characteristic is a crude approximation of a constant resistance, the magnitude of which depends on the base current. The base is driven by a control signal to give a resistance voltage and time dependence similar to that of the sodium resistance of the nerve membrane.

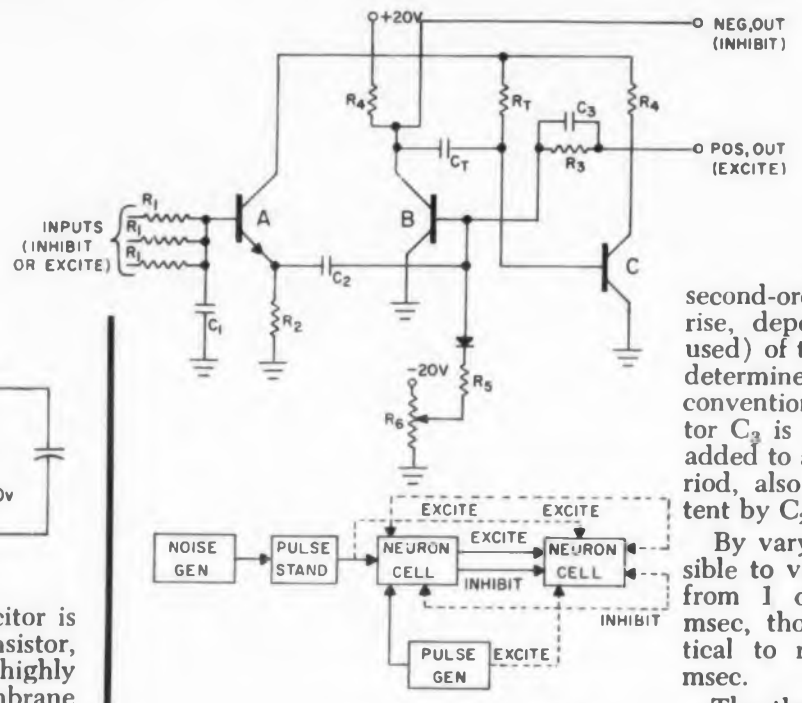
A voltage proportional to the turn-on effort of the cell, which increases sodium conductance in an actual cell, is generated by an integrator of the membrane potential change, the output of which is clamped not to exceed a fixed



value. The integrating capacitor is discharged through the transistor, which is biased so that it is highly conducting when the membrane potential is near its resting value.

A voltage proportional to the inactivation, or turn-off effort, is generated simply by an integrator of the membrane potential change with a large time constant.

The turn-off fraction of the turn-on value of the sodium conductance is taken by a multiplier consisting of the voltage divider shown. The lower arm of the divider is the transistor, whose base is fed in the turn-off signal arranged so that as the signal decreases, the transistor conducts more heavily.



Clever circuit design enabled researchers at the Applied Physics Laboratory of Johns Hopkins University to build a more ambitious neuron analog by modifying a single-shot multivibrator. Transistor A is an emitter follower included to sum several inputs without interfering with the time constants on the base of transistor B of the multivibrator. Capacitor C_1 simulates the second-order rise (or exponential rise, depending on the reference used) of the membrane. R_T and C_T determine the pulse width, as in a conventional multivibrator. Capacitor C_3 is the feedback, which was added to achieve the refractory period, also determined to some extent by C_2.

By varying C_2 and C_3 it is possible to vary the refractory period from 1 or 2 msec to about 50 msec, though it becomes impractical to raise the period to 100 msec.

The threshold is determined by R_6, which can be made to have any range desirable. In the particular simulation, the negative output was used to simulate an inhibitory pulse when three such cells were interconnected. Inputs were randomly spaced 1-msec pulses of fixed amplitude to simulate noise inputs. Output was a standard pulse of 1 msec and 15 v. Maximum firing rate was about 500 cps.

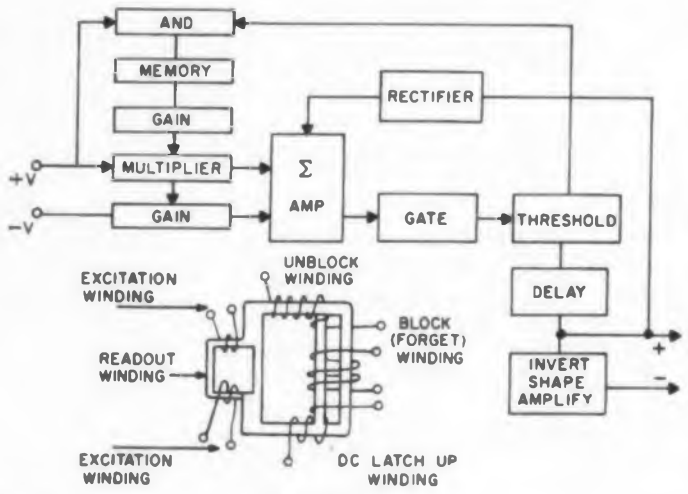
Shown above is a still more sophisticated simulation. Developed by General Electric, it is capable of adaption and could be modified for perceptron experiments.

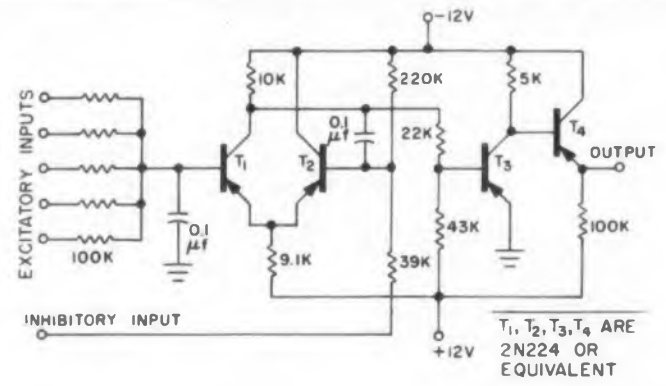
Ten excitatory and 10 inhibitory inputs are weighted so that the cell may operate on the basis of the difference between the weighted sums of the excitatory and inhibitory input signals.

Adaption is initiated within the cell whenever the integral of the output determined over a given time interval is larger than some specified value. This produces a brief state during which the rate at which the cell can be fired by an exciting input signal is reduced.

Each of the exciting inputs has a multiplier, memory and means for changing the memory associated with it. Summation of the inputs is performed by the summing amplifier. The threshold circuit is a monostable vibrator that produces a pulse whenever the output of the summing amplifier exceeds the threshold level. This pulse increases the gain of the exciting channels that contributed to the firing of the cell.

The memory unit shown, which is the key component of the simulation, is a transfluxer on which pulse excitation is used. The unblock winding is fed from the input AND gate and serves to increase the transfluxor output by an increment each time it is pulsed. The block, or forget, winding receives pulses from an external source at a fixed rate and causes the transfluxor output to decrease by increment with each pulse. The dc lockup winding is provided to maintain the transfluxor in the maximum memory state once it has been reached.





This electronic neuron, developed at Bell Telephone Laboratories is a four-transistor device with variable threshold capable of an integrating time constant of 2 msec and a refractory time constant of about 10 msec. These values approximate those of biological neurons.

Quiescent threshold is from 1 to 5 v, depending on the number of inputs connected. The output-pulse level is 10 v. These levels are many times greater than those in nerve tissue, but the ratios between threshold and output levels are commensurate. These ratios in part determine the characteristics when several cell outputs combine.

Output pulse duration is about 4 msec, which is considerably greater than the action spike length found in biological nerve, but it can be shortened by use of a suitable differentiating network. Output characteristics are compatible with the excitatory and inhibitory input requirements such as a chain or network can be readily assembled. One unit will drive up to 100 others without serious deterioration of output waveform or output level.

L. D. Harmon, of Bell Labs, reports that the simulation can be used to give either single-pulse outputs or variable-frequency pulse trains, depending on the nature of the input.

Photoresistive cadmium selenide cells have been used with this model to simulate some of the simple structures and functions of the retina. The relatively simple unit is said to cost less than $10 to construct.

ing. The self-organizing feature would permit design of systems that would combine high performance with small size.

Current work with neuron analogs appears to fall into two categories. One group of workers, including some at Bell Labs and the University of Illinois, believe that because operation of the cortex networks will not be understood for a long time, effort should be concentrated on developing neuron models patterned as closely as possible on actual neurons, rather than on connecting arrays of neurons. This would permit better understanding of neurons, which, in turn, would make possible better analogs.

Other researchers, however, like the perceptron builders at Cornell Aeronautical Laboratories, are less concerned with developing precise simulations of the neuron than with interconnecting arrays of approximate analogs, the analogs having only some of the properties of neurons.

Though the approaches taken by the neuron simulators vary, the goal is generally the same—an adaptive element, which, like a neuron, is a transducer with a binary output and two general types of inputs. Within its operating limits it takes an input signal of varying character and either fires an output signal or does not. The output signal is standard if produced at all. Input is either excitatory or inhibitory. Though some neurons can be considered binary switches, actual neurons cannot, because they have nonlinear characteristics.

What the Neuron Does

L. D. Harmon, of Bell Labs, describes the general properties of a biological neuron in terms of its input and output this way:

"**Input.** *Inhibition:* A particular input connection to a neuron can, while energized, inhibit firing of the neuron by other inputs.

"*Excitation:* Other input connections to a neuron will, if sufficiently energized, always fire the neuron if certain conditions are met.

"*Threshold:* A neuron may be fired if the triggering energy supplied to it exceeds a certain threshold value within a time limit. There are input pulses which have insufficient amplitude to cause firing no matter how long they last. This threshold is variable, being a function of the previous history of firing of the neuron.

"*Refractory period:* Immediately after firing, a neuron's threshold rises effectively to infinity and for a period on the order of a few milliseconds, no input signal can fire the neuron again. This absolutely refractory period is followed by a relatively refractory phase. During this second phase a decreasing threshold is ob-

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Bionics and Contracts

Most bionics research is financed by one or more of the research branches of the Air Force or Navy. The following projects currently sponsored by these services are either directly bionic or are basic research considered of potential value to future bionics or electronics systems. Most of these projects are funded by the Office of Naval Research and the Air Force's Office of Scientific Research. Wright Air Development Division is about to announce letting of contracts for an additional series of purely bionics projects.

U. of Illinois. Self-organizing bionic systems. (See p 54)

Applied Physics Laboratory. Neuron measurements and simulation. (See p 40)

General Electric. Construction of an electronic neuron. (See p 40)

Stanford Research Institute. Neuristor logic. (See p 48)

served, approaching the pre-firing threshold and reaching it after a few tens of milliseconds.

"*Summation:* Two or more input pulses, each of insufficient energy to excite a neuron, can be integrated by the cell so that firing occurs. To be successful, this summation must occur within a maximum time, typically on the order of a millisecond or so. Since these inputs may arrive via different pathways, there can be both spatial and temporal summation.

"**Output:** The output of a neuron is 'all-or-none.' If firing occurs, then a pulse of standard amplitude and duration is produced. There are exceptions, of course, but as a first approximation the energy per output pulse may be considered constant."

Eye and Ear Neuron Analogs Coming

Workers at Bell Labs have built several versions of electronic neurons, including the one shown on p. 40, which operates in several modes and is said to be useful for simulating peripheral receptors such as retinal elements. Mr. Harmon has developed a conceptual model of an analog that would have some of the properties of an eye. It is implemented with simulated neurons, filters and other components. Work is also underway at Bell Labs on an artificial neuron patterned after neurons of the cochlea, a transducing organ of the human ear. Breadboarded

Cornell Aeronautical Laboratory. Perception studies. (See p 50)

National Biomedical Research Foundation. How to construct and use a billion-gate computer (mathematical analysis).

U. of Arizona. The antenna of moths as a model for antenna design.

American Museum of Natural History. Communication behavior in fishes.

Aeronutronic. Tiny magnetic integrating core. (See p 40)

U. of Wisconsin. Orientation of aquatic animals —especially by olfactory processes.

U. of Minnesota. Electrical characteristics of living tissues and excitatory processes.

Princeton U. Physiology and chemistry of biological clocks. This and following project are part of a broad program to learn more about internal clocks of living systems.

Northwestern U. Rhythmic variations in metabolic rate.

Duke U. Migratory behavior of pigeons.

U. of California. Physics of cell division, with emphass on information transfer.

Commonwealth Research Institute (Virgin Islands). Intellectual capability of porpoises.

Catholic U. Setting up a biological mathematics center to interest mathematicians in biology.

U. of Oregon. Analysis of waves in ear.

Syracuse U. Multidimensional information theory, for analysis of patterns.

circuits of transistors and resistors mounted on 3-by-4-in. circuit boards have been duplicated and are being used in conjunction with an existing analog of the cochlea to study network activity. W. A. van Bergeijk, who developed the cochlea neuron analog, is proposing that all artificial neurons be called neuromimes. He suggests that the suffix -mime be used to describe analogs of any biological system.

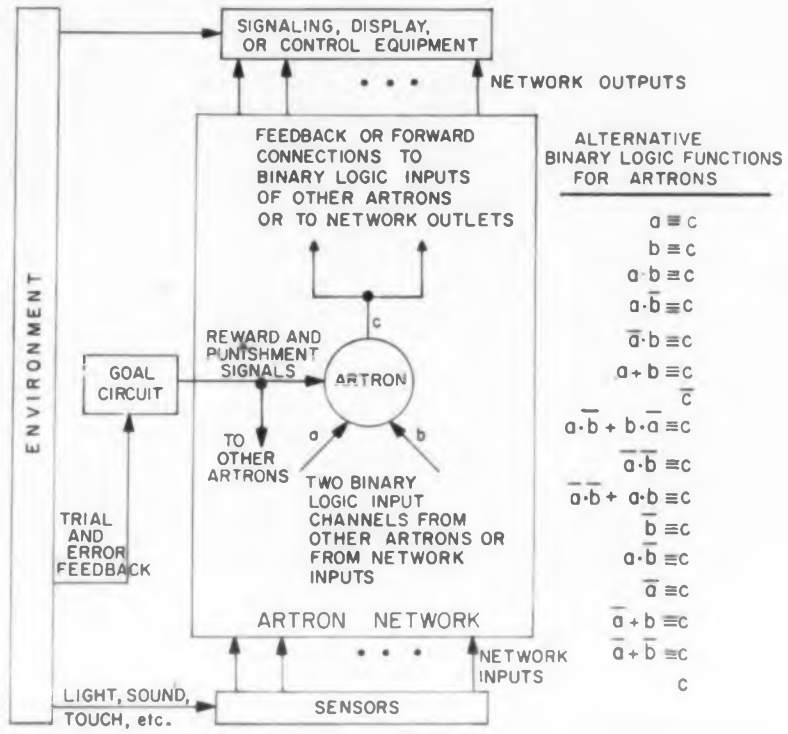
The Artron: Neuron-Based Learning Machine

An example of an application for neuron analogs has been designed by R. J. Lee, of Melpar, Inc., who is developing a turtle-type machine with generalized learning ability. The artificial neuron on which a theoretical model of the machine is based is called the artron by Mr. Lee. Like the neuromime, it is in the breadboard stage of construction.

As shown in the drawing, the artron has two inputs, reward and punish, which correspond to the excitatory and inhibitory inputs of the Bell Labs and other neuron simulations. Another pair of input channels is used in transferring signals in logical operations from artron to artron in conjunction with a branched output channel. The logical gating functions of the artron operate in one direction, from the *a* and *b* inputs (dendrites in actual neurons) to the output channel (corresponding to the neuron

REPORT ON BIONICS

Model of a turtle-type learning machine under development at Melpar, specifies a network of artificial neurons in feedback circuits to modify machine's operation in accordance with reward and punishment signals. Artron unit is a simulation of an actual neuron. Inputs *a* and *b* correspond to the dendrites of neurons. Output corresponds to neuron axons. The 16 possible logic states of the artron, which are listed at the right, are selected as required by environmental changes. A possible goal for such a machine would be keeping its source of power charged.



axon). The artron has 16 states and a delay capability.

When the axons of one artron stage are soldered to the dendrites of another to form a network, each artron would initially be unspecialized. The goals of the machine would also be unspecialized. As goals are specified during the course of learning, criteria would be established for adaptation to a wide range of environments. The artrons would gate their *a* and *b* inputs according to the alternative binary logic available to them.

Initially, noise generators cause the logic to fluctuate in each artron. For the conditioning process, however, the model rewards or punishes itself by means of the goals, according to the trial-and-error feedback. By associating logic that has arisen in each stimulated artron with reward or punishment, the noise generators are biased to make such logic more persistent or less persistent, respectively.

Property Filters

Or how to save "computer" time by processing only needed information

An important characteristic of biological systems has recently been established—property filtering. The concept promises to have far-reaching effects on sensing and input systems of the future and has already led to construction of a device that senses "n-ness."

The relationship of a property filter to sensory information processing in general can be clarified by quoting a question put by researchers at MIT, who verified the existence of property filtering in a frog's eye:

"The assumption has always been that the eye mainly senses light—whose local distribution is transmitted to the brain in a kind of copy by a mosaic of impulses. Suppose we held otherwise, that the nervous apparatus in the eye is itself devoted to detecting certain patterns of light and their changes corresponding to particular relations in the visible world?" The MIT team then showed that the frog's eye actually does deliver a filtered, highly-organized signal to the brain.

Described another way, a property filter is an information-processing network that preorganizes data for self-organizing systems by extracting from the set of all possible inputs a particular subset defined by the internal structure of the network. Paul Weston, of the University of Illinois, describes a simple electronic property filter built at his lab as follows:

"The device consists first of the customary finite array of peripheral transducer elements, analogous to those seen almost universally in biological individuals. Secondly, these elements supply signals to a non-adaptive encoding device with a single two-valued output so that all possible input patterns are divided into two categories. When one of these categories coincides with the set of input patterns displaying what is recognized by its human operators as some particular invariant characteristic, for example, 'having four sides,' 'being a perfect third,' 'being hard,' the device can be considered a property filter."

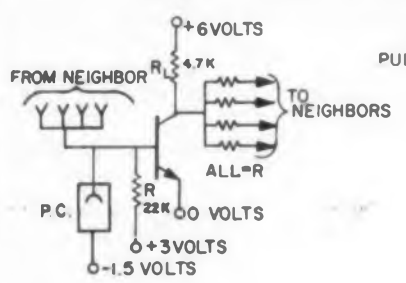
He adds, "It should be noted that each transducer in the input array is in itself a valid property filter insofar as it has a limited or selective sensitivity to certain "environmental variables."

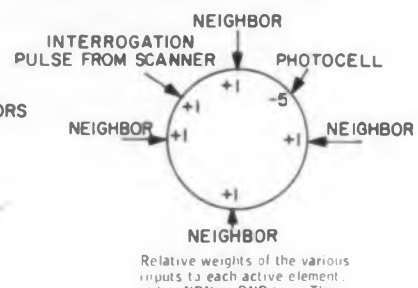
A device called a "numa-rete" has been built at the University of Illinois to demonstrate the concept of property filtering. It automatically counts the number of black objects that are simultaneously presented on a light field to its 12-by-12-cell "retina," subject to inherent resolution limitations. The device has a similar 12-by-12 array of "ganglion cells" each receiving an absolutely inhibitory signal from its associated retina cell when this is in a lighted part of the pattern.

The network is a rectangular array of photocells connected point-by-point to an indentical array of flip-flops. These are connected bilaterally along rows and columns of the array such that when one is in its "on" state, it will force those directly connected to it to go on, provided these are connected to photocells in shadow. Lighted photocells prevent the associated flip-flops from going "on."

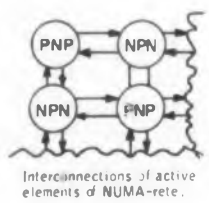
Operation begins with all flip-flops in the "off" state. Several distinct shadows of objects of any shape are allowed to fall on the retina, and a flip-flop connected to a photocell under one particular shadow is turned on. All other units under the shadow will go "on" while the remainder of the network is unchanged. A scanning program which turns "on," sequentially, all elements which are "off" and not inhibited by a photocell signal will thus reveal all of the objects in turn. Appropriate output signals are obtained by observing changes in state of the over-all network, there being one of these for each separate object during each scanning program.

Simple extensions of the device could yield size and position information for each object as well, state the designers. At the university, property filtering capability is being built into a sensory device that will serve as input for a sophisticated learning machine (see p 54).

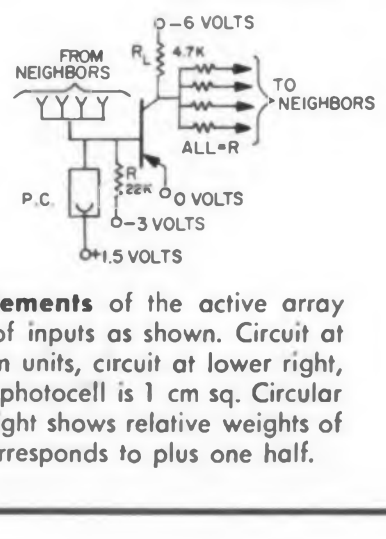




Relative weights of the various inputs to each active element, either NPN or PNP type. The threshold corresponds to +1/2



Interconnections of active elements of NUMA-rete.



Wiring of the elements of the active array permits weighting of inputs as shown. Circuit at upper left is for npn units, circuit at lower right, for pnp units. Each photocell is 1 cm sq. Circular drawing at upper right shows relative weights of inputs; threshold corresponds to plus one half.

Experience Means Organization

The result is to favor selective re-enforcement and stabilization of rewarded logic, so that the artrons become specialized with experience, and organization is promoted in the network. Spontaneity is replaced by consistency as learning proceeds, although the model will alter logic functions to meet changing environmental conditions. Chains or interconnecting circuits and feedback loops composed of artrons can evolve by this process, though present theory is limited to fairly uncomplicated cases.

The goals are pro-survival. For example, one goal may be to keep a battery—serving as a primary power source—charged. A trainer may thus charge the battery if the machine is able to recognize elementary patterns. Or the machine may run a simple maze, in a situation not including a trainer, and obtain a charge (and hence a reward) by running up against a battery charger after proper navigation. In general, for simple situations, the machine would tend to learn whatever is necessary to keep its battery charged, or to satisfy other goals which need not be specialized to particular problems. The system would be self-actuating and programed by environment to generate solutions to whatever specific problems may arise.

Bionic "Plugsucker" in Design

A similar device is being planned at the Applied Physics Laboratory of Johns Hopkins University. However, the APL "thinking" machine will be built first with a standard logical network as its brain. Layout work is now in progress on the machine, which will be programed to ride on caterpillar tracks and seek wall sockets to recharge its batteries. The "plugsucker" will be built so its original logic net may be interchanged with a second, neuron-type network. Researchers at APL expect that by observing the organization of the first network they will learn information useful in designing the neuron-analog network.

V. J. Caggiano, of APL, has built a neuron simulation based on principles suggested by recent measurements of actual neuron pulse signals. In this simulation, which is diagrammed on p 40, inhibition is accomplished by "pulling out" pulses from the train of a neuron-analog's output by nullifying the effect of a positive pulse with a negative pulse so that potential at the "synapse" of the artificial neuron is kept below threshold level.

In the APL analog, nearly all of the actual neuron's characteristics are simulated by a multivibrator circuit. APL reports that a one-shot

REPORT ON BIONICS

multivibrator gives a fair simulation of the main known properties of a neuron, except for providing an equivalent of the neuron's capability for adaptation.

In another APL project, neurons are being simulated on an analog computer. Although a great many neuron programs exist for digital computers this is believed the only analog simulation. F. F. Hiltz, of APL, who designed the program for an Electronic Associates 1631R computer, reports the use of an analog computer makes programing and wiring changes simple. The computer's capability is augmented by attachments.

The program is said to describe the complete generalized cycle of neuron activity from inadequate to adequate stimulus. As in actual neurons, spacing of pulses in the output signal of the analog computer simulation is pseudo-random. The program makes use of Polissar equations, which describe potential across a cell membrane and how potential is transferred along an axon. To include nonlinear characteristics in the simulator, which the Polissar analog equations do not describe, an attachment consisting of a series of five single-shot vibrators is wired into the computer.

General Electric researchers have reported a neuron simulation that exhibits adaptation. In this analog, which is shown on p. 40, each of the inputs is different. Adaptation is initiated within the analog whenever the integral of the output over a given time interval is larger than some specified value. This produces a short-lived state during which the firing rate of each cell is reduced.

This artificial neuron was constructed as a feasibility model that originated from company studies of neural nets. Though it is not being used at present, it has enabled the company to pursue a more ambitious project under a contract let by WADD.

Neural Activity via Electroluminescence

GE's electronics laboratory at Syracuse, N.Y. is developing a single-neuron analog that will be constructed of about 90 pairs of thin-film electroluminescent cells. Most of the elements have nonlinear characteristics, and the finished simulation will be adaptive. The device is reported to be based on equations for neural activity provided by WADD. These equations require the element to perform many multiplications

and summations, which the GE designers have decided will be done by analog methods. Because the multiplications will be analog, the company is using electroluminescent rather than magnetic thin films, which would have provided digital operation.

One of the requirements of any neuron intended for inclusion in complex networks in large numbers is that they be reproducible at low cost. GE is attempting to deposit the photoconductive thin films on glass substrates in quantities of hundreds at a time. But the problems arising from reproducibility requirements are reported to be delaying progress. In addition, the minimum size and power requirements specified by the Air Force for the completed unit are said to be hard to meet.

Quads: Redundancy at Component Level

One characteristic of biological systems appears to be the use of redundant components and circuits to achieve reliability. This idea is being exploited at Magnavox, where engineers in the company's research laboratory are elaborating on a revolutionary approach to reliability through component redundancy that reportedly originated at the University of Michigan.

The technique is to quadruple each circuit element in a closed-H configuration with two of the four identical components in parallel and two in series so that if in any circuit one component fails, three more of that component will remain to function; if two components fail, two will still function; and if three fail, the remaining component will carry on the function of the original four and will enable the parent circuit to operate at a tolerable efficiency.

The values of any components of any "quad" are chosen to give the complete quad circuit the nominal characteristics it needs to function within the parent circuit. This circuit is in turn designed to tolerate the variations that would result from failure of one or more individual components, and a similar toleration would be designed into each succeedingly larger circuit and subassembly.

The Magnavox designs, on which patents are being sought, result from a design study of a satellite communications system that was to operate without maintenance for one year. So far the company reports that it has successfully designed a family of flip-flops and AND and OR gates. Plans, reportedly, call for inclusion of these logic circuits in the company's own computers. Magnavox says that computers built with conventional techniques to the reliability achievable with quadded computers would be prohibitively large.

Other new approaches to better computer design are being uncovered by bionics research.

(continued on p 49)

The Neuristor

Or how to synthesize digital logic functions with only one element and in possibly only one plane

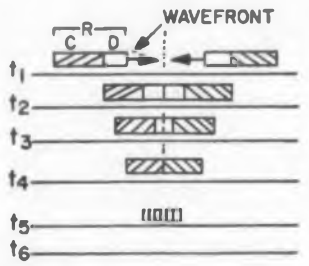
H. D. Crane of the Stanford Research Institute has postulated a neuron-like computer element called the neuristor that may make possible compact, versatile computers that would have low-power consumption and only one component.

The neuristor can be considered a two-terminal active device with some of the properties of neurons: attenuationless propagation, uniform velocity of propagation, and a refractory period. It would work this way:

Consider a two-terminal distributed active device made of a strip of thermistor material (active device) connected in parallel with an equal length of a distributed capacitor (energy storage), the parallel combination being fed, along its length, by a uniform distributed current (energy source). The distributed current source develops a uniform potential corresponding to the active region of the thermistor structure. In this condition the channel is stable. If the distributed capacity has a magnitude C per unit length, then in this equilibrium condition the channel is characterized by a 'resting' energy of $1/2\ CV_0^2$ per unit length.

If any portion of the channel is suitably triggered (elevated to its active region) the energy stored at that portion is released into the channel with a corresponding increase of temperature of the local thermistor material. The increased temperature triggers the adjacent portions of channel, which in turn 'fire,' releasing their stored energy into the channel with a corresponding rise of local temperature, resulting in the subsequent firing of adjacent portions of the channel, and so on.

In this manner, the discharge propagates at a uniform velocity and without attenuation. When the energy at any portion of the channel is discharged, that portion is 'refractory' and cannot again be fired until its associated energy storage is suitably recharged. This process is characterized in the drawing. The energy condition of the line (or channel) is shown at

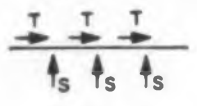


the instant of a passing discharge. For some distance behind the wavefront the associated energy storage is in various states of discharge (portion labelled D at t). Behind this region the line is recovering, the associated energy storage being (re) charged from the distributed energy source. This portion is labelled C (for charge). The over-all length of the discharge and charge regions together represents the refractory distance R. A second discharge can follow immediately behind the refractory distance, but not any closer since there would then be insufficient energy to support this second discharge.

A very important consequence of the refractory period is that two discharge waves approaching each other on the same line annihilate each other upon collision, since at the instant of collision there is zero (or low) energy on either side of the collision point and neither wave can 'pass.' This condition is indicated in the time sequence of the figure.

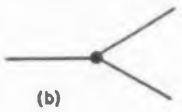
How Neuristors Interconnect

Neuristors may be interconnected in two basically different modes, defined at T junctions and S junctions. A T junction has the property



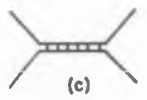
(a)

that a discharge signal reaching it on any line triggers a discharge signal on every other connected line, each signal propagating away from the junction point with uniform velocity. T-connected lines are coupled in their T variable. An S junction has the property that the refractory period following the passage of a wave on any one line is simultaneously experienced by all S-connected lines; thus, all connected lines become mutually refractive as the result of the passage of a wave on any one of them. S-connected lines are coupled in their S-variable (but not their T-variable). The connected lines share a common energy source so that a propagating signal on any one line discharges the (common) energy thereby making all channels mutually refractive (but without triggering discharge waves in the connected lines). A T junction (with three branches) is indicated by the



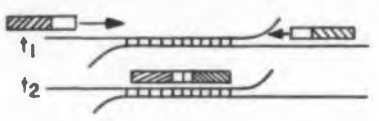
(b)

heavy dot in the second drawing. An S junction (between two channels) is indicated by the cross-hatching between the connected channels.



(c)

Before considering any simple logic arrangements it is necessary to point out that two waves approaching each other on an S junction, experience the same destructive

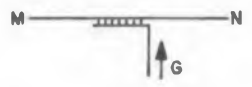


collision process as two waves approaching on the same line. The moving 'block' of D-and-C regions, symbolizing the propagating discharge, actually represents the state of energy storage. As a block moves onto an S region, the block cannot be said to belong to either line, but rather to the pair of lines, since the state of energy is always identical for each of the S connected lines. Hence, the blocks are shown on the same side of the junction, and the collision process takes the same form as already indicated in the first drawing.

How Neuristor Logic Operates

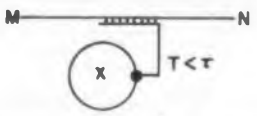
For the development of a logic system, consider first the storage of a binary variable. If a neuristor is close-looped, and is physically longer than one refractory length, then a pulse once started in the ring will circulate indefinitely. Thus the value of a binary variable can

be 'stored' in a ring with the following representation: a pulse circulates in the ring to represent the value *one*, no pulse circulates to represent the value *zero*. The state of the variable can be read via a T junction as indicated in the figure. If the ring is circulating a pulse P, each time the pulse passes the junction it generates a pair of pulse P' and P''; the latter pulse continues the circulation and the former represents an output pulse. During each 'revolution' of the pulse one output pulse is issued, so that the output line carries a uniform pulse train if the variable has the value *one*, but remains unexcited for a variable value *zero*.



A basic gate structure is indicated in this drawing. The aim is to control the MN by means of a gate signal G. Thus, with no gate signal applied, a pulse may be passed at will over the line MN. However, a single gate pulse G inhibits the use of the line for some interval of time. As long as the pulse G propagates along the S junction, no pulse may be passed from M to N since it would be sure to collide with G, resulting in the annihilation of both pulses. Define τ as the time of inhibition due to the pulse G.

To inhibit the line MN permanently it is only necessary to excite G from a pulse source whose pulse period T is less than τ. A storage ring may be used for this purpose, as indicated here, so that if variable



x=1 the line MN is permanently inhibited to use, if x=0 the line is completely free for use. The structure shown controls pulse propagation from M to N only, but symmetrical control can be obtained by use of a symmetrical gate. (Note that if $T>\tau$, then a probability of pulse passage along MN is obtained.)

This gate structure represents an elementary example of the logic facility possible with interconnected neuristors. This structure is somewhat analogous to a relay coil and an associated contact. Actually, all digital logic functions may be realized in a simple manner by the extension of this approach.

SARKES TARZIAN
SILICON ZENER VOLTAGE REGULATORS

Tarzian silicon voltage regulators, commonly called zener diodes, are constant voltage devices used to control output voltage of power sources and as voltage reference elements capable of operating over a wide temperature range. Hermetic sealing and mechanical ruggedness provide long term reliability even under the most adverse conditions.

Three power classifications cover a wide range of applications.

¼ Watt Zener Regulators

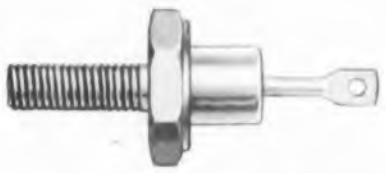
Specifications 25°C.

Tarzian Type	Zener Volt. (V)	Test Cur. (Ma)	Dyn. Imp. (Ohms)	Jedec Type
.25T5.6	5.6	25	3.6	1N708
.25T6.2	6.2	25	4.1	1N709
.25T6.8	6.8	25	4.7	1N710
.25T7.5	7.5	25	5.3	1N711
.25T8.2	8.2	25	6.0	1N712
.25T9.1	9.1	12	7.0	1N713
.25T10	10	12	8.0	1N714
.25T11	11	12	9.0	1N715
.25T12	12	12	10	1N716
.25T13	13	12	11	1N717
.25T15	15	12	13	1N718
.25T16	16	12	15	1N719
.25T18	18	12	17	1N720
.25T20	20	4	20	1N721
.25T22	22	4	24	1N722
.25T24	24	4	28	1N723
.25T27	27	4	35	1N724
.25T30	30	4	42	1N725
.25T33	33	4	50	1N726
.25T36	36	4	60	1N727
.25T39	39	4	70	1N728
.25T43	43	4	84	1N729
.25T47	47	4	98	1N730
.25T51	51	4	115	1N731
.25T56	56	4	140	1N732
.25T62	62	2	170	1N733
.25T68	68	2	200	1N734
.25T75	75	2	240	1N735
.25T82	82	2	280	1N736
.25T91	91	1	340	1N737
.25T100	100	1	400	1N738

1 Watt Zener Regulators

Specifications 25°C.

Tarzian Type	Zener Volt. (V)	Test Cur. (Ma)	Dyn. Imp. (Ohms)	Jedec Type
1T5.6	5.6	100	1.2	1N1803
1T6.2	6.2	100	1.5	1N1804
1T6.8	6.8	100	1.7	1N1805
1T7.5	7.5	100	2.1	1N1806
1T8.2	8.2	100	2.4	1N1807
1T9.1	9.1	50	3.0	1N1808
1T10	10	50	3.5	1N1351
1T11	11	50	4.2	1N1352
1T12	12	50	5.0	1N1353
1T13	13	50	5.8	1N1354
1T15	15	50	7.6	1N1355
1T16	16	50	8.6	1N1356
1T18	18	50	11	1N1357
1T20	20	15	13	1N1358
1T22	22	15	16	1N1359
1T24	24	15	18	1N1360
1T27	27	15	23	1N1361
1T30	30	15	28	1N1362
1T33	33	15	33	1N1363
1T36	36	15	39	1N1364
1T39	39	15	45	1N1365
1T43	43	15	54	1N1366
1T47	47	15	64	1N1367
1T51	51	15	74	1N1368
1T56	56	15	88	1N1369
1T62	62	5	105	1N1370
1T68	68	5	125	1N1371
1T75	75	5	150	1N1372
1T82	82	5	175	1N1373
1T91	91	5	220	1N1374
1T100	100	5	260	1N1375



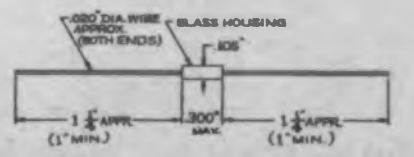
10 Watt Zener Regulators

Specifications 25°C.

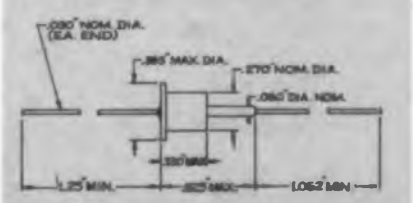
Tarzian Type	Zener Volt. (V)	Test Cur. (Ma)	Dyn. Imp. (Ohms)	Jedec Type
10T5.6	5.6	1000	1	1N1803
10T6.2	6.2	1000	1	1N1804
10T6.8	6.8	1000	1	1N1805
10T7.5	7.5	1000	1	1N1806
10T8.2	8.2	1000	1	1N1807
10T9.1	9.1	500	1	1N1808
10T10	10	500	2	1N1351
10T11	11	500	2	1N1352
10T12	12	500	2	1N1353
10T13	13	500	2	1N1354
10T15	15	500	2	1N1355
10T16	16	500	3	1N1356
10T18	18	150	3	1N1357
10T20	20	150	3	1N1358
10T22	22	150	3	1N1359
10T24	24	150	3	1N1360
10T27	27	150	3	1N1361
10T30	30	150	4	1N1362
10T33	33	150	4	1N1363
10T36	36	150	5	1N1364
10T39	39	150	5	1N1365
10T43	43	150	6	1N1366
10T47	47	150	7	1N1367
10T51	51	150	8	1N1368
10T56	56	150	9	1N1369
10T62	62	50	12	1N1370
10T68	68	50	14	1N1371
10T75	75	50	20	1N1372
10T82	82	50	22	1N1373
10T91	91	50	35	1N1374
10T100	100	50	40	1N1375

NOTES: Standard tolerance is ± 10% however, closer or wider tolerances are available on request.
Also available on request:
(a) Special voltage ratings.
(b) Symmetrical double anode types (for clippers).

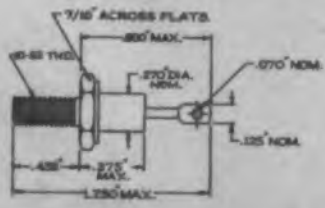
DIMENSIONS



DIMENSIONS



DIMENSIONS

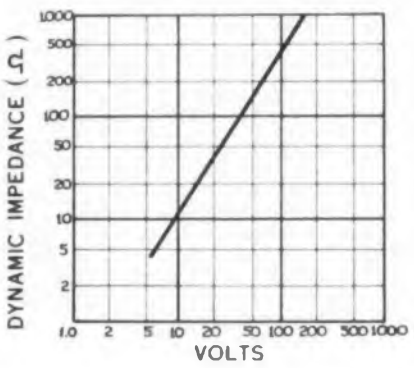


SARKES TARZIAN SILICON VOLTAGE REGULATOR ZENER DIODES
Characteristics and Application

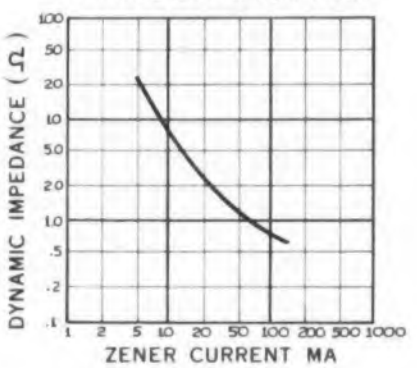
Dynamic Impedance

Dynamic impedance is a measure of voltage change effects on operating current and provides a practical measure of regulating performance. Dynamic impedance is measured by superimposing a small AC current upon the DC test current and measuring the resultant voltage across the diode.

The following curves show the effects of voltage and current on dynamic impedance.

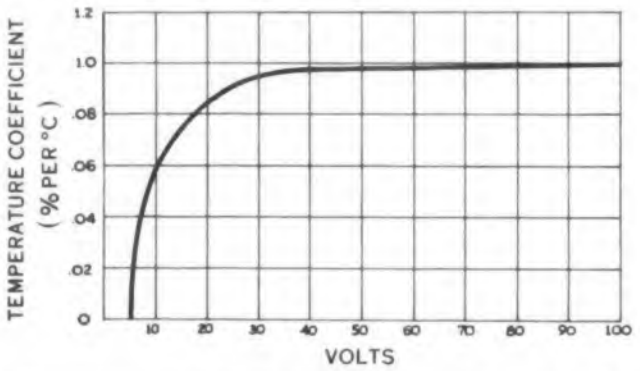


TYPICAL CURVE FOR 1T7.5



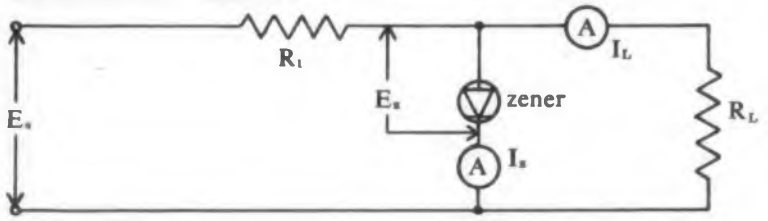
Temperature Coefficient

The operating voltage of a silicon regulator changes with operating temperature. This characteristic must be considered in design. The following curve shows temperature—voltage relationships typical in silicon zener diodes.



Typical Application

REGULATOR CIRCUIT



As the input voltage increases the inverse bias across the zener diode will increase and cause a large current to flow. This increase will cause more current to flow through R_1 and increase the drop thereby adjusting the load voltage. Load variations have a similar effect. The result is a substantially constant output voltage.

Determination of R_1 is as follows:

$$R_1 = \frac{E_s - E_z}{I_z + I_L}$$

$$I_z = \left(\frac{E_s - E_z}{R_1}\right) - I_L$$

$$P_z = \left(\frac{E_s - E_z}{R_1} - I_L\right) E_z$$

Where:

R_1 is the series resistor
E_s is the source voltage
E_z is the zener diode voltage
I_z is the zener diode current
I_L is the load current
P_z is the zener diode power dissipation

Where the load current and input voltage are variable:

$$R_1 = \frac{E_s\ (\text{min.}) - E_z}{1\ (\text{max.}) + .1 I_L\ (\text{max.})}$$

$$P_z\ (\text{max.}) = \left(\frac{E_s\ (\text{max.}) - E_z}{R_1} - I_L\ (\text{min.})\right) E_z$$

For constant load current but variable input voltage:

$$R_1 = \frac{E_s\ (\text{min.}) - E_z}{I_L + .1 I_L}$$

$$P_z\ (\text{max.}) = \left(\frac{E_s\ (\text{max.}) - E_z}{R_1} - I_L\right) E_z$$

For constant input voltage but variable load current:

$$R_1 = \frac{E_s - E_z}{I_L\ (\text{max.}) + .1\ I_L\ (\text{max.})}$$

$$P_z\ (\text{max.}) = \left(\frac{E_s - E_z}{R_1} - I_L\right) E_z$$

NOTES: The above equations allow a tolerance of 10% to compensate for load regulation.
If dynamic impedance is a significant percentage of the value of R_1, this must be taken into consideration.
A high impedance source presents additional problems and must be considered if it is significant compared to R_1.

At Stanford Research Institute, a program is under way that may result in a new logical component promising to make possible the synthesis of conventional and unconventional digital logic functions with arrays of only one neuron-like element. This component is called the neuristor by H. D. Crane who hypothesized it and who is now completing a mathematical model of its behavior. Though so far hypothetical, the neuristor may be realized as a distributed two-terminal active device in the form of a length of thermistor or four-layer diode material.

The neuristor (see box on p 48 for detailed description), has attenuationless propagation, uniform velocity of propagation, and a refractory period. These are also the gross properties of the axon portion of a biological neuron. In the neuristor, a signal is propagated along a one-directional channel as a discharge. Following the discharge is a refractory period during which a second discharge cannot be supported. Therefore, the neuristor may be considered a distributed version of a chain of suitably interconnected lumped-circuit monostable circuits.

Homogeneity Called Key to Neuristors

Mr. Crane calls homogeneity the key characteristic of neuristor systems. On one level neuristors are homogeneous because, as a totally distributed active-passive structure, they are both device and wire in one. Also, as mentioned, logic networks can be derived with neuristors only, with no passively interconnected active lumps.

Another form of homogeneity results from information signals throughout the system being describable in identical variables. There are no transducers; there is only one technology involved in the whole system.

Still another form of homogeneity exists, Mr. Crane reports. With neuristors, any digital logic system, planar or not, may be realized in a two-dimensional plane. Neuristors need not cross in three dimensions, but may be made to connect in a plane while preserving non-interacting propagation properties.

Mr. Crane's work is being supported by the Office of Naval Research.

Perceptron Research Expanding

Of all bionics projects, the most advanced in development, and the most widely known, are those connected with perceptron research. Perceptrons are systems of particular types capable of performing cognitive functions such as recognition, classification and learning, either theoretically or in actual practice. They may exist as mathematical analyses, computer programs or as hardware. They are self-organizing systems based on principles believed operative in the

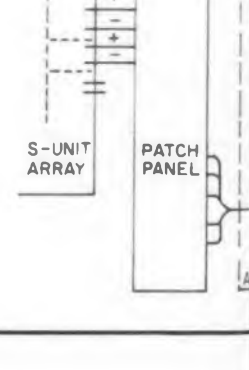
REPORT ON BIONICS

The Original Perceptron

Now hard at work on bionics research

Organization of the famous Mark I perceptron built at Cornell Aeronautical Laboratory is shown in this simplified schematic. The sensory S-units translate the stimulus pattern shown to the perceptron by an array of photoresistive cells into a set of discrete signals. The photocell currents actuate transistor-driven relays which supply the excitatory and inhibitory (plus and minus) S-unit output signals. Each photocell that receives sufficient light supplies both signal polarities to a large patch board. Because 20 output connections are available for each signal from an S-unit and there are 400 S-units, with bipolar outputs, the randomly connected patch board has 16,000 available output connections.

The A-unit inputs are transistor-driven relay circuits with a common threshold. They are data-digesting units so connected and numerous that their responses constitute a statistical analysis of input information. When an A-unit becomes active, its relay closes and connects the A-unit to the output; it connects the integrator and applies voltage to an indicating lamp. Each A-unit integrator consists of a d motor driving a potentiometer. The voltage o the potentiometer arm provides a measure o



human brain, and have as their basic element neuron-like components.

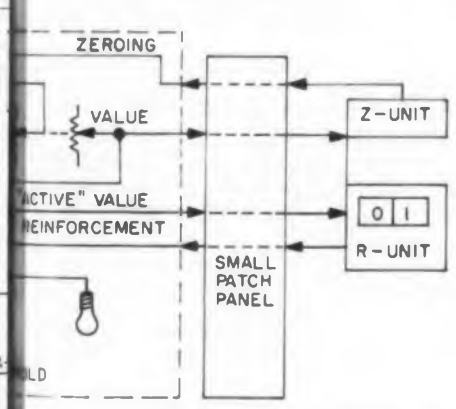
The original perceptron, developed by Dr. Frank Rosenblatt, of Cornell Aeronautical Laboratory, grew from a mathematical, to a computer, to an electronic, model. It is now used for experiments in further perceptron research by teaching it to recognize and classify visual images (see above).

As an approach to designing an adaptive perceiving machine, the original, Mark I perceptron has proved remarkably successful, in the opinion of many. In addition, it has led to much analyti-

an A-unit value. A second potentiometer on the same shaft provides a local feedback loop to allow decay of the A-unit value with time. Normally, the decay voltage is applied only during the resetting of the A-unit to its zero position for the start of tests. There are 512 A-units in the Mark I perceptron; Mark II, now in design will have many more.

The R-units are two-state devices consisting of a dc amplifier driving a relay. The R-unit input signal is the sum of a set, the source set, of A-unit outputs. They complete the sequence that makes the perceptron's over-all response a function of input patterns stimuli. The R-unit provides a visual indication of this state, which is actually the perceptron's output. It also transmits a reinforcement signal to its source set of A-units. This is done by a human operator during training. If an R-unit decision is incorrect the operator forces the perceptron to correct its decision, which it does by feedback signal to the integrator motor of each active A-unit to cause it to reset its potentiometer.

During training, the signal paths which are frequently active for one class of training patterns tend to have their value settings frequently modified. This becomes a selection process leading to some A-units acquiring a stronger or weaker voice in each of the various response cliques to which their connections relegate them. There are eight R-units on the Mark I. Originally built to verify mathematical analyses of perception operation, the Mark I electromechanical perception now successfully recognizes patterns with the help of an operator who forces it to make the right identification decision if the machine errs. The perceptron can identify all letters of the alphabet after 15 exposures of each, if its operator corrects mistakes during training. Bank of relay-driven A-units is shown.



cal and design work at more than a dozen organizations. Two similar experimental adaptive machines have been built that are said to be capable of perception.

One built by Aeronutronics Div., Ford Motor Co., to learn logic functions, operates similarly to the Mark I perceptron but uses modified Biax magnetic core components as storage units to give non-destructive readout (see box, p 52).

The other, an "adaptive reorganizing automaton," exists in an early version at the University of Illinois, and appears to be the most adaptive machine yet built. Its basic neuron element is

REPORT ON BIONICS

capable of active operation, in which it makes trial-and-error searches for the proper response, in contrast to the CAL and Aeronutronic machines (and a Litton Industries design not yet built), which have neurons with relatively passive characteristics. These must be pulsed into responding to stimuli.

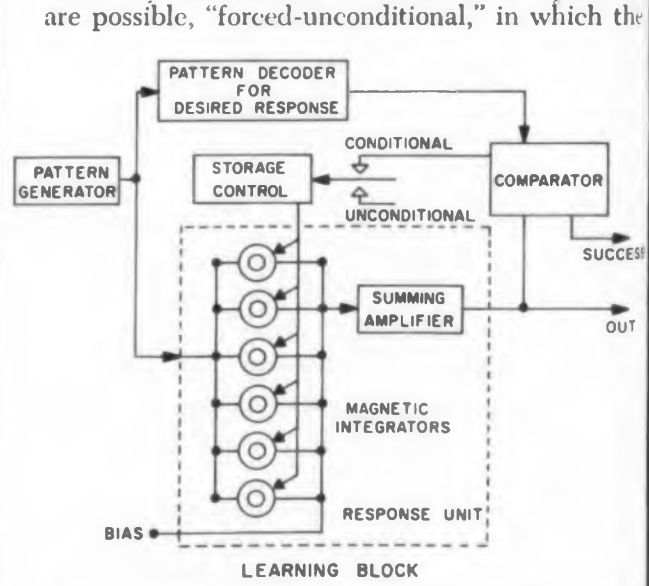
In addition, the "automaton" built at the University of Illinois is designed to take inputs from

Miniature Perceptron Learns Logic; Has Non-Destructive Readout

This learning machine built by Aeronutronic Div., Ford Motor Co., learns logic functions by recognizing all possible patterns of five bits. It is a stripped-down version of a perceptron, with only six "w" or storage units connected in a six-input, one-output, single-logical-level network.

The units are storage units, which correspond to the motor-driven integrators of the CAL perceptron, Biax magnetic integrating elements modified to give the device a linear, non-destructive readout. The modified element is able to read out a signal proportional to the stored flux, to permit use to be made of information stored in the component. This can be done because the orthogonal field of the modified Biax is not uniform throughout the element's cross-sectional area.

In the Aeronutronic machine shown, output of each neuron-type network is either 0 or 1 in response to each five-bit input combination presented by the pattern generator. This output is dependent on pattern, stored weights, and threshold level. Desired output is set into the decoder. In the complete system, weights of the integrating units adjust to cause the output of the learning block to agree with the desired output produced by the decoder. Two modes of operation are possible, "forced-unconditional," in which the

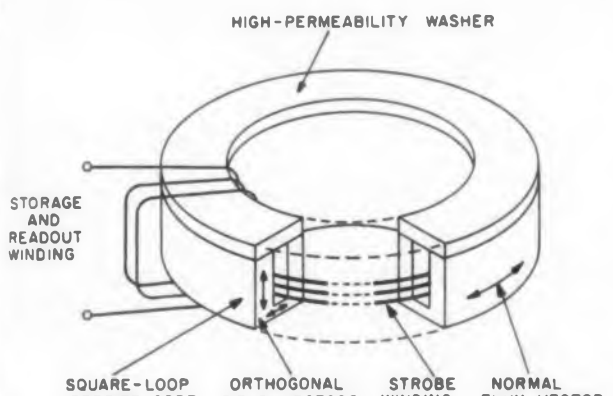


How modified Biax elements are connected in learning block of Aeronutronic perceptron.

a sensing unit capable of property filtering (see p 44). Aeronutronics is starting construction of a perception machine similar to the logic-function unit but capable of property filtering.

On the drawing boards at CAL is a Mark II perceptron that is planned to have a greater number of neuron-like elements than the Mark I and which will interconnect them, to more closely simulate brain organization. It will probably also use Beax-type magnetic cores that will give the Mark II about 20 times the memory capacity of the Mark I.

According to Prof. H. M. von Foerster, of the University of Illinois, who heads the team of researchers at the university's biological com-

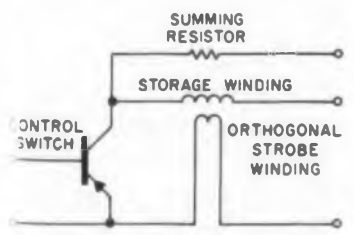


In this modified Biax element, orthogonal field is not uniform throughout cross-section.

storage units change value with each input pattern, according to a logic table, and, "forced-conditional," in which values change only if the decoder signal disagrees with that of the learning network.

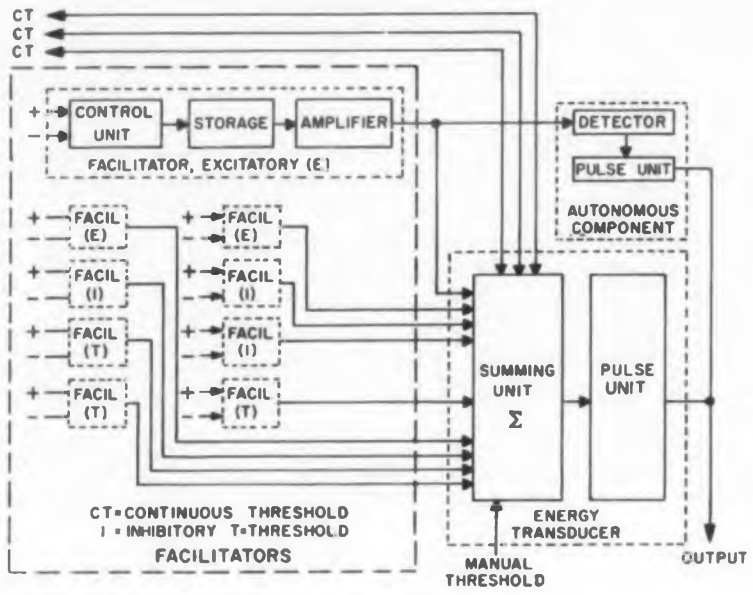
The summing amplifier is a Kirchoff adder; the comparator adds a signal to a sum and detects and amplifies the resultant voltage; logical output is obtained by transistor-gating one of two clock signal sources onto the output bus.

Aeronutronic is now designing a larger version of the learning machine which will have 100 neuron-type biax elements, and, unlike the Cornell Aeronautical Laboratory perceptron, will be interconnected non-randomly. In addition, its input array of photocells will have property-filtering capability.



Schematic of integrator includes one resistor for summing.

An Active Neuron and the Automaton it Serves



This "elementary unit" of the University of Illinois "adaptive reorganizing automaton" is believed to be the only neuron simulation that is truly active—one that gives a response when there is no stimulus. It is the basic building block of the adaptive machine, which has learned to recognize such situations as a person walking from left to right across the field of its photocell retina.

The neuron analog in the block diagram shown above is composed of three basic units and is shown connected in one of a great many possible arrangements. In this neuron, there are three each of excitation, inhibition, threshold, and continuous threshold inputs, and one output, on the energy transducer unit. In addition, there are two inputs (plus and minus) and one output on each facilitator unit, for a total of 21 inputs and one output for only three basic components.

Each of the components is flexible. The energy transducer, which corresponds to a neuron cell body and assimilates information from all parts of the automaton, can serve as an OR or an AND circuit, a summing circuit, a pulse-repetition-rate divider or multiplier and in many other functions. Its summing unit exercises a control function; its pulse unit generates a standard pulse when the input signal exceeds threshold.

The autonomous unit triggers the energy transducer and makes possible the active operation of the neuron simulation. Its detector unit is basically a pulse inverter. Its pulse unit has an internal control potential that increases in the absence of an input until it exceeds a threshold and triggers firing of an output pulse, which starts another cycle.

The facilitator unit, reportedly the most difficult-to-design circuit in the automaton, corresponds to the synapse of a biological neuron—in function, the plastic storage element of the cortex. The facilitator gives the automaton its ability to change its function with regard to its environment, past or present. It is a variable conductance unit which varies to increase the ability of information to flow over a path between two points when that path was used more than other paths, and is also a unit which remembers or stores this used information (not the information transferred)—for periods measured in hours.

puter lab, perceptron or adaptive machines involve a tradeoff of complexity between that of the elementary neuron component and that of the machine as a whole. If the basic component is relatively simple, greater numbers of them have to be included and their interconnections have to be more complex. He believes such machines of the future will have relatively few but more complex and active trial-taking components, property filtering capability and the ability to forget adaptively.

Researchers at Cornell Aeronautical Laboratory, however, believe that future perceptrons may have hundreds of thousands of neuron-like elements. Such a quantity may make neuron-based machines very useful in industrial, military and many other applications, but would fall far short of the 10^{10} neurons believed contained in the human brain.

In commenting on the present perceptron, Dr. Frank Rosenblatt, of CAL, sums up the state of much bionic designs as he says, "The perceptron has been kept consistent, as far as possible, with current anatomical and physiological data on the number of neurons, logic of connections, degree of individual unit reliability, random variation in 'wiring diagram,' and types of signals employed in biological systems.

"The fact that a system which is consistent with these constraints begins to show some of the 'psychological' properties of biological systems suggests that we may possibly be on the right track in trying to understand the operation of such systems, but it is by no means conclusive. Viewed as a biological model, the perceptron is entirely hypothetical, and still requires experimental confirmation before any real claims can be made for it."

Making these comments, Dr. Rosenblatt speaks for many workers in bionics, who realize that only the surface of biological knowledge is being scratched for electronic applications. But unsure foundation notwithstanding, a substantial amount of developmental bionics work is going on.

In bionics there already is a state of the art and researchers are looking forward to the next generation of projects. A New York company is designing an airborne ground-speed indicator after the sensory, correlation, and control features in the navigating system of the Beetle. The Navy is thinking about a billion-gate bionic computer, and at the University of Illinois, researchers hope to interconnect electronics equipment with living creatures to bypass the design of analogs.

Bionics has a present, and appears to have a bright future. ■ ■

NEWS

Radiation Effects on Components Studied With New Army Reactor

Radiation effects on military electronic components are being studied with a new research reactor. The reactor, capable of providing short pulses of intense nuclear energy, is being built by the Army's Diamond Ordnance Fuze Laboratory and the General Dynamics Corp.

The pulsed Training Research Isotope (Production) General Atomic reactor (TRIGA) is designed to produce intense but self-limiting pulses of neutron and gamma-ray radiations for short periods at repeated intervals.

The TRIGA reactor core will be suspended from a movable carriage, permitting the exposure of samples in either a dry, shielded exposure room or a water-filled pool. Lead shielding doors separating the exposure room from the pool irradiation area can be closed to give access to the exposure room while the core is being used for other experiments in the pool.

SEIC Issues Newsletter For Military, Civil Readers

A newsletter, highlighting events in solar energy of interest to the military, is being published by the Solar Energy Information Center.

SEIC has been established at the U. S. Army Signal R&D Laboratory, Fort Monmouth, N.J., under the direction of the Department of Defense. The Laboratory's Power Sources Div. directs this Center for the purpose of collecting, collating, analyzing, and disseminating technical information on projects, programs, and research activities in the three military departments and those civilian organizations concerned with the collection and conversion of solar energy into forms suitable for military use.

The newsletter will emphasize those materials and processes which are related to the conversion of solar energy to electrical power. Technical information in other areas in the field of solar energy, such as heating, cooking, distillation, photosynthesis, will be reported when it may be related to the military services. Other items will also be reported.

Contributions from those persons engaged in research and development work relating to military applications of solar energy, should be sent to: SEIC Newsletter, Arizona State University, Tempe, Ariz. Requests for copies of the newsletter should be addressed to: Commanding Officer, U. S. Army Signal R&D Laboratory, Fort Monmouth, N.J., Attn: SIGRA/SL-PS.

NEWS

Mobile TV Tape Recorder Used in Army Classrooms

Mobile TV tape-recording equipment is providing live quality TV pictures of vehicle maintenance demonstrations and other training activities for classroom viewing at the Army Transportation Training Command School at Fort Eustis, Va.

Tapes are played back over a closed-circuit TV system linked to 22 classroom receivers. In addition to two mobile units, the school's TV facilities include a main studio, equipped with three RCA cameras, for live programming and slide and film presentations.

The tape-recording equipment has enabled the Army to build a library of instruction courses on a wide variety of transportation subjects, with pictures of live pickup quality recorded at widely-scattered points on the post. Also they have a permanent record of individual presentations which are readily available for classroom use when an instructor is occupied with other duties.

The recorder is carried in a specially designed van which provides space for both the recorder and allied control equipment. A second mobile unit, equipped with two RCA cameras, is used for live pickups from maintenance, repair, and other work areas, with pictures relayed over the closed circuit hookup. The units can be operated independently, or used in tandem for remote spot pickups and simultaneous recording of training scenes.

Symposium on Space Electronics To Be Held in Washington in Fall

The Professional Group on Space Electronics and Telemetry will sponsor the Fifth National Symposium concerning this field at the Shoreham Hotel in the nation's capital on September 19-21. This year's symposium will emphasize discussion of new design philosophies and advances in the state of the art.

The program is organized around ten panel sessions, each directed by a chairman prominent in a particular technical field. Plans are to prepublish the panelists' papers in the symposium proceedings and limit paper presentations to highlights.

A brief summary indicates there are many well known panelists on the program such as Dr. Lawrence Rauch, University of Michigan; Dr. Sonnett, Space Technology Laboratory; David Hogg, Bell Telephone Laboratory and Dr. Eberhardt Rechtin, Jet Propulsion Laboratory.

Scandinavian Science Center Established in Washington, D.C.

A Scandinavian Documentation Center, SCANDOC, has been opened in Washington, D.C. Its purpose is to further the mutual exchange of scientific and technical information and documentation between the Scandinavian countries on the one hand, and the U.S. and Canada on the other.

SCANDOC is a non-profit organization, rendering free service to all interested parties and it is financed and directed by the Research Councils and Science Academies of four Scandinavian countries through their common Scandinavian Council for Applied Research.

Headed by Arne Sverdrup, SCANDOC will procure non-classified and non-confidential documents and information and channel this to the respective interested countries through information offices organized under the research councils and academies of the countries. It is the first time that an international office of this kind has been established in Washington.

Titan's Underground Launcher

Titan ICBM check-out missile is in firing position in the underground launcher designed and built by American Machine & Foundry Co. of New York. The missile is fueled and guided from the underground launching complex. During the last few minutes of the countdown the doors open and the missile raised to ground level for launching.

NEWS

Magnetic Videotape Employed On Undersea Video Recorder

An undersea magnetic videotape recorder is being used aboard the U. S. nuclear submarine Sea Dragon. The videotape will record and store data on under-the-ice characteristics of icebergs and ice flows through use of externally installed TV cameras. The recorded information will be used to speed navigation training of U. S. Navy submarine personnel.

According to the developers, Reeves Soundcraft Corp. of Danbury, Conn., Soundcraft magnetic tape was also used in the development of the Radio Corp. of America undersea recorder. The recorder itself has been transistorized and is approximately 60 per cent smaller than existing videotape recorder equipment. It is reported small enough to fit on a torpedo rack.

Five Major Computer Makers To Cooperate at Business Show

Five U.S. manufacturers of data-processing equipment will exhibit nearly $2 million in equipment at next fall's National Business Show in New York City.

A special exhibit, called "The CompuCenter," will include the following, according to present plans: the Bendix G-15 general-purpose digital computer and a line of accessory equipment, Control Data Corp.'s Model 160 computer and Model 180 data collector, Philco S-2000 general-purpose data-processing equipment, RCA 501 data-processing equipment, and Remington Rand's Univac 90.

The National Business Show will be held in the New York Coliseum from Oct. 24 to 28.

Digital Servo System Under Development at Lear

A digital servo system is being designed and developed by Lear, Inc. of Grand Rapids, Mich., under a contract from the Lockheed Missile and Space Div.

This phase in ground-support equipment involves servo driving and controlling the tilt and translation of a mirror system capable of assuming 200 positions in each of two axes. A memory-tape device provides automatic sequencing and instantaneous readout of all positioning data. Digital-control techniques are used throughout, and an error detecting system is a part of the design.

The control panel offers an automatic mode

commanded by a tape, a pre-select mode and a manual mode using push-button and dials. According to Lear, it is designed in accordance with the latest human engineering specifications. A precision gear train drives a digital shaft encoder for the tilt axis and another is provided for the translation axis. A block-type reader reacts to a prepunched tape using the binary decimal system.

The design calls for off-the-shelf items of digitalized hardware and circuitry. Solid state components and miniature relays are specified to achieve a minimum package.

First Suit Designed to Protect Against RF Radiation Is Tested

A suit designed to be worn by workers in areas of high-density rf radiation is undergoing final tests by its designers.

Leonard Milton, vice president of Filtron, Co., Flushing, N.Y., which developed the suit, reports that the garment is the first one developed for protection against the hazards of rf radiation. The garment is said to give protection in environments of 10 w per sq cm—10,000 times the limit set for Air Force personnel.

The outside covering of the four-layer garment is neoprene-coated nylon, which encloses a double interlining of coarse, dence nylon mesh. Thread filaments of the mesh are treated to reflect and absorb radiation. The inner lining is nylon silk. A wire mesh visor protects the faces.

The suit is a one-piece garment with integral socks and mittens. It requires assistance to get in and out of it, Filtron reports.

Suit to protect against high-density rf radiation is made of neoprene-coated nylon with nylon linings. Visor is wire mesh.

"Electronic Packaging" and Gracious Living

While some designers are busy with space flights, others are busy with flights of fancy in creating housings for home electronic equipment—stereo, radio, and television. To demonstrate that the living room or family room need not be dominated by the Cyclops eye of the TV set, Westinghouse enlisted the aid of top U. S. interior decorators to create rooms in which electronic products would "find a home." The results, in a show at the National Design Center in New York, are shown on these pages.

Stereo blends into Old-Boston-inspired music room.

Miniature armoire holds dining-room TV in French Provincial dining room.

Traditional stereo design against contemporary wall.

Early-American design in stereo set fits into Southwestern decor.

Radio is an integral part of office.

Stereo rectangles balance modular wall.

NEWS

Ammonia Batteries Suggested For Stand-By Satellite Power

Automatically activated ammonia batteries may play a role in outer space vehicles, especially as a stand-by source of power.

This possibility was raised at the Pacific General Meeting of the AIEE in a paper—Reserve-Type Ammonia Electrochemical Systems as Secondary Electric-Power Sources for Space Vehicles. It was presented by H. S. Gleason and G. S. Gunnison, of the Eastman Kodak Co., Rochester, N.Y., during a symposium on power sources.

Advantages of the ammonia battery were given as:

- Hermetically sealed cases make the battery operation independent of external pressure.
- Long unactivated storage is practical because of the hermetically sealed cases and the reserve system of electrolyte distribution.
- Operation is feasible over a wide temperature range and short time and high-rate discharges can be obtained with good recovery from large transient currents.

It was explained that although primarily aimed at extreme low-temperature operation, the ammonia system, operating as reserve batteries, have some characteristics that should be of use to space vehicles in general. Hermetically sealed in containers capable of withstanding space conditions, there would be no trouble with gas or electrolyte leakage.

The ammonia filling systems are usually contained within the battery case itself and require only an electrical pulse or a mechanical motion transmitted through a diaphragm or bellows to activate. Call construction is extremely rugged and should handle any of the accelerations and vibrations encountered in launch, as well as later impacts.

Storage life is unusually long and the batteries will operate from well below —65 to 160 F.

Texas Instruments' ASR-4 Radar Slated for 34 Air Terminals

Installation of the ASR-4 radar, developed by Texas Instruments of Dallas, Tex., is planned for 34 airports during the next year and a half.

The ASR gear will aid the Federal Aviation Agency's traffic controllers in directing planes, especially jets, safely through the heavy air traffic around major airports. These radars have

Effects of moving target capabilities of Texas Instruments ASR-4 radar are shown in display.

Ground clutter is displayed in a metropolitan area. Little changes will be noticed with successive sweeps of the radar beam.

a range of 60 miles, reach an altitude of 25,000 feet.

With the new FAA radar, controllers can pick out individual airplanes on the scope. Controllers will have a choice of several types of improved presentation on the 16-in. TV-like picture tubes. They may see fixed and moving objects or moving objects only.

This FAA radar is designed to provide 24-hour safe guidance to pilots. Flexibility and precise control information are given air-traffic controllers by means of an electronic map which shows navigation aids and ground installations. When set to present moving objects only, ground clutter is eliminated.

Modernization kits will improve older-model airport radars so that another 48 cities will have operational capability equal to the ASR-4 in most important functions.

NEWS

Device Maintains Mace Missile On Round-the-Clock Alert

A rotary power conversion Unit can keep the TM-76B Mace tactical missile alert around the clock. The device was described by J. A. Hedges, The Martin Co. of Baltimore, Md., and G. O. Williams, Hobart Brothers, Inc. of Troy, N.Y., in a paper, Precise Rotary Power Conversion for Ground Support of Aero-Space Vehicles, presented at a space symposium during the Pacific General Meeting of the AIEE.

The unit, which was developed for 24-hour continuous service with the missile, allows 0.01 sec for voltage recovery when full-rated load is suddenly applied or removed.

Heretofore, the engineers explained, there has been little call for precise direct current power of less than 100 v, but the advent of aero-space vehicles of the immediate future is "bringing stringent demands for precise 28-v sources during preflight checkout.

"Mace's theory of operations is to be partially counted down and ready to go on a few minutes' notice," the paper said. The guidance system and its associated electronic and servo controls must be energized at all times with precise dc ground power subject to the limitations of voltage between 25 and 29 v, voltage stability of plus or minus 5 per cent, recovery following transients to plus or minus 2 per cent of steady-state voltage in 0.01 sec or less.

To meet these conditions, Martin subcontracted the design and production of a rotary power conversion type generator to convert 440 v, three-phase, 60-cycle power in 29 v, with superior qualities, including high reliability.

Packard Data-Processing System Installed At Brooklyn Shipyards

An analog-to-digital conversion data-processing system, developed by Packard Bell Computer Corp. of Los Angeles, is in use at the U. S. Naval Shipyards at Brooklyn, N. Y.

The system is used to gather data in real time and convert it to digital form. After conversion, the data are used in the solution of the inertial navigation problem of the Navy's long-range missile ships.

Seventeen analog voltages representing acceleration and velocities and data from 30 shaft position encoders are provided as inputs to the system. After digitization, the data are inserted

into a 14-bit shift-register, the contents of which are added to a previously accumulated value and then read out from one of the 17 36-bit accumulator channels. The multiplexer allows periodic readout of various accumulator channels under control of the timing and control unit. The shaft encoder inputs provide a parallel digit readout proportional to the average angular displacement of the encoder shafts, over a 6-min interval.

After each readout cycle, once every 6 min, data derived from the input analog signals, from the parallel digital encoders, and from the serial pulse train are punched on tape. Time of readout and a system self-check record are generated internally and also recorded.

Atom-Powered Electronic 'Sentry' Under Development at Martin Co.

An automatic electronic "sentry," powered by nuclear energy and capable of recording data and transmitting it from a remote ground location, is under development at the Martin Co. The device is reportedly capable of operating for at least two years without refueling or servicing.

The device will be linked with weather instruments to measure temperature, wind speed, wind direction and barometric pressure; but it could be modified easily to detect seismic disturbances or to record continuously any other type of information in a remote area.

Energy will be supplied by a 5-w generator, which will convert heat from safely enclosed pellets containing Strontium-90 directly into a continuous flow of electricity. The complete data processing and telemetry station is scheduled for completion by early 1961.

The generator will be similar in principle to the SNAP 1-A and SNAP-3 units also built by Martin. The difference in temperature between the hot fuel cylinder and the outer wall produces a flow of electricity in sets of thermocouples connecting the two surfaces.

In the telemetry station the output of the generator will be used to recharge conventional nickel-cadmium storage batteries. Besides translating the measurements into electronic code form, the station will use a sudden burst of power every three hours to broadcast the data to a manned listening station hundreds of miles away.

The Martin Co. is developing the device under a contract from the U. S. Atomic Energy Commission.

EDITORIAL

Bionics—A New Discipline Emerges

For electronic designers of the future, the phenomena behind the pigeon that homes, the bat that navigates by echolation, and the frog that jumps according to light patterns will be as important as Maxwell's equations. These and other processes of Nature are already being applied to designing new electronic components and computers by specialists in bionics—the name for this new discipline. This broad new field of endeavor is comprehensively covered by ELECTRONIC DESIGN's Staff Report which starts on p 38.

Here for the first time is information on such concepts as the neuristor, property filters and the redundant quad. And so new are some of these developments that specialists in one laboratory are completely unaware of the efforts in another. Establishing communications between bionics experts is a big problem. Establishing a sound foundation—an organized body of information for developing experts—is an even bigger problem. Specialists in life sciences and physical sciences must understand one another.

Major Jack E. Steele of the Bio-Medical Laboratory of Wright Field—Mr. Bionics to the workers in this field—appraised the situation for ELECTRONIC DESIGN this way: "Biologists know a great many answers but very few questions—particularly questions of interest to electronic designers. In too many laboratories where biologists and engineers work together, the engineers help the biologists, rather than the other way around. Together they have to find problems that engineers and animals have in common and which the animals solve better. Only then can a way be found to adapt and adopt the animals' solution. When this is done on a large-enough scale, the character of electronics may change."

Progress in the field of bionics may very well change the character of electronics. One need only read about the neuristor to be convinced of that. Bionics is a new concept—at once a device, a machine, a system. It cannot be ignored.

(n_f/cm^2)

Guidelines In Designing For a Nuclear Environment

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Design engineers are often at a loss in applying the data scattered throughout the literature describing radiation effects on electronic components. They are confused by differences in units of measure used from report to report, and confounded by differences in gamma-neutron mix encountered from reactor to reactor. Often, the non-radiation environment parameters, which can completely change the damage picture, are not adequately specified.
In this article, P. Miglicco (left) and M. Newell emphasize environmental parameters, while the radiation doses are expressed in the very basic and easily measured units of fast neutron per square centimeter (n_f/cm^2). Test results are given for many materials. Many valuable tips are given in this article for applying these findings to design problems.

THE RADIATION environment has a definite influence on the standard procedure for electrical design. The eight stages normally involved in developing an electronic system are as follows:

1. System requirements
2. Block diagram
3. Circuit sketches for each block
4. Circuit breadboards
5. Circuits, developed to satisfy electrical requirements
6. System prototype
7. Final units, built and electrically checked
8. System test, under required environmental conditions.

Between stages 3 and 4, a major step is missing. It is: "Find the components which satisfy both the electrical and environmental requirements which the system must meet." This step is present regardless of the type of environment required. The degree of difficulty incurred lies in the amount and types of information available.

To satisfy a design problem for a radiation application today, a designer must arm himself with all available radiation effects data on materials, components, systems, and with a radiation effects "Yardstick." Theoretical methods of predicting radiation damage can be used only for simple materials. In the area of commercial materials and components, the gap between theoretical predictions and experimental results has not been bridged.

Parameters which influence the degree of damage in electronic components include the total dose, types of particles, average energy, intensity of the field, temperature, humidity, and atmosphere. Among the damaging particles, the two major contributors to radiation effects outside the reactor shield are neutrons and gamma rays. Convair's present electronic components program, conducted for the U. S. Air Force, is designed to separate the effects of the various nuclear parameters. This information will facilitate:

1. Solutions to system and components shielding problems
2. Optimum location or orientation of equipment within a vehicle with respect to the nuclear power plant
3. Economical and efficient proof-testing
4. Prediction of system life.

Non-Nuclear Parameters Can Greatly Influence Effects of Radiation

An example of the importance of atmosphere in radiation damage studies is the irradiation of natural rubber. When irradiated in air, the rubber cracked and decomposed from the attack of ozone. When protected from air, the rubber withstood a higher radiation dose before breaking down. The concentration of ozone, which is always present in air, is increased through the conversion of oxygen by the radiation field. Fortunately, few materials are as sensitive to ozone degradation as natural rubber.

Temperature is a parameter that must be given consideration for two reasons. The first is that frequently the type of damage due to heat is the same as, or very similar to, that due to radiation. A failure in a radiation field, may come much sooner if the component is at a marginally high temperature during the irradiation. The second reason is the problem of gamma heating. In any bulky system exposed to a gamma flux of over 5×10^{12} γ/cm^2-sec, gamma heating may be a serious problem. The amount of energy absorbed in the form of heat is a function of the density of the materials in the component. The maximum temperature is determined by this and by the heat dissipation factors. These factors depend on the size and configuration of the component and on the ambient air temperature.

A good illustration of the magnitude of this problem is shown in Fig. 1. A sheet of one-inch lead was used as shielding in a radiation test. When exposed to a gamma flux of 2×10^{13} γ–

cm^2 sec, a hole developed after 1.6 hr of radiation. Heat generated by the flux melted the lead.

Radiation Can Cause Either Transient Or Permanent Damage

Radiation effects on materials and components may be divided into two basic types—transient and permanent. A transient effect denotes response of a component that varies with dose rate. In addition, the response of the component returns to normal immediately after removal of the radiation field. Fig. 2 is an example of a pure transient effect. Here we see the dark current response of three different reactor power levels for an average time of 6.1 minutes per level. After irradiation, the dark current returned to its pre-irradiation value.

One of the transient effects which is very dose-rate sensitive is that of air ionization. This phenomenon can be very troublesome in dielectrics exposed to a flux of 10^{10} n/cm^2-sec or greater: a normal 10^{15}-ohm insulation resistance may very well be reduced to 10^7 ohms, depending on the geometry of the collecting electrodes and the electric field strength. Fig. 3 shows that the insulation resistance of mica, Glassmike, and ceramic capacitors decreased by factors of 100, 55 and 10, respectively. The change in insulation resistance during irradiation is due to air ionization and depends on electrode area and separation.

The collecting electrodes are the ends of the capacitors. This explains the different values and the order of increased resistance in Glassmike, mica, and the ceramic tubular. The increase in insulation resistance of the ceramic capacitor during irradiation is believed to be due to a residual charge on the dielectric from previous voltage applications. Post-irradiation recovery was immediate, portraying a transient effect.

A permanent effect denotes a change in response which remains after removal of the radiation field and in general is a function of the total dose received. This effect is illustrated in Fig. 4. Here the forward resistance of the 1N91 germanium diode is shown to increase as a function of the total dose received until it reached some type of damage saturation. The data taken with the radiation field removed show that the effect is permanent. Oven-heating of the irradiated diodes to 100 C and 150 C did not anneal out the damage in these cases.

Replacement Of A Few Components Can Greatly Improve Performance

The system can be expected to function improperly when its weakest component passes its damage threshold. This is known as the "weakest-link" concept. If analysis indicates premature failure of the system, a substitution of components must be made prior to the radiation tests.

Fig. 1. In just over 1-1/2 hr, a hole was melted through this 1-in. lead shield by gamma flux of 2 x 10^{13} γcm^2-sec.

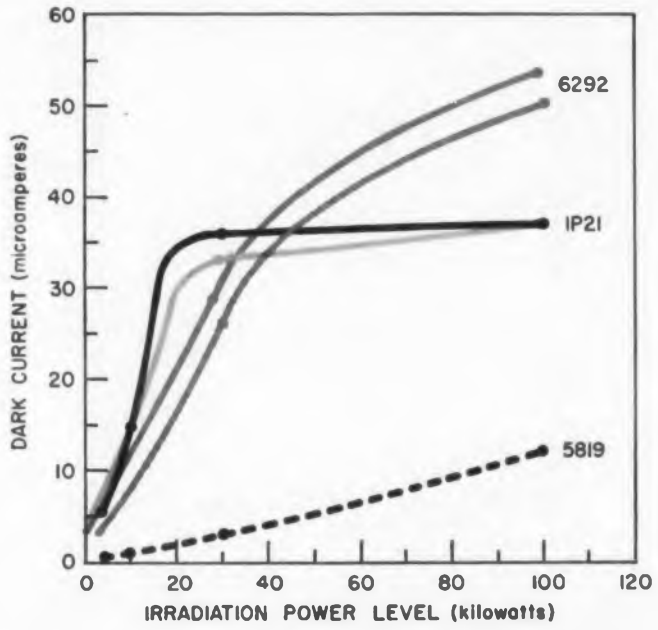

Fig. 2. In a typical transient effect, three photomultiplier types exhibit increased dark current during irradiation, return to normal afterwards.

Table 1. Electronic Component Yardstick Of Radiation Effects*

Component Class	Threshold Dose (in n/cm^2)	Component Material
Light Detectors	10^{12}	Photomultipliers (rate sensitive)
		Lead Sulfide Cells
Semiconductors	10^{12} to 10^{14}	Silicon Transistors
		Germanium Transistors
		Germanium Diodes
		Silicon Diodes
Insulators	10^{12} to over 10^{16}	Teflon
		Nylon
		Silicone Rubber
		Polyvinyl Chloride
		Silicone Resins
		Formex
		Polystyrene
		Polyethylene
		Mylar
		Mycalex
		Supramica
		Phenolic (Bakelite)
		Ceramic
Resistors	10^{13} to over 10^{16}	Fixed Composition
		Deposited Carbon
		Boron Carbon
		Carbon Film
		Wirewound
Relays (Time Delay Only)	10^{14}	Pneumatic Type
		Fluid Damped Type
Capacitors	10^{14} to over 10^{16}	Tantalum Electrolytic
		Aluminum Electrolytic
		Paper-Solid Impregnant
		Paper-Oil Impregnant
		Glassmike
		Molded Mica
		Ceramic
Piezocrystals	over 10^{16}	Barium Titanate
		Quartz
Vacuum Tubes	over 10^{16}	Receiving Type
Gas Filled Tubes	over 10^{16}	Voltage Regulators
Electromagnetic Devices	over 10^{16}	Transformers, Chokes, Motor-Type Devices, Relays (other than Time Delay)

Note: *All doses are for neutrons with energies 2.9 mev (n/cm^2). Gamma doses are = 175 times greater, except for the gas filled tubes, where the gamma are = 2000 times greater on a particle basis

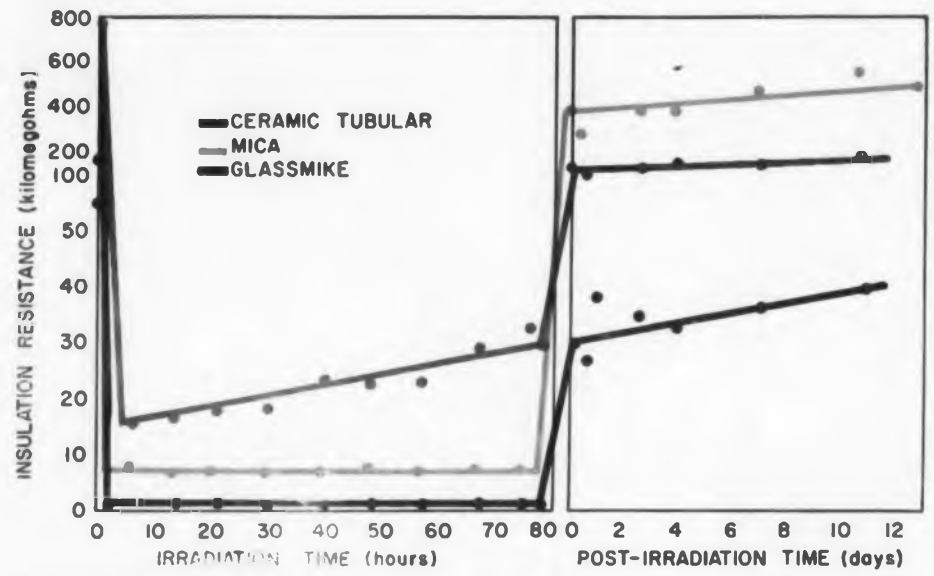

Fig. 3. Post-irradiation recovery of insulation resistance is illustrated for three capacitor materials.

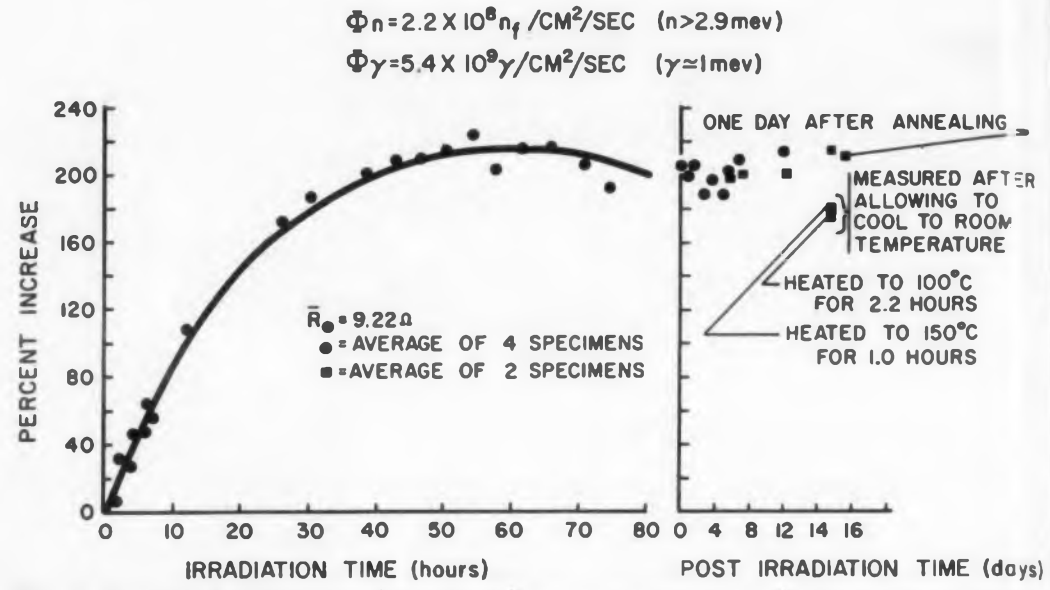

Fig. 4. Permanent increase of forward resistance of germanium diodes would not be reduced by annealing.

Of course, the final test is in actually operating the units under the required nuclear and non-nuclear conditions. Progressing from this point by further substitution or redesign of the circuits, a fully qualified system will develop.

Design data are being accumulated for a wide range of typical components. With these data, the components can be arranged in a comparison table, which may be called a Radiation Effects Yardstick. From the Yardstick shown in Table 1, we can determine:

1. The relative resistance of various classes of components
2. The relative resistance of the types of components within a class
3. An order of magnitude of the dose at which the response of the component will begin to change.

The Yardstick also emphasizes several other points:

In nearly every class of components there are types which will withstand what are presently considered "high" doses. However, none of the light detectors or semiconductors can withstand a high dose. The thresholds shown for insulation are due to physical rather than electrical deterioration. Though electrical insulation resistance data are sparse (because of air ionization problems), indications are that physical destruction occurs before permanent electrical degradation. Finally brought out is that inorganics are more radiation-resistant than organics.

Organic materials, when exposed to a mixed field, are damaged more by the gamma rays than by the neutrons. The thermal neutron flux has been reduced to insignificance by use of a boral shield. The mixed-field exposures have been reported in terms of fast neutrons because they can be measured more accurately than the associated gamma radiation. Hence, flux strengths are expressed as neutrons/cm². Gamma dosage can be calculated, if required by the gamma-neutron ratios of 175 or 2000 noted in the table.

Most electronic designers are very familiar with component terminology and with some of the trade names of the parts within each component. Few are familiar with the chemical names of the various dielectric or structural parts. An excellent plastics reference chart to be used with Table 1 may be found in reference 8 (*ED*, Sept. 3, 1958, p 20).

Dielectric Oils Break Down Because of Formation of Gas or Gel

Two principal reactions occur in the dielectric oils. The first, the results of which are illustrated in Fig. 5, is a splitting off of small fragments of the molecules which are evolved as gas. The most common gases evolved are hydrogen and methane. However, many other gases are evolved, depending on the structure of the oil. The second pronounced effect on oils is a polymerization of the molecules. This always affects the viscosity and usually results in formation of a gel. The material is considered a gel when it has become a rubbery non-pourable solid. Nearly all oils undergo this phenomenon if exposed to a sufficient dose. In some applications, no harm will occur until a gel is formed. In other applications, such as oil-filled time delay relays, a change in viscosity will change the operating characteristics of the component. The designer must consider the degree of viscosity change which will conform to this criterion. Considerable data exist on the silicone dielectrics and on some of the non-silicone dielectrics. When viscosity or gelation is the potential problem, the designer must look at *G* values for gelation. When pressure or gas appears to be the problem, then he must look at *G* values for gas formation. The *G* value is the number of molecules affected or formed (according to the individual case) per 100 ergs of absorbed energy.

The fluorocarbon oils have very poor radiation resistance in regard to both gel formation and gas. The silicone oils are somewhat better, since they do not release any corrosive gases. Moreover, the *G* values for gas formation are lower than those for fluorocarbons. They do present a problem in gel formation, however. When a silicone oil is used, the phenyl types should be chosen over the methyl types because this type of silicone offers a lower *G* value for gelation.

The standard hydrocarbon oils give trouble in both gas formation and gelation. Unsaturated oils, such as castor oil, are not as good as the saturated types. Among the aromatics, polyphenyl ethers, biphenyl, and terphenyl have been exposed to over 10^{15} n/cm² with almost no danger.

The electrical properties of these oils examined have not been seriously affected. The silicone oils suffer very little in dielectric strength and loss tangent. The fluorinated and chlorinated hydrocarbons were damaged more as a result of the halides formed.

Halogenated oils should be avoided wherever possible. When silicone oils are used, the phenyl type should be specified. When hydrocarbon oils are used, the aromatic type should be specified if possible. The designer must be aware of the gassing and gelatin problems in his design, and have *G* values for these on all available oils when specifying a dielectric oil.

Proper Choice of Solid Insulators and Parts Makes The Difference

Teflon* will have to be replaced in any application where it is expected to receive over 10^{12} n/cm² integrated flux. The other fluorinated

*Trade mark, E. I. du Pont de Nemours & Co.

hydrocarbons are not much better. Fig. 6 lists the relative radiation resistance of only a few typical insulating materials.

Nylon and the present commercial silicone rubbers break down at 10^{14} n/cm². There are, however, high phenyl silicone rubbers under development which should give 100 times longer life than the present commercial stocks.

The non-elastomeric resins are considerably better in radiation resistance than the commercial elastomers. This class of materials includes the resins and enamels, laminates used for structural applications, molding compounds, etc.

A number of these silicone dielectric materials have been irradiated. After irradiation to a maximum integrated flux of 10^{15} n_f/cm², no damage was found in the dielectric strength of any of the materials except Dow Corning resin 997 on glass cloth. There was a 65 per cent loss in the dielectric strength of the latter.

Physical embrittlement, evident in some silicone samples, was not serious. The per-cent water absorption of Dow Corning 301 molding compound doubled when exposed to 9.9 x 10^{14} n_f/cm² (Table 2). Other physical properties tested, and dielectric strength underwent no detectable permanent damage at the same integrated flux. The associated gamma dose for this irradiation, using the Convair Ground Test Reactor (GTR) source, was 5.5 x 10^9 ergs/gm(C), the source's characteristic.

Fig. 5. Irradiation to 10^{16} n_f/cm² caused organic impregnated paper capacitors to leak and paper capacitors to crumble.

Table 2. Water Absorption Of DC301 Molding Compound

Gamma Dose (ergs/gm) (C)	Fast Neutrons/cm² E greater than 0.33 mev	% Water absorbed 24 hr
Control	Control	0.113
5.5 x 10^6	9.9 x 10^{11}	0.106
5.5 x 10^7	9.9 x 10^{12}	0.101
5.5 x 10^8	9.9 x 10^{13}	0.129
5.5 x 10^9	9.9 x 10^{14}	0.231

The problems are many in designing electronics for a nuclear environment. However, these problems can be solved just as problems of similar magnitude have been solved in the past for other environments. Many more answers are needed. The need for a greater understanding of radiation effects, that is air ionization, gamma heating transient damage, and permanent damage, is of utmost importance. The designer of today must choose the components which will satisfy both the electrical and the environmental requirements of the system. As in nearly all branches of science, the final proof lies in the comprehensive testing of the materials, components, and systems. ■ ■

Bibliography

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8. Electronic Design, Sept. 3, 1958.

9. The Effects of Nuclear Radiation on B-36 Aircraft Systems, Addenda 1 and 3. Convair-Fort Worth Reports MR-N-167-1 and MR-N-167-3, August and December 1957.

10. Baker, M. L., and Gammon, E. P., "Effect of Nuclear Reactor Radiation on the Operation of Aircraft Type Gyros." Second Semi-Annual Symposium of Radiation Effects, Columbus, Ohio, Oct. 22-23, 1957.

*This reference contains a complete bibliography.

Multivibrator Gives Nanosecond Pulses With Variable Width, High-Duty Cycle

Delivery of high-duty-cycle pulses in the nanosecond region is virtually beyond the capability of conventional monostable multivibrators. Rob Roy here explains why, and tells how he added to the basic circuitry to solve the problem.

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A REVISION of the conventional transistor monostable multivibrator combines high duty-cycle and variable width in the nanosecond region—where such characteristics have been almost impossible to obtain.

A conventional collector-coupled, monostable multivibrator is shown in Fig. 1.

Assume Q_1 initially is OFF (nonconducting) and Q_2 is ON (fully conducting). A positive pulse applied at A, or a negative pulse at B will turn Q_1 ON, and Q_2 OFF.

The positive swing, E v at A, is transmitted through capacitor C to the base of Q_2, holding it OFF. The capacitor C then discharges towards $-E$ v with a time constant $T = RC$. When the voltage at the base of Q_2 is more negative than the emitter, Q_2 turns back ON.

The resulting positive swing at B turns and holds Q_1 OFF until another triggering pulse arrives. The voltage at point A decays towards $-E$ v with a time constant $T = R_LC$.

Capacitor Must be Large

To transmit the positive pulse from A to D, the capacitance of C must be much greater than the input capacitance to Q_2. Because Q_2 is ON, this capacitance is considerable. Hence, capacitor C is fairly well fixed for most short-pulse-width circuits.

This time constant, R_LC, fixes the duty cycle of the circuit. Attempting to increase the duty cycle by increasing R will result in unequal pulse widths, as shown in Fig. 3. If C is made as small as possible, then R must be increased to maintain the other time constant, RC.

For a given R_L, the base resistor necessary to keep Q_2 ON is $R < \beta R_L$. If R_L is small, then to maintain a given rise time, R must also be small. These two requirements for R are virtually independent and often cannot be satisfied simultaneously. If R is increased beyond the point necessary to hold Q_2 ON, the output swing of Q_2 is decreased, as shown in Fig. 3. For some applications this is a serious drawback.

The circuit of Fig. 4 eliminates the disadvantages associated with the circuit of Fig. 1.

Duty Cycle Increased by Factor β

Transistor Q_3, an emitter follower, isolates point A from the coupling capacitor. The coupling capacitor discharges through the output impedance of Q_3, which is approximately the same as R_L/β. This action increases the duty cycle by a factor β.

Transistor Q_4 increases the current fed to Q_2 by a factor β. This circuit feature, known commonly as the "Darlington Connection," frees R from its two independent requirements. The resistance of R now can be increased, and the desired output swing still maintained.

Triggering of a monostable multivibrator is another problem. It was mentioned that a positive pulse at A of a negative pulse at B of Fig. 1 would trigger the circuit. However, a positive pulse at A sees the input impedance of an ON transistor, which requires a large drive signal for triggering OFF.

There is also the serious problem of loading capacitance onto point A. For the speeds and pulse times concerned, less than 1 μsec, this is a serious limitation. Also, triggering at this point requires a trigger signal of shorter duration than the pulse width of the multivibrator.

Negative Pulse Triggering Uses Small Signal

Although triggering from point B with a negative pulse requires a smaller drive signal, than does a positive trigger at A, there is still the

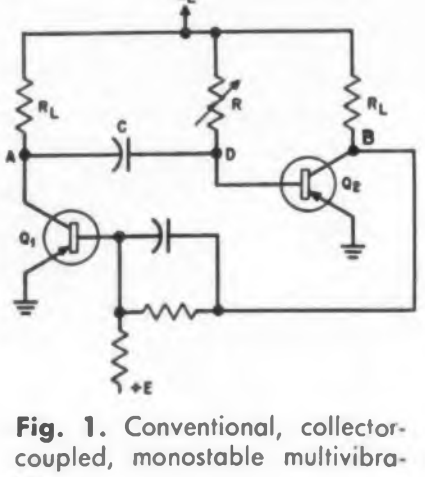

Fig. 1. Conventional, collector-coupled, monostable multivibrator.

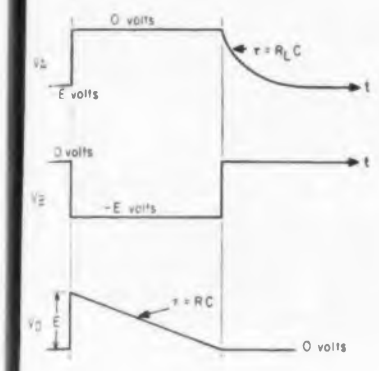

Fig. 2. Voltage waveforms at several points of conventional multivibrator circuit for a fixed R, and low-duty cycle.

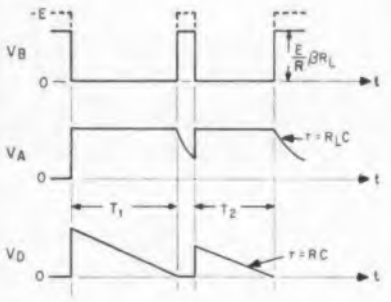

Fig. 3. The voltage waveforms of Fig. 2 when R is increased beyond BR_6, the value necessary to keep the ON transistor on. The duty cycle has increased, but voltage swing has decreased.

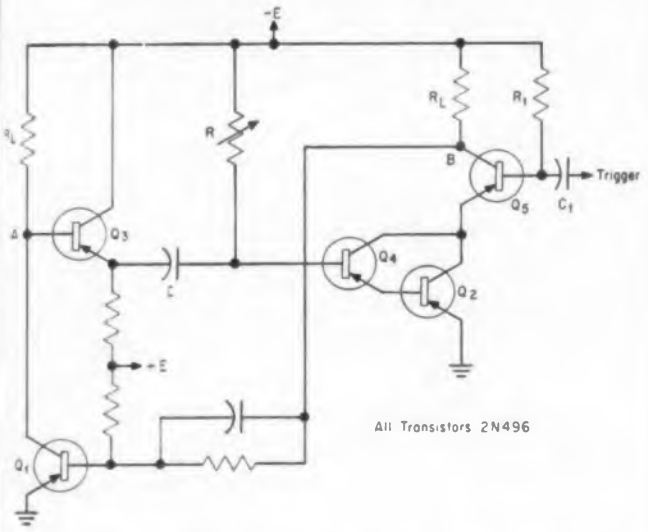

Fig. 4. This circuit gives high duty cycle with proper R value and maximum voltage swing.

loading capacitance problem, the pulse-width problem, and possibly a pulse-polarity problem.

The use of Q_5 eliminates most of these problems. Transistors Q_5 and Q_2 serve as an "AND" circuit. Either Q_5 or Q_2 may be switched to get switching at point B.

Transistor Q_5 is used as the triggering transistor. A small trigger applied to the differentiating network R_1C_1, turns OFF Q_5 and triggers the circuit. Thus Q_5 isolates the trigger from point B.

The positive trigger required for Q_5 is much less than the trigger required at point A. Differentiating allows the use of fairly broad input triggers.

The waveforms at both points A and B are of excellent quality, having rise and fall times below 50 nsec. This allows the system designer to use the differentiated trailing edge of point A as a delayed trigger pulse. The pulse width can be changed, using the variable R, through a 10:1 range. The duty cycle is better than 95 per cent. ■ ■

RFI

RFI Test Equipment

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In *ELECTRONIC DESIGN*'s Feb. 3 issue, containing a series of articles on radio-frequency interference (RFI), a partial listing of available measuring equipment was included. A complete, up-to-date tabulation is now presented to assist new interference-control groups to select equipment. Please note that the table does not include simplified go/no-go devices, some obsolete equipment or spectrum analyzers.

Index of Manufacturers

Empire Devices Products Corp.
Amsterdam, N.Y.

Ferris Instrument Co.,
Boonton, N.J.

Measurements Corp.
Boonton, N.J.

Polarad Electronics Corp.
Long Island City, N.Y.

Sprague Electric Co.
North Adams, Mass.

Stoddart Aircraft Radio Co., Inc.
Hollywood, Calif.

Frequency Range (mc)	Model	Manufacturer	Detector Functions			Antenna Systems				MIL-I-26600 (Air Force)	MIL-I-11748B (Proposed) (Army)	MIL-I-16910A Amendment 2 (Navy)	Availability	
			Avg	QP	Peak	Loop	Rod	Dipole	Discone	Horn				Immediate	Remarks
30 C - 0.015 mc	NM-40A or AN/URM-41	Stoddart	X	X	X	X	X							X	
			(Also RMS)												
0.014 - 0.25	NM-10A or AN/URM-6B or AN/URM-106	Stoddart	X	X	X	X	X					0.014 - 0.15 mc.	Class I	X	
0.014 - 1000	NF-205	Empire	X		X	X	X	X	X			0.014 - 1000 mc. (Preferred over NF105)	Class II	X	
0.014 - 1000	NF105	Empire	X		X	X	X	X	X		Category A, C2	0.014 - 1000 mc.		X	
0.15 - 25	NM-20B or AN/PRM-1A	Stoddart	X	X	X	X	X				Category A, C2		Class I	X	
0.15 - 0.4, 1.6 - 40	AN/URM-3	Designed by Army			X		X					0.15 - 20 mc. (Broadband only)	Class II		Used by Army.
0.15 - 80	NF114 or AN/PRM-14	Empire	X		X		X								Obsolete, but still used.
0.15 - 1000	AN/URM-85	Empire	X		X	X	X	X	X			0.15 - 1000 mc.			Development models in use. Production started.
			(Also dipole with corner reflector)												
0.54 - 216	500	Sprague		X		X	X	X							
0.55 - 25	32D	Ferris	X	X	X	X	X								
15 - 150	58AS	Measurements	X	X	X			X						X	
15 - 400	NMA-5A or TS-587A/U	Stoddart	X	X	X			X					Class IV		Obsolete, but still used.
20 - 400	NM-30A or AN/URM-47	Stoddart	X	X	X			X			Category A, C2	20 - 400 mc.	Class I	X	
20 - 400	AN/URM-7	Empire			X			X				20 - 400 mc.		X	
150 - 1000	AN/TRM-4	(Information not available)											Class III		
375 - 1000	NM-50A or AN/URM-17	Stoddart	X	X	X			X			Category A, B, C1	400 - 1000 mc.	Class I	X	
375 - 1000	NM-52A	Stoddart	X	X	X			X	X					X	
9[illegible]0 - 11,000	AN/TRM-6	(Information not available)										Suggested only: 1000 - 10,000 mc.			
1000 - 10,000	FIM	Polarad	X	X	X	(Also omni-directional)				X	Category A	1000 - 10,000 mc.		X	
1000 - 10,000	NM-60A or AN/URM-42	Stoddart	X	X	X				X	X		1000 - 10,000 mc.		X	
1000 - 15,000	NF-112	Empire	X		X	(Also broadband parabolic antenna)				X		1000 - 10,000 mc.		X (1-10 kmc)	10-15 kmc being developed

1

Putting Boolean Algebra to Work

R. C. Harrison, electrical circuit design coordinator for Douglas Aircraft's Missile Division, says his job is to check circuit designs, and assist younger "and, often, brighter" engineers in making effective design presentations. In this article, he offers assistance to younger—and older—engineers in formulating problems in Boolean algebra, and converting algebraic solutions into useful hardware.

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BOOLEAN algebra can be fun. But it also can be useless unless one knows how to put a problem in its terms and extract a solution in the form of hardware—switches, relays, transistors, diodes.

The techniques of the Boolean approach can best be illustrated by a typical problem.

Suppose it was desired to adapt a Nike-Ajax launching site into a Nike-Hercules site. We must install switching to enable a remote-control center to choose either an Ajax system or any of six Hercules systems. (The Hercules uses any of three different warheads, and can fly either of two different missions.)

Specifically, the problem is to design circuits, using Boolean algebra, that compare a *prepared* launching configuration with a *requested* configuration. If the missile were of the same configuration as requested, the "Missile Prepared" relay already existing in the Ajax system would be energized. If the missile were not of the requested configuration, the relay automatically would be opened.

It also is desirable to provide safeguards against spurious signals that might result from short or open circuits.

The first step in using Boolean algebra is to assign algebraic symbols to all functions (configuration signals) to be considered. These are indicated in Table I.

The second step is to determine how many combinations of signals are possible, what each combination includes, and which ones are acceptable for energizing the "Missile Prepared" relay—that is, what combinations of signals will indicate that *prepared* configurations are the same as *requested* configurations?

Each signal has two possible states, "ON" or "OFF," and there are 12 signals to be considered. Hence, the total number of theoretically possible combinations is 2^{12}, or 4,096.

Without prior knowledge of which combinations are acceptable and which are not, it would

Table 1. Designation of the Variables in the Design Problem.

CONFIGURATION	REQUEST SIGNAL	PREPARED SIGNAL
NIKE-AJAX MISSILE	A	a
HERCULES MISSILE & WH # 1	B	b
HERCULES MISSILE & WH # 2	C	c
HERCULES MISSILE & WH # 3	D	d
FLIGHT MISSION #1	E	e
FLIGHT MISSION #2	F	f

Table 2. Combinations of the Variables.*

LINE	REQUESTS						PREPARED						RESULT
	A	B	C	D	E	F	a	b	c	d	e	f	
1	1	0	0	0	1	0	1	0	0	0	1	0	1
2	1	0	0	0	0	1	1	0	0	0	0	1	1
3	0	1	0	0	1	0	0	1	0	0	1	0	1
4	0	1	0	0	0	1	0	1	0	0	0	1	1
5	0	0	1	0	1	0	0	0	1	0	1	0	1
6	0	0	1	0	0	1	0	0	1	0	0	1	1
7	0	0	0	1	1	0	0	0	0	1	1	0	1
8	0	0	0	1	0	1	0	0	0	1	0	1	1
9	0	1	0	0	1	0	0	0	1	0	0	1	0
10	1	1	1	0	1	0	1	1	1	0	1	0	0
11	0	0	0	0	0	1	0	0	1	0	0	1	0

*Acceptable combinations yield the mathematical result "1", unacceptable combinations yield a "0".

be necessary to tabulate the 4,096 possible combinations and examine each one.

However, as in many similar problems, prior knowledge of the physical structure of the configurations indicates that most mathematically possible combinations are not physically possible. Hence, only those combinations that we know to be acceptable are listed.

In such tabulations, as in Table II, a "1" indicates the signal is "ON," and a "0" indicates it is "OFF." In the "Result" column, a "1" on any line indicates that the combination of signals on that line has been examined and found acceptable. A "0" on any line indicates the combinations on that line have been examined and found unacceptable.

In Table II, lines 9, 10 and 11 illustrate a few signal combinations for which the "Missile Prepared" relay would not be energized. Line 9 shows the *prepared* missile has a different configuration than that *requested;* line 10 shows an abnormal condition that might result from short-circuited wiring; and line 11 shows another abnormal condition that might result from an open circuit in the *request* signal wiring.

The third step is to prepare an equation expressing all acceptable combinations of signals in algebraic terms. In this equation, the "ON" state is denoted by a letter, as assigned in Table I, and the "OFF" state is denoted by a letter with a bar under it. Thus with "A" and "$\bar{A}$", "A" is read "Not A." Also, algebraic multiplication denotes "and;" the algebraic plus sign "+" denotes "or."

Hence, the equation $XY + Z = 1$ would be read; "X and Y, or Z, is an acceptable combination." The equation $X + \bar{Y}Z = 1$, would be read; "Not X, or Z-and-not-Y is an acceptable combination."

In Table II, the combinations on line 1 OR on line 2, OR on line 3, etc. are acceptable. Line 1 alone would be written "$ABCDEFabcdef = 1$." The equation expressing all eight acceptable combinations would be:

$$\begin{aligned} &ABCDEFabcdef + ABCDEFabcdef + \\ &\bar{A}BCDEFabcdef + A\bar{B}CDEFabcdef + \quad (1) \\ &\bar{A}\bar{B}CDEFabcdef + \bar{A}B\bar{C}DEFabcdef + \\ &\bar{A}\bar{B}\bar{C}DEFabcdef + \bar{A}\bar{B}\bar{C}\bar{D}\bar{E}\bar{F}abcdef \\ &= 1 \end{aligned}$$

This equation is an exact, concise statement of the circuit requirements with respect to the "Missile Prepared" relay.

The fourth step is to simplify the equation by

Vol. 2, No. 3

Nickelonic News

DEVELOPMENTS IN NICKEL AND NICKEL ALLOYS AND THEIR APPLICATIONS

Nickel shields tube against cracking

When General Electric engineers were designing the two-electrode high-vacuum kenotron tube (GL-5973), they needed a metal for the electrostatic shields with an exceedingly low vapor pressure. Otherwise the metal would deposit on the glass of the tube and crack it.

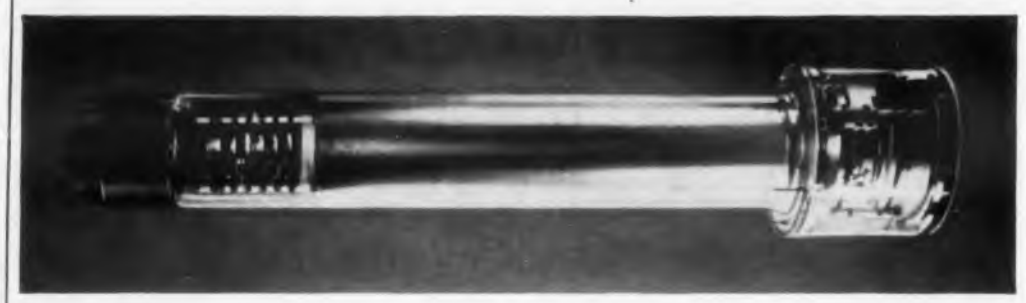
The material also had to offer excellent oxidation resistance, ease of fabrication, cleanliness, strength, ease of degassing and physical stability. According to A. A. Chatham, G.E. process control engineer. Electronic Grade "A"* Nickel was selected for the shields because of its combination of the needed properties.

In rectifier service, the tube will operate at average currents as high as 1.25 amperes at 40,000 volts and one ampere at higher voltages. In limiter service, a rating as high as 20 amperes at 75,000 volts applies. These ratings make the tube particularly suitable for use in radar as a charging diode to supply d-c power to magnetrons or as a limiter to restrict fault currents.

Pertinent Literature: ***Nickel Alloys for Electronic Uses.***

HIGH-VACUUM, HIGH-VOLTAGE rectifier made by General Electric with shield of Electronic Grade "A" Nickel.

Called "major advance in camera tube design"



INCONEL "X" ALLOY CHOSEN FOR SPRINGS IN SUPER-SENSITIVE TV CAMERA TUBE

SCHENECTADY, N. Y. — A super-sensitive television camera tube incorporating three leaf springs of Inconel "X"* nickel-chromium alloy to hold the target mesh assembly has been developed by General Electric Company. Use of the new tube will widen the scope of black-and-white TV and will also permit color televising of night baseball and other evening outdoor events.

Inconel "X" alloy was selected for the spring material because of the unique combination of properties it offers. It retains outstanding spring properties, for example, when tube temperatures rise as high as 375°C during the bake-out cycle. It is clean and easily degassed, displays high resistance to oxidation and corrosion. In addition, Inconel "X" alloy has a low creep rate, good relaxation resistance, and is non-magnetic. (Spring Temper Inconel "X" alloy wire is used for temperatures up to 370°C. No. 1 Temper wire can be used in the range between 370 and 540°C, and Solution Treated wire between 540 and 650°C.)

The new image orthicon, type GL-7629, is interchangeable with standard camera tubes. It can produce pictures of usable black-and-white quality at one foot candle of scene illumination or less, compared with ten foot candles required by black-and-white image orthicons.

Low-cost changeover

J. F. McAllister, general manager of the company's power tube department, calls the new tube "a major advance in camera tube design." He says it offers color TV much of the programming flexibility of its black-and-white counterpart.

Color-equipped stations, he points out, will be able to reduce operating costs sharply. He also says that many of the nation's regular TV studios can be converted to color without significant additional investment.

Reliable cathode material

According to J. S. Fitzsimmons, process control engineer in GE's camera tube department, "220" Nickel was selected for the cathode because they wanted a passive material that was non-contaminating. The copper, iron, manganese, and magnesium content is closely controlled and held at low levels.

Pertinent Literature: Electronic grades of Nickel and Nickel alloys — with their uses —are fully described in our booklet, ***Nickel Alloys for Electronic Uses.*** **Write us for a copy.**

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

Nickel alloys prevent warpage and leaking in VHF tetrode

Proper selection of materials enabled G.E. engineers to eliminate both warpage and leakage in their four-electrode transmitting tube (GL-6251). This water-and-forced-air-cooled tube is used as a power amplifier or oscillator in grounded-grid circuits with both grids maintained at radio-frequency ground potential.

When the tube is functioning, the temperature at the edge of the grid cones is as high as 850°C, while the other portions of the cones remain much cooler. Use of Electronic Grade "A" Nickel for these grid cones provided a material with adequate mechanical strength, combined with good, deep drawing qualities, to facilitate the manufacture of these parts.

During developmental stages of this tube, G.E. found that there was leakage at the joints of the water jacket. This problem was solved by using easy-to-weld Monel* nickel-copper alloy for the jacket.

High operating efficiency is attributable to the close spacing of the electrodes, ring-seal construction, and the low-loss factor resulting from silver-plated external parts and a ceramic insulator. The ring-seal design also permits quick plug-in installation.

*Inco trademark

Pertinent Literature: ***Nickel Alloys for Electronic Uses*** **and T-5 —** ***Engineering Properties of Monel and "R" Monel.***

INCO TRADE MARK **ALLOY PRODUCTS**

CIRCLE 67 ON READER-SERVICE CARD

ordinary algebraic factoring, and to rewrite it thus:

$$(\overline{A}\overline{B}\overline{C}\overline{D}abcd + A\overline{B}\overline{C}\overline{D}abcd + \overline{A}B\overline{C}\overline{D}abcd + \overline{A}\overline{B}C\overline{D}abcd + \overline{A}\overline{B}\overline{C}Dabcd)(\overline{E}\overline{F}ef + E\overline{F}ef) = 1 \quad (2)$$

Further factoring simplifies it to:

$$[\overline{C}\overline{D}(\overline{A}\overline{B}ab + A\overline{B}ab)cd + \overline{A}B(\overline{C}\overline{D}cd + C\overline{D}cd)ab](\overline{E}\overline{F}ef + E\overline{F}ef) = 1 \quad (3)$$

With no more possibilities of simplification apparent, the fifth step is undertaken. This is conversion of the simplified equation into a circuit diagram. (It could be converted into a "Logic Diagram" if Static State switching were to be used. But, because relays are to be used, it will be converted into a diagram with symbols for relay contacts.

The following rules apply to the conversion process:

(a) A letter without a bar represents a normally open contact (closed when the signal is ON).
(b) A letter with a bar represents a normally closed contact (opened when the signal is ON.)
(c) Letters, or goups of letters, connected by the "And" sign represent contacts in series.
(d) Letters, or groups of letters connected by the "Or" sign represent parallel circuits.
(e) Contacts in series give the same result regardless of the sequence in which they are written.
(f) Two or more like-acting contacts on the same relay can be replaced by a single contact of the same action.
(g) A contact in parallel with an open contact can perform the same function if the open contact is omitted.
(h) Each of the signals (represented by the letters assigned in Table I) must be considered as operating a separate relay.

The diagram is constructed, as shown in Fig. 1, by merely replacing the albegraic symbols of Eq. 3 with diagramatic symbols for relay contacts (as required by rules a, b, c, d).

Each contact is associated with the relay denoted by the letter assigned to its signal (as re-

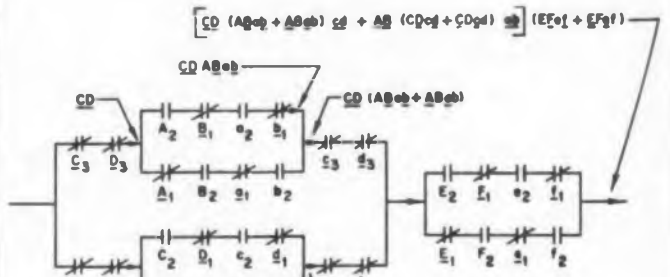


Fig. 1. The hardware equivalent of the mathematical solution. Each symbol represents a relay contact. The letter denoting the contact denotes what relay it is on. Letters with bars represent normally closed contacts; letters without bars, normally open contacts.

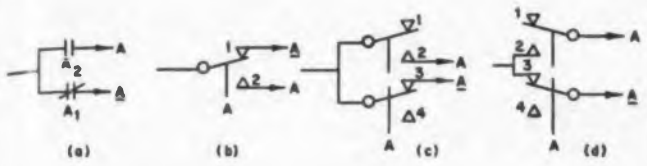


Fig. 2. How to convert the symbol for two parallel, opposite-acting contacts on the same relay into the actual relay configuration.

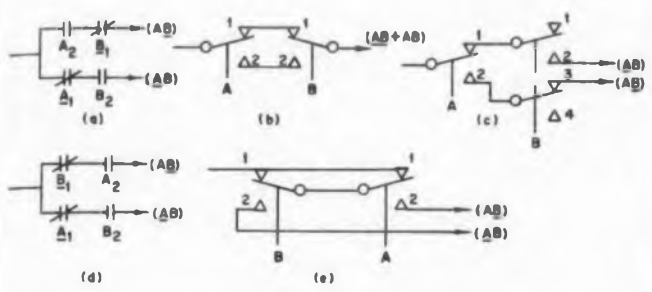


Fig. 3. How to deal with parallel paths through two relays. Part (*b*) indicates how a careless arrangement of connections can give an undesirable output.

quired by rule h). The separate contacts of each relay are identified by subscripts—even numbers for normally open contacts, and odd numbers for normally closed contacts.

If the relays used have four terminals per double-throw pole, Fig. 1 is a complete solution to the problem. However, if the relays used had only three terminals per double-throw pole, the symbols of Fig. 1 would have to be replaced by proper symbols for this type of relay. In the interest of minimizing the number of poles, it also may be desirable to revise the sequence of some contacts.

This is the sixth and last step, and considerable care must be exercised to avoid pitfalls that could ruin an otherwise perfect solution. Figs. 2, 3, 4, show how the symbols of Fig. 1 may be converted and rearranged.

All parts of Fig. 2 give the same results, but the position of the outputs are inverted in (b), giving rise to the possibility of errors when combining this relay with other relays in the circuit. Two poles, instead of only one, are used in (c) and (d).

Fig. 3 (b) illustrates an erroneous arrangement of connections that might result from carelessness. It would be correct only if the parallel paths were intended to merge after traversing the two relays. Fig 3(c) will work, but, like 2(b), it inverts the output positions. It also uses one more relay pole than might be desirable.

Fig. 3(d) is like 3(a), except the sequence of contacts in the top half of the diagram has been reversed (rule e). Fig. 3(e), constructed from 3(d), is a correct arrangement, and it also minimizes the number of relay poles used. ■ ■

Make Your Own Transistor Parameter Converter

James R. McDermott

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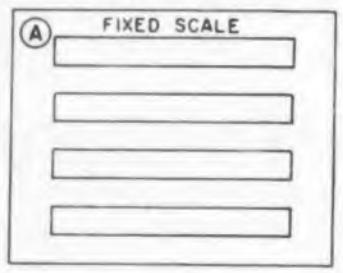
ONE BASIC problem in transistor selection lies in non-standardization of transistor parameters appearing on manufacturers' specifications. For example, a mixture of both "*h*" and "*T*" parameters frequently appears on the same transistor specification. Also, a large percentage of parameters are specified in terms of grounded-base circuits, while applications are almost exclusively in terms of grounded-emitter circuits. Result is, that even in making preliminary estimates, tedious conversion of parameters is almost always necessary.

Making a Parameter Converter

Considerable reduction of time and effort in parameter conversion can be accomplished by constructing and using a "Transistor Circuit Calculator" with the scales reproduced here. This handy slide rule speeds conversion of any one "*h*" or "*T*" parameter to another. It can easily be assembled by cutting out the scales, and pasting them onto cardboard in accord with the following directions.

First, obtain three pieces of thin, tough cardboard, approximately 8 by 10 in. Suitable materials are manila file folders or thin bristol board. One piece is for the *A* or top scale, the second is for the *B* or sliding scale, while the third serves as backing to hold the sliding scale against the front, as shown in Fig. 1.

For those engineers too busy converting parameters to construct their own calculator, it may be obtained for $1.00 from McDermott Associates, 1472 Broadway, New York 36, N.Y.



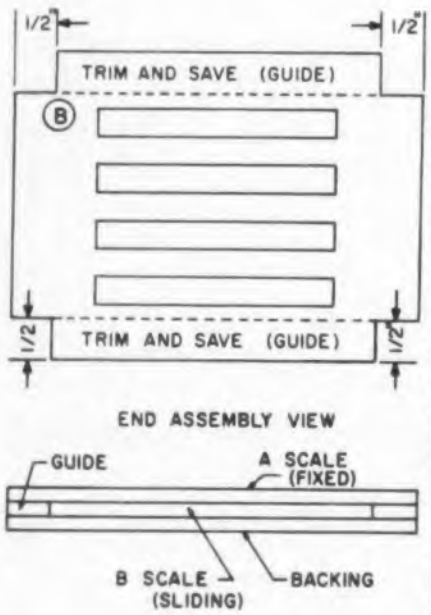
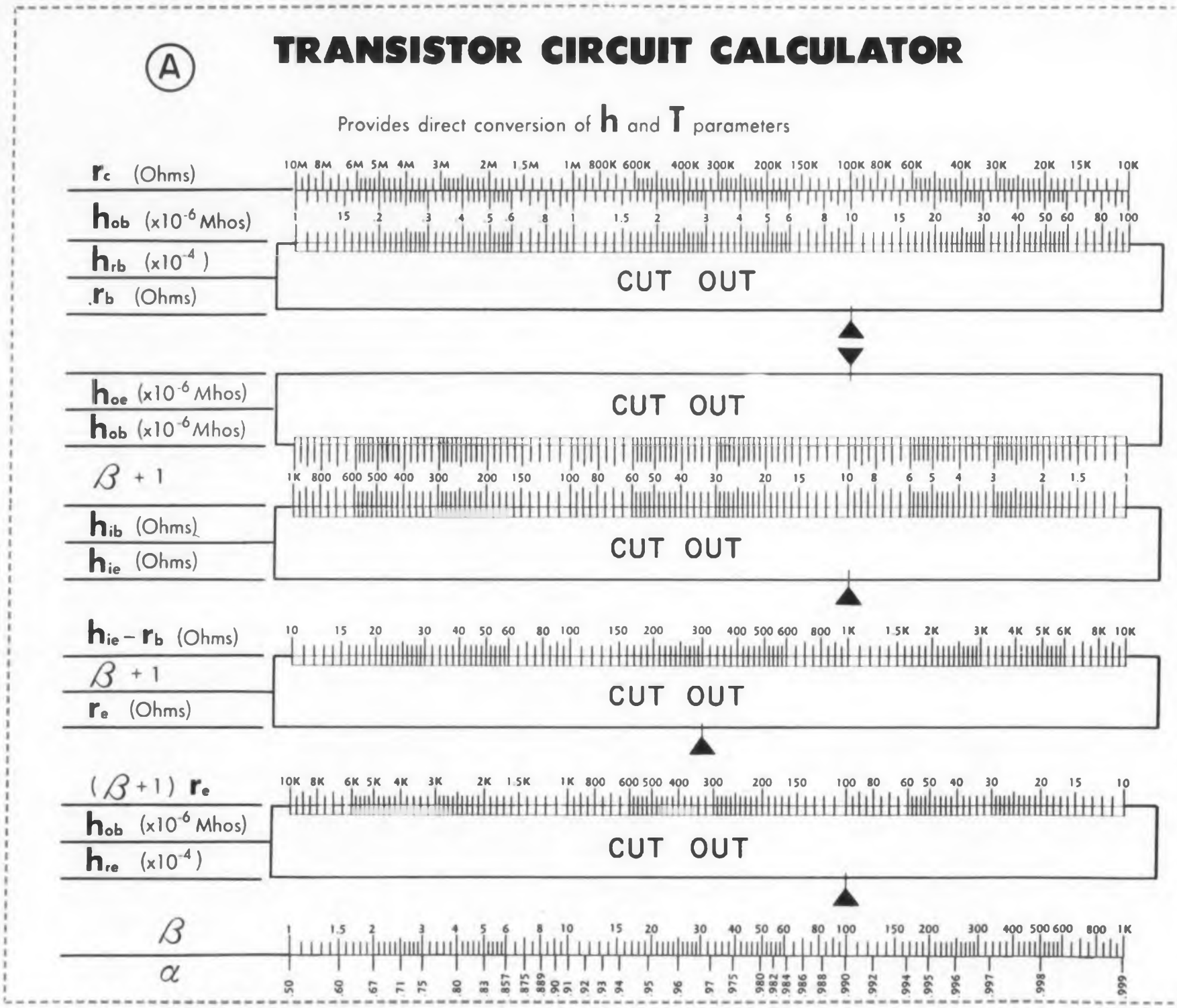


Fig. 1. Assembly details for the transistor parameter converter.



Next, center the *A* scale on one of the cardboards, and paste it in this position. Rubber cement is recommended. With a sharp razor blade or Exacto knife, trim along the outside guide lines, and then cut out the areas indicated, including those portions of the scales lying within. The *A* scale is now prepared.

Paste the *B* scale in the center of the second piece of cardboard. Lay the *A* scale over this and adjust until the scales are properly lined up in the windows previously cut. Hold in this position, and carefully mark the outline of the *A* scale on the *B* scale cardboard.

On the *B* scale, draw horizontal lines 1/2-in. from the top and bottom of the *A* scale outline, as indicated by Trim and Save in Fig. 1. Trim the top and bottom of *B* flush with the top and bottom of the *A* scale outline. Trim the left and right edges of the sliding portion of *B* 1/2-in. beyond *A* on both sides. Trim the top and bottom guides flush with *A* as shown in Fig. 1.

Set the *A* scale in the center of the remaining piece of cardboard, draw an outline, and trim the backing piece to the same size as *A*.

Place the moving *B* slide in the center of the backing cardboard, and glue the top and bottom guides in place. Make sure the slide moves snugly between them. Finally, apply glue to the guides and press the scale down on them. Adjust the *A* scale until it lines up with the *B*. Trim rough edges.

Scale Equations

The slide rule scales shown in the drawing below are based on the following equations, which provide close approximations:

$$h_{ob} = \frac{1}{r_c}$$

$$r_b = \frac{h_{rb}}{h_{ob}}$$

$$h_{oe} = (\beta + 1)\, h_{ob}$$

$$h_{ie} = (\beta + 1)\, h_{ib}$$

$$r_e = \frac{h_{ie} - r_b}{(\beta + 1)}$$

$$h_{re} = (\beta + 1)\, r_e \cdot h_{ob}$$

$$h_{fb} = \alpha$$

$$h_{fe} = \beta$$

$$\beta = \frac{\alpha}{1 - \alpha}$$

Grounded-collector parameters can easily be obtained from the following relations: $h_{ic} = h_{ie}$; $h_{rc} = 1 - h_{re}$; $h_{fc} = \beta + 1$; $h_{oc} = h_{oc}$. ■ ■

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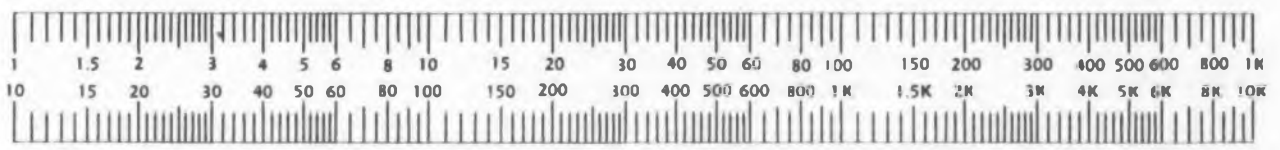
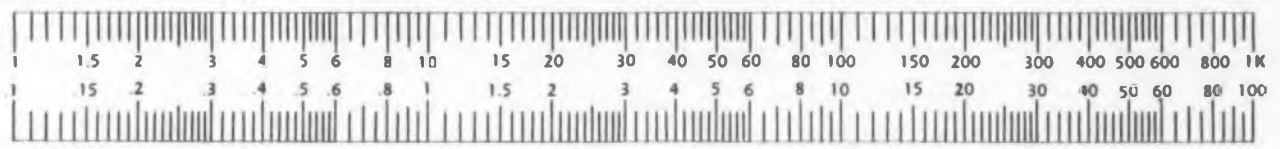
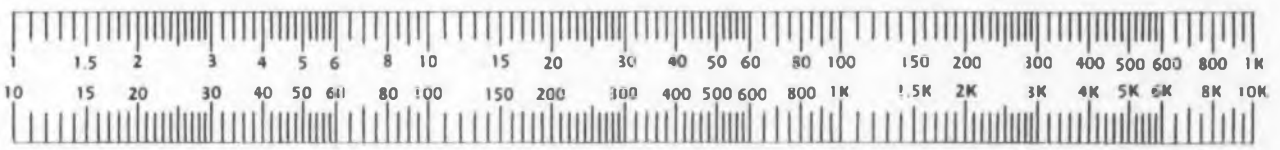
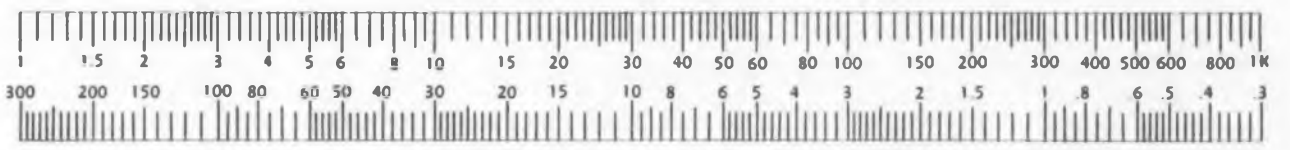








How to Design Scales That Humans Can Read

Henry Littlejohn, who heads General Radio Co.'s standards department, often commiserates with the engineer who is losing his eyesight trying to read scales. In this article, he offers rules for selecting the number of subdivisions in a scale length, and for choosing the length of lines. The rules were determined with the limits of human eyesight in mind.

Henry Littlejohn
General Radio Co.
West Concord, Mass.

GRADUATED scales are meant for humans. This obvious fact has not deterred designers from occasionally producing scales that were almost impossible to read. Although accuracy is the prime requirement of a scale, readability is easily the second most important consideration. Without readability, accuracy is unusable.

Personal preferences for various graduated scales stem from aesthetic evaluations, traditional concepts, and habits formed by using such scales. It is possible, however, to reduce the design of all scales to a few basic principles, whose application will result in maximum readability for a given length of scale. The satisfactory use of many thousands of precision scales, designed according to these principles, is testimony to the soundness of these rules.

Graduated scales are linear or nonlinear. The design criteria are the same whether the scales are straight or curved as long as the radius of a curved scale is not small compared to the length of division lines. Two problems are involved in designing a scale: (1) selecting the optimum number of subdivisions for a particular scale interval, (2) choosing line lengths that make subdivision lines readily distinguishable.

Too Many Subdivisions Spoil The Scale

Scales often can be improved by having fewer rather than more subdivisions. The number of subdivisions depends on the line width, which determines the minimum distance between centers of adjacent lines. This distance should not be less than four times the line width; otherwise the scale is difficult to read.

When, for example, the distance between line centers is three times the line width, the space between lines is twice the line width, and the scale looks like a series of bars one and two units wide.

A distance between adjacent line centers of more than seven times the line width can be subdivided profitably once more, unless nonlinear scales are used or special circumstances prevail. In all cases, the line width should be as fine as possible, but should not be less than 0.005 in., which is a practical minimum for the naked eye.

The most widely used linear scales are scales of inches and centimeters. With these units the question is not how many subdivisions to use per unit, but how to select a line width no more than 1/4 the subdivision required.

(This selection has been made correctly by manufacturers of inch and centimeter scales. Considerable improvement, however, can be made in the scales of many reputable manufacturers if the criteria set forth later, on choice of line lengths, is followed. Examples of scales that need improvement are those recommended by the American Standard Association in "American Standard Scales for use with Decimal-Inch Dimensioning Z75, 1-1955.")

Consider a linear, decimally divided scale where the unit is of arbitrary length, and the objective is to divide the unit most effectively. It is apparent that the only practical subdivisions are 1/10, 2/10, and 5/10. Fig. 1 shows scales of progressively shorter units subdivided, as suggested above, so the minimum interval between line centers is four times the line width; the maximum interval is seven times the line width. In Fig. 2 the same scales have been subdivided more frequently. Consider the ease of seeing that the indicator is at 1.36 on the top scale of Fig. 1 and then on the top scale of Fig. 2.

Nonlinear scales can be of a wide variety, but one frequently encountered is logarithmic. Assuming the only practical decimal scale subdivisions are 1/10, 2/10, and 5/10 it follows that three is the maximum feasible number of changes in subdivision per decade.

Dividing the decade into three equal sections puts the subdivision changes at intervals of $10^{1/3}$. Approximately, then, these subdivisions are at 2, 5, and 10. Using the previously established criterion of a minimum, center-to-center, line spacing of four times the line width, and changing spacing at 2, 5, and 10, results in the example of Fig. 3.

In each case, the subdivisions are chosen so that as the point of maximum crowding is reached —just before 2, 5, and 10—the spacing between line centers is no less than four times the line width. The same scales subdivided twice as frequently are shown in Fig. 4. Comparing the indicated value of 4.96 in Fig. 3 with that in Fig. 4 makes the better readability of Fig. 3 obvious.

Don't Associate Line Length With Particular Unit or Fraction

Choosing line lengths is more complicated than selecting the length of a subdivision. A mistake frequently made is to associate a length with a unit and other lengths with particular fractions of the unit. However, the user of a scale does not generally associate a line length with a particular unit or fraction, but simply tries to distinguish one line from another.

Rules for Scale Design

(1) Minimize the length of lines; make the shortest length about four times the line width.

(2) Minimize the number of different line lengths.

(3) Make the longer of two lines that must be distinguished at least as long as the interval between the centers of these lines.

(4) Make the distance between adjacent line centers no less than four times and no more than seven times the line width.

Fig. 1. Linear scales of arbitrary units divided according to rules for maximum readability.

Fig. 2. The scales of Fig. 1 subdivided further. Too many subdivisions reduce scale readability and, hence, utility.

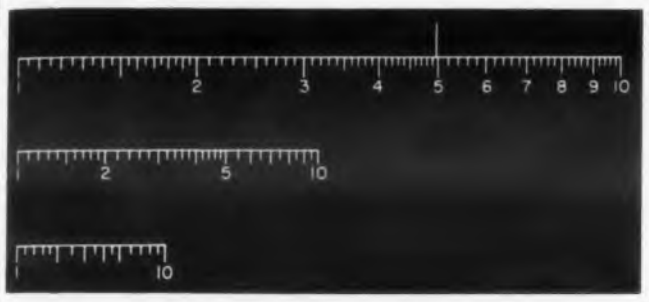


Fig. 3. Logarithmic scales of arbitrary units divided according to rules for maximum readability.

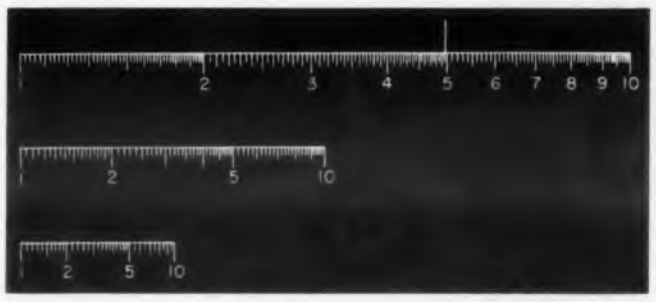


Fig. 4. The scales of Fig. 3 subdivided twice as often. Excessive subdivision of scales reduces readability.

Fig. 5. Greatest readability results when a particular unit or fraction of unit is not associated with any particular length of line. Thus, the length that denotes one-tenth between 1 and is not used to denote one-tenth between 4 and 5.

Fig. 6. Arbitrarily assigning line lengths to particular units can reduce readability of linear scales, such as this drafting scale. This is most clearly pronounced on the edge divided into one-fiftieths.

Fig. 7. Shortening the length of lines on logarithmic scale of Fig. 5 improves readability.

Fig. 8. Shortening length of lines on linear scale of Fig. 6 improves readability.

The practice of using particular lengths for particular fractions is especially poor for non-linear scales, as the scale in Fig. 5 indicates. In this scale, 1/20, 1/10, 2/10, 5/10, and unit divisions have respectively longer lines. The 1/10 lines, for example, are good between 1 and 2, but not between 4 and 5.

The practice of arbitrarily assigning line lengths to particular units can also result in poor linear scales. This is shown in the typical drafting scale shown in Fig. 6; apparently poor readability is the result of standardizing line lengths at 1/4, 3/16, 5/32, and 1/8 in. This is not too bad on the edge divided into 1/16ths, but it makes readout very difficult on the edge divided into 1/50ths.

Lines are easily distinguished if:

(1) The length of the lines is minimized

(2) the longer of two lines that must be distinguished is at least as long as the interval between their centers

(3) the number of line lengths is minimized.

A Line Is a Line When Length Is Four Times Its Width

The shorter the lines, the easier it is for the observer to shift his eye from the edge of the scale to the ends of the lines, and differentiate among the lengths. There is a minimum length that a line can have, however, and still look like a line; this is about four times the width.

Re-doing the logarithmic and drafting scales of Figs. 5 and 6 in accordance with these rules results in the scales of Figs. 7 and 8.

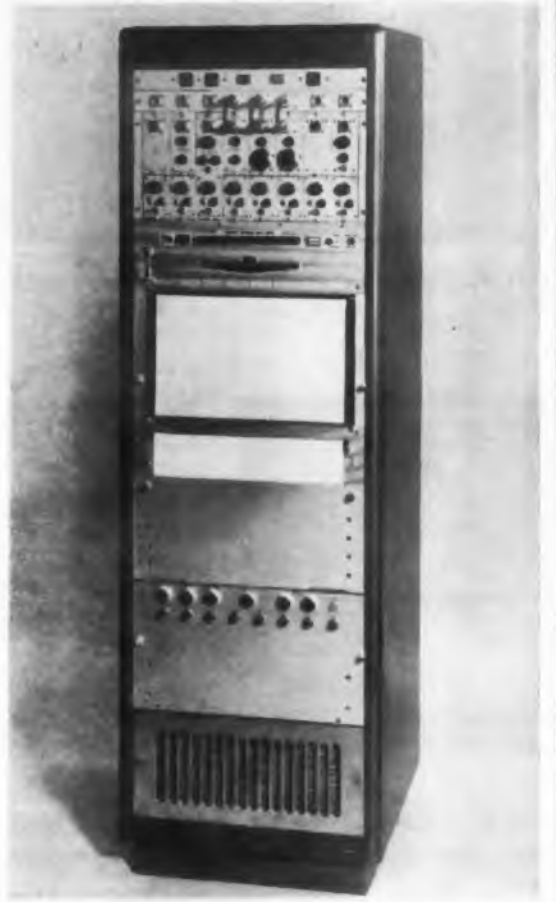
Examine first the logarithmic scale. The length of lines is minimized first according to rule (1) by making the length of the shortest line (that is, for 1.95, 4.9, and 9.8) no more than four times the line width. The lengths are further minimized by using rule (2)—the longer of two lines which must be distinguished must be at least as long as the interval between their centers. Thus the length of the second-from-shortest length of line is dictated by the interval between 1.05 and 1.1, and the longest line is dictated by the interval between 1.4 and 1.5.

Using rule (3), the same length is used for 0.05's, 0.1's, and 0.2's; another length is used for 1.1, 1.2, 1.3, 1.4, 1.6, 1.8, 1.9, 2.5, 3.5, 4.5, 6, 7, 8, 9; and the lines for 1, 1.5, 2, 3, 4, 5, and 10 are the same length.

Fig. 8 shows the drafting scale of Fig. 6 after it is treated according to these rules. Most users find the scales of Figs. 7 and 8 better than those of Figs. 5 and 6. ■ ■

Direct Writing Recorder Operates Over a 100% Wider Bandwidth

THE TRACE-MASTER recording system offers fidelity of reproduction over a bandwidth up to 100 per cent wider than has heretofore been practicable in direct-writing recording. The "band-amplitude" product, a performance figure of merit, is claimed to be "six times higher than was previously attainable" by company spokesmen. For square-wave monitoring a selection of optimum phase or frequency response may be made. The carbon trace produced is a thin, uniformly clear line which cannot fade and is reproducible.



The Tracemaster 8-channel direct-wiring recording system.

Eight Independent Channels

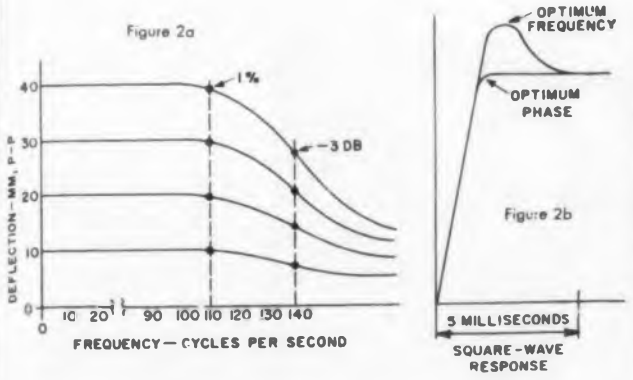
The system contains eight independent recording channels which may be set up to accept any one of a number of signals. The user can select the characteristics desired for each channel by applying an appropriate combination of the following plug-in modules:

Match-Master Input Couplers	Gain-Master Signal Amplifiers	Drive-Master Driver Amplifiers
dc strain gage	dc	standard
0 to 1 v zero suppression	dc differential	high impedance
direct	carrier	high impedance

The frequency response of the channels is dc to 110 cps ±1 per cent, dc to 140 cps ±3 db with all amplifier modules. Maximum sensitivity is: with the dc amplifier, 100 mv per cm; with the dc differential amplifier, 1 mv per cm; with the carrier amplifier, 10 μv per cm. Input impedance varies from 2,500 ohms, when the carrier amplifier is used, to 100 K for the dc amplifier and 1 megohm for the dc differential amplifier. The amplifiers are transistorized and self-calibrating by integral, pre-aged mercury cells and a precision divider network.

Uses The Direct-Carbon-Transfer Method

The direct-carbon-transfer method of writing used produces a thin, black line that does not fade and can be repro-



Frequency and amplitude response are shown in Fig. 2a, while Fig 2b depicts the square-wave response for optimum frequency and optimum phase monitoring.

duced by all conventional processes. It will clearly trace a faithful representation of minute variations in the phenomenon being recorded. The stylus may be driven at speeds up to 70 mph without discernible distortion or impairment of the trace. Recording speeds are selectable from 0.1 to 500 mm per sec. The chart speed can be changed, by pushbutton selection, in 0.2 sec, eliminating lag in chart speed stabilization. The stylus does not touch and therefore cannot distort or tear the chart paper. As it traces, the stylus is imperceptibly vibrated laterally 400 times per second to eliminate friction and static error. Changes in temperature and humidity do not affect the quality of the trace.

Under Development Two Years

Manufactured by the Instrument Division of the American Optical Co., Buffalo 15, N.Y., this system has been under development for two years, according to Vice President W. K. Hannan. He adds, "we have no doubt that the Trace-Master System is the most significant advance in direct-writing recording design in recent years."

The system is installed in a floor-mounting rack cabinet, and requires input power of 115 v ac, 60 cps, 15 amp. Chart rolls are available in various widths in 1,000 ft lengths.

For further information on this direct-writing recorder turn to the Reader-Service Card and circle **250.**

The Model 150 is small enough to fit snugly in the palm of a man's hand.

Transistorized Oscilloscope

Weighs Less Than 2 Lb

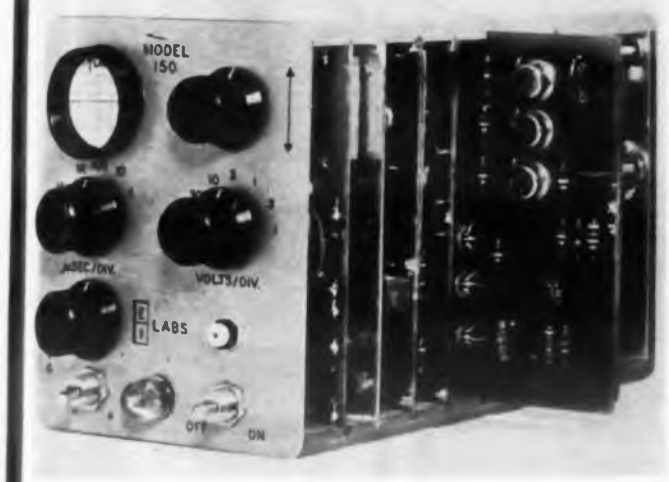
THESE PORTABLE, transistorized oscilloscopes are small enough, and light enough, to hold in the palm of one hand while they are being used. Though they operate primarily on internal, rechargeable batteries, ac power or low-voltage dc can be used while the batteries are being recharged. Despite the small size of the unit, the display presentation is equivalent to those of laboratory instruments according to spokesman Joseph Davenport, vice president of Electro Instruments Co. All components are mounted on plug-in cards while an etched circuit board accepts and interconnects all the plug-ins.

Response Is From Dc To 1.5 Mc

In the vertical deflection amplifiers, cascaded, transistorized circuitry provides the necessary high voltage and frequency deflection potentials. The sweep is generated by a gated, constant current generator with a variable charging capacitor. Battery voltage in the model 150, the one-inch display size, is converted to the required higher potentials by a 5-kc converter. This includes the 100-v deflection supply and the 600-v acceleration potential. The response of the vertical amplifiers is from dc to 1.5 mc, independent of the sensitivity setting. Input impedance is one megohm. The sensitivity is calibrated in seven steps to 0.1 v per division. Sweep range is in 5 calibrated steps to 1 μsec per division, and is triggered from a plus or a minus slope with variable amplitude control.

Nickel Cadmium Batteries

The nickel cadmium batteries used are rechargeable through the use of an accessory power pack which will be available shortly. This power pack also contains the circuitry necessary to power the scope from ac or dc sources while the batteries are being recharged. The oscilloscope can be used therefore, while charging process is taking place. For ease of maintenance and assembly all components are mounted on plug-in cards



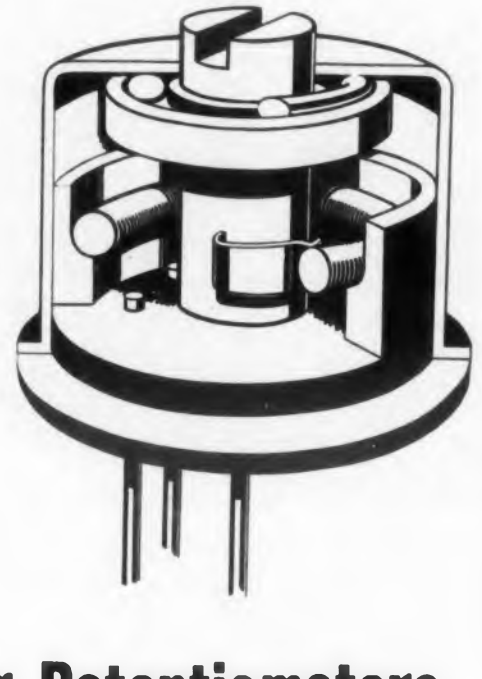
The Oscilloscope consists of 11 parts, the case, guide rails, "mother" board, 5 circuit cards, plug-in front and rear panel assemblies.

2 x 3 in. in size. An etched circuit board, called a "mother board" by EI engineers, accepts all the plug-in cards and interconnects all components, thus eliminating the need for a considerable amount of wiring.

The Scope For Design and Service Engineers

Representatives of the manufacturer, the EI Laboratory Div. of Electro Instruments Inc., 1165 Morena Blvd., San Diego, Calif., describe the new line as providing the ideal oscilloscope where an accessibility or space problem exists. They compare the two-pound weight, and the 2-3/4 x 3-1/4 x 5-1/2 in. dimensions of their product with those of conventional oscilloscopes. Past experience indicates the conservative, transistorized circuitry used in the design will provide many times the reliability of conventional scopes and the improved performance and reliability, coupled with complete portability make these instruments ideal for both design and service engineers, they add. The model 150 is available with 90-day delivery at a cost of less than $500.

For further information on this transistorized, portable oscilloscope turn to the Reader-Service Card and circle **251.**



Cut-away shows simple construction of miniature trimming pot. Total outside diameter, including flanges, is 0.345 in. Pot is said to be one quarter the volume of conventional trimming units. Rotor screw is at top.

Wirewound Trimming Potentiometers For Printed-Circuit Applications

BUILT in TO-9 transistor cases, a new line of wirewound trimming potentiometers is designed to be used in printed circuits. About a quarter the volume of conventional trimming pots, the new trimmers measure 1/3-in. in diameter, weigh 1 g; and are useful for missile and airborne equipment.

Manufactured by Spectrol Electronics Corp., 1704 South Del Mar Ave., San Gabriel, Calif., the model 80 one-turn pots have standard resistances ranging in seven values from 50 ohms to 10 K, with ±1.0 per cent linearity. According to chief engineer Warren Hulbert, the model 80 offers better resolution and resettability than conventional miniature trimmers, because its resistance element is almost twice as long—about 750 mils, Compared to around 400 mils.

The pots are sealed by silicone O-rings as in the cut-away drawing, to keep out moisture and to help secure the rotor elements. Units will meet military 10-day humidity cycling and immersion in hot water tests, as well as 96-hr salt spray tests. They are rated at 50 g shock and 30 g to 2 kc vibration.

Power rating is 1 w at 70 C. Load life is 1000 hr.

Unusual, Simple Rotor

The rotor mechanism consists of a bored Teflon post, with a precious metal spring contact inserted at right angles through the Teflon, slightly off axis. The rotor is seated on the center terminal (simply the extension of the center lead wire through the resin header), and forms the contact to the shape of the 26-mil-diam bore. This locks the contact to the rotor post, preventing its shaking loose during vibration.

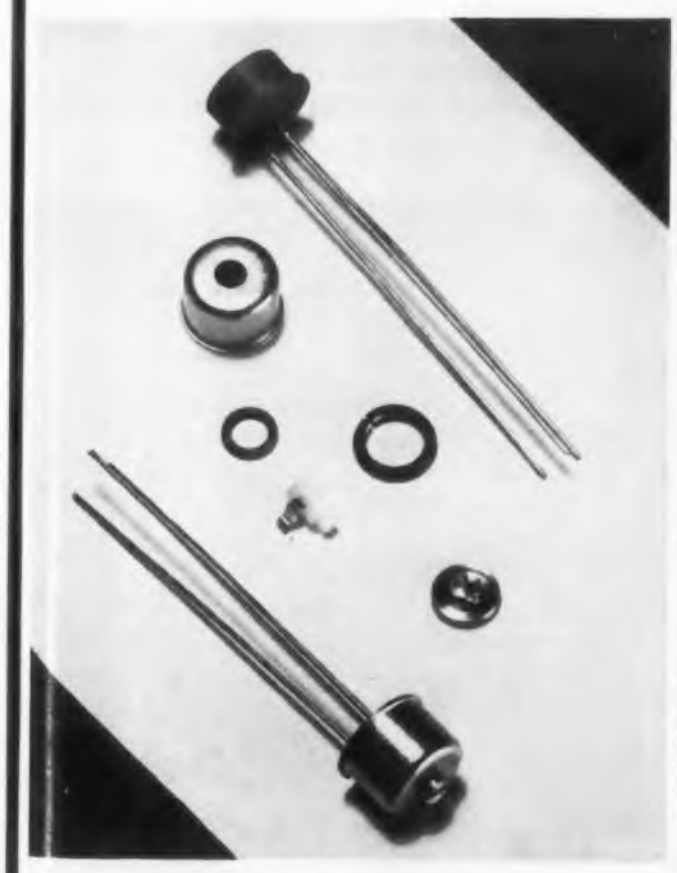
"Teflon," said Mr. Hulbert, "was used instead of nylon, because of nylon's instability at high temperatures." At the

pot's 150 C maximum rating (derated to zero at 150 C) nylon would work; but Spectrol hopes to upgrade the trimmer line to 175 or 200 C, where nylon gets brittle, shrinks and crumbles. "We may pack the metal case—which is a fair heat sink—with silicone grease as a further heat sink, to get up to higher temperatures," said Hulbert.

"Another reason for using Teflon," he pointed out, "is the necessity for making a center bore 26 mils in diameter and 150 mils deep; more difficult with nylon." The resistance wire is wound on a 35-to-45-mil core, which in turn, is formed to a 260-mil outside diameter.

Price of the model 80 is $6.00 each for one to nine units. They are immediately available at distributors and Spectrol representatives.

For further information on this transistor-size trimming pot, turn to the Reader-Service Card and circle **252**.



Trimming Pot in TO-9 transistor case is simple, easy to assemble, designed for transistor circuit boards.

Equalizer Extends Transducer Range

FLAT FREQUENCY range of transducers can be extended three or four times by the Tranqualizer [*sic*], an instrument designed for on-line compensation of transducing systems with previously determined parameters. The Tranqualizer compensates for the transducer's resonance characteristics.

According to Del Kahan, director of operations for Data Instruments Div. of Telecomputing Corp., 12838 Saticoy St., North Hollywood, Calif., the company that markets the device, transducer inputs—or components of inputs—with frequencies higher than 15 or 20 per cent of a transducer's natural frequency are amplified and delayed to varying degrees.

Sine wave inputs above the flat frequency response region undergo a change of amplitude and phase; almost any inputs of a non-sinusoidal or transient nature are distorted and may bear little resemblance to the original.

Confronted with distorted data in the past, the engineer has had to resign himself to using it or to correct the data during data reduction by involved and lengthy mathematical analysis. With the Tranqualizer, the extension of the transducer's flat range is often enough to obviate the need for mathematical treatment.

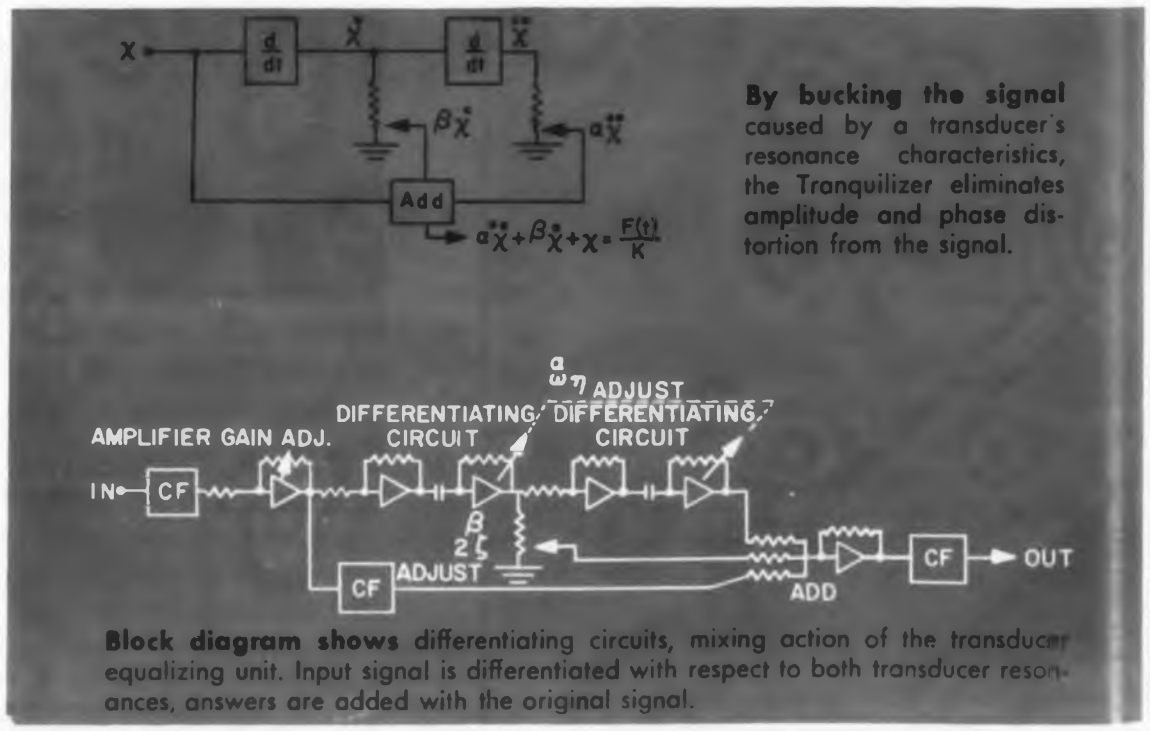
Principal use of the Tranqualizer is for on-line compensation of a two-degree-of-freedom system—pressure transducers, for example—with previously determined resonant frequencies and damping factors. The operator sets the inertia and damping controls, hi-lo range and gain controls for each channel; and a true picture of the input function to the transducer appears at the Tranqualizer output.

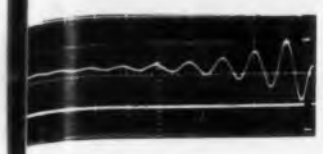
Used in reverse, the transducing system is excited by a known waveform like a square wave, and the Tranqualizer controls are adjusted for best compensation. The required parameters may be read directly from the dials.

Device is Computer

Essentially an analog computer, the Tranqualizer works by inserting a transfer function in the line that is the reciprocal of the transducer's transfer function. "If $H_1(s)$ and $H_2(s)$ are the transfer functions of the transducer and the Tranqualizer respectively, s being the Laplace variable," Del Kahan explains, "then H_1 times H_2 is equal to one. This provides a flat-frequency response up to the frequency—or close to, in practice—at which the transducer's amplification ratio drops to zero."

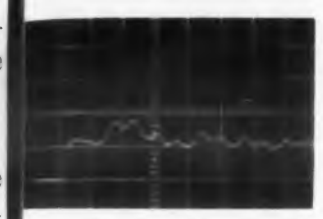
The linear differential equation $A_1\ddot{x}_1 +$





Effect of a Tranqualizer in the line. Upper trace is a pulse driving function; middle is the output of a transducer showing ringing; bottom (barely visible as pulse and white line at bottom edge of illustration) is the equalized Tranqualizer output. Sweep speed was 10 μsec per cm.

A shock function becomes clearly legible with the addition of the transducer equalizer device. Amplitude and sweep rates are equal. Tranqualizer output had inertia setting of 94.9 and damping set full counter clockwise. Shock tube chamber pressure was 350 psig, ring frequency 78.6 kc, damping coefficient 0.008. Normal output above—Tranqualizer output below.



$A_2\ddot{x}_2 + B_1\dot{x}_1 + B_2\dot{x}_2 + x_1 + x_2 = DF(t)$ is electronically solved by the device. This equation describes physical configurations representative of physical systems like condenser microphones, double-diaphragm, condenser-type pressure transducers or thrust measuring transducers.

$F(t)$ is the quantity to be recorded. Output of the transducer is X, where X is either x_1 or $(x_1 + x_2)$, depending on the type of transducer. The Tranqualizer operates on X such that the analog of $F(t)$ is recorded, by:

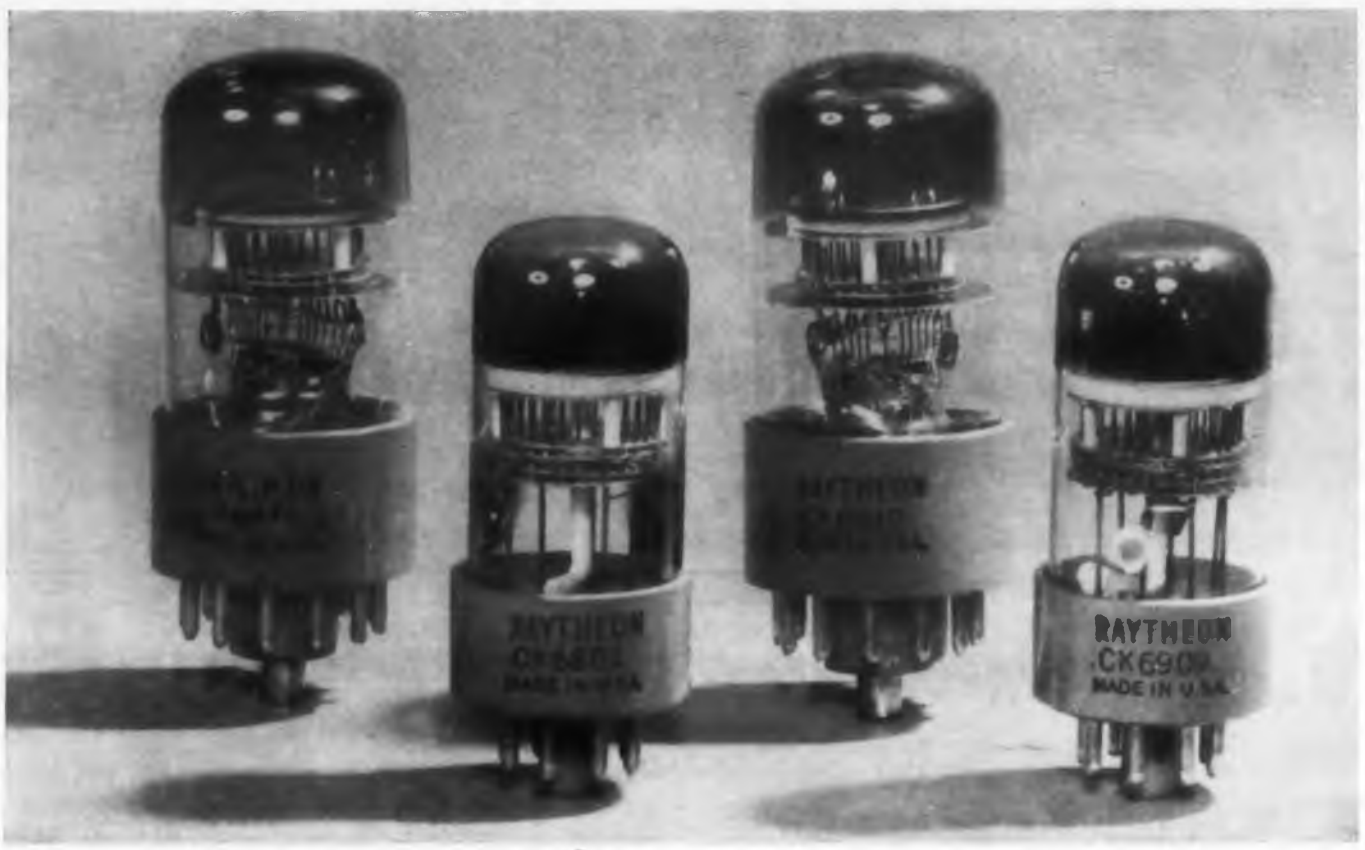
- Differentiating X twice with respect to one of the system's resonant frequencies, forming $A_1d^2x_1dt^2$ and B_1dx_1/dt,
- Doing the same with respect to the other resonant frequency to get $A_2d^2x_2/dt^2$ and B_2dx_2/dt, and
- Mixing these four quantities with the original signal to form the expression on the left side of the above equation.

Weighing about 71 lb and occupying 18 in. of standard 19-in. rack space including power supplies, the Tranqualizer is capable of compensating resonant modes up to 100 kc, and can be used with any system where the input information is in voltage form—analogs of mechanical, acoustic, electrical or other systems having one or two resonances.

For further information on this transducer equalizing device, turn to the Reader-Service Card and circle 253.

NEW PRODUCTS

Covering all new products generally specified by engineers designing electronic original equipment. Use the Reader's Service Card for more information on any product. Merely circle number corresponding to that appearing at the top of each description.



Decade Counters Display 100,000 Units Per Sec — 447

The decade counters above are capable of counting 100,000 units in 1 sec. The electron-tube devices indicate the count on ten glowing cathodes in luminescent dials. The count can be converted to electrical pulses. Applications are in automatic machine programing and control and in high speed processes such as coil and transformer winding. Types CK6909 and CK6910, shown at the right, operate at up to 100 kc; types CK6802 and CK6476, left, operate at up to 4 kc.

Raytheon Co., Industrial Components Div., Dept. ED, 55 Chapel St., Newton, Mass.

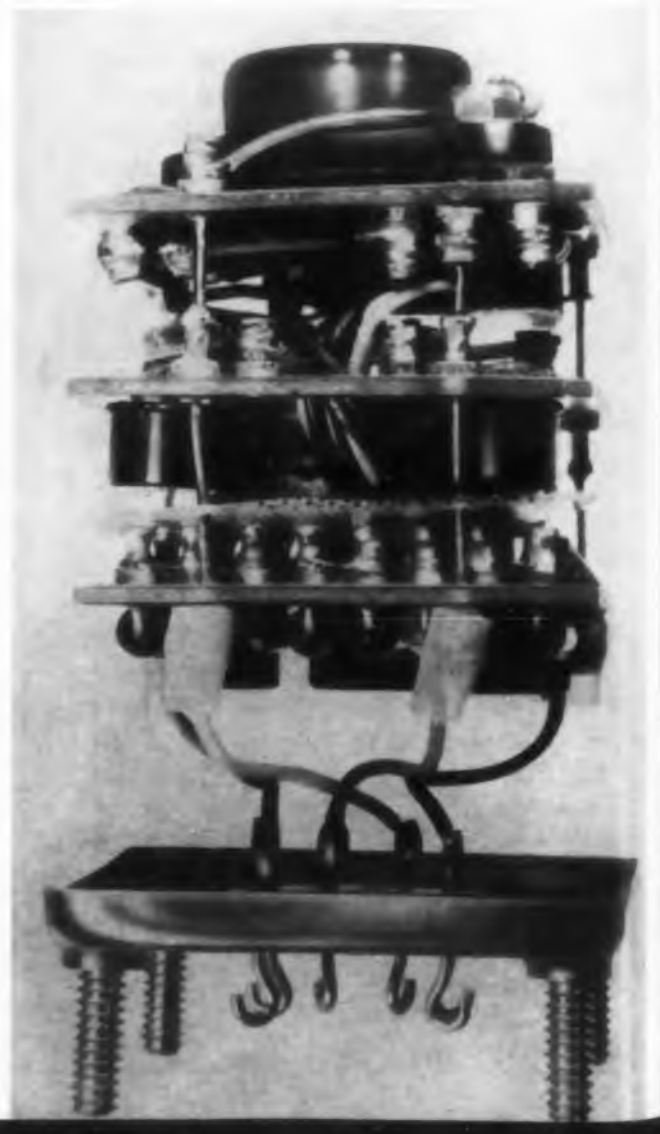
Price & Availability: *CK-6802 and CK-6909, $11.43; CK-6476 and CK-6910, $13. 37; delivery is immediate in sample quantities.*

Gallium-Arsenide Mixer Diode For K-Band Operation — 446

Specified for 24,000-mc operation as a first detector, this gallium-arsenide diode, type 1N-3096R, is said to have a greater mobility value than did previous models, allowing a considerable increase in sensitivity. The device operates at higher temperatures than germanium or silicon components, and has an over-all noise figure of 10.5 db. The coaxial package housing is identical to that of existing silicon K-band diodes.

Philco Corp., Dept. ED, Lansdale, Pa.

Price & Availability: *Single units, $75; matched pairs (type 1N3096RM), $187.50, are available within three weeks.*



Solid-State Relay Utilizes Modular Construction — 444

The relay at the right is modularly constructed. It is a sold-state device said to have a life span of millions of cycles. Designated model SR-101-1A, the unit is designed for high-reliability requirements in space and air vehicles, for computers, automation, data processing and proportionate control systems. The modular "layer cake" construction permit rapid modification of special-purpose-designs. Operating voltage is 30 v dc at 60 ma max. Contacts are rated for 1 amp at 28 v. Operating time is about μsec. Unit weighs 10 oz.

Leach Corp., Controls Div., Dept. ED, 5915 Avalon Blvd., Los Angeles 3, Calif.

Price & Availability: *$225; delivery 6 to 8 weeks.*

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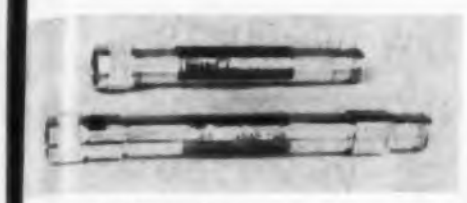


Coaxial Isolators **448**
Nearly 100% Shielded

Magnetic fields of several hundred oersteds have a negligible effect on the performance of these shielded coaxial line isolators. The devices have no external permanent magnets. Models D44C7, D44S7 and D44L7, for C, S, and L-band operations respectively, operate over 10% bandwidths, provide more than 15-db isolation and have an insertion loss of less than 1 db. The units measure 3/4 in. in diameter, 4-1/4 to 6-5/8 in. long, and can be designed for operation from uhf to X-band frequencies. Potential applications include missile and aircraft equipment, telemetry, radar and communications systems.

Sperry Microwave Electronics Co., Dept. ED, Clearwater, Fla.

Price & Availability: C and S-band units are $225; L-band unit is $235; delivery is 30 to 60 days.

Complementary Silicon Controlled Rectifiers **445**

Providing both positive and negative operation in controlled rectifier circuits, these complementary silicon controlled rectifiers are available in npnp as well as pnpn styles. The npnp types utilize negative gate current triggering. Designated models HCR-30N through HCR-200N (npnp) and HCR-30P through HCR-400P (pnpn), the units are rated at 1 amp average-rectified-forward-current, and 1.4 amp dc at 80 C. Temperature range is —65 to +150 C. Five npnp units with voltages of 30, 50, 100, 150 and 200 v, and seven pnpn units with voltages of 30, 50, 100, 150, 200, 300 and 400 v are available.

Hoffman Electronics Corp., Semiconductor Div., Dept. ED, 3761 S. Hill St., Los Angeles 7, Calif.

Price & Availability: $5.60 to $60, depending on voltage; delivery is immediate in sample quantities.

CIRCLE 77 ON READER-SERVICE CARD ➤

Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 2, No. 3

RAYTHEON 1,000,000-WATT MAGNETRON LOGS OVER 13,000 HOURS IN MOBILE RADAR

This is the first reported history of a Raytheon QK-358 magnetron substantiated with an exhibit. Still, there are numerous other cases in which these exceptional Raytheon tubes have been clocked in excess of 10,000 hours, radiating at peak power.

The case in point concerns the application of a QK-358 magnetron in an AN/FPS-8 radar, for which the General Electric Company is the prime contractor. When the tube was replaced after 13,000 hours of service for "preventative maintenance" reasons, it was returned to Raytheon where the tube was found to be operating within specifications. Findings showed it to be highly stable and still capable of radiating more than one megawatt of power.

A large measure of the reliable operation and outstanding life of the QK-358 was achieved through special attention given to its unique characteristics in the overall design of the radar transmitter.

For your information, the QK-358 is a mechanically tunable pulsed-type oscillator with an integral magnet and is designed for coupling to a standard 3" x 6" waveguide. Typical operating characteristics include:

Frequency Range	"L" Band
Peak Power Output	1.3 Mw
Average Power Output	1,630 W

AN/FPS-8 high-power search system by General Electric, used primarily in aircraft control and early-warning operation. The complete mobile version (AN/MPS-11A) shown here, can be airlifted or carried on nine trucks and two trailers.

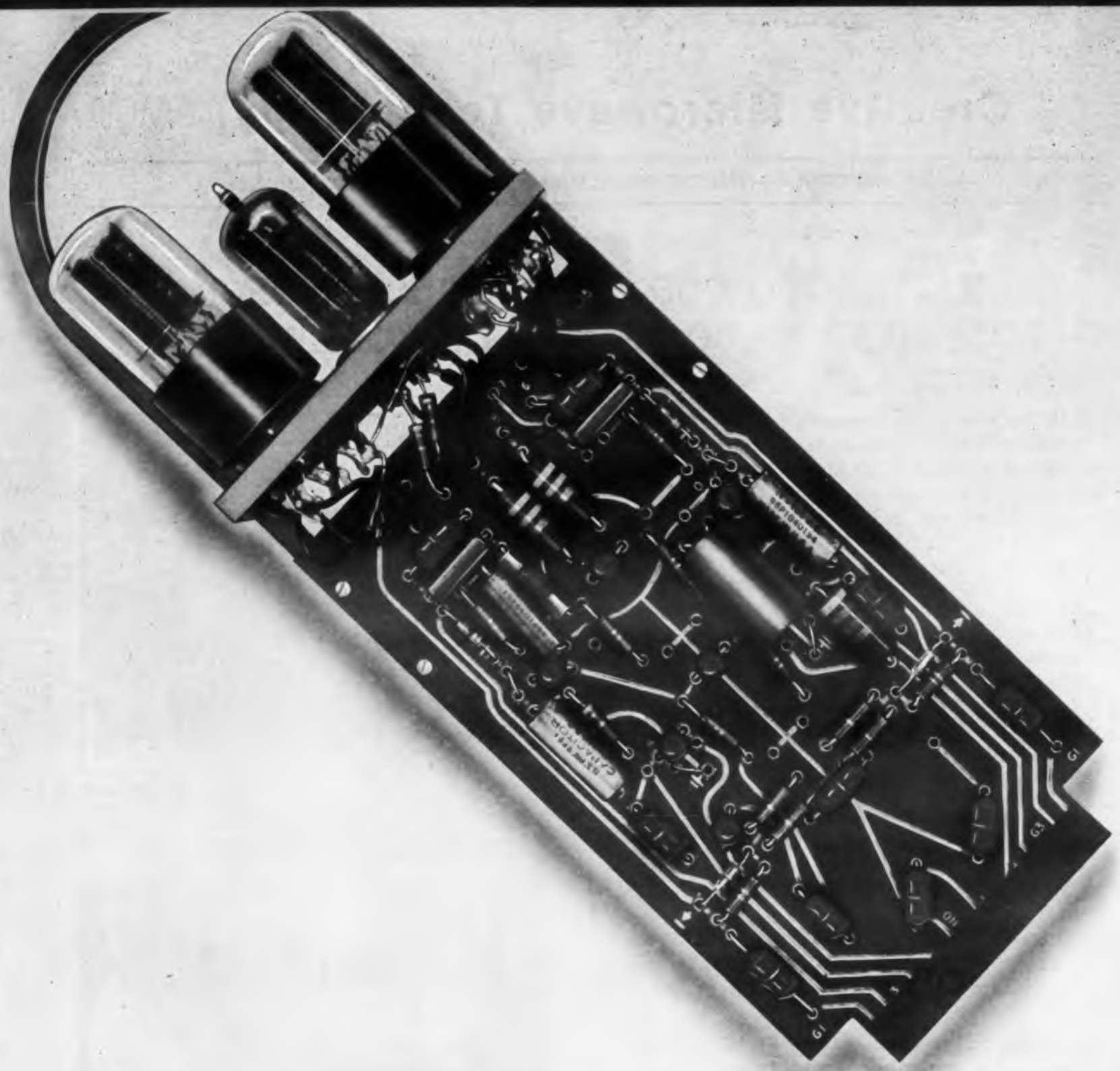
Life testing of Raytheon tubes, such as the QK-358 magnetron, for six weeks or more serves as a quality check of their performance characteristics as recorded and plotted against time.

Excellence in Electronics

RAYTHEON

You can obtain detailed application information and special development services by contacting: Microwave and Power Tube Division, Raytheon Co., Waltham 54, Mass. In Canada: E. Waterloo, Ontario. In Europe: Zurich, Switzerland.

A LEADER IN CREATIVE MICROWAVE TECHNOLOGY



NEW PRODUCTS

Neon Lamps 556

Life is to 5,000 hr

Types SLT2-32-1, RT2-32-1A, RLT2-27-1 and RLT2-27-1A neon lamps are for use as switches, voltage regulators, and indicators. Voltages are 55 to 80 v dc; currents, 6 to 20 ma. Life is up to 5,000 hr. Some types contain a radioactive additive for reduced dark starting effect.

Signalite, Inc., Dept. ED, 37-41 Neptune Highway, Neptune, N.J.

Price & Availability: *Price ranges from $0.10 to $0.25 ea in quantities to 100. Samples can be delivered immediately. Production quantities can be delivered in two or three weeks.*

Motor-Driven Switch 554

Has voltage-sensing element

For satellites, deep space probes, or extended space flights, this motor-driven switch has a voltage-sensing element. It stands 40 g of vibration from 5 to 2,000 cps. Voltage drop across typical contacts is less than 10 mv at 22 amp. No power is required to hold the switch open or closed. Up to 21 circuits can be contained in less than 14 cu in.

Kinetics Corp., Dept. ED, 410 S. Cedros Ave., Solana Beach, Calif.

Availability: *Built to customer specs, units can be delivered in 45 days.*

Data Processing System 570

Capable of 45,000 floating-point operations per sec

The G-20 data processing system is capable of 45,000 floating point operations per sec. Control buffers are used in the central processor of the system. Operator duties consist of loading and unloading paper tape, punched cards, and printing paper. Magnetic tape units read and write 120,000 digits per sec and 600 to 1250 line-per-minute printers. The central processor measures 66 x

60 x 28 in. Built of solid state components, the system has an expandable, random-access magnetic-core memory which may consist of 1 to 8 modules of 4096 words each.

Bendix Aviation Corp., Computer Div., Dept. ED, Los Angeles 45, Calif.

Price & Availability: *A typical system for scientific problems is leased for less than $10,000 per month.*

Paper-Base Laminate 565

Is flame retardant

This paper-base, phenolic laminate provides flame retardance and excellent cold-punching characteristics. Designated XXXPC-476, the base stock meets NEMZ standards and UL tests. Type XXXPC-476-1 foil copper-clad laminate with standard adhesive bonding is for commercial radio and TV applications. Type XXXPC-476-2 copper-clad laminate is for computer printed circuits and military applications.

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

Price & Availability: *Price is $0.96 per sq ft, 1/16 in. thick. Samples can be furnished immediately.*

Test Sockets 551

Come in 150 configurations

These test sockets come in 150 standard configurations to accept a wide variety of relays, chokes, packaged circuits, and other hermetically sealed components. The sockets accept headers with hook, pin, turret, and other types of terminals. All sockets have two mutually-insulated contacts for each terminal. Contacts are beryllium copper with gold plating and have a maximum resistance of 0.005 ohms. The sockets are made of mica-filled epoxy or urethane rubber.

Barnes Development Co., Dept. ED, 213 W. Baltimore Ave., Lansdowne, Pa.

Price & Availability: *Delivery time ranges from one to four weeks. Price is $24 to $65 with quantity discounts.*

CIRCLE 79 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Variable Delay Line 351

Continuous delays from 3 to 500 μsec

Model VM-1030 Delay Line features a continuous range of delays from 3 to 500 μsec with an accuracy of ±0.5 μsec. It has an optimum pulse input of 1 μsec and can be supplied with an impedance range of 50 ohms to 4 K. Insertion loss at the end of the range is 56 db and the maximum number of pulses per second is 300 kc. The unit is 4.406 in. in length with an OD of 3.398 in. Total weight is 2 lb.

Control Electronics Co., Dept. ED, 10 Stepar Place, Huntington Sta., Long Island, N.Y.
Availability: Approximately 30 days.

Synchronous Motor 508

Self-orienting within ±5 deg

This self-orienting, synchronous motor insures synchronization of the rotor within ±5 deg with respect to the rotating stator field. No dc excitation of the rotor is required. Motor is two phase, 60 cps, 115 v ac; synchronizing pull-in torque is 0.50 oz-in.; fall-out torque is 0.65 oz-in. Unit measures 2 in. long with a 1-3/4 in. diam and weighs 10 oz. Units designed for 400 cps are also available.

Kollsman Motor Corp., Dept. ED, Mill St., Dublin, Pa.
Price & Availability: *Type 1497 ranges from $78.45 to $102; type 287C1 ranges from $130.70 to $179. Availability is 3 to 6 mo.*

Fixed Delay Line 521

For computer applications

Delay-line flat No. F840W is designed for computer applications and uses an elliptical core to obtain a relatively long delay at a high impedance level. The unit has an impedance of 3,300 ohms, a delay of 0.8 μsec with a rise time of 0.2 μsec. Pulse attenuation is 0.2 db, ripple ratio is less than 5%, dc resistance is under 100 ohms. The unit is 1-7/8 in. long, with a cross-section of 1/4 in. x 11/16 in.

Columbia Technical Corp., Dept. ED, 61-02 31 Ave., Woodside, N.Y.

Elapsed Time Indicator 420

Has 1/8-in. characters

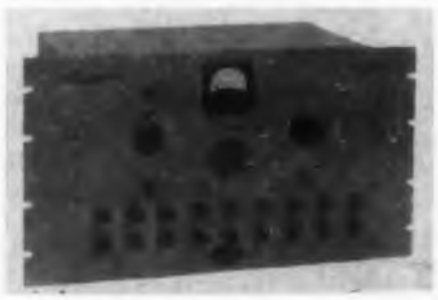
Having numerals 1/8-in. high, model 1440 elapsed time indicator provides readings from 0000 to 9999 hr. Nominal input requirements is 115 v at 400 cps, single phase. The unit meets the environmental requirements of MIL-E-5272. It weighs about 1.8 oz, has an over-all diameter of 0.67 in. and a height of 1-7/8 in.

Bowmar Instrument Corp., Dept. ED, 8000 Bluffton Road, Fort Wayne, Ind.

Availability: Made on order.

Thermocouple Control Unit 518

For voltage calibration



Model TC 2R thermocouple control unit simulates thermocouples for voltage calibration of oscillograph records. Available in 12- and 18-channel capacity models, the units have sensitivity adjustments in each channel. An adjustable voltage source is included for establishing a reference temperature calibration point.

Pace Engineering Co., Dept. ED, 13035 Saticoy St., N. Hollywood, Calif.

NEW PRODUCTS

Transistor Test Set 515

Measures to 30 amp collector current

Power transistor measurements to 30 amp collector current and 300-v breakdown test potentials are possible with the Type 300 precision power transistor test set. Direct meter readings of large signal current gain, H_{FE} and collector characteristics, I_{CBO}, I_{CER}, BV_{CEC}, and BV_{CBO}, can be made under conditions typical of their actual applications.

Owen Laboratories, Inc., Dept. ED, 55 Beacon Place, Pasadena, Calif.
Price: *$675 ea.*

Motor Analyzer 500

For digital stepper motors

Developed for digital stepper motors, this motor analyzer automatically checks motor response by comparing the total number of applied voltage steps with the actual number of motor mechanical steps. The analyzer consists of a square wave generator with provisions for varying the frequency, pulse width, and amplitude of the output waveform; a pick-off assembly which detects the actual mechanical rotation of the stepper motor; and counter circuits to tally and record the stepper motor input and output pulses. The test fixture provides stepping rates to 1,000 and the stepping pulse duty factor can be varied from 10% to 90%.

Mechatrol, Div. of Servomechanisms, Inc., Dept. ED, 1200 Prospect Ave., Westbury, N.Y.

Magnetic Tape Head 504

For 1-in. tape

Model DTH 2132 digital magnetic-tape head is a 32-track interlaced unit for 1-in. tape. The gap length of the head is 10 μin., allowing its use at high-bit densities. The unit is shown mounted on type TG tape slot guide. A precision unit, the tape guide virtually eliminates tape skew and scrape-flutter.

Shepherd Industries, Inc., Dept. ED, 103 Park Ave., Nutley, N.J.

Feedback Control System 433

Laboratory type

Called laboratory for servomechanisms, this equipment includes a master panel, a rack, a mechanical breadboard, and a controls analyzer for demonstration or development work. Necessary components are provided to perform all linear as well as many non-linear feedback-control experiments.

Superior Manufacturing & Instrument Corp., Dept. ED, 154-01 Barclay Ave., Flushing 55, N.Y.

DC Power Supplies 505

Have 0.01% line and load regulation

The series 60 power supplies, providing a variable output of 0 to 60 v dc at 0 to 2.5 and 0 to 5 amp, have a line and load regulation of 0.01%. Ripple is less than 1 mv rms. The 2.5-amp unit is programable over the entire voltage range and the 5-amp unit is programable over any 36-v range.

Trygon Electronics Inc., Dept. ED, 111 Pleasant Ave., Roosevelt, L.I., N.Y.

Price & Availability: $695 to $845; 4 weeks.

NEW PRODUCTS

DC Power Supplies 419

All solid state

The TRHV series of regulated, high-voltage dc power supplies are all solid state. Referencing and regulating is done at low voltage. Operating temperature is —20 to +55 C. The series consists of five models with output voltages of 1 kv at 5 ma to 10 kv at 1 ma. No warm-up time is required.

Del Electronics Corp., Dept. ED, 521 Homestead Ave., Mount Vernon, N.Y.

Chopper 417

Microminiature

Type 40 dc-ac chopper is housed in a metal casement measuring 5/16 x 1/2 x 5/8 in. It has a rugged, taut-band armature suspension and an armature action exerting over 50 times more contact force than the firm's earlier type 20 model. Units are offered with the following driving ranges: 20 to 140 cps, 400 to 600 cps, and 1,000 to 1,500 cps. Coil excitation voltages are 3 to 28 v, square or sine wave. The unit stands environmental extremes.

Rawco Instruments, Inc., Dept. ED, 3527 W. Rosedale, Fort Worth 7, Tex.

Phase Shifter 412

Accuracy is 20 min

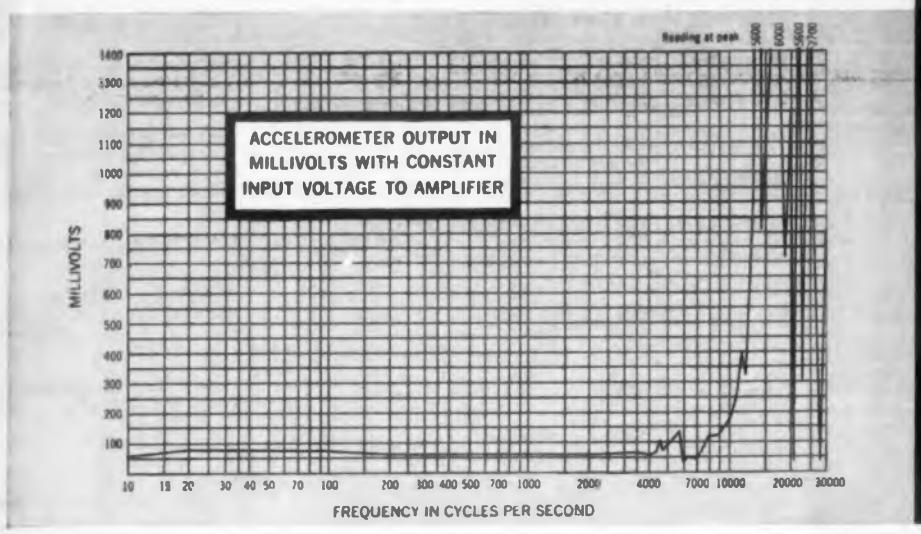
Model PG-5 phase generator produces a carrier phase shift at constant amplitude which corresponds to the rotation angle of the input shaft. The device is servo-mounted. Its input can be impedance-loaded without adverse error effects. Specifications include: phase accuracy, 20 min; range, 0 to 360 deg, continuous; diameter, 2.5 in.; and length, 3.25 in.

Theta Instrument Corp., Dept. ED, 520 Victor St., Saddle Brook, N.J.

Price & Availability: *$210; from stock.*

for vibration testing the ITT Model 1201 is a completely self-contained console built around the ST-100 fifty force pound Vibration Exciter.

for vibration and shock testing the ITT Model 1205 offers all the features of the vibration console, plus shock test equipment. Both systems are particularly suited to accelerometer calibration as is seen in the graph below.



VIBRATION AND SHOCK TESTING

THE ITT MODEL ST-100 AIR-SUSPENDED VIBRATION EXCITER

- no measureable distortion to 10 KC
- first major resonance above 12 KC
- shock testing to over 3,000 g
- useful frequency range exceeds 50 KC
- 50 force-pound rated output
- handles test samples up to 5 lbs.
- simple to operate—even by unskilled personnel

The ITT Model ST-100 is the first shaker table of its type designed to be used for both vibration and shock testing. In either application, its greatly advanced design and performance features make it ideal, not only for production testing, but as an R & D tool as well. In addition, its "flat" response to 10,000 cps, with negligible distortion, provides *an exact method of accelerometer calibration.*

With the ST-100, force levels at the table are always accurately known. Thus, unnecessary test failures are eliminated and the failure of sub-standard specimens is assured. This, combined with a useful frequency range in excess of 50,000 cps and the simple, one-man operation of the ST-100 greatly expands areas of practicable testing... substantially reduces testing time and expense.

After 7 years of development, the ITT Model ST-100 Vibration Exciter is now available to reliably upgrade your vibration and shock testing results, while it cuts your testing costs.

For complete technical data and applications information, contact your ITT Instruments representative. Or write us direct for Data File ED-1291-1.

Check ITT for your other test instrument requirements such as: ***Bar Graph Oscilloscopes...Frequency Synthesizers... Large Screen Oscilloscopes and Accessories...Swept Frequency Generators...High Stability Oscillators...Storascope.***

Control Chassis 409

For digital data

Model K-111A control chassis is designed for the acquisition, storage, and translation of digital data. It features transistor buffer storage with relay contact closure output. It has a maximum capacity of six decimal digits or 24 binary bits. The output can be decimal or any required binary code. It is 8-3/4 in. high, 19 in. wide, 6 in. deep and weighs 40 lb.

Datex Corp., Dept. ED, 1307 S. Myrtle Ave., Monrovia, Calif.

Crystal-Controlled Oscillators 411

Stabilities from ±0.1% to ±0.001%

These crystal-controlled oscillators operate from 60 cps to 10 mc with standard stabilities from ±0.1% to ±0.001%. Custom units with stabilities to ±5 parts in 10^8, and temperature ranges from —65 to +125 C are also available. Outputs are pulse, square wave or sine wave, with load impedances from 50 ohms and up. Standard units are plug-in or stud mounted; custom configurations can be supplied.

Valpey Crystal Corp., Dept. ED, Holliston, Mass.

Price & Availability: *Price is dependent upon frequency and stability required, with delivery 40 days after order is received.*

Resistivity Test Set 416

For semiconductor materials

This resistivity test set is designed for semiconductor materials. Control on measurements is ±2%. Separate heads are provided for germanium and silicon; others can be designed for special uses. A 12-in. traversing platform is provided for long crystals. Probes project 1/16 in. beyond their mounting. A tolerance of 0.0001 in. variation in probe point spacing is maintained.

Semimetals, Inc., Dept. ED, 18, N.Y.
133-20 91st Ave., Richmond Hill

◄ CIRCLE 82 ON READER-SERVICE CARD

NEW PRODUCTS

Communication Wire Connector 388

Self-stripping, moisture-proof

The type UR communication wire connector is self-stripping, moisture-proof and pre-insulated. Designed to accommodate any 2- or 3-wire combination of No. 19 to 26 AWG solid or No. 20 to 26 AWG stranded wire, this connector handles all common types of insulation, has an average pull-out strength equal to 95% of wire-breaking strength.

Minnesota Mining and Manufacturing Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

Comparison Bridge 381

Detects deviations of 1 in 10,000

Model 544-B comparison bridge detects deviations as small as one part in 10,000. Resistance limits that can be measured are 3 ohms to 5 meg; capacitance limits are 500 pf to 1,000 μf; inductance limits are 3 mh to 10,000 h. The instrument has three meter ranges, indicating full-scale differences of ±1.5%, ±7.5% and ±25%.

Metronix, Inc., Dept. ED, Chesterland, Ohio.

Directional Coupler 382

With type N or C connector

This series of dual directional couplers, for broadband applications, come with either type N or C connectors. Specifications are: coupling 30 db at 100 mc and 12.5 db at 1,000 mc; vswr is 1.15 max in the primary arm and 1.2 max in the secondary arm; directivity above coupling is 20 db min; coupling and directivity accuracy is ±1 db; nominal impedance of the unit is 50 ohms. It withstands 500 w, cw.

Maury and Associates, Dept. ED, 10373 Mills Ave., Montclair, Calif.

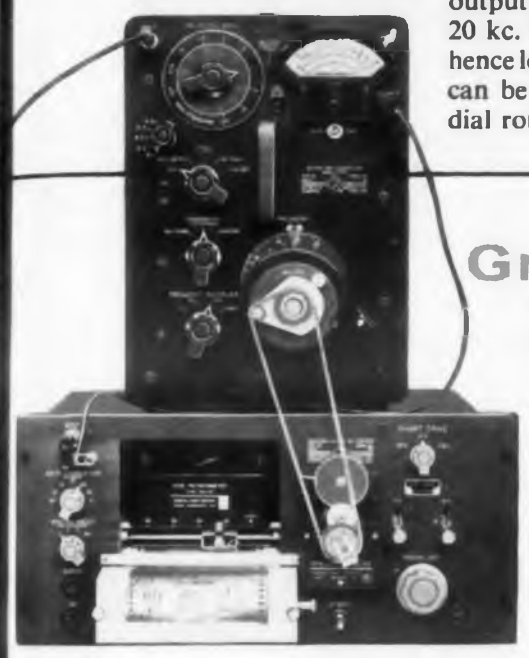
Price: *Type N connector model is $120, type C connector model is $130.*

Automatic Frequency-Response Measurements

The system shown at right is useful for studying filters, networks, amplifiers, equalizers, loudspeakers, microphones, and transducers of all types.

The 1521-A Graphic Level Recorder plots frequency-response data automatically when coupled by Drive and Link Units to the 1304-B Beat-Frequency Audio Generator.

The Generator lends itself well to automatic recording, since its output is flat within ±0.25 db from 20c to 20 kc. Its frequency range is logarithmic, hence logarithmic frequency-response plots can be obtained simply by synchronizing dial rotation with paper motion.



Graphic Spectrum Analysis

The Recorder is readily coupled to the 1554-A Sound and Vibration Analyzer for continuous plotting of the spectrum from 25 to 250c, 250c to 2.5 kc, and 2.5 to 25 kc. Manual resetting of controls is necessary only between ranges. (The recorder also couples to the superseded Type 760-B Sound-Analyzer for coverage from 25 to 7500c).

1304-B Beat-Frequency Generator . . . **$680**
1554-A Sound and Vibration Analyzer . . . **$1060**
1521-A Graphic Level Recorder . . . **$995**

1521-P10 Drive Unit . . . **$72**
1521-P11 Link Unit . . . **$18**
1521-P12 Link Unit (for coupling to 760-B Analyzer) . . . **$18**

NEW Audio-Video Beat-Frequency Generator

for manual-tuning or sweep applications

1300-A Beat-Frequency Video Generator . . . $1950

. . . an all-purpose instrument for wide-range frequency response measurements, i-f testing, and investigations throughout the audio, ultrasonic, and video ranges.

- **Sine-Wave Outputs:** from 20c to 12 Mc, and 30 Mc to 42 Mc
- **Square-Wave Output:** from 20c to 2 Mc
- **As Sweep Generator** — may be centered at any frequency from 20 kc to 12 Mc or from 36 to 42 Mc and driven at any sweep width up to ±6 Mc. Sweep rate is 60 cps.
- Output for scope horizontal deflection voltages and blanking pulses
- Two calibrated incremental frequency dials for accurate point-by-point investigations centered about **any** frequency
- Output flat within ±0.25 db from 40c to 20 kc (±0.75 db at 20c) and within ±1 db from 20 kc to 12 Mc
- 10-volt output over entire frequency range
- Built-in step attenuator provides accurate low-level outputs
- Excellent frequency stability
- Low harmonic distortion; less than 1.5% on audio range, and less than 4% on video range
- Low hum; less than 0.1% of output

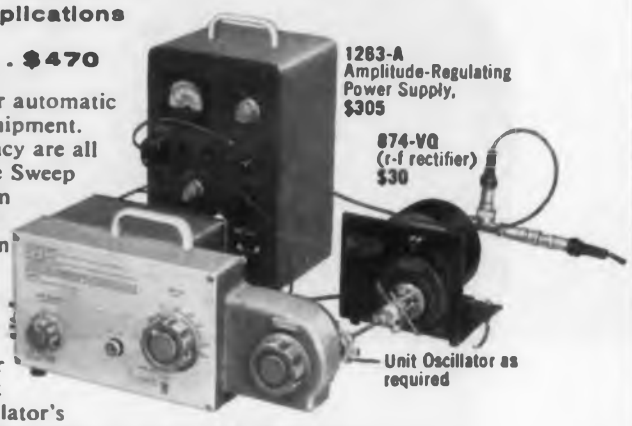
Mechanical Sweep Drives

adapt Manually-Operated Equipment to Automatic Sweep Applications

Type 1750-A Sweep Drive . . . $470

Attaches to knobs, dials or shafts for automatic sweeping of oscillators and other equipment. Sweep arc, speed, and center frequency are all continuously variable, even while the Sweep is in motion. Speed is adjustable from 0.5 to 5 cps — a CRO sweep voltage proportional to shaft-angular position is supplied, permitting calibration of CRO horizontal axis — limit switch, universal coupling system and many other features.

The Type 1263-A Regulated Power Supply is designed to power the Unit Oscillator as well as to keep the oscillator's output constant over wide ranges of frequency. It does this by comparing the rectified r-f output of the oscillator against an internal reference voltage, and applying any necessary corrections to the oscillator through its plate voltage supply. With this setup, output is maintained within 2% over the oscillator's entire frequency range.



Type 908-P
Synchronous Dial Drives . . . $32 each

Self-reversing dial drives that readily attach to G-R Unit Oscillators, 1304-B and 1330-A Oscillators and other equipment with G-R Type 907 and 908 Dials — 4-rpm model for use with graphic recorders; 30-rpm model for use with oscilloscopes.

Type 907-R 144 and 908-R 96 Dial Drives . . .

Similar to 908-P but provide sweep voltage proportional to shaft position as well, for driving horizontal axes of oscilloscopes, x-y plotters and other recording systems — panel knob disengages motor for manual operation — 4 rpm pinion speed (144°/min. for G-R 907 Dial and 96°/min. for 908 Dial). Model for 907 dials, $70; for 908 dials, $67.

Equipment Chassis Slide 389

For left or right side of cabinet

This electronic equipment slide provides interchangeability between the left to the right side of the cabinet. Classed a thin slide, the Tronic-Slide handles a maximum of 300 lb, has a quick disconnect feature and is ball-bearing mounted with a dry-film lubricant.

Flotron Industries, Dept. ED, 1608 Centinella Ave., Inglewood 3, Calif.

Price & Availability: *Prices range from $25.90 to $44.50. They are available within 30 days after receipt of order.*

Microwave Receiver 383

Solid-state circuits

Model TMR-1419 receiver is a solid-state unit composed of an orthomode X-band mixer, a low-noise transistorized preamplifier and a transistorized main amplifier. It provides an over-all noise figure of 10 db, a gain of 95 db, and a nominal 9-mc passband. Less than 1/2 w of total input power is required.

LEL Inc., Dept. ED, 380 Oak St., Copiague, Long Island, N.Y.

Microwave Coaxial Cable Connectors 377

For high-power airborne systems

These cable connectors transmit high-power microwave energy in airborne electronic systems. They are designed in straight and right-angle configurations, have a range of 50 to 5,000 mc and handle 1,000 w. Connectors are designed for RG-119/U, RG-209/U and RG-211/U coaxial cables and can be modified for other types. They operate from −54 to +95 C up to 70,000 ft. Units are moisture-sealed in either mated or unmated conditions.

Thompson Ramo Wooldridge, Inc., Dept. ED, 23555 Euclid Ave., Cleveland 17, Ohio.

◀ CIRCLE 83 ON READER SERVICE CARD

NEW PRODUCTS

Voltage Regulator 506

For airborne use

This 5-v regulator is designed for airborne telemetering transducer circuits. Voltage inputs are from 22 to 29 v dc; regulated outputs are from 4.975 to 5 v. Load is 0 to 100 ma. The unit operates over the temperature range of —65 to +185 F, weighs 5 oz, and occupies 1.5 cu in.

Vapor Heating Corp., Dept. ED, 6420 W. Howard St., Chicago 48, Ill.

Microwave Amplifiers 428

For X- and C-bands

These traveling-wave-tube amplifiers are for serrodyne, amplitude, or phase-modulation applications. Type M2204-A operates in the range of 7 to 12.4 kmc and type M2203-B operates from 4 to 8 kmc. Either type provides greater than 20-db gain and at least 10-mw power output. The sideband suppression at a modulation rate of 150 kc is at least 35 db.

Microwave Electronics Corp., Dept. ED, 4061 Transport St., Palo Alto, Calif.

Price & Availability: *$1,100; two-week delivery.*

Static Inverter 507

Output is 750 v at 120 v ac

Operating from an input of 28 v dc, this static inverter provides 750 w at 120 v ac. Weight is 8.75 lb. The unit contains no moving parts. Efficiencies of 80% can be achieved.

Vapor Heating Corp., Dept. ED, 6420 W. Howard St., Chicago 48, Ill.

Transitron

introduces

an exciting new device for simpler, more reliable, more economical switching circuitry

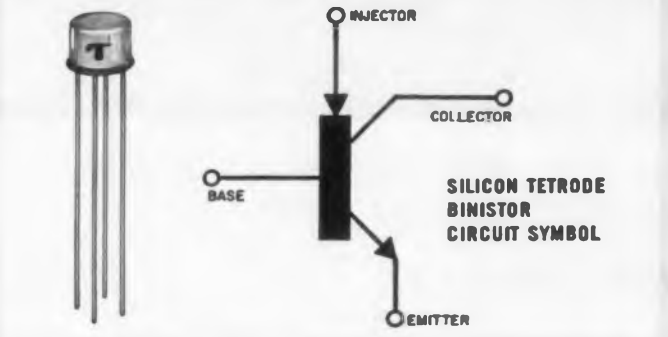
BINISTOR

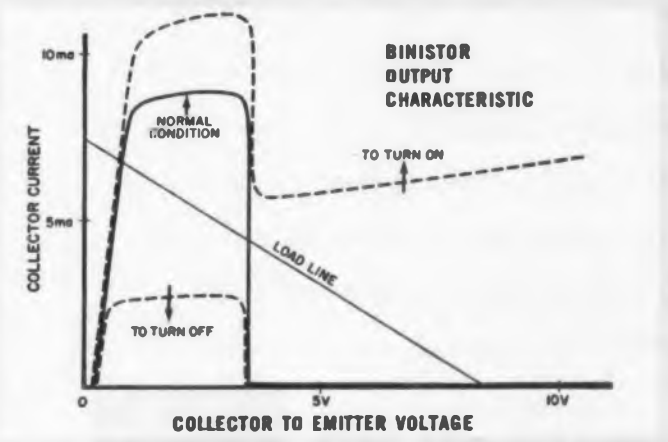
(BY-NIS-TOR)

The Silicon NPN Tetrode binistor is a new component and a new concept for the circuit designer!

The key parameters of this bi-stable, negative resistance device are determined by external circuitry in contrast to existing devices. The significant reduction of peripheral circuitry results in outstanding savings in cost, space, weight and solder connections. For example, a typical flip-flop requires at least 13 components versus only 4 in an equivalent binistor stage. Very large current and voltage gains are realized in both on and off directions. Inputs and output are compatible in level with typical transistor and diode circuits. The tetrode binistor can operate from −80°C to +200°C.

To learn more of this important new development — THE BINISTOR — and how it works — write for Bulletin No. TE-1360.





CONDENSED SPECIFICATIONS TRANSITRON BINISTOR

Typical Turn-off Current Gain	50 @ 15ma Collector Current
Operating Collector Current Range	50μa to 15ma
I_j critical	0.5ma @ 5ma Collector Current
Operating Temperature Range without Temperature Compensation	−65°C to 150°C

Transitron electronic corporation

wakefield, melrose, boston, mass.

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PLeasant 2-7191

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Pioneer 8-8211

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EMpire 1-1100

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NEW PRODUCTS

Microwave Filter 503

Range is 8.5 to 9.6 kmc

Type 60017, tunable, single-section filter operates in the range of 8.5 to 9.6 kmc. This dual-mode unit has a 3-db bandwidth that varies from 29 to 36 mc. The insertion loss is —21 db min at a center frequency of 60 mc. Insertion length is 2.75 in.

Waveline, Inc., Dept. ED, Caldwell, N.J.

Epoxy Compounds 429

Two types offered

Meta-Gel 103 100% solids epoxy is particularly suited to encapsulation of mica and ceramic capacitors for MIL-C-105 requirements. Meta-Gel 151 is for heat-sensitive components such as rectifiers, tantalum capacitors, and precison resistors.

Metachem Resins Corp., Mereco Products Div., Dept. ED, 530 Wellington Ave., Cranston 10, R.I.

Waveguide Units 497

Transmission lines and components

This line of large waveguide transmission lines and components meets the requirements of multi-megawatt radar systems and other high-power microwave applications. The firm will provide specialized units and fitting to customer specifications.

Schutter Microwave Corp., Dept. ED, 80 E. Montauk Highway, Lindenhurst, N.Y.

Availability: *Twists, elbows, and bends are available on a prompt delivery schedule.*

Precision Wirewound Resistor 510

Measures 1/8 x 1/8 in.

Type 375-P wirewound resistor is an encapsulated, precision unit that measures 1/8 in, long by 1/8 in. in diameter. Wattage rating is 0.05 w; resistance is 100 K; voltage is 50 v max. Temperature range is —65 to +125 C, standard tolerances are from 1% to 0.05%; standard temperature coefficient is ±0.002% per deg C.

Kelvin Electric Co., Dept. ED, 5907 Noble Ave., Van Nuys, Calif.

Reference Power Supply 426

Accuracy is better than 0.01%

Model 851 programed calibration reference supply has an absolute accuracy of better than 0.01% for line-voltage variations or ±10% over the temperature range of 40 to 125 F. Tracking accuracy is better than 0.005%. Output voltages range from 0 to 10 v from a constant impedance output of 10 ohms. Selection of 10 programed voltages is by mercury contactors with panel pushbuttons or remote selection.

Owen Laboratories, Inc., Dept. ED, 55 Beacon Place, Pasadena, Calif.

Price & Availability: About $2,000; delivery is from stock to 60 days.

Elapsed-Time Indicator 502

Has digital readout

Type WT-3 elapsed-time indicator with digital readout weighs 3.75 oz, measures 1-1/16 in. OD x 2-3/4 in., and operates at 360 to 440 cps with a 2.5-w maximum power input. The digital presentation runs to 9,999 hr and the numerals are 5/32 in. high. Jewel bearings are used.

Waltham Precision Instrument Co., Dept. ED, 221 Crescent St., Waltham 54, Mass.

Electronic Products NEWS
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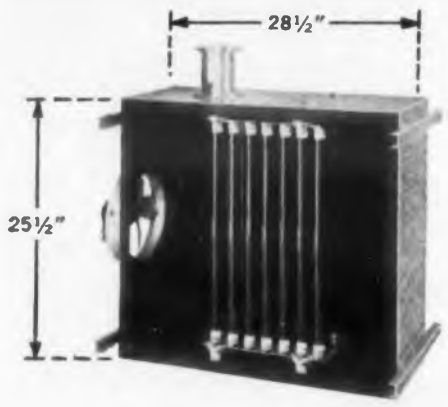
Need High-Power Packaged Loads? Here's an example:
Custom engineered PULSE AND RF LOADS

Designed to individual customer requirements, completely assembled pulse and RF loads are offered by Carborundum's Globar Plant. They utilize GLOBAR® high power, non-inductive resistors mounted so as to present the lowest possible inductance.



A typical modulator load is pictured here. Peak pulse voltage is 12 KV and the average power rating is 10 KW. The load is cooled by forced air at 300 CFM. A viewing resistor is provided so that 1/1000 of the pulse voltage is available at a BNC jack. Similar loads can be designed using cooling.

Loads utilizing the non-linear characteristics of GLOBAR varistors are also supplied for simulating the characteristics of magnetrons and other microwave tubes. For information, write Globar Plant, Refractories Division, Dept. EDL-90, The Carborundum Co., Niagara Falls, N. Y.

CIRCLE 804 ON READER-SERVICE CARD

BORON NITRIDE...new Carborundum material offers wide possibilities for MACHINED INSULATING SHAPES

Boron nitride is a comparatively new insulating material having high electrical resistivity, high dielectric strength, and good mechanical properties even at elevated temperatures. It differs from the usual ceramic materials in that parts can be easily machined using standard machining techniques. No subsequent firing is involved. Close tolerances, high surface finishes and intricate shapes are readily produced. Advantages for many electronic applications will be apparent.

Production of machined shapes to customer specifications is a specialty of Carborundum's Latrobe Plant. Tooling provides for long or short runs on the most economical basis. Savings in time due to simplicity of production are often considerable.

The photo shows the machining of a semi-conductor jig produced in volume for a leading electronics manufacturer. A technical bulletin giving the properties of boron nitride is available. Write Latrobe Plant, Refractories Div., Dept. EDB-90, Carborundum Co., Latrobe, Pa.

CIRCLE 805 ON READER-SERVICE CARD

Close tolerances possible in ALUMINA SHAPES

Ceramics made of high purity alumina withstand most voltages, frequencies and temperatures encountered in electronic applications. Both simple and highly complex shapes are produced in volume by Carborundum. Machining and grinding operations both before and after firing make it possible to manufacture intricate O.D. and I.D. designs to extremely close tolerances.

The photo shows examples of parts designed for a radome application. Similar shapes are produced for missiles, rockets and aircraft. Three types of alumina are available from Latrobe:

1. 1510 (100% alumina) special purpose porous body for vacuum devices. Can be degassed easily.
2. 1542 (96% alumina) developed primarily for vacuum tube envelopes. Exceptional strength, refractoriness and wear resistance.
3. 1550 (85% alumina) vitreous body with high mechanical strength.

For information, write Latrobe Plant, Refractories Div., Dept. EDA-90, Carborundum Co., Latrobe, Pa.

CIRCLE 806 ON READER-SERVICE CARD

LATEST INFORMATION ON KOVAR® ALLOY

Kovar is the standard matched-expansion alloy for critical glass-to-metal sealing problems. Bulletin gives data on composition, properties and applications. Write Latrobe Plant, Refractories Div., Dept. EDK-90, Carborundum Co., Latrobe, Pa.

CIRCLE 807 ON READER-SERVICE CARD

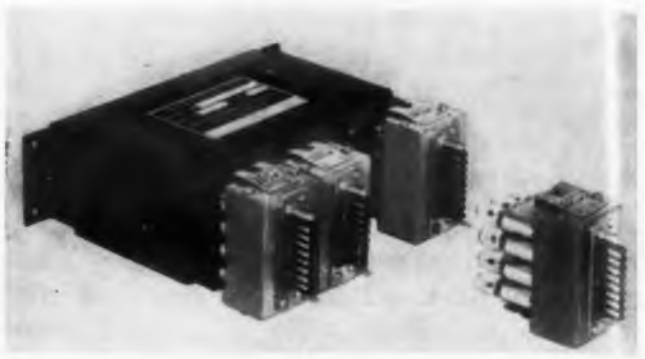
For ceramic parts and metallized assemblies, Kovar alloy, ceramic resistors, varistors and thermistors . . . count on CARBORUNDUM®

CIRCLE 804, 805, 806, 807 ON READER-SERVICE CARD

NEW PRODUCTS

Digital Displays 376

Have quick-disconnect lamps

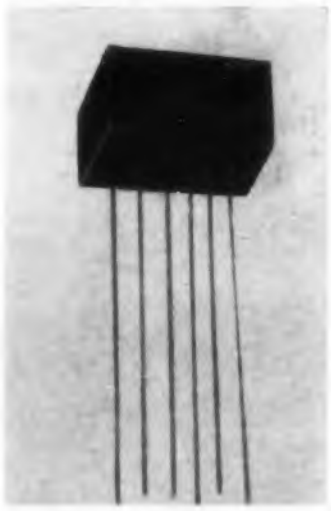


Series 10oooP plug-in digital displays have a quick-disconnect feature for in-the-field lamp servicing. Lamps may be changed on the spot without disturbing the internal wiring of the equipment in which the unit is used. Wiring may be potted to customer specifications. When one of the twelve lamps at the rear of the unit is lighted, it projects a corresponding digit or character on the front viewing screen. The character displayed is 1-in. high. Dimensions of the individual plug-in unit are 1-9/16 x 2-5/8 x 6-9/32 in.

Industrial Electronic Engineers, Inc., Dept. ED, 5528 Vineland Ave., N. Hollywood, Calif.
Price & Availability: $30.50; 30 days.

Transistor Audio Amplifier 357

Measures 1/2 x 1/4 x 1/4 in.

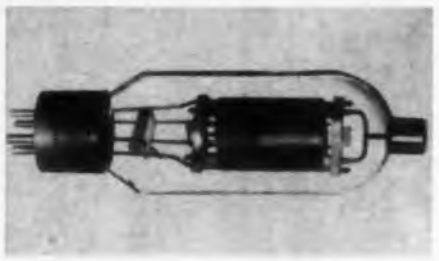


This rectangular transistor audio amplifier, measuring 1/2 x 1/4 x 1/4 in., has four stages and a density of 416 components per cu in. The device has a gain of 65 db at 1 kc, an input impedance of 2,500 ohms, and an output of 5 mw without clipping. Response is to 20 kc. A 1.34 v mercury battery serves as power supply. The amplifier drains 1.8 to 2.4 ma.

Centralab Div., Globe Union, Inc., Dept. ED, 900 E. Keefe Ave., Milwaukee 1, Wis.

Power Triode 511

Ruggedized replacement for type 811A



Type 572 triode is a ruggedized, one way replacement for the prototype 811A in most applications. Ruggedized construction includes hard glass envelope, heavy-duty tungsten lead wires, a non-frangible filament and enclosed getter traps. The manufacturer claims the 572 has a 50% increase in plate dissipation over the 811A.

United Electronics Co., Dept. ED, 42 Spring St., Newark 4, N.J.

Ratio Bridge 431

For comparing resistors

Model 240-P Kelvin ratio bridge compares an unknown resistor to a standard resistor. The range dial permits comparison in the ratio of 10:1 or 100:1. For example, with the range dial set at 10, the dial reads the difference between the unknown and 10 times the standard. Multiplier ratios are 0.01, 0.1, 1, 10 and 100. Accuracy is ±0.005% on the 1:1 range, and ±0.01% on other ranges with negligible power dissipation. The unit measures 5-1/4 x 19 x 7 in.

Electro Scientific Industries, Inc., Dept. ED, 7524 S. W. Macadam Ave., Portland 19, Ore.

Price & Availability: $900; 60 days.

Telemetry Subcarrier Calibrator 519

Completely transistorized

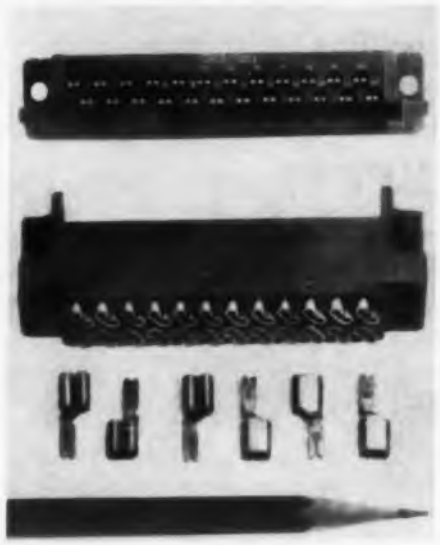
Model TCM-411 subcarrier, 11-point calibrator provides discriminator linearity measurements in all 18 IRIG fm/fm channels, a source for multiple frequency references, and checks of vco deviation linearity. It is completely transistorized and is 7 in. high. The unit has 0.01% accuracy and distortion components are at least 40 db down. Dwell periods of 1/4 to 4 sec per deviation may be selected.

Panoramic Radio Products, Dept. ED, 520 S. Fulton Ave., Mount Vernon, N.Y.

NEW PRODUCTS

Printed Circuit Connector 364

Has 24 contacts



The series 7009, Varitwin-Pin printed circuit connectors have 24 contacts. Wire terminations are twin taper-pin type. Insulator is one-piece, glass-filled diallyl phthalate. Contact terminations have dual connections and accept Series 53 taper pins. A polyethylene tab can polarize the unit.

Elco Corp., Dept. ED, M St. below Erie Ave., Philadelphia 24, Pa.

Function Generator 370

Uses a punched-card memory

In model 100 diode function generator, a hole pattern in a punched card replaces the setting and adjusting of potentiometers. Functions are composed of 20 contiguous line segments. Slopes range from 0.005 to 10.16 v per v. Absolute accuracy is 0.1%, long-term repeatability is 0.02%, input impedance is 1 meg, output power is ±100 v into 10 K, and frequency response is from dc to 10 kc.

General Computers, Inc., Dept. ED, 9000 W. Pico Blvd., Los Angeles 35, Calif.

Price & Availability: *$2,750; 90 days.*

Photoconductive Cells 352

Rated at 60 v max

The L series of photoconductive cells is rated at 60 v max, with a resistance as low as 40 ohms at 100 ft-c. It consists of five units of the cadmium selenide variety and two of the cadmium sulphide variety. They are available with diameters from 1/4 to 1/2 in. and in lengths from 1/2 to 1 in.

Clairex Corp., Dept. ED, 19 W. 26th St., New York 10, N.Y.

***Price:** $1.15 to $4.00 ea depending on quantity.*

Static Inverter 425

Supplies 28 v of single-phase output

Designed for use in commercial and military aircraft and missile instrumentation, the PI series dc-to-ac static inverters supply a 28-v, single-phase, 400-cps, square-wave output. Input is 28 v dc. Completely transistorized, the unit occupies less than 11.5 cu in. and stands adverse conditions of temperature, altitude, vibration, and shock. Regulation is better than 8% from no load to full load. Frequency stability is ±5%.

Electrodynamic Instrument Corp., Dept. ED, 1841 Old Spanish Trail, Houston 25, Tex.

***Price & Availability:** $85 fob Houston; 6 to 8 weeks.*

Ten-Point Stepping Switch 361

For digital operation

Type 210 stepping switch, with ten points, is designed for digital operation. It has a maximum length of 4-5/16 in., weighs 1-1/2 lb, and is capable of over one-hundred-million operations on 12, 10-point levels. Units with four, 30-point levels are available.

C. P. Clare & Co., Dept. ED, 3101 Pratt Blvd., Chicago 45, Ill.

NEW LIGHT is shed daily on microwave tube state-of-the-art by the engineers and scientists at Sperry's Gainesville, Florida plant. If existing hardware doesn't readily solve your tube application problem, call Gainesville, FRanklin 2-0411 collect, for full information about Sperry capabilities.

SPERRY ELECTRONIC TUBE DIVISION

Gainesville, Florida • A Division of Sperry Rand Corporation

A COMPLETE LINE of klystron tubes is manufactured and marketed by Sperry Electronic Tube Division, Gainesville, Fla. The division also performs extensive research and development toward advances in klystron state-of-the-art.

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Now you can have Sperry's complete family of klystron and traveling wave tubes right at your fingertips for faster, more accurate tube selection. Attractively packaged and comprehensively indexed, the Sperry Speci-File gives you complete electronic and physical characteristics of every tube in the Sperry line.

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CIRCLE 247 ON READER-SERVICE CARD

SPERRY ELECTRONIC TUBE DIVISION

GAINESVILLE, FLORIDA
A Division of Sperry Rand Corporation

CIRCLE 248 ON READER-SERVICE CARD

NEW PRODUCTS

Digital Tape System 499

Transfers 300,000 characters per sec

Model TD 100 digital tape system is capable of transfer rates of 300,000 characters per sec. Total storage is greater than 300,000,000 bits. Magnetic tape 1-in. wide is used. Average access time is 20 sec. Average loading and unloading times are 60 sec. Speeds to 30 in. per sec can be achieved. The unit can be mounted in 72 in. of 24-in. rack space.

Shepherd Industries, Inc., Dept. ED, 103 Park Ave., Nutley 10, N.J.

Servo Amplifier 501

For industrial automation applications

Model 1810-0500 servo-amplifier and power-supply combination is specifically designed for industrial automation applications. Output power is 8 w when it is used with a typical servo motor. Maximum power of 12 w is available under the following conditions: load impedance of 250 ohms, center-tapped, resistive; and load dc resistance of less than 2 ohms. Continuous adjustment over the voltage-gain range of 4,000 to 600 is provided by negative feedback. Power gain is 85 db and carrier frequency is 50 to 70 cps.

M. Ten Bosch, Inc., Dept. ED, 80 Wheeler Ave., Pleasantville, N.Y.

NEW PRODUCTS

Insulating Material 380

Combines fibre and phenolic properties

Anilite insulating material combines the electrical properties and mechanical strength of vulcanized fibre with the low moisture absorption of phenolic laminates. It is flame resistant and has the arc resistance of vulcanized fibre. It can be drawn or formed into permanent shapes, and can be punched and machined.

National Vulcanized Fibre Co., Dept. ED, 1060 Beech St., Wilmington 99, Del.

Transmitting Antennas 397

Feature wide frequency coverage

This series of transmitting antennas gives wide frequency coverage for outdoor service on microwave antenna test ranges. Features include high gain, optimum side lobe-bandwidth characteristics, and easily interchangeable feeds. Reflectors are spun aluminum paraboloids which vary in diameter from 1 to 10 ft.

Scientific-Atlanta, Inc., Dept. ED, 2162 Piedmont Road, N.E., Atlanta 9, Georgia.

PNPN Silicon Switch 392

Device is bistable

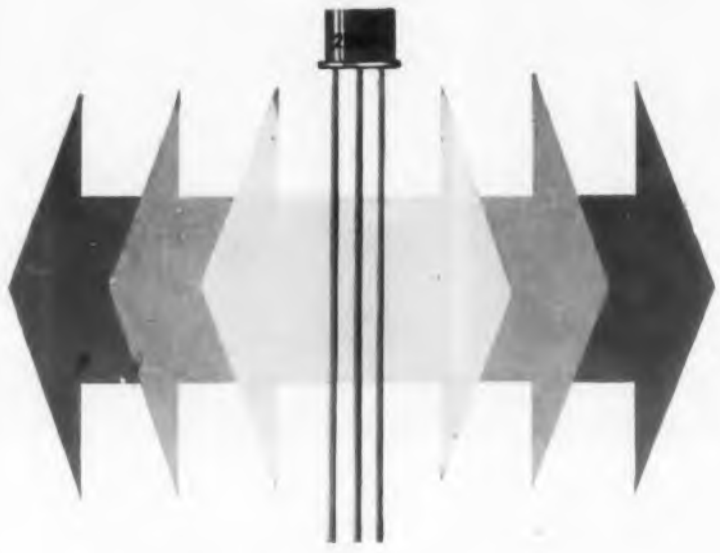
Type 3280 silicon switch is a bistable device of the pnpn class transistors having four terminals. It can be used in circuit designs utilizing 2, 3 or 4 terminals. The device can be turned on or off with current to either or both of the control bases. The switch is designed for computer devices requiring low current and fast switching operation. It is packaged in a four-lead TB-4 base measuring 0.217 in. in diameter x 0.34 in. high.

Electronic Computer Co., Dept. ED, 618 Maple St., Conshohocken, Pa.

Price & Availability: *Delivery from stock at $10.*

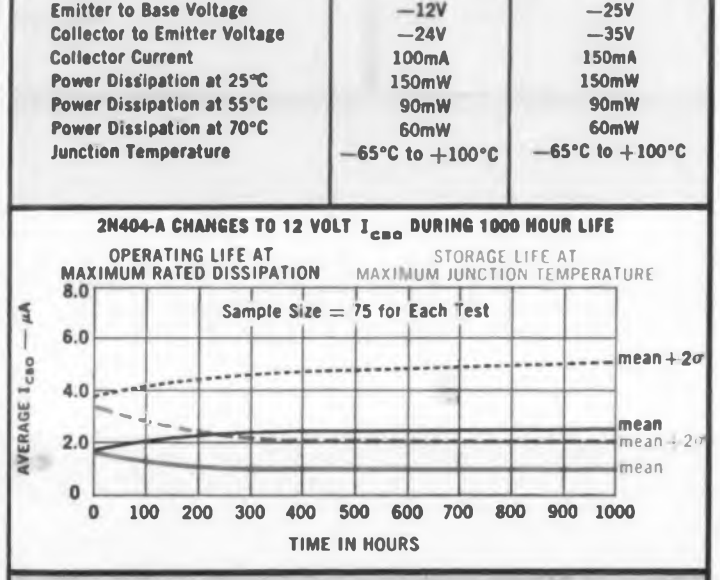
New! Switching Transistor

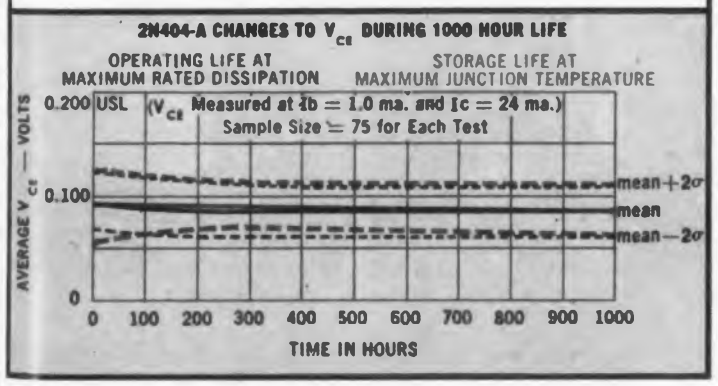
SYLVANIA 2N404A



features improved

ABSOLUTE MAX RATINGS AT 25°C	2N404	2N404A
Collector to Base Voltage	−25V	−40V
Emitter to Base Voltage	−12V	−25V
Collector to Emitter Voltage	−24V	−35V
Collector Current	100mA	150mA
Power Dissipation at 25°C	150mW	150mW
Power Dissipation at 55°C	90mW	90mW
Power Dissipation at 70°C	60mW	60mW
Junction Temperature	−65°C to +100°C	−65°C to +100°C





- **ELECTRICAL STABILITY ASSURED BY TIGHT AQLs**
- **POWER DISSIPATION OF 150mW**
- **VOLTAGE RATINGS OF −40V**
- **OPERATING TEMPERATURE CAPABILITIES OF 100°C**

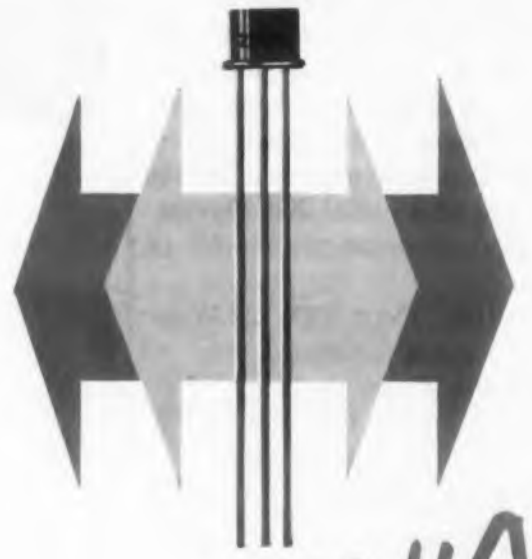
Sylvania introduces the 2N404A, PNP germanium-alloy switching transistor—unilaterally interchangeable with the popular 2N404. A medium-speed switching transistor, Sylvania-2N404A is recommended for service where high reliability, electrical stability and resultant long-life expectancy are prime performance considerations. Reliability is assured by a tighter AQL. Sylvania-2N404A must meet a 1% combined AQL for the following parameters: collector cutoff current at 25°C and 80°C; emitter cutoff current; emitter floating potential; saturation voltage at 12mA and 24mA; input voltage at 12mA and 24mA; and stored base charge.

Designing now? Sylvania-2N404A is available now! Contact your Sylvania Field Office *or* your local franchised Sylvania Semiconductor Distributor for price and delivery information. For technical data, write Semiconductor Division, Sylvania Electric Products Inc., Dept. 189, Woburn, Massachusetts.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

- Premium Quality Switching Transistor



SYLVANIA 2N404A

immediately available at OEM prices 1 to 999

through your SYLVANIA franchised Semiconductor DISTRIBUTOR today!

NEW PRODUCTS

Silicon Bridge Rectifier 384

Is compact, shock resistant

This single-phase, full wave, silicon bridge rectifier is designed for compact, shock resistant power supplies. It is molded in epoxy resin to withstand extreme environments. It has a surge current rating of 35 amp, a recurrent peak rating of 5 amp and a piv of 200. Operating temperature range is —65 to +120 C.

Ledex, Inc., Dept. ED, 123 Webster St., Dayton 2, Ohio.
Availability: *From stock.*

Rack and Panel Connectors 379

Micro-miniature size

Series 7030 microminiature rack and panel connectors are available in units to accommodate 5, 7, 9, 11, 14, 20, 26, 29, 34, and 44 wires. Locked-in floating contacts are individually self-aligning. Positive polarization is assured by pairs of opposed guide pins and guide sockets.

Precision Connectors Inc., Dept. ED, P. O. Box 96, Mineola, Long Island, N.Y.
Availability: *From stock.*

Relays 404

Miniature, multipole

These multipole relays require as little operating power as 25 mw per pole. Model 52C is a dpdt unit and the 54C is a 4 pdt unit. Both types have self-wiping contacts that are rated at: 2 amp, 28 v dc and 115 v ac, for the 25-mw version; and 5 amp, 28 v dc and 115 v ac, for the 50- and 100-mw versions. The units can be supplied with coil resistances of less than 1 ohm to 20,000 ohms.

Kurman Electric Co., Dept. ED, 191 Newel St., Brooklyn 22, N.Y.
Price & Availability: *$5.30 to $7.40; from stock.*

GL-6771

GL-6897

Z-5387

Z-5099A

CERAMIC

high-gain, high-mu, closed-spaced ode with useful output in excess 500 mw at 4000 mc, CW and der pulsed conditions. Several ndred mw obtainable at 6000 mc. atures low interelectrode capaci- nces and rugged planar construc- n. Height is 2 39/64".

commended for low and inter- diate level amplifier and multi- ier applications because of its ex- ptional gain.

This version of the 2C39 family is especially suited to high-frequency operation. Has 100 watt anode dissipation. Gives 30% efficiency and 10 db gain at 1860 mc and 600 volts. Height is 2 11/16". Efficient pulse performance to 3000 mc.

Notable for consistent high-gain performance, resulting from closely controlled manufacturing and processing tolerances and thorough characteristic testing in accordance with MIL-E-1/10037B.

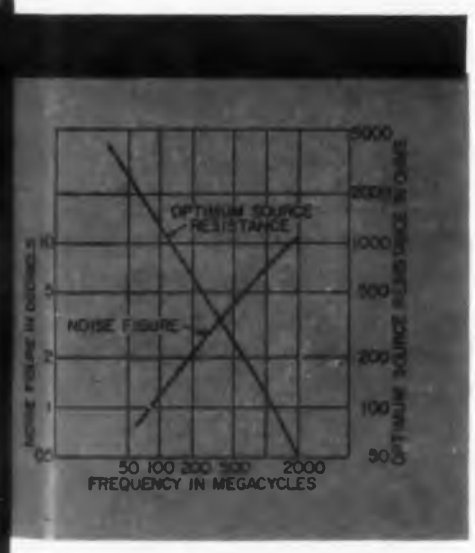
This tube is a finless version of type GL-6897 for applications where there are space limitations, and the full plate dissipation of the GL-6897 is not required. Height is 2¾".

Possible applications include pulsed airborne navigational equipment and airborne communications. The tube is operable as a Class C pulsed or CW amplifier, oscillator, and frequency multiplier.

A conduction-cooled version of type GL-6897, for grounded-grid Class C power amplifiers, oscillators, or frequency-multiplier circuits up to 2500 mc. 35 watts plate dissipation readily obtainable. Features same rugged disc-seal construction as type GL-6897. Gives consistent high performance. Height is 2⅝".

Designed specifically for missile and other non-air-cooled applications.

y's Most Complete Line of Microwave Triodes



Calculated Noise Performance for Noise-matched, Grid-return Circuit Operation, Input Circuit Losses Neglected.

GL-6299 • GL-7644 • Z-5435

Operating Conditions

$E_f = 6.3$ volts

$E_c = 0$ volts

$E_b / I_b = 10$ milliamperes

Illustrated on these two pages are just twelve of the more than twenty microwave triode types General Electric now offers . . . industry's most complete line. Rugged, versatile G-E "lighthouse" triodes are now available for all types of microwave communication, navigation, identification and radar equipment . . . for all ground, sea and airborne applications.

For more information on General Electric's complete line of microwave triodes, and for competent application engineering assistance, contact your General Electric Power Tube Sales Office.

NEW ENGLAND
701 Washington Street
Newtonville, Massachusetts
Telephone: WOodward 9-9422

SYRACUSE
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Syracuse, New York
Telephone: HArrison 2-1030

SCHENECTADY
Building 267
Schenectady 5, New York
Telephone: FRanklin 4-2211
Ext: 5-3433

EASTERN
200 Main Avenue
Clifton, New Jersey
Telephone: GRegory 3-6387
Dial direct from New York City
WIsconsin 7-4065-6-7-8

CENTRAL
3800 No. Milwaukee Avenue
Chicago 41, Illinois
Telephone: SPring 7-1600

DAYTON
118 West First Street
Dayton 2, Ohio
Telephone: BAldwin 3-7151

WESTERN
11840 West Olympic Boulevard
Los Angeles 64, California
Telephone: GRanite 9-7765

WASHINGTON
Wyatt Building—Room 1313
777—14th Street, N. W.
Washington, D. C.
Telephone: EXecutive 3-3600

POWER TUBE DEPARTMENT

GENERAL ELECTRIC

265-01-8481-28

Receiving System 401

Stability is 0.01% or better at 540 kc

The SP-600-SSB receiving system, made up of the SP-600 receiver and the SPC-10 SSB converter, with or without speaker, is designed for commercial and military communications. The receiver has a stability range of 0.01% or better at 540 kc to better than 0.001% at 54 mc. Image rejection is 74 db down. The converter provides vernier passband tuning control of 3 kc.

Hammarlund Manufacturing Co., Inc., Dept. ED, 460 W. 34th St., New York 1, N.Y.

Power Supply 398

Rated at 28 v dc

Model M-1560 power supply has an output of 28 v dc at a continuous-duty rating of 7.5 amp. It has magnetic amplifier regulation and hermetically sealed silicon rectifiers for high temperature operation. Regulation is ±1% for combined variations of line and load; ripple is 5% rms max. It meets specifications of Mil-E-4970.

Perkin Engineering Corp., Dept. ED, El Segundo, Calif.

High-G Rotary Accelerator 395

For testing miniature components

This compact centrifuge is designed for acceleration testing of subminiature components up to 20,000 g. Capabilities include operation up to 15,300 rpm at a g rating of 20,000 with a speed variation of less than 1% and a speed resolution of better than 0.1%. Time from standstill to full speed is less than 20 sec and speed readings are given directly in revolutions per second.

Schaevitz Engineering, Dept. ED, Route 130 at Schaevitz Blvd., Pennsaucken, N.J.

Price & Availability: *Price is estimated at $2,286 to $2,500 depending on specifications, with delivery 12 weeks after order is received.*

◀ CIRCLE 96 ON READER-SERVICE CARD

CIRCLE 97 ON READER-SERVICE CARD

NEW PRODUCTS

Digital Transducers 402

For flow, pressure, and temperature

The DX-100 series digital transducers measure pressure, flow, temperature, or other variables and provide a digital output in the form of contact closures for data recording or transmission. The transducers are completely mechanical and employ mechanical-force amplifiers to drive shaft-position encoders from bourdon tubes, bellows, diaphragms, or similar devices. Drive power for the unit is obtained from a small electric motor.

Datex Corp., Dept. ED, 1307 S. Myrtle Ave., Monrovia, Calif.

Film Recorder And Viewer 393

Used with crt or galvanometers

The Develocorder is an automatic processing, 16-mm film recorder and viewer which can be used with from one to 16 galvanometers to record data from dc to 20 cps (150 cps on special order). A crt can also be used with the unit to record dc to 15 kc data. From 4 to 32 hr of data can be recorded on self-contained reels of standard Microfile film at speeds of 3 to 20 cm per min. Display is on a 6 x 17 in. screen using a two-directional, variable-speed drive. Date, time, and film number are printed during recording. Film trace width is 0.05 mm and linearity is better than 2%. Weight is 175 lb.

The Geotechnical Corporation, Dept. ED, 3401 Shiloh Road, Garland, Tex.

Price & Availability: *$7,250 per unit with delivery 120 days after receipt of order.*

Broadband Helical Telemetry Antenna 394

Has low side, back lobes

The Helicone telemetry antenna system, type 52055 (890-990), combines high gain with low side and back lobes. The broadband feed has a relatively constant impedance and pattern over a wide frequency band. The feed is adaptable to several parabolic reflectors ranging from 6 to 28 ft and serving several frequency ranges. The antenna system is designed for severe environmental conditions and is mounted on a heavy-duty, two-axis rotator.

Andrew Corporation, Dept. ED, 363 E. 75 St., Chicago 19, Ill.

Price & Availability: *Rotator is $10,500; antenna is $2,500; with delivery 12 weeks after order is received.*

Voltage Variation Detector 378

Records short-duration disturbances

This instrument is intended for detecting and recording small voltage variations and short-duration pulses. It is a transient-sensitive recording ac voltmeter, capable of recording variations or transients of 2 v with durations of less than 32 msec. Applications include monitoring regulated power supplies. The instrument is scaled from 0 to 150 v, 60 cps.

Esterline-Angus Co., Dept. ED, P. O. Box 596, Indianapolis 6, Ind.

Miniature Servo Gearhead 418

For standard size 11 motor

Model E11 servo gearhead is primarily designed for mounting to a standard size 11 motor; however, adapters are available for mounting to other sizes. Ratios from 3.08:1 to 16,384:1 are obtained by using from two to seven gear stages and a motor output pinion. Output torque is 25 oz-in. continuous and the starting torque is 0.015 oz-in. max. Backlash through the gear train is less than 45 sec for the two-stage unit and less than 30 sec for all other units.

Exact Engineering and Manufacturing Co., Dept. ED, Oceanside, Calif.

Accelerometer 385

Sensitive to 0.0025 g

Low level g measurements and vibration studies are possible with model 408 accelerometer. It has a sensitivity of 100 mv per g and operates down to 0.0025 g. Maximum acceleration is 10,000 g; frequency response is from 1 cps to 3 kc with resonance at 55 kc; amplitude linearity is ±1%. Temperature range is −65 to +300 F, extendable to +500 F with less than 10% variation. The unit is in a stainless steel hexagonal case measuring 3/4 in. on a side and 0.45 in. high. Weight is 23.5 gm.

Columbia Research Laboratories, Dept. ED, MacDade Blvd. and Bullens Lane, Woodlyne, Pa.

Price & Availability: *For one to five units, $160; two-week delivery.*

Precision Drives 415

Operate with rotary components

These precision drives include dual-speed drives and a worm gear drive to operate with rotary components such as resolvers, synchros, potentiometers, capacitors, and timing coils. Type PDW-1 worm gear drive uses a 180:1 ratio to allow direct dial readings of 1 min of arc. Type DSD-2 dual-speed unit is a gear reducer that positions and indicates with an accuracy of 6 min of arc. Ratios offered are through 72:1. Ratios of 20:1 and 36:1 are available with vernier. Type DSD-3 is similar but has an accuracy of 12 min of arc. Type DSD-4 gear reducer has no backlash and an accuracy of 6 min of arc. Its velocity ratio is 10:1 and may be increased to 1,000:1.

Technology Instrument Corp., Dept. ED, 531 Main St., Acton, Mass.

Crystal Controlled Converter 396

Frequency is 324 mc

This crystal-controlled converter for the 324-mc satellite tracking frequency features a low-noise crystal diode mixer followed by a low-noise if preamplifier. This provides a noise figure that is stable and does not deteriorate with time. Output frequencies are 30 and 60 mc with 6 and 6.5 db over-all noise figures, respectively.

Tapetone, Inc., Dept. ED, 10 Ardlock Place, Webster, Mass.

Price & Availability: *$350 per unit, with delivery 30 days after receipt of order.*

Flexible-Shaft Couplings 414

Two types available

These instrument type, flexible-shaft couplings have no backlash and are designed to accommodate both lateral and angular misalignment. Type MPC-1 consists of two flanged aluminum hubs and nylon or stainless steel disks with vee grooves displaced 90 deg and fastened with springs. Its over-all dimensions are 7/8 x 7/8 in. Type MPC-2 consists of two cylindrical aluminum hubs each having two ball pivots attached. The hubs are attached to a pair of phosphor bronze flexible disks that captivate and load the ball pivots. Over-all dimensions are 3/4 x 1/2 in.

Technology Instrument Corp., Dept. ED, 531 Main St., Acton, Mass.

Millivolt Reference Supply 410

Absolute accuracy is 0.02%

This reference supply, Model 850, is a programed, millivolt calibration unit with an absolute accuracy of 0.02% for line-voltage variations of ±10% over the temperature range of 40 to 125 F. Calibration voltages from 0 to 0.1 v are delivered from a constant impedance output of 0.01 ohms.

Owen Laboratories, Inc., Dept. ED, 55 Beacon Place, Pasadena, Calif.

Price & Availability: *Price is approximately $2,000 with delivery from stock and up to 60 days.*

NEW PRODUCTS

Accelerometer 374

Potentiometric type

This potentiometeric accelerometer uses flexures and dual seismic masses. The seismic mechanism has no rubbing parts. Cross-talk is kept at a minimum. Linearity is ±2% from —55 to +70 C. Error due to vibration is less than ±0.03 in. displacement at 10 to 55 cps and less than 6% under ±10 g at 55 to 500 cps.

Dynamic Devices, Inc., Dept. ED, 3170 Valleywood Drive, Dayton 20, Ohio.

Molding Powder 422

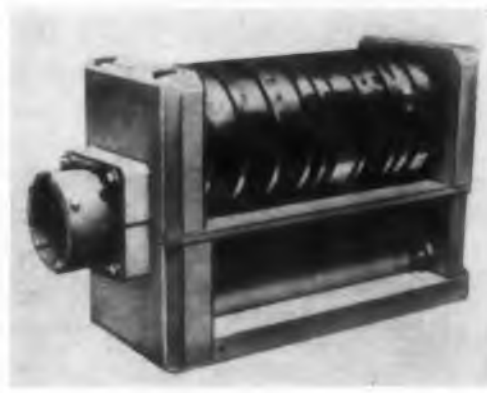
Compounded of Teflon, inorganic material

The molding power is compounded of 100-FEP Teflon and an inorganic material such as Fiberglas or graphite. Typical applications include coil forms and bobbins, tube sockets and connector assemblies, and incapsulation of valve components.

Crane Packing Co., Dept. ED, 6400 Oakton St., Morton Grove, Ill.

Electro-Mechanical Programer 366

For on-off functions



The model 602 electro-mechanical programer is designed for programing on-off functions. It will handle 30, 2-amp circuits. Time range is 60 to 5,000 sec. Accuracy is 1%, 3% or 5%. Units include reset, solenoid latching, and a positive zero-time indicator.

The Sloan Co., Auto-Timer Div., Dept. ED, 7704 San Fernando Road, Sun Valley, Calif.

CIRCLE 100 ON READER-SERVICE CARD

Ohmmeter 403

Provides ranges to 20 meg

This general-purpose ohmmeter provides ranges up to 20 meg. It is suitable for industrial, laboratory, and general-servicing use. Five ranges, selectable by a switch, are: 0 to 2,000 ohms, 0 to 20,000 ohms, 0 to 200,000 ohms, 0 to 2 meg, and 0 to 20 meg. The unit measures 2-3/4 x 4-1/4 x 1-3/16 in.

The Triplett Electrical Instrument Co., Dept. ED, Bluffton, Ohio.

Strain-Gage Subcarrier Oscillator 391

Operates on IRIG channels 1 to 14 and A

This transistorized, subcarrier oscillator converts strain-gage bridge signals into fm subcarrier signals on IRIG channels 1 to 14 and A. Designated model 179A, the device is designed for missile and aircraft environments. It operates with a four-arm strain-gage bridge with 100 to 150 ohm elements. Reactive balancing is unnecessary. No output filter is required. Linearity is within 0.1%. The unit operates from a 25 to 29 v dc source.

Electro-Mechanical Research, Inc., Dept. ED, Sarasota, Fla.
Price & Availability: $800; 60 days.

Recorder-Reproducer 399

Solid-state circuits

Recorder/reproducer PR-2300 is an all-solid-state, magnetic tape instrument which is modularized, small in size, and weighs less than 150 lb. Up to 14 channels of direct-record or wide-band fm analog data can be recorded and played back bi-directionally. Speeds range from 1-7/8 to 60 ips. Input range is 0.25 to 25 v rms for normal record level; frequency response is 100 to 100,000 cps ±3 db at 60 ips for the direct record system. Input range for an fm system is 0.5 to 50 v rms for 100% modulation, drift is less than 2% and linearity is 1%.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 101 ON READER-SERVICE CARD ➤

* CIRCLE 100 ON READER-SERVICE CARD

NEW PRODUCTS

Ferrite Switch 354

Switching time 0.1 μsec

Switching time is 0.1 μsec for the Model SX-102 ferrite switch. This switch is for the 9.0 to 10.2 kmc band; isolation is 25 db min and insertion loss is less than 1 db. Associated electronic driver units are available.

Rantec Corporation, Dept. ED, Calabasas, Calif.

Price: *Price is $550 ea in small quantities.*

Crystal Filters 423

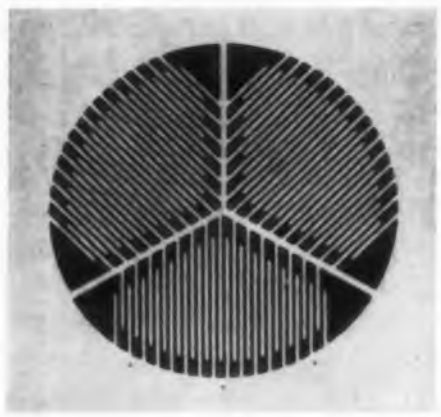
Center frequency is 10 mc

Type BP-10000-40 crystal filters are for application in transistorized if amplifiers. Specifications include: center frequency, 10 mc; ripple, 0.5 db; stopband rejection, 70 db; and dimensions, 1/2 x 1-1/8 x 2 in.

Systems Inc., Dept. ED, 2400 Diversified Way, Orlando, Fla.

Rosette Strain Gage 356

Resists temperature effects



This rosette strain gage is a single-plane unit designed for a maximum of sensing elements per unit area, and constructed of materials treated to resist temperature effects. Gages are available in 1/2 and 1/4 in. sizes, in 45 and 60-deg configurations, and on either epoxy, paper or phenolic matrices.

Baldwin Lima Hamilton Corp., Electronics & Instrumentation Div., Dept. ED, 42 Fourth Ave., Waltham 54, Mass.

NEW PRODUCTS

Synchronous Motor 355

Has torque of 250 oz-in.

Type SS250 synchronous motor is designed primarily for industrial uses. It has a torque of 250 oz-in. and a constant speed of 72 rpm. A dc voltage applied to its field windings converts one revolution of the motor shaft into 200 precise steps. Ratings are: input, 120 v, single phase, 40 to 70 cps, 0.6 amp max at 60 cps; 72 rpm output at 60 cps.

The Superior Electric Co., Dept. ED, 83 Laurel St., Bristol, Conn.

Price & Availability: *Price is $65 per unit with quantity prices on request, available from stock.*

Sensing and Switching System 658

Use ultrasonic energy

With an ultrasonic beam, the Sonac can sense liquids, solids, ferrous and non-ferrous metals, opaque and transparent objects. Operation is unaffected by ambient light, dust, mist or a normal collection of residual solids on the face of the acoustic lens. The hermetically sealed sensors operate from —100 to +220 F. The unit consumes about 1 w.

Delavan Manufacturing Co., Electro-Sonics Div., Dept. ED, West Des Moines, Iowa.

Price & Availability: *The unit is available from stock at $119.00.*

Vibration Monitor 656

For control or alarm

The Sonalarm, Model 160, operates relay contacts (NC or NO) at a preset 70- to 100-db sound pressure level; it has a differential of 2 db. An electronic delay prevents tripping on single impacts. An audio output jack is provided for earphone or power amplifier.

H. H. Scott, Inc., Instrument Div., Dept. ED, 111 Powder Mills Road, Maynard, Mass.

Price & Availability: *Presently available only in sample quantities, the unit will be in stock by Sept. 1, 1960. Price will be about $150 less microphone.*

Precision Bearings 460

This 3.25-in., double-row, pre-loaded bearing rotates with a centerline angle variation of under three arc seconds. It is presently used to support an inertial guidance system component.

Industrial Tectonics, Inc., Dept. ED, 18301 Santa Fe Ave., Compton, Calif.

Pressure Transducer 461

Model CP51 pressure transducer is operable from 115 v ac and can furnish an output of 0 to 5 v dc for voltage-controlled systems or 0 to 1 ma for galvanometer recording. It accepts corrosive liquids or gases both sides and is available in ranges 0.5 to 1,000 psi differential, gage or absolute.

Pace Engineering Co., Dept. ED, 13035 Saticoy St., N. Hollywood, Calif.

Flexible Epoxy 462

Type TC-3047 is for coating printed-circuit boards. It can be brushed on in thicknesses of 2 to 20 mils in one application. Moisture absorption is negligible; shrinkage is low.

Electronic Production & Development, Inc., Dept. ED. 501 N. Prairie Ave., Hawthorne, Calif.

Self-Locking Nuts 463

These miniature floating-anchor nuts perform at high temperatures. Type LHA4259 straddle type offers a vibration-resistant method of fastening 1/16-in. printed circuit boards to walls and brackets. Type LHA27M, made of a heat and corrosion resistant alloy, operates at 900 F.

Elastic Stop Nut Corp. of America, Dept. ED, 2330 Vauxhall Road, Union, N.J.

DC-AC Inverter 464

This inverter has sine wave output with a maximum distortion of 5%. Output voltage varies with input, if the unit is not used with a transistorized regulator. It can be hermetically sealed for military applications.

Freed Transformer Co., Inc., Dept. ED, 1718 Weirfield St., Brooklyn 27, N.Y.

Vidicon Tubes 465

The 7697 vidicon is for industrial TV cameras with automatic sensitivity control requiring a low value of signal electrode voltage held to close limits. The tube provides excellent live pick-up with as little as 0.2 ft-c illumination at the face plate.

General Electrodynamics Corp., Dept. ED, Garland, Tex.

Center-Post Insulators 466

These four center-post insulators have heights of 1.5, 1.75, 2, and 2.25 in. Molded of fiber-glass reinforced polyester, they come with threaded hole diameters through 5/8 in.

The Glastic Corp., Dept. ED, 4321 Glenridge Road, Cleveland 21, Ohio.

◀ CIRCLE 105 ON READER SERVICE CARD

NEW PRODUCTS

Angular Motion Transducer 360

Linearity is 0.25% over 40-deg movement

Type 34A rugged, angular motion Metrisite transducer converts angular motion of up to ±40 deg to voltage outputs with 0.25% linearity. The device has a negligible reactive force. It measures 3 x 2-5/8 x 1-7/8 in. and weighs 20 oz.

Brush Instruments Div., Clevite Corp., Dept. ED, 37th and Perkins, Cleveland 14, Ohio.

Silicon Diode 430

With planar structure

Type 1N251 Planar-structure, silicon diode meets the JAN specs of MIL-E-1/1023. It is suitable for switching and rf applications requiring low shunt capacitance. Some of its specifications are: working inverse voltage, 30 v; average rectified current, 75 ma; forward voltage at 25 C, 1 v; breakdown voltage, 40 v.

Fairchild Semiconductor Corp., Dept. ED, 4300 Redwood Highway, San Rafael, Calif.

Price & Availability: *$6 ea for 1 to 99 units; immediately available in production quantities.*

PNP Transistors 424

Germanium-alloy type

These PNP germanium-alloy transistors are designed for military and commercial applications in the audio range. Designated types 2N464, 2N465, 2N466, and 2N467, the units have a maximum collector current of 100 ma, a maximum junction temperature of 100 C, and a maximum power dissipation in free air of 150 mw. Types 2N466 and 2N467 have a maximum collector-to-base voltage of 35 v; types 2N464 and 2N465, 45 v.

Sylvania Electric Products Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

Price & Availability: *Price ranges from $1.65 to $2.21 ea in quantities of 1 to 99. Units are furnished by distributors.*

Epoxy Test Kit 434

This test kit contains an epoxy resin and hardener. The epoxy is engineered for permanent adhesive use for metal, glass, ceramic, hard rubber, wood, etc., It has electronic applications, will not expand or contract, and is resistant to acids, alkalies, grease and solvents.

Fybrglas Industries, Dept. ED, 3010 W. Montrose Ave., Chicago 18, Ill.

Lighted Push-Button 435

This lighted push-button, a turn-to-test device, is intended primarily for industrial applications such as motor and equipment remote control. The unit is oil-tight and has heavy-duty contacts. Caps are available in six colors.

Arrow-Hart & Hegeman Electric Co., Industrial Control Div., Dept. ED, 103 Hawthorn St., Hartford 6, Conn.

Neon Panel Indicator Light 436

These plastic neon panel indicator lights are about 3/4 in. long, mount in 5/6 in. diameter holes, and protrude 1/4 in. in front of the panel. Units have speed-nut mounting. They use NE-2-H neon bulbs. MIL specs are met.

The Sloan Co., Color-Lite Div., Dept. ED, 7704 San Fernando Road, Sun Valley, Calif.

Strain Gage Transducer 437

Type 4-325 unbonded strain gage transducer is 3/4 in. in diameter, 1/3 in. high and weighs 8 g. The unit is suitable for airborne instrumentation or wind tunnel applications. Pressure ranges are 10 to 100 psi absolute, 2 to 100 psi gage, and ± 2 to ± 50 psi differential. Operating temperature range is -320 to $+300$ F. Excitation is 5 and 12 v rms; carrier frequency is 0 to 20 kc. The sensing element is housed in a stainless steel case.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

Mass Spectrometer 438

Type 21-110 mass spectrometer is a high-resolution instrument designed for materials research applications. It is suitable for identification and estimation of trace impurities and components in semiconductors, ceramics, Cermets and high-performance materials.

Consolidated Electrodynamics Corp., Dept. ED, 360 Sierra Madre Villa, Pasadena, Calif.

Subminiature Ceramics 442

These subminiature ceramics with electronic applications can be held to a tolerance of ± 0.001 in. with comparable tolerances on concentricity. Available in complex shapes, they are useful where coefficients of expansion must be matched.

American Lava Corp., Dept. ED, Chattanooga 5, Tenn.

NEW PRODUCTS

Speed Control 679

Package is 1.5 x 1.5 x 3 in.

Having package dimensions of 1.5 x 1.5 x 3 in., this servo speed control contains a solid state amplifier, servo motor, gear train, and a special potentiometer-switch combination 1/2 in. long. The pot has four electrically isolated wipers spaced 90 deg apart. Capable of driving many components, resolvers, tachometers, and other pots and switches, the unit accepts dc signals from −10 to +10 v.

Spectrol Electronics Corp., Dept. ED, 1704 S. Del Mar Ave., San Gabriel, Calif.

Chopper 681

For operation from −55 to +150 C

Model 150 silicon-transistor electronic chopper is designed to alternately connect and disconnect a load from a signal source. It may also be used as a synchronous demodulator to convert an ac signal to dc. Linear switching or chopping of voltages can be done from a fraction of 1 mv to ±150 v. The unit can be driven from 270 cps to 30 kc and operates over the temperature range of −55 to +150 C.

Solid State Electronics Co., Dept. ED, 15321 Rayen St., Sepulveda, Calif.

Damping Compound 673

Is viscoelastic

Designated Vibrodamper, this viscoelastic material can be sprayed or trowelled onto metal plate, reducing structurally borne noise and vibration. It is suitable for use on sheet metal chassis, aircraft structures, base plates, printed circuit boards, and brackets on computers, amplifiers, gyros, and other devices. It is non-toxic and non-flammable.

The Korfund Co., Dept. ED, 48-778 32nd Place, Long Island City 1, N.Y.

Price & Availability: *$15 per gal; two-week delivery time.*

Adjustable Slip Clutches 413

Friction type

These friction-type, adjustable slip clutches protect components against excessive shock loads or those caused by inertia. Compact and light, the clutches are adjustable over a wide torque range without having to be removed from the system. Type ASC-1 measures 7/8 x 1 in. and type ASC-2 measures 5/8 x 5/8 in.

Technology Instrument Corp., Dept. ED, 531 Main St., Acton, Mass.

Silicon Rectifier 678

Rated at 60 amp at 20 C

Style 40 double-diffused, hermetically sealed, silicon rectifier is rated at 60 amp avg at 20 C on a 7 x 7 x 1/8 in. copper-heat sink. Range of piv is 100 to 400 in 100-v steps. Typical forward dynamic resistance is 0.0015 ohms. The temperature range is −75 to +175 C and the thermal drop from junction to case is 1 C per w. Peak surge current is 1,000 amp for 1/2 cycle of 60-cps sine wave.

Syntron Co., Lexington Ave., Homer City, Pa.

Price & Availability: *Price ranges from $5.84 to $24.46 ea. depending on quantity and piv. Delivery time is 14 days.*

Magnetic Disc Memory 674

For production line operation

This magnetic disc memory, using the Magdelay memory technique, provides on-off signal storage and retrieval synchronized with product flow in automated process lines. Line speeds from 1,000 ft per min down to a dead stop are accommodated through the use of static flux detector heads with 1,200-cycle reset frequency.

Automation, Inc., Dept. ED, 212 Worchester St., Wellesley Hills 82, Mass.

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NEW PRODUCTS

Pressure Meter 677

Senses 0.0001 mm of mercury

The Equibar pressure meter reads directly differential pressures as low as 0.0001 mm of mercury. The instrument is suitable for a variety of low differential pressure measurements, recording, and control applications. Eight ranges cover 0.01 mm to 30 mm of mercury. Response time is 10 msec. Input is about 60 w at 105 to 125 v ac. The unit provides phase-sensitive ac and polarized dc electrical outputs. It measures 8 x 12-1/2 x 12 in. and weighs 24 lb.

Trans-Sonics, Inc., Dept. ED, Burlington, Mass.

Meters 405

Six types available

These electrical measuring devices include the following: model 400 Transclip, a pistol design clamp-on ammeter and voltmeter; model 432 multitester, having 20,000 ohms per v sensitivity and 1.5% accuracy; model 461, a coat-pocket size multimeter; model 477, a laboratory instrument with 44 ranges; model 301, a transistor meter; model 405, a megohmmeter with a self-contained 500-v power supply.

Rowan Controller Co., Dept. ED, Red Bank, N.J.

Oscillator 672

Provides hf square waves or pulses

This voltage-controlled oscillator provides hf square waves or pulses with frequency output linearly controlled by a dc input. Units are furnished with constant amplitude output and linear frequency change with varied dc or both linear amplitude and linear frequency change with dc input. Frequency ranges available are: 200 cps to 6 kc, 10 to 70 kc, 30 to 150 kc, 70 to 240 kc, and 200 kc to 1 mc. Switching time is less than 0.1 μsec. The units can be used in telemetering, radar gat-

◀ CIRCLE 111 ON READER-SERVICE CARD

ing, data multiplexing, and other applications.

Transystems Electronic Co., Dept. ED, 94A Donor Ave., E. Paterson, N.J.

Dc Power Supplies 675

Modular

These power supplies are of modular design for standard rack or cabinet installation. Model EA 137 operates from an input of 105 to 125 v ac, provides an output of 12 v dc at 200 ma, and has a regulation of 0.5% from 50 to 200 ma. Model EA 124 operates from an input of 28 v dc and has an output of 250 v at 250 ma with a regulation of ±1%. Model EA 134 operates from an input of 105 to 125 v at 60 cps and provides an output of 28 v dc at 130 ma. Its regulation is ±1% from 30 to 130 ma.

Thermador Electrical Manufacturing Co., Dept. ED, 715 S. Raymond Ave., Alhambra, Calif.

Closed Circuit TV System 680

Three dimensional

This three-dimensional, closed-circuit television system consists of two of the firm's standard closed-circuit TV cameras and a monitor-control console housing two monitors, two camera control units, and a polarized optical system. The optical system presents the overlapping images from each camera on a single viewing plane, with one image polarized horizontally and one polarized vertically. The standard console uses 14-in. monitors, but units from 8 to 27 in. are available. The system permits accurate, remote manipulation of dangerous materials up to 1,000 ft away.

Cohu Electronics, Inc., Kin Tel Div., Dept. ED, 5725 Kearny Villa Road, San Diego 11, Calif.

Price & Availability: The standard system, with fixed focal length lenses, is priced at about $9500; delivery is 6 wk.

CIRCLE 112 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Balanced Mixer 353

Covers C to H band

This C to H band balanced mixer uses a varying signal-local oscillator system that does not require very narrow-band, electronically tuned filters. The conversion loss is 6 db over 5200 to 5800 mc; vswr is less than 3:1 over the local oscillator band of 3900 to 4500 mc and less than 1.7:1 over the signal frequency band. All components following the mixer are designed for use at a single frequency rather than a band of frequencies.

Bogart Manufacturing Corp., Dept. ED, 315 Seigel St., Brooklyn 6, N.Y.

Diffused Silicon Diodes 358

Fast recovery, high conductance types

Types 1N625 through 1N629 diodes are fast recovery units providing 400,000 ohms in 1 μsec. Types 1N482 through 1N485 diodes are high-conductance units with a 100-ma max avg forward current at 1.1 v. The devices are designed for airborne and industrial computers. Shock and vibration resistance exceeds MIL-STD 202A.

CBS Electronics, Semiconductor Operations, Dept. ED, 900 Chelmsford St., Lowell, Mass.

Signal Simulators 408

Provide serial pulse train

Model 202 simulates a precise pam or pdm serial pulse train; model 203 simulates pam-nrz (non-return to zero) as well as pam and pdm. Both models are for precise calibration of telemetry ground stations, data transmission

lines and data processing equipment. In addition to the IRIG standard pulse rates, they provide a range of 20 to 7,200 pps. Negative and positive output signals are available with provisions for introducing missing pulses, or external modulation. Linearity and stability are within 0.20%, noise and crosstalk are within 0.1%.

Telemetrics, Inc., Dept. ED, 12927 S. Budlong Ave., Gardena, Calif.

Availability: Delivery 30 days after order received.

Vane-Axial Blower 373

Delivers 64 cfm

The V-line vane-axial blower, 2-in. in diameter and 1.5-in. long, delivers 64 cfm at an SP of 0 and 3 in. at shut-off in the two-pole version. It requires an input of 37 w and has a temperature rise of 40 C max. In the four-pole design, rated at 11,000 rpm nominal, input is 8 w at 0.08 amp. Temperature rise is 15 C.

Eastern Air Devices, Inc., Dept. ED, 385 Central Ave., Dover, N.H.

Mylar Film Capacitors 498

For high-altitude space probes

The HI-Lar mylar film capacitors are for high-altitude space probe applications. Other uses are in instrument-quality recorders, pulse networks, and computers. The line is available in increments of 100, 200, 400, and 600 v and in ranges of 0.0047 to 1 μf. Temperature range is —55 to +125 C, dielectric absorption is 0.1%, and retrace stability is less than 0.2%. Dissipation factor is less than 0.5 at 25 C and 100 cps.

Scientific Electronics, Inc., Dept. ED, 3810 Cohasset St., Burbank, Calif.

NEW PRODUCTS

Insulated Cable 421

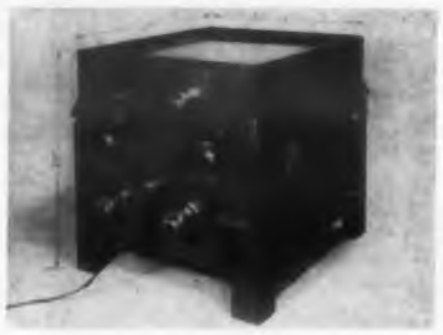
Conductivity is 85%

Using Alloy 63, this insulated cable has a conductivity of 85%. Other specifications include: tensile strength, 60,000 psi; ultimate elongation 8%; and yield strength, 55,000 psi. It comes in AWG sizes 16 to 38 and can be stranded or solid, bare wire, tin-plated, silver-plated, nickel-plated, or silver-nickel plated.

Suprenant Manufacturing Co., Dept. ED, 172 Sterling St., Clinton, Mass.

Test Fixture 512

Measures heat transfer rate



Heat transfer test fixture, model T-400, measures the heat transfer rate from an electronic module to the cooling air stream in a well-defined temperature environment surrounding the module. It can accommodate a module up to 9-in. wide by 4.5-in. high. The outer structure measures 20 x 20 x 20 in. The fixture will condition 0.4 lb of dry inlet air per min over a temperature range of −20 to +70 C. Maximum input power is 900 w.

Melpar, Inc., Dept. ED, 3000 Arlington Blvd., Falls Church, Va.

Silicon Rectifiers 427

Forward-current rating is 400 ma

Designated types X4M2 through X4M6, these silicon rectifiers have a forward-current rating of 400 ma and a piv range of 225 to 600 v. Two hundred of these units occupy 1 cu in. Each rectifier junction is protected by a Tri-Seal that completely encloses the case. Reverse leakage is 1 μa at 25 C and at rated piv; maximum voltage drop is 1 v at rated current, and surge current is 3 amp from −65 to +130 C. Current output is 150 ma at 100 C.

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

Price & Availability: *$0.75 to $1.75 in quantities of 1 to 99. Production quantities are in stock.*

Garlock electronic components are skillfully engineered for high temperature, high voltage, high frequency service.

Diode Electronic Multiplier 676

Has eight channels

Model C404-13 diode electronic multiplier console incorporates eight channels of multiplication, eight dc computing amplifiers, a power supply, and a metering panel. It can be expanded to a total of 16 channels of multiplication. The unit has a static multiplication accuracy of 0.125%. With the addition of a special circuit, the accuracy can be increased to 0.05%. Maximum amplitude error is 0.5% at 100 cps.

Reeves Instrument Corp., Dept. ED, Garden City, N.Y.

Availability: *Delivery can be made within 90 days after receipt of order.*

Silicon Transistors 682

High power, diffused mesa type

This series of six high power, diffused mesa type silicon transistors will cover the full current range from 100 μa to 5 amp. They provide a saturation resistance of 0.8 ohms; good beta linearity; typical cut-off frequency of 15 μc; voltages up to 100 v. They replace Types 2N1015-16, 2N424, 2N389, 2N1487-90.

Transitron Electronic Corp., Dept. ED, 168 Albion St., Wakefield, Mass.

Availability: *Available from stock.*

Silicon Glass Diodes 683

Can switch 0.5 amp

Types 1N690, 1N691, 1N692, and 1N693 silicon glass diodes are capable of switching 0.5 amp. They are suitable for use in high-current pulse circuits and diode logic circuits, for high-speed computer switching, pulse clamping, gating, and blocking. The temperature range is −65 to +150 C. Power dissipation is 400 mw max at 25 C.

Silicon Transistor Corp., Dept. ED, Carle Place, N. Y.

Availability: *Immediate delivery.*

◀ CIRCLE 116 ON READER-SERVICE CARD

NEW PRODUCTS

Panel Instruments 362

In streamlined plastic case

The Model 25 panel meters are 2.5-in. diam units mounted in streamlined plastic cases. Microammeters, milliammeters, ammeters, and voltmeters are available in the series. The devices have self-shielding, internal core magnets.

DeJur-Amsco Corp., Electronics Div., Dept. ED, 45-01 Northern Blvd., Long Island City 1, N.Y.

Counter-Timer 432

For automatic checkout systems

Model 1036 programable, 1-mc counter timer is designed to Mil specs and is suitable for use in field consoles of automatic checkout systems. It measures frequency, period, time interval, frequency ratio, and phase to accuracies of 1 ppm.

Systron Corp., Dept. ED, 950 Galindo St., Concord, Calif.

Low Noise Mixer Diodes 517

For K- and Ku-band operation

Diodes 1N26BR and 1N78DR are the electrically reverse versions of types 1N26B and 1N78D. With both forward and reverse types now available, balanced mixer operations are facilitated. The 1678DR has an over-all noise figure of 7.5 db, the 1N26BR over-all noise figure is 10 db. Both types can withstand 150 F operating temperatures.

Philco Corp., Lansdale Div., Dept. ED, Lansdale, Pa.

Price & Availability: *From $9 to $72 ea. for quantities of 100 and up; delivery within two weeks of order.*

Air Blower 443

Type AO blowers are available in single and double units rated 115 or 230 v, 60 cps. Odd voltages and frequencies can also be obtained. They are self-contained power packages with deliveries of 800 cfm.

Redmond Company Inc., Dept. ED, Owosso, Mich.

Cabinet Dehydrators 492

Weighing as little as 0.06 lb, these disposable cartridge units come in plastic capsule form. They are for static air drying and purifying applications. They can be fastened within electronic cabinets or black boxes using snap-in component clips.

Robbins Aviation, Inc., Dept. ED, 2350 E. 38th St., Los Angeles, Calif.

Miniaturized Synchronizer Drive 493

Dimensions of this drive are 2.2 x 1.4 x 3 in. and weight is less than 1 lb. The 96-pitch gearing has a backlash of 6 sec max. The unit has a control transformer, a motor-generator and two -signal switches, all tied together with the precision gear train. A typical application is nulling out gyro signals before an aircraft's autopilot is engaged.

Clifton Precision Products Co., Inc., Dept. ED, 9014 W. Chester Pike, Upper Darby, Pa.

Miniature Insulated Termostat 494

This 1/4-in. diameter, insulated thermostat can be factory calibrated or externally adjusted for the desired actuating temperature. Its maximum differential is 1/2 C. Contacts are insulated from the case by two glass seal solder terminals and a ceramic tip in the adjustment screw.

Chatham Controls Corp., Dept. ED, 102 River Road, Chatham, N.J.

Transistor Washer 495

This unit washes and rinses diodes, transistors, missile and electronic parts. The purification system has a regenerative heat exchanger, cartridge holders for organic removal, demineralizing cartridges and a submicron filter. The wash system provides 5 separate rinses of pure hot water; final rinse is about 18 meg and 210 F.

Barnstead Still and Sterilizer Co., Dept. ED, 333 Lanesville Terrace, Boston 31, Mass.

Instrument Case 496

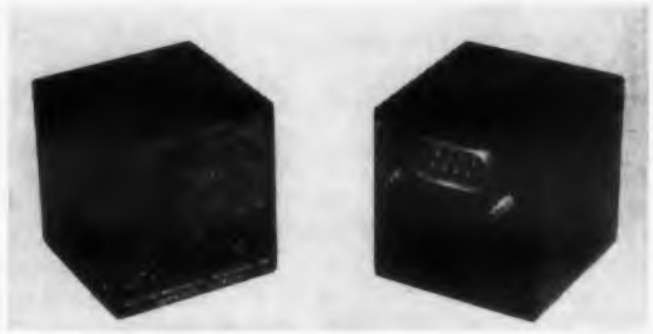
This standard case for test instruments features a plug-in chassis which is quickly locked in or removed. The open-sided chassis permits use of snap-in terminal cards. Accessible point of check for all leads can be graphically identified with circuit legends. Available in 2, 4, 8 in. widths, 10 in. in height.

Alden Products Co., Dept. ED, 117 N. Main St., Brockton, Mass.

NEW PRODUCTS

FM Subcarrier Oscillator 372

Is housed in a 1.5-in. cube



Designed for aircraft and missile fm telemetering systems, model 185C fm subcarrier oscillator is housed in a 1.5-in. cube. It accepts transducer outputs of +3, ±5, or ±1.5 v and supplies a 5-v rms output into 5,000 ohms. It is available with IRIG channels 7 to 18 and A to E. Linearity is better than 0.1%. Data is translated with amplitude and harmonic distortion of less than 1% to a modulation index of 5.

Electro-Mechanical Research, Inc., Dept. ED, Sarasota, Fla.

Potting Compound 690

Withstands 275 F continuous exposure

Type 767 potting compound is permanently flexible, polysulfide based material designed to withstand prolonged exposure to 275 F and intermittent exposure to 300 F. It is available in two parts which are blended equally by weight or volume for room temperature or heat curing.

Coast Pro-Seal and Mfg. Co., Dept. ED, 2235 Beverly Blvd., Los Angeles 57, Calif.

Inverter 367

Supplies 100 to 500 v

These static inverters, series 115SA, available in three power ratings, have fast response, low distortion, and lightweight design. They provide 400 cps power for airborne or missile applications at either 100, 250, or 500 v. Units, transistorized, measure 7 x 10 x 6 in. max and weigh from 6 to 20 lb. MIL specs are met.

Arnoux Corp., Dept. ED, 11924 W. Washington Blvd., Los Angeles 66, Calif.

Magnetic Brakes and Clutches 684

Size 11

These size 11 magnetic clutches, brake clutches, and brakes may be used in a variety of military and industrial applications. Clutch torque is typically 6 oz-in. for the magnetic clutches and 4 oz-in. for the magnetic brake clutch. Brake torque is 6 oz-in. for the magnetic brake clutch and 16 oz-in. for the magnetic brake. Units meet MIL-E-5272A and are rated for a life of 3,000,000 cycles.

Kearfott Div. of General Precision, Inc., Dept. ED, 1150 McBride Ave., Little Falls, N.J.

Calorimeter Bridges 685

Frequency range is dc to 12 kmc

These calorimeter bridges measure 10 to 5,000 w full scale with an accuracy of 2% or better. Frequency range is dc to 12 kmc. It can be used with a coaxial cable or waveguide. Designed for continuous operation at full scale power, the bridges are direct reading on all scales. No thermometers or flow meters are needed. The instruments measure 22 x 17 x 18 in.

Electro Impulse Laboratory, Dept. ED, 208 River St., Red Bank, N.J.

Availability: 30 days.

Temperature Test Chamber 686

Range is —100 to +350 F

The Econ-O-Line low-high temperature test chamber has a range from —100 to +350 F. Accuracy is ±2 F. Internal dimensions are 14 x 14 x 14 in. Chamber has a stainless steel interior and is heliarc welded. There is an externally mounted circulation motor and a 2-in. port and plug for leads and tubing. A viewing window is optional.

Associated Testing Laboratories, Dept. ED, Caldwell, N.J.

Price: Chamber sells for $735; viewing window is $100 extra.

CIRCLE 123 ON READER-SERVICE CARD

NEW PRODUCTS

Microwave Absorbed Ceramic 479

This absorber ceramic, CFI-1003, has losses of 9.05 db per cm at 25 C and minimum attenuation over a wide range of frequencies. It is stable in air or vacuum at temperatures in excess of 1,000 C in both low and high power systems.

Ceramics For Industry Corp., Dept. ED, Cottage Place, Mineola, N.Y.

Insulating And Protective Coating 480

Humiseal type X-242 is a fast-drying coating which becomes tack-free in 10 min. Used in the manufacture of semiconductor devices affected by ultraviolet rays, it may be applied by dip, brush or spray. Maximum operating temperature is 130 C, dielectric strength is 1,700 v per mil, dielectric constant is 2.3.

Columbia Technical Corp., Dept. ED, 61-02 31 Ave., Woodside 77, N.Y.

Vacuum Pencil 481

Made to speed assembly of semiconductor devices, the vacuum pencil enables the assembler to pick-up and deposit wafers, and pellets. A choice of 24 straight and curved needle models are offered. The ID range is 0.012 to 0.033 in.

Sandland Tool and Machine Co., Dept. ED, 52 Duryee St., Newark, N.J.

Availability: Immediate.

Force Transducers 482

Measuring 2 in. in diameter and less than 3 in. high, these compression cells are for industrial uses in ranges of 5,000 to 50,000-lb capacity. Applications include thrust measurement on jet engines and rocket test stands. Cells are load tested to 125% of rated capacity.

Schelm Industries, Inc., Dept. ED, 201 Anna St., East Peoria, Ill.

Pressure Transducers 483

Series IP-2010 potentiometer, pressure transducers are available in full scale ranges from 0 to 4 through 0 to 10,000 psi. In both absolute and differential pressure service, ranges are 0 to 4 through 0 to 2,000 psi. A helical bourdon tube is used as the sensing element.

H. E. Sostman & Co., Dept. ED, 347 Lincoln Ave., Cranford, N.J.

Gyro Tester 484

Made to operate in conjunction with rate tables for checking performance characteristics of rate gyros, this device incorporates controls and metering circuits to control and measure all gyro inputs and outputs.

Sterling Precision Corp., Instrument Div., Dept. ED, 17 Matinecock Ave., Port Washington, N.Y.

MOTOROLA now has a *standard* power transistor to match nearly any design requirement. With the addition of the new "low silhouette" TO-36 package, Motorola is now your *most complete... most dependable* source for industrial and military power transistors.

11 TYPES OFFERED IN NEW "LOW SILHOUETTE" TO-36 CASE

- 15 amps — 150 watts
- 40 to 100 volts
- Requires 30% less headroom than other TO-36 packages.
- 43% less thermal resistance (0.5°C/W max.) than comparable types.
- h_{FE} ranges from 20-70
- 100°C junction temperature
- Improved internal construction

118 TYPES OFFERED IN INDUSTRY STANDARD TO-3 CASE

- 3, 5, 10, 15 and 25 amps
- 90 watts power dissipation
- Up to 120 volts
- 0.8°C/W maximum dissipation
- Special "Meg-A-Life" units provide military-quality for industrial applications.
- 100°C junction temperature

All Motorola power transistors are stabilized at 125°C for 100 hours and 100% lot life-tested to assure highest reliability.

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MOTOROLA
Semiconductor Products Inc.
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3 AMP POWER TRANSISTORS—TO-3 CASE

MAXIMUM RATINGS					Electrical Characteristics		
Type Number	BV_{CBO} volts	BV_{CES} volts	T_J °C	I_C amps	h_{FE} @ I_C amps min	max	
2N1380	50	40	100	3.0	60	140	3
2N379	80	60	100	3.0	35	90	3
2N610	80	60	100	3.0	60	140	3
2N1382	100	75	100	3.0	35	90	3
2N1383	100	75	100	3.0	60	140	3
2N1384	120	100	100	3.0	35	90	3
2N1385	120	100	100	3.0	60	140	3
2N297A	80	50	100	3.0	40	100	2
2N2876 (2N. C)	80	50	100	3.0	40	100	2
2N1611	80	80	100	3.0	30	75	3
2N1611 (2N. C)	80	80	100	3.0	30	75	3

5 AMP POWER TRANSISTORS—TO-3 CASE

MAXIMUM RATINGS					Electrical Characteristics		
Type Number	BV_{CBO} volts	BV_{CES} volts	T_J °C	I_C amps	h_{FE} @ I_C amps min	max	
2N1529*	40	30	100	5	20	40	3
2N1530*	60	45	100	5	20	40	3
2N1531*	80	60	100	5	20	40	3
2N1532*	100	75	100	5	20	40	3
2N1533	120	90	100	5	20	40	3
2N1534*	40	30	100	5	35	70	3
2N1535*	60	45	100	5	35	70	3
2N1536*	80	60	100	5	35	70	3
2N1537*	100	75	100	5	35	70	3
2N1538	120	90	100	5	35	70	3
2N1539*	40	30	100	5	50	100	3
2N1540*	60	45	100	5	50	100	3
2N1541*	80	60	100	5	50	100	3
2N1542*	100	75	100	5	50	100	3
2N1543	120	90	100	5	50	100	3
2N1544*	40	30	100	5	75	150	3
2N1545*	60	45	100	5	75	150	3
2N1546*	80	60	100	5	75	150	3
2N1547*	100	75	100	5	75	150	3
2N1548	120	90	100	5	75	150	3

10 AMP POWER TRANSISTORS—TO-3 CASE

MAXIMUM RATINGS					Electrical Characteristics		
Type Number	BV_{CBO} volts	BV_{CES} volts	T_J °C	I_C amps	h_{FE} @ I_C amps min	max	
2N627	40	30	100	10.0	10	30	10
2N628	60	45	100	10.0	10	30	10
2N629	80	60	100	10.0	10	30	10
2N630	100	75	100	10.0	10	30	10
2N1120	60	70	100	10.0	10	50	10
2N1121 (2N. C)	80	70	100	10.0	10	50	10

15 AMP POWER TRANSISTORS—TO-3 CASE

MAXIMUM RATINGS					Electrical Characteristics		
Type Number	BV_{CBO} volts	BV_{CES} volts	T_J °C	I_C amps	h_{FE} @ I_C amps min	max	
2N1548*	40	30	100	15	10	30	10
2N1549*	60	45	100	15	10	30	10
2N1551*	80	60	100	15	10	30	10
2N1552*	100	75	100	15	10	30	10
2N1553*	40	30	100	15	30	60	10
2N1554*	60	45	100	15	30	60	10
2N1555*	80	60	100	15	30	60	10
2N1556*	100	75	100	15	30	60	10
2N1557*	40	30	100	15	50	100	10
2N1558*	60	45	100	15	50	100	10
2N1559*	80	60	100	15	50	100	10
2N1560*	100	75	100	15	50	100	10

25 AMP POWER TRANSISTORS—TO-3 CASE

MAXIMUM RATINGS					Electrical Characteristics		
Type Number	BV_{CBO} volts	BV_{CES} volts	T_J °C	I_C amps	h_{FE} @ I_C amps min	max	
2N1182*	50	35	100	25	15	65	25
2N1183*	50	35	100	25	15	65	25
2N1184*	80	60	100	25	15	65	25
2N1185*	80	60	100	25	15	65	25
2N1186	100	75	100	25	15	65	25
2N1187*	100	75	100	25	15	65	25

NEW 15 AMP POWER TRANSISTORS IN "low silhouette" TO-36 CASE

MAXIMUM RATINGS					Electrical Characteristics		
Type Number	BV_{CBO} volts	BV_{CES} volts	T_J °C	I_C amps	h_{FE} @ I_C amps min	max	
2N441	40	40	100	15	20	40	5
2N442	50	45	100	15	20	40	5
2N443	60	50	100	15	20	40	5
2N174	80	70	100	15	25	50	5
2N1388	80	70	100	15	25	50	5
2N1189	100	80	100	15	25	50	5
2N1612	100	80	100	15	25	50	5
2N277	40	40	100	15	35	70	5
2N278	50	45	100	15	35	70	5
2N173	60	50	100	15	35	70	5
2N1090	80	70	100	15	35	70	5

* "A" series of these devices is offered under "Meg-A-Life" program... providing military quality units for industrial applications.

MEG-A-LIFE CERTIFIED RELIABILITY

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CIRCLE 124 ON READER-SERVICE CARD

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105 Bartley Drive
Toronto 16, Ontario
PL 9-2222

MOTOROLA
Semiconductor Products Inc.

CIRCLE 125 ON READER-SERVICE CARD

NEW PRODUCTS

Miniature Oscillograph 514

Capable of withstanding severe shock

This Oscillograph, model 560A, is a miniature instrument weighing less than 10 lb. It is capable of accurate data recording under severe shock accelerations. Some models have withstood two-phase shocks in excess of 3,000 g for 2 msec and 300 g for 25 msec. The unit can record 14 different data traces on 3-5/8-in. wide record paper or film.

Midwestern Instruments, Dept. ED, P.O. Box 7186, Tulsa, Okla.

Resistor Decade Box 659

Handles 225 w

The Model 240C power resistor decade box allows selection of resistances in one-ohm steps from 1 to 999,999 ohms. Power rating is 225 w max, at 1000 v dc or 660 v ac max.

Clarostat Manufacturing Co., Inc., Dept. ED, Dover, N.H.

Price & Availability: The unit, available from stock, is priced at $110.

Paper Tape Reader 368

Rate up to 600 characters per second

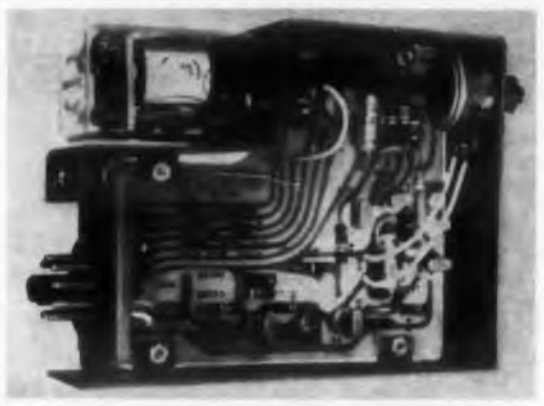
The model 600 Tape Reader is capable of providing outputs at up to 600 characters per sec, on a start-stop basis. The reader, especially suited to industrial automated control systems, reads 5, 6, 7, or 8 level code combinations on

punched paper tape. Unit provides input to computers in data-processing applications. The sensing head, which can be used separately, is readily adapted to different block lengths.

Anelex Corp., Dept. ED, 150 Causeway St., Boston 14, Mass.

Voltage Monitor 371

Reacts in 50 msec



This transistorized voltage monitor reacts in less than 50 msec to voltages falling below the limiting set point. It is applicable to a wide range of uses such as diode sorting, thickness gaging, and weighing. Insensitive to positive levels, it has a hysteresis of less than 250 mv at 25 C, and uses reference levels between −250 and +250 v. Output is 5 amp at each contact, which is spdt. The device provides limit indications with accuracies exceeding 0.05%, full scale.

General Automatics, Inc., Dept. ED, 2443 Ash St., Palo Alto, Calif.

Pulse Pattern Generator 365

Tests data-processing systems

The model 3-201 Uni-Bloc pulse pattern generator is a transistorized test instrument that provides simulated input data words for data-processing systems and magnetic data-storage units. The unit generates data words at rates up to 100 kc and contains separate logic levels for partial word blanking.

Applied Development Corp., Dept. ED, 12838 Weber Way, Hawthorne, Calif.

Price & Availability: Off-the-shelf delivery at $1,950.

NEW PRODUCTS

VHF Amplifier 375

Has three-octave bandwidth

Model HFW-5(C)-326 vhf amplifier, having a coverage of better than three octaves, provides a 20-db gain and an 8-db noise figure. The range is 30 to 265 mc; source and output impedances are low. The unit features synchronous tuning. Using five tubes, it requires 22.5 w of anode power and 1.5 w of heater power. Dimensions, not including those of the optional power supply, are 19 x 3.5 x 6.5 in. Weight is 7.25 lb.

Applied Research Inc., Dept. ED, 76 S. Bayles Ave., Port Washington, N.Y.

Microwave Receiver Assembly 509

Covers the 8.5- to 9.6-kmc range

The MMX-6 matched X-band microwave receiver head end assembly covers the 8.5- to 9.6-kmc range with a maximum noise figure of 7.5 db. It has a typical noise figure of less than 7 db, an if bandwidth of 8 mc and an if gain of 25 db. The MMX-6 is electrically similar to the MMX-2.

LEL Inc., Dept. ED, 380 Oak St., Copiague, Long Island, N.Y.

Price & Availability: *$830 per unit with delivery 45 days after order is received.*

Oscilloscope 660

Range is dc to 450 kc

The Type 504 oscilloscope operates in the dc to 450 kc range. Its basic sensitivity is 5 mv per cm. The input stage to the vertical amplifier is electronically regulated. There are 12 calibrated steps to 20 v per cm, and to over 50 v per cm un-

calibrated. Input impedance is constant at all sensitivities. Device has an 8 x 10 cm viewing area, 18 calibrated sweep rates and adaptable trigger facilities.

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

Price: The type 504 oscilloscope is available at $525. The rack-mounting model, RM504, is available at $535.

Coaxial Termination 513

Two models of tunable load available

Model TL-2000 coaxial termination covers the 250 to 2,000 mc range, the TL-4000 covers the 2,000 to 4,000 kmc range; both units can be tuned to a vswr of 1.02 max within their respective frequency ranges. The variable mismatch that can be introduced is 1.5 from 1,000 to 2,000 μc for the TL-2000 and the same for the TL-4000. This is done without changing the reference plane. Impedance is 50 ohms; power handling, 1 w cw.

Maury and Associates, Dept. ED, 10373 Mills Ave., Montclair, Calif.

Price: Both models are $120 with the type N connector, $125 with the type C connector.

Dual Polarized Microwave Antennas 369

For 6-kmc operation

This series of dual-polarized 6-kmc antennas combine two microwave signals in a single antenna. The signals are fed by different waveguides. System does not require circulators. Tower windloading, installation and maintenance costs are reduced. Antennas are available in 4, 6, 8, and 10-ft sizes.

Andrew Corp., Dept. ED, P.O. Box 807, Chicago 42, Ill.

PRODUCTION PRODUCTS

Ultrasonic Cleaning System 260

Is self-adjusting

The SonBlaster Ultrasonic Cleaning System is a self-adjusting unit whose only operating control is an on-off switch. Compensations for variations of liquid-level, operating temperature, and changes in work load are automatic. It is now available in a 5-gal size.

The Narda Ultrasonics Corporation, Dept. ED, 625 Main St., Westbury, Long Island, N.Y.

Availability: *Units may be ordered on a six to eight week delivery; stock delivery available shortly.*

Diode Production Machine 261

Produces 2,000 pieces per hr

Type 3438 automatic beading and cat-whisker welding machine produces up to 2,000 pieces per hr. The lead wire is fed from the spool, is straightened, cut-off, and beaded. The cat-whisker wire is fed from the spool, welded, cut-off, and formed. Operation is fully automatic. The machine is 5 ft 7 in. high and has a diameter of 4 ft 6 in.

Kahle Engineering Co., Dept. ED, 3322 Hudson Ave., Union City, N.J.

Transistor Welder 262

Handles 2,000 transistors per hr

This automatic transistor welder uses standard key components and can be tooled for dial feed or single-point operation. A table 3 x 4 ft accommodates a standard dry box. An operator, seated at the console and hand-loading a six station dial, can produce 2,000 transistors per hr. Dies for the projection ring are machined to suit the job requirements from standard spot-welding electrodes. The transistor cap and header are virtually self-aligning in the dies.

National Electric Welding Machines Co., Dept. ED, 1846 Trumbull St., Bay City, Mich.

Conveyor Furnace 263

For brazing semiconductor components

Type BAC-12M Humpback Conveyor Furnace is designed for controlled brazing of semiconductor components. It has an elevated heating chamber with inclined loading and unloading sections, this insures positive flushing and purging of the assemblies before they enter the heating zone. Operating temperatures of 2,050 F are held within critical tolerances through a saturable core reactor control system. Dewpoint of the atmosphere entering the furnace is controlled to insure proper wet-ability of the bonding material.

C. I. Hayes, Inc., Dept. ED, 896 Wellington Ave., Cranston, R.I.

Wire Stripping Machine 264

For AWG 48, 49, 50 and finer

This machine is designed for stripping Formvar insulation from AWG 50 copper wire and enamel from No. 56 Nichrome. It uses two conical Grade 89 fiberglass wheels as abrasive. Designated Model 89 TwinCone wire stripping machine, the device is suitable for bench mounting and can strip wire leads to within 1/16 in. of component bodies.

Carpenter Mfg. Co., Inc., Dept. ED, P. O. Box 217, Highbridge Road, DeWitt 14, N. Y.

Metal Dust Hoods 265

Filter 0.5 micron particles

Called Metal Microvoid, these hoods allow dust-free handling of small, delicate assemblies. A blower forces room air through a large-area filter capable of removing particles as small as 0.5-micron diameter. Units are supplied either with open-front or arm-port panels which are air-tight when not in use. They are available in a variety of sizes and shapes in both aluminum and stainless steel.

Air-Shields, Inc. Dept. ED, Hatboro, Pa.

Price & Availability: *Aluminum models are $350 without arm ports, $380 with. Delivery time is 2 to 4 weeks for standard sizes.*

PRODUCTION PRODUCTS

Ultrasonic Spot Welder 266

Has self-tuning circuit

Designed for joining such components as semiconductors, printed circuit boards and foil-wound transformers, this ultrasonic spot welder has a self-tuning circuit which assures weld uniformity and minimizes need for operator skill. The 100-w generator operates on 60 cps, 115 v. Nominal output is 40 kc. An automatic weld timer is adjustable from 0.1 to 5 sec.

International Ultrasonics, Inc., Dept. ED, 1697 Elizabeth Ave., Rahway, N.J.

Slicing Machine 267

Cuts semiconductor samples

This slicing machine cuts semiconductor samples as thin as 0.005 in. It cuts nearly plano-parallel sections which are ready for examination; they rarely need final polishing. Samples are imbedded in plastic and secured to a movable motor-driven stage assembly. Once positioned, the sample is automatically advanced at a constant speed through a balanced diamond-edged wheel rotating at 6,500 rpm.

Will Corp., Dept. ED, Box 1050, Rochester 3, N.Y.

Dual-Chamber Machine 268

Refrigerates to —100 F

The two chambers of this dual-chamber chilling machine can be controlled individually down to —100 F. The unit, Model SU2-80-4, is designed for testing or processing lines where operators are located on both sides of the line. Each chamber has two adjustable shelves, full opening doors, and a 1-1/2 in. access port. Thermal capacity is 500 BTU per hour. Entire unit measures 46 in. high, 46 in. long, and 32 in. wide. Power required is 230 v, 60 cps.

Cincinnati Sub Zero Products, Dept. ED, 3930 Reading Road, Cincinnati 29, Ohio.

Availability: 45 days.

Plastic Molding Machine 269

Air-operated, fully automatic

The Min-matic Model 60AM80 machine is a fully automatic, air-operated unit for production of items in all thermoplastics up to 3/4 oz. It has horizontal clamping with molds 6 x 5-1/8 x 5 in., four-tie rod construction, and a normal cycle time of two to four per min. Dry cycles are 480 per hr. A safety feature automatically opens the mold

and stops the operation of the machine if the part is not ejected at the end of any cycle.

Newbury Industries, Inc., Dept. ED, Newbury, Ohio.

Production Glass Welder 270

Welds six terminals in 80 sec

This unit welds and seals six anode terminals in glass in 80 sec. A built-in atmosphere control regulates internal and external atmospheres on the anode. A memory circuit automatically selects from one station to another. Features offered are RF current-meter indicators, and indicating lights for the various cycles.

Induction Heating Corp., Dept. ED, 181 Wythe Ave., Brooklyn, N.Y.

Molding Compound 271

Is flame resistant

Resistrac grade 1403 fiber-glass reinforced alumina-polyester molding compound has high track and flame resistance. It is designed to take the place of ceramics in electronic apparatus of many types. No carbon formation is shown after 400 hr of ASTM testing. Impact strength is 3 to 6 lb.

The Glastic Corp., Dept. ED, 4321 Glenridge Road, Cleveland 21, Ohio.

Availability: Data and samples will be sent upon letterhead request.

Welding Head 272

For bench mounting

Model 1037 bench-mounted welding head has twin ball-bearing races for precise control over the placement of the weld. This permits linear movement of the upper electrode and eliminates electrode wiping action. Preset electrode pressure is variable from 2 to 50 lb.

Unitek Corp., Weldmatic Div., Dept. ED, 950 Royal Oaks Drive, Monrovia, Calif.

Price: $325 fob Pasadena.

Insulation Laminator 273

For double-coated electrical tape

Type E-10 insulation laminator was designed for use with double-coated polyester film tape. Any insulating material may be made pressure-sensitive, saving time on the production line. The laminator has feed spools for the tape and the insulating material, with a take-up spool for the tape separation liner.

Minnesota Mining and Manufacturing Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

NEW LITERATURE

Rotary DC Solenoids 274

Five basic frame sizes of rotary dc solenoids are illustrated and described in this six-page brochure. Detailed specifications, dimensional drawings, typical torque characteristics and applications are included. A tear-out requirement data form is incorporated. PSP Engineering Co., Maywood, Calif.

Electronic Timers 275

This series of technical data sheets covers engineering specifications on time delay relays. Included are typical application and ordering information. Data are in tabular form. Voi Shan Electronics, 13259 Sherman Way, North Hollywood, Calif.

Synchros 276

These two four-page brochures, Nos. 204 and 206, cover size 8 and size 11 synchros respectively. Engineering data in tabular form lists input and output voltages, accuracy, shaft configurations, sensitivity, resistance, and impedance. Induction Motors of California, 6060 Walker Ave., Maywood, Calif.

SCR Magnetic Modulators 277

Engineering specifications for the firm's silicon controlled rectifier magnetic modulators are given in this two-page data sheet. Included are input and output voltages, pulse widths, efficiency, environmental information, temperature range, altitude, weight and physical dimensions. Voi-Shan Electronics, 13259 Sherman Way, North Hollywood, Calif.

Counters 278

Electric reset counters, manual reset counters, monodecade counters, predetermining counters, short counters with pushbutton reset, hours-minutes-seconds indicators, printing counters, heavy duty counters and impulse transmitters in the Sodeco line are described in this four-page bulletin. Electrical properties are tabulated. Landis & Cyr, Inc., 45 W. 45th St., New York 36, N.Y.

Insulating Resins 279

The firm's line of epoxy resins is cataloged in this four-page brochure. Physical, mechanical, thermal and electrical properties are tabulated. Marblette Corp., 37-31 Thirtieth St., Long Island City 1, N.Y.

Laminated Plastics Guide 280

The "Laminated Plastics Selection Guide" combines a 12-page manual with a quick-reference chart of characteristics of 21 common laminate grades. The manual includes a description of high-pressure laminates and a discussion of their properties and specifications. A glossary of related terms appears at the end. Properties of the firm's laminates are tabulated. The table evaluates the firm's line of laminates under mechanical, electrical and general purpose headings. Taylor Fibre Co., Norristown, Pa.

Miniature Motors 281

This bulletin, No. 135, describes 7/8-in. diameter permanent-magnet precision miniature motors with integral planetary gear reducers in 21 ratios from 3.82:1 to 36873:1. Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio.

Electronic Component Parts 282

In 36 pages, this catalog lists the firm's lines of terminals, terminal boards and strips, banana plugs and other parts for military and commercial precision products. The catalog also contains basic information on laminates, including physical and electrical properties of those used in terminal boards and special fabricated parts. National Tel-Tronics Corp., 52 Saint Casimir Ave., Yonkers, N.Y.

Time Delay Relays 283

This four-page brochure, No. 359, describes and illustrates the company's line of solid state time delay relays for commercial, industrial and military applications. Marstan Electronics Corp., 204 Babylon Turnpike, Roosevelt, L.I., N.Y.

Magnetic Laminations 284

This two-color, 36-page catalog, No. Tb-106, entitled "Magnetic Laminations" describes the firm's line of EE, EI, F, DU and W shape laminations. Formulae, engineering data and other information are included. G-L Electronics, Camden 5, N.J.

Epoxy Pellets 285

This four-page bulletin, No. 3, describes E-form epoxy pellets. It covers the variety of compounds available and various epoxy packaging techniques including encapsulating, sealing, impregnating, ruggedizing, potting, end sealing, embedding and bonding. Epoxy Products, 137 Coit St., Irvington, N.J.

Magnets and Memory Planes 286

Three research papers entitled "Transmission Electron Diffraction of Alnico V," "Long Term Magnetic Stability of Alnico and Barium Ferrite Magnets," and "Miniature Memory Planes for Extreme Environmental Conditions" are printed in this six-page publication. The papers were presented at a recent Conference on Magnetism and Magnetic Materials. General Ceramics Div., Indiana General Corp., Keashey, N.J.

Airborne Power Supplies 287

Two bulletins, Nos. 1494A and 1540, each 2 pages, give specifications of the firm's unregulated transformer-rectifiers, Models 6RW102YF1A and 6RW162YF1, respectively. Both units are rated at 28 v, 200 amp. A photo, electrical and mechanical characteristics, graph and outline drawings are included. General Electric Co., Schenectady 5, N. Y.

Carbon-Dioxide Cooling 288

The use of carbon dioxide systems for fast cooling and absolute control in environmental testing is described in this booklet, form C-7. The firm's vapor recycle system of cooling is described and illustrated, along with descriptions of five other methods of cooling test chambers. Carbon-dioxide cooling and mechanical refrigeration are compared. Cardox Div., Chemetron Corp., 840 N. Michigan Ave., Chicago 11, Ill.

Surge Protectors 289

The Captivolt line of surge protectors for silicon rectifiers is described in this four-page bulletin, No. EPD 3135-1. Construction information, performance characteristic curves and tables are included. Vickers Inc., Electric Products Div., 1815 Locust St., St. Louis 3, Mo.

Radio Interference Filters 290

The firm's line of standard radio interference filters is cataloged in this four-page publication. A guide for choosing the appropriate coil from specific electrical and physical requirements is included. All-Tronics, 45 Bond St., Westbury, L. I., N. Y.

Parts Catalog 291

This 252-page catalog contains detailed product listings on a wide variety of electronic parts and equipment primarily for industrial and research applications, including an extensive selection of semiconductor products and power tubes for industry and broadcast. Electronic Publishing Co., 180 N. Wacker Drive, Chicago, Ill.

Magnetic Memory Systems 292

These three four-page bulletins supply information on the firm's ferrite devices for memory systems. A Transfluxor for non-destructive readout is described in No. 500M1 bulletin. Another bulletin, No. 100M1, describes a ferrite aperture plate which is the equivalent of 156 cores. High-speed ferrite cores are described in Bulletin No. 227M1. Radio Corp. of America, Semiconductor and Materials Div., Somerville, N. J.

Testing Equipment 293

This 16-page folder, No. E(6), describes the firm's line of laboratory and testing instruments. Fully illustrated, it contains specifications, application information and prices on six different portable potentiometers, two dc galvanometers, an ac and a dc null detector, a guarded Wheatstone bridge facility, a universal radio set and two electrolytic conductivity indicators. Leeds and Northrup Co., 4939 Stenton Ave., Philadelphia 44, Pa.

IMPULSE

A DIGEST OF NEW DEVELOPMENTS IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE DIV. OF ALCOA, ROME, N. Y.

PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

SETTLED. The American Standards Association has officially adopted the long-used symbol of the Atomic Energy Commission to warn of the presence of radiation. The familiar three-bladed propeller (purple) on a yellow background is intended for use on signs at the entrance to rooms or areas where sources of radiation are present, on any kind of package containing radioactive materials, on equipment generating radiation, and on material or equipment contaminated with radioactive substances.

PROBLEMS, PROBLEMS, PROBLEMS. Electronic engineers have been handed more challenges by the government. In the area of *intelligence*, first there's need for completely new types of sensors and sensor systems for telling what's going on in Russia. Such sensors will be used in satellites as well as in planes and watch stations along the borders. Secondly, the Defense Department is seeking electronic machines to process the various types of information (photographs, electronic reports, translations and such) acquired through many sources. And the National Academy of Sciences—National Research Council has called for a greatly stepped-up program in *oceanography*. Specific hardware requirements include instruments for measuring radioactivity at all ocean depths, direct density measuring devices, precision salinometers and echo sounders, turbulence measuring devices, and underwater cameras.

PICK YOUR BAND. According to a recent report issued by the National Bureau of Standards, the best frequencies for communicating between earth and space lie between 70 and 6,000 megacyles. The actual frequency picked, of necessity, will be a compromise involving size of the antenna, beam width needed to track, and background radio noise. Up to now, 108 megacycles has been the frequency on which many United States satellites have been tracked and information relayed earthward.

BUSY SIGNAL? In case anyone should ask you, the average number of daily telephone conversations in 1959 was 266 million. Any wonder, then, that you often get that telltale buzz when you place a call?

MEDIC-ELECTRONICS. Bridging the gap between medicine and biology on the one hand, and physical science on the other, may require a new type of creative scientist who is competent in both fields. Such is the opinion of authorities in the field of medical electronics. One approach calls for a new degree in medical engineering to include the following: four years leading to a B.S. degree, two years for the M.S., and an additional four years for a Ph.D.

BIG EAR. What's thought to be the world's largest receiving antenna will soon be put through its paces. Referred to as TAHA (Tapered Aperture Horn Antenna), it is 1000 feet long, 500 feet wide, and 250 feet high.

CABLEMAN'S CORNER. The subject of cable testing is an important one. This is the phase of production that determines whether or not the cable you are purchasing is in accordance with your standards and requirements. In the field of electronics and automation, cables are required to suit various stringent electrical, mechanical, and/or chemical environments. Many years of study and testing have gone into the design of test equipment to be used for these critical tests. It is not enough to know that a cable has been tested in a manner that is "essentially" the same as the required standard. Slight variations in equipment design or methods of tests can mean the difference between conformance and non-conformance. Make sure the test data you receive gives a true picture of the performance of your cable. When you need cable, call on a cable specialist. Our number is Rome FF 7-3000, or write: Rome Cable Division of Alcoa, Dept. 11-90, Rome, New York.

These news items represent a digest of information found in many of the publications and periodicals of the electronics industry or related industries. They appear in brief here for easy and concentrated reading. Further information on each can be found in the original source material. Sources will be forwarded on request.

CIRCLE 144 ON READER-SERVICE CARD

NEW LITERATURE

RFI Measuring Equipment 294

This four-page bulletin gives complete description, applications and specifications of the NM-52A radio interference-field intensity measuring equipment. Outline drawings are included for the power supply, the meter unit, and dipole and broadband antennas. Stoddart Aircraft Radio Co., Inc., 6644 Santa Monica Blvd., Hollywood 38, Calif.

Rotary Switches 295

Ten decimal-to-binary rotary input switches are described in this two-page data sheet, No. 170. In addition to an outline drawing, the data sheet includes data on coded switching sequences, operating positions, electrical rating, contact arrangement and switching mechanism. Micro Switch, Freeport, Ill.

Relays 296

This four-page buyers' guide lists general purpose relays, overload relays, time delay types, latching and sensitive types, and subminiature types, among others. The illustrated bulletin includes details of application, performance and specifications of the line of Advance Elgin relays. Schweber Electronics, 60 Herricks Road, Mineola, Long Island, N.Y.

Synthetic Lubricant 297

This three-page bulletin describes the Pentalube TP-653-B high temperature synthetic lubricant. The bulletin covers typical properties and performance against MIL-9236B requirements. Data are included for temperature-viscosity characteristics, WADC deposition number, spontaneous ignition temperature and other mechanical and chemical standards. Heyden Newport Chemical Corp., Market Development Dept., 342 Madison Ave., New York 17, N.Y.

Stock Nylon Parts 298

This six-page catalog illustrates molded nylon parts available from stock molds. Among the assortment are bushings, washers, rollers, gears, bearings and glides. Several parts designed for specific applications are also illustrated. Nylomatic Corp., 136 W. Trenton Ave., Morrisville, Pa.

Magnetic Modulators 299

This two-page data sheet describes the design and engineering features of magnetic modulators. Engineering specifications are listed. Illustrations of separate low and high-voltage sections as well as combination units are included. Voi-Shan Electronics, 13259 Sherman Way, N. Hollywood, Calif.

Linear Encoder System 300

The company's linear encoded system is described in this four-page bulletin, No. 318. The illustrated bulletin covers the three major units in the system, describes the available readout formats, and gives general specifications for the standard system. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

Winding Machines 301

This 40-page catalog contains complete descriptions and specifications on the company's line of winding machines and accessories. Among the equipment included in the catalog are toroidal coil winders, tape winders and bobbin winders. Catalog No. 60 is illustrated. Boesch Manufacturing Co., Danbury, Conn.

Molded Plastics 302

Laminated plastic molded products are covered in this eight-page bulletin. Some of the products described are: a slip ring assembly; cable connector; brush block; electrical connector; missile segment, and a bus bar insulator. The illustrated bulletin gives mechanical and electrical properties of various products. Formica Corp., 4612 Spring Grove Ave., Cincinnati 32, Ohio.

Miniature Ball Bearings 303

This four-page catalog describes the RMB line of miniature ball bearings. Designated catalog No. 2-E-1, it covers dimensional data, load factors, ball sizes and weights of sealed and open radial, flanged radial and pivot type miniature ball bearings. Landis & Gyr, Inc., 45 W. 45th St., New York 36, N.Y.

Telemetry Subcarrier Oscillator 304

A self-commutating telemetry subcarrier oscillator is described in this two-page bulletin. Specifications include: input and output characteristics; over-all system characteristics; power requirements; environmental characteristics, and physical characteristics. Electrosolids Corp., Solidtronics Div., 14751 Keswick St., Van Nuys, Calif.

NEW LITERATURE

Microwave Components 305

The Series SF-60 short form catalogs consist of three catalogs describing, illustrating and tabulating specifications on microwave products. The catalogs describe the firm's semiconductor products, their microwave components, and their microwave tubes and devices. Microwave Associates, Inc., South Ave., Burlington, Mass.

Alloys 306

This technical bulletin, "Handbook of the Alloyist," describes the properties, applications and advantages of several groups of alloys used in the electronic industries. H. T. Porter Co., Inc., Riverside, N. J.

Insulating Washers and Trimmer Capacitors 307

This bulletin, No. CW, illustrates and describes the firm's lines of 3000 wvdc coaxial trimmer capacitors and insulating washers for commercial, industrial and military applications. Marstan Electronics Corp., 204 Babylon Turnpike, Roosevelt, L.I., N.Y.

Motor-Tachometer Generator 308

This data sheet, No. 6204-01, illustrates a size 8, precision, high-temperature motor-tachometer generator and tabulates electrical, mechanical and physical characteristics. An outline drawing, a schematic, and torque curves are included. John Oster Manufacturing Co., Avionic Div., 1 Main St., Racine, Wisc.

Infrared Detectors 309

This four-page publication, "Kodak Ektron Detectors—for the Infrared," illustrates and describes characteristics of the firm's various infrared detectors. Response and signal-to-noise ratios are graphed, and basic applications are described. Eastman Kodak Co., Rochester 4, N. Y.

Copper-Clad Laminates 310

Technical information on copper-clad laminates is given in this four-page data sheet, No. 8-1A. Physical, mechanical and electrical properties of the laminates are included in tabular form. Taylor Fibre Co., Norristown, Pa.

Automatic Circuit Printer 311

A precision, automatic screen printer for high-speed production of printed circuit boards is described in this 6-page illustrated bulletin. Operations and applications of the machine are described. Wyrco Projects, Inc., 66 Main St., Binghamton, N. Y.

Rotary Switch Terminals 312

This bulletin, No. 20, describes the different types of quick-connect terminals used on the firm's Type P 10-amp rotary switch. Photographs, dimension drawings, electrical ratings, mounting styles and contact diagrams are included. Electro Switch Corp., King Ave., Weymouth, Mass.

Acceleration Recorders 313

This four-page brochure describes and illustrates instruments recently added to the firm's line of acceleration recorders. Four 3-directional and a 1-directional instrument and various accessories are included. Impact-O-Graph Corp., 1900 Euclid Ave., Cleveland 15, Ohio.

Mobile Tape Recorder 314

This four-page bulletin, No. DD-5, describe the firm's Model 3116 mobile tape recorder. The instrument is designed as the equivalent of a laboratory system in a 60-lb mobile package. The literature includes illustrations and specifications of the instrument. Minneapolis-Honeywell Regulator Co., Industrial Systems Div., 10721 Hanna St., Beltsville, Md.

Engraving and Stamping 315

This brochure illustrates and describes engraved and stamped materials such as engraved dials and instruction data plates. Stencils for chassis marking are also shown. J. S. Packard, Inc., 200 Hudson St., New York 13, N. Y.

NEW LITERATURE

Tape Search Control System 316

This two-page data sheet, No. ZA-821, describes the operation and suggests applications of the type ZA-821 tape search and control system. The equipment described uses a time code detection technique in conjunction with a type ZA-801 time code generator. Electronic Engineering Co. of California, 1601 E. Chestnut Ave., Santa Ana, Calif.

Relay Catalog 317

In this catalog the relay lines of over 20 manufacturers are listed with descriptions and prices. A thumb-indexed table of contents is included. Relay Sales, Inc., Box 186, West Chicago, Ill.

Markers and Signs 318

This multi-colored, 24-page catalog describes electrical markers, numerals, letters, and identification signs. North Shore Nameplate Div., Anodyne Inc., 214-27 Northern Blvd., Bayside 61, N.Y.

Solid State Devices 319

Solid-state devices, instruments, and components for commercial, industrial and military applications are illustrated and described in this bulletin, No. PL. Marstan Electronics Corp., 204 Babylon Turnpike, Roosevelt, L.I., N.Y.

Punched Tape Programer 320

This two-page data sheet describes the firm's model TP-860 eight-channel, time-base punched tape programer. Electronics Engineering Co., Anaheim Electronics Div., 1601 E. Chestnut Ave., Santa Ana, Calif.

Switch Catalog 321

Technical engineering data and ordering information on snap-action switches are contained in this catalog. Enclosed and open stack switches for precision applications are included. Cherry Electrical Products Corp., 1650 Deerfield Road, Highland Park, Ill.

Winding Transformers 322

This two-page bulletin, No. 162-B01, describes a series of tapped-winding transformers intended to supply standard-voltage power from an off-standard line. Physical and electrical specifications are included. Acme Electric Corp., Cuba, N.Y.

Semiconductor Microforms 323

This four-page bulletin on precision-purity microforms for semiconductor and electronic production describes high-purity spheres, discs, dots and washers. Anchor Alloys, Inc., 968 Meeker Ave., Brooklyn 22, N.Y.

High-Impact Phenolic Parts 324

This four-page editorial reprint, "Designing High-Impact Phenolic Molded Parts," presents 12 design rules for reducing cost, based on industrial experience with fiberglass-reinforced phenolic resins. Tables giving mechanical data of the phenolics are included. Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y.

Potentiometer Transducers 325

This four-page bulletin gives specification data for six potentiometer transducers as applied to pressure, motion, altitude, weight, flow, indicating, recording, systems and controlling. H. E. Sostman & Co., 426 E. Lincoln Ave., Cranford, N. J.

Brazing Preforms 326

Design considerations and examples of metal joints suitable for using brazing preform are considered in this 20-page booklet, "Designing for Preforms." Discussions of varying preform shapes and materials for specific applications are included. A section considers applications of preforms in the electronics industry. Lucas-Milhaupt Engineering Co., Cudahy, Wis.

Multiplexer 327

This four-page brochure describes the Radiplex 89 low-level Multiplexer. Operating specifications and applications are included. Radiation Inc., Melbourne, Fla.

NEW LITERATURE

Digital Data Plotting 328

This eight-page brochure, No. DP6001, describes the Dataplotter, its accessories, and its capabilities in converting digital computer outputs into chart, graph or mechanical-drawing form. Electronic Associates, Inc., Long Branch, N.J.

Push Button Switch 329

This one-page data sheet, No. 5500, gives electrical and mechanical specifications and dimensional diagrams for the Series 5500 momentary-action push-button switches. Donald P. Mossman, Inc., Brewster, N.Y.

Tantalum Capacitors 330

This four-page catalog, No. 215/B2.1, gives technical and engineering information on Aerotan solid tantalum capacitors. Curves and reference tables are included. Aerovox Corp., New Bedford, Mass.

Air Dielectric Coaxial Cable 331

This four-page, two-color, illustrated bulletin describes aluminum sheathed air-dielectric coaxial cable which can be bent into a variety of shapes and configurations. American Tube Bending Co., Electronics Div., P.O. Box 1841, 5 Lawrence St., New Haven, Conn.

Instrumentation Tape Recorders 332

A 16-channel, digital, magnetic-tape recorder, Model PS-216-D, is described in this two-page catalog sheet, No. 58. Specifications and illustrations are included. Precision Instrument Co., 1011 Commercial St., San Carlos, Calif.

High-Speed Computer 333

A high-speed digital computer, Model PDP-1, is described in this four-page folder. Speed, memory size and access time, programming features, input-output equipment, instruction format, instruction list and prices are included. Digital Equipment Corp., Maynard, Mass.

Stepping Relays 334

A stepping relay designed for counting, scanning and information storage is described in this two-page data sheet. Electrical and mechanical ratings and dimensional drawings are included. Artisan Electronics Corp., 171 Ridgedale Ave., Morristown, N. J.

Transistorized Instruments 335

Transistorized power supplies, dc to dc voltage regulators and a transistor checker are described in this two-page catalog sheet, No. SF1259. Specifications and prices of the instruments are included. Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.

Compressed-Sheet Mica 336

This 24-page catalog, No. 26, gives technical information on mica hard plates, flexibles and flexible combinations, micapaper rolls, sheets and tapes, as well as fabricated parts made to customer specifications. A section of the catalog outlines the advantages of compressed sheet mica over natural mica. Data on grading and classifying types, properties and processing of natural mica is included. Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.

Tantalum Capacitors 337

This four-page bulletin, No. GEA-7065, describes light-weight, high-voltage tantalytic capacitors for 85 and 125 C applications. Mechanical and electrical specifications, performance characteristics and curves for the capacitors are included. General Electric Co., Capacitor Dept., Irmo, S.C.

Strain Gage 338

A mono-filament subminiature wire strain gage and a similar strain insert, with insulated lead ends to aid in alignment, are described in this four-page bulletin. Line drawings, tables and graphs supply operating data. Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.

IDEAS FOR DESIGN

Get $10.00 plus a by-line for the time it takes you to jot down your clever design idea. Payment is made when the idea is accepted for publication.

Visual Display Helps Determine Tuning Fork Q

OBTAINING the Q of a tuning fork can be an easy process if the fork's transient, rather than its steady state response, is considered. This is done with the circuit of Fig. 1, which determines Q with the aid of a visual display of the fork's transient decay pattern. It replaces the cumbersome, conventional method which measures the tuning fork's response at its resonant and half-power frequencies. Since the Q's varied from about 600 to 3500, this method requires both critical adjustments and a good deal of time.

Circuit Sets RC Time Constant Equal to Tuning Forks

For a decaying oscillatory system

$$Q = \pi N_e \tag{1}$$

where Q = figure of merit and N_e = number of cycles in which the amplitude decreases by a factor of $1/e$,

Since $$N_e = ft_e \tag{2}$$

where f = frequency of oscillation and t_e = time required for N_e cycles to occur at the frequency f,

then $$Q = \pi f t_e \tag{3}$$

The oscillation decay time, t_e, can be set equal to the time constant of an RC circuit, or

$$t_e = T = RC, \tag{4}$$

Equating, Eqs. 3 and 4 yields

$$Q = \pi fRC \tag{5}$$

In order to have a convenient, decade reading of Q, the numerical equality

$$Q = C_\mu \times 10^3 = C \times 10^9 \tag{6}$$

should hold true, where $C\mu$ = capacitance in microfarads.

It follows from Eqs. 5 and 6 that

$$\frac{Q}{C_\mu(10^3)} = 1 = \pi fR(10^{-9}), \tag{7}$$

and therefore

$$R = \frac{10^9}{\pi f}. \tag{8}$$

For f = 400 cps,

$$R = \frac{10^9}{\pi\,(4 \times 10^2)} = 7.957 \times 10^5 \text{ ohms}$$

and is accurate to 0.5 per cent for 397.5 cps $> f >$ 402.5 cps, which was the range of interest. Obviously, for other applications, the resistance could be adjusted for various frequencies.

With S_1A and S_1B closed (the normal position), Fig. 1, e_1 is applied to TF, whose amplified output, e_2, is imposed on channel A of the oscilloscope and the primary of T_1. Voltage e_3, the rectified output of T_1 is applied across the $[R_t\ R_{in}/(R_t + R_{in}]C$ network, and displayed on channel B of the oscilloscope. After adjusting e_1 to the rated valve of TF, the zero traces of channels A and B are superimposed. With e_1 applied,

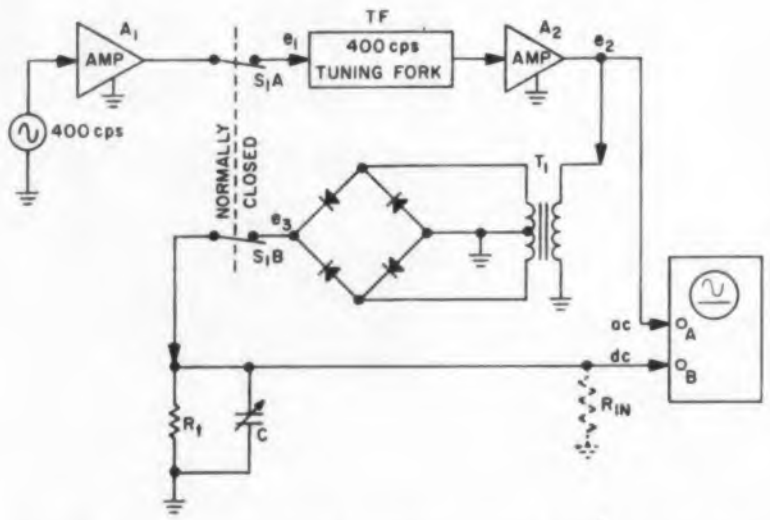


Fig. 1. Q-measuring circuit displays tuning fork's decay transient. The actual time constant is determined from the value of the capacitance C.

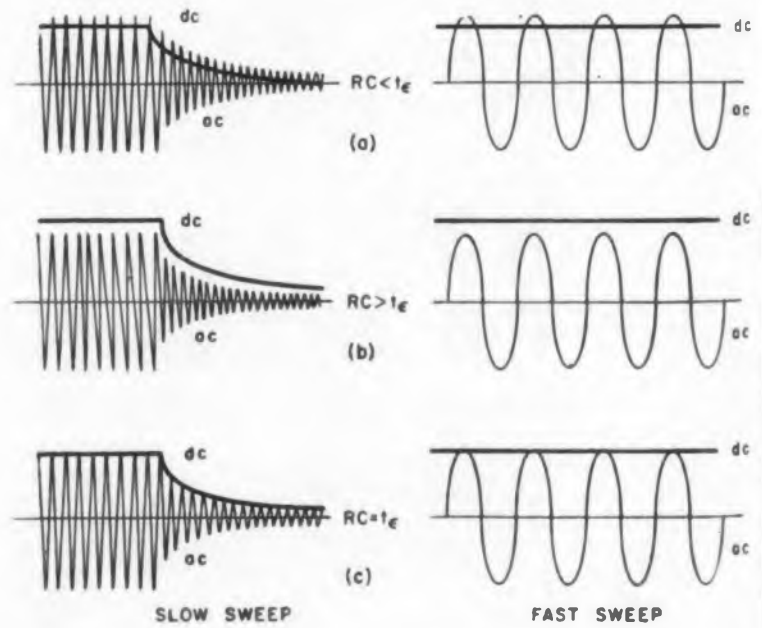


Fig. 2. Oscilloscope patterns for different values of capacitor C. In practice R is held constant and C is varied, until rectified and alternating waves are lined up as in pattern (c).

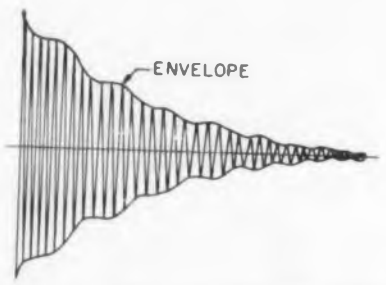


Fig. 3. This oscilloscope (slow sweep) pattern results when tuning fork is unbalanced (tines are at two different frequencies).

the maximum traces of e_2 and e_3 are adjusted, with the channel amplifier sensitivity controls, for congruency.

Time Constants Equalized By Scope Display

Pushing down S_1 (A and B), which is a dpst, normally-closed, spring-loaded, push-button switch, will produce any one of the three oscilloscope patterns, shown in Fig. 2. The pattern displayed depends on the setting of capacitor C.

Pattern (a) results when $RC < t_e$, or when the capacitance of C is too small. Pattern (b) results when $RC > t_e$, and pattern (c) is produced when $RC = t_e$. The fast sweep patterns are, of course, of exponentially decreasing amplitude. The patterns are a comparison of the decay time of the resonant system versus that of the RC-network. When pattern 2c is obtained, the Q of the tuning fork is equal to the decade capacitor setting (to 3 significant digits) times 1,000. It was found, in actual operation, that the fast sweep patterns of Fig. 2 give greater resolution (the zero can be suppressed) and consequently reduced operator fatigue and reading error.

Another advantage of this system is that it displays any fork unbalance (that is, two adjacent resonant peaks in its transfer function) as a sinusoid envelope of the ac decay pattern. Such a case is shown in Fig. 3.

The resistor R_t, which is actually a frequency scale-factor adjustment, must be computed together with the input impedance of the oscilloscope. That is

$$R = 7.957 \times 10^5 \text{ ohms} = \frac{R_t R_{in}}{R_t + R_{in}} \qquad (9)$$

R_t can be a variable resistor, calibrated in operating frequency, should this system be applied as a Q-meter for a large frequency range.

This method of Q measurement is difficult to apply for $Q < 200$. The decay time, t_e, is too fast for an accurate reading. However, this doesn't present any difficulties, since resonant systems with $Q < 200$ can be easily measured by the orthodox methods.

Walter Plywaski, Engineer, The Martin Co., Denver, Colo.

IDEAS FOR DESIGN

Modified Circuit Limits Pulse Amplitude More Effectively

The pulse amplitude limiter described in *ED*'s, April 27, 1960, Ideas for Design column is not really a limiter because the output voltage is still a function of the input voltage.

Given the device shown in Fig. 1, when $|E_{in}| > |E_g|$ the output voltage is

$$E_{out} = \frac{\frac{E_{in}}{R_g} + \frac{E_b}{R_p}}{\left[\frac{1}{R_g} + \frac{1}{R_p}\,\frac{1}{R_L}\right]}$$

In order to truly clamp to E_B, R_p would have to equal zero. This would eliminate the use of a bled-down power supply, as the author suggests. If another power supply is used and $R_p = 0$, then there is the danger of excessive current in the base lead if R_g is small.

If R_p is finite and $R_{ri} \ll R_p$, the output would follow the input. In effect, all you would have is a resistive attenuator. As a matter of fact, no emitter follower action results when $|E_{in}| > |E_b|$ because of the saturation of the transistor.

A more effective way of limiting or clipping is shown in Fig. 2.

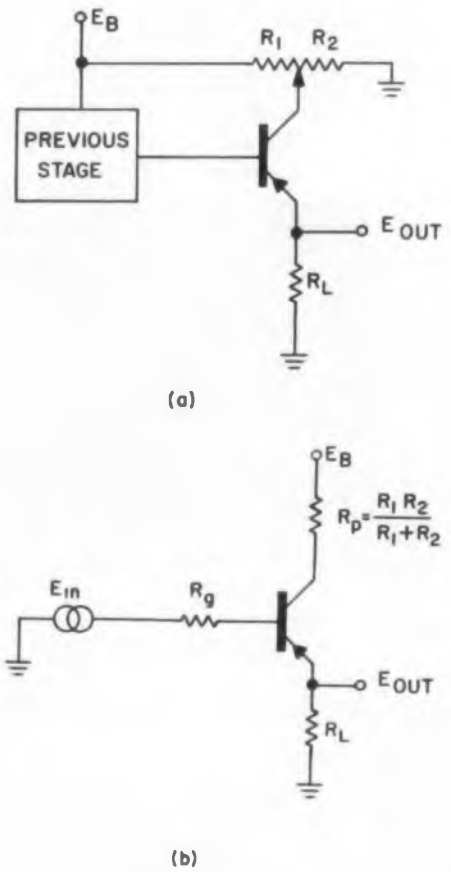


Fig. 1. Output voltage of this pulse amplitude limiting circuit (reprinted from Ideas for Design, *ED*, April 27, 1960, p 120) is still a function of the input voltage (see Eq. 1).

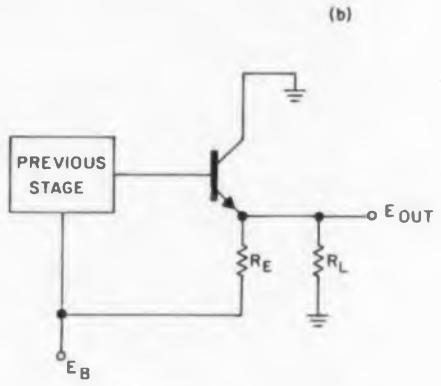


Fig. 2. With this circuit, the output voltage will clip at a value independent of the input voltage (for $|E_{in}| > |E_b|$).

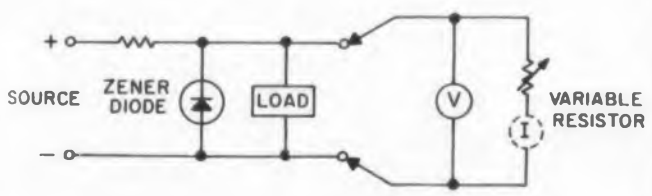
Using an npn transistor for the emitter follower, the transistor will cut off when $|E| > |E_G|R_L/(R_E + R_L)$. Then the output voltage will clip at $E_bR_L/(R_E + R_L)$ for any E_{in} whose absolute value is greater than $|E_b|$.

The above discussion holds for negative pulses. Obviously, a pnp transistor properly biased could be used to limit a positive pulse.

Burt H. Liebowitz, Engineer, Airborne Instruments Laboratory, Huntington, N.Y.

Voltmeter-Variable Resistor Measures Zener Current

To measure the current flowing through a Zener diode without breaking the circuit, connect a voltmeter and variable resistor across it as shown in the figure. The variable resistance is then reduced until the voltmeter reading just starts to drop. At this point the resistor is absorbing all the current which used to flow in the



Current in variable resistor equals Zener diode current when voltmeter reading begins to drop as resistance value is reduced.

diode. The resistance may then be measured and Ohm's law used to calculate the current, or an ammeter may be used as shown. The accuracy of the measurement is determined by the sharpness of the Zener breakdown, which is usually described by the diode's manufacturer.

David J. Goldman, Electrical Engineer, Di/An Controls, Inc., Boston, Mass.

IDEAS FOR DESIGN

Simplified Conversion Eliminates Slide Rule Step

The decibel conversion method outlined in "Log-Log Slide Rule Converts Voltage, Power Ratios Directly to Db" (*ED*, May 11, 1960, p 231 and July 20, 1960 p 149) is more difficult to use and remember than is necessary. The difficulty lies in the assumption that the voltage or power ratio has already been determined. Actually this would require an extra setting of the slide rule. This decimal ratio must then be remembered for use after the slide rule has been set as recommended in the article. A much simpler method is available.

If the log scale is on the stationary part of the rule, power ratios are determined by performing the ratio division on the *C* and *D* scales. The cursor is then brought to the index of the *C* scale, and the power decibel ratio is read directly off the log scale by moving the decimal point one place to the right.

For voltage ratios, the same procedure is used, except that in addition to moving the decimal point one place to the right on the log scale, the numbers on the log scale are also multiplied by two. This can be done by inspection. With either of these methods, it is only necessary to note whether the original ratio is greater than 10, and by how many decades. A suitable number of 10-db steps for the power ratio or 20-db steps for the voltage ratio is added to the number read on the log scale.

If the log scale is on the slide, the same procedure is used, except that the division must be done "in reverse." The smaller number of the ratio is set on the *D* scale and the larger number on the *C* scale. The cursor is set to the index of the *D* scale.

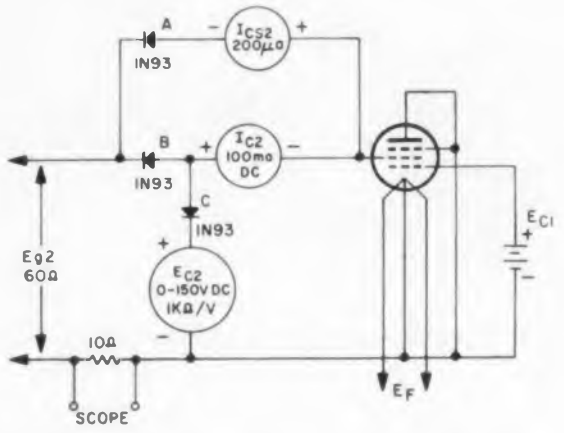
Donald E. Williamson, Williamson Development Co., Inc., West Concord, Mass.

Measuring Primary Screen Grid Emission

The circuit shown was used to measure the reverse screen grid current of a tube and determine the extent of its primary screen grid emission.

A 60-cps voltage E_{g2}, is applied to the screen grid through 1N93 diodes *A* and *B*. Screen current, I_{c2}, flows during the positive half of the cycle causing the grid to heat. Diode *C*, causes the E_{c2} meter, to read on the positive half of the cycle.

Source voltage E_{g2}, is adjusted for the maximum screen dissipation specified for the tube.



Reverse screen grid current is measured after tube has been operated at rated screen dissipation for five minutes.

The equation used, $P_{c2} = 2.48\ E_c 2 I_{c2}$ is based on positive rectified halves of a sine wave. Dissipation is applied for five minutes before readings are taken.

The screen current should conduct for 180 deg during each cycle. This is observed on an oscilloscope placed across the 10-ohm resistor.

Control grid voltage E_{c1}, is set so the screen dissipation is not exceeded before the conduction angle of I_{c2} reaches 180 deg.

After dissipation has been applied for the specified time, the reverse grid current I_{cs2}, or primary screen emission, is measured. This measurement is made during the negative half of the input cycle.

H. E. Wood, Engineer, Lansdale Tube Co., Lansdale, Pa.

Woods Metal Good For Plugging Plumbing

Corrobend, or Woods Metal, a fusible alloy which melts at 160 F may be used in the experimental laboratory as an easily worked material for making adjustable shorts or plugs in waveguide, cavities, etc. It gives a good mechanical and electrical fit and is easy to insert and remove.

A minimum of tools are required, only a source of heat 150 to 200 F to melt the alloy in place. There is no danger of damage to the parts from excessive heat or mechanical stress, as might occur when using machined brass or aluminum plugs.

There are probably many ways in which this "liquid" technique could be used. One very satisfactory use is that of an easily adjusted short in crystal mounts or transitions. By adding to, or drilling out the material, and remelting, tolerances of 0.002 in. are easily obtained.

J. D. Stewart, National Research Council, Radio & Electrical Engineering Div., Ottawa, Canada.

BOOKS

Theory and Application of Ferrites

Ronald F. Soohoo, Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N.Y., 288 pp, $12.00. (For a special preview of this book, see p 000.)

Designed to introduce the reader to the study of the theory and applications of ferrites at and below microwave frequencies, this text is suitable for both the practicing engineer and physicist. Theory developed in part I is applied, in part II, to the design and analysis of practical ferrite devices. Physical reasoning is stressed throughout, with the more complicated mathematical derivations collected in an Appendix.

Chapter 1 introduces the subject of ferrites while Chapter 2 deals with the general properties of matter in the solid state. Chapters 3 and 4 deal respectively with the dielectric and magnetic properties of ferrites. The permeability tensor is derived with ferrite losses and property measurement techniques discussed next. In Chapters 8 and 9 the propagation of electromagnetic waves through ferrites are treated.

Topics discussed in Part II are applications of ferrites at and below microwave frequencies, various ferrite devices such as the Faraday rotator, resonance isolator, phase shifter, and recirculator. Also discussed are cut-off phenomena, ferrite behavior at large signals and finally, the system applications of microwave ferrites.

Numerous graphs and illustrations are included for illustrative purposes. Only material that has been experimentally tested is included (a substantial portion

of this is original with the author). Problems are presented at the end of each chapter.

Principles of Quantum Mechanics

William V. Houston, Dover Publications, Inc., 180 Varick St., New York 14, N.Y. 288 pp, $1.45.

The author, having taught a graduate course in nonrelativistic quantum mechanics, attempts to present a unified work in this field for the student or the scientist. The object of the book is to acquaint the reader with quantum mechanics on a level that will enable him to understand published work in this area. The reader is assumed to have a working knowledge of elementary mathematical physics.

The first part of the book provides a formulation of quantum mechanics in terms of Schroedinger's wave mechanics. Subsequent chapters deal with applications in spectroscopy, collision problems, electrons in solids, and electromagnetic radiation.

Advances in Space Science Vols. I and II

Frederick I. Ordway, III, Academic Press Inc., 111 Fifth Ave., New York 3, N.Y., Vol I, 412 pp, $12; Vol. II, 450 pp, $13.

Of interest to scientists and engineers working in fields related to astronautics, this series endeavors to keep them abreast of the progress in this field. The first volume includes sections on interplanetary rocket trajectories, interplanetary communications, power supplies for orbital and space vehicles, and bio-astronautics. The second volume, a survey of the principles of construction and the performance of rockets and rocket engines, covers the following topics: space physics, tracking, materials, electrical propulsion, and attitude control.

SPECIAL BOOK PREVIEW

System Applications of Ferrite Devices

by

Dr. Ronald F. Soohoo

This material is taken from the concluding chapter in Mr. Soohoo's recently published book "Theory and Application of Ferrites" (Prentice-Hall, Inc., $12.00). One of the first in the ferrite field to include both theoretical and practical design information, it was written while the author was with Lincoln Laboratories, Lexington, Mass. He is currently Director of Research Analysis, Cascade Research Corp., Los Gatos, Calif.

The chapter selected discusses the use of ferrite devices in microwave systems to perform such functions as isolating power sources from the load, switching a source from one antenna to another, etc. The theoretical and practical design aspects of these devices—circulators, modulators, phase shifters, and others—are discussed in earlier chapters.

Of general, as well as specific interest, this chapter illustrates both the book's content and method of presentation. *(For a more complete review of the text, see p 166.)*

1. Use of Isolators in Microwave Systems

1a. ***To Isolate Source from Load Reflections.*** Isolators can be used to improve klystron and magnetron stability. In the case of a klystron, its frequency of oscillation is affected by reflection from the load in a phenomenon known as frequency pulling. Thus, if an antenna fed by a klystron were scanning the sky, the impedance seen by the antenna might be a function of its orientation. Some means of isolation must be provided if the impedance change is not to affect the frequency of oscillation of the klystron source. Conventionally, an attenuator (~6 db) is placed between the klystron and load to absorb the energy reflected from the load. However, the conventional attenuator, being bilateral, equally attenuates the power traveling from the klystron to the load, as well. If an isolator is used in place of the attenuator, then the power loss can be made small in the oscillator-to-load (forward) direction, and yet the attenuation in the load-to-oscillator (reverse) direction will be large. This is accomplished by proper orientation of the isolator.

To demonstrate the power gain obtained in replacing an attenuator by an isolator, let us consider the following typical example: In Fig. 1a, the power transmitted to the load P_2 is reduced to 25 per cent (—6 db) of the output value from the klystron P_1 by insertion of the attenuator. Any reflections from the load are reduced by another 6 db or to 6.25 per cent of P_1. On the other hand, the power P_2 reaching the load in Fig. 1b is 93.3 per cent (—0.3 db) that of P_1 at the output of the klystron, owing to the insertion of the isolator. Any reflection from the load would be attenuated another 11.7 db, or a total of 12 db. It is noted that the attenuation of the signal through the attenuator to the load and back is also 12 db. Thus, as far as the effect of the load mismatch is concerned, the klystrons of Figs. 1a and 1b will be equally stable. If we were to define a figure of merit called transmission efficiency of the attenuator or isolator as:

$$\eta_T = \frac{P_2}{P_1} \quad \text{or} \quad \frac{P'_2}{P_1} \qquad (1$$

we would find that $\eta_T = 25$ per cent for the attenuator and 93.3 per cent for the isolator, for equal klystron stability.

Thus, to achieve the same stability, one half the sum of the forward and reverse attenuation of an isolator should equal the attenuation of the attenuator in either direction of propagation.

In a similar manner, the isolator can be used to eliminate long line effects, present where antennas are located far from the source, and which are particularly detrimental to magnetron operation. Since the use of an isolator greatly reduces the mismatch seen by the magnetron, it eliminates the tendency of a magnetron to lock on some frequencies or to fail to operate at others

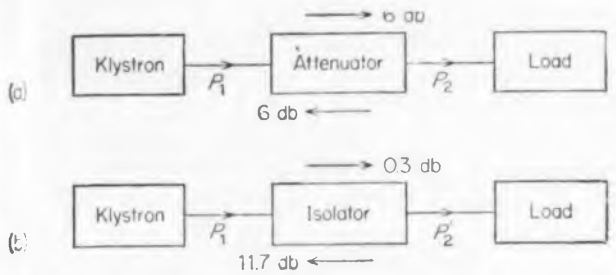


Fig. 1. Load isolation using attenuator and isolator.

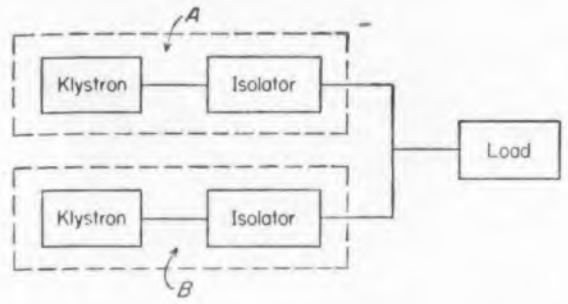


Fig. 2. Use of isolators in isolating sub-systems.

Pulsed magnetrons with mismatched loads may also transmit pulses of more than one frequency.[1]

The variation of impedance Z_i, seen by the magnetron, due to a load Z_L at the end of a long line of length l may be seen from the following equation.[2]

$$Z_i = Z_0 \frac{Z_L \cos \beta l + jZ_0 \sin \beta l}{Z_0 \cos \beta l + jZ_L \sin \beta l} \qquad (2)$$

Since:

$$\beta = \frac{2\pi}{\lambda_g} = \frac{2\pi f}{c} \sqrt{1 - \left(\frac{f_c}{f}\right)^2} \qquad (3)$$

where β and λ_g are the phase constant and the guide wavelength, respectively. It is clearly seen that Z_i of Eq. 2 is a function of frequency f.

The width of the frequency spectrum of a pulsed magnetron is not necessarily constant. when magnetrons are operated into a long line with a mismatched load, the frequency spectrum may tend to broaden and to vary for different pulses. A closer approach to the theoretical spectrum is obtained where an isolator is used.

1b. ***To Isolate Subsystems.*** The klystron in subsystem *A*, Fig. 2, is isolated from that in subsystem *B* for any signal coming from *B* to the klystron in *A*. Such a signal is attenuated by an amount equal to the sum of the forward attenuation of the isolator in subsystem *B* and the reverse attenuation of the isolator in subsystem *A*. Thus, not only is the load isolated from the klystrons in subsystems *A* and *B*, but the klystrons in subsystems *A* and *B* are themselves isolated from each other.

2. Use of Modulators and Phase Shifters

2a. ***Amplitude Modulation.*** The attenuation of a resonance isolator in the reverse direction

can be varied by sweeping the dc magnetic field in the vicinity of ferromagnetic resonance. In this way, the amplitude of a cw (continuous-wave) signal may be varied as a prescribed function of time.

Similarly, a Faraday rotator may be used for amplitude modulation. The variation of the magnetic field biasing the ferrite varies the amount of rotation θ. Since the output of a Faraday rotator is usually joined to a rectangular waveguide, the amplitude of the transmitted signal is

$$E_T = E_m \cos \theta \tag{4}$$

where $\theta = 0$ represents the direction parallel to the narrow dimensions of the rectangular guide.

2b. ***Frequency and Phase Modulation.*** Since the phase velocity in a ferrite medium is a function of magnetic field bias at a fixed frequency, the phase shift of a ferrite-containing section can be varied by changing the magnetic field bias. Depending upon whether quarter-wave plates are used in the longitudinal-field type phase shifter, nonreciprocal or reciprocal phase modulation may be achieved. In the rectangular guide case, a ferrite slab, only if located at the center between side walls, gives a reciprocal phase shift.

To demonstrate the phase constant dependence on magnetic field, let us consider the infinite medium magnetized in the direction of propagation. The permeability for the two directions of propagation are $\mu \pm K$. Thus:

$$\beta_\pm = \frac{1}{\sqrt{\mu_\pm \epsilon_f \mu_0}} = \frac{1}{\sqrt{\mu_0 \epsilon_f (\mu \pm K)}} \tag{5}$$

$$= \frac{1}{\sqrt{\epsilon \left(1 + \dfrac{|\gamma_e| M_0}{|\gamma_e| H_0 \mp \omega}\right)}} \tag{5}$$

It is seen readily from Eq. 5 that $\beta\pm$, or the phase shift per unit length, is a function of applied field.

Frequency or phase modulation can also be accomplished by using a phase shifter. Letting the electric field be $E_m \sin (\omega t + \phi)$ in which $\phi = m_p \sin \omega_m t$, we have:

$$E = E_m \sin (\omega t + m_p \sin \omega_m t) \tag{6}$$

Expansion of Eq. 6 gives the ω carrier component as well as $\omega \pm n\omega_m$ sideband components. The amplitude of the carrier and the sidebands are determined by the maximum phase shift m_p.

3. Use of Circulators in Microwave Systems

3a. ***For Antenna Switching.*** Consider the schematic diagram of a four-port circulator as shown in Fig. 3. As explained in Chapter 12, when the magnetic field is in one direction, the

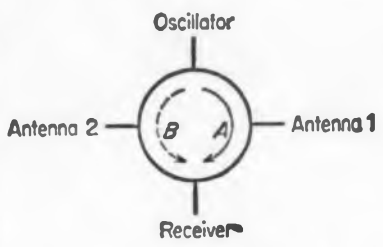


Fig. 3. Switching of antennas using circulator.

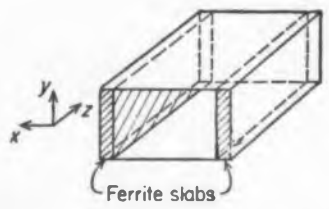


Fig. 4. Magnetic tuning of the resonance frequency of a ferrite-loaded cavity.

phase relations are such that the circulation is clockwise, as indicated by path *A*. Thus, the oscillator output is fed into antenna *1*. If the direction of the magnetic field is reversed, the phase relations are such that the circulation path is now counterclockwise, as indicated by path *B*. Consequently, the output of the oscillator will be radiated out of antenna 2. Therefore, by merely changing the direction of an applied magnetic field, the oscillator can be made to feed into either one antenna or another.

It may be noted that signals received from antennas *1* and *2* both would travel to the receiver by way of paths *A* and *B*, respectively. Thus, the circulator scheme enables antennas *1* and *2* to perform both transmitting and receiving functions. Without the circulator, a tr tube would have to be used for a single antenna to perform both transmitting and receiving functions.

3b. ***For Source and Antenna Isolation.*** As shown in Fig. 3, for path *A*, signals received from antenna *1* will go to the receiver, and in the ideal case the oscillator is completely isolated from antenna *1*. The same can be said of the isolation between the oscillator and antenna *2* in path *B*. However, to accomplish perfect isolation between antenna and oscillator, the phase relations in the circulator must be exactly correct so that the waves coming from the antenna via different paths will interfere destructively at the oscillator terminal. Over a band of frequency, this condition is not, in general, attainable, and the isolation ratio remains finite.

One feature of the antenna switching scheme of Fig. 3 should be mentioned. While the oscillator energy is fed to antenna *1* via path *A*, any signal received from antenna 2 will travel toward the oscillator (of course, via path *A*). This may cause frequency pulling in the oscillator and thus may be objectionable.

4. Other Applications

4a. ***Magnetic Tuning of Cavities.*** The resonance frequency of a ferrite-loaded cavity may be changed by changing the magnetic field applied to the ferrite. This effect[3,4] may be utilized

SPECIAL BOOK PREVIEW

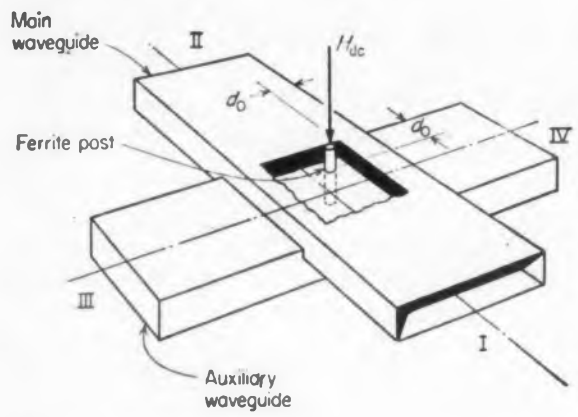


Fig. 5. Crossguide ferrite directional coupler.

for frequency modulating a klystron over a considerable bandwidth, without accompanying amplitude modulation. To accomplish this usually requires that the klystron employ an external cavity and that the ferrite sample be not too small.

With the ferrite slabs located at the sidewalls of the cavity, Fig. 4, and a magnetic field applied in the z direction, large negative frequency shifts may be obtained for small changes in magnetic field; when the field is applied in the y direction, very large linear shifts can be obtained. With the ferrite on the bottom of the cavity and the magnetic field applied in the x direction, small linear shifts can be obtained.

4b. ***Ferrite Directional Couplers.***[5] The incident wave in the main waveguide, Fig. 5, assumed to be of the fundamental mode, produces a dielectric polarization current parallel to the axis of the post. As far as the auxiliary waveguide is concerned, it is a dielectric antenna radiating equally in both directions. Thus, the power transfer from the main to the auxiliary waveguide is nondirectional.

The electron spins in the upper half of the ferrite post are made to precess about the orienting field H_{dc} by the circularly polarized rf magnetic field of the incident wave. For a wave traveling from terminal II to terminal I, this precession amplitude is small. On the other hand, if an H_{dc} nearly equal to the value required for ferromagnetic resonance is applied, power traveling from I to II may cause large precession. Because of spin-to-spin coupling, this precessional motion is transferred to the spins of the lower half of the post. Thus, the ferrite cylinder acts like a stack of magnetic dipoles rotating about its axis at the frequency of the rf field. For a fixed sense of rotation of these dipoles there is a corresponding fixed direction in which power in the auxiliary waveguide can propagate. This direction is from IV to III in Fig. 5. As the magnetic field value approaches that required for ferromagnetic resonance, the magnetic coupling

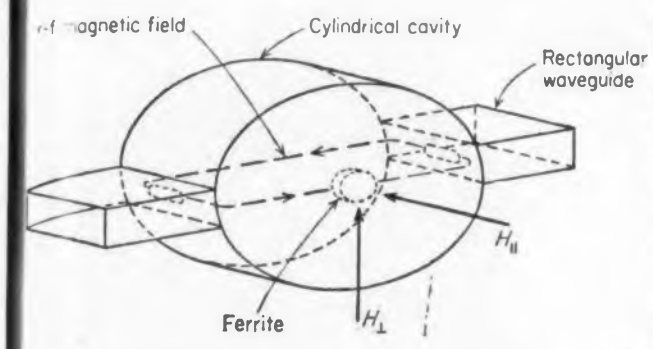


Fig. 6. Ferrite-loaded band pass filter, TE_{111} cavity mode.

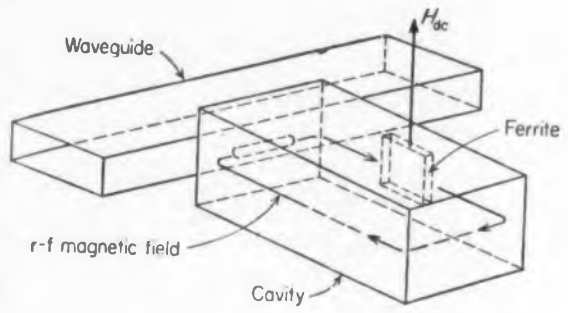


Fig. 7. Ferrite-loaded band elimination filter, TE_{101} cavity mode.

becomes predominant and the over-all coupling becomes directional.

Perturbation analysis shows that the coupling for a very small ferrite post in decibels is:

$$\text{Coupling} = -20 \log_{10} \left(\frac{Q_m \pi D^2}{L^2} \sin^2 \frac{\pi d_0}{L} \frac{x - K}{x - K + 2} \right) \quad (7)$$

and the directivity in db is:

$$\text{Directivity} = 20 \log_{10} \frac{(x - K)(x + K + 2)}{(x + K)(x - K + 2)} \quad (8)$$

where D is the diameter of the post, L the width of the waveguide, and d_0 the distance from the points of circular polarization to the nearest wall of the waveguide. Q_m is an empirical factor which measures the extent to which magnetic polarization currents in the upper half of the ferrite post penetrate into the lower half.

The preceding theoretical expressions predict that the coupling and the directivity should go through a single resonance as the strength of the dc magnetic field increases. Experimentally, however, even for rather small ferrite diameters, two resonances have been found. This may be due, in part, to the inadequacies of the perturbation theory.

4c. ***Ferrite Filters.***[6] It is evident that a tunable cavity could be used as tunable band pass and band elimination filter. The kind of filter action depends upon the geometrical configuration and the mode used.

Fig. 6 above shows a band pass filter using a TE_{111} cavity mode. Since the wave is linearly polarized, it is a bilateral device. The magnetic

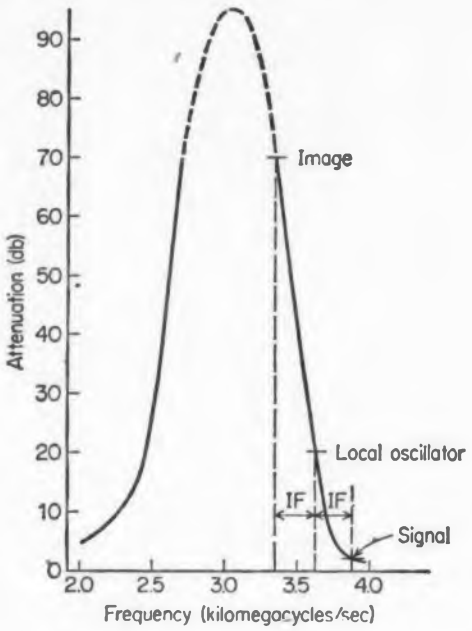


Fig. 8. Ferrite resonance absorption curve showing application to receiver image rejection.

field may be changed to change the resonance frequency.

At the resonance frequency of the cavity shown in Fig. 7, the cavity reflects and therefore acts as a band elimination filter. The filter uses the TE_{101} mode. Again, the resonance frequency can be changed by changing the magnetic field applied to the ferrite.

Since a ferrite has a finite resonance line width, it is a band rejection filter when biased to ferromagnetic resonance. This property has been utilized[7] to reject image frequency, as shown in Fig. 8. In order to detect a microwave signal, it can be mixed in a crystal mixer with a local oscillator signal whose frequency is lower than the signal frequency by an amount if (intermediate frequency, whose typical value of 30 mc/sec is predetermined by the center frequency of the bandpass filter in the mixer). If there is another signal at a frequency if below the local oscillator frequency, called the image frequency, the detector will give an output also. In order to insure that the detector output is indicative of the presence of the desired signal, some means must be found to suppress the signal at the image frequency.

The device is composed of a longitudinal magnetized ferrite rod forming a section of the center conductor of a coaxial line. Again, the resonance frequency can be tuned by changing the magnetic field.

4d. ***Ferrite Radiators.***[8,9] If a ferrite slab is placed at the end of a rectangular waveguide as shown in Fig. 9, there will be radiation out through the ferrite. The lobe pattern and orientation are functions of the applied field H_{de} and

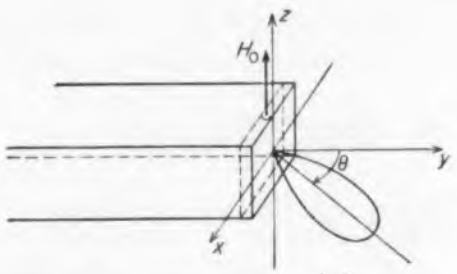


Fig. 9. Ferrite radiator. θ is measured in y-x plane.

can therefore be varied with it. A similar situation occurs when an axial field is applied to a ferrite rod protruding from an open circular guide.

4e. ***Traveling-Wave Tube Attenuators.***[10,11] In a traveling wave amplifier, the reflections of the waves from the output of the tube may cause undesirable oscillations. Conventionally, an attenuator is placed somewhere along the propagating helix to attenuate the reflections. Other things being fixed, this reciprocal attenuation reduces the gain of the amplifier. If we investigate the magnetic field configuration near the helix, we find that it is nearly circularly polarized in the r-θ plane and elliptically polarized in the r-z plane. Thus, if ferrite slabs were placed near the helix and axially magnetized, or if a ferrite ring were placed around the helix and circumferentially magnetized, non-reciprocal attenuation would be obtained. The ferrite will then greatly attenuate the reflected wave to avoid oscillations without a consequent decrease in gain of the traveling wave amplifier. ■ ■

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9. G. Tyras and G. Held, "Radiation from a Rectangular Waveguide Filled with Ferrite," *Trans. IRE* on Microwave Theory and Techniques, MTT-6, No. 3, (July 1958) p 268.
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RUSSIAN TRANSLATIONS

J. George Adashko

Designing Phase-Sensitive Transistor Circuits

SEVERAL practical circuits using semiconductor diodes and transistors in phase-sensitive configurations are presented, together with their design equations. Using these equations, the circuits were built and then tested in such devices as signal and relay-feeding amplifiers, phase-sensitive scalers, and driving amplifiers for reversing motors.

Single-Ended Phase-Sensitive Vacuum Tube Analog

The schematic of Fig. 1 is an analog of a phase-sensitive vacuum tube circuit. Here, the vacuum tube is replaced by a transistor-diode combination, with the diode's polarity opposite that of the collector junction's. It is similar to the vacuum tube circuit because during one half cycle of the supply voltage no load current flows. Current pulses fed to the load can be smoothed by shunting the load with a capacitor.

With the diode included, the output voltage is directly proportional to the input signal. The

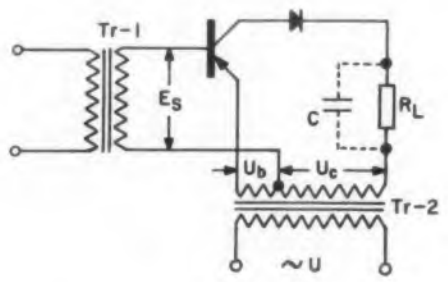

Fig. 1. Single-ended phase-sensitive circuit.

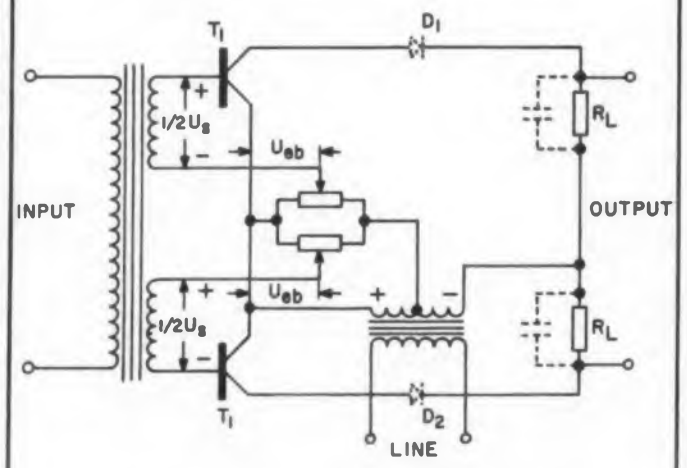

Fig. 2. Push-pull phase-sensitive circuit.

diode also reduces the gain of the circuit and the voltage drop across the load. However, at the same time it reduces, by a factor of approximately 3, the power consumed and dissipated by the transistor. This is an important consideration for high-power phase-sensitive stages.

For this circuit, the following equations hold.

- Current gain:

$$k_{idc} = \frac{k_i}{\pi}. \tag{1}$$

- Direct load current component:

$$I_L = \frac{I_b k_i}{2\pi} (\cos \phi - 1), \tag{2}$$

where ϕ varies from 0 to π.

- Effect of the phase shift on the direct load current component:

$$M = \frac{k_i \cdot I_{bm}}{2\pi} \sin \phi. \tag{3}$$

- Power gain:

$$k_p = \frac{k_i^2 \cdot R_L}{\pi \cdot R_{inf}}. \tag{4}$$

- Input resistance:

$$R_{inf} = r_b + r_e \frac{k_i}{\pi}; \tag{5}$$

since:

$$r_b \approx r_e \cdot k_i, \quad \text{and} \quad R_{inf} \approx \frac{2}{3} R_{in} \tag{6}$$

- Efficiency:

$$\eta = \frac{U_{om} - U_{ef}}{U_{om}}. \tag{7}$$

Phase-Sensitive Push-Pull Circuit

A push-pull half-wave phase-sensitive circuit, Fig. 2, is often used in phase discriminators and relay drivers. For power stages, diodes D_1 and D_2 can be added to the collector circuits. The sign of the dc voltage at the output depends

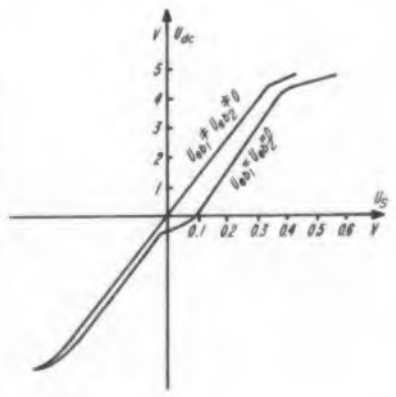

Fig. 3. Dependence of the dc load voltage of a push-pull phase sensitive circuit on the signal, for different (but constant) emitter - base voltages U_{eb}.

RUSSIAN TRANSLATIONS

upon the phase ratio of the input and supply voltages.

With the polarity of the input signal and the supply voltage as shown in Fig. 2, the direct current through transistor T_1 will be amplified, while that through the other transistor will decrease. In the absence of an input signal, the collector currents of both transistors are equal and opposite, and consequently the output voltage will be zero.

The voltage U_{eb} is used to set the initial values of the collector currents of both transistors. The absolute values of the half voltage of the signal and the voltage U_{ebm} should be related as follows:

$$\left|\frac{U_s}{2}\right| \leqslant \left|U_{ebm}\right| \tag{8}$$

Load current is given by:

$$I_L = \frac{U_{om} - U_{ef}}{\pi R_L} + \frac{I_b K_i}{2\pi}(\cos\phi - 1) \tag{8a}$$

The following equations also hold for the circuit:

When $\phi = 0$

- Dc output voltage

$$U_{dc} = I_L \cdot R_{L\mathrm{I}} - I_{L\mathrm{II}} \cdot R_{L\mathrm{II}}. \tag{9}$$

- Direct load current component

$$I_{L\mathrm{I}} = \frac{U_{cm} - U_{ef}}{\pi R_L}, \tag{10}$$

Note that usually:

$$R_{L\mathrm{I}} = R_{L\mathrm{II}} = R_L \tag{11}$$

When $\phi = \pi$

- Dc output voltage

$$U_{dc} = \frac{k_i \cdot I_{bm} \cdot R_L}{\pi}. \tag{12}$$

- Direct load current component

$$I_{L\mathrm{II}} = \frac{U_{cm} - U_{ef}}{\pi \cdot R_L} - \frac{k_i \cdot I_{bm}}{\pi},$$

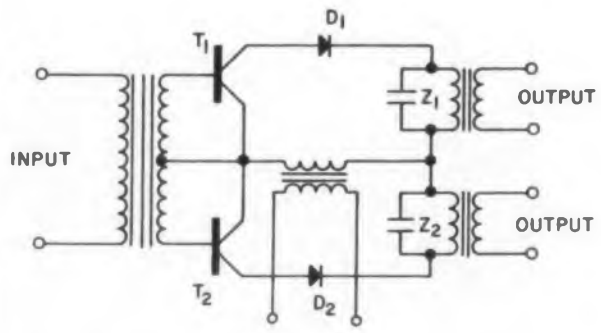

Fig. 4. Phase-sensitive circuit feeds load through twin transformers.

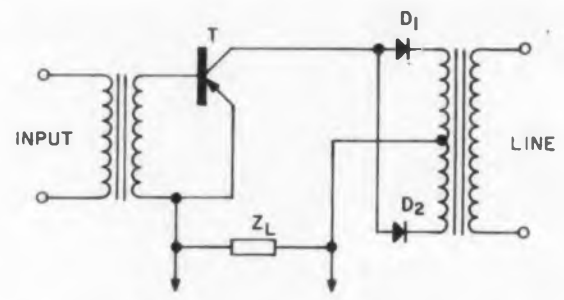

Fig. 5. Amplifier fed with pulsating current.

In addition:

- Input voltage

$$U_{cm} = I_{bm} R_{inf} \tag{13}$$

- Voltage gain

$$k_{Udc} = \frac{U_{dc}}{U_{am}} = \frac{k_i \cdot R_L}{\pi \cdot R_{inf}}. \tag{14}$$

- Input resistance

$$R_{inf} = r_b + \frac{k_i}{\pi} r_e. \tag{15}$$

The effect of the voltage U_{eb} on the character of the curve $U_{dc} = f(U_{ac})$ is seen from Fig. 3.

Phase-Sensitive Circuit With Transformer Load

Of considerable interest is the circuit shown in Fig. 4. The pulsating output voltage is transformed by the transformer circuit. Depending on the signal phase, an output voltage is produced in either of the two windings. The circuit can be used in high-power phase sensitive devices, with dc power amplifiers used in the driver stages.

Amplifier Stage Fed With Pulsating Current

The circuit of Fig. 5 is intermediate between the phase-sensitive and ordinary amplifier circuit. The combination of a transistor with two diodes is the analog of a double triode in a phase-sensitive vacuum tube circuit. At the same time, the transistor operates in class B when fed with rectified pulsating dc. The design formulas for phase-sensitive circuits are also valid for this stage.

Thus, the power gain at $\varphi = 0$ or $\varphi = \pi$ is

$$k_p = \frac{k_i^2 \cdot Z_L}{\pi \cdot Z_{in}}. \tag{16}$$

The efficiency of the stage approaches 50 per cent.

Translated from "Certain Transistorized Phase-Sensitive Devices by N. S. Nikolayenko, Leningrad Electrotechnical Institute, News of the Higher Institutions of Learning, *Instrument Bldg., No 5, 1959, pp 20-25.*

GERMAN ABSTRACTS

E. Brenner

Microwave noi

THE POSITIVE column in a self-maintained gas discharge is a source of noise that, at frequencies above 1 kmc, is superior to noise diodes. At high frequencies, the latter not only exhibit a reduction in shot noise caused by transit time effects, but they also present broadband matching problems.

The electron temperature in a gas discharge depends only slightly on the pressure-distance product $p \cdot r$, once this product exceeds a certain value, Fig. 1. The high energy content of the electron gas is, at least in part, radiated with a

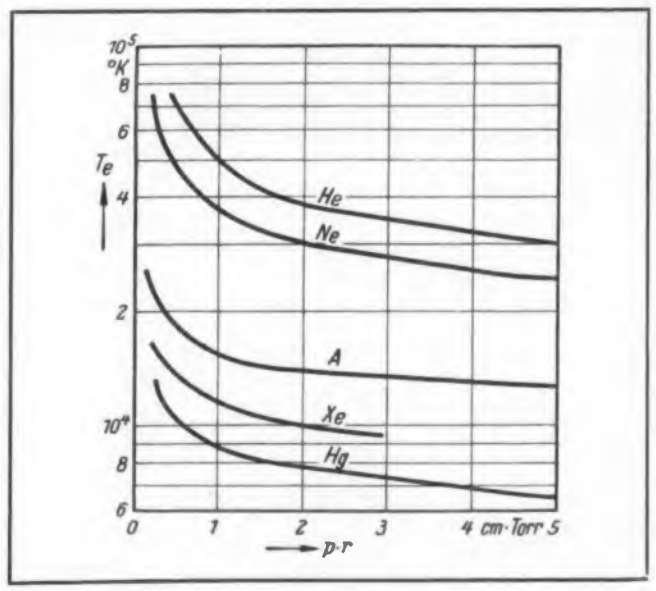

Fig. 1. Electron temperature, T_e, of various gasses as a function of discharge pressure-distance product (1 Torr = 1/760 atmosphere).

...oise Source

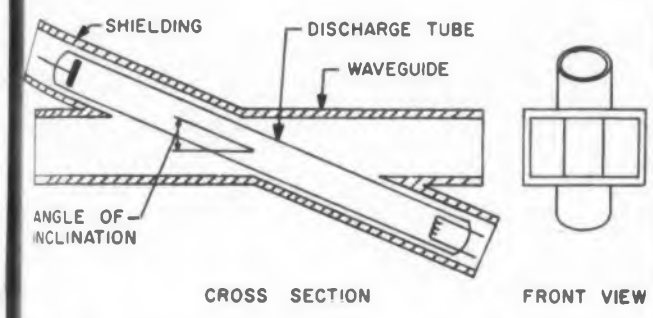

Fig. 2. Microwave noise source is placed in waveguide at angle of 5-10 deg.

continuous (white) spectrum. The noise energy obeys the general two-port noise formula

$$N = F \cdot k \cdot T \Delta f$$

with $T = T_c$ and $F = 1$.

While in general T_c depends on pressure and current, it is independent of pressure above about 0.006 atmospheres. To obtain a variable noise source, a directly-calibrated attenuator is introduced between the gas tube and the indicator. The discharge is arranged to occur with constant current.

The gas tube is introduced in a waveguide section as shown in Fig. 2. To obtain the required minimum length of positive column, as well as to aid in matching, the tube is inclined at an angle of 5-10 deg. Experience has shown that good match and high noise power considerations lead to a tube diameter that is one-third to one-fourth of the waveguide width.

Abstracted from an article by R. Saier, Frequenz, Vol. 14, No. 2, February 1960, pp 68-70.

ELECTRONIC DESIGN
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The Stable Platform: Key to Inertial Guidance

STABLE platforms are gyro instruments which provide accurate azimuth, pitch, and roll attitude information. In addition to serving as reference elements, they are used to stabilize accelerometers, star trackers, or similar devices in space.

Essentially a cluster of gyros mounted within gimbals, the gyro outputs of the stable platform control gimbals through servo loops. Different arrangements of gimbals and gyros can produce a great variety of platform types. Discussed here is the "three-gimbal, three single-degree-of-freedom gyro" type of platform. This is then compared with a four-gimbal system.

Three-Gyro Platform Controls Roll, Pitch and Yaw

Any gyroscope mounted in gimbals tries to maintain its position fixed in space. In an ideal, frictionless gimbal structure, the gyro has a fixed reference. In reality, frictional and accelerating torques cause the gyro to precess, or drift. This, in effect, disturbs its spatial reference. In devices which do not have to have extreme accuracy, such as vertical or free gyros, this drift is tolerable. However, increasing flight vehicle performance demands greater and greater accuracy. Today's desired drift rates of 0.001 degree per hour for inertial systems to 0.5 degree per hour for less sophisticated navigation systems can be achieved only with stable platforms. These are designed to use the gyro as a sensor. They control a null-seeking servo loop which provides power to generate a counter-torque to the gimbals and maintain the gyro reference fixed in space.

With auxiliary power available to drive the gimbals, a cluster composed of a number of gyros can be built. In a platform using single-degree-of-freedom gyros, three such gyros are mounted together with their input axes forming a mutually orthogonal triad. Associated with each gyro is a gimbal servo-system which maintains the corresponding gyro axis fixed in space.

The three-gyro triad is positioned so that the input axes correspond to the roll, pitch, and yaw axes of the flight vehicle. The frame to which the three gyros are mounted is itself mounted in a succession of gimbals. This frame, free to move in azimuth, is called the azimuth gimbal, and its motion is controlled by the yaw gyro. The azimuth gimbal is mounted within a gimbal called the pitch gimbal which, in turn, is mounted within a gimbal identified as the roll gimbal. Relative motion between pitch and roll gimbals is a measure of pitch motion. The roll gimbal is mounted in a case referred to as the fixed gimbal which is fastened to the airframe. The relative angle between the roll gimbal and the fixed case is a measure of roll motion.

Single-Axis Platform

For simplicity of discussion, a single-axis platform is first analyzed. Since each gyro controls a corresponding gimbal, a three-axis platform is, in effect, three single-axis platforms with coupling inputs. These coupling inputs, however, are not considered in the single-axis analysis.

Fig. 1 illustrates a typical single-axis platform with rate integrating gyros. Laplace operator notation is used. Consider a case where the single-axis platform is subjected to a torque, T_y, about the input axis Y, and a torque, T_z, about the output axis, Z. The resulting motion is described by the equations:

$$T_y = (s^2 J_y + s F_y)\,\alpha + s H$$

$$T_z = (I s^2 + D s)\,\beta - s H \alpha$$

where:

α = angular motion about input axis

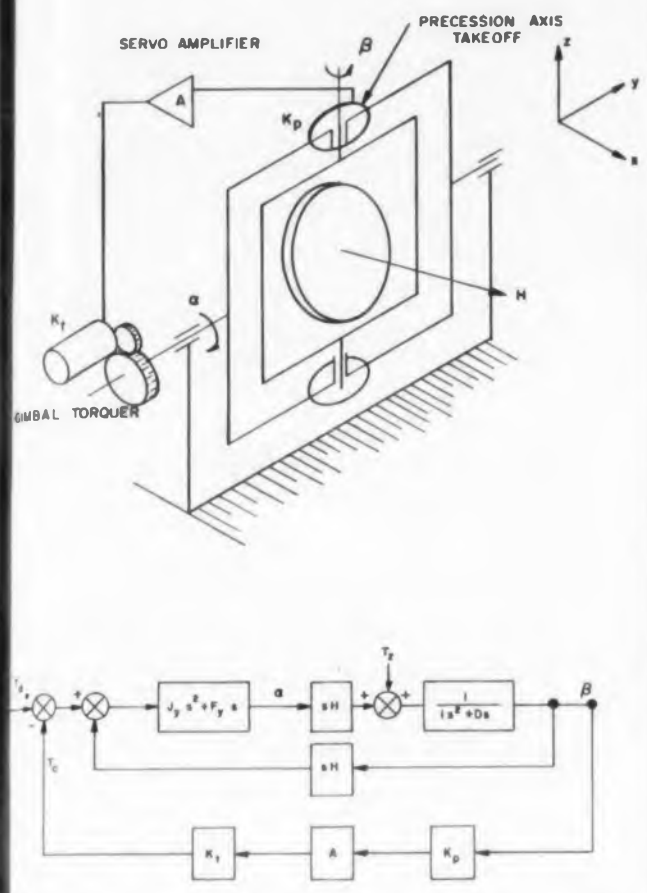


Fig. 1. Typical single axis platform with rate integrating gyros. The block diagram is used to analyze the platform motion.

β = angular motion about output axis
J_y = moment of inertia of gimbal about input axis
I = moment of inertia of gyro about output axis
D = damping coefficient of gyro about output axis
F_y = damping coefficient of gimbal about input axis
H = angular momentum of gyro rotor

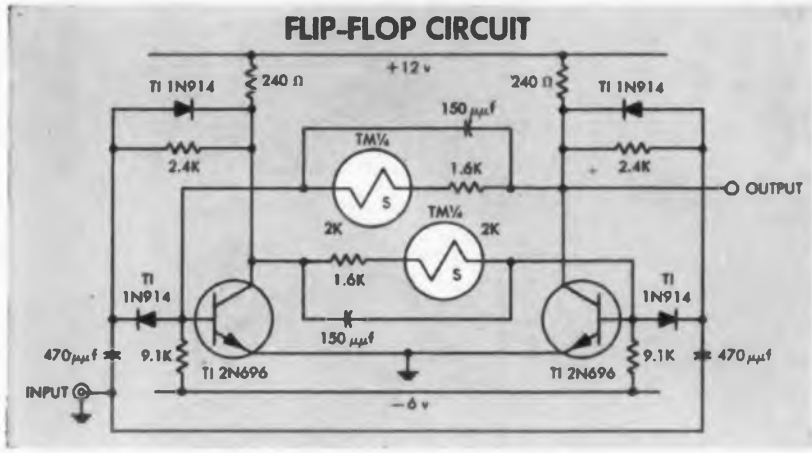
If a disturbing torque T_d is applied to the gimbal structure and to the gyro input axis, the gyro spin axis precesses about the output axis. The precession motion generates an output signal from the gyro pickoff, which is fed to an amplifier driving a gimbal torquer. The gimbal torquer produces a counter torque to the platform. The net input torque to the gimbal axis is the difference between the disturbing torque T_d and the counter torque T_c.

$$T_y = T_d - T_c$$

If the disturbing torques are removed by the servo system so that T_y becomes zero, the platform will not move about its input axis.

The gimbal servo loop is usually referred to as the alignment loop. It is subject to criteria of stability and response over a range of operating frequencies, and a typical analysis is concerned with the transfer function between the disturbing torque T_d and the input angle α, or between T_d and the gyro precession angle β. In actual prac-

How to compensate for temperature variation in a transistorized flip-flop



This flip-flop circuit, designed by Texas Instruments, uses *sensistor*® silicon resistors in the cross-coupling network to compensate for increases in h_{FE} with temperature. At 125°C, it resolves 100 mμsec input pulses arriving at a 5 mc rate whereas a fixed resistor version was limited to 3.6 mc. In addition, at +125°C the circuit will operate at a resolution rate greater than 5 mc if the input pulse can be greater than 10 volts when the pulse width is decreased from 100 mμsec.

Another advantage of *sensistor* silicon resistors in a flip-flop using high h_{FE} transistors is the reduction in input voltage required to trigger at high temperatures. For instance, the *sensistor* silicon resistor circuit requires only 10 volts to trigger whereas the fixed resistor circuit required 14 volts.

Sensistor silicon resistors are temperature-sensitive devices that feature a positive temperature coefficient of +0.7% per °C. This predictable rate of resistance change makes *sensistor* resistors ideal for temperature compensation from —50°C to +200°C at frequencies up to 250 mc.

The *sensistor* silicon resistor, developed by TI, provides circuit design engineers with a lightweight temperature compensating and sensing device. Commercially available for over two years, the devices have been used successfully for bias stabilization in a-c coupled stages and in the first stages of d-c amplifiers; and have found wide application in amplifiers, power supplies, servos, telemetry, magnetic amplifiers, computer switching, and thermometry.

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CDM¼	¼	RN65B	10 Ohm-1 Meg	500
CDM½	½	RN70B	10 Ohm-5 Meg	750
CDM 1	1	RN75B	10 Ohm-10 Meg	1000
CDM 2	2	RN80B	50 Ohm-50 Meg	2000

MIL-LINE ±1% tol

TI type number	wattage rating watts	MIL design-nation	standard resistance ranges	max. recom-mended voltage volts
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CD¼R	¼	RN10X	10 Ohm-1 Meg	500
CD½PR	½	RN15X	10 Ohm-3 Meg	650
CD½MR	½	RN20X	10 Ohm-5 Meg	750
CD½SR	½	—	50 Ohm-10 Meg	850
CD1R	1	RN25X	10 Ohm-10 Meg	1000
CD2R	2	RN30X	50 Ohm-50 Meg	2000

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CDH⅛	⅛	RN60B	10 Ohm-1 Meg	350
CDH¼	¼	RN65B	10 Ohm-1 Meg	500
CDH½P	½	—	10 Ohm-3 Meg	650
CDH½A	½	RN65B	10 Ohm-3 Meg	650
CDH½M	½	RN70B	10 Ohm-5 Meg	750
CDH½S	½	—	50 Ohm-10 Meg	850
CDH 1	1	RN75B	10 Ohm-10 Meg	1000
CDH 2	2	RN80B	50 Ohm-50 Meg	2000

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tice, compensation networks are required to assure that:

(a) Adequate gain margin is allowed for unusual gain changes.

(b) Adequate phase margin is provided to minimize torque resonance between T_e and T_d.

(c) The phase lead and gain characteristics limit the counter-torque T_c above the system natural frequency.

Three-Axis Platform

Fig. 2 shows a three-axis stable platform. Each of the three gimbal-alignment servo loops performs in the manner described for the single-axis platform. In addition, however, the three-axis platform requires an azimuth coordinate resolver. This is because the inner cluster is free to move relative to the gimbals and, as a result, gyro input axes are not aligned with their corresponding gimbal axes. The outputs of gyros sensing roll and pitch are fed to the azimuth coordinate resolver.

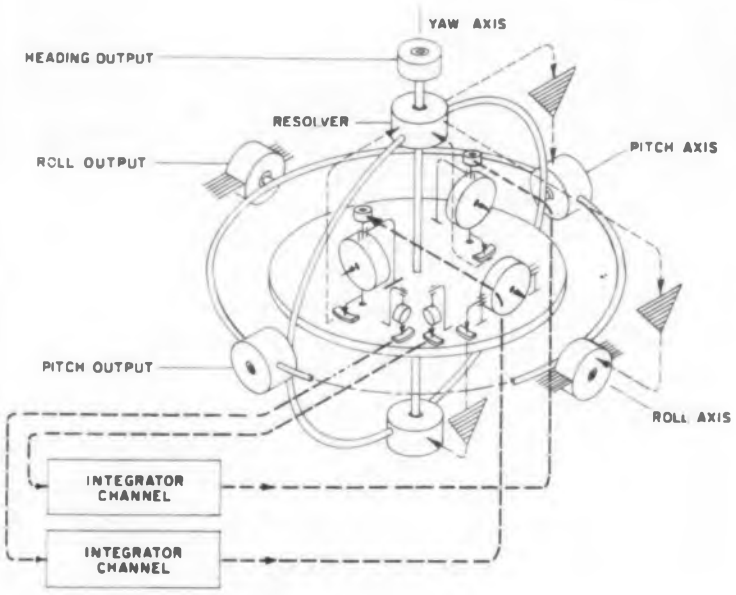


Fig. 2. Three-gimbal stable platform consists basically of three single axis systems to control roll, pitch and yaw. An additional azimuth coordinate resolver is also required.

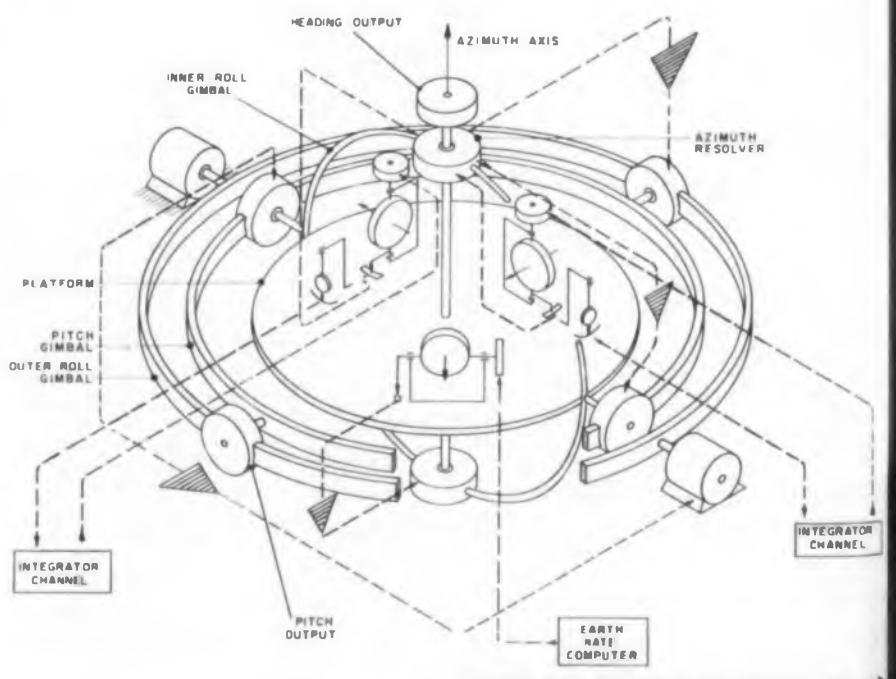
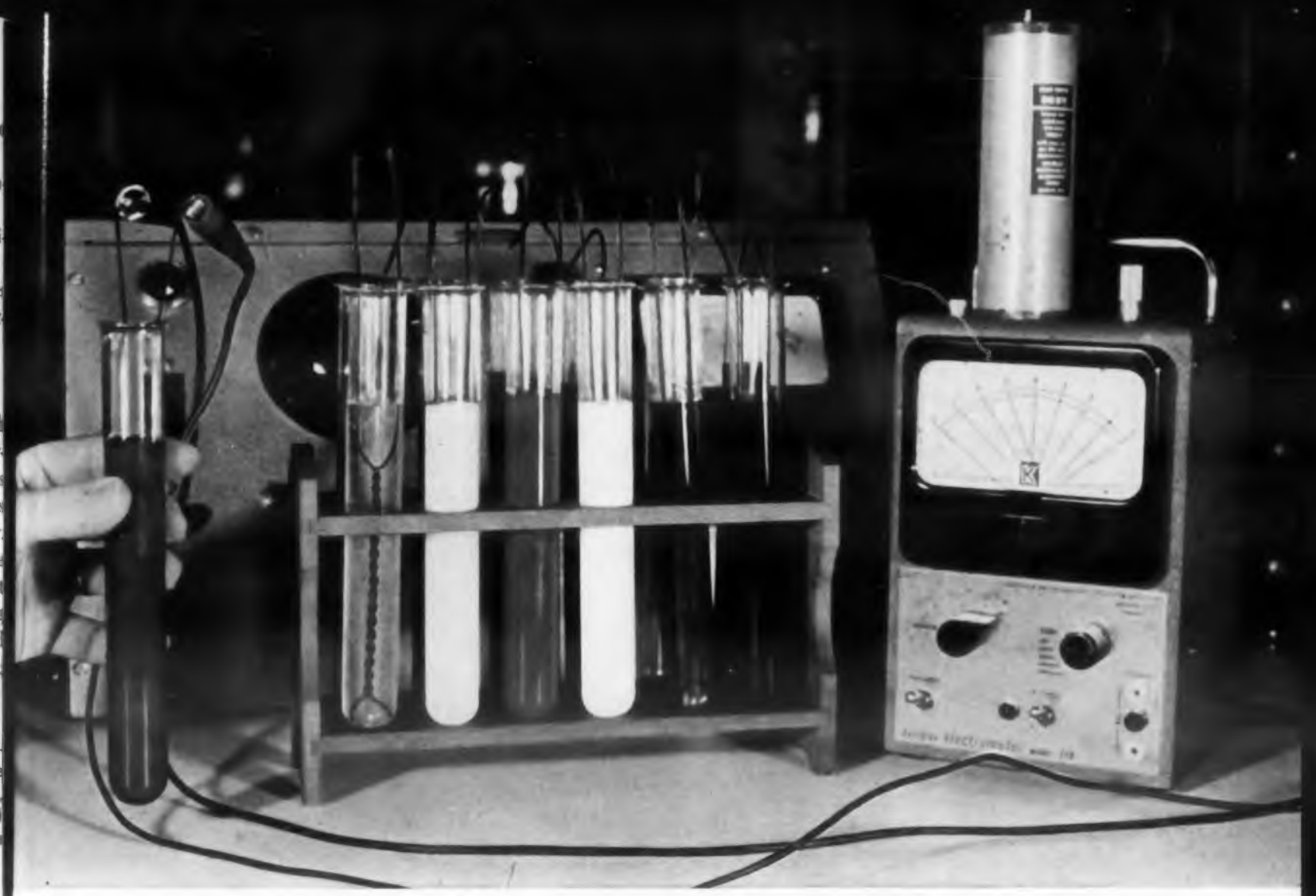


Fig. 3. Four-gimbal stable platform controls azimuth, inner roll, pitch and outer roll. Most of the burden for roll stabilization is on the outer roll gimbal.



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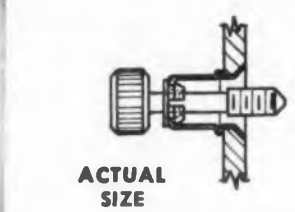

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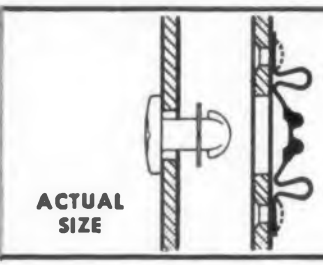

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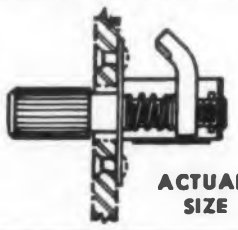

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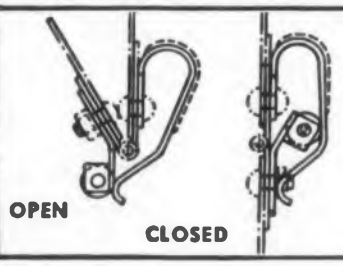

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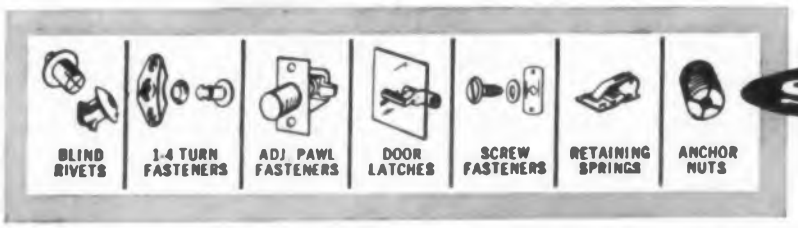

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and the output of the resolver is then fed to the gimbal alignment amplifier.

The three-axis platform analysis must consider cross coupling effects between the loops and the additional degrees of freedom represented. An extended analysis must consider effects which are products of inertia, products of angular motion, and gyro pickoff response. However, an initial analysis which considers only the gyro pickoff response usually suffices. This approach sets up the three-axis and single-axis platform equations in matrix form.

As yet, the spatial orientations that the gyros assume have not been specified. For space travel some convenient astral body could be chosen as a reference. However, the surface of the earth is still the zone of most immediate concern for navigation systems. Travel on the surface of the earth (and lower altitudes) implies a reference based on "vertical." A platform fixed in inertial space does not provide an earth's vertical although some means is required to establish this vertical with the platform. One method gimbal-mounts a vertical sensing reference on the platform, but a more convenient and common method applies correction signals to the platform. These signals torque the platform so that it maintains vertical with respect to the earth.

Schuler Pendulum

The direction of vertical on the earth's surface can be obtained by the use of a mass suspended from a fixed support point by a string. Such an arrangement also represents a pendulum. If the mass is displaced a small angle from vertical, it oscillates with a period expressed by $T = 2\pi\sqrt{l/g}$, where l is the length of the string and g is gravity acceleration. If the support point is moved from rest, the mass is deflected from vertical by an angle θ which is expressed as $\theta = \tan^{-1}a/g$, where a represents the acceleration of the support point.

Hypothetically assuming that the support string is increased to a length equal to the radius of the earth so that the suspended mass is located at the center of the earth, the support point may move in any manner on the earth's surface. Therefore, the supporting string remains vertical regardless of accelerations to which the support may be subjected.

In effect, a simple undamped pendulum has been created with a period $T = 2\pi\sqrt{L/g}$, in which L is equal to the radius of the earth. The period for an earth's-radius pendulum is 84.4 min. Such a device is called a Schuler pendulum, named for its discoverer, Max Schuler.

A mechanical compound pendulum having the same period and properties as the simple 84-min pendulum has insurmountable design limitations. However, an analogous system using accelerome-

DIGEST

ters can be made to behave in the same manner as a Schuler pendulum.

When the system is disturbed by an input acceleration, the error oscillation of the position output will have a period of 84.4 minutes just as in the case in which the mass of the Schuler pendulum is displaced from vertical.

Schuler Pendulum Analog Maintains Vertical Reference

A Schuler-tuned platform system refers to a stable platform whose accelerometers are used in a loop which is an analog of the Schuler Pendulum. This loop includes a gyro precession axis torquer. Since the Schuler pendulum maintains an accurate vertical reference, it can be used to generate correction signals to tilt the gyro spin axes to a vertically referenced plane rather than its inertial space reference. The accelerometer output is proportional to aircraft acceleration. If this acceleration signal is integrated with respect to time, it represents the instantaneous velocity of the aircraft. Dividing this velocity by the earth's radius (Schuler-tuned) gives the angular velocity at which the platform must rotate to remain tangent to the earth's surface. The Schuler-tuned signal is applied to the gyro precession torquer which is properly scaled to indicate the required angular velocity.

Since the value of an oscillating reference may be questioned, system designs use auxiliary signals to provide damping. Effective damping may be provided by data available from air-speed measurements, doppler radar, or acceleration signals.

Having established a means of maintaining vertical, initial erection of the platform remains to be accomplished. Since gravity is an acceleration, common practice uses the accelerometer as a vertical reference. Its output is fed to a gyro precession torquer which actuates the gimbal alignment loop. The gimbals drive until the accelerometer output is at null, indicating vertical. In those cases where accelerometers are not required, vertical erection may be achieved by pendulous reference devices or mercury or electrolytic switches.

The Four-Gimbal System

The four-gimbal system, Fig. 3, is similar to the three-gimbal system previously described. The difference lies in the gimbal sequence and in the type of control associated with the addition of the fourth or redundant roll gimbal. The four-gimbal sequence is azimuth, inner roll, pitch, and outer roll. The outer roll gimbal receives its control signal from a pick-off mounted between the inner roll and pitch gimbals. This pick-off maintains perpendicularity between the inner roll and pitch gimbals. A gyro signal to control the outer

roll gimbal is not necessary. As a result, roll motions of an aircraft produce only low level platform disturbances. The outer roll gimbal servo bears most of the burden for roll stabilization.

Three-Gimbal vs Four-Gimbal Systems

The advantages and disadvantages of the three- and four-gimbal systems are briefly summarized below.

Three-Gimbal System

Advantages:

- Smaller size and weight
- Lower cost

Disadvantages:

- Limited maneuverability of aircraft
- Lower system accuracy
- Higher susceptibility to vibration

Four-Gimbal System

Advantages:

- Unlimited maneuverability of aircraft
- Magnitude of inner roll gimbal deflections are small (on the order of control signal level)
- Reduction of platform drift due to torque rectification
- Attenuation gyro non-linearities effects
- High system stability

Disadvantages:

- Greater size and weight due to extra gimbal
- Greater complexity due to additional servo
- Higher over-all cost

Aircraft Maneuverability

Three-Gimbal System

The use of only three gimbals poses a problem when the pitch angle approaches 90 deg. In this instance, the azimuth and roll axes coincide, and one degree of freedom is inadvertently lost (gimbal lock). For this reason, it is necessary to limit the pitch of the aircraft to ±85 deg for a three-gimbal system.

Four-Gimbal System

The four-gimbal stable platform has 360 deg of freedom about the roll, pitch and azimuth axes. This freedom of motion is maintained even when the aircraft pitches 90 deg and the redundant outer roll gimbal is inactivated by coincidence with the azimuth axis. Through the use of an output synchro on the inner-roll gimbal, roll stabilization is maintained by slaving the redundant outer roll gimbal to maintain the pitch and inner-roll gimbals orthogonal. In effect the three-gimbal platform has been roll-stabilized. Thus unlimited aircraft maneuvers can be programed, since the four-gimbal platform does not suffer from limitations due to gimbal axis orientation.

Reduction of Platform Drift Due to Torque Rectification

Drift rate of a gyroscopic stable element is af-

fected by aircraft vibration. Vibration, a cyclic disturbance, is particularly detrimental when the subsequent gyro displacements are relatively large. This phenomenon is ascribed to torque rectification, which occurs when positive and negative portions of the undulating disturbances are not averaged out, but instead rectified. Resulting biased torque causes the gyros to drift at an appreciable rate, degrading system performance.

Three-Gimbal System

Torque rectifying characteristics of a three-gimbal system become evident in the presence of yaw oscillation when the aircraft is pitched. In this case, angular oscillation causes the roll gimbal to cycle, requiring the gimbal torquer to provide the motivation. Reaction torque, felt by the platform cluster, produces an undulating precession. During these undulations, a minute component of the momentum vector lies in the plane of the roll gimbal, providing the necessary conditions for a vector product. The sense of the vector product (the uncompensated torque on the gyro) remains unchanged because the projection of the momentum vector and the axis of roll oscillation are in phase. Thus the disturbance, oscillatory in nature, is rectified, and a unilateral gyro drift is, in essence, produced.

Four-Gimbal System

The four-gimbal system is relatively unaffected by torque rectification because the necessary outer roll gimbal signal is generated by the non-orthogonality of the inner roll and pitch gimbals. Since the orientation of these two gimbals, and not that of the gyros, is involved, gyro excursions are small. Consequently, platform drift due to torque rectification is minimized.

Effects Resulting From Gyro Non-Linearities

Three-Gimbal System

Gyro non-linearities are a product of large gyro displacements, and they decrease long-range platform reference stability. Direction as well as velocity of gyro excursions significantly affect the gyro damping constant. Since the magnitude of gyro drift is a function of the amplitude of gyro excursions, the latter must be limited to low levels.

Four-Gimbal System

The effects of rectification are minimized because gyro excursions are small. This lessening occurs because the method of control associated with the outer roll gimbal involves a variation in the orthogonality of the inner roll and pitch gimbals, instead of a gyro displacement. As a result, roll stabilization is accomplished at the expense of gimbal, rather than gyro, orientation. Since external disturbances are predominantly evident along the roll axis, the fourth gimbal offers a dis-

cernible degree of platform isolation, minimizing the gyro drift.

System Servo Stability

During aircraft motions involving large pitch angles, the gimbal roll axis (which is parallel to the aircraft roll axis) assumes an angle with respect to the stable cluster. Under this condition, the gimbal roll axis is not parallel to the plane containing the input axes of the vertical gyros. The respective gyros perceive a component of roll, while the system is required to displace the appropriate gimbals by an amount equal to the full value of roll. This is accomplished by multiplying the gain of the roll servo by the reciprocal of the cosine of the pitch angle.

Three-Gimbal System

Over-all stability of the roll servo is a function of the open loop gain and the gyro damping feedback torque. For a three-gimbal system, both the open loop gain of the roll axis and the gyro damping feedback torque vary as the cosine of the pitch angle. The value of the cosine function is small at high pitch angles. Hence the gain and damping are also small, and it is evident that a "cone of instability" exists.

Four-Gimbal System

Various applications that do not evolve the secant expander and the variable gain associated with it are available in four-gimbal systems. Thus, the variable gain required by changing geometric orientation of the pitch gimbal is a problem that is easily resolved by a four-gimbal system. Improved system stability and extended frequency response result.

Summary

In applications which do not require a high degree of maneuverability and precision, a three-gimbal stable element provides the advantages of low cost, low weight, compactness, and simplicity.

The four-gimbal platform is recommended when high accuracy and utmost reliability are essential requirements for an intertial platform. Although it is larger in size and weight and more complex than a three-gimbal stable element, the four-gimbal arrangement provides the advantages of unlimited maneuverability, system stability, and the lowest drift rate obtainable.

Digested from "The Stable Platform," a chapter in the recently published handbook Technical Information for the Engineer—Gyros *by Bernard Lichtenstein of the Kearfott Corp. Other sections in the handbook deal with gyroscope theory, drift errors, vertical, free, rate, and rate integrating gyros, and precision accelerometers. Free copies can be obtained by writing on company letterhead to Dept. 9-9600, Kearfott Div., General Precision, Inc., Little Falls, N.J.*

Cost, Failure Time Dictate Unit Size In Reliability Test

WHAT IS the best unit of equipment—or sub-system—for reliability testing?

This report considers a system composed of two sub-assemblies, X and Y. One of the sub-units, X, can be marketed on its own, and requires reliability data as an individual piece. When considered alone, or apart from the entire system, the X unit will be denoted by Z.

The question is: Should the reliability test be carried out on Z and the XY combination, or should the tests be made on Z and X and Y separately (with Z and X considered interchangeable)?

Reliability Test Would Consist Of Running Unit for *t* Hours

In practice, the reliability test would consist of running the unit for t hours, without failure or a drop in top performance. The probability of successful operation for t hours is:

$$P = e^{-\frac{t}{\mu}}$$

where μ is the actual Mean Time Between Failure (MTBF) of the system. Therefore the cost of a successful test would be:

$$I(a) = e^{-\frac{t}{\mu}} C_t$$

where C is the cost per hour of testing. Letting a be t/μ,

$$I(a) = e^{-a} C a \mu$$

The probability of unsuccessful operation for the t hour test is:

$$P' = (1 - e^{-\alpha})$$

Therefore, if D is the totality of costs associated with, and incurred by, unsuccessful operation, the cost of an unsuccessful reliability run of t hours is:

$$I(b) = (1 - e^{-\alpha})D$$

The cost D is interpreted to include the delay in shipment from the production line when unreliability is discovered and until reliability is restored.

Probability of Unsuccessful Test Considered in Computing Cost

Therefore, the probable cost of testing Z and the XY combination is the sum of the probable costs of successful and unsuccessful operation of Z and the XY combination:

$$I = e^{-\alpha} C_Z \alpha\mu_Z + (1 - e^{-\alpha}) D_Z + e^{-\alpha} C_{XY} \alpha\mu_{XY} + (1 - e^{-\alpha}) D_{XY}$$

If the alternative method of testing were considered—combining Z and X data because Z and X are interchangeable and treating Y as a separate unit—test data become available more rapidly producing lower C values. However, D values would increase because a failure in Z would delay both Z and X (and hence XY) shipments. The cost equation for this alternative case is:

$$I' = e^{-\alpha}(1-s) C_Z \alpha (\mu_Z - \mu_{XY}) + 0.5 (1-e^{-\alpha(1-s)}) (D_Z + D_{XY}) + 0.5 (1-e^{-\alpha s}) (D_Z + D_{XY}) + e^{-\alpha(1-s)} C_{XY} \mu_{XY} + (1-e^{-\alpha(1-s)}) D_{XY}$$

where the subscripts denote the equipment unit to which the quantity applies and s is the ratio μ_{XY}/μ_Z.

Testing X and Y Separately is Better When MTBF's are Low

For the testing alternatives considered, the following conclusions were drawn. Testing the X and Y portions of XY separately and regarding X and Z as interchangeable is the better method when:

1) XY, Y and Z MTBF's are low.
2) The MTBF's are nearly equal.
3) Testing time is kept to a minimum.
4) Delay costs are nearly equal.

Testing XY as a combined unit is preferable if it is necessary to test to a high confidence or when there is a significant disparity between delay costs for the two methods.

Digested from Balancing Equations for Mode Selection in Reliability Analysis, *by Leonard Janofsky. Delivered to Operations Research Society of America, May 19, 1960.*

REPORT BRIEFS

RFI-Filters

A description is given of ratio interference filter F-312(XW-1)/G as delivered on contract AF30(635)2908. The filter is a development model of a capacitor storage signal integrator designed for use in direction finding equipment. Designed as a replacement for other more cumbersome equipment, it is an effective means of improving the signal-to-noise ratio to the point where a usable output is obtained when the input signal-to-noise ratio is 0.066. Certain recommendations are made for further improvement and reduction in the input power requirements. *Radio Interference Filter F-312(XW-1)/G, Andersen Laboratories, Inc., West Hartford, Conn., Feb. 15, 1957, 22 pp, Microfilm $2.70, Photocopy $4.80. Order PB 145439 from Library of Congress, Washington 25, D.C.*

Reliability

Outlined is the basic program required to develop reliability prediction techniques, to standardize reliability terminology, and to provide a tentative prediction technique for verification experiments on existing systems. Application to new systems now in the system-planning stage is also discussed. Prepared early in the course of the overall program, this report is somewhat speculative in nature. However, it describes the frame of reference within which the investigation is being undertaken. *Investigation of Electronic Equipment Reliability, Progress Report No. 1 on Air Force Reliability Assurance Program, Aeronautical Radio, Inc., Washington, D.C., Feb. 15, 1956, 107 pp, Microfilm $5.70, Photocopy $16.80. Order PB 145919 from Library of Congress, Washington 25, D. C.*

Equipment Cooling

Results of a study of cooling systems for electronic equipment for vehicles operating at velocities of mach 8.0 to 20.0 at altitudes from 80,000 to 200,000 ft. Included are problems of ballistic and glide re-entry, but not of space and orbital flight and sustained-power aerodynamic flight. Comparisons are presented of expendable heat sink materials, pressurization gases, heat transport fluids and several simplified cooling systems. The effect on system weight of such things as compartment insulation, electric load, leakage, flight time, equipment operating temperature and ground operations are shown. A system using water as the heat sink, water on liquid ammonia

as the transport fluid and vaporized ammonia for pressurization was the lightest system of those analyzed. *Study of Equipment Cooling Systems, Fred E. Schroeder, Edward E. Towe et al., Boeing Airplane Co., Seattle, Wash., Nov. 1959, 173 pp, $3.00. Order PB 161484 from OTS, Washington 25, D.C.*

PCM Timing

The underlying principle of the PCM timing system is pulse transmission of data; precise timing and control functions are derived by digital techniques and sent to test-range instrument sites via a 9-channel pulse-code-modulated uhf radio link. This report, one of a series on the entire timing system, is an introduction to the system as a whole. *The NOTS PCM Timing System: An Over-All Description, J. B. Moffett, Naval Ordnance Test Station, China Lake, Calif., Aug. 1959, 67 pp, Microfilm $3.90, Photocopy $10.80. Order PB 145382 from Library of Congress, Washington 25, D.C.*

RFI—Spurious Emissions

The mechanism for generating unwanted signals in high power microwave tubes was studied qualitatively. Several techniques for suppression of these signals are reported. These are by: (1) modulator design, (2) drive signal filtering, (3) undesired signal monitoring, (4) mode suppression and integral filtering, and (5) improved tube design. A cold-test model integral filter tube was made, and the incorporation of a harmonic filter in the vacuum envelope was found to be feasible. *Measurement and Control of Harmonic and Spurious Microwave Energy, Gabriel Novick and Vernon G. Price, General Electric Microwave Laboratory, Palo Alto, Calif., May 1959, 86 pp, Microfilm $4.80, Photocopy $13.80. Order PB 145604 from Library of Congress, Washington 25, D.C.*

Thin Magnetic Films

Magnetic properties of thin Permalloy films and also MnBi films having their easy-magnetization axis perpendicular to the plane of the film were investigated. The engineering parameters of importance for high-speed memory applications are defined. Several appendices are devoted to instrumentation that has been found useful in magnetic-film research. *The Magnetic Properties of Thin Films, J. B. Goodenough and D. O. Smith, Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass., Jan. 1959, 42 pp, Microfilm $3.30, Photocopy $7.80. Order PB 146498 from Library of Congress, Washington 25, D.C.*

STANDARDS
AND
SPECS

MIL-STD-704 Helps Designers Achieve More Performance, Reliability In Airborne Equipment

Oscar Markowitz

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PROPER APPLICATION of MIL-STD-704, "Characteristics and Utilization Of Aircraft Electric Power" (6 October 1959), will help designers achieve better performance and increased reliability in electronic equipment destined for airborne use. It contains many new facets never specified previously by the Services.

MIL-STD-704, currently released by the Government Printing Office, is an extensive revision and modernization of MIL-E-7894A, "Electric Power, Aircraft Characteristics Of". MIL-E-7894A was a limited-coordinated specification between the U. S. Navy and Air Force; MIL-STD-704 is a fully coordinated standard, binding on all Services. During its period of coordination, MIL-STD-704 has been used as a guide for the more sophisticated systems and a guide for missile, 400-cps power.

Background and Philosophy of MIL-STD-704

With increasing sophistication of airborne electronics, it has become clear that aircraft electric power cannot be subservient and accede to all the demands imposed by power utilization equipment. Power characteristic demands of utilization equipment vary so widely from each other, but are so narrow in themselves that many conflicts arise with many utilization equipments drawing power from the same source. It is an engineering impossibility to obtain a perfect electric power source, that is:

a. All characteristics are fixed parameters (for example: frequency, voltage) with no measurable variations,

b. There are no losses from distribution of power and protection of power source, and

c. The utilization load condition will not reflect a change of any power system characteristic.

The imperfections are considered in MIL-STD-704; it defines the electric system characteristics, delineates limits of variations and, in turn, restricts the use of aircraft electric power so that the characteristics are not altered beyond their defined limits.

MIL-STD-704 implements the weapons concept by considering the aircraft as a complete functioning unit; it considers each power characteristic as a distinct design influence on utilization equipment. An electric system characteristic is often subdivided to segregate differences of design influence on the utilization equipment, although the over-all electric system characteristic would be adequate in terms of defining electric power.

MIL-E-7894 was originally developed to end controversy between aircraft electric system designers and utilization equipment designers. Power system designers tried to maintain wide limits, while the utilization equipment designers tried to narrow the same limits. Thus, a specification was required to step between and define the characteristics of electric power at the terminals of the utilization equipment—at the point where the power system stops and utilization equipment begins. From such a specification the electric power designer will know what power characteristics he must supply before any knowledge of the connected load; and the utilization equipment designer will know what power he must use before any knowledge of the actual power source (each knowing his responsibilities in his areas). This concept is described in MIL-STD-704 as quoted below:

1.1 *Scope*—This standard delineates the characteristics of electric power to be supplied to airborne equipment at the equipment terminals and the requirements for the utilization of such electric power by the airborne equipment.

1.2 *Purpose*—The purpose of this standard is to foster compatibility between aircraft electric system and airborne utilization equipment to the extent of confining the aircraft electric power characteristics within definitive limits and restricting the requirements imposed on the electric power by the airborne utilization equipment.

Spec Helps Make Aircraft Integrated Weapon

Aircraft electric power equipments are developed without any knowledge of the actual aircraft loads that will be seen in service. The power system developments have lead times between one-half to three years. Utilization equipments are developed with one to five years of lead time. Utilization equipment designers seldom know in advance what electric systems will be used with their equipments. In such situations a common denominator is sorely needed; it is MIL-STD-704. Thus this spec is an essential key in coordinating electric power with utilization equipment and helping to make the aircraft an integrated weapon.

Increasing sophistication of utilization equipment is becoming more demanding on electric systems characteristics. Different utilization equipment within one aircraft often demand different limits within a characteristic in conflict with each other, creating a situation impossible for any given electric system to meet. MIL-STD-704 attempts to resolve these differences with distinct and bold limits that avoid the conflicting aspects at an early enough design stage so that only minimum penalties are absorbed by the equipments involved.

Developers of MIL-STD-704 balanced the special requirements of sophisticated airborne electronics equipments against "state of art" in airborne power. Setting the defined MIL-STD-704 limits to meet all the electronics special require-

ments would put all the weight penalty on the power system while being impossible in terms of "state of art."

It was realized that no specification or standard could be made to include all aircraft utilization equipments and electric systems. If MIL-STD-704 had been written to allow every requirement such breadth and tolerance that all electric systems could conform, then there would be no usefulness remaining as a control. All penalties would have to be built into the utilization equipment to make the over-all situation compatible. Each characteristic was weighed independently in terms of a compromise most economical to the over-all aircraft.

No compromise could be made completely satisfactory to those responsible for electric power system design and those responsible for utilization equipment design. The Services, thus, anticipate pressures from "both sides of the fence" for changes. When arguments become sufficiently potent in an individual application a deviation may be allowed by the cognizant Service for that particular case. Constant monitoring is anticipated by the Services to provide sufficient surveillance of "state of art," actual conformance to MIL-STD-704, and approved or disallowed "deviations." These surveillance experiences will provide the basis for future revisions.

Because each additional pound of equipment in a new design aircraft adds seven pounds of weight to the aircraft, minimum-weight accessory equipment are essential for the aircraft to achieve maximum range, pay load, and speed. The obvious complex between minimum weight and maximum accessory performance or reliability must be continuously explored and resolved.

Studies were made to find the common denominators for aircraft. It was considered that inclusive allowance of extremes would penalize every aircraft for the extremes of few aircraft. Each extreme was studied for validity as a factor toward the common denominators. As a result, basic decisions and assumptions were made to define the boundaries to remain consistent throughout the standard. Exclusions because of the assumptions are the rare situation that will require independent consideration and approval from the Services. For a fuller understanding and easier interpretation of MIL-STD-704, the following assumptions and decisions are discussed:

Twelve of Spec's Assumptions Discussed

1. Characteristics of the aircraft electric power system are not summations of all the extremes of characteristics obtained from qualification requirements of the individual component parts that make up the electric power system. Such a

STANDARD AND SPECS

summation would be unrealistic in terms of actual aircraft operation and force excessive penalties on all aircraft utilization equipments.

2. The characteristics of the electric power systems do not consider a source smaller than 1,500 va, ac, or 50 amp dc. The steady-state voltage limits and transient limits are much wider in these low-capacity power sources. Primary dc power sources of less than 50-amp capacity are relatively rare in military aircraft. There are a few applications of transformer-rectifiers (T-R) having capacities under 50 amp dc. These T-R systems should be evaluated carefully to determine characteristics when providing power to the actual equipment. There are quite a few inverters used in military aircraft for instrument systems of capacity less than 1,500 va. These inverters were excluded because they cannot provide regulation or phase balance within limits reasonable for primary ac power systems. With increasing instruments loads for the latest aircraft and primary electric power system redundancy for reliability, the low-power inverter for instruments can become rare.

3. Electric power systems will be rated from discrete capacities such as 1.5, 2.5, 10, 20, 30, 40, 60, 90, and 120 kva; or 50, 100, 200, 300, and 400 amp. This assumption was made to eliminate the cases where special required characteristics are obtained such as up-rating a generator, while other characteristics cannot be maintained at the new rating. There are many interdependent characteristics within a generating system. With generating equipment qualified for the discrete rating, over-all characteristics can be maintained only when used within the discrete rating.

4. Initial warm-up of the electric power system (first 5 min) is not included with other aircraft operations such as take-off, climb, cruise, combat, or landing operations. Limits for steady-state voltage can be narrowed considerably, if warm-up is not included. This is a valid assumption that most utilization equipments will be warming up during the electric power system warm-up period, and their maximum performance will not be required.

5. No electric generating system characteristic is included unless it is usual and normal for the generating system to be tied to the power distribution bus at the time the characteristic becomes evident. There are certain operations (such as reset after a fault) that cause the characteristics to go to extremes. Since the generating system is disconnected from the power distributing bus, these extremes are never seen by utilization equipment.

6. The electric power systems include hydraulic constant-speed drives (CSD), air turbine CSD, mechanical CSD, turboprop direct-driven gener-

ator, piston-engine direct-driven generators, inverters, transformer-rectifiers, and batteries supported by generators. This group provides the "state of art" 115/200-v ac, 3-phase, and 28-v dc systems, including conversion devices. Batteries alone are considered as power sources only for emergency conditions. During other aircraft operations, batteries are normally "floated" across the dc generator power system.

7. Normal steady-state loading of an aircraft electric system is between 15 and 85 per cent of the power system basic rated capacity and will be from 30 to 85 per cent for cruise-combat conditions. Electric systems are seldom operated at 100 per cent rated capacity for these reasons: (1) Basic design of the electric system allows for a growth factor; (2) Actual operational conditions often force significant derating of the generator; (3) Paralleled generators have derating factors applied. In application, it is rare to have 100 per cent of the possible load simultaneously applied, yet the generator rating is selected on the basis of 100 per cent possible load.

8. Balance of loads in 3-phase ac electric systems is within 15 per cent, i.e., no phase (line-to-neutral) is loaded so that the volt-ampere difference between phases is more than 15 per cent of one-third the electric power system basic rated capacity. Generators are qualified to unbalance conditions of 33 per cent of the one-phase rated load. The 33 per cent unbalance is rarely encountered in actual aircraft. Certain steady-state limits are narrowed for qualified generators, with smaller unbalance usual for aircraft operation.

9. Electric power system power factor during aircraft flight will be greater than 0.85. Ac generators are qualified to a 0.75 power factor. Since total aircraft loads normally create power factors greater than 0.85, certain electric power system characteristics can be narrowed.

10. Any device or devices, placed between the electric power system and the utilization equipment to modify the characteristics of the power, are not considered a part of the electric power system but are considered part of the utilization equipment systems. This assumption takes care of the many types of line regulators and filters designed to improve the basic MIL-STD-704 characteristics, such as steady-state voltage, balance, wave form, which remain part of the utilization equipment.

11. Loads on the ac system are required to be three-phase loads except for very small loads. The power distribution enonomies of three-phase systems are best achieved with balanced three-phase loads.

12. There will be exceptions to MIL-STD-704 for airborne applications. These exceptions are to be analyzed individually and be approved on their merits by the procuring activity. ■ ■

YOUR CAREER

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Below are courses and seminars intended to provide the engineer with a better knowledge of various specialties. Our grouping includes several different types of meetings: National Courses—those held on consecutive days and intended to draw attendees from all geographical areas; One-Day Seminars—one-day intensive seminars which move from city to city; and Regional Lectures—regional symposia or lecture series which generally run one night a week for several weeks.

National Courses

Packaging, Plant Layout and Material Handling, Sept. 25-30, University of California

A course in packaging, plant layout and material handling, presented by the Department of Engineering and Engineering Extension, University of California, Los Angeles, Calif., will be given Sept. 25 through 30 at the University of California Conference Center, Lake Arrowhead, Calif.

Lectures during the morning and early afternoon will present current thinking and solutions to the general problems encountered in the average industrial plant. Evening workshops and problem sessions will consider individual problems with the emphasis placed on back-home applications. The late afternoons have been left open in order to provide ample time for informal exchange of ideas and discussion of problems.

The short course is designed for middle and operating management and executives charged with the responsibility for initiating industrial packaging, material handling and plant layout programs (military and commercial).

To ensure full opportunity for individual participation, the total number of students accepted will be limited. Enrollments will be accepted in the order in which they were received. Registration may be made by individuals or by companies. The fee for the course, including room and board, is $215.

For further information write Engineering Extension, Room 6266, Engineering Bldg., Unit 11, University of California, Los Angeles 24, Calif.

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Home Address _____ *City* _____ *Zone* _____ *State* _____

Date of Birth _____ *Place of Birth* _____ *Citizenship* _____

Position Desired _____

Educational History

College	*Dates*	*Degree*	*Major*	*Honors*

Recent Special Training _____

Employment History

Company	*City and State*	*Dates*	*Title*	*Engineering Specialty*

Outstanding Engineering and Administrative Experience _____

Professional Societies _____

Published Articles _____

Minimum Salary Requirements (Optional) _____

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Circle Career Inquiry numbers of companies that interest you

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925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949

CAREER COURSES

National Courses *(cont.)*

tem engineering symposium and exhibit sponsored by the Texas Div. of Collins Radio Co. is currently being conducted on a nationwide tour.

Purpose of the symposium is to acquaint management and communication personnel in governmental and industrial circles, with the engineering parameter and application techniques of microwave and carrier equipment.

The exhibit to accompany the symposium will include two terminals of operating microwave and carrier equipment.

Cities and dates of appearance include: Washington, D.C., Sept. 12-16; Chicago, Ill., Sept. 26-30; Omaha, Neb., Oct. 10-14; Atlanta, Ga., Oct. 24-28; New York, N.Y., Nov. 7-11 and Minneapolis, Minn., Nov. 21-25; Denver, Colo., Nov. 28-Dec. 2; Seattle, Wash., Dec. 12-18; Helena, Mont., Jan. 9-13; Portland, Ore., Jan. 23-27; San Francisco, Calif., Feb. 6-10; Los Angeles, Calif., Feb. 20-24; Albuquerque, N.M., March 6-10; New Orleans, La., March 20-24; Jacksonville, Fla., April 3-7 and Charlotte, N.C., April 17-21.

Regional Courses

1960-61 Evening Design Course

The 1961 Evening Design Course of the Design Division of the Institute of Contemporary Art in Boston aims to consider problems brought about by a wider sharing of the design decision. An evening session is planned, to begin early in October, 1960 to cover the new developments in design production and distribution. The design contributions of the non-designer, and the non-design contributions of the designer will be examined in order to relate the designer effectively to his associates in industry and commerce.

The course will be held Wednesday evenings at the Boston Architectural Center, 16 Somerset St., Boston, subject to the latter's being available. The course is planned in three sections covering a total of 16 weekly meetings. The last eight weeks will be a workshop series in which the application of the content of the first eight weeks will take place.

Fees for the course will be $60 for each eight-week session, or a combined fee of $110 for the full program. A $15 deposit is required to reserve your place in the course. For further information write: John J. McHugh, Education Director, Design Div., Institute of Contemporary Art, Soldiers Field Road, Boston 34, Mass.

HALLENGING OPPORTUNITIES
N FLIGHT CONTROLS WITH
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analytical, systems, components engineers

Honeywell introduced the first successful electronic autopilot in 1941—the C-1 of World War II. Since, we have produced more flight control systems than any other company and have developed concepts in flight controls that are now standard in this field. Today, most top aircraft and missiles are equipped with Honeywell flight controls. Honeywell's Flight Control Systems Group has expanded steadily and now has openings for the following:

NALYTICAL ENGINEERS–must be capable of simulating (mathematically on paper or computers) characteristics and problems in missiles and aircraft control, stability, and control systems. Should have good math backgrounds with analog computer experience.

YSTEMS ENGINEERS–should be capable of interpreting analytical results into navigation, guidance, or flight control systems. Should be electrical engineers experienced in systems—ideally, with experience in flight control in the aviation industry.

OMPONENTS ENGINEERS–should be electronics men with emphasis on transistor circuitry. Will be responsible for designing components which go into the system. Must have circuitry design experience.

o discuss these or other openings, write Mr. James H. Burg, Dept. 820, Aeronautical Division, 1433 Stinson Blvd., Minneapolis 13, Minn.

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CIRCLE 906 ON CAREER INQUIRY FORM ➤

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Because this can be mighty important to an engineer and his family, we've developed a completely new technique that should be as enjoyable as it is helpful to you—*technical quizzes* on Radar, Microwave, Communications, Packaging... and, for those interested in Engineering Administration, a special psychological questionnaire.

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Simply check off any 2 subjects on the coupon and we'll mail you the corresponding tests, answer sheets and evaluation guides.

During a quiet evening hour, work them through and grade yourself with the answer sheet. Then, use the evaluation guide to figure out your own probability for success on the Light Military staff.

MAIL THIS COUPON FOR YOUR TESTS

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LMED

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

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Mr. R. Bach 76-MI
Light Military Electronics Dept.
General Electric Company, French Road, Utica, New York

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☐ RADAR ☐ MICROWAVE
☐ ELECTRONIC PACKAGING (ME)
☐ COMMUNICATIONS ☐ ADMINISTRATIVE ENGINEERING

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Home Address_____ Home Phone_____
City_____ Zone_____ State_____
Degree(s)_____ Years(s) Received_____

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If you are qualified for and interested in any of the positions described below, we will invite you to visit us in Nashua, meet some Sanders engineers as well as the manager of a group you may work with. Please send a complete resume to Roland E. Hood, Jr., Employment Manager.

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Senior Microwave Engineer with a high degree of creativity to administratively and technically supervise a microwave department consisting of approximately 50 engineers and technicians. Should have knowledge of subcontracting, marketing, project cost control and technical familiarity with ferrite devices, parametric amplifiers, crystal mixers, antennas for multi-element arrays (and other types of antennas), components involving strip line techniques, and systems from 1 mc to 20 kmc. Minimum BS in EE or Physics and 5 to 12 years experience.

SYSTEMS ENGINEERS

Through Project Engineer level. Should have creative abilities and background of VHF transmitters and receivers, communications systems in general, data processing techniques, propagation and must be capable of translating this knowledge into complex integrated systems. Also requires knowledge of radar systems, pulse Doppler systems, steerable beam techniques and pulse techniques.

RECEIVER DESIGN ENGINEERS

VHF electronically scanned airborne receivers, filters, problems in spurious response reduction and multiplexing.

CIRCUIT DESIGN ENGINEERS

With particular emphasis on transistor application to analog and digital techniques; data handling equipment; audio, video, RF circuitry and switching.

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Project Engineers, EE. For automatic astro tracking systems. Up to 5 years' related experience.

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a) Experience in the research and development of transistors in servo, digital and instrumentation application. Minimum 3 years' experience desired in transistor circuit design for military applications.
b) Experienced with IR to UV radiation properties and applications, noise theory and detectors.
c) Optics—IR through visual optical design, lens design, materials.
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CIRCLE 875 ON READER-SERVICE CARD

OPENINGS IN

Systems Analysis
Design & Development
Evaluation

Systems Analysis

Weapons Systems analysts with BS or MS in mathematics or physics, or BSEE, to work on weapons system and component lethality, evaluations, optimization studies, feasibility studies, and concept synthesis. Also a BSEE or MSEE with a minimum of 3 years in electronic systems with emphasis on remote control, data handling, signal processing.

Design and Development

A number of openings now exist for experienced design and development engineers with the following qualifications:

BSEE or MSEE, minimum 3 years experience in any of these fields: Solid state circuit design, including amplifiers and switching circuitry; RF techniques, including circuit design; antenna design, propagation studies, modulation techniques. Signal processing and data handling, including techniques for encoding, decoding, storage, digital data processing, display, system integration. Also: openings for BSEE with minimum one year in synthesis servo analysis or servo application.

Evaluation

BSEE. Prefer 1-8 years in test, design, or related areas. Work involves testing specific unit systems, parts, or materials. May involve designing and building non-standard testing equipment; field or simulated field testing; tests on production instruments.

All above openings are in Minneapolis area. For complete information, write Allan J. McInnis, Professional Manpower Staff, Ordnance Division, Honeywell, 600 Second St. North, Hopkins, Minn.

Honeywell

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To explore professional opportunities in other Honeywell operations, coast to coast, send your application in confidence to H. D. Eckstrom, Honeywell, Minneapolis 8, Minn.

CIRCLE 908 ON CAREER INQUIRY FORM

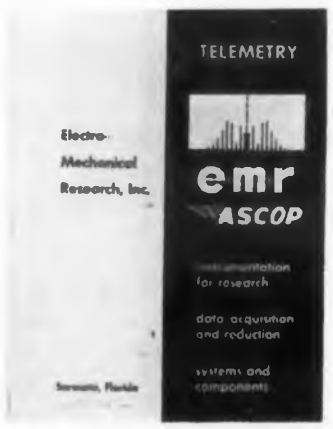
CAREER OPPORTUNITIES BROCHURES

Stromberg-Carlson

In this 24-page illustrated brochure, the San Diego Div. of Stromberg-Carlson describes its organization, facilities, and products. Engineers are needed for work on cathode-ray tubes, transistor-circuit design, tube-circuit design, reliability, logical and digital design, field service, and electro-mechanical devices.

Stromberg-Carlson, Div. General Dynamics Corp., Dept. ED, 1895 Hancock St., San Diego 12, Calif.

CIRCLE 870 ON READER-SERVICE CARD



E-M-R ASCOP

Electro-Mechanical Research, Inc., as outlined in its 26-page illustrated brochure, has its main office in Sarasota, Florida. Total employment is more than 450, of whom approximately 150 are engineers and technicians at a ratio of one to two. The ASCOP Division located in Princeton, N.J. employs over 350. The major activities of E-M-R are in the field of instrumentation for research, both in data acquisition and processing.

Candidates for Equipment Development Engineers and Systems Engineers should be graduate electrical engineers with some previous experience. For further information contact Mr. John G. Truitt, Personnel Manager, Electro-Mechanical Research, Inc., Sarasota, Florida; Mr. Marmaduke Jacobs, Personnel Manager, ASCOP Division of E-M-R, P. O. Box 44, Princeton, N.J.

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SYSTEMS ENGINEERS

As an active participant in the formulation and design of microwave data telemetry and tracking systems, your responsibilities will include analysis of equipment design and performance, specification and technical direction of system test, analysis of flight test data, and preparation of system test report.

DESIGN ENGINEERS

Direct your ingenuity to the design of circuits forming integral parts of CW range measuring equipment and the integration of complex timing and coding circuitry for earth satellites. You will also establish and supervise test programs, direct the testing of setups, component parts, circuits and complete ranging systems, supervise and monitor electrical and environmental testing for qualification. Familiarity with transistor switching circuitry is required.

RANGE DESIGN ENGINEERS

Challenging assignments can be yours in the production of installation criteria, specifications, instructions and drawings required to implement advanced radar, telemetry, data processing, computing and communications systems.

RANGING AND TRACKING ENGINEERS

If your experience includes low-frequency phase measurements, tracking or radar, openings exist at PHILCO WDL for engineers to design, develop and insure fabrication of specialized test equipment.

RELIABILITY ASSURANCE

Your assignments will include evaluation of electronic components, preparation of specifications and drawings of components, analysis of failure of semi-conductors, tubes, or electromechanical devices.

QUALITY ASSURANCE

Qualified engineers are required immediately for in-process, final acceptance and testing of electronic and electromechanical equipment associated with missile and satellite tracking systems. Types of equipment include data processing, UHF and VHF transmitters and receivers, antenna systems.

Consider a career at Philco Western Development Laboratories, elite electronics center on the San Francisco Peninsula. For you . . . the encouragement of graduate study on a Tuition Refund basis at any of the excellent surrounding educational institutions, liberal employee benefits, and the facilities of Philco's new, modern R & D laboratories. For you and your family . . . the perfect climate, whether seasonal or cultural, in which to pursue all-year recreational activities. Only 45 minutes from cosmopolitan, dynamic San Francisco. We invite your inquiry in confidence as a first step toward expanding your skills at Philco, Palo Alto. Resumes may be sent to Mr. J. R. Miner.

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